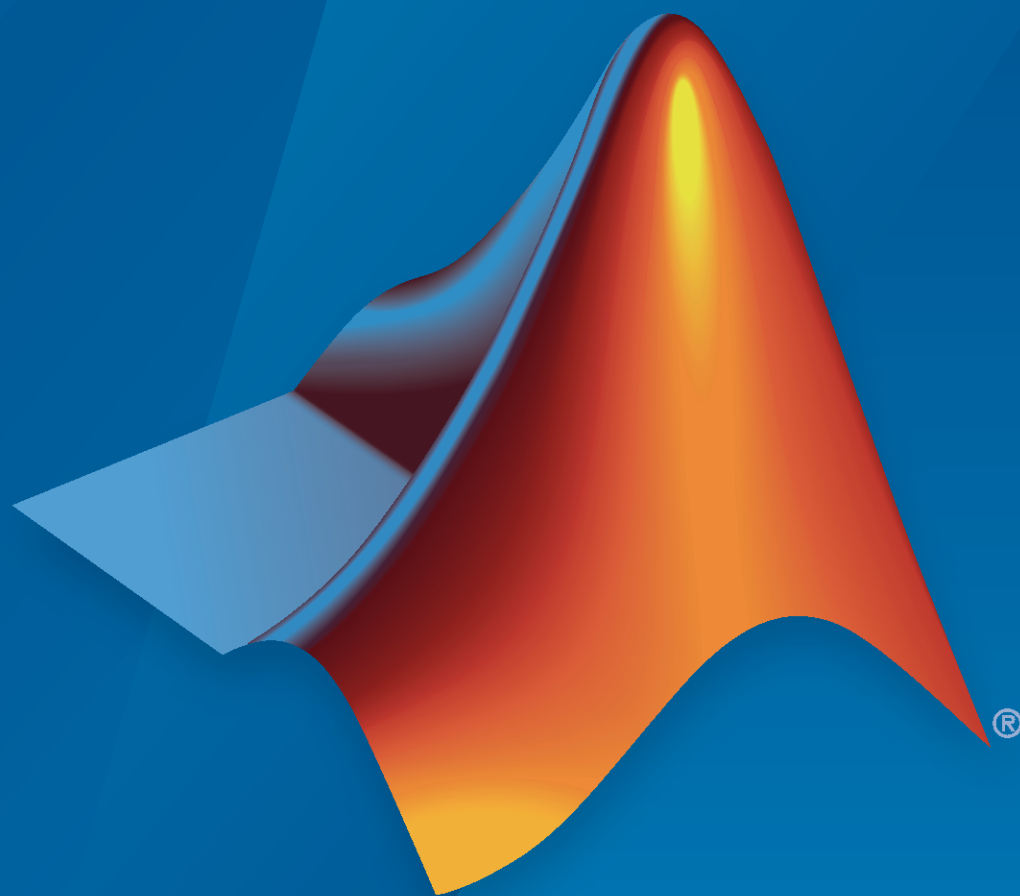


Mapping Toolbox™

Reference



MATLAB®

R2023a



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Mapping Toolbox™ Reference

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Revision History

May 1997	First printing	New for Version 1.0
October 1998	Second printing	Version 1.1
November 2000	Third printing	Version 1.2 (Release 12)
July 2002	Online only	Revised for Version 1.3 (Release 13)
September 2003	Online only	Revised for Version 1.3.1 (Release 13SP1)
January 2004	Online only	Revised for Version 2.0 (Release 13SP1+)
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September 2005	Online only	Revised for Version 2.2 (Release 14SP3)
March 2006	Online only	Revised for Version 2.3 (Release 2006a)
September 2006	Seventh printing	Revised for Version 2.4 (Release 2006b)
March 2007	Online only	Revised for Version 2.5 (Release 2007a)
September 2007	Eighth printing	Revised for Version 2.6 (Release 2007b)
March 2008	Online only	Revised for Version 2.7 (Release 2008a)
October 2008	Online only	Revised for Version 2.7.1 (Release 2008b)
March 2009	Online only	Revised for Version 2.7.2 (Release 2009a)
September 2009	Online only	Revised for Version 3.0 (Release 2009b)
March 2010	Online only	Revised for Version 3.1 (Release 2010a)
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April 2011	Online only	Revised for Version 3.3 (Release 2011a)
September 2011	Online only	Revised for Version 3.4 (Release 2011b)
March 2012	Online only	Revised for Version 3.5 (Release 2012a)
September 2012	Online only	Revised for Version 3.6 (Release 2012b)
March 2013	Online only	Revised for Version 3.7 (Release 2013a)
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March 2014	Online only	Revised for Version 4.0.1 (Release 2014a)
October 2014	Online only	Revised for Version 4.0.2 (Release 2014b)
March 2015	Online only	Revised for Version 4.1 (Release 2015a)
September 2015	Online only	Revised for Version 4.2 (Release 2015b)
March 2016	Online only	Revised for Version 4.3 (Release 2016a)
September 2016	Online only	Revised for Version 4.4 (Release 2016b)
March 2017	Online only	Revised for Version 4.5 (Release 2017a)
September 2017	Online only	Revised for Version 4.5.1 (Release 2017b)
March 2018	Online only	Revised for Version 4.6 (Release 2018a)
September 2018	Online only	Revised for Version 4.7 (Release 2018b)
March 2019	Online only	Revised for Version 4.8 (Release 2019a)
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March 2020	Online only	Revised for Version 4.10 (Release 2020a)
September 2020	Online only	Revised for Version 5.0 (Release 2020b)
March 2021	Online only	Revised for Version 5.1 (Release 2021a)
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March 2022	Online only	Revised for Version 5.3 (Release 2022a)
September 2022	Online only	Revised for Version 5.4 (Release 2022b)
March 2023	Online only	Revised for Version 5.5 (Release 2023a)

1	Functions
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Functions

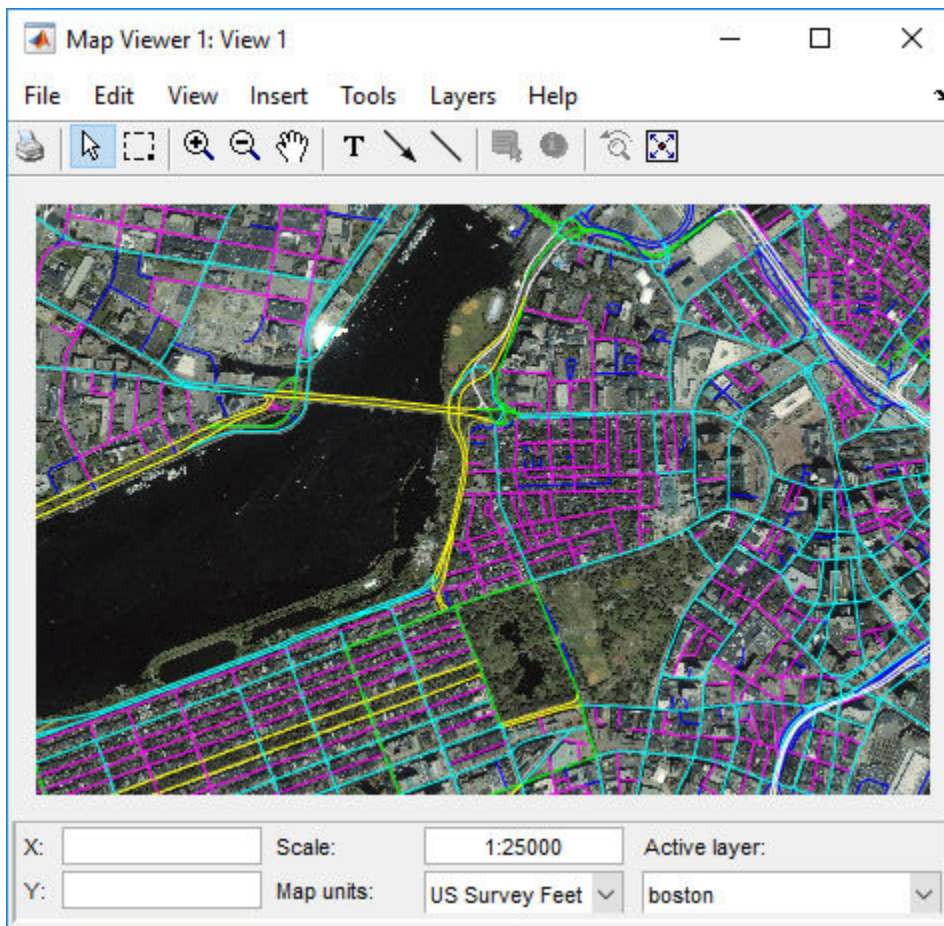
Map Viewer

(Removed) View and explore data in map coordinates

Note The Map Viewer app has been removed.

Description


The Map Viewer app enables you to view geospatial data in map (x - y) coordinates. The Map Viewer works with vector, image, and raster data grids in a map coordinate system. You can pan and zoom on the map, specify the map scale of your screen display, and control the order, visibility, and symbolization of map layers. In addition, you can add annotations to your map and click to learn more about individual vector features.



Open the Map Viewer App

- MATLAB® command prompt: Enter mapview.

Limitations

The **Select area** tool  is not supported in MATLAB Online™. To view a particular region on the map, use the **Zoom in**, **Zoom out**, and **Pan** tools instead.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `mapview` function has been removed.

R2022a: To be removed

Warns starting in R2022a

The `mapview` function issues a warning that it will be removed in a future release.

See Also

Functions

`mapshow`

addCustomBasemap

Add custom basemap

Syntax

```
addCustomBasemap(basemapName,URL)
addCustomBasemap(basemapName,mbtilesFilename)
addCustomBasemap( ____,Name,Value)
```

Description

`addCustomBasemap(basemapName,URL)` adds the custom basemap specified by URL to the list of basemaps available for use with mapping functions. `basemapName` is the name you choose to call the custom basemap. Added basemaps remain available for use in future MATLAB sessions.

You can use custom basemaps with several types of map displays, for example, geographic axes created using the `geoaxes` function, geographic globes created using the `geoglobe` function, and web maps created using the `webmap` function.

`addCustomBasemap(basemapName,mbtilesFilename)` adds the custom basemap specified by `mbtilesFilename`, an MBTiles file containing raster or vector map tiles. You can use the basemap in future MATLAB sessions, provided the MBTiles file is still on the same path as when you add it.

Web maps do not support custom basemaps created from MBTiles files.

`addCustomBasemap(____,Name,Value)` specifies name-value arguments that set additional parameters of the basemap.

Examples

Add Basemap from OpenStreetMap

Display point locations on a geographic bubble chart using a basemap from OpenStreetMap®.

Specify values for these arguments:

- A name that identifies the custom basemap.
- The URL of the map tiles. For load balancing, this provider has three servers you can use (a, b, and c).
- An attribution that gives credit to the provider of the map tiles. When you plot data, this attribution appears at the bottom of the map. Map tile providers can define specific requirements for the attribution.

```
basemapName = "openstreetmap";
url = "a.tile.openstreetmap.org/{z}/{x}/{y}.png";
copyright = char(uint8(169));
attribution = copyright + "OpenStreetMap contributors";
```

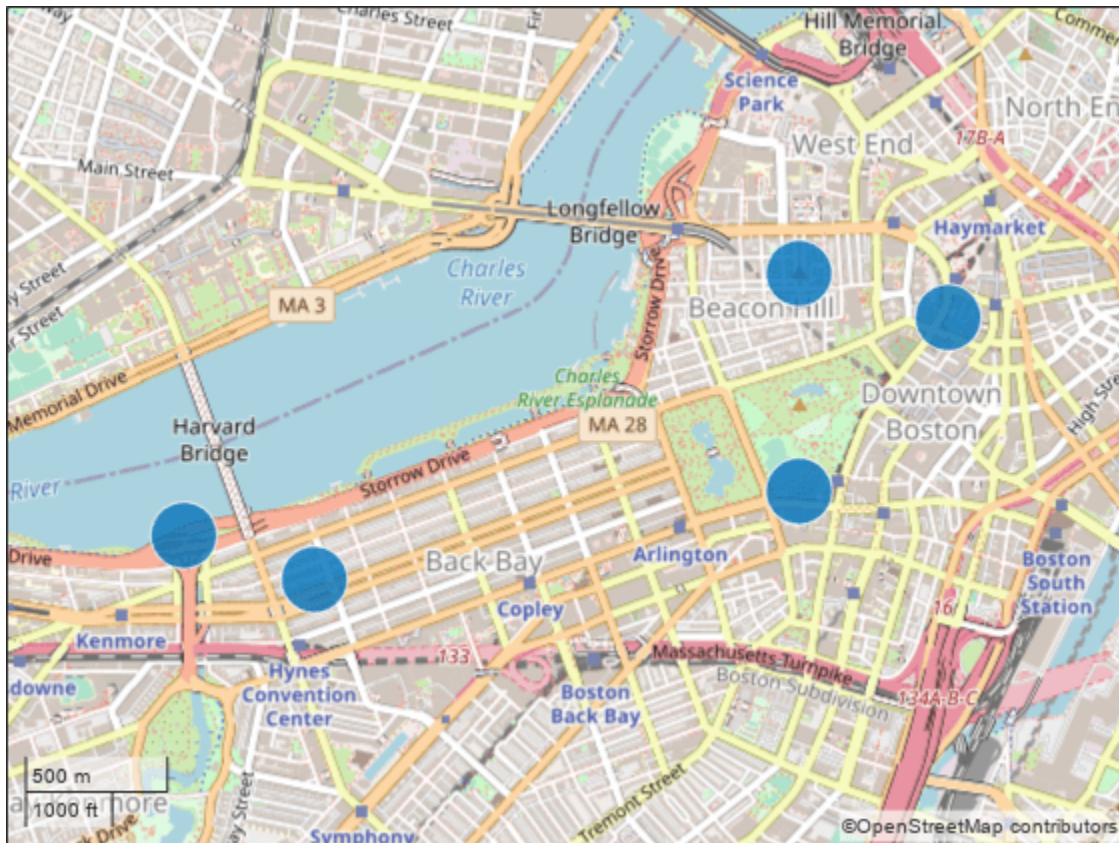
Add the custom basemap to the list of basemaps available for use with mapping functions.

```
addCustomBasemap(basemapName,url,"Attribution",attribution)
```

Specify the latitude and longitude coordinates of several point locations. Then, plot the coordinates using a geographic bubble chart.

```
lat = [42.3501 42.3515 42.3598 42.3584 42.3529];
lon = [-71.0870 -71.0926 -71.0662 -71.0598 -71.0662];
```

```
gb = geobubble(lat,lon,"Basemap",basemapName);
gb.BubbleWidthRange = 25;
gb.MapLayout = "maximized";
gb.ZoomLevel = 14;
```



Add Basemap from Esri

Display data on a basemap hosted by Esri®.

Add the basemap to the list of basemaps available for use with mapping functions. For this example, add the basemap using the map tiles URL and style URL for National Geographic Style [1] on page 1-7.

```
basemapName1 = "natgeostyle";
url = "https://basemaps.arcgis.com/arcgis/rest/services/World_Basemap_v2/VectorTileServer/tile/$";
style = "https://www.arcgis.com/sharing/rest/content/items/3d1a30626bbc46c582f148b9252676ce/reso";
addCustomBasemap(basemapName1,url,Style=style)
```

Import a GPX file that contains the path of a glider. Extract the latitude coordinates, longitude coordinates, and elevations.

```
trk = readgeotable("sample_mixed.gpx", "Layer", "track_points");
lat = trk.Shape.Latitude;
lon = trk.Shape.Longitude;
h = trk.Elevation;
```

Display the path in 2-D using the National Geographic Style basemap.

```
geoplot(lat, lon, "m", LineWidth=2)
geobasemap(basemapName1)
```

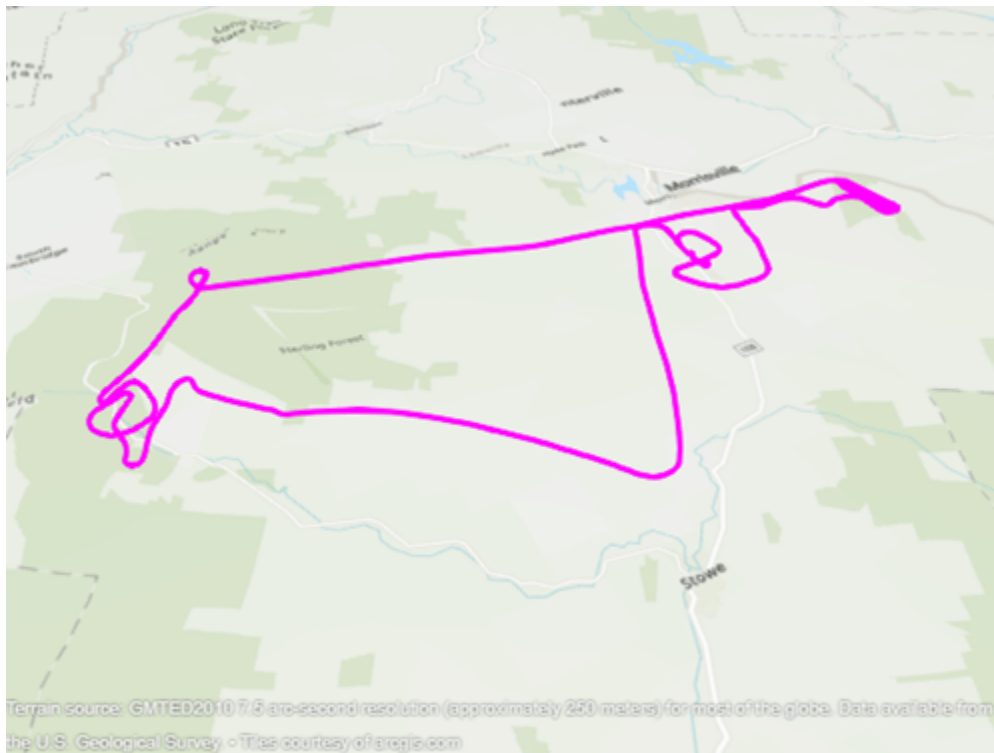


You can also customize the appearance of the basemap by using a predefined style. For example, add another basemap using the same map tiles URL and a predefined topographic style.

```
basemapName2 = "topostyle";
addCustomBasemap(basemapName2, url, Style="topographic")
```

Display the path in 3-D using the new basemap.

```
uif = uifigure;
g = geoglobe(uif, Basemap=basemapName2);
geoplot3(g, lat, lon, h, "m", LineWidth=2)
```

[1] "National Geographic Style - Overview." ArcGIS Online. Accessed December 8, 2022. <https://www.arcgis.com/home/item.html?id=3d1a30626bbc46c582f148b9252676ce>.

Add Basemap from MBTiles File

Creating custom basemaps from MBTiles files is useful when you do not have internet access.

MBTiles files can contain raster or vector map tiles. Raster map tiles are useful for displaying satellite imagery and orthoimagery. Vector map tiles enable you to customize the appearance of the basemap and typically include higher zoom levels than raster map tiles. If you do not know whether your MBTiles file contains raster or vector map tiles, check with your data provider.

Raster MBTiles File

Create a basemap from an MBTiles file containing raster map tiles. Mapping Toolbox includes a raster MBTiles file, `usgsimagery.mbtiles`, with low-resolution USGS imagery.

Add the USGS Imagery basemap to the list of basemaps available for use with mapping functions. The `addCustomBasemap` function uses the attribution and maximum zoom level contained in the file.

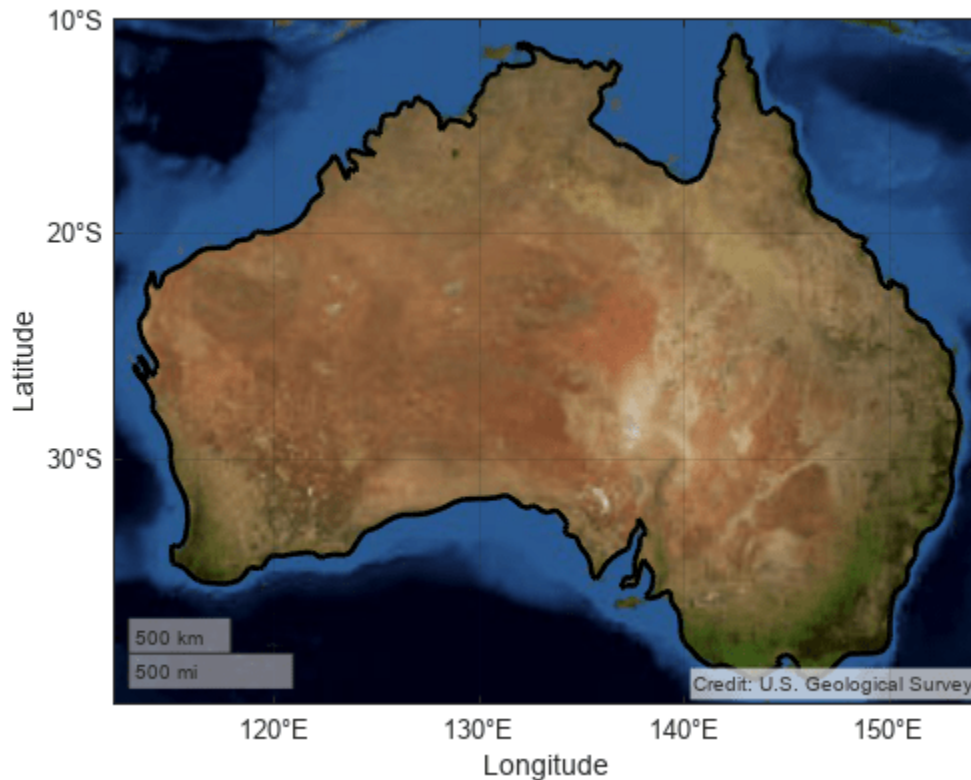
```
basemap1 = "usgsimagery";
mbtilesFilename1 = "usgsimagery.mbtiles";
addCustomBasemap(basemap1,mbtilesFilename1)
```

Read worldwide land areas into the workspace as a geospatial table. Create a subtable containing only Australia.

```
GT = readgeotable("landareas.shp");  
australia = GT(GT.Name == "Australia",:);
```

Display the outline of Australia over the USGS Imagery basemap.

```
figure  
geoplot(australia,"LineWidth",2,"FaceColor","none")  
geobasemap usgsimagery
```



Vector MBTiles File

(Since R2023a)

Create a basemap from an MBTiles file containing vector map tiles. Mapping Toolbox includes a vector MBTiles file, `naturalearth.mbtiles`, with low-zoom levels of region and land boundaries.

Add the Natural Earth basemap to the list of basemaps available for use with mapping functions. Specify the appearance of the basemap, including the colors and fonts, using a predefined style.

```
basemap2 = "naturalearth";  
mbtilesFilename2 = "naturalearth.mbtiles";  
style = "streets";  
addCustomBasemap(basemap2,mbtilesFilename2,Style=style)
```

Create a map using the Natural Earth basemap. Zoom into a region including the northeast United States.

```
figure
geobasemap naturalearth
geolimits([38.6 47.8],[-81.4 -65.4])
```



Compare Vector and Raster Basemap Tiles

Starting in R2023a, you can add custom basemaps using vector map tiles hosted by Esri. Vector map tiles enable you to customize the appearance of the basemap and typically include higher zoom levels than raster map tiles. This example creates vector and raster versions of similar Esri basemaps and compares the map tiles at different zoom levels.

Specify the maximum zoom level to use for the custom basemaps.

```
maxzoom = 20;
```

Add a custom basemap using the map tiles URL for Streets [1] on page 1-11. This basemap uses vector map tiles.

```
basemapName1 = "streetsvector";
url1 = "https://basemaps.arcgis.com/arcgis/rest/services/World_Basemap_v2/VectorTileServer/tile/";
addCustomBasemap(basemapName1,url1,Style="streets",MaxZoomLevel=maxzoom)
```

Add the custom basemap using the map tiles URL for World Street Map [2] on page 1-11. This basemap uses raster map tiles.

```

basemapName2 = "streetsraster";
url2 = "https://services.arcgisonline.com/arcgis/rest/services/World_Street_Map/MapServer/tile/$";
attribution = "Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community";
addCustomBasemap(basemapName2,url2,Attribution=attribution,MaxZoomLevel=maxzoom)

```

Create two maps in a tiled chart layout. Place the vector basemap in the left tile and the raster basemap in the right tile. Center both maps on the Statue of Liberty in New York City.

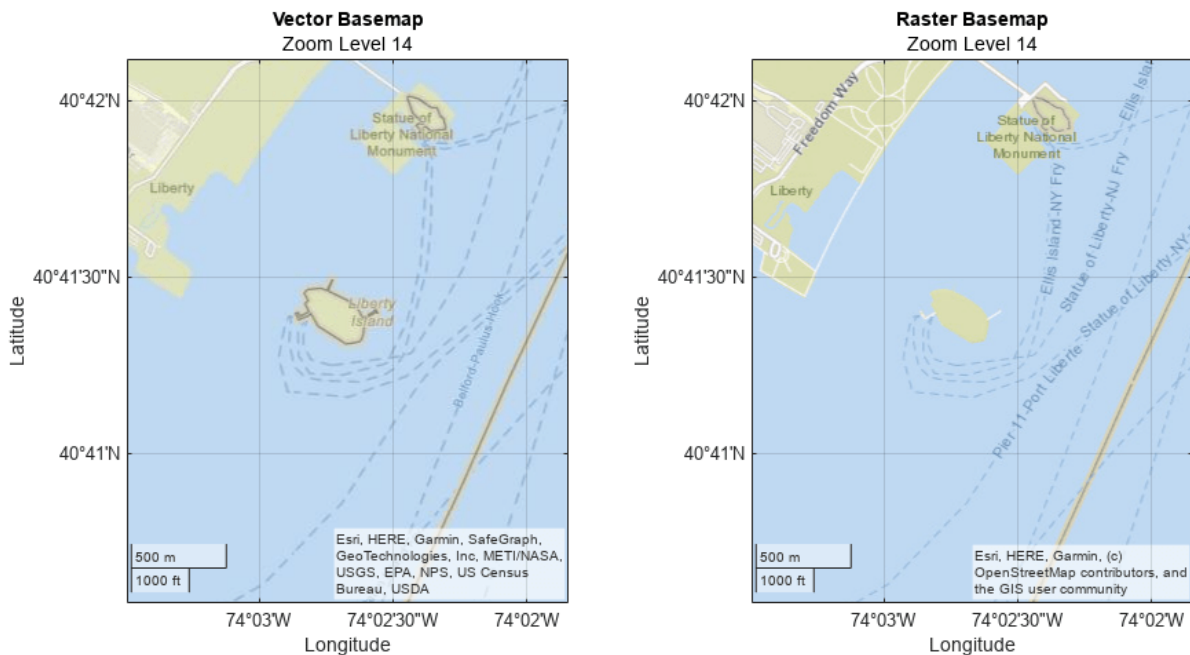
```

f = figure(Position=[500 500 1000 500]);
center = [40.689125327367890 -74.044492429136966];
initialzoom = 14;

t = tiledlayout(1,2);
gx1 = geoaxes(t,Basemap=basemapName1,MapCenter=center,ZoomLevel=initialzoom);
title("Vector Basemap")
subtitle("Zoom Level " + initialzoom)

gx2 = geoaxes(t,Basemap=basemapName2,MapCenter=center,ZoomLevel=initialzoom);
gx2.Layout.Tile = 2;
title("Raster Basemap")
subtitle("Zoom Level " + initialzoom)

```



Use a loop to view the basemap at increasing zoom levels. Unlike the vector basemap at this location, the raster basemap does not contain data at zoom level 20.

```

for zoom = initialzoom:0.5:maxzoom
    gx1.ZoomLevel = zoom;
    gx2.ZoomLevel = zoom;

    subtitle(gx1,"Zoom Level " + zoom)
    subtitle(gx2,"Zoom Level " + zoom)

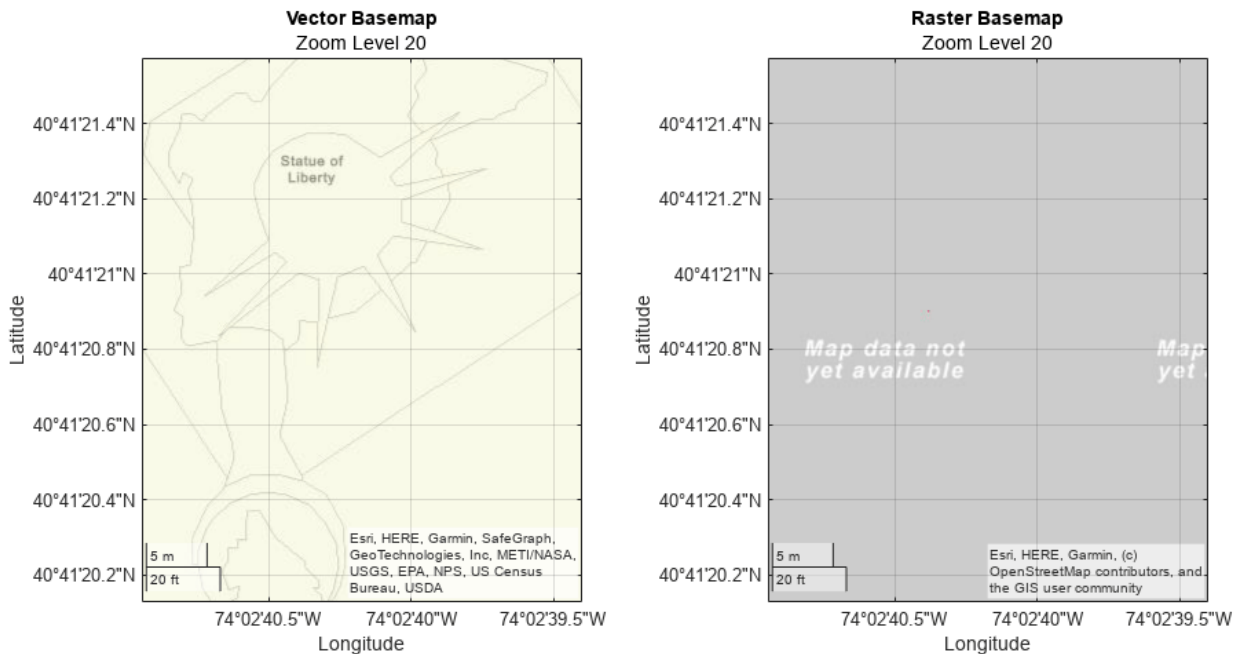
drawnow

```

```

pause(0.75)
end

```



[1] "Streets - Overview." ArcGIS Online. Accessed December 7, 2022. <https://www.arcgis.com/home/item.html?id=de26a3cf4cc9451298ea173c4b324736>.

[2] "World Street Map - Overview." ArcGIS Online. Accessed December 7, 2022. <https://www.arcgis.com/home/item.html?id=3b93337983e9436f8db950e38a8629af>.

Add Basemap from USGS National Map

Display the route of a glider in 2-D and 3-D using a topographic basemap from the USGS National Map.

Specify values for these arguments:

- A name that identifies the custom basemap.
- The URL for the map tiles. This URL includes the URL of the National Map ArcGIS REST Services Directory and the path to the map tiles from the USGS Topo basemap service.
- An attribution that gives credit to the provider of the map tiles. When you plot data, this attribution appears at the bottom of the map. Map tile providers can define specific requirements for the attribution.

```

basemapName = "usgstopo";
url = "https://basemap.nationalmap.gov/ArcGIS/rest/services/USGSTopo/MapServer/tile/{z}/{y}/{x}";
att = "Credit: US Geological Survey";

```

Add the basemap to the list of basemaps available for use with mapping functions.

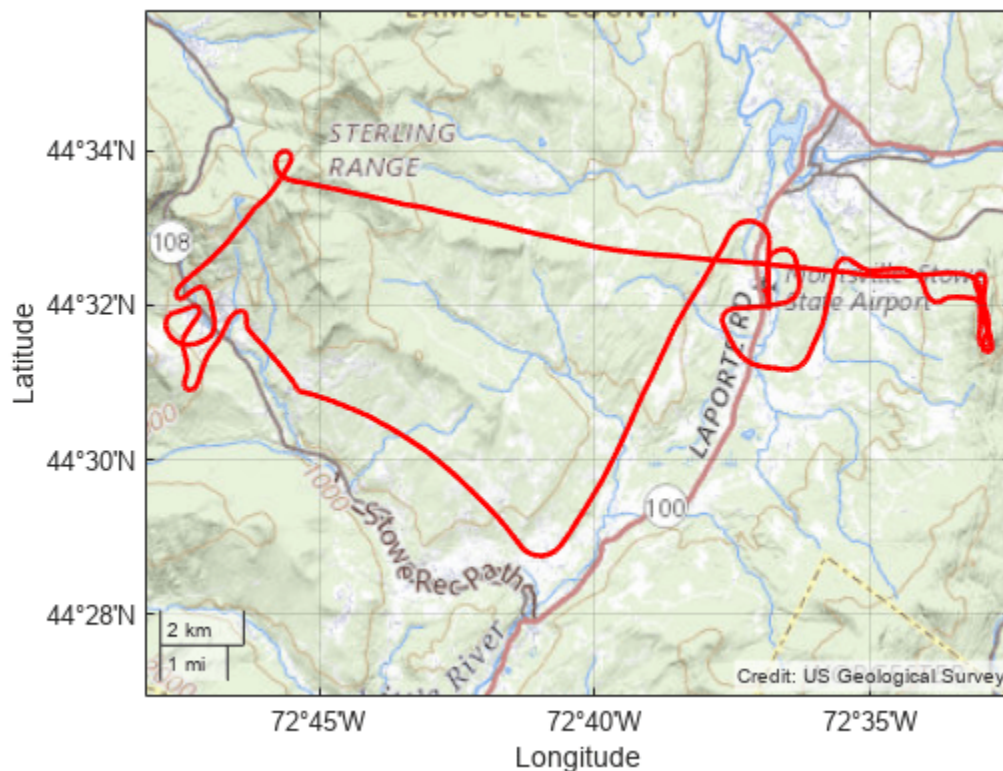
```
addCustomBasemap(basemapName,url,"Attribution",att)
```

Import a GPX file that contains the path of a glider. Extract the latitude coordinates, longitude coordinates, and elevations.

```
trk = readgeotable("sample_mixed.gpx","Layer","track_points");
lat = trk.Shape.Latitude;
lon = trk.Shape.Longitude;
h = trk.Elevation;
```

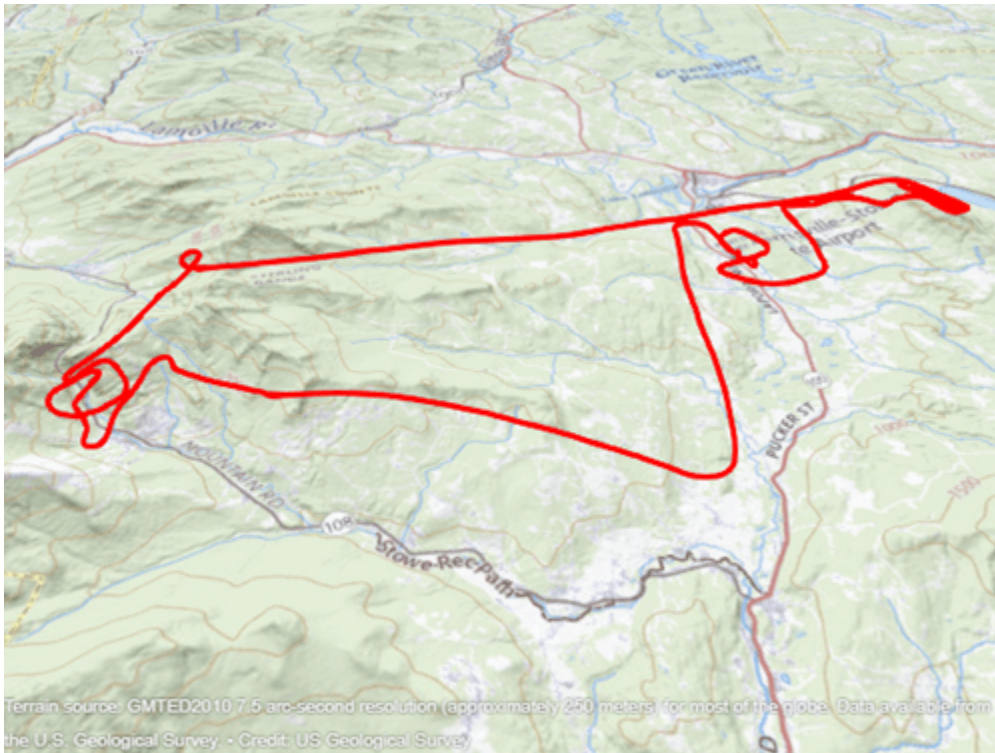
Display the path in 2-D using the USGS Topo basemap.

```
geoplot(lat,lon,"r","LineWidth",2)
geobasemap(basemapName)
```



Display the path in 3-D using a geographic globe and the same basemap. By default, the view is directly above the path. Tilt the view by holding **Ctrl** and dragging.

```
uif = uifigure;
g = geoglobe(uif,"Basemap","usgstopo");
geoplot3(g,lat,lon,h,"r","LineWidth",2)
```

Add Several Basemaps from USGS National Map

Plot the path of a glider over a variety of basemaps that are available from the USGS National Map site. Viewing data over several maps can help you determine which map provides the best background.

This example adds each basemap using a loop. Prepare to add the basemaps by specifying these arguments:

- The URL of the map tiles. The USGS National Map supports several tiled web maps. For this example, insert the word **BASEMAP** into the URL string. The loop replaces the word **BASEMAP** with the names of the maps supported by the USGS National Map.
- The names of USGS basemaps. The loop inserts these names into the URL in place of **BASEMAP**.
- The display names to use for each basemap. For this example, use display names that match the names used by the `webmap` function, so that `webmap` does not contain duplicate maps.
- An attribution that gives credit to the provider of the map tiles. When you plot data, this attribution appears at the bottom of the map. Map tile providers can define specific requirements for the attribution.
- The maximum zoom level for the basemaps.

```
baseURL = "https://basemap.nationalmap.gov/ArcGIS/rest/services";
usgsURL = baseURL + "/BASEMAP/MapServer/tile/{z}/{y}/{x}/png";
basemapNames = ["USGSImageryOnly" "USGSImageryTopo" "USGSTopo" "USGSHydroCached"];
displayNames = ["USGS Imagery" "USGS Topographic Imagery" "USGS Shaded Topographic Map" "USGS Hy
attribution = "Credit: U.S. Geological Survey";
maxZoomLevel = 16;
```

Import a GPX file that contains the path of a glider.

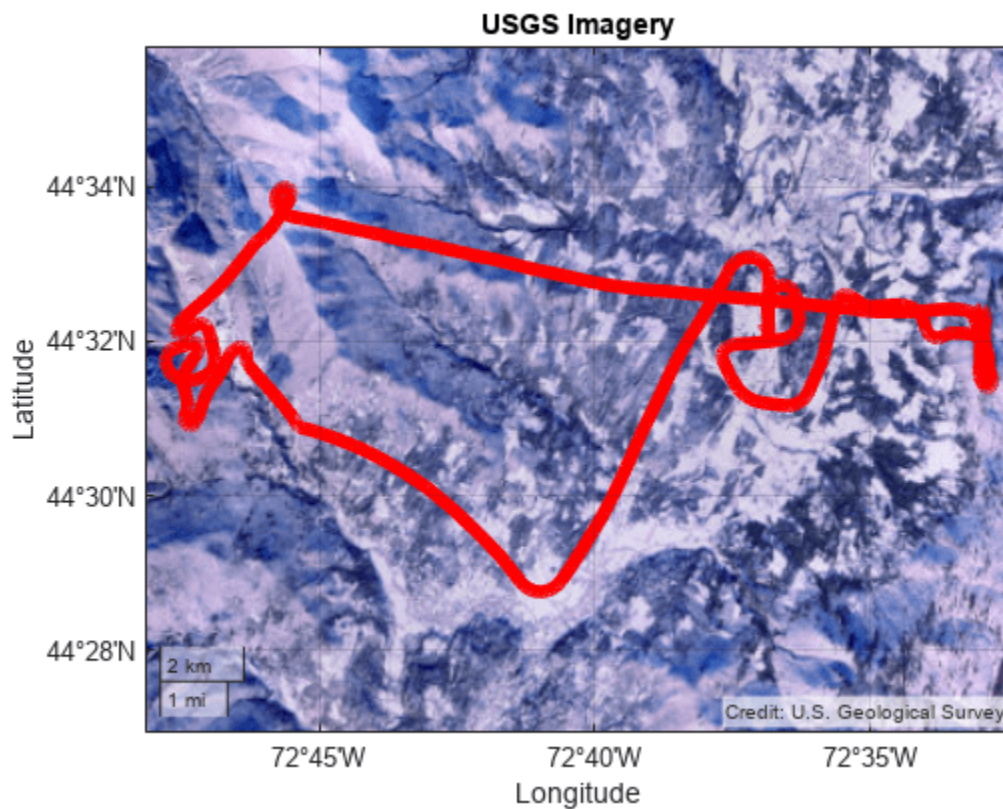
```
GT = readgeotable("sample_mixed.gpx","Layer","tracks");
```

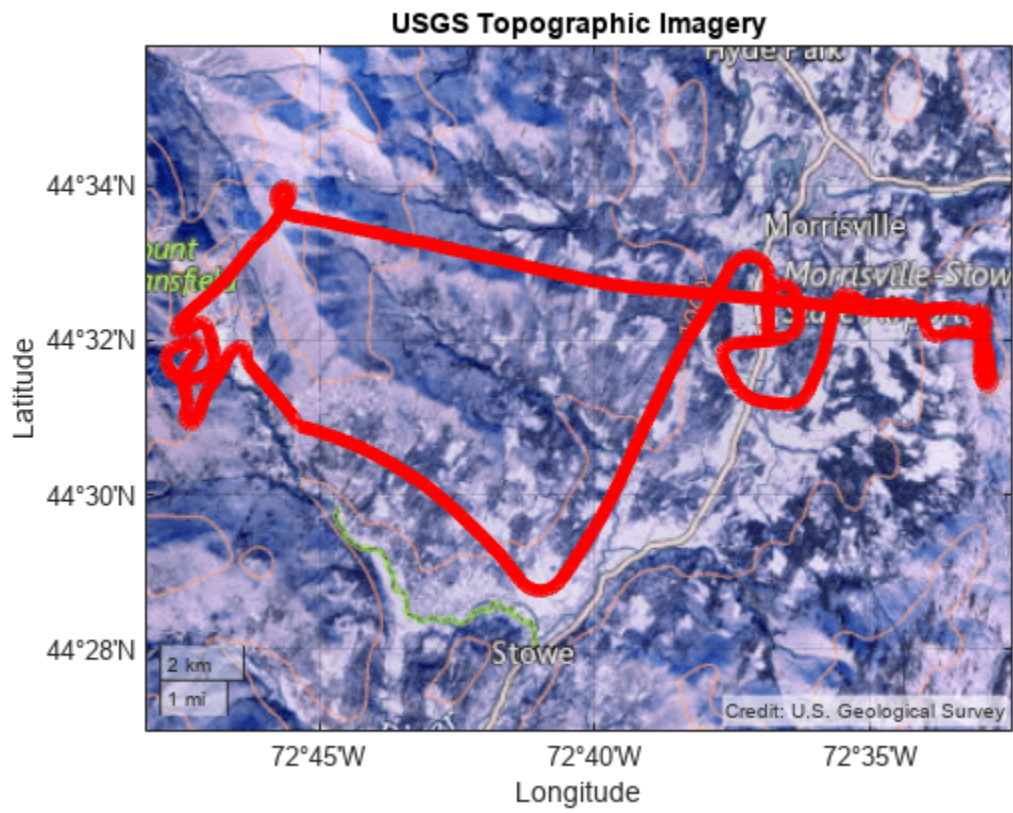
Use a loop to add each basemap and display the glider path over each basemap.

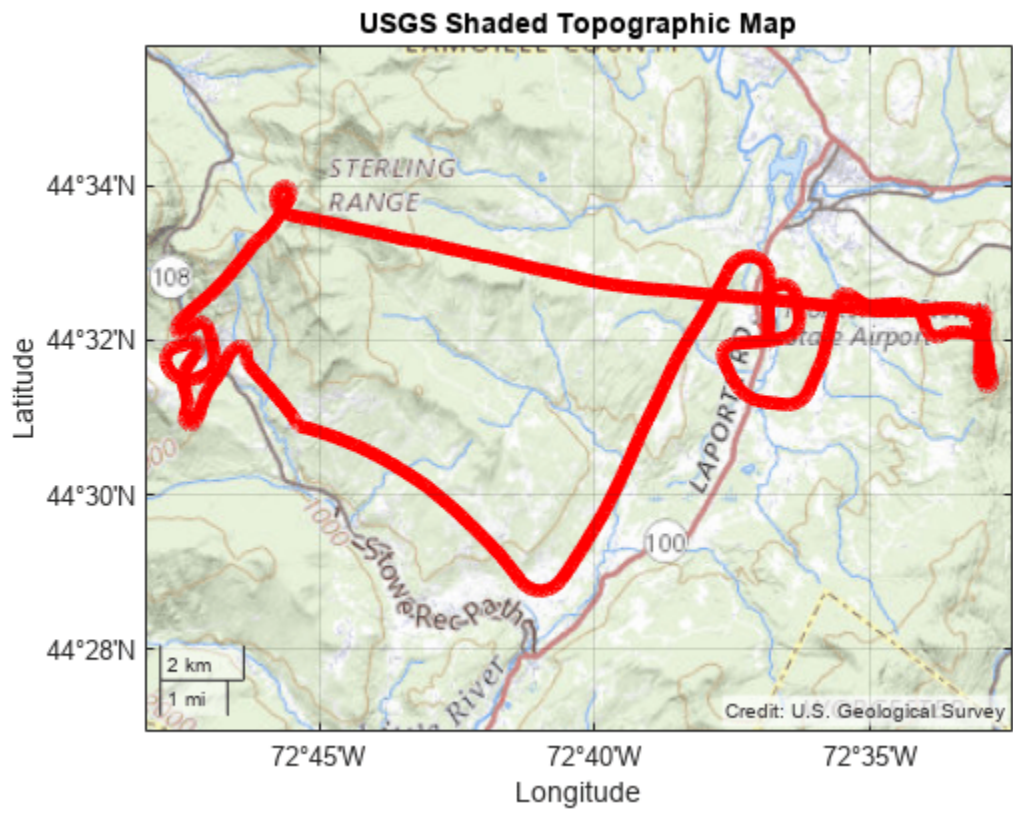
```
for k =1:length(basemapNames)
    basemap = basemapNames(k);
    name = lower(basemap);
    url = replace(usgsURL,"BASEMAP",basemap);
    displayName = displayName(k);

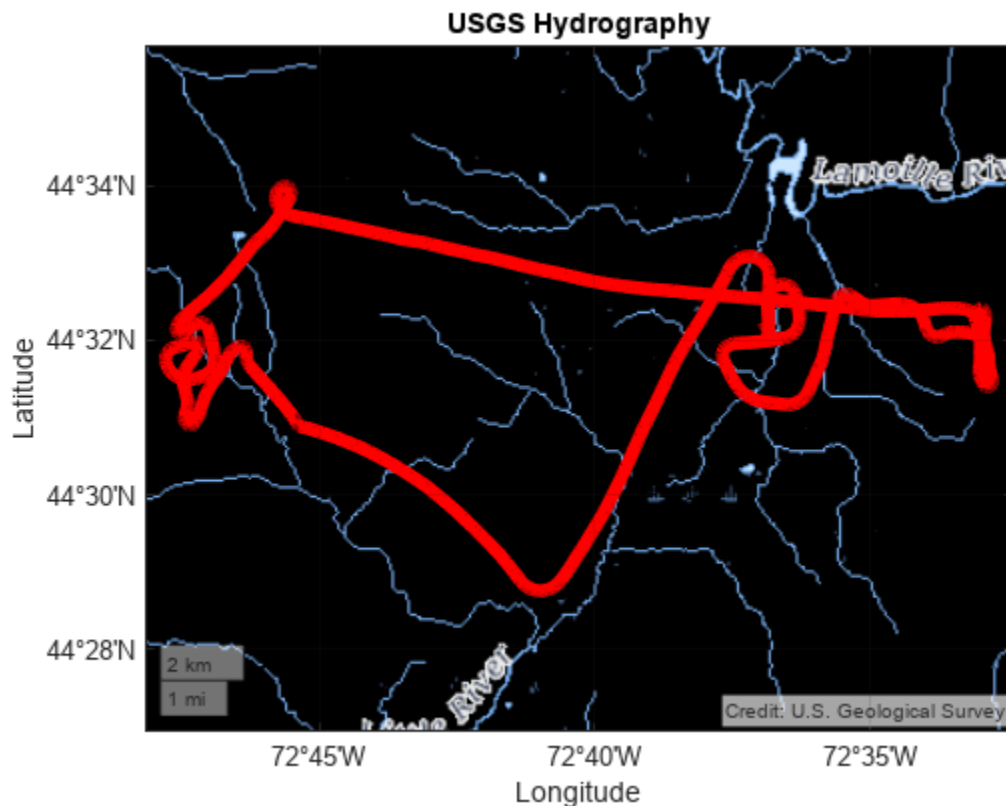
    addCustomBasemap(name,url,"Attribution",attribution, ...
        "DisplayName",displayName,"MaxZoomLevel",maxZoomLevel)

    figure
    geobasemap(basemap)
    geoplot(GT,"r","LineWidth",5);
    title(displayName)
end
```









Add Basemap from OpenTopoMap

Display the route of a glider on a web map using a basemap from OpenTopoMap.

Specify values for these arguments:

- A name that identifies the custom basemap.
- The URL of the map tiles. For load balancing, this provider has three servers you can use (a, b, and c).
- An attribution that gives credit to the provider of the map tiles. When you plot data, this attribution appears at the bottom of the map. Map tile providers can define specific requirements for the attribution.
- The name that appears in the Layer Manager tab of the web map.

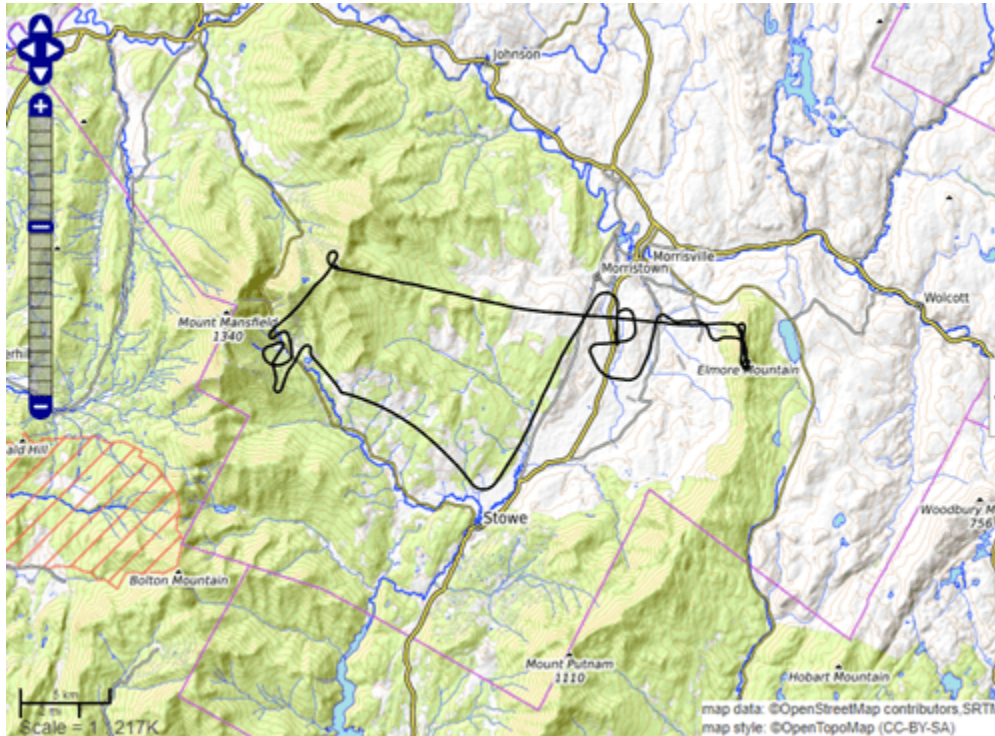
```
basemapName = "opentopomap";
url = "a.tile.opentopomap.org/{z}/{x}/{y}.png";
copyright = char(uint8(169));
attribution = [ ...
    "map data: " + copyright + "OpenStreetMap contributors,SRTM", ...
    "map style: " + copyright + "OpenTopoMap (CC-BY-SA)"];
displayName = "Open Topo Map";
```

Add the custom basemap to the list of basemaps available for use with mapping functions.

```
addCustomBasemap(basemapName,url,"Attribution",attribution, ...
                 "DisplayName",displayName)
```

Open a web map that uses the OpenTopoMap basemap. Then, read glider data into the workspace and plot it over the basemap.

```
webmap(basemapName)
trk = readgeotable("sample_mixed.gpx","Layer","tracks");
wmline(trk,"LineWidth",2)
```



Input Arguments

basemapName — Name used to identify basemap programmatically

string scalar | character vector

Name used to identify basemap programmatically, specified as a string scalar or character vector.

Example: 'openstreetmap'

Data Types: string | char

URL — Parameterized map URL

string scalar | character vector

Parameterized map URL, specified as a string scalar or character vector.

The parameterized map URL typically includes:

- The URL of the basemap tiles.

- An index of the map tiles, formatted as `{z}/{x}/{y}` or `{z}/{y}/{z}`, where `z` is the tile zoom level, `x` is the tile column index, and `y` is the tile row index.
- The file format of the map tiles. The `addCustomBasemap` function can read tiles in image formats supported by the `imread` function and tiles in PBF format (requires Mapping Toolbox) when the map tiles are hosted by Esri®. Depending on the data provider, map tiles are available in different file formats.

The way you structure this argument can depend on the data provider. For more information about how to structure a URL, see “Examples” on page 1-0 or ask your data provider.

Example: `"https://hostname/{z}/{y}/{x}.png"`

Example: `"https://hostname/{z}/{x}/{y}/png"`

Data Types: `string` | `char`

mbtilesFilename — Name of MBTiles file

character vector | string scalar

Name of an MBTiles file containing raster or vector map tiles, specified as a character vector or string scalar. You must include the extension `.mbtiles`. The way you specify `mbtilesFilename` depends on the location of your file.

- If the file is in your current folder or in a folder on the MATLAB path, then specify the name of the file, such as `"myFile.mbtiles"`.
- If the file is not in the current folder or in a folder on the MATLAB path, then specify the full or relative path name, such as `"C:/myfolder/myFile.mbtiles"` or `"dataDir/myFile.mbtiles"`.

Data Types: `char` | `string`

Name-Value Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `addCustomBasemap(basemapName,URL,Attribution="My attribution")` specifies the attribution for the custom basemap.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `addCustomBasemap(basemapName,URL,"Attribution","My attribution")` specifies the attribution for the custom basemap.

Attribution — Attribution of custom basemap

string scalar | string array | character vector | cell array of character vectors

Attribution of the custom basemap, specified as a string scalar, string array, character vector, or cell array of character vectors. To create a multiline attribution, specify a string array or a nonscalar cell array of character vectors.

When you create a custom basemap from a URL, the default attribution is `'Tiles courtesy of DOMAIN_NAME_OF_URL'`, where `DOMAIN_NAME_OF_URL` is the domain name from the URL input argument. If the host is `'localhost'`, or if URL contains only IP numbers, specify the attribution as an empty string (`""`).

When you create a custom basemap from an MBTiles file with an attribution in the metadata, the `addCustomBasemap` function gets the attribution from the file. If the file does not contain an attribution, the default attribution is an empty string.

When you add a basemap from vector map tiles hosted by Esri, the `addCustomBasemap` function ignores this argument and uses an attribution based on the location and zoom level.

Example: "Credit: U.S. Geological Survey"

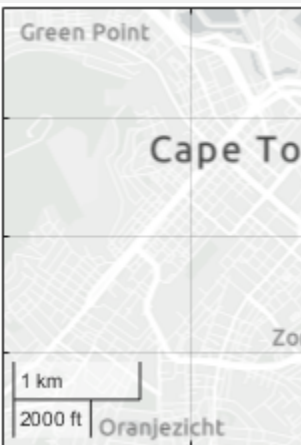

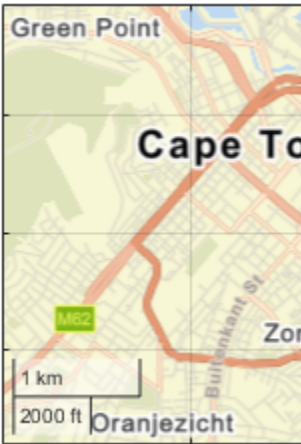

Data Types: string | char | cell

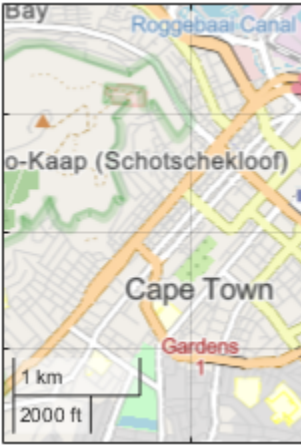
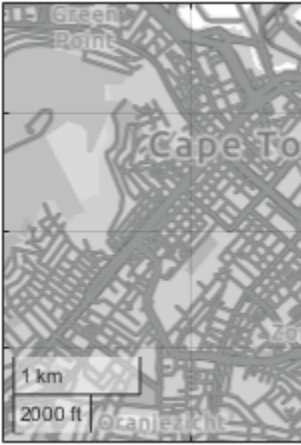
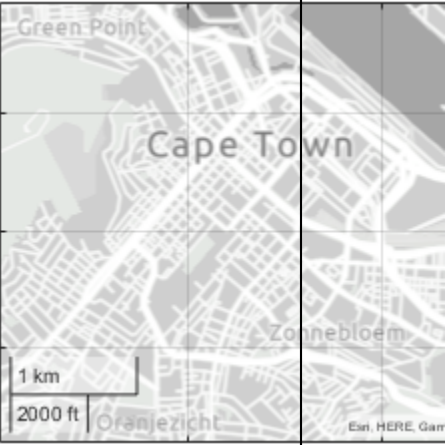
Style — Style of vector basemap

"auto" (default) | "streets-light" | "streets-dark" | "streets" | "topographic" | name of JSON file | URL | ...

Style of the vector basemap, specified as a predefined style, the name of a JSON file, or a URL. The appearance of the basemap, such as the line colors and font names, depends on the style you specify when you add the basemap.

This table lists the predefined style options. The predefined style options do not require internet access.

Value	Sample Image	Value	Description
"streets-light" — Provides geographic context while highlighting user data on a light background.		"streets-dark" — Provides geographic context while highlighting user data on a dark background.	
"streets" — Emphasizes roads and transit networks.		"topographic" — Emphasizes topographic features.	

Value	Sample Image	Value	Description
"openstreetmap" — Uses colors based on OpenStreetMap®.		"bluegreen" — Uses light green for land areas and light blue for water areas.	
"grayland" — Uses gray for land areas and white for water areas.		"darkwater" — Uses light gray for land areas and dark gray for water areas.	

The default is "auto", which chooses a style based on the MATLAB theme. When you select the light theme, "auto" uses the "streets-light" style. When you select the dark theme, "auto" uses the "streets-dark" style.

When you use a predefined style and specify the map tiles using an MBTiles file, the `addCustomBasemap` function creates a JSON file with the style information and places the file in the same folder as the MBTiles file. You can use the JSON file to customize the appearance of the predefined basemap. For more information, see "Customize Appearance of Vector Basemaps".

When you specify the name of a JSON file, you must include the extension `.json`. The way you specify the file depends on the location of the file.

- If the file is in your current folder or in a folder on the MATLAB path, then specify the name of the file, such as "myFile.json".
- If the file is not in the current folder or in a folder on the MATLAB path, then specify the full or relative path name, such as "C:/myfolder/myFile.json" or "dataDir/myFile.json".

JSON files can require internet access, for example, when the file specifies fonts or icons that are stored on a web server. When the file includes references to web servers, the paths must be full paths (not relative paths).

Style Limitations

- The predefined styles use a font supported only in English locales.
- Styles specified using URLs must include the transfer protocol. Only `https` is supported.
- Styles specified using URLs and JSON files can contain attributes that the `addCustomBasemap` function does not support. These unsupported attributes can affect the appearance of the basemap or can cause the function to issue an error.
- The `addCustomBasemap` function creates the custom basemap by matching layers contained in the map tiles with layer IDs specified by the style. If the function fails to match a layer with a layer ID, then the basemap displays the geometry of the layer (such as polygon edges and lines) and does not display other aspects of the layer (such as points and text).
- Styles specified using URLs or JSON files from Esri can cause basemaps on globe viewers to appear in unexpected blue colors. These colors appear because the style specifies some layers as semitransparent instead of completely opaque. Within a JSON file, you can make layers completely opaque by changing values of the "fill-opacity" properties to 1. After you update the JSON file, you must add the custom basemap again.

Data Types: `char` | `string`

DisplayName — Display name of custom basemap

`string scalar` | `character vector`

Display name of the custom basemap, specified as a string scalar or character vector.

The `webmap` function uses this name in the Layer Manager. The `addToolBarMapButton` function uses this name in the basemap picker.

Example: `"OpenStreetMap"`

Data Types: `string` | `char`

MaxZoomLevel — Maximum zoom level of basemap

18 (default) | integer in range [0, 25]

Maximum zoom level of the basemap, specified as an integer in the range [0, 25].

When you create a custom basemap from an MBTiles file with the maximum zoom level in the metadata, the `addCustomBasemap` gets the maximum zoom level from the file.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

IsDeployable — Map is deployable using MATLAB Compiler™

`false` or `0` (default) | `true` or `1`

Map is deployable using MATLAB Compiler, specified as a numeric or logical `0` (`false`) or `1` (`true`).

To deploy a map application that uses a custom basemap, set `IsDeployable` to `true`. If you create the custom basemap from an MBTiles file, then you must include the file in the deployed application package, unless you deploy the application to the same computer you used to compile the application or if the file is on a network file system that the application can access from a different computer. You must set this argument whether you use the `addCustomBasemap` function in your application or outside your application.

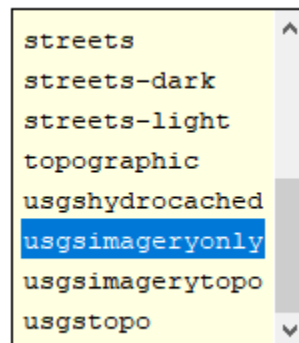
Data Types: `logical`

Limitations

- When you add a custom basemap from vector map tiles, text that crosses tile boundaries can appear clipped.

Tips

- You can find tiled web maps from various vendors, such as OpenStreetMap, the USGS National Map, Mapbox, DigitalGlobe, Esri ArcGIS Online, the Geospatial Information Authority of Japan (GSI), and HERE Technologies. Abide by the map vendors terms-of-service agreement and include accurate attribution with the maps you use.
- To access a list of available basemaps, press **Tab** before specifying the basemap in your plotting function. This image shows a sample list of available basemaps, including several custom basemaps from the USGS National Map.



```
geobubble (lat, lon, "Basemap", "
```

Version History

Introduced in R2018b

R2023a: Add custom basemaps from vector basemaps hosted by Esri and from MBTiles files containing vector data

Add vector basemaps from these sources:

- Vector basemaps hosted by Esri. Specify the basemap using a URL.
- MBTiles files containing vector map tiles.

Specify the appearance of vector basemaps using the `Style` name-value argument.

Mapping Toolbox includes an MBTiles file, `naturalearth.mbtiles`, with low-zoom levels of region and land boundaries.¹ The file was created using data from Natural Earth.

R2022a: Add custom basemaps from MBTiles files

¹ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks®.

Add a custom basemap from an MBTiles file containing raster map tiles. Creating custom basemaps from MBTiles files is useful when you do not have internet access. Mapping Toolbox includes an MBTiles file with low-resolution USGS imagery called `usgsimagery.mbtiles`.

See Also

`geobasemap` | `geobubble` | `geoglobe` | `webmap` | `addToolbarMapButton` | `removeCustomBasemap` | `readBasemapImage`

Topics

“Use Basemaps in Offline Environments”

“Specify a Custom Base Layer”

“Customize Appearance of Vector Basemaps”

addCustomTerrain

Add custom terrain data

Syntax

```
addCustomTerrain(terrainName,files)
addCustomTerrain( ____,Name,Value)
```

Description

`addCustomTerrain(terrainName,files)` adds terrain data specified by `files` for use with geographic plotting functions such as `geoglobe`. The terrain is named `terrainName`, and you can specify it by this name when calling a plotting function. Custom terrain data is available for current and future sessions of MATLAB, until you call `removeCustomTerrain`.

`addCustomTerrain(____,Name,Value)` adds custom terrain data with additional options specified by one or more name-value pairs.

Examples

Display Custom Terrain Using Geographic Globe

Display a line from the surface of Gross Reservoir to a point above South Boulder Peak using custom terrain.

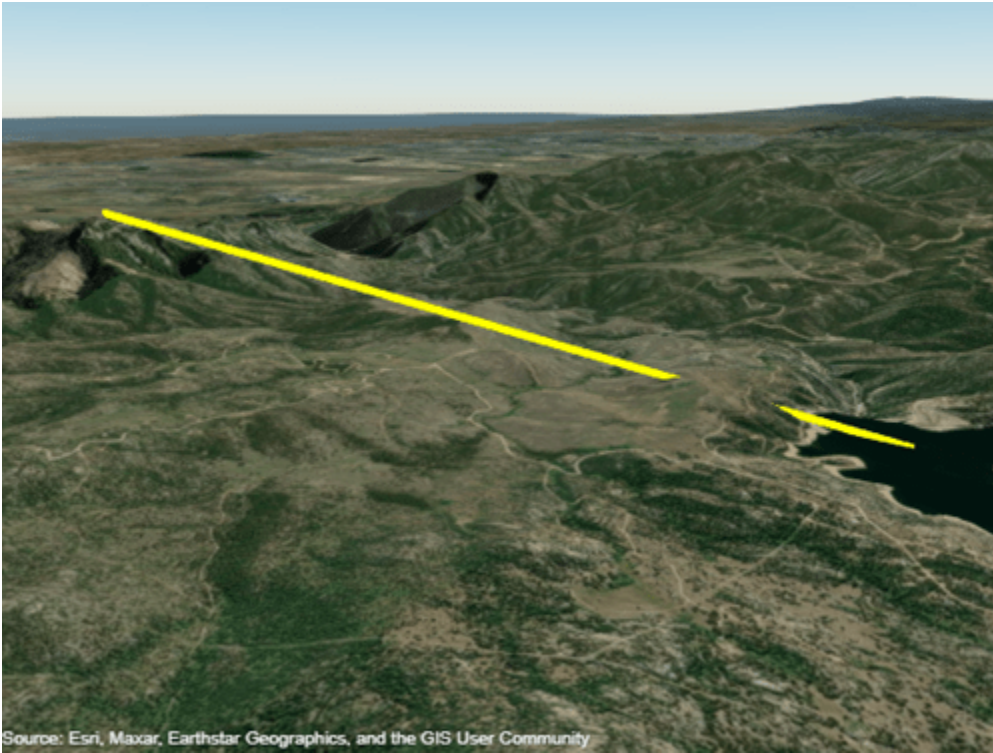
First, add terrain for an area around South Boulder Peak by calling `addCustomTerrain` and specifying a DTED file. The DTED file is from the SRTM Void Filled data set, available from the US Geological Survey. Name the terrain "southboulderpeak".

```
addCustomTerrain("southboulderpeak","n39_w106_3arc_v2.dt1")
```

Create a geographic globe. Specify the terrain by name, using the "Terrain" argument of the `geoglobe` function. Then, plot the line. Tilt the view by holding **Ctrl** and dragging.

```
uif = uifigure;
g = geoglobe(uif,"Terrain","southboulderpeak");

lat = [39.95384 39.95];
lon = [-105.29916 -105.3608];
hTerrain = [10 0];
geoplot3(g,lat,lon,hTerrain,"y","HeightReference","Terrain","LineWidth",3)
```



Close the geographic globe and remove the custom terrain.

```
close(uif)
removeCustomTerrain("southboulderpeak")
```

Input Arguments

terrainName — User-defined identifier for terrain data

string scalar | character vector

User-defined identifier for terrain data, specified as a string scalar or a character vector.

Data Types: char | string

files — Names of DTED files to read

string scalar | character vector | string vector | cell array of character vectors

Names of DTED files to read, specified as a string scalar, a character vector, a string vector, or a cell array of character vectors.

- To add custom terrain from one DTED file, specify **files** as a string scalar or a character vector.
- To add custom terrain from multiple DTED files, specify **files** as a string vector or a cell array of character vectors. If you specify multiple files that do not cover a complete rectangular geographic region, you must set the `FillMissing` name-value argument to `true`.

The form of each element of **files** depends on the location of the file.

- If the file is in your current folder or in a folder on the MATLAB path, then specify the name of the file, such as "myFile.dt1".

- If the file is not in the current folder or in a folder on the MATLAB path, then specify the full or relative path name, such as "C:\myfolder\myFile.dtl" or "dataDir\myFile.dtl".

Data Types: char | string | cell

Name-Value Arguments

Specify optional pairs of arguments as Name1=Value1, . . . , NameN=ValueN, where Name is the argument name and Value is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: 'FillMissing',true

Attribution — Attribution of custom terrain data

character vector | string scalar

Attribution of custom terrain data, specified as a character vector or a string scalar. Attributions display on geographic plots that use the custom terrain. By default, the attribution is empty.

Data Types: char | string

FillMissing — Fill data of missing files with value 0

false (default) | true

Fill data of missing files with value 0, specified as true or false. Missing file values are required to complete a rectangular geographic region with the input files.

Data Types: logical

WriteLocation — Name of folder to write extracted terrain files to

character vector | string scalar

Name of folder to write extracted terrain files to, specified as a character vector or a string scalar. The folder must exist and have write permissions. By default, addCustomTerrain writes extracted terrain files to a temporary folder that it generates using the tempname function.

Data Types: char | string

Tips

- To deploy an application with custom terrain using MATLAB Compiler, call addCustomTerrain in the application and include the DTED files in the deployed application package.
- You can find and download DTED files by using EarthExplorer, a data portal provided by the US Geological Survey (USGS). From the list of data sets, search for DTED files by selecting **Digital Elevation**, **SRTM**, and then **SRTM 1 Arc-Second Global** and **SRTM Void Filled**.

Version History

Introduced in R2020a

See Also

removeCustomTerrain | geoglobe | addCustomBasemap

Topics

“Access Basemaps and Terrain for Geographic Globe”

addToolBarMapButton


Add map button to toolbar

Syntax

```
addToolBarMapButton(tb)
addToolBarMapButton(tb,"basemap")
addToolBarMapButton(tb,"basemap",Name=Value)
```

Description

`addToolBarMapButton(tb)` adds all map buttons to the axes toolbar `tb`. The axes toolbar must be in a `GeographicAxes` object and the `GeographicAxes` object must be in a figure created by using the `uifigure` function.

`addToolBarMapButton(tb,"basemap")` creates a basemap picker and adds it to the axes toolbar. Open the basemap picker by selecting  **Pick Basemap** from the axes toolbar. The basemap picker appears near the upper-right corner of the map.

`addToolBarMapButton(tb,"basemap",Name=Value)` specifies basemap options using name-value arguments. For example, specify basemaps to include in the basemap picker by using the `BasemapNames` name-value argument.

Examples

Add and Remove Map Buttons from Toolbar

Create a figure by using the `uifigure` function. Place a geographic axes in the figure.

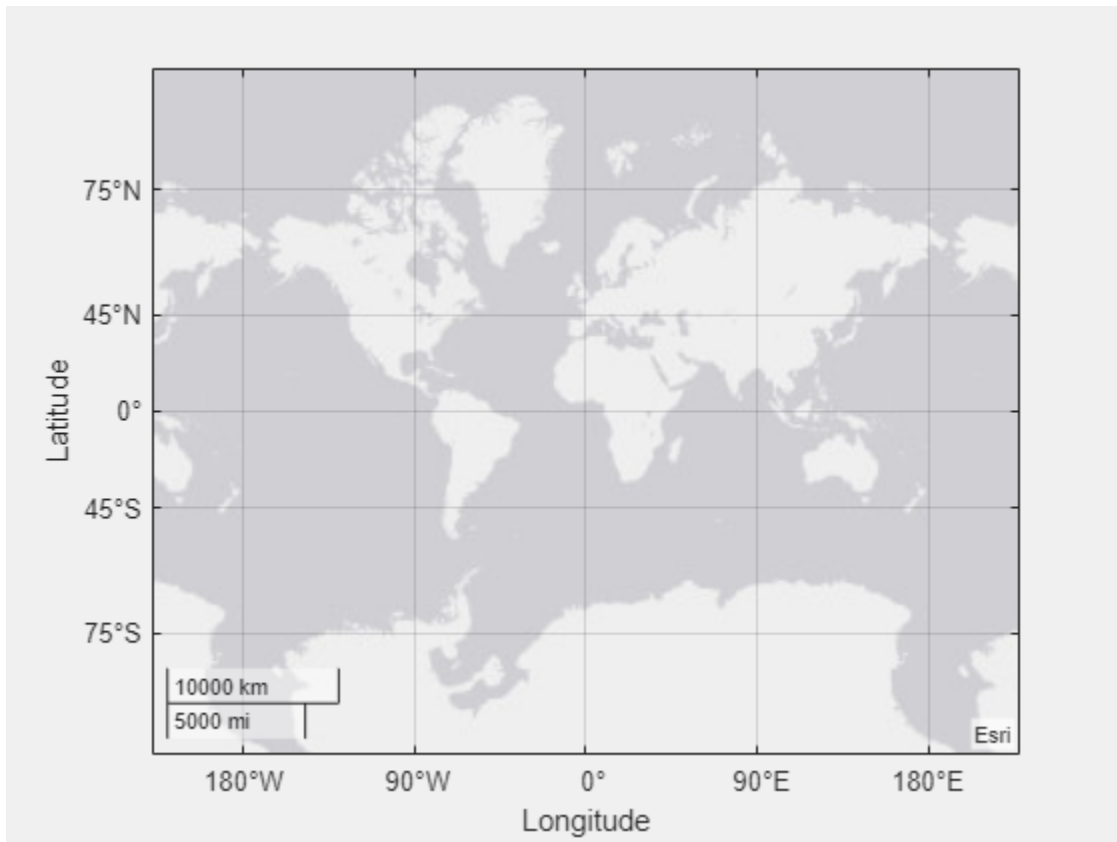
```
uif = uifigure;
gx = geoaxes(uif);
```

Create a custom axes toolbar. Add all map buttons to the toolbar.

```
tb = axtoolbar(gx,"default");
addToolBarMapButton(tb)
```

Remove all map buttons from the toolbar.

```
removeToolBarMapButton(tb)
```



Add Basemap Picker to Geographic Plot

Read latitude and longitude data from a shapefile into a table by using the `readgeotable` function.

```
T = readgeotable("tsunamis.shp", CoordinateSystemType="geographic");
lat = T.Shape.Latitude;
lon = T.Shape.Longitude;
```

Display the latitude and longitude data on a map. To add a basemap picker to the toolbar, you must create a figure by using the `uifigure` function and a geographic axes within the figure by using the `geoaxes` function. By default, geographic plots use the "streets-light" basemap.

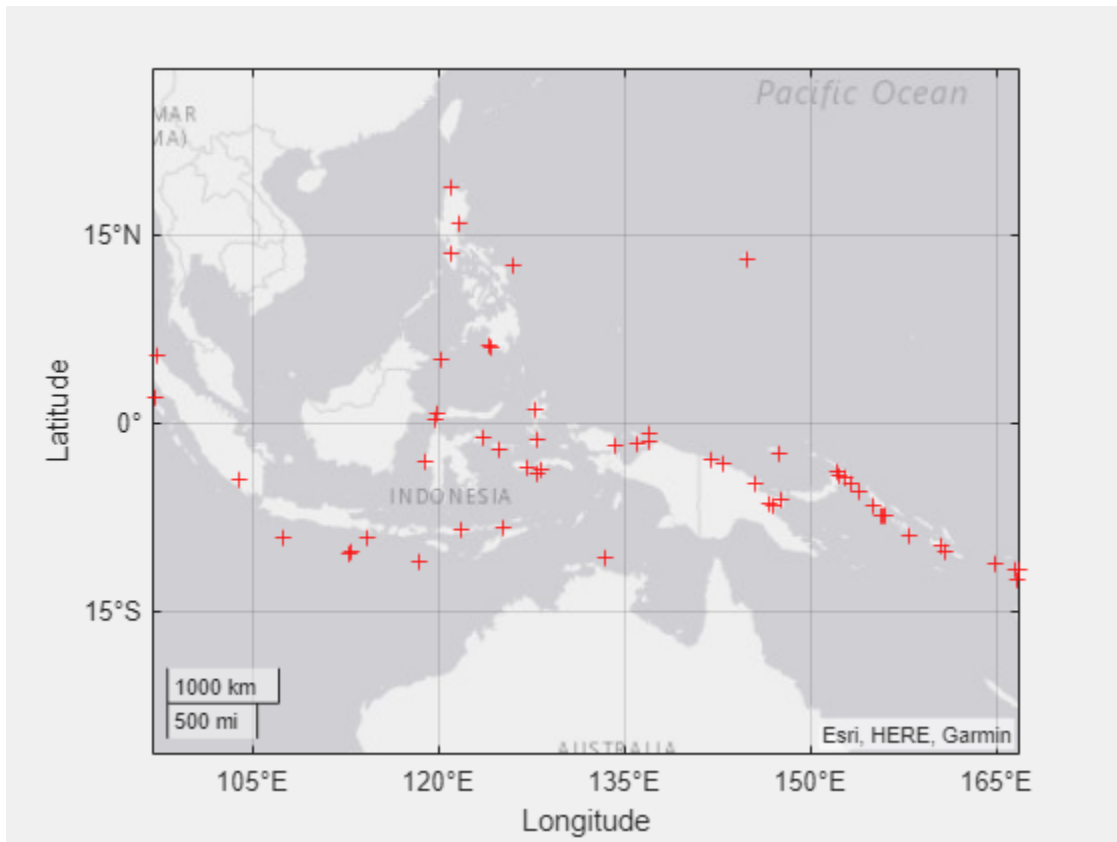
```
uif = uifigure;
gx = geoaxes(uif);
geoscatter(gx, lat, lon, "r+")
geolimits(gx, [-25.8016 27.4532], [96.9154 166.8728])
```

Preserve the specified toolbar, limits, and plotted data by using the `hold` function.

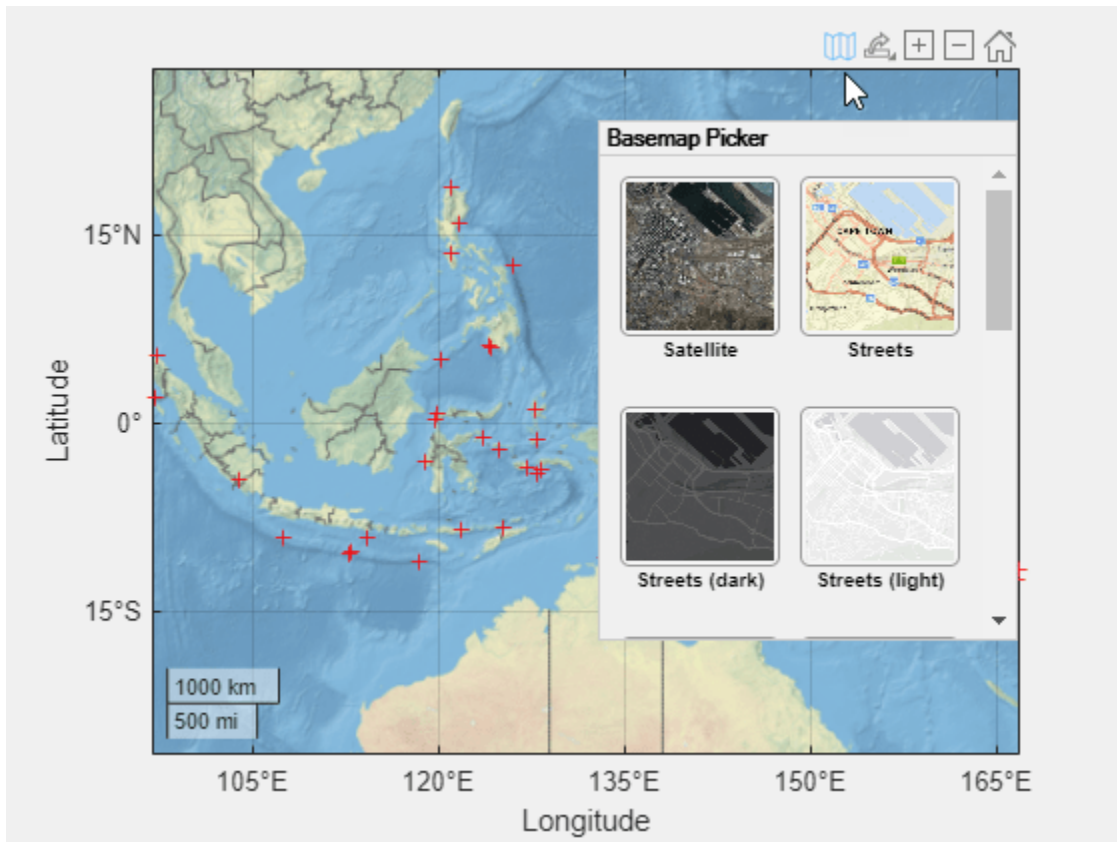
```
hold(gx, "on")
```

Create a custom toolbar by using the `axtoolbar` function. Add the basemap picker to the toolbar.

```
tb = axtoolbar(gx, "default");
addToolbarMapButton(tb, "basemap")
```

Open the toolbar and select a basemap.



Add Custom Basemap to Basemap Picker

Add the OpenStreetMap© basemap to the list of basemaps available for use with mapping functions. After you add the basemap, you do not need to add it again in future sessions. The basemap picker uses the display name you specify when you add the basemap.

```
name = "openstreetmap";
url = "https://a.tile.openstreetmap.org/{z}/{x}/{y}.png";
copyright = char(uint8(169));
displayName = "OpenStreetMap";
attribution = copyright + "OpenStreetMap contributors";
addCustomBasemap(name,url,Attribution=attribution,DisplayName=displayName)
```

Read latitude and longitude data from a GPX file into a table.

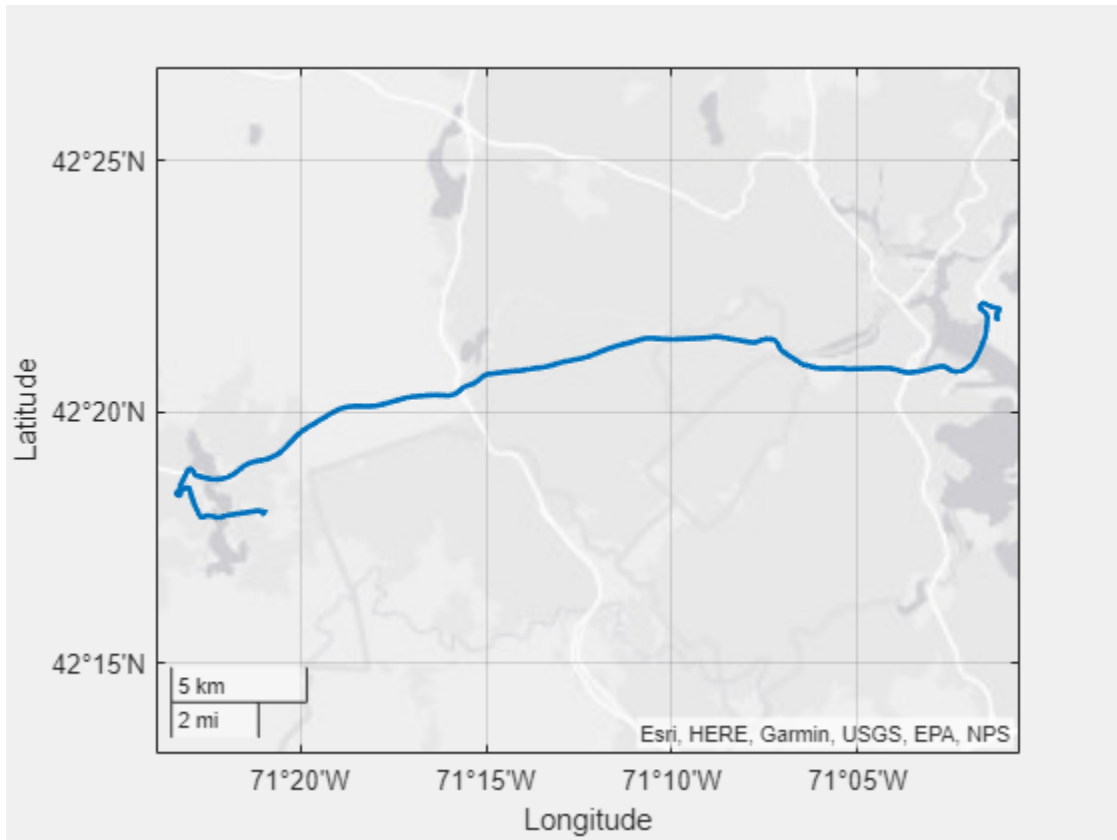
```
T = readgeotable("sample_route.gpx");
lat = T.Shape.Latitude;
lon = T.Shape.Longitude;
```

Display the latitude and longitude data on a map.

```
uif = uifigure;
gx = geoaxes(uif);
geoplot(gx,lat,lon,LineWidth=2)
hold(gx,"on")
```

Add a basemap picker to the axes toolbar. Include the OpenStreetMap basemap and the high-zoom-level basemaps provided by Esri®.

```
tb = axtoolbar(gx, "default");  
bmaps = ["openstreetmap", "streets", "streets-light", ...  
         "streets-dark", "topographic", "satellite"];  
addToolBarMapButton(tb, "basemap", BasemapNames=bmaps)
```



Open the basemap picker and select the OpenStreetMap basemap.



Add Custom Icons to Basemap Picker

By default, the basemap picker uses the Level 1, North America tile as the icon for custom basemaps. Create a basemap picker with custom icons.

Add the OpenStreetMap basemap to the list of basemaps available for use with mapping functions. After you add the basemap, you do not need to add it again in future sessions.

```
name = "openstreetmap";
url = "https://a.tile.openstreetmap.org/{z}/{x}/{y}.png";
copyright = char(uint8(169));
displayName = "OpenStreetMap";
attribution = copyright + "OpenStreetMap contributors";
addCustomBasemap(name,url,Attribution=attribution,DisplayName=displayName)
```

Read latitude and longitude data from a GPX file into a table.

```
T = readgeotable("sample_route.gpx");
lat = T.Shape.Latitude;
lon = T.Shape.Longitude;
```

Display the latitude and longitude data on a map.

```
uif = uifigure;
gx = geoaxes(uif);
```

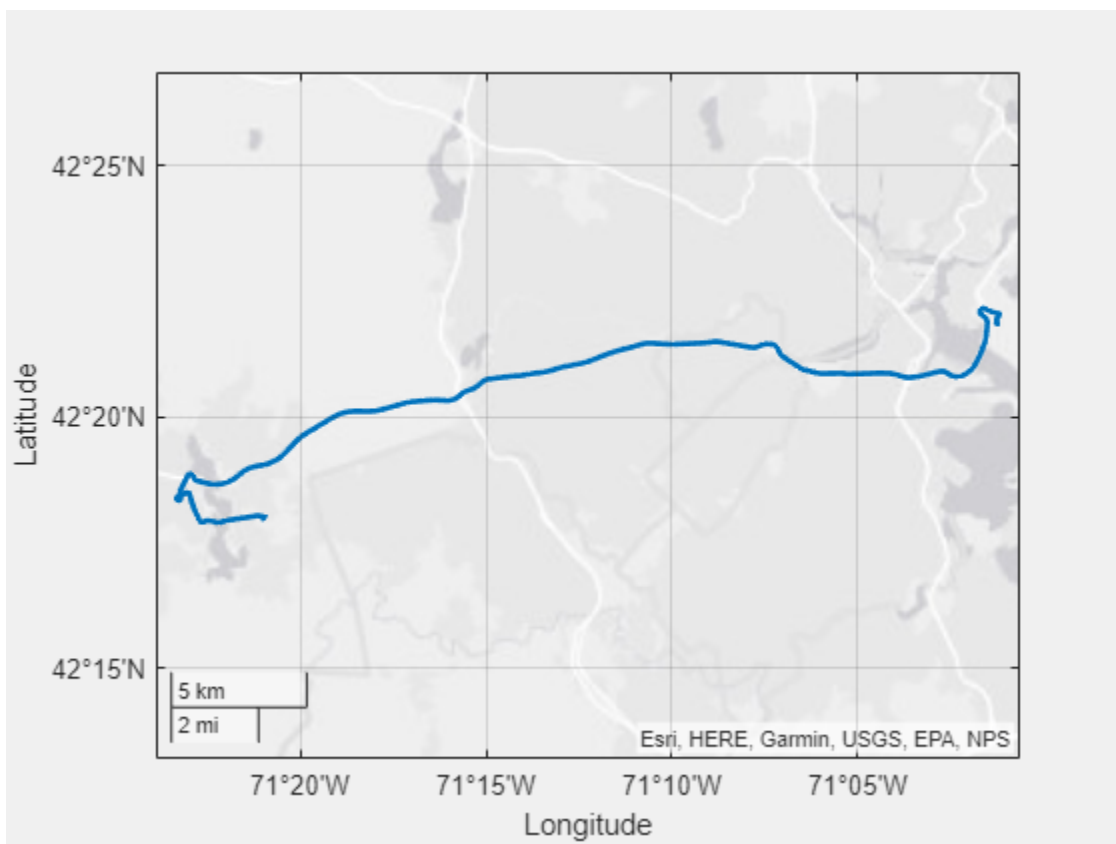
```
geoplot(gx,lat,lon,LineWidth=2)
hold(gx,'on')
```

Specify the locations of the icons. For the custom basemap, use an icon that shows an area around Cape Town, South Africa. For the streets basemap, use the default icon.

```
osm_filename = "openstreetmap_256.png";
streets_filename = fullfile(matlabroot,"toolbox","shared","basemaps", ...
    "resources","icons","streets.png");
```

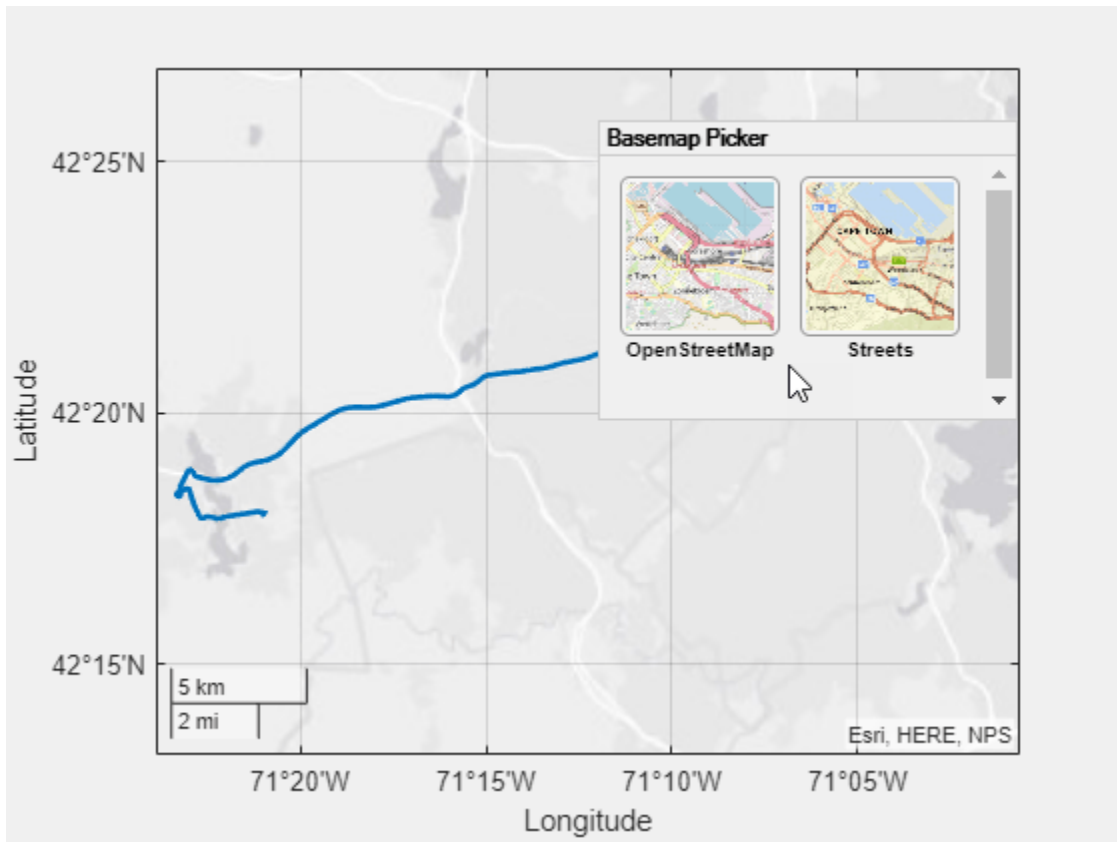
Create a basemap picker that includes the custom basemap, the "streets" basemap, and the custom icon.

```
tb = axtoolbar(gx,"default");
```



```
addToolBarMapButton(tb,"basemap",BasemapNames=["openstreetmap","streets"], ...
    BasemapIcons=[osm_filename,streets_filename])
```

Open the basemap picker and view the icons.



Input Arguments

tb — Axes toolbar

AxesToolbar object | array of AxesToolbar objects

Axes toolbar, specified as an AxesToolbar object or an array of AxesToolbar objects. The axes toolbar must be in a GeographicAxes object. Create the toolbar by using the `axtoolbar` function.

You can add only one of each type of map button to the axes toolbar. Adding a new button replaces any existing icons of the same type.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example:


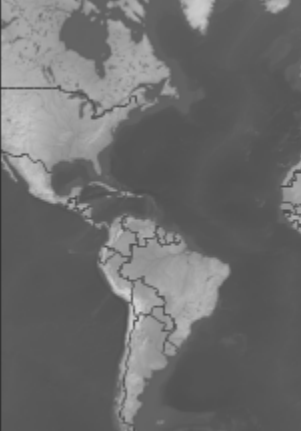


```
addToolbarMapButton(tb, "basemap", BasemapNames=["streets", "satellite"], NumColumns=1) specifies a basemap picker with one column and the "streets" and "satellite" basemaps.
```

BasemapNames — Basemaps to include in basemap picker

string array | cell array of character vectors

Basemaps to include in the basemap picker, specified as a string array or a cell array of character vectors. You can specify the basemaps shown in the table and basemaps added using the `addCustomBasemap` function. Five basemaps in the table are high-zoom-level maps hosted by Esri. The other six basemaps are tiled data sets created using Natural Earth. By default, the basemap picker includes all available basemaps, including custom basemaps, except "none".

	<p>"streets-light" (default)</p> <p>Map designed to provide geographic context while highlighting user data on a light background.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, NGA, USGS</p>		<p>"streets-dark"</p> <p>Map designed to provide geographic context while highlighting user data on a dark background.</p> <p>Hosted by Esri.</p> <p>Esri, HERE, Garmin, NGA, USGS</p>
	<p>"streets"</p> <p>General-purpose road map that emphasizes accurate, legible styling of roads and transit networks.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, NGA, USGS</p>		<p>"satellite"</p> <p>Full global basemap composed of high-resolution satellite imagery.</p> <p>Hosted by Esri.</p> <p>Earthstar Geographics, CNES/Airbus DS</p>
	<p>"topographic"</p> <p>General-purpose map with styling to depict topographic features.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, USGS, NGA</p>		<p>"landcover"</p> <p>Map that combines satellite-derived land cover data, shaded relief, and ocean-bottom relief. The light, natural palette is suitable for thematic and reference maps.</p> <p>Created using Natural Earth.</p>

	<p>"colorterrain"</p> <p>Shaded relief map blended with a land cover palette. Humid lowlands are green and arid lowlands are brown.</p> <p>Created using Natural Earth.</p>		<p>"grayterrain"</p> <p>Terrain map in shades of gray. Shaded relief emphasizes both high mountains and micro-terrain found in lowlands.</p> <p>Created using Natural Earth.</p>
	<p>"bluegreen"</p> <p>Two-tone, land-ocean map with light green land areas and light blue water areas.</p> <p>Created using Natural Earth.</p>		<p>"grayland"</p> <p>Two-tone, land-ocean map with gray land areas and white water areas.</p> <p>Created using Natural Earth.</p>
	<p>"darkwater"</p> <p>Two-tone, land-ocean map with light gray land areas and dark gray water areas. This basemap is installed with MATLAB.</p> <p>Created using Natural Earth.</p>	<p>N/A</p>	<p>"none"</p> <p>Blank background that plots your data with a latitude-longitude grid, ticks, and labels.</p>

All basemaps except "darkwater" require Internet access. The "darkwater" basemap is included with MATLAB.

If you do not have consistent access to the Internet, you can download the basemaps created using Natural Earth onto your local system by using the Add-On Explorer. The five high-zoom-level maps are not available for download. For more information about downloading basemaps and changing the default basemap on your local system, see "Access Basemaps for Geographic Axes and Charts".

The basemaps hosted by Esri update periodically. As a result, you might see differences in your visualizations over time.

Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

If you specify any combination of `BasemapNames`, `DisplayNames`, and `BasemapIcons`, they must all be the same size. The elements of `BasemapNames` correspond with the elements of `DisplayNames` and `BasemapIcons`.

Example: `BasemapNames=["streets","satellite"]`

Data Types: `char` | `string`

DisplayNames — Basemap labels

`string array` | `cell array of character vectors`

Basemap labels, specified as a string array or a cell array of character vectors. When a label is longer than the width of a column, MATLAB breaks the label into separate lines so that each line fits within the width of the column, and avoids breaking words when possible. Basemap labels display up to three lines. MATLAB truncates labels that are longer than three lines.

The default display name for each basemap is:

- "satellite" — **Satellite**
- "streets" — **Streets**
- "streets-dark" — **Streets (dark)**
- "streets-light" — **Streets (light)**
- "topographic" — **Topographic**
- "darkwater" — **Dark Water**
- "bluegreen" — **Blue Green**
- "grayterrain" — **Gray Terrain**
- "colorterrain" — **Color Terrain**
- "landcover" — **Land Cover**
- "none" — **none**
- Custom basemap — Display name specified by the `addCustomBasemap` function. If you do not specify a display name when you add the custom basemap, then the basemap picker uses the basemap name.

Create a basemap picker with no display names by specifying `DisplayNames` as "".

If you specify any combination of `BasemapNames`, `DisplayNames`, and `BasemapIcons`, they must all be the same size. The elements of `DisplayNames` correspond with the elements of `BasemapNames` and `BasemapIcons`.

Example: `DisplayNames=["Road Map","Satellite Imagery"]`

Data Types: `char` | `string`

BasemapIcons — Icon file names

`string array` | `cell array of character vectors`

Icon file names, specified as a string array or a cell array of character vectors. Supported image formats include JPEG, PNG, GIF, and SVG.

Specify file names based on the locations of your files.

- If a file is in your current folder or in a folder on the MATLAB path, then specify the name of the file only, such as "myIcon.png".
- If a file is not in the current folder or in a folder on the MATLAB path, then specify the full or relative path name, such as "C:\myfolder\myFile.png" or "dataDir\myFile.png".

The default basemap icons are in the folder *matlabroot*/toolbox/shared/basemaps/resources/icons. When you add a custom basemap using the `addCustomBasemap` function, the default icon is the Level 1, North America tile.

When an icon has a side length greater than 80 pixels, MATLAB scales the icon to fit.

Create a basemap picker with no icon images by specifying `BasemapIcons` as "". In this case, the icons display the basemap names instead of images.

If you specify any combination of `BasemapNames`, `DisplayNames`, and `BasemapIcons`, they must all be the same size. The elements of `BasemapIcons` correspond with the elements of `BasemapNames` and `DisplayNames`.

Example: `BasemapIcons=["myIcon1.png" , "myIcon2.png"]`

Data Types: char | string

NumColumns — Number of basemap picker columns

2 (default) | positive integer

Number of basemap picker columns, specified as a positive integer.

Example: `NumColumns=3`

Data Types: single | double

Limitations

- When the `Scrollable` property of the figure is `true`, the basemap picker may not appear, or may appear in a different location than the upper-right corner.

Version History

Introduced in R2021b

See Also

Functions

`axtoolbar` | `geoaxes` | `geobasemap` | `geoplot` | `geoscatter` | `removeToolBarMapButton`

Topics

"Access Basemaps for Geographic Axes and Charts"

aer2ecef

Transform local spherical coordinates to geocentric Earth-centered Earth-fixed

Syntax

```
[X,Y,Z] = aer2ecef(az,elev,slantRange,lat0,lon0,h0,spheroid)
[ ___ ] = aer2ecef( ___,angleUnit)
```

Description

`[X,Y,Z] = aer2ecef(az,elev,slantRange,lat0,lon0,h0,spheroid)` transforms the local azimuth-elevation-range (AER) spherical coordinates specified by `az`, `elev`, and `slantRange` to the geocentric Earth-centered Earth-fixed (ECEF) Cartesian coordinates specified by `X`, `Y`, and `Z`. Specify the origin of the local AER system with the geodetic coordinates `lat0`, `lon0`, and `h0`. Each coordinate input argument must match the others in size or be scalar. Specify `spheroid` as the reference spheroid for the geodetic coordinates.

`[___] = aer2ecef(___,angleUnit)` specifies the units for azimuth, elevation, latitude, and longitude. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate ECEF Coordinates from AER Coordinates

Find the ECEF coordinates of a satellite, using the AER coordinates of the satellite relative to the geodetic coordinates of a satellite dish.

First, specify the reference spheroid as WGS84 with length units measured in kilometers. For more information about WGS84, see "Comparison of Reference Spheroids". The units for the ellipsoidal height, slant range, and ECEF coordinates must match the units specified by the `LengthUnit` property of the reference spheroid.

```
wgs84 = wgs84Ellipsoid('kilometers');
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is the satellite dish. Specify `h0` as ellipsoidal height in kilometers.

```
lat0 = 42.3221;
lon0 = -71.3576;
h0 = 0.0847;
```

Specify the AER coordinates of the point of interest. In this example, the point of interest is the satellite. Specify the slant range in kilometers.

```
az = 24.8012;
elev = 14.6185;
slantRange = 36271.6327;
```

Then, calculate the ECEF coordinates of the satellite. In this example, the results display in scientific notation.

```
[x,y,z] = aer2ecef(az,elev,slantRange,lat0,lon0,h0,wgs84)
```

```
x = 1.0766e+04
```

```
y = 1.4144e+04
```

```
z = 3.3992e+04
```

Reverse the transformation using the `ecef2aer` function. In this example, `slantRange` displays in scientific notation.

```
[az,elev,slantRange] = ecef2aer(x,y,z,lat0,lon0,h0,wgs84)
```

```
az = 24.8012
```

```
elev = 14.6185
```

```
slantRange = 3.6272e+04
```

Input Arguments

az — Azimuth angles

scalar | vector | matrix | N-D array

Azimuth angles of one or more points in the local AER system, specified as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Specify values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

elev — Elevation angles

scalar | vector | matrix | N-D array

Elevation angles of one or more points in the local AER system, specified as a scalar, vector, matrix, or N-D array. Specify elevations with respect to a plane that is perpendicular to the normal of the spheroid surface. If the local origin is on the surface of the spheroid ($h_0 = 0$), then the plane is tangent to the spheroid.

Specify values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

slantRange — Distances from local origin

scalar | vector | matrix | N-D array

Distances from the local origin, specified as a scalar, vector, matrix, or N-D array. Specify each distance as along a straight, 3-D, Cartesian line. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Data Types: `single` | `double`

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h0 — Ellipsoidal height of local origin

scalar | vector | matrix | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

X — ECEF x-coordinates

scalar | vector | matrix | N-D array

ECEF x-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Y — ECEF y-coordinates

scalar | vector | matrix | N-D array

ECEF y-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Z — ECEF z-coordinates

scalar | vector | matrix | N-D array

ECEF z-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `aer2ecef` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`aer2geodetic` | `ecef2aer` | `enu2ecef` | `ned2ecef`

Topics

“Comparison of 3-D Coordinate Systems”

aer2enu

Transform local spherical coordinates to local east-north-up

Syntax

```
[xEast,yNorth,zUp] = aer2enu(az,elev,slantRange)
[ ___ ] = aer2enu( ___ ,angleUnit)
```

Description

`[xEast,yNorth,zUp] = aer2enu(az,elev,slantRange)` transforms the local azimuth-elevation-range (AER) spherical coordinates specified by `az`, `elev`, and `slantRange` to the local east-north-up (ENU) Cartesian coordinates specified by `xEast`, `yNorth`, and `zUp`. Both coordinate systems use the same local origin. Each input argument must match the others in size or be scalar.

`[___] = aer2enu(___ ,angleUnit)` specifies the units for azimuth and elevation. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate ENU Coordinates from AER Coordinates

A sensor captures the AER coordinates of a nearby ground vehicle. Find the ENU coordinates of the vehicle with respect to the sensor, using the AER coordinates of the vehicle with respect to the same sensor.

First, specify the AER coordinates of the vehicle. Specify the azimuth and elevation in degrees. For this example, specify the slant range in meters.

```
az = 34.1160;
elev = 4.1931;
slantRange = 15.1070;
```

Then, calculate the ENU coordinates of the vehicle. The units for the ENU coordinates match the units specified by the slant range. Thus, the ENU coordinates are specified in meters.

```
[xEast,yNorth,zUp] = aer2enu(az,elev,slantRange)

xEast = 8.4504
yNorth = 12.4737
zUp = 1.1046
```

Reverse the transformation using the `enu2aer` function.

```
[az,elev,slantRange] = enu2aer(xEast,yNorth,zUp)

az = 34.1160
elev = 4.1931
```

```
slantRange = 15.1070
```

Input Arguments

az — Azimuth angles

scalar | vector | matrix | N-D array

Azimuth angles of one or more points in the local AER system, specified as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Specify values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

elev — Elevation angles

scalar | vector | matrix | N-D array

Elevation angles of one or more points in the local AER system, specified as a scalar, vector, matrix, or N-D array. Specify elevations with respect to the `xEast-yNorth` plane that contains the local origin. If the local origin is on the surface of the spheroid, then the `xEast-yNorth` plane is tangent to the spheroid.

Specify values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

slantRange — Distances from local origin

scalar value | vector | matrix | N-D array

Distances from the local origin, specified as a scalar, vector, matrix, or N-D array. Specify each distance as along a straight, 3-D, Cartesian line.

Data Types: `single` | `double`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

xEast — ENU x-coordinates

scalar | vector | matrix | N-D array

ENU x-coordinates of one or more points in the local ENU system, returned as a scalar, vector, matrix, or N-D array. Values are returned in the same units as the `slantRange` argument.

yNorth — ENU y-coordinates

scalar | vector | matrix | N-D array

ENU y-coordinates of one or more points in the local ENU system, returned as a scalar, vector, matrix, or N-D array. Values are returned in the same units as the `slantRange` argument.

zUp — ENU z-coordinates

scalar | vector | matrix | N-D array

ENU z-coordinates of one or more points in the local ENU system, returned as a scalar, vector, matrix, or N-D array. Values are returned in the same units as the `slantRange` argument.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `aer2enu` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`aer2ned` | `enu2aer` | `aer2ecef` | `aer2geodetic`

Topics

“Comparison of 3-D Coordinate Systems”

aer2geodetic

Transform local spherical coordinates to geodetic

Syntax

```
[lat,lon,h] = aer2geodetic(az,elev,slantRange,lat0,lon0,h0,spheroid)
[ ___ ] = aer2geodetic( ___ ,angleUnit)
```

Description

[lat,lon,h] = aer2geodetic(az,elev,slantRange,lat0,lon0,h0,spheroid) transforms the local azimuth-elevation-range (AER) spherical coordinates specified by az, elev, and slantRange to the geodetic coordinates specified by lat, lon, and h. Specify the origin of the local AER system with the geodetic coordinates lat0, lon0, and h0. Each coordinate input argument must match the others in size or be scalar. Specify spheroid as the reference spheroid for the geodetic coordinates.

[___] = aer2geodetic(___ ,angleUnit) specifies the units for azimuth, elevation, latitude, and longitude. Specify angleUnit as 'degrees' (the default) or 'radians'.

Examples

Calculate Geodetic Coordinates from AER Coordinates

Find the geodetic coordinates of the Matterhorn, using the AER coordinates of the Matterhorn with respect to the geodetic coordinates of Zermatt, Switzerland.

First, specify the reference spheroid as WGS 84. For more information about WGS 84, see “Comparison of Reference Spheroids”. The units for the ellipsoidal height and slant range must match the units specified by the LengthUnit property of the reference spheroid. The default length unit for the reference spheroid created by wgs84Ellipsoid is 'meter'.

```
wgs84 = wgs84Ellipsoid;
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is Zermatt. Specify h0 as ellipsoidal height in meters.

```
lat0 = 46.017;
lon0 = 7.750;
h0 = 1673;
```

Specify the AER coordinates of the point of interest. In this example, the point of interest is the Matterhorn. Specify the slant range in meters.

```
az = 238.08;
elev = 18.744;
slantRange = 8876.8;
```

Then, calculate the geodetic coordinates of the Matterhorn. The result `h` is the ellipsoidal height of the Matterhorn in meters. To view the results in standard notation, specify the display format as `shortG`.

```
format shortG
[lat,lon,h] = aer2geodetic(az,elev,slantRange,lat0,lon0,h0,wgs84)

lat =
    45.977

lon =
    7.658

h =
    4531
```

Reverse the transformation using the `geodetic2aer` function.

```
[az,elev,slantRange] = geodetic2aer(lat,lon,h,lat0,lon0,h0,wgs84)

az =
    238.08

elev =
    18.744

slantRange =
    8876.8
```

Input Arguments

az — Azimuth angles

scalar | vector | matrix | N-D array

Azimuth angles of one or more points in the local AER system, specified as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Specify values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

elev — Elevation angles

scalar | vector | matrix | N-D array

Elevation angles of one or more points in the local AER system, specified as a scalar, vector, matrix, or N-D array. Specify elevations with respect to a plane that is perpendicular to the normal of the spheroid surface. If the local origin is on the surface of the spheroid ($h_0 = 0$), then the plane is tangent to the spheroid.

Specify values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

slantRange — Distances from local origin

scalar | vector | matrix | N-D array

Distances from the local origin, specified as a scalar, vector, matrix, or N-D array. Specify each distance as along a straight, 3-D, Cartesian line. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Data Types: `single` | `double`**lat0 — Geodetic latitude of local origin**

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`**lon0 — Geodetic longitude of local origin**

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`**h0 — Ellipsoidal height of local origin**

scalar | vector | matrix | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`**spheroid — Reference spheroid**

referenceEllipsoid object | oblateSpheroid object | referenceSphere object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`**angleUnit — Angle units**`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

lat — Geodetic latitude

scalar | vector | matrix | N-D array

Geodetic latitude of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in degrees within the interval $[-90\ 90]$. To use values in radians, specify the `angleUnit` argument as `'radians'`.

lon — Geodetic longitude

scalar | vector | matrix | N-D array

Geodetic longitude of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in degrees within the interval $[-180\ 180]$. To use values in radians, specify the `angleUnit` argument as `'radians'`.

h — Ellipsoidal height

scalar | vector | matrix | N-D array

Ellipsoidal height of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `aer2geodetic` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`aer2ecef` | `enu2geodetic` | `geodetic2aer` | `ned2geodetic`

Topics

“Comparison of 3-D Coordinate Systems”

aer2ned

Transform local spherical coordinates to local north-east-down

Syntax

```
[xNorth,yEast,zDown] = aer2ned(az,elev,slantRange)
[ ___ ] = aer2ned( ___ ,angleUnit)
```

Description

`[xNorth,yEast,zDown] = aer2ned(az,elev,slantRange)` transforms the local spherical azimuth-elevation-range (AER) coordinates specified by `az`, `elev`, and `slantRange` to the local north-east-down (NED) coordinates specified by `xNorth`, `yEast`, and `zDown`. Both coordinate systems use the same local origin. Each input argument must match the others in size or be scalar.

`[___] = aer2ned(___ ,angleUnit)` specifies the units for azimuth and elevation. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate NED Coordinates from AER Coordinates

A sensor in an aircraft measures the AER coordinates of a nearby landmark. Find the NED coordinates of the landmark with respect to the aircraft, using the AER coordinates of the landmark with respect to the same aircraft.

First, specify the AER coordinates of the landmark. Specify the azimuth and elevation in degrees. For this example, specify the slant range in kilometers.

```
az = 155.427;
elev = -23.161;
slantRange = 10.885;
```

Then, calculate the NED coordinates of the landmark. The units for the NED coordinates match the units specified by the slant range. Thus, the NED coordinates are specified in kilometers.

```
[xNorth,yEast,zDown] = aer2ned(az,elev,slantRange)
xNorth = -9.1013
yEast = 4.1617
zDown = 4.2812
```

Reverse the transformation using the `ned2aer` function.

```
[az,elev,slantRange] = ned2aer(xNorth,yEast,zDown)
az = 155.4270
elev = -23.1610
```

```
slantRange = 10.8850
```

Input Arguments

az — Azimuth angles

scalar | vector | matrix | N-D array

Azimuth angles of one or more points in the local AER system, specified as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Specify values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

elev — Elevation angles

scalar | vector | matrix | N-D array

Elevation angles of one or more points in the local AER system, specified as a scalar, vector, matrix, or N-D array. Specify elevations with respect to the `xNorth-yEast` plane that contains the local origin. If the local origin is on the surface of the spheroid, then the `xNorth-yEast` plane is tangent to the spheroid.

Specify values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

slantRange — Distances from local origin

scalar value | vector | matrix | N-D array

Distances from the local origin, specified as a scalar, vector, matrix, or N-D array. Specify each distance as along a straight, 3-D, Cartesian line.

Data Types: `single` | `double`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

xNorth — NED x-coordinates

scalar | vector | matrix | N-D array

NED x-coordinates of one or more points in the local NED system, returned as a scalar, vector, matrix, or N-D array. Values are returned in the same units as the `slantRange` argument.

yEast — NED y-coordinates

scalar | vector | matrix | N-D array

NED y-coordinates of one or more points in the local NED system, returned as a scalar, vector, matrix, or N-D array. Values are returned in the same units as the `slantRange` argument.

zDown — NED z-coordinates

scalar | vector | matrix | N-D array

NED z-coordinates of one or more points in the local NED system, returned as a scalar, vector, matrix, or N-D array. Values are returned in the same units as the `slantRange` argument.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `aer2ned` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`aer2enu` | `ned2aer` | `aer2ecef` | `aer2geodetic`

Topics

“Comparison of 3-D Coordinate Systems”

almanac

Parameters for Earth, planets, Sun, and Moon

Note `almanac` is not recommended. Use `earthRadius`, `referenceEllipsoid`, `referenceSphere`, or `wgs84Ellipsoid` instead.

Syntax

```
almanac
almanac(body)
data = almanac(body,parameter)
data = almanac(body,parameter,units)
data = almanac(parameter,units,referencebody)
```

Description

`almanac` displays the names of the celestial objects available in the almanac.

`almanac(body)` lists the options, or parameters, available for any of the following celestial bodies:

```
'earth'      'pluto'
'jupiter'    'saturn'
'mars'       'sun'
'mercury'    'uranus'
'moon'       'venus'
'neptune'
```

`data = almanac(body,parameter)` returns the value of the requested parameter for the celestial body specified by *body*.

Valid parameter values are `'radius'` for the planetary radius, `'ellipsoid'` or `'geoid'` for the two-element ellipsoid vector, `'surfarea'` for the surface area, and `'volume'` for the planetary volume.

For the Earth, parameter can also be any of the following valid predefined ellipsoid values. In this case, the two-element ellipsoid vector for that ellipsoid model is returned. Valid ellipsoid definitions for the Earth are:

<code>'everest'</code>	1830 Everest ellipsoid
<code>'bessel'</code>	1841 Bessel ellipsoid
<code>'airy'</code>	1830 Airy ellipsoid
<code>'clarke66'</code>	1866 Clarke ellipsoid
<code>'clarke80'</code>	1880 Clarke ellipsoid
<code>'international'</code>	1924 International ellipsoid
<code>'krasovsky'</code>	1940 Krasovsky ellipsoid
<code>'wgs60'</code>	1960 World Geodetic System ellipsoid

'iau65'	1965 International Astronomical Union ellipsoid
'wgs66'	1966 World Geodetic System ellipsoid
'iau68'	1968 International Astronomical Union ellipsoid
'wgs72'	1972 World Geodetic System ellipsoid
'grs80'	1980 Geodetic Reference System ellipsoid
'wgs84'	1984 World Geodetic System ellipsoid

For the Earth, the parameter values 'ellipsoid' and 'geoid' are equivalent to 'grs80'.

`data = almanac(body,parameter,units)` specifies the units to be used for the output measurement, where `units` is any valid distance units. Note that these are linear units, but the result for surface area is in square units, and for volume is in cubic units. The default units are 'kilometers'.

`data = almanac(parameter,units,referencebody)` specifies the source of the information. This sets the assumptions about the shape of the celestial body used in the calculation of volumes and surface areas. A reference body of 'actual' returns a tabulated value rather than one dependent upon a ellipsoid model assumption. Other possible referencebody s are 'sphere' for a spherical assumption and 'ellipsoid' for the default ellipsoid model. The default reference body is 'sphere'.

For the Earth, any of the preceding predefined ellipsoid definition s can also be entered as a reference body.

For Mercury, Pluto, Venus, the Sun, and the Moon, the eccentricity of the ellipsoid model is zero, that is, the 'ellipsoid' reference body is actually a sphere.

Tips

Take care when using angular arc length units for distance measurements. All planets have a radius of 1 radian, for example, and an area unit of *square degrees* indicates unit squares, 1 degree of arc length on a side, not 1-degree-by-1-degree quadrangles.

Version History

Introduced before R2006a

See Also

[distance](#) | [earthRadius](#) | [referenceEllipsoid](#) | [referenceSphere](#) | [wgs84Ellipsoid](#)

angl2str

Convert angles to character array

Syntax

```
str = angl2str(angles)
str = angl2str(angles,signcode)
str = angl2str(angles,signcode,format)
str = angl2str(angles,signcode,format,n)
```

Description

`str = angl2str(angles)` converts numeric angles in degrees to a character array that represents the angles. This function is useful for displaying angles as text on maps.

`str = angl2str(angles,signcode)` returns a character array that represents the angles using the signs or directions specified by `signcode`.

`str = angl2str(angles,signcode,format)` returns a character array that formats the angles as degrees, degrees-minutes, degrees-minutes-seconds, or radians. The function does not convert degrees to radians or vice-versa.

`str = angl2str(angles,signcode,format,n)` specifies the number of decimal places to use in the character array.

Examples

Convert Angles to Character Array in Degrees

Convert numeric angles to a character array. By default, the `angl2str` function formats the angles as degrees.

```
angles = [-9.7 12.95 24];
str = angl2str(angles)
```

```
str = 3x16 char array
    ' - 9.70^{\circ} '
    ' 12.95^{\circ} '
    ' 24.00^{\circ} '
```

Convert the same angles to a character array and prefix a plus sign (+) to the positive angles.

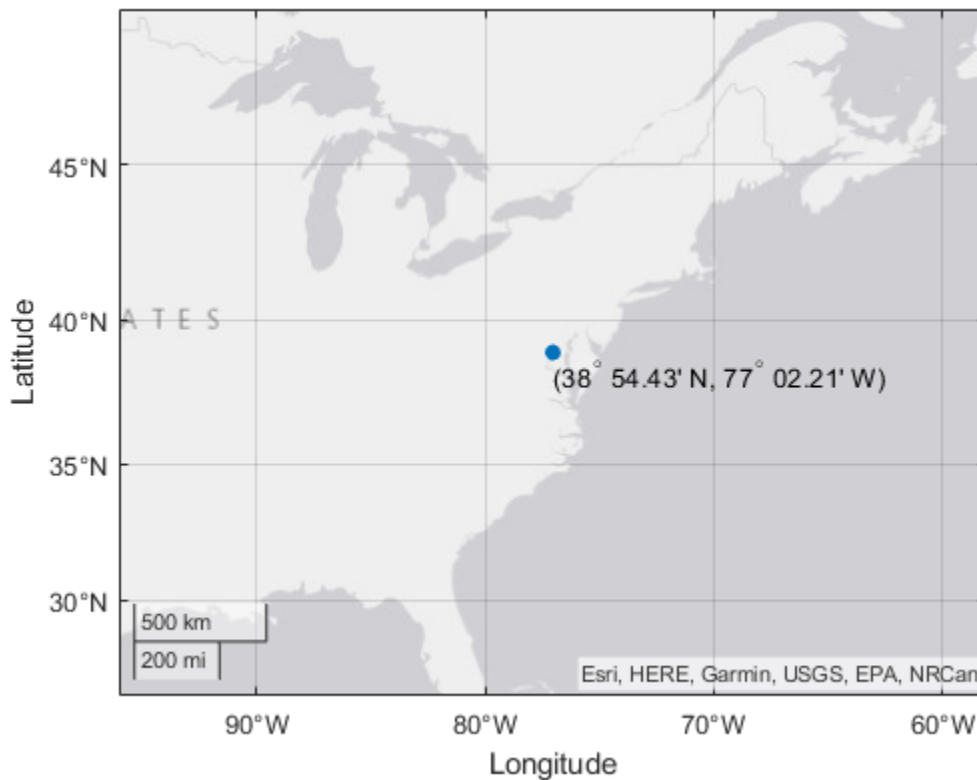
```
strPlus = angl2str(angles,"pm")
```

```
strPlus = 3x16 char array
    ' - 9.70^{\circ} '
    ' +12.95^{\circ} '
    ' +24.00^{\circ} '
```

Convert Angles to Character Array in Specified Format

Convert the coordinates of Washington, DC to a character array that uses degrees-minutes. Remove the leading and trailing whitespaces.

```
lat = 38.9072;  
lon = -77.0369;  
  
latStr = angl2str(lat,"ns","degrees2dm");  
latStr = strtrim(latStr);  
  
lonStr = angl2str(lon,"ew","degrees2dm");  
lonStr = strtrim(lonStr);  
  
coordStr = "(" + latStr + ", " + lonStr + ")";  
  
Display the location and character array on a map.  
  
geoscatter(lat,lon,"filled")  
text(lat,lon,coordStr,VerticalAlignment="top")
```



Convert Angles to Character Array with Specified Number of Digits

Convert angles in degrees to a character array. Round the angles to the nearest tenth.

```
angles = [8.523 -34.79 -89];
str = angl2str(angles, "none", "degrees", -1)

str = 3x15 char array
    ' 8.5^{\circ} '
    '-34.8^{\circ} '
    '-89.0^{\circ} '
```

Input Arguments

angles — Angles

numeric array

Angles in degrees or radians, specified as a numeric array.

signcode — Signs or directions to use in character array

"none" (default) | "ew" | "ns" | "pm"

Signs or directions to use in the character array, specified as one of these options:

- "ew" — Input angles are longitudes. The character array indicates positive longitudes using E and negative longitudes using W.
- "ns" — Input angles are latitudes. The character array indicates positive latitudes using N and negative latitudes using S.
- "pm" — The character array indicates positive angles using a plus sign (+) and negative angles using a minus sign (-).
- "none" — The character array indicates negative angles using a minus sign (-) and does not use a plus sign (+) for positive angles.

Data Types: char | string

format — Format to use in character array

"degrees" (default) | "degrees2dm" | "degrees2dms" | "radians"

Format to use in the character array, specified as one of these options.

Option	Format	Example
"degrees"	Degrees	angl2str(31.26, "none", "degrees") ans = ' 31.26^{\circ} '
"degrees2dm"	Degrees-minutes (DM)	angl2str(31.26, "none", "degrees2dm") ans = ' 31^{\circ} 15.60' '

Option	Format	Example
"degrees2dms"	Degrees-minutes-seconds (DMS)	<pre>angl2str(31.26, "none", "degrees2dms") ans = ' 31^{\circ} 15' 36.00" '</pre>
"radians"	Radians	<pre>angl2str(pi/6, "none", "radians", -5) ans = ' 0.52360 R '</pre>

The value $\^{\circ}$ is the LaTeX representation of $^{\circ}$.

Data Types: char | string

n — Number of digits to include in character array

-2 (default) | scalar integer

Number of digits to include in the character array, specified as an integer. When you specify n , the `angl2str` function rounds angles to the nearest multiple of 10^n .

The sign convention for this argument is opposite to the one used by the `round` function.

Example: `angl2str(31.467, "none", "degrees", -2)` returns `' 31.47^{\circ} '`, which is 31.467 rounded to the nearest hundredth.

Example: `angl2str(31.467, "none", "degrees", 0)` returns `' 31^{\circ} '`, which is 31.467 rounded to the nearest integer.

Output Arguments

str — Text representation of input angles

character array

Text representation of the input angles, returned as a character array.

Data Types: char

Version History

Introduced before R2006a

See Also

Functions

`str2angle` | `dist2str` | `text`

Topics

“Angle Representations and Angular Units”

angledim

Convert angles units

Note

Note The `angledim` function has been replaced by four, more specific, functions: `fromRadians`, `fromDegrees`, `toRadians`, and `toDegrees`. However, `angledim` will be maintained for backward compatibility. The functions `deg2rad`, `rad2deg`, and `unitsratio` provide additional alternatives.

Syntax

```
angleOut = angledim(angleIn, from, to)
```

Description

`angleOut = angledim(angleIn, from, to)` returns the value of the input angle `angleIn`, which is in units specified by `from`, in the desired units given by `to`. Angle units are 'degrees' for "decimal" degrees or 'radians' for radians.

Examples

Convert from degrees to radians:

```
angledim(23.45134, 'degrees', 'radians')
```

```
ans =  
    0.4093
```

Version History

Introduced before R2006a

See Also

`degrees2dms` | `deg2rad` | `fromDegrees` | `fromRadians` | `toDegrees` | `toRadians` | `rad2deg` | `unitsratio`

antipode

Point on opposite side of globe

Syntax

```
[newlat,newlon] = antipode(lat,lon)
[newlat,newlon] = antipode(lat,lon,angleunits)
```

Description

`[newlat,newlon] = antipode(lat,lon)` returns the geographic coordinates of the points exactly opposite on the globe from the input points given by `lat` and `lon`. All angles are in degrees.

`[newlat,newlon] = antipode(lat,lon,angleunits)` where `angleunits` specifies the input and output units as either 'degrees' or 'radians'. It can be abbreviated and is case-insensitive.

Examples

Find Antipode of Given Point

Given a point (43°N, 15°E), find its antipode:

```
[newlat,newlong] = antipode(43,15)
```

```
newlat =
```

```
    -43
```

```
newlong =
```

```
   -165
```

```
or (43°S, 165°W).
```

Find Antipode of North and South Poles

Perhaps the most obvious antipodal points are the North and South Poles. The function `antipode` demonstrates this:

```
[newlat,newlong] = antipode(90,0,'degrees')
```

```
newlat =
```

```
   -90
```

```
newlong =
```

```
   180
```

Note that in this case longitudes are irrelevant because all meridians converge at the poles.

Find Antipode of MathWorks Headquarters

This example shows how to find the antipode of the location of the MathWorks corporate headquarters in Natick, Massachusetts. The example maps the headquarters location and its antipode in an orthographic projection.

Specify latitude and longitude as degree-minutes-seconds and then convert to decimal degrees.

```
mwlát = dms2degrees([ 42 18 2.5])
mwlát = 42.3007
mwlón = dms2degrees([-71 21 7.9])
mwlón = -71.3522
```

Find the antipode.

```
[amwlát amwlón] = antipode(mwlát,mwlón)
amwlát = -42.3007
amwlón = 108.6478
```

Prove that these points are antipodes. The distance function shows them to be 180 degrees apart.

```
dist = distance(mwlát,mwlón,amwlát,amwlón)
dist = 180.0000
```

Generate a map centered on the original point and then another map centered on the antipode.

```
figure
subplot(1,2,1)
axesm ('MapProjection','ortho','origin',[mwlát mwlón],...
      'frame','on','grid','on')
load coastlines
geoshow(coastlát,coastlón,'displaytype','polygon')
geoshow(mwlát,mwlón,'Marker','o','Color','red')
title(sprintf('Looking down at\n(%s,%s)', ...
             angl2str(mwlát,'ns'), angl2str(mwlón,'ew'))))

subplot(1,2,2)
axesm ('MapProjection','ortho','origin',[amwlát amwlón],...
      'frame','on','grid','on')
geoshow(coastlát,coastlón,'displaytype','polygon')
geoshow(amwlát,amwlón,'Marker','o','Color','red')
title(sprintf('Looking down at\n(%s,%s)', ...
             angl2str(amwlát,'ns'), angl2str(amwlón,'ew'))))
```

Looking down at
(42.30° N , 71.35° W)



Looking down at
(42.30° S , 108.65° E)



Version History

Introduced before R2006a

append

Append features to geographic or planar vector

Syntax

```
vout = append(vin,lat,lon)
vout = append(vin,x,y)
vout = append( ___,field,value)
```

Description

`vout = append(vin,lat,lon)` appends the latitude and longitude values in `lat` and `lon` to the Latitude and Longitude properties of the geographic vector `vin`. `vin` is either a `geopoint` or a `geoshape` object.

`vout = append(vin,x,y)` appends the planar x- and y-coordinates in `x` and `y` to the X and Y properties of the planar vector `vin`. `vin` is either a `mappoint` or a `mapshape` object.

`vout = append(___,field,value)` appends the values specified in `value` to the corresponding dynamic property, `field`. If the property does not exist, `append` adds the dynamic property to the object using the value of `field` for the name and assigning the field the value specified in `value`. You can specify multiple field-value pairs. Enclose each field name in single quotes.

Examples

Append Points to Geopoint Vector

Create a geopoint vector.

```
p = geopoint(42,-110)
p =
  1x1 geopoint vector with properties:

  Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
  Feature properties:
    Latitude: 42
    Longitude: -110
```

Append the vector with three new geographic points.

```
lat1 = [42.1 44 44.1];
lon1 = [-101 -120 -121];
p = append(p,lat1,lon1)
p =
  4x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [42 42.1000 44 44.1000]
  Longitude: [-110 -101 -120 -121]
```

The length of the geopoint vector increases by three, as expected, and the 'Latitude' and 'Longitude' feature properties list the new coordinates.

Append Points to Mapshape Vector

Create a mapshape vector, designating a dynamic 'Temperature' property. This vector has one feature with three vertices.

```
s = mapshape(42:44,30:32, 'Temperature', {65:67})
```

```
s =
1x1 mapshape vector with properties:
```

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  X: [42 43 44]
  Y: [30 31 32]
  Temperature: [65 66 67]
```

Append the vector with two new planar points. The points are stored as a new feature with two vertices.

```
x1 = [44.5 45];
y1 = [32.5 33];
s = append(s,x1,y1)
```

```
s =
2x1 mapshape vector with properties:
```

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
(2 features concatenated with 1 delimiter)
  X: [42 43 44 NaN 44.5000 45]
  Y: [30 31 32 NaN 32.5000 33]
  Temperature: [65 66 67 NaN 0 0]
```

The features are separated by NaN. The 'Temperature' value of the new points is set to 0 by default, since no value was specified during the call to `append`. The mapshape vector grew from 1x1 to 2x1 in length because the number of features increased.

Append Point with New Property to Mappoint Vector

Create a mappoint vector with a dynamic property Temperature.

```
mp = mappoint(42, -110, 'Temperature', 65)
```

```
mp =
  1x1 mappoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: 42
  Y: -110
  Temperature: 65
```

Add a point to this vector. The point contains a new dynamic property, Pressure.

```
mp = append(mp, 42.2, -110.5, 'Temperature', 65.6, 'Pressure', 100.0)
```

```
mp =
  2x1 mappoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [42 42.2000]
  Y: [-110 -110.5000]
  Temperature: [65 65.6000]
  Pressure: [0 100]
```

A default Pressure value of 0 is automatically added to the first point.

Append Points with New Properties to Geoshape Vector

Create a geoshape vector, designating a dynamic 'Temperature' property. The 'Temperature' values are input as a cell array so that they belong to a single feature. This vector has one feature with three vertices.

```
lat1 = [42, 42.2, 43];
lon1 = [-110, -110.3, -110.5];
temp1 = {[65, 65.1, 65.2]};
s = geoshape(lat1, lon1, 'Temperature', temp1)
```

```
s =
  1x1 geoshape vector with properties:
```

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  Latitude: [42 42.2000 43]
  Longitude: [-110 -110.3000 -110.5000]
```

```
Temperature: [65 65.1000 65.2000]
```

Add three points to the geoshape vector, including a two new dynamic properties 'Precipitation' and 'CloudCover'. The latitude and longitude values are added as a two-element cell array, so two features are added to the geoshape vector. Note that the 'Temperature' and 'Precipitation' values are specified as two-element vectors, while the new 'CloudCover' values are specified as a one-element cell array.

```
lat2 = {[50 50.2],60};
lon2 = {[ -120 -121],-130};
temp2 = [60.2 60.4];
precip = [0.07 0.19];
cloud = {[20,80]};
s2 = append(s,lat2,lon2,'Temperature',temp2,'Precipitation',precip,'CloudCover',cloud)
```

```
s2 =
3x1 geoshape vector with properties:

Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
Vertex properties:
(3 features concatenated with 2 delimiters)
    Latitude: [42 42.2000 43 NaN 50 50.2000 NaN 60]
    Longitude: [-110 -110.3000 -110.5000 NaN -120 -121 NaN -130]
    Temperature: [65 65.1000 65.2000 NaN 60.2000 0 NaN 60.4000]
    CloudCover: [0 0 0 NaN 20 80 NaN 0]
Feature properties:
    Precipitation: [0 0.0700 0.1900]
```

This appended vector `s2` now has three features, separated by `NaN`, with some Vertex properties and some Feature properties. The two cells of the latitude and longitude cell arrays form the two newly-added features, one with two vertices and the other with one vertex. Since 'Temperature' had previously been designated as a Vertex property in `s`, the new 'Temperature' values are added as Vertex properties. The 'Temperature' value of one new point has not been assigned, so it is set to the default value of 0.

However, the new 'Precipitation' and 'CloudCover' properties are designated as a Vertex or Feature property, whichever is more appropriate for the value format. 'Precipitation' values are provided as a two-element vector, so they are assigned as Feature properties, where each element of `precip2` belongs to a separate feature of the geoshape vector. Since 'CloudCover' values are provided as a cell array, the values must belong to the same feature, so they are set as Vertex properties corresponding to the first added feature. No 'CloudCover' values have been specified for the second added feature, so vertices in the second feature are assigned the default value 0. Finally, 'Precipitation' and 'CloudCover' values for the original feature are set to the default value of 0.

Input Arguments

vin — Input geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Input geographic or planar vector, specified as a `geopoint`, `geoshape`, `mappoint`, or `mapshape` object.

lat — Latitude values

numeric scalar or vector

Latitude values, specified as a numeric scalar or vector.

Data Types: `single` | `double`

lon — Longitude values

numeric scalar or vector

Longitude values, specified as a numeric scalar or vector.

Data Types: `single` | `double`

x — Planar x-coordinates

numeric scalar or vector

Planar x-coordinates, specified as a numeric scalar or vector.

Data Types: `single` | `double`

y — Planar y-coordinates

numeric scalar or vector

Planar y-coordinates, specified as a numeric scalar or vector.

Data Types: `single` | `double`

field — Field name

string scalar | character vector

Field name, specified as a string scalar or character vector. `Field` can specify the name of an existing property in the vector data, or the name you want assigned to a new property that you want to add to the vector data.

Data Types: `char` | `string`

value — Value you want to assign to the property specified by field

cell array | scalar | vector

Value you want to assign to the property specified by `field`, specified as a cell array, or a scalar or vector of any numeric class or logical.

- When `value` is a cell array, `append` adds the property as a Vertex property.
- When `value` is a numeric array, `append` adds the property as a Feature property.
- When `value` is empty, `append` removes the property.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical` | `char` | `string` | `cell`

Output Arguments

vout — Output geographic or planar vector

`geopoint`, `geoshape`, `mappoint`, or `mapshape` object

Output geographic or planar vector, returned as a `geopoint`, `geoshape`, `mappoint`, or `mapshape` object. The object type of `vout` matches the object type of `vin`.

Version History

Introduced in R2012a

See Also

`cat`

arcgridread

(Not recommended) Read gridded data set in ArcGrid ASCII or GridFloat format

Note arcgridread is not recommended. Use readgeoraster instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z,R] = arcgridread(filename)
[Z,R] = arcgridread(filename,coordinateSystemType)
```

Description

[Z,R] = arcgridread(filename) imports a grid in either ArcGrid ASCII or GridFloat format from the file specified by filename. Returns Z, a 2-D array containing the data values, and raster referencing information in R. If the input file is accompanied by a projection file (with extension .prj or .PRJ), then R is a raster reference object whose type matches the coordinate reference system defined in the projection file. Otherwise R is a referencing matrix.

[Z,R] = arcgridread(filename,coordinateSystemType) returns R as a raster reference object whose type is consistent with the value specified by coordinateSystemType. This optional input argument can be helpful in the absence of a projection file. The function throws an error if a projection file is present and coordinateSystemType contradicts the type of coordinate reference system defined in the projection file.

Examples

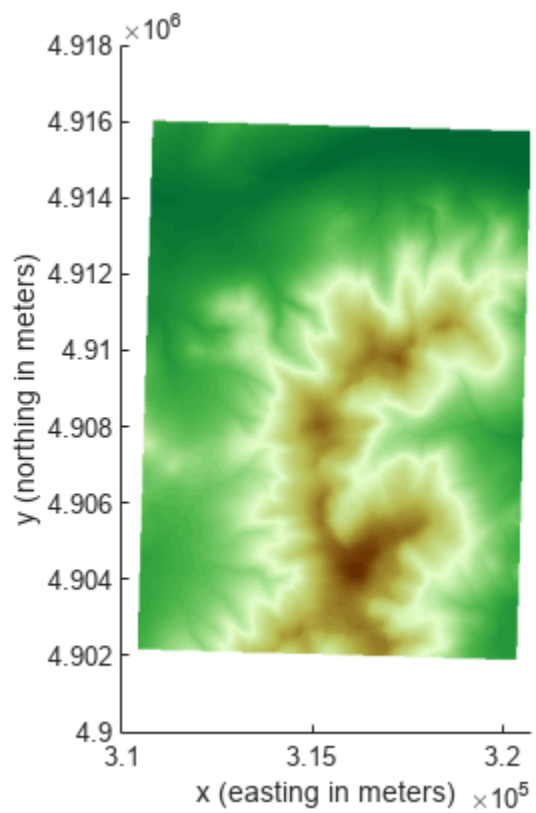
Load and View Mount Washington Terrain Elevation Data

Read the data.

```
[Z,R] = arcgridread('MtWashington-ft.grd');
```

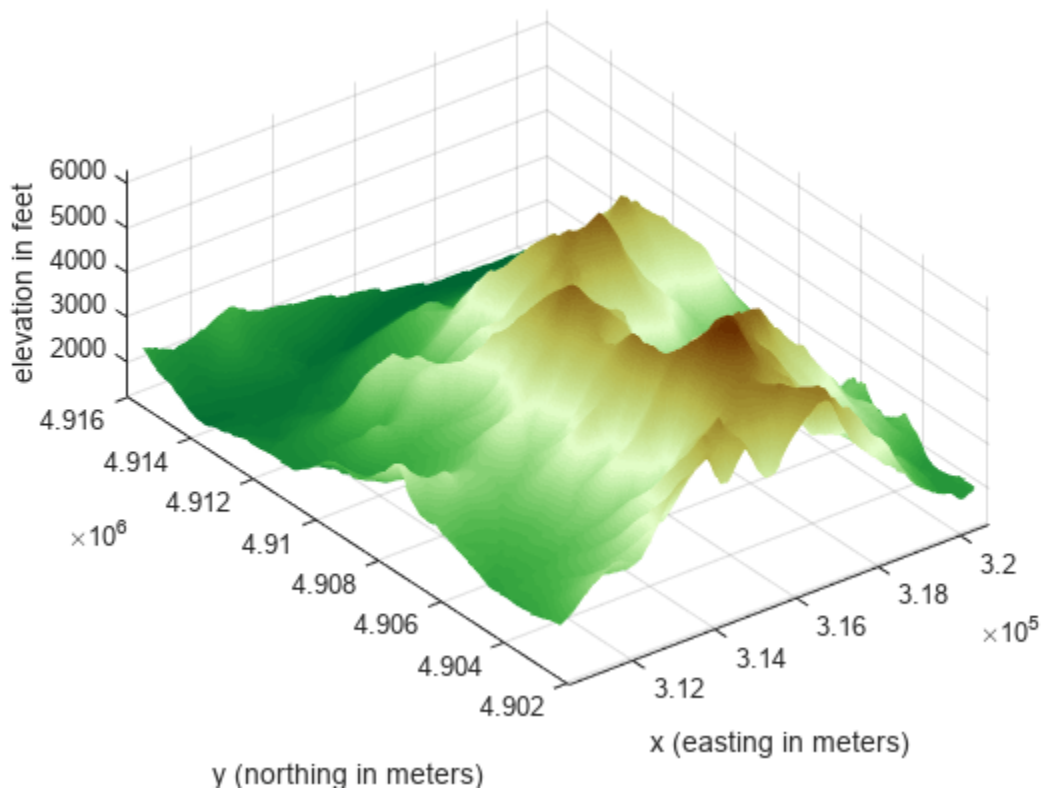
Display the data as a surface. Add two labels to the display and set the colormap.

```
mapshow(Z,R,'DisplayType','surface')
xlabel('x (easting in meters)')
ylabel('y (northing in meters)')
demcmap(Z)
```



View the terrain in 3-D.

```
axis normal
view(3)
axis equal
grid on
zlabel('elevation in feet')
```



Input Arguments

filename — Name of file containing the grid

character vector

Name of file containing the grid, specified as a character vector. The `arcgridread` function supports the following formats.

Format	Description
ArcGrid ASCII	In this format, created by the ArcGIS GRIDASCII command, the data and header information are in a single text file. <code>arcgridread</code> will also read a <code>.prj</code> file, if one is present. This format is also known as Arc ASCII Grid or Esri ASCII Raster format.
GridFloat	In this format, created by the ArcGIS GRIDFLOAT command, data and header information are in separate files (<code>.flt</code> and <code>.hdr</code>). Specify the name of the <code>.flt</code> file (including the file extension). <code>arcgridread</code> will also read a <code>.prj</code> file, if one is present. This format is also known as Esri GridFloat.

Data Types: char

coordinateSystemType — Coordinate system type identifier

'auto' (default) | 'geographic' | 'planar'

Coordinate system type identifier, specified as one of the following values.

Type Identifier	Description
'geographic'	Returns a geographic cells reference object appropriate to a latitude/longitude system.
'planar'	Returns a map cells reference object appropriate to a projected map coordinate system.
'auto'	Type of raster reference object determined by the file contents.

Data Types: char

Output Arguments

Z — Gridded data set

2-D array

Gridded data set, returned as a 2-D array. The class of the array depends on the format of the data, described in the following table. `arcgridread` assigns NaN to elements of Z corresponding to null data values in the grid file.

Format	Class of Returned Gridded Data
ArcGrid ASCII	2-D array of class double.
GridFloat	2-D array of class single.

R — Raster referencing information

raster reference object | referencing matrix

Raster referencing information, returned as a raster reference object whose type matches the coordinates reference system defined in the projection file. If no projection file exists and you do not specify the `coordinateSystemType` parameter, R is a referencing matrix.

Tips

- The `arcgridread` function does not import data in the ArcGrid Binary format (also known as ArcGrid, Arc/INFO Grid, and Esri ArcInfo Grid). ArcGIS uses this format internally and it uses multiple files in a folder with standard names such as `hdr.adf` and `w001001.adf`.

Version History

Introduced before R2006a

R2020a: `arcgridread` is not recommended

Not recommended starting in R2020a

`arcgridread` is not recommended. Use `readgeoraster` instead. There are no plans to remove `arcgridread`.

Unlike `arcgridread`, which returns a referencing matrix in some cases, the `readgeoraster` function returns a raster reference object. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns. For examples of reference object properties, see `GeographicCellsReference` and `MapPostingsReference`.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` or `mapcrop` functions.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` or `mapresize` functions.

This table shows some typical usages of `arcgridread` and how to update your code to use `readgeoraster` instead.

Not Recommended	Recommended
<code>[Z,R] = arcgridread(filename);</code>	<code>[Z,R] = readgeoraster(filename);</code>
<code>[Z,R] = arcgridread(filename,cst);</code>	<code>[Z,R] = readgeoraster(filename, ... 'CoordinateSystemType',cst);</code>

The `readgeoraster` function does not automatically replace missing data with NaN values. If your data set uses large negative numbers to indicate missing data, replace instances with NaN values using the `standardizeMissing` function.

```
[Z,R] = readgeoraster('MtWashington-ft.grd');
info = georasterinfo('MtWashington-ft.grd');
m = info.MissingDataIndicator;
Z = standardizeMissing(Z,m);
```

See Also

[worldfileread](#) | [readgeoraster](#)

areaint

Surface area of polygon on sphere or ellipsoid

Syntax

```
a = areaint(lat,lon)
a = areaint(lat,lon,ellipsoid)
a = areaint( ____,units)
```

Description

`a = areaint(lat,lon)` calculates the surface area of the polygon with geographic vertices `lat` and `lon`. This syntax references the coordinates to a unit sphere and returns `a` as the fraction of the sphere that the polygon covers.

`a = areaint(lat,lon,ellipsoid)` specifies the reference ellipsoid for the vertices. This syntax returns the area in square units using the units of the semimajor axis of the reference ellipsoid.

`a = areaint(____,units)` specifies the angle units for the vertices.

Examples

Calculate Approximate Area of Polygon

The accuracy of the `areaint` function depends on the distance between the specified vertices. Calculate more accurate approximations by specifying vertices that are closer together.

Specify vertices for a 30° lune, using a point every 30° of latitude. Approximate the surface area as the fraction of the unit sphere that the lune covers.

```
lat1 = [-90:30:90 60:-30:-60];
lon1 = [zeros(1,7) 30*ones(1,5)];
a1 = areaint(lat1,lon1)
```

```
a1 = 0.0792
```

Specify vertices for the same lune, this time using a point every 10° of latitude. Approximate the area of the lune using the new vertices.

```
lat2 = [-90:10:90 80:-10:-80];
lon2 = [zeros(1,19) 30*ones(1,17)];
a2 = areaint(lat2,lon2)
```

```
a2 = 0.0829
```

You can find the exact area of the lune by using the `areaquad` function. A 30° lune covers 1/12 the surface of the unit sphere.

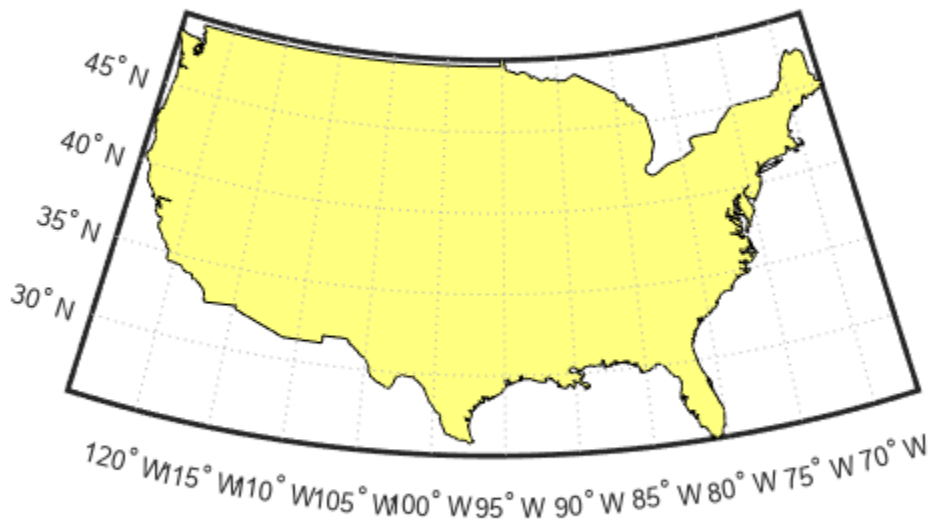
```
a = areaquad(90,0,-90,30)
```

```
a = 0.0833
```

Calculate Area of Polygon on Ellipsoid

Load a MAT file containing coordinates for the conterminous United States, Long Island, and Martha's Vineyard into the workspace. Display the coordinates on a map using polygons.

```
load("conus.mat","uslat","uslon")
figure
usamap([min(uslat) max(uslat)],[min(uslon) max(uslon)])
geoshow(uslat,uslon,"DisplayType","polygon")
```



Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of kilometers. Then, calculate the areas of the polygons in square kilometers by referencing the coordinates to the ellipsoid. In this case, the `areaint` function returns three areas. The largest area is for the polygon representing the conterminous United States. The other two areas are for the polygons representing Long Island and Martha's Vineyard, respectively.

```
wgs84 = wgs84Ellipsoid("km");
a = areaint(uslat,uslon,wgs84)
```

```
a = 3×1
106 ×
```

```
7.9326
0.0035
```

0.0004

Input Arguments

lat — Latitude coordinates of polygon vertices

numeric vector

Latitude coordinates of the polygon vertices, specified as a numeric vector.

- Define one polygon by specifying a vector, such as [39 45 19 39].
- Define multiple polygons by specifying a vector and indicating breaks between the polygons using NaN values, such as [37 46 31 20 37 NaN 45 49 35 32 45 NaN 35 40 42 35]. The NaN values in `lat` must correspond to the NaN values in `lon`.

The size of `lat` must match the size of `lon`.

Data Types: `single` | `double`

lon — Longitude coordinates of polygon vertices

numeric vector

Longitude coordinates of the polygon vertices, specified as a numeric vector.

- Define one polygon by specifying a vector, such as [39 45 19 39].
- Define multiple polygons by specifying a vector and indicating breaks between the polygons using NaN values, such as [37 46 31 20 37 NaN 45 49 35 32 45 NaN 35 40 42 35]. The NaN values in `lon` must correspond to the NaN values in `lat`.

The size of `lon` must match the size of `lat`.

Data Types: `single` | `double`

ellipsoid — Reference ellipsoid

[1 0] (default) | `referenceSphere` object | `referenceEllipsoid` object | `oblateSpheroid` object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element vector of the form [semimajor_axis eccentricity], where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of [1 0] represents the unit sphere.

units — Angle unit for vertices

"degrees" (default) | "radians"

Angle unit for the vertices, specified as one of these options:

- "degrees" — Degrees
- "radians" — Radians

Data Types: `char` | `string`

Output Arguments

a — Surface area of polygon

scalar | vector

Surface area of the polygon, returned as a scalar or a vector.

- When `lat` and `lon` define one polygon, `a` is a scalar.
- When `lat` and `lon` define multiple polygons, `a` is a vector. Each element of the vector is the area of the corresponding polygon.

When you specify the `ellipsoid` argument, the area is in square units using the units of the semimajor axis of the reference ellipsoid. Otherwise, the area is the fraction of the unit sphere that the polygon covers.

Regardless of the polygon vertex order, the elements of `a` are positive.

Data Types: `double`

Algorithms

- The `areaint` function measures areas enclosed by arbitrary polygons by using a line integral approach based on Green's Theorem. The accuracy is inversely proportional to the distance between the polygon vertices.
- When you specify `ellipsoid` as a nonspherical ellipsoid, the function converts the latitude data to the auxiliary authalic sphere.

Version History

Introduced before R2006a

See Also

Functions

`areamat` | `areaquad`

Topics

“Create and Display Polygons”

areamat

Surface area covered by nonzero values in binary data grid

Syntax

```
A = areamat(BW,R)
A = areamat(BW,R,ellipsoid)
[A, cellarea] = areamat(...)
```

Description

`A = areamat(BW,R)` returns the surface area covered by the elements of the binary regular data grid `BW`, which contain the value 1 (`true`). `BW` can be the result of a logical expression such as `BW = (topo60c > 0)`. Specify `R` as a `GeographicCellsReference` object. The `RasterSize` property of `R` must be consistent with `size(BW)`.

The output `A` expresses surface area as a fraction of the surface area of the unit sphere (4π), so the result ranges from 0 to 1.

`A = areamat(BW,R,ellipsoid)` calculates the surface area on the ellipsoid or sphere defined by the input `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The units of the output, `A`, are the square of the length units in which the semimajor axis is provided. For example, if `ellipsoid` is replaced with `wgs84Ellipsoid('kilometers')`, then `A` is in square kilometers. If you do not specify `ellipsoid` and `R` has a non-empty `GeographicCRS` property, then `areamat` uses the ellipsoid contained in the `Spheroid` property of the `geocrs` object in the `GeographicCRS` property of `R`.

`[A, cellarea] = areamat(...)` returns a vector, `cellarea`, describing the area covered by the data cells in `BW`. Because all the cells in a given row are exactly the same size, only one value is needed per row. Therefore `cellarea` has size `M-by-1`, where `M = size(BW,1)` is the number of rows in `BW`.

Examples

Find Surface Area in Normalized Units

Find the surface area in normalized units of the part of Earth's terrain that is above sea level.

First, load elevation raster data and a geographic cells reference object. The raster contains terrain heights relative to mean sea level. Then, create a logical array representing the terrain above sea level.

```
load topo60c
topoASL = topo60c > 0;
```

Find the surface area in normalized units of the elements of the array that contain `true`.

```
areamat(topoASL, topo60cR)
```

```
ans = 0.2890
```

The result means 28.9% of Earth's terrain is above sea level.

Find Surface Area in Kilometers

Find the surface area in kilometers of the part of Earth's terrain that is above sea level.

First, load elevation raster data and a geographic cells reference object. The raster contains terrain heights relative to mean sea level. Then, create a reference sphere for Earth and specify its units as kilometers.

```
load topo60c
s = referenceSphere('earth', 'km');
```

Create a logical array representing the terrain above sea level.

```
topoASL = topo60c > 0;
```

Find the surface area in kilometers of the elements of the array that contain `true`.

```
areamat(topoASL, topo60cR, s)
```

```
ans = 1.4739e+08
```

The result means that approximately 147 million square kilometers of Earth's terrain is above sea level.

Tips

Given a regular data grid that is a logical 0-1 matrix, the `areamat` function returns the area corresponding to the true, or 1, elements. The input data grid can be a logical statement, such as `(topo60c > 0)`, which is 1 everywhere that `topo60c` is greater than 0 meters, and 0 everywhere else. This is an illustration of that matrix:



This calculation is based on the `areaquad` function and is therefore limited only by the granularity of the cellular data.

Version History

Introduced before R2006a

R2022b: areamat will not accept referencing vectors or referencing matrices as input

Not recommended starting in R2022b

The `areamat` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

R2020b: areamat uses reference ellipsoid information in raster reference objects

When you specify `R` as a geographic raster reference object, the `areamat` function uses the reference ellipsoid within the object. To find the reference ellipsoid for a geographic raster reference object, `R`, first get its geographic coordinate reference system as a `geocrs` object. Then, query the `Spheroid` property of the `geocrs` object.

```
g = R.GeographicCRS;  
g.Spheroid
```

To use `areamat` with a different ellipsoid, specify the `ellipsoid` argument.

See Also

`areaint` | `areaquad`

areaquad

Surface area of latitude-longitude quadrangle

Syntax

```
a = areaquad(lat1,lon1,lat2,lon2)
a = areaquad(lat1,lon1,lat2,lon2,ellipsoid)
a = areaquad( ____,units)
```

Description

`a = areaquad(lat1,lon1,lat2,lon2)` calculates the surface area of the latitude-longitude quadrangle on page 1-85 bound by the parallels `lat1` and `lat2` and the meridians `lon1` and `lon2`. This syntax references the coordinates to a unit sphere and returns `a` as the fraction of the sphere that the quadrangle covers.

`a = areaquad(lat1,lon1,lat2,lon2,ellipsoid)` specifies the reference ellipsoid for the parallels and meridians. This syntax returns the area in square units using the units of the semimajor axis of the reference ellipsoid.

`a = areaquad(____,units)` specifies the angle units for the parallels and meridians.

Examples

Calculate Area of Quadrangle

Find the surface area of the quadrangle bound by the parallels 30°N and 45°N and the meridians 25°W and 60°E. When you do not specify a reference ellipsoid as input, the `areaquad` function references the quadrangle to the unit sphere and returns the area as the fraction of the sphere that the quadrangle covers, where 1 is the entire sphere.

```
a = areaquad(30,-25,45,60)
a = 0.0245
```

This quadrangle covers approximately 2.45% of the unit sphere.

Calculate Area of Quadrangle on Ellipsoid

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of kilometers.

```
wgs84 = wgs84Ellipsoid("km");
```

Find the area of the quadrangle that is bound by the parallels 30°N and 45°N and the meridians 25°W and 60°E. When you specify a reference ellipsoid as input, the `areaquad` function returns area in square units using the length unit of the ellipsoid.

```
a = areaquad(30,-25,45,60,wgs84)
```

a = 1.2477e+07

Input Arguments

lat1 — Latitude of first parallel

scalar | vector | matrix | N-D array

Latitude of the first parallel, specified as a scalar, vector, matrix, or N-D array.

When you specify a vector, matrix, or N-D array, each element specifies the latitude of the first parallel of a separate quadrangle.

The sizes of `lat1`, `lon1`, `lat2`, and `lon2` must match.

Data Types: double

lon1 — Longitude of first meridian

scalar | vector | matrix | N-D array

Longitude of the first meridian, specified as a scalar, vector, matrix, or N-D array.

When you specify a vector, matrix, or N-D array, each element specifies the longitude of the first meridian of a separate quadrangle.

The sizes of `lat1`, `lon1`, `lat2`, and `lon2` must match.

Data Types: double

lat2 — Latitude of second parallel

scalar | vector | matrix | N-D array

Latitude of the second parallel, specified as a scalar, vector, matrix, or N-D array.

When you specify a vector, matrix, or N-D array, each element specifies the latitude of the second parallel of a separate quadrangle.

The sizes of `lat1`, `lon1`, `lat2`, and `lon2` must match.

Data Types: double

lon2 — Longitude of second meridian

scalar | vector | matrix | N-D array

Longitude of the second meridian, specified as a scalar, vector, matrix, or N-D array.

When you specify a vector, matrix, or N-D array, each element specifies the longitude of the second meridian of a separate quadrangle.

The sizes of `lat1`, `lon1`, `lat2`, and `lon2` must match.

Data Types: double

ellipsoid — Reference ellipsoid

[1 0] (default) | referenceSphere object | referenceEllipsoid object | oblateSpheroid object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element vector of the form `[semimajor_axis eccentricity]`, where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of `[1 0]` represents the unit sphere.

units — Angle units of parallels and meridians

`"degrees"` (default) | `"radians"`

Angle units of the parallels and meridians, specified as one of these options:

- `"degrees"` — Degrees
- `"radians"` — Radians

Data Types: `char` | `string`

Output Arguments

a — Surface area of quadrangle

`scalar` | `vector` | `matrix` | `N-D array`

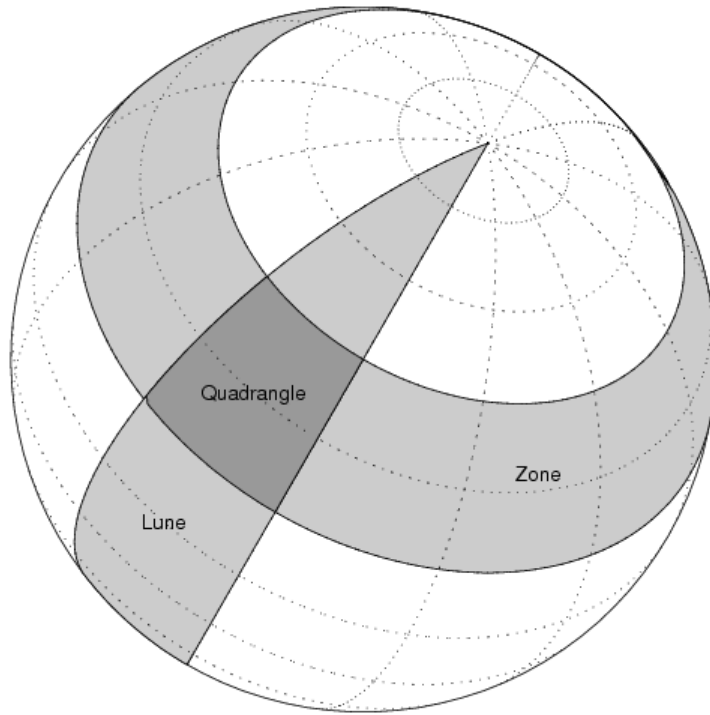
Surface area of the quadrangle, returned as a scalar, vector, matrix, or N-D array of the same size as `lat1`, `lon1`, `lat2`, and `lon2`. Each element of `a` is the area for the quadrangle defined by the corresponding elements of `lat1`, `lon1`, `lat2`, and `lon2`.

When you specify the `ellipsoid` argument, the area is in square units using the units of the semimajor axis of the reference ellipsoid. Otherwise, the area is the fraction of the unit sphere that the quadrangle covers.

More About

Latitude-Longitude Quadrangle

A latitude-longitude quadrangle is a region bounded by two meridians and two parallels. In spherical geometry, a quadrangle is the intersection of a lune (a section bounded by two meridians) and a zone (a section bounded by two parallels).



Algorithms

- The `areaquad` function uses spherical geometry and returns exact calculations.
- When you specify `ellipsoid` as a nonspherical ellipsoid, the function converts the latitude data to the auxiliary authalic sphere.

Version History

Introduced before R2006a

See Also

Functions

`areamat` | `areaint`

map.geodesy.AuthalicLatitudeConverter

Convert between geodetic and authalic latitudes

Description

An `AuthalicLatitudeConverter` object provides conversion methods between geodetic and authalic latitudes for an ellipsoid with a given eccentricity.

The authalic latitude maps an ellipsoid (oblate spheroid) to a sphere while preserving surface area. Use authalic latitudes when implementing equal area map projections on the ellipsoid.

Creation

Syntax

```
converter = map.geodesy.AuthalicLatitudeConverter  
converter = map.geodesy.AuthalicLatitudeConverter(spheroid)
```

Description

`converter = map.geodesy.AuthalicLatitudeConverter` creates an `AuthalicLatitudeConverter` object for a sphere and sets the `Eccentricity` to 0.

`converter = map.geodesy.AuthalicLatitudeConverter(spheroid)` creates an authalic latitude converter object and sets the `Eccentricity` property to match the specified spheroid object.

Input Arguments

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

Properties

Eccentricity — Ellipsoid eccentricity

0 | numeric scalar

Ellipsoid eccentricity, specified as a numeric scalar. Eccentricity is in the interval [0, 0.5]. Eccentricities larger than 0.5 are possible in theory, but do not occur in practice and are not supported.

Data Types: double

Object Functions

forward Convert geodetic latitude to authalic, conformal, isometric, or rectifying latitude

inverse Convert authalic, conformal, isometric, or rectifying latitude to geodetic latitude

Examples

Create an Authalic Converter

Create a Geodetic Reference System 1980 (grs80) reference ellipsoid.

```
grs80 = referenceEllipsoid('GRS 80');
```

Create an authalic converter object and set the value of the Eccentricity property.

```
conv1 = map.geodesy.AuthalicLatitudeConverter;  
conv1.Eccentricity = grs80.Eccentricity
```

```
conv1 =
```

```
AuthalicLatitudeConverter with properties:
```

```
  Eccentricity: 0.0818
```

Create an Authalic Converter Specifying a Spheroid

Create a reference ellipsoid.

```
grs80 = referenceEllipsoid('GRS 80');
```

Create an authalic latitude converter object based on the ellipsoid.

```
conv2 = map.geodesy.AuthalicLatitudeConverter(grs80)
```

```
conv1 =
```

```
AuthalicLatitudeConverter with properties:
```

```
  Eccentricity: 0.0818
```

Version History

Introduced in R2013a

See Also

Functions

[geocentricLatitude](#) | [parametricLatitude](#)

Objects

[ConformalLatitudeConverter](#) | [IsometricLatitudeConverter](#) | [RectifyingLatitudeConverter](#)

avhrrgoode

Read AVHRR data product stored in Goode Projection

Syntax

```
[latgrat,longrat,z] = avhrrgoode(region,filename)
[...] = avhrrgoode(region,filename,scalefactor)
[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim)
[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize)
[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,...
nrows,ncols)
[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,...
nrows,ncols,resolution)
[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,...
nrows,ncols,resolution,precision)
```

Description

[latgrat,longrat,z] = avhrrgoode(region,filename) reads data from an Advanced Very High Resolution Radiometer (AVHRR) data set with a nominal resolution of 1 km that is stored in the Goode projection. Data in this format includes a nondimensional vegetation index (NDVI) and Global Land Cover Characteristics (GLCC) data sets. *region* specifies the geographic coverage of the file, using the following values:

- 'g' or 'global'
- 'af' or 'africa'
- 'ap' or 'australia/pacific'
- 'ea' or 'eurasia'
- 'na' or 'north america'
- 'sa' or 'south america'

filename is a string scalar or character vector specifying the name of the data file. Output *Z* is a geolocated data grid with coordinates *latgrat* and *longrat* in units of degrees. *Z*, *latgrat*, and *longrat* are of class double. Projected coordinates that lie within the interrupted areas of the projection are set to NaN. A scale factor of 100 is applied to the original data set, so that *Z* contains every 100th point in both X and Y directions.

[...] = avhrrgoode(region,filename,scalefactor) uses the integer *scalefactor* to downsample the data. A scale factor of 1 returns every point. A scale factor of 10 returns every 10th point. The default value is 100.

[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim) returns data for the specified region. The returned data can extend somewhat beyond the requested area. Limits are two-element vectors in units of degrees, with *latlim* in the range [-90 90] and *lonlim* in the range [-180 180]. *latlim* and *lonlim* must be ascending. If *latlim* and *lonlim* are empty, the entire area covered by the data file is returned. If the quadrangle defined by *latlim* and *lonlim* (when projected to form a polygon in the appropriate Goode projection) fails to intersect the bounding box of the data in the projected coordinates, then *Z*, *latgrat*, and *longrat* are returned as empty.

[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize) controls the size of the graticule matrices. gsize is a two-element vector containing the number of rows and columns desired. By default, latgrat, and longrat have the same size as Z.

[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,... nrows,ncols) overrides the dimensions for the standard file format for the selected region. This syntax is useful for data stored on CD-ROM, which may have been truncated to fit. Some global data sets were distributed with 16347 rows and 40031 columns of data on CD-ROMs. The default size for global data sets is 17347 rows and 40031 columns of data.

[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,... nrows,ncols,resolution) reads a data set with the spatial resolution specified in meters. Specify resolution as either 1000 or 8000 (meters). If empty, the full resolution of 1000 meters is assumed. Data is also available at 8000-meter resolution. Nondimensional vegetation index data at 8-km spatial resolution has 2168 rows and 5004 columns.

[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,... nrows,ncols,resolution,precision) reads a data set expecting the integer precision specified. If empty, 'uint8' is assumed. 'uint16' is appropriate for some files. Check the metadata (.txt or README) file in the GLCC ftp folder for specification of the file format and contents. In either case, Z is converted to class double.

Background

The United States maintains a family of satellite-based sensors to measure climate change under the Earth Observing System (EOS) program. The precursors to the EOS data are the data sets produced by NOAA and NASA under the Pathfinder program. These are data derived from the Advanced High Resolution Radiometer sensor flown on the NOAA Polar Orbiter satellites, NOAA-7, -9, and -11, and have spatial resolutions of about 1 km. The data from the AVHRR sensor is processed into separate land, sea, and atmospheric indices. Land area data is processed to a nondimensional vegetation index (NDVI) or land cover classification and stored in binary files in the Plate Carrée, Goode, and Lambert projections. Sea data is processed to surface temperatures and stored in HDF formats. avhrrgoode reads land data saved in the Goode projection with global and continental coverage at 1 km. It can also read 8 km data with global coverage.

Limitations

Most files store the data in scaled integers. Though this function returns the data as double, the scaling from integer to float is not performed. Check the data's README file for the appropriate scaling parameters.

Examples

Example 1 — Downsampled Classified Global GLCC Coverage

Read and display every 50th point from the Global Land Cover Characteristics (GLCC) file covering the entire globe with the USGS classification scheme, named gusgs2_0g.img. (To run the example, you must first download the file.)

```
[latgrat, longrat, Z] = avhrrgoode('global', ...
    'gusgs2_0g.img',50);
```

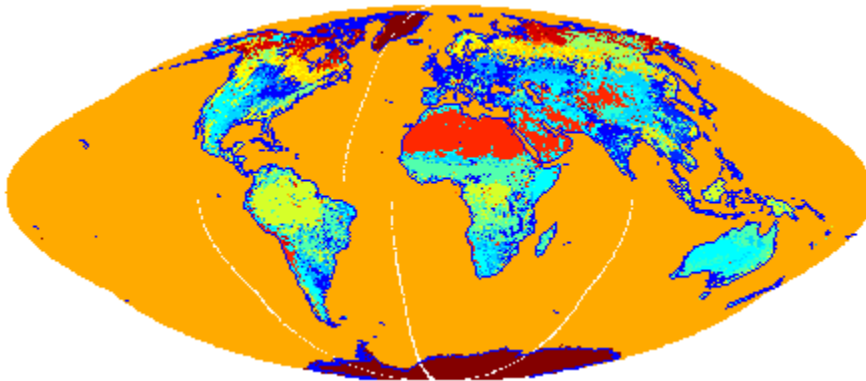
```

% Convert the geolocated data grid to an geolocated image.
uniqueClasses = unique(Z);
RGB = ind2rgb8(uint8(Z), jet(numel(uniqueClasses)));

% Display the data as an image using the Goode projection.
origin = [0 0 0];
ellipsoid = [6370997 0];
figure
axesm('MapProjection', 'goode', 'Origin', origin, ...
      'Geoid', ellipsoid)
geoshow(latgrat, longrat, RGB, 'DisplayType', 'image');
axis image off

% Plot the coastlines.
hold on
load coastlines
plotm(coastlat,coastlon)

```



Example 2 — Classified GLCC Data for California

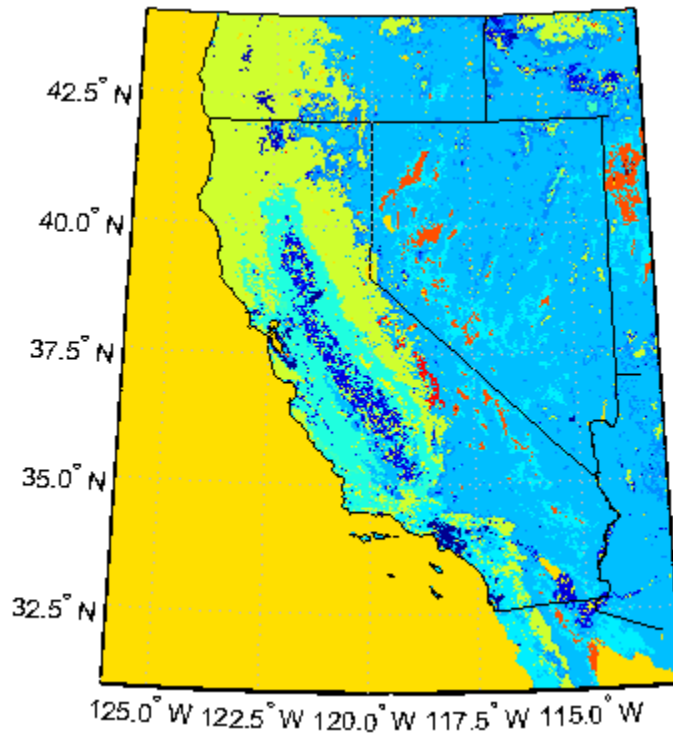
Read and display every point from the Global Land Cover Characteristics (GLCC) file covering California with the USGS classification scheme, named `nausgs1_2g.img`. You must first download the file to run this example.

```

figure
usamap california
mstruct = gcm;
latlim = mstruct.maplatlimit;
lonlim = mstruct.maplonlimit;
scalefactor = 1;
[latgrat, longrat, Z] = ...
    avhrrgoode('na', 'nausgs1_2g.img', scalefactor, latlim, lonlim);
geoshow(latgrat, longrat, Z, 'DisplayType', 'texturemap');

% Overlay vector data from usastatehi.shp.
california = shaperead('usastatehi', 'UseGeoCoords', true, ...
    'BoundingBox', [lonlim;latlim]);
geoshow([california.Lat], [california.Lon], 'Color', 'black');

```



Tips

This function reads the binary files as is. You should not use byte-swapping software on these files.

The AVHRR project and data sets are described in and provided by various U.S. Government Web sites. See the entry for Global Land Cover Characteristics (GLCC) in the tech note referred to below.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: "Find Geospatial Data Online".

Version History

Introduced before R2006a

See Also

avhrrlambert

avhrrlambert

Read AVHRR data product stored in eqaazim projection

Syntax

```
[latgrat,longrat,Z] = avhrrlambert(region,filename)
[...] = avhrrlambert(region,filename, scalefactor)
[...] = avhrrlambert(region,filename, scalefactor, latlim, lonlim)
[...] = avhrrlambert(region,filename, scalefactor, latlim, lonlim, gsize)
[...] = avhrrlambert(region,filename, scalefactor, latlim, lonlim,
gsize,precision)
```

Description

[latgrat,longrat,Z] = avhrrlambert(*region*,*filename*) reads data from an Advanced Very High Resolution Radiometer (AVHRR) data set with a nominal resolution of 1 km that is stored in the Lambert Equal Area Azimuthal projection. Data of this type includes the Global Land Cover Characteristics (GLCC). *region* specifies the coverage of the file. Valid regions are listed in the following table. *filename* is a string specifying the name of the data file. *Z* is a geolocated data grid with coordinates *latgrat* and *longrat* in units of degrees. A scale factor of 100 is applied to the original data set such that *Z* contains every 100th point in both X and Y.

Region Specifiers
'a' or 'asia'
'af' or 'africa'
'ap' or 'australia/pacific'
'e' or 'europe'
'na' or 'north america'
'sa' or 'south america'

[...] = avhrrlambert(*region*,*filename*, *scalefactor*) uses the integer *scalefactor* to downsample the data. A scale factor of 1 returns every point. A scale factor of 10 returns every 10th point. The default value is 100.

[...] = avhrrlambert(*region*,*filename*, *scalefactor*, *latlim*, *lonlim*) returns data for the specified region. The result may extend somewhat beyond the requested area. The limits are two-element vectors in units of degrees, with *latlim* in the range [-90 90] and *lonlim* in the range [-180 180]. If *latlim* and *lonlim* are empty, the entire area covered by the data file is returned. If the quadrangle defined by *latlim* and *lonlim* (when projected to form a polygon in the appropriate Lambert Equal Area Azimuthal projection) fails to intersect the bounding box of the data in the projected coordinates, then *latgrat*, *longrat*, and *Z* are empty.

[...] = avhrrlambert(*region*,*filename*, *scalefactor*, *latlim*, *lonlim*, *gsize*) controls the size of the graticule matrices. *gsize* is a two-element vector containing the number of rows and columns desired. If omitted or empty, a graticule the size of the grid is returned.

[...] = avhrrlambert(*region*,*filename*, *scalefactor*, *latlim*, *lonlim*, *gsize*,*precision*) reads a data set with the integer *precision* specified. If omitted, 'uint8' is

assumed. 'uint16' is appropriate for some files. Check the metadata (.txt or README) file in the ftp folder for specification of the file format and contents.

Background

The United States plans to build a family of satellite-based sensors to measure climate change under the Earth Observing System (EOS) program. Early precursors to the EOS data are the data sets produced by NOAA and NASA under the Pathfinder program. These are data derived from the Advanced High Resolution Radiometer sensor flown on the NOAA Polar Orbiter satellites, NOAA-7, -9, and -11 with a spatial resolution of about 1 km. The data from the AVHRR sensor is processed into separate land, sea, and atmospheric indices. Land area data is processed to a nondimensional vegetation index or land cover classification and stored in binary files in the Plate Carrée, Goode, and Lambert Equal Area Azimuthal projections. Sea data is processed to surface temperatures and stored in HDF formats. This function reads land cover data for the continents saved in the Lambert Equal Area Azimuthal projection at 1 km.

Examples

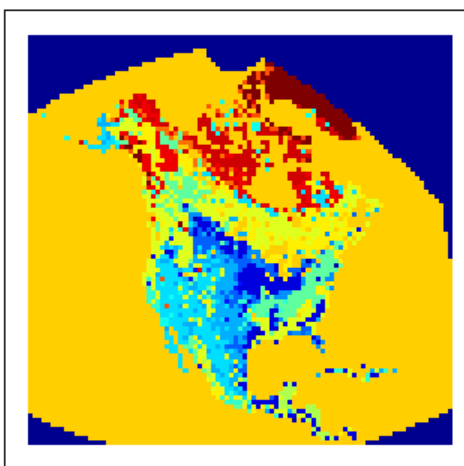
Example 1

Read and display every 100th point from the Global Land Cover Characteristics (GLCC) file covering North America with the USGS classification scheme, named `nausgs1_2l.img`. To run this example, you must first download the file.

```
[latgrat, longrat, Z] = avhrrlambert('na','nausgs1_2l.img');
```

Display the data using the Lambert Equal Area Azimuthal projection.

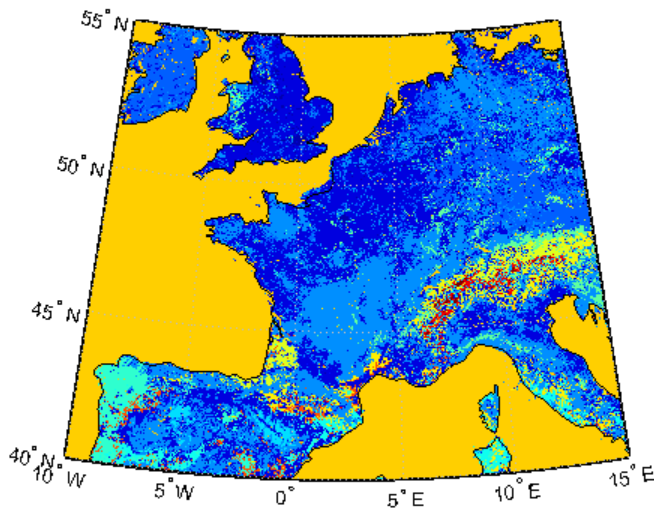
```
origin = [50 -100 0];
ellipsoid = [6370997 0];
figure
axesm('MapProjection', 'eqaazim', 'Origin', ...
      origin, 'Geoid', ellipsoid)
geoshow(latgrat, longrat, Z, 'DisplayType', 'texturemap');
```



Example 2

Read and display every other point from the Global Land Cover Characteristics (GLCC) file covering Europe with the USGS classification scheme, named `eaugs1_2le.img`. To run this example, you must first download the file.

```
figure
worldmap france
mstruct = gcm;
latlim = mstruct.maplatlimit;
lonlim = mstruct.maplonlimit;
scalefactor = 2;
[latgrat, longrat, Z] = avhrrlambert('e', 'eaugs1_2le.img', ...
    scalefactor, latlim, lonlim);
geoshow(latgrat, longrat, Z, 'DisplayType', 'texturemap');
geoshow('landareas.shp', 'FaceColor', 'none', 'EdgeColor', 'black')
```

**Tips**

This function reads the binary files as is. You should not use byte-swapping software on these files.

The AVHRR project and data sets are described in and provided by various U.S. Government Web sites.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: “Find Geospatial Data Online”.

Version History

Introduced before R2006a

See Also

avhrrgoode

axes2ecc

Eccentricity of ellipse from axes lengths

Syntax

```
ecc = axes2ecc(semimajor,semiminor)
```

Description

`ecc = axes2ecc(semimajor,semiminor)` computes the eccentricity `ecc` of an ellipse or an ellipsoid of revolution given the semimajor and semiminor axes lengths.

Examples

Eccentricity of Ellipse from Semimajor and Semiminor Axes

Find the eccentricity of an ellipse from the lengths of the semimajor and semiminor axes.

```
ecc = axes2ecc(6378137,6356752)
```

```
ecc = 0.0818
```

Input Arguments

semimajor — Semimajor axis length

positive numeric scalar

Semimajor axis length, specified as a positive numeric scalar. The value of `semimajor` must be greater than that of `semiminor`.

Data Types: double

semiminor — Semiminor axis length

positive numeric scalar

Semiminor axis length, specified as a positive numeric scalar. The value of `semiminor` must be less than that of `semimajor`.

Data Types: double

Output Arguments

ecc — Eccentricity of ellipse

numeric scalar

Eccentricity of the ellipse, returned as a numeric scalar in the range [0, 1].

Version History

Introduced before R2006a

R2013b: Only numeric scalars will be accepted as input

Not recommended starting in R2013b

The `axes2ecc` function will not accept vectors or matrices as input in a future release. To update your code, specify a numeric scalar instead.

See Also

`ecc2flat` | `ecc2n` | `majaxis` | `minaxis`

axesm

Create axesm-based map

Syntax

```
axesm  
axesm(Name,Value)  
axesm(projid,Name,Value)
```

Description

The `axesm` function creates an axesm-based map (previously referred to as map axes) into which both vector and raster geographic data can be projected using functions such as `plotm` and `geoshow`. Properties specific to axesm-based maps can be assigned upon creation with `axesm`, and for an existing axesm-based map they can be queried and changed using `getm` and `setm`. Use the standard `get` and `set` methods to query and control the standard MATLAB axes properties of an axesm-based map.

An axesm-based map is a standard MATLAB axes with different default settings for some properties and a MATLAB structure for storing projection parameters and other data. The main differences in default settings are:

- Axes properties `XGrid`, `YGrid`, `XTick`, `YTick` are set to 'off'.
- The hold mode is 'on'.

The map projection structure stores the properties of the axesm-based map, which, in addition to the special standard axes settings, allow Mapping Toolbox functions to recognize an axes or an opened FIG-file as an axesm-based map. See axesm-Based Map Properties for descriptions of the axesm-based map properties.

`axesm` with no input arguments, initiates the `axesmui` graphical user interface, which can be used to set the properties of the axesm-based map. This is detailed on the `axesmui` reference page.

`axesm(Name,Value)` creates an axesm-based map and modifies the appearance using name-value pairs to set properties. You can specify multiple name-value pairs. Enclose each property name in quotes. For example, 'FontSize',14 sets the font size for the map text. Properties may be specified in any order, but the `MapProjection` property must be included. For a full list of properties, see axesm-Based Map Properties.

`axesm(projid,Name,Value)` specifies which map projection to use. `projid` should match one of the entries in the last column displayed by the `maps` function. You can also find these listed in "Summary and Guide to Projections".

Examples

Create axesm-Based Map for Mercator Projection

Create an axesm-based map for a Mercator projection, with selected latitude limits:

```
axesm('MapProjection','mercator','MapLatLimit',[-70 80])
```

All properties not explicitly addressed in the call are set to either fixed or calculated defaults. The file `mercator.m` defines a projection function, so the same result could have been achieved with the function.

```
axesm('mercator','MapLatLimit',[-70 80])
```

Each projection function includes default values for all properties. Any following property name/property value pairs are treated as overrides.

In either of the above examples, data displayed in the given map is in a Mercator projection. Any data falling outside the prescribed limits is not displayed.

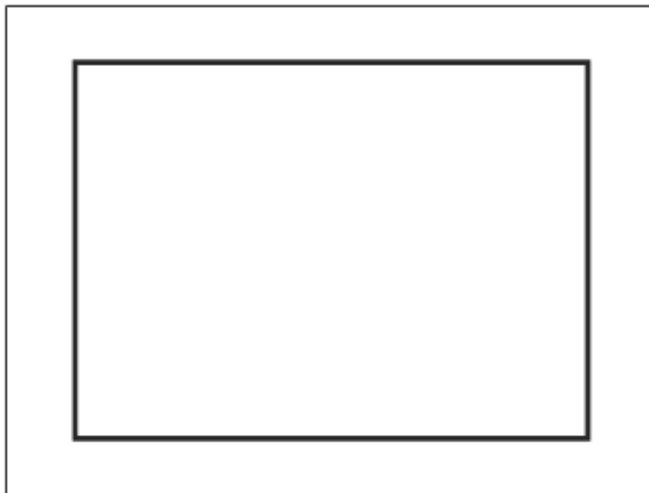
Access and Change axesm-Based Map Properties

Similar to accessing and manipulating standard axes properties by using the `get` and `set` functions, you can access and manipulate the properties of axesm-based maps by using the `getm` and `setm` functions.

Use the `axesm` function only to *create* an axesm-based map. Use the `setm` function to *modify* an existing axesm-based map.

Create an axesm-based map that contains no map data. Note that you specify MapProjection ID values in lowercase.

```
axesm('MapProjection','miller','Frame','on')
```



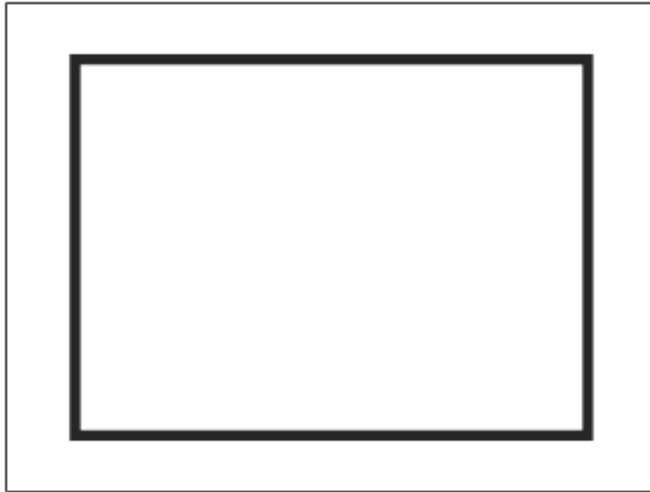
At this point you can begin to customize the map. For example, you might decide to make the frame lines bordering the map thicker. First, you need to identify the current line width of the frame, which you do by querying the current axes, identified as `gca`.

```
getm(gca, 'LineWidth')
```

```
ans = 2
```

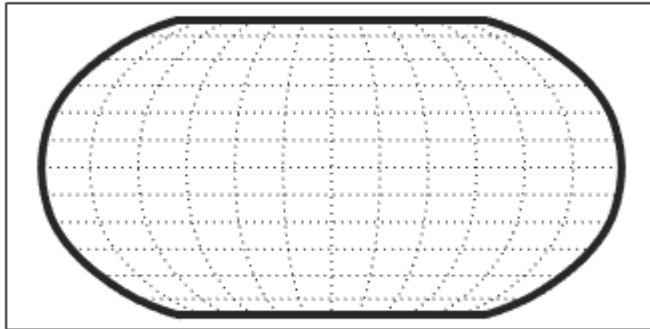
Now reset the line width to four points. The default `fontunits` value for axes is `points`. You can set `fontunits` to be `points`, `normalized`, `inches`, `centimeters`, or `pixels`.

```
setm(gca, 'LineWidth', 4)
```



You can set any number of properties simultaneously with `setm`. Continue by reducing the line width, changing the projection to equidistant cylindrical, and verify the changes.

```
setm(gca, 'LineWidth', 3, 'Grid', 'on', 'MapProjection', 'robinson')
```



```
getm(gca, 'LineWidth')
```

```
ans = 3
```

```
getm(gca, 'MapProjection')
```

```
ans =  
'robinson'
```

Inspect the entire set of map properties at their current settings. Note that the list of properties includes both those particular to `axesm`-based maps and general ones that apply to all MATLAB® axes.

```
getm(gca)
```

```
ans = struct with fields:  
  mapprojection: 'robinson'  
    zone: []  
  angleunits: 'degrees'  
  aspect: 'normal'  
  falsenorthing: 0  
  falseeasting: 0  
  fixedorient: []  
    geoid: [1 0]  
  maplatlimit: [-90 90]  
  maplonlimit: [-180 180]  
  mapparallels: 38  
    nparallels: 0  
    origin: [0 0 0]  
  scalefactor: 1  
    trimlat: [-90 90]  
    trimlon: [-180 180]  
    frame: 'on'  
    ffill: 100  
  fedgecolor: [0.1500 0.1500 0.1500]
```

```

ffacecolor: 'none'
flatlimit: [-90 90]
flinewidth: 3
flonlimit: [-180 180]
  grid: 'on'
galtitude: Inf
  gcolor: [0.1500 0.1500 0.1500]
glinestyle: ':'
glinewidth: 0.5000
mlineexception: []
  mlinefill: 100
  mlinelimit: []
  mlinelocation: 30
  mlinevisible: 'on'
plineexception: []
  plinefill: 100
  plinelimit: []
  plinelocation: 15
  plinevisible: 'on'
  fontangle: 'normal'
  fontcolor: [0.1500 0.1500 0.1500]
  fontname: 'Helvetica'
  fontsize: 10
  fontunits: 'points'
  fontweight: 'normal'
  labelformat: 'compass'
  labelrotation: 'off'
  labelunits: 'degrees'
  meridianlabel: 'off'
mlabellocation: 30
mlabelparallel: 90
  mlabelround: 0
  parallellabel: 'off'
plabellocation: 15
plabelmeridian: -180
  plabelround: 0

```

Similarly, use the `setm` function alone to display the set of properties, their enumerated values, and defaults.

`setm(gca)`

```

AngleUnits          [ {degrees} | radians ]
Aspect              [ {normal} | transverse ]
FalseEasting
FalseNorthing
FixedOrient         FixedOrient is a read-only property
Geoid
MapLatLimit
MapLonLimit
MapParallels
MapProjection
NParallels         NParallels is a read-only property
Origin
ScaleFactor
TrimLat            TrimLat is a read-only property
TrimLon            TrimLon is a read-only property

```

```
Zone
Frame [ on | {off} ]
FEdgeColor
FFaceColor
FFill
FLatLimit
FLineWidth
FLonLimit
Grid [ on | {off} ]
GAltitude
GColor
GLineStyle [ - | -- | -. | {:} ]
GLineWidth
MLineException
MLineFill
MLineLimit
MLineLocation
MLineVisible [ {on} | off ]
PLineException
PLineFill
PLineLimit
PLineLocation
PLineVisible [ {on} | off ]
FontAngle [ {normal} | italic | oblique ]
FontColor
FontName
FontSize
FontUnits [ inches | centimeters | normalized | {points} | pixels ]
FontWeight [ {normal} | bold ]
LabelFormat [ {compass} | signed | none ]
LabelRotation [ on | {off} ]
LabelUnits [ {degrees} | radians ]
MeridianLabel [ on | {off} ]
MLabelLocation
MLabelParallel
MLabelRound
ParallelLabel [ on | {off} ]
PLabelLocation
PLabelMeridian
PLabelRound
```

Many, but not all, property choices and defaults can also be displayed individually.

```
setm(gca, 'FontUnits')
```

```
FontUnits [ inches | centimeters | normalized | {points} | pixels ]
```

```
setm(gca, 'MapProjection')
```

An axes's "MapProjection" property does not have a fixed set of property values.

```
setm(gca, 'Frame')
```

```
Frame [ on | {off} ]
```

```
setm(gca, 'FixedOrient')
```

```
FixedOrient FixedOrient is a read-only property
```

In the same way, `getm` displays the current value of any axes property.

```

getm(gca, 'FontUnits')

ans =
'points'

getm(gca, 'MapProjection')

ans =
'robinson'

getm(gca, 'Frame')

ans =
'on'

getm(gca, 'FixedOrient')

ans =

[]

```

To identify which properties apply to a given map projection, see the reference page for that projection.

Input Arguments

projid — Map projection ID

character vector | string scalar

Map projection ID, specified as a string scalar or character vector. `projid` should match one of the entries in the last column displayed by the `maps` function. You can also find these listed in “Summary and Guide to Projections”.

Note The names of projection files are case sensitive. The projection files included in Mapping Toolbox software use only lowercase letters and Arabic numerals.

Example: 'eqdcylin'

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `axesm('MapProjection', 'pcarree', 'Frame', 'on')` creates a map with a Plate Carree projection, and makes the map frame visible.

Note The properties listed here are only a subset. For a full list, see `axesm-Based Map Properties`.

MapProjection — Map projection

character vector | string scalar

Map projection, specified as a string scalar or character vector. `MapProjection` sets the projection, and hence all transformation calculations, for the map. It must be a member of the recognized projection set, which you can list by typing `getm('MapProjection')` or `maps`. For more information on projections, see the *Mapping Toolbox User's Guide*. Some projections set their own defaults for other properties, such as parallels and trim limits.

MapLatLimit — Geographic latitude limits of the display area

two-element vector

Geographic latitude limits of the display area, specified as a two-element vector of the form `[southern_limit northern_limit]`. This property can be set for many typical projections and geometries, but cannot be used with oblique projections or with `globe`, for example.

When applicable, the `MapLatLimit` property may affect the origin latitude if the `Origin` property is not set explicitly when calling `axesm`. It may also determine the value used for `FLatLimit`.

MapLonLimit — Geographic longitude limits of the display area

two-element vector

Geographic longitude limits of the display area, specified as a two-element vector of the form `[western_limit eastern_limit]`. This property can be set for many typical projections and geometries, but cannot be used with oblique projections or with `globe`, for example.

When applicable, the `MapLonLimit` property may affect the origin longitude if the `Origin` property is not set explicitly when calling `axesm`. It may also determine the value used for `FLonLimit`.

Tips

- In general, after re-opening a saved figure that contains an `axesm`-based map, you should not attempt to modify the projection properties of that map.
- When you create an `axesm`-based map with `axesm` and right click in the axes, a context menu appears. If you do not need the menu or it interferes with your application, you can disable it by resetting the `'ButtonDownFcn'` property of the axes:

```
ax = axesm('mercator');      % Right-clicking brings up context menu.  
set(ax, 'ButtonDownFcn', []) % Context menu has been disabled.
```

- By default, `axesm` does not clip graticules or labels that occur outside the boundaries of the axes. Enable clipping by setting the `'Clipping'` property of these objects.

```
objects = [handlem('grid'); handlem('mlabel'); handlem('plabel')];  
set(objects, 'Clipping', 'on');
```

Version History

Introduced before R2006a

See Also

Properties

`axesm`-Based Map Properties

Functions

`axes` | `gcm` | `getm` | `setm`

Topics

“axesm-Based Maps”

“The Map Frame”

“Map Limit Properties”

“The Map Grid”

axesm-Based Map Properties

Control axesm-based map appearance and behavior

Description

axesm-based map properties control the appearance and behavior of an axesm-based map. By changing property values, you can modify certain aspects of the axesm-based map.

You can create an axesm-based map (previously called map axes) by using the axesm, worldmap, or usamap function.

Properties

Properties That Control the Map Projection

AngleUnits — Angular unit of measure

'degrees' (default) | 'radians'

Angular unit of measure — Controls the units of measure used for angles (including latitudes and longitudes) in the map. All input data are assumed to be in the given units; 'degrees' is the default. For more information on angle units, see “Angle Representations and Angular Units” in the *Mapping Toolbox User's Guide*.

Aspect — Display aspect

'normal' (default) | 'transverse'

Display aspect — Controls the orientation of the base projection of the map. When the aspect is 'normal' (the default), north in the base projection is up. In a transverse aspect, north is to the right. A cylindrical projection of the whole world would look like a *landscape* display under a 'normal' aspect, and like a *portrait* under a 'transverse' aspect. Note that this property is not the same as projection aspect, which is controlled by the Origin property vector discussed later.

FalseEasting — Coordinate shift for projection calculations

0 (default) | numeric scalar

Coordinate shift for projection calculations — Modifies the position of the map within the axes. The projected coordinates are shifted in the x-direction by the amount of FalseEasting. The FalseEasting is in the same units as the projected coordinates, that is, the units of the first element of the Geoid axesm-based map property. False eastings and northings are sometimes used to ensure nonnegative values of the projected coordinates. For example, the Universal Transverse Mercator uses a false easting of 500,000 meters.

FalseNorthing — Coordinate shift for projection calculations

0 (default) | numeric scalar

Coordinate shift for projection calculations — Modifies the position of the map within the axes. The projected coordinates are shifted in the y-direction by the amount of FalseNorthing. The FalseNorthing is in the same units as the projected coordinates, that is, the units of the first element of the Geoid axesm-based map property. False eastings and northings are sometimes used to ensure nonnegative values of the projected coordinates. For example, the Universal Transverse

Mercator uses a false northing of 0 in the northern hemisphere and 10,000,000 meters in the southern.

FixedOrient — Projection-based orientation

[] (default) | numeric scalar

This property is read-only.

Projection-based orientation — This read-only property fixes the orientation of certain projections (such as the Cassini and Wetch). When empty, which is true for most projections, the user can alter the orientation of the projection using the third element of the `Origin` property. When fixed, the fixed orientation is always used.

Geoid — Reference spheroid definition

[1 0] (default) | referenceSphere object | referenceEllipsoid object | oblateSpheroid object | [semimajor_axis eccentricity]

Reference spheroid definition — The spheroid (ellipsoid or sphere) for calculating the projections of any displayed map objects. It can be an `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a two-element vector of the form [semimajor_axis eccentricity]. The default value is an ellipsoid vector representing the unit sphere: [1 0].

MapLatLimit — Geographic latitude limits of the display area

[southern_limit northern_limit]

Geographic latitude limits of the display area — Expressed as a two-element vector of the form [southern_limit northern_limit]. This property can be set for many typical projections and geometries, but cannot be used with oblique projections or with `globe`, for example. When applicable, the `MapLatLimit` property may affect the origin latitude if the `Origin` property is not set explicitly when calling `axesm`. It may also determine the value used for `FLatLimit`.

MapLonLimit — Geographic longitude limits of the display area

[western_limit eastern_limit]

Geographic longitude limits of the display area — Expressed as a two-element vector of the form [western_limit eastern_limit]. This property can be set for many typical projections and geometries, but cannot be used with oblique projections or with `globe`, for example. When applicable, the `MapLonLimit` property may affect the origin longitude if the `Origin` property is not set explicitly when calling `axesm`. It may also determine the value used for `FLonLimit`.

MapParallels — Projection standard parallels

[lat] | [lat1 lat2]

Projection standard parallels — Sets the standard parallels of projection. It can be an empty, one-, or two-element vector, depending upon the projection. The elements are in the same units as the `axesm`-based map `AngleUnits`. Many projections have specific, defining standard parallels. When an `axesm`-based map is based upon one of these projections, the parallels are set to the appropriate defaults. For conic projections, the default standard parallels are set to 15°N and 75°N, which biases the projection toward the northern hemisphere.

For projections with one defined standard parallel, setting the parallels to an empty vector forces recalculation of the parallel to the middle of the map latitude limits. For projections requiring two standard parallels, setting the parallels to an empty vector forces recalculation of the parallels to one-sixth the distance from the latitude limits (e.g., if the map latitude limits correspond to the northern

hemisphere [0 90], the standard parallels for a conic projection are set to [15 75]). For azimuthal projections, the `MapParallels` property always contains an empty vector and cannot be altered.

See the *Mapping Toolbox User's Guide* for more information on standard parallels.

MapProjection — Map projection

character vector

Map projection — Sets the projection, and hence all transformation calculations, for the axesm-based map. It is required in the creation of the axesm-based map. It must be a member of the recognized projection set, which you can list by typing `getm('MapProjection')` or `maps`. For more information on projections, see the *Mapping Toolbox User's Guide*. Some projections set their own defaults for other properties, such as parallels and trim limits.

Origin — Origin and orientation for projection calculations

[latitude longitude orientation]

Origin and orientation for projection calculations — Sets the map origin for all projection calculations. The latitude, longitude, and orientation should be in the axesm-based map `AngleUnits`. Latitude and longitude refer to the coordinates of the map origin; orientation refers to an angle of skewness or rotation about the axis running through the origin point and the center of the earth. The default origin is 0° latitude and a longitude centered between the map longitude limits. If a scalar is entered, it is assumed to refer to the longitude; if a two-element vector is entered, the default orientation is 0°, a normal projection. If an empty origin vector is entered, the origin is centered on the map longitude limits. For more information on the origin, see the *Mapping Toolbox User's Guide*.

Parallels — Number of standard parallels

0 | 1 | 2

This property is read-only.

Number of standard parallels — This read-only property contains the number of standard parallels associated with the projection. See the *Mapping Toolbox User's Guide* for more information on standard parallels.

ScaleFactor — Scale factor for projection calculations

1 (default) | scalar

Scale factor for projection calculations — Modifies the size of the map in projected coordinates. The geographic coordinates are transformed to Cartesian coordinates by the map projection equations and multiplied by the scale factor. Scale factors are sometimes used to minimize the scale distortion in a map projection. For example, the Universal Transverse Mercator uses a scale factor of 0.996 to shift the line of zero scale distortion to two lines on either side of the central meridian.

Zone — Zone for certain projections

[] or 31N (default) | ZoneSpec

Zone for certain projections — Specifies the zone for certain projections. A zone is a region on the globe that has a special set of projection parameters. In the Universal Transverse Mercator Projection, the world is divided into quadrangles that are generally 6 degrees wide and 8 degrees tall. The number in the zone designation refers to the longitude range, while the letter refers to the latitude range. Most projections use the same parameters for the entire globe, and do not require a zone.

Properties That Control the Frame

Frame — Frame visibility

'off' (default) | 'on'

Frame visibility — Controls the visibility of the display frame box. When the frame is 'off' (the default), the frame is not displayed. When the frame is 'on', an enclosing frame is visible. The frame is a patch that is plotted as the lowest layer of displayed map objects. Regardless of its display status, the frame always operates in terms of trimming map data.

FFill — Frame plotting precision

100 (default) | scalar plotting point density

Frame plotting precision — Sets the number of points to be used in plotting the frame for display. The default value is 100, which for a rectangular frame results in a plot with 100 points for each side, or a total of 400 points. The number of points required for a reasonable display varies with the projection. Cylindrical projections such as the Miller require very few. Projections resulting in more complex frames, such as the Werner, look better with higher densities. The default value is generally sufficient.

FEdgeColor — Color of displayed frame edge









[0 0 0] (default) | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...

Color of displayed frame edge — Specifies the color used for the displayed frame. You can specify an RGB triplet, a hexadecimal color code, a color name, or a short name. By default, the frame edge is displayed in black.

For a custom color, specify an RGB triplet or a hexadecimal color code.





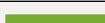


- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

FFaceColor — Color of displayed frame face








'none' (default) | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...

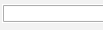
Color of displayed frame face — Specifies the color used for the displayed frame face. You can specify an RGB triplet, a hexadecimal color code, a color name, or a short name. The default, 'none', means no face color is filled in.

For a custom color, specify an RGB triplet or a hexadecimal color code.

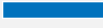
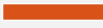

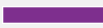
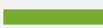
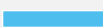

- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

FLatLimit — Latitude limits of map frame relative to projection origin

[southern_limit northern_limit]

Latitude limits of map frame relative to projection origin — The map frame encloses the area in which data and graticule lines are plotted and beyond which they are trimmed. For non-oblique and non-azimuthal projections, which have quadrangular frames, this property controls the north-south extent of the frame. If a projection is made oblique by the inclusion of a non-zero rotation angle (the third element of the `Origin` vector), `FLatLimit` still applies, but in the rotated latitude-longitude system rather than in the geographic system. In the case of azimuthal projections, which have circular frames, `FLatLimit` takes the special form `[-Inf radius]` where `radius` is the spherical distance (in degrees or radians, depending on the `AngleUnits` property of the projection) from the projection origin to the edge of the frame.

Note In most common situations, including non-oblique cylindrical and conic projections and polar azimuthal projections, there is no need to set `FLatLimit`; use `MapLatLimit` instead.

FLineWidth — Frame edge line width

2 (default) | scalar

Frame edge line width — Sets the line width of the displayed frame edge. The value is a scalar representing points, which is 2 by default.

FLonLimit — Longitude limits of map frame relative to projection origin

[western_limit eastern_limit]

Longitude limits of map frame relative to projection origin — The map frame encloses the area in which data and graticule lines are plotted and beyond which they are trimmed. For non-oblique and non-azimuthal projections, which have quadrangular frames, this property controls the east-west extent of the frame. If a projection is made oblique by the inclusion of a non-zero rotation angle (the third element of the `Origin` vector), `FLonLimit` still applies, but in the rotated latitude-longitude

system rather than in the geographic system. The `FLonLimit` property is ignored for azimuthal projections.

Note In most common situations, including non-oblique cylindrical and conic projections, there is no need to set `FLonLimit`; use `MapLonLimit` instead.

TrimLat — Bounds on FFlatLimit

`[southern_limit northern_limit]`

This property is read-only.

Bounds on FFlatLimit — This read-only property sets bounds on the values that `axesm` and `setm` will accept for the `MapFlatLimit` and `FFlatLimit` properties, which is necessary because some map projections cannot display the entire globe without extending to infinity. For example, `TrimLat` is `[-90 90]` degrees for most cylindrical projections and `[-86 86]` degrees for the Mercator projection because the north-south scale becomes infinite as one approaches either pole.

TrimLon — Bounds on FLonLimit

`[western_limit eastern_limit]`

This property is read-only.

Bounds on FLonLimit — This read-only property sets bounds on the values that `axesm` and `setm` will accept for the `MapLonLimit` and `FLonLimit` properties, which is necessary because some map projections cannot display the entire globe without extending to infinity. For example, `TrimLon` is `[-135 135]` degrees for most conic projections.

Properties That Control the Grid

Grid — Grid visibility

`'off'` (default) | `'on'`

Grid visibility — Controls the visibility of the display grid. When the grid is `'off'` (the default), the grid is not displayed. When the grid is `'on'`, meridians and parallels are visible. The grid is plotted as a set of line objects.

GAltitude — Grid z-axis setting

`Inf` (default) | scalar

Grid z-axis setting — Sets the *z*-axis location for the grid when displayed. Its default value is infinity, which is displayed above all other map objects. However, you can set this to some other value for stacking objects above the grid, if desired.

GColor — Color of the displayed grid

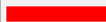




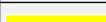

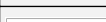
`[0 0 0]` (default) | RGB triplet | hexadecimal color code | `'r'` | `'g'` | `'b'` | ...

Color of the displayed grid — Specifies the color used for the displayed grid. You can specify an RGB triplet, a hexadecimal color code, a color name, or a short name. By default, the map grid is displayed in black.








For a custom color, specify an RGB triplet or a hexadecimal color code.

- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range $[0, 1]$, for example, $[0.4 \ 0.6 \ 0.7]$.
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

GLineStyle — Grid line style

: (default) | LineStyle

Grid line style — Determines the style of line used when the grid is displayed. You can specify any line style supported by the MATLAB `line` function. The default line style is a dotted line (that is, ':' :').

GLineWidth — Grid line width

0.5 (default) | scalar

Grid line width — Sets the line width of the displayed grid. The value is a scalar representing points, which is 0.5 by default.

MLineException — Exceptions to grid meridian limits

[] (default) | vector

Exceptions to grid meridian limits — Allows specific meridians of the displayed grid to extend beyond the grid meridian limits to the poles. The value must be a vector of longitudes in the appropriate angle units. For longitudes so specified, grid lines extend from pole to pole regardless of the existence of any grid meridian limits. This vector is empty by default.

MLineFill — Grid meridian plotting precision

100 (default) | scalar plotting point density

Grid meridian plotting precision — Sets the number of points to be used in plotting the grid meridians. The default value is 100 points. The number of points required for a reasonable display varies with the projection. Cylindrical projections such as the Miller require very few. Projections resulting in more complex shapes, such as the Werner, look better with higher densities. The default value is generally sufficient.

MLineLimit — Grid meridian limits

[] (default) | [north south] | [south north]

Grid meridian limits — Establishes latitudes beyond which displayed grid meridians do not extend. By default, this property is empty, so the meridians extend to the poles. There are two exceptions to the meridian limits. No meridian extends beyond the map latitude limits, and exceptions to the meridian limits for selected meridians are allowed (see above).

MLineLocation — Grid meridian interval or specific locations

30 (default) | scalar | vector

Grid meridian interval or specific locations — Establishes the interval between displayed grid meridians. When a scalar interval is entered in the axesm-based map MLineLocation, meridians are displayed, starting at 0° longitude and repeating every interval in both directions, which by default is 30°. Alternatively, you can enter a vector of longitudes, in which case a meridian is displayed for each element of the vector.

PLineException — Exceptions to grid parallel limits

[] (default) | vector

Exceptions to grid parallel limits — Allows specific parallels of the displayed grid to extend beyond the grid parallel limits to the International Date Line. The value must be a vector of latitudes in the appropriate angle units. For latitudes so specified, grid lines extend from the western to the eastern map limit, regardless of the existence of any grid parallel limits. This vector is empty by default.

PLineFill — Grid parallel plotting precision

100 (default) | scalar plotting point density

Grid parallel plotting precision — Sets the number of points to be used in plotting the grid parallels. The default value is 100. The number of points required for a reasonable display varies with the projection. Cylindrical projections such as the Miller require very few. Projections resulting in more complex shapes, such as the Bonne, look better with higher densities. The default value is generally sufficient.

PLineLimit — Grid parallel limits

[] (default) | [east west] | [west east]

Grid parallel limits — Establishes longitudes beyond which displayed grid parallels do not extend. By default, this property is empty, so the parallels extend to the date line. There are two exceptions to the parallel limits. No parallel extends beyond the map longitude limits, and exceptions to the parallel limits for selected parallels are allowed (see above).

PLineLocation — Grid parallel interval or specific locations

15 (default) | scalar | vector

Grid parallel interval or specific locations — Establishes the interval between displayed grid parallels. When a scalar interval is entered in the axesm-based map PLineLocation, parallels are displayed, starting at 0° latitude and repeating every interval in both directions, which by default is 15°. Alternatively, you can enter a vector of latitudes, in which case a parallel is displayed for each element of the vector.

Properties That Control Grid Labeling

FontAngle — Select italic or normal font for all grid labels

'normal' (default) | 'italic' | 'oblique'

Select italic or normal font for all grid labels — Selects the character slant for all displayed grid labels. 'normal' specifies nonitalic font. 'italic' and 'oblique' specify italic font.

FontColor — Text color for all grid labels

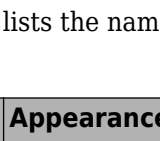
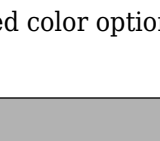
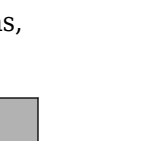

'black' (default) | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...

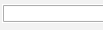
Text color for all grid labels — Sets the color of all displayed grid labels. You can specify an RGB triplet, a hexadecimal color code, a color name, or a short name.

For a custom color, specify an RGB triplet or a hexadecimal color code.

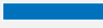
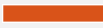





- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

FontName — Font family name for all grid labels

'helvetica' (default) | 'courier' | 'symbol' | 'times'

Font family name for all grid labels — Sets the font for all displayed grid labels. To display and print properly, FontName must be a font that your system supports.

FontSize — Font size

0 (default) | scalar

Font size — An integer specifying the font size to use for all displayed grid labels, in units specified by the FontUnits property. The default point size is 9.

FontUnits — Units used to interpret the FontSize property

'points' (default) | 'normalized' | 'inches' | 'centimeters' | 'pixels'

Units used to interpret the FontSize property — When set to normalized, the toolbox interprets the value of FontSize as a fraction of the height of the axes. For example, a normalized FontSize of 0.1 sets the text characters to a font whose height is one-tenth of the axes' height. The default units ('points') are equal to 1/72 of an inch.

FontWeight — Select bold or normal font

'normal' (default) | 'bold'

Select bold or normal font — The character weight for all displayed grid labels.

LabelFormat — Labeling format for grid

'compass' (default) | 'signed' | 'none'

Labeling format for grid — Specifies the format of the grid labels. If 'compass' is employed (the default), meridian labels are suffixed with an "E" for east and a "W" for west, and parallel labels are suffixed with an "N" for north and an "S" for south. If 'signed' is used, meridian labels are prefixed with a "+" for east and a "-" for west, and parallel labels are suffixed with a "+" for north and a "-"

for south. If 'none' is selected, straight latitude and longitude numerical values are employed, so western meridian labels and southern parallel labels will have a "-", but no symbol precedes eastern and northern (positive) labels.

LabelRotation — Label Rotation

'off' (default) | 'on'

Label rotation — Determines whether the meridian and parallel labels are displayed without rotation (the default) or rotated to align to the graticule. This option is not available for the Globe display.

LabelUnits — Specify units and formatting for grid labels

'degrees' (default) | 'dm' | 'dms' | 'radians'

Specify units and formatting for grid labels — The display of meridian and parallel labels is controlled by the axesm-based map LabelUnits property, as described in the following table.

LabelUnits value	Label format
'degrees'	decimal degrees
'dm'	degrees/decimal minutes
'dms'	degrees/minutes/decimal seconds
'radians'	decimal radians

LabelUnits does not have a default of its own; instead it defaults to the value of AngleUnits at the time the axesm-based map is constructed, which itself defaults to degrees. Although you can specify 'dm' and 'dms' for LabelUnits, these values are not accepted when setting AngleUnits.

MeridianLabel — Toggle display of meridian labels

'off' (default) | 'on'

Toggle display of meridian labels — Specifies whether the meridian labels are visible or not.

MLabelLocation — Specify meridians for labeling

scalar | vector

Specify meridians for labeling — Meridian labels need not coincide with the displayed meridian lines. Labels are displayed at intervals if a scalar in the axesm-based map MLabelLocation is entered, starting at the prime meridian and repeating at every interval in both directions. If a vector of longitudes is entered, labels are displayed at those meridians. The default locations coincide with the displayed meridian lines, as specified in the MLineLocation property.

MLabelParallel — Specify parallel for meridian label placement

'north' (default) | 'south' | 'equator' | scalar

Specify parallel for meridian label placement — Specifies the latitude location of the displayed meridian labels. If a scalar latitude is specified, all meridian labels are displayed at that latitude. If 'north' is specified, the maximum of the MapLatLimit is used; if 'south' is specified, the minimum of the MapLatLimit is used. If 'equator' is specified, a latitude of 0° is used.

MLabelRound — Specify significant digits for meridian labels

0 (default) | integer scalar

Specify significant digits for meridian labels — Specifies to which power of ten the displayed labels are rounded. For example, if MLabelRound is -1, labels are displayed down to the tenths. The default

value of `MLabelRound` is 0; that is, displayed labels have no decimal places, being rounded to the ones column (10^0).

ParallelLabel — Toggle display of parallel labels

'off' (default) | 'on'

Toggle display of parallel labels — Specifies whether the parallel labels are visible or not.

PLabelLocation — Specify parallels for labeling

scalar | vector

Specify parallels for labeling — Parallel labels need not coincide with the displayed parallel lines. Labels are displayed at intervals if a scalar in the axesm-based map `PLabelLocation` is entered, starting at the equator and repeating at every interval in both directions. If a vector of latitudes is entered, labels are displayed at those parallels. The default locations coincide with the displayed parallel lines, as specified in the `PLineLocation` property.

PLabelMeridian — Specify meridian for parallel label placement

'west' (default) | 'east' | 'prime' | scalar

Specify meridian for parallel label placement — Specifies the longitude location of the displayed parallel labels. If a longitude is specified, all parallel labels are displayed at that longitude. If 'east' is specified, the maximum of the `MapLonLimit` is used; if 'west' is specified, the minimum of the `MapLonLimit` is used. If 'prime' is specified, a longitude of 0° is used.

PLabelRound — Specify significant digits for parallel labels

0 (default) | integer scalar

Specify significant digits for parallel labels — Specifies to which power of ten the displayed labels are rounded. For example, if `PLabelRound` is -1, labels are displayed down to the tenths. The default value of `PLabelRound` is 0; that is, displayed labels have no decimal places, being rounded to the ones column (10^0).

Version History

Introduced before R2006a

See Also

axesm | axes | gcm | getm | setm

Topics

“axesm-Based Maps”

“The Map Frame”

“Map Limit Properties”

“The Map Grid”

axesscale

Resize axes for equivalent scale

Syntax

```
axesscale
axesscale(hbase)
axesscale(hbase,hother)
```

Description

`axesscale` resizes all axes in the current figure to have the same scale as the current axes (`gca`). In this context, scale means the relationship between axes x - and y -coordinates and figure and paper coordinates. When `axesscale` is used, a unit of length in x and y is printed and displayed at the same size in all the affected axes. The `XLimMode` and `YLimMode` of the axes are set to 'manual' to prevent autoscaling from changing the scale.

`axesscale(hbase)` uses the axes `hbase` as the reference axes, and rescales the other axes in the current figure.

`axesscale(hbase,hother)` uses the axes `hbase` as the base axes, and rescales only the axes in `hother`.

Examples

Display Multiple Regions with a Common Scale

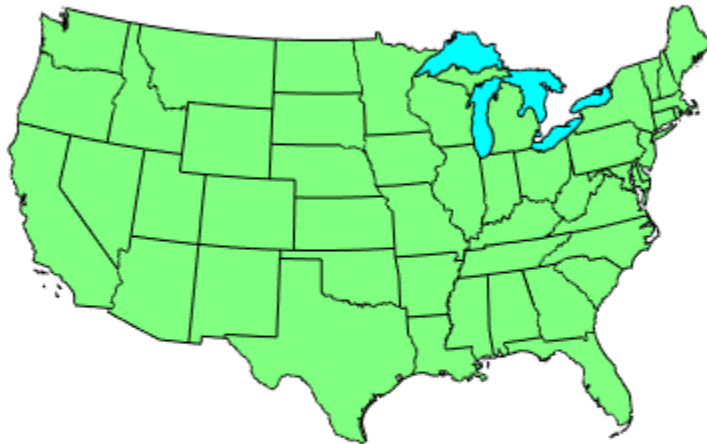
Display the conterminous United States, Alaska, and Hawaii in separate axes in the same figure, with a common scale.

Read state names and coordinates. Extract Alaska and Hawaii.

```
states = readgeotable("usastatehi.shp");
alaska = states(states.Name == "Alaska",:);
hawaii = states(states.Name == "Hawaii",:);
```

Create a figure for the conterminous states.

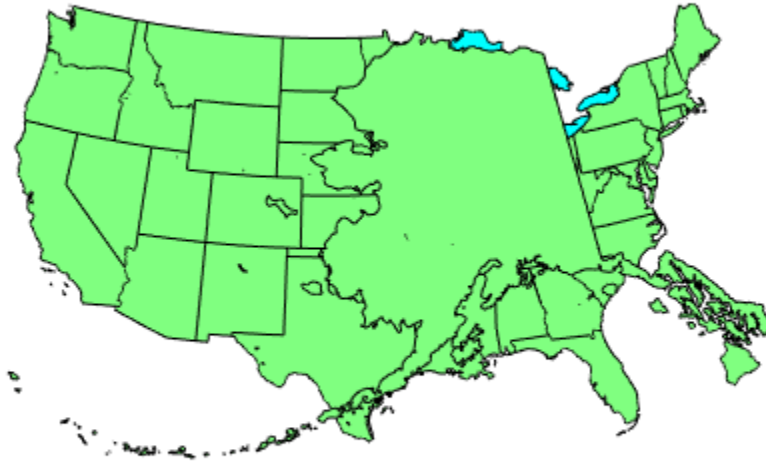
```
f = figure;
hconus = usamap("conus");
geoshow(states,"FaceColor",[0.5 1 0.5]);
load conus gtlakelat gtlakelon
geoshow(gtlakelat,gtlakelon,...
        "DisplayType","polygon","FaceColor","cyan")
framem off
gridm off
mlabel off
plabel off
```



Display Alaska and Hawaii on different axes. For now, the axes overlap.

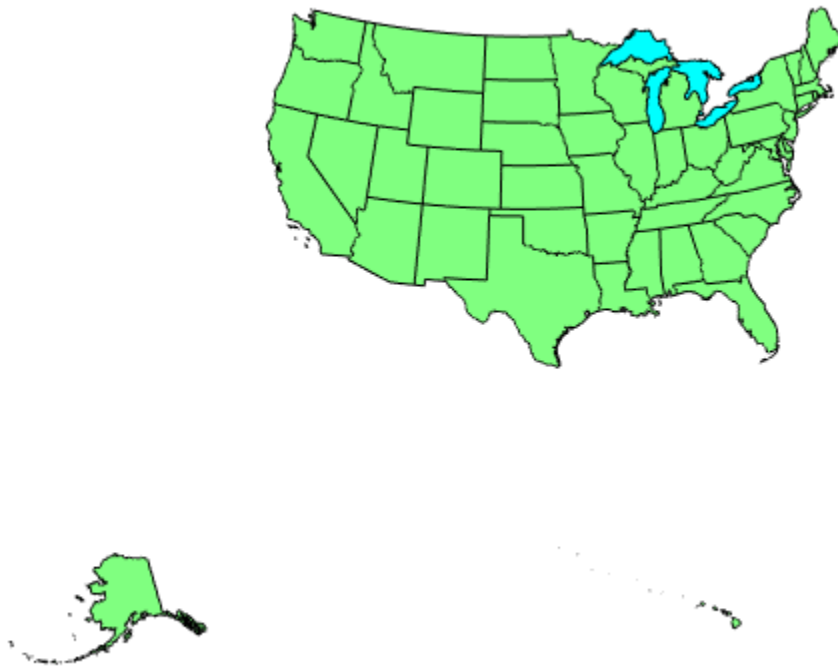
```
halaska = axes("Parent",f);  
usamap("alaska")  
geoshow(alaska,"FaceColor",[0.5 1 0.5]);  
framem off  
gridm off  
mlabel off  
plabel off
```

```
hhawaii = axes("Parent",f);  
usamap("hawaii")  
geoshow(hawaii,"FaceColor",[0.5 1 0.5]);  
framem off  
gridm off  
mlabel off  
plabel off
```

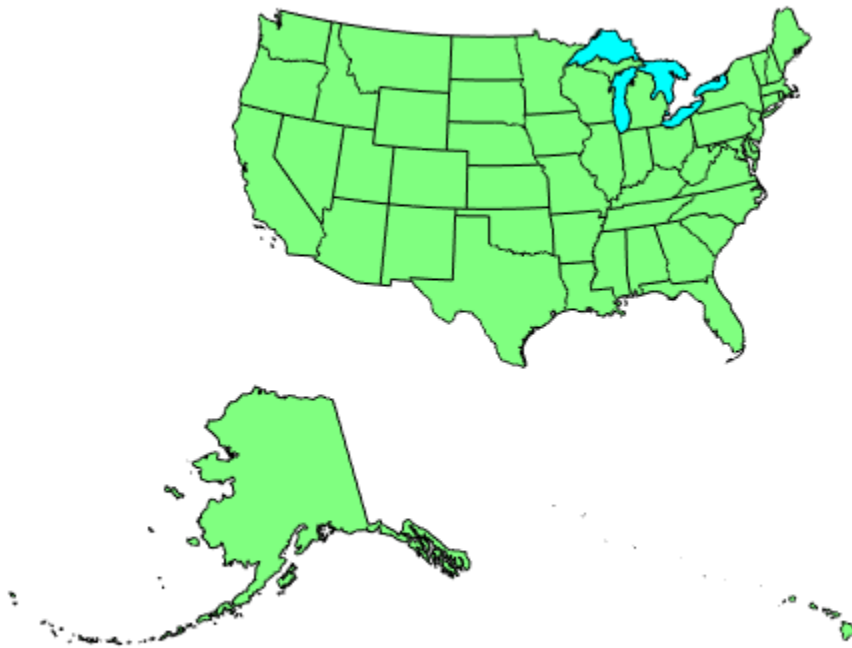



Arrange the axes so they do not overlap. However, this changes the scale of the axes.

```
set(hconus, "Position", [0.1 0.35 0.85 0.6])  
set(halaska, "Position", [0.02 0.08 0.2 0.2])  
set(hhawaii, "Position", [0.5 0.1 0.2 0.2])
```



Resize the Alaska and Hawaii axes based on the size of the conterminous United States.
`axesscale(hconus)`



Limitations

The equivalence of scales holds only as long as no commands are issued that can change the scale of one of the axes. For example, changing the units of the ellipsoid or the scale factor in one of the axes would change the scale.

Tips

To ensure the same map scale between axes, use the same ellipsoid and scale factors.

Version History

Introduced before R2006a

See Also

`paperscale`

azimuth

Azimuth between points on sphere or ellipsoid

Syntax

```
az = azimuth(lat1,lon1,lat2,lon2)
az = azimuth(lat1,lon1,lat2,lon2,ellipsoid)
az = azimuth( ____,units)
az = azimuth(method, ____,)
```

Description

`az = azimuth(lat1,lon1,lat2,lon2)` calculates the great circle azimuth on page 1-129 from the point with geographic coordinates `lat1` and `lon1` to the point with geographic coordinates `lat2` and `lon2`. The function measures azimuths clockwise from north. This syntax references the coordinates to a sphere and returns `az` in degrees.

`az = azimuth(lat1,lon1,lat2,lon2,ellipsoid)` specifies a reference ellipsoid for the coordinates.

`az = azimuth(____,units)` specifies the angle units for the coordinates and azimuth, in addition to any combination of input arguments from the previous syntaxes.

`az = azimuth(method, ____,)`, where `method` is "rh", calculates the rhumb line azimuth between the points. The default for `method` is "gc", which calculates the great circle azimuth (for a sphere) or the geodesic azimuth (for an ellipsoid).

Examples

Calculate Azimuth Between Two Points

Find the azimuth between two points on the same parallel. By default, the `azimuth` function references the points to the unit sphere and calculates the great circle azimuth.

```
az1 = azimuth(10,10,10,40)
```

```
az1 = 87.3360
```

Find the rhumb line azimuth between the same two points.

```
az2 = azimuth("rh",10,10,10,40)
```

```
az2 = 90
```

Calculate Azimuth Between Points on Ellipsoid

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of kilometers.

```
wgs84 = wgs84Ellipsoid("km");
```

Calculate the azimuth between Munich and Madrid. Reference the coordinates to the ellipsoid.

```
az = azimuth(48.155,11.4716,41.6427,-5.1327,wgs84)
```

```
az = 247.1825
```

Input Arguments

lat1 — Latitude of start point

scalar | array

Latitude of the start point, specified as a scalar or array.

You can specify `lat1`, `lon1`, `lat2`, and `lon2` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

lon1 — Longitude of start point

scalar | array

Longitude of the start point, specified as a scalar or array.

You can specify `lat1`, `lon1`, `lat2`, and `lon2` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

lat2 — Latitude of end point

scalar | array

Latitude of the end point, specified as a scalar or array.

You can specify `lat1`, `lon1`, `lat2`, and `lon2` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

lon2 — Longitude of end point

scalar | array

Longitude of the end point, specified as a scalar or array.

You can specify `lat1`, `lon1`, `lat2`, and `lon2` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

ellipsoid — Reference ellipsoid

[1 0] (default) | referenceSphere object | referenceEllipsoid object | oblateSpheroid object | two-element numeric vector

Reference ellipsoid, specified as a referenceSphere object, a referenceEllipsoid object, an oblateSpheroid object, or a two-element vector of the form [semimajor_axis eccentricity], where semimajor_axis is the length of the semimajor axis and eccentricity is the eccentricity. The values semimajor_axis and eccentricity must be of data type double.

The default value of [1 0] represents the unit sphere.

units — Angle unit

"degrees" (default) | "radians"

Angle unit, specified as one of these options:

- "degrees" — Degrees
- "radians" — Radians

Data Types: char | string

method — Type of curve connecting start point and end point

"gc" (default) | "rh"

Type of curve connecting the start point and end point, specified as one of these options:

- "gc" — For spheres, calculate the azimuth using the starting point of the great circle path that connects the points. For ellipsoids, calculate the azimuth using the starting point of the geodesic that connects the points.
- "rh" — Calculate the azimuth using the rhumb line that connects the points.

For more information about rhumb lines and great circles, see “Comparison of Rhumb Lines and Great Circles”.

Data Types: char | string

Output Arguments**az — Azimuth**

scalar | array

Azimuth, returned as a scalar or an array that matches the size of the largest latitude or longitude input.

- When units is "degrees", the azimuth is in the range in the range [0, 360) degrees.
- When units is "radians", the azimuth is in the range [0, 2 π) radians.

This table shows the azimuths associated with cardinal and intercardinal compass directions.

Compass Direction	Azimuth
North	0° or 360°
Northeast	45°

Compass Direction	Azimuth
East	90°
Southeast	135°
South	180°
Southwest	225°
West	270°
Northwest	315°

More About

Azimuth

An azimuth is the angle at which a smooth curve crosses a meridian, taken clockwise from north. For example, the north pole has an azimuth of 0° from every other point on the globe.

Algorithms

Azimuths over Long Geodesics

The accuracy of geodesic azimuth calculations decreases as the distance between the points increases. Additionally, the calculations can break down when the points are nearly antipodal or close to the equator.

When you specify a reference ellipsoid and two points that are both close to the equator and nearly antipodal, the azimuth function issues a warning and returns a value of NaN.

Eccentricity

Geodesic azimuths on an ellipsoid are valid only when the ellipsoid has a small eccentricity typical of Earth, such as 0.08 or less.

Alternative Functionality

Calculate both the distance and the azimuth between two points by using the `distance` function.

Version History

Introduced before R2006a

See Also

Functions

`distance` | `reckon`

Topics

“Comparison of Rhumb Lines and Great Circles”

boundImageSize

Bound size of raster map

Syntax

```
mapBound = boundImageSize(mapRequest, imageLength)
```

Description

`mapBound = boundImageSize(mapRequest, imageLength)` sets the bounds of the raster map `mapRequest` based on `imageLength`, the length in pixels for the row (`ImageHeight`) or column (`ImageWidth`) dimension.

Examples

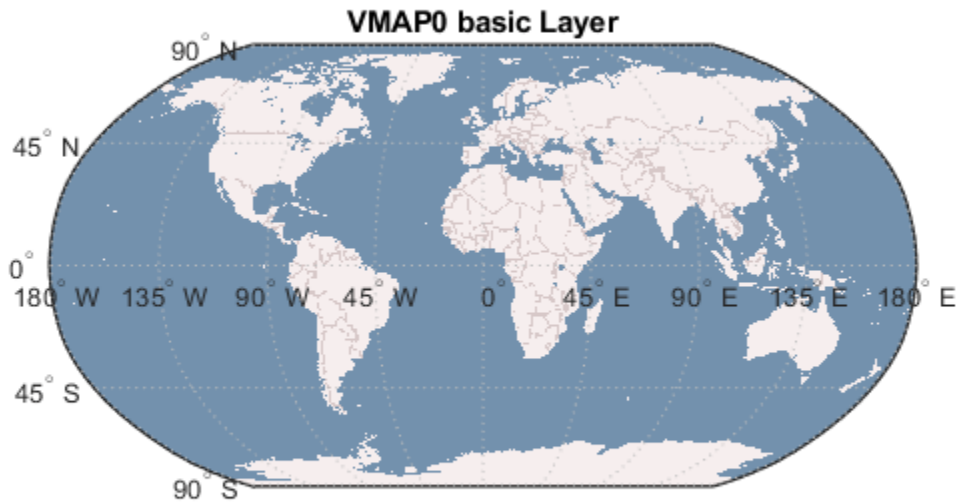
Read and Display VMAP0 Basic Layer for Entire Globe

Read the VMAP0 basic layer for the entire globe.

```
vmap0 = wmsfind('vmap0.tiles', 'SearchField', 'serverurl');  
vmap0 = wmsupdate(vmap0);  
layer = refine(vmap0, 'basic');  
request = WMSMapRequest(layer);  
request.Transparent = true;  
imageLength = 720;  
request = boundImageSize(request, imageLength);  
globalImage = getMap(request.Server, request.RequestURL);
```

Display the map. The rendered map has a spatial resolution of 0.5 degrees per cell and an image size of 360-by-720 pixels.

```
figure  
worldmap('world')  
geoshow(globalImage, request.RasterReference);  
title(['VMAP0 ' layer.LayerTitle ' Layer'])
```

The data used in this example is from Metacarta.

Read and Display Multiple Layers Centered Around London

Read multiple layers centered around London.

```

vmap0 = wmsfind('vmap0.tiles','SearchField','serverurl');
vmap0 = wmsupdate(vmap0);
layers = [ refine(vmap0, 'rail'); refine(vmap0, 'river'); ...
           refine(vmap0, 'priroad'); refine(vmap0, 'secroad'); ...
           refine(vmap0, 'ctylabel'); refine(vmap0, 'basic')];
request = WMSMapRequest(layers);

cities = readgeotable('worldcities.shp');
row = cities.Name == 'London';
london = cities(row,:);

extent = [-.25 .25];
request.Latlim = london.Shape.Latitude + extent;
request.Lonlim = london.Shape.Longitude + extent;

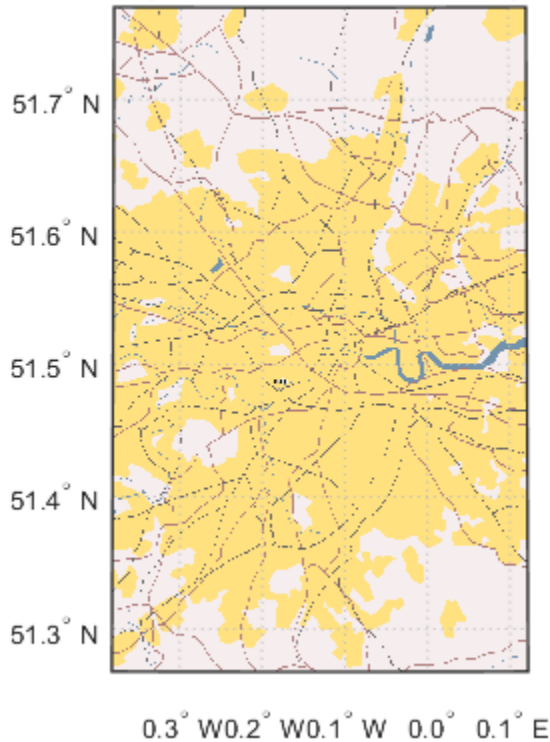
request.Transparent = true;
imageLength = 1024;
request = boundImageSize(request,imageLength);
londonImage = getMap(request.Server,request.RequestURL);

```

Display the map. The rendered map has a spatial extent of 0.5 degrees and an image size of 1024-by-1024 pixels.

```
figure
worldmap(londonImage, request.RasterReference)
geoshow(londonImage, request.RasterReference)
title({'Region Surrounding London, England', ...
      ['with Primary and Secondary Roads, ', ...
       'Rivers, Rails, City Label, and Basic Layers']})
```

**Region Surrounding London, England
with Primary and Secondary Roads, Rivers, Rails, City Label, and Basic Layers**



The data used in this example is from Metacarta.

Input Arguments

mapRequest — Original Web map service map

WMSMapRequest object

Original Web map service map, specified as a WMSMapRequest object.

imageLength — Row or column length of input WMS map

positive scalar

Row or column length of input WMS map, specified as a positive scalar. `imageLength` indicates the length in pixels for the row (`ImageHeight`) or column (`ImageWidth`) dimension.

Example: 720

Data Types: double

Output Arguments

mapBound — Bound Web map service map

WMSMapRequest object

Bound Web map service map, returned as a WMSMapRequest object.

Algorithms

The boundImageSize function calculates the row or column dimension length by using the aspect ratio of the LatLim and LonLim properties or the aspect ratio of the XLim and YLim properties of , if they are set.

boundImageSize measures image dimensions in geographic or map coordinates. The function sets the longest image dimension to imageLength, and the shortest to the nearest integer value that preserves the aspect ratio, without changing the coordinate limits. The maximum value of the MaximumHeight and MaximumWidth properties becomes the maximum value of imageLength.

Version History

Introduced in R2009b

bufferm

Buffer zones for latitude-longitude polygons

Syntax

```
[latb,lonb] = bufferm(lat,lon,bufwidth)
[latb,lonb] = bufferm(lat,lon,bufwidth,direction)
[latb,lonb] = bufferm(lat,lon,bufwidth,direction,npts)
```

Description

`[latb,lonb] = bufferm(lat,lon,bufwidth)` computes the buffer zone around a line or polygon. If the vectors `lat` and `lon`, in units of degrees, define a line, then `latb` and `lonb` define a polygon that contains all the points that fall within a certain distance, `bufwidth`, of the line. `bufwidth` is a scalar specified in degrees of arc along the surface. If the vectors `lat` and `lon` define a polygon, then `latb` and `lonb` define a region that contains all the points exterior to the polygon that fall within `bufwidth` of the polygon.

`[latb,lonb] = bufferm(lat,lon,bufwidth,direction)` where `direction` specifies whether the buffer zone is inside ('in') or outside ('out') of the polygon. A third option, 'outPlusInterior', returns the union of an exterior buffer (as would be computed using 'out') with the interior of the polygon. If you do not supply a `direction` value, `bufferm` uses 'out' as the default and returns a buffer zone outside the polygon. If you supply 'in' as the `direction` value, `bufferm` returns a buffer zone inside the polygon. If you are finding the buffer zone around a line, 'out' is the only valid option.

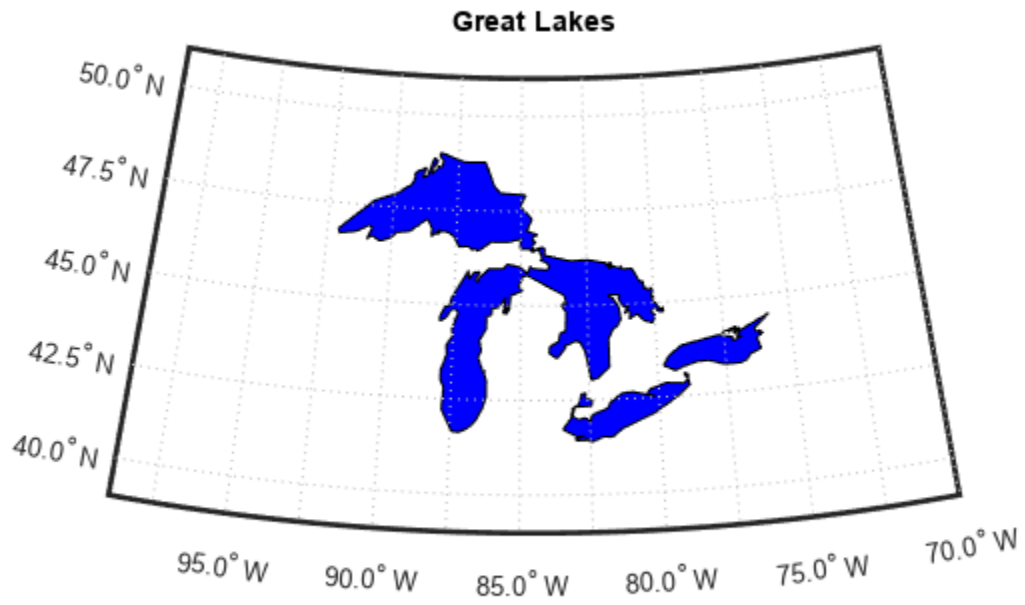
`[latb,lonb] = bufferm(lat,lon,bufwidth,direction,npts)` controls the number of points used to construct circles about the vertices of the polygon. A larger number of points produces smoother buffers, but requires more time. If `npts` is omitted, 13 points per circle are used.

Examples

Display Buffer Zones Inside and Outside the Great Lakes

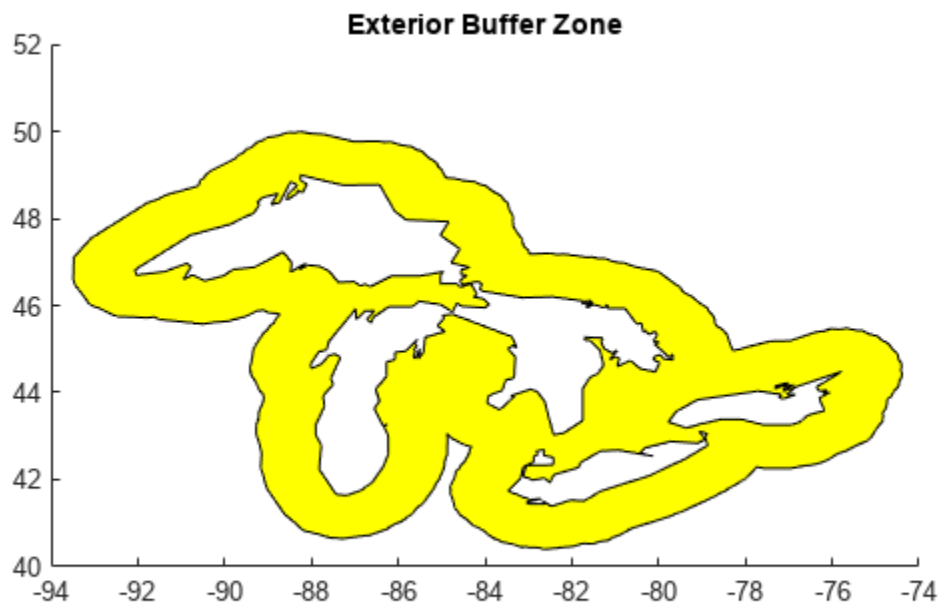
Display a simplified version of the five polygons that represent the Great Lakes.

```
load conus
tol = 0.05;
[latr,lonr] = reducem(gtlakelat, gtlakelon, tol);
figure('Color','w')
ax = usamap({'MN','NY'});
setm(ax,'MLabelLocation',5)
geoshow(latr,lonr,'DisplayType','polygon',...
        'FaceColor','blue')
title('Great Lakes')
```



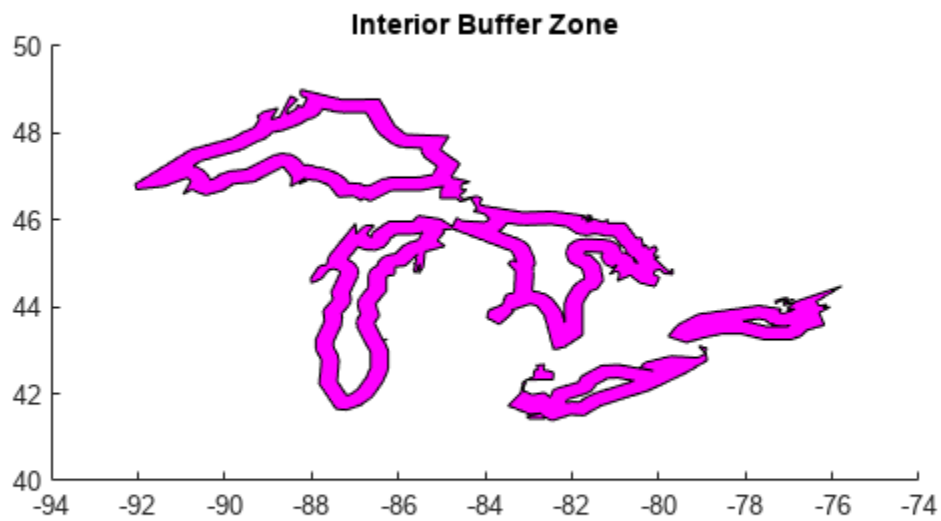
Set the buffer width and display a buffer zone outside the lakes.

```
figure;  
bufwidth = 1;  
[latb, lonb] = bufferm(latr, lonr, bufwidth);  
geoshow(latb, lonb, 'DisplayType', 'polygon', ...  
        'FaceColor', 'yellow')  
title('Exterior Buffer Zone')
```



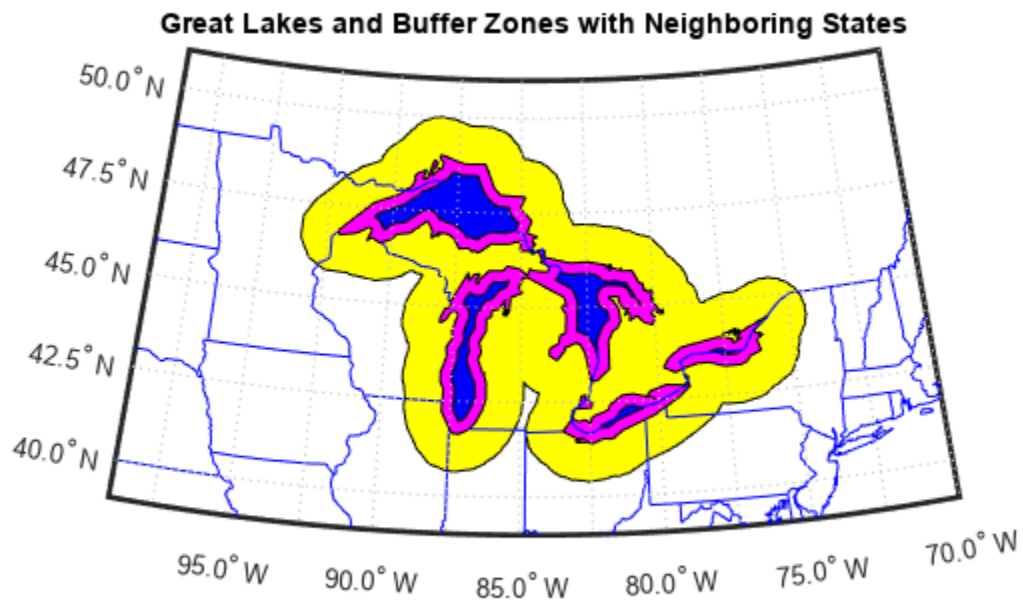
Display a buffer zone inside the polygon.

```
figure;  
[lati, loni] = bufferm(latr, lonr, 0.3*bufwidth, 'in');  
geoshow(lati, loni, 'DisplayType', 'polygon', ...  
        'FaceColor', 'magenta')  
title('Interior Buffer Zone')
```



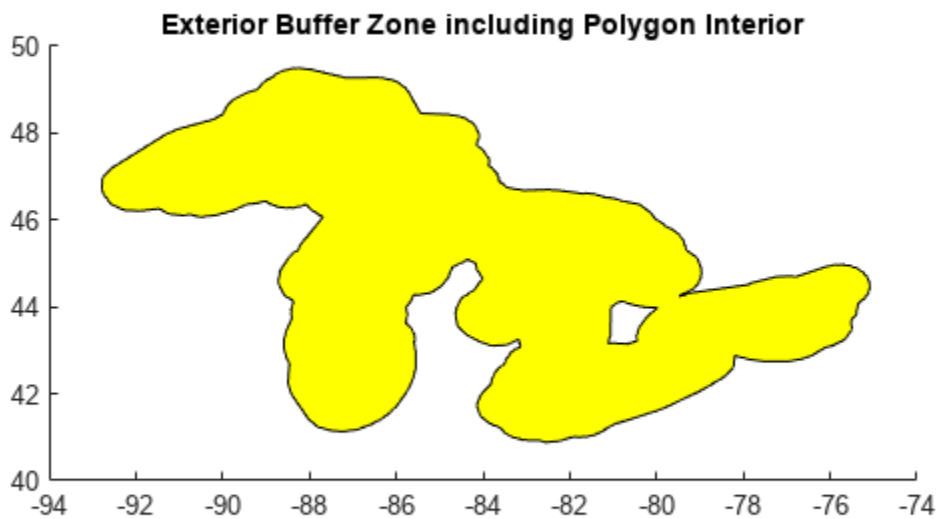
Display the Great Lakes with interior and exterior buffer zones on a backdrop of neighboring states.

```
figure('Color','w')
ax = usamap({'MN','NY'});
setm(ax,'MLabelLocation',5)
geoshow(latb, lonb, 'DisplayType', 'polygon', 'FaceColor', 'yellow')
geoshow(latr, lonr, 'DisplayType', 'polygon', 'FaceColor', 'blue')
geoshow(lati, loni, 'DisplayType', 'polygon', 'FaceColor', 'magenta')
geoshow(uslat, uslon)
geoshow(statelat, statelon)
title('Great Lakes and Buffer Zones with Neighboring States')
```



Use the 'outPlusInterior' option.

```
bufWidth = 0.5;  
[latz, lonz] = bufferm(latr, lonr, bufWidth, 'outPlusInterior');  
figure  
geoshow(latz, lonz, 'DisplayType', 'polygon', 'FaceColor', 'yellow')  
title('Exterior Buffer Zone including Polygon Interior');
```

Tips

Close all polygons before processing them with `bufferm`. If a polygon is not closed, `bufferm` assumes it is a line.

Version History

Introduced before R2006a

R2019b: Order of polygon vertices might be different

Behavior changed in R2019b

The `bufferm` function might return polygon vertices in a different order. The polygons that these vertices define are geometrically equivalent to those in previous releases.

See Also

Functions
`polyshape`

Topics
“Create and Display Polygons”

bufgeoquad

Expand limits of geographic quadrangle

Syntax

```
[latlim,lonlim] = bufgeoquad(latlim,lonlim,buflat,buflon)
```

Description

[latlim,lonlim] = bufgeoquad(latlim,lonlim,buflat,buflon) returns an expanded version of the geographic quadrangle defined by latlim and lonlim.

Examples

Bounding Quadrangle for U.S.

Bounding quadrangle for the Conterminous United States, buffered 2 degrees to the north and south and 3 degrees to the east and west.

Load data and expand the limits of the quadrangle.

```
conus = load('conus.mat');  
[latlim, lonlim] = geoquadline(conus.uslat,conus.uslon);  
[latlim,lonlim] = bufgeoquad(latlim,lonlim,2,3)
```

```
latlim =
```

```
    23.1200    51.3800
```

```
lonlim =
```

```
   -127.7200   -63.9700
```

Input Arguments

latlim — Latitude limits

1-by-2 vector

Latitude limits of a geographic quadrangle, specified as a 1-by-2 vector of the form [southern_limit northern_limit], with latitudes in degrees. The two elements must be in ascending order, and lie in the closed interval [-90 90].

Data Types: single | double

lonlim — Longitude limits

1-by-2 vector

Longitude limits of a geographic quadrangle, specified as a 1-by-2 vector of the form [western_limit eastern_limit], with longitudes in degrees. The two limits need not be in numerical ascending order.

Data Types: single | double

buflat — Latitude buffer size

nonnegative scalar

Latitude buffer size, specified as a nonnegative scalar, in units of degrees.

Data Types: double

buflon — Longitude buffer size

nonnegative scalar

Longitude buffer size, specified as a nonnegative scalar, in units of degrees.

Data Types: double

Output Arguments

latlim — Latitude limits

1-by-2 vector

Latitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form [southern_limit northern_limit], in units of degrees. The elements are in ascending order, and both lie in the closed interval [-90 90].

lonlim — Longitude limits

1-by-2 vector

Longitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form [western_limit eastern_limit], in units of degrees. The limits are wrapped to the interval [-180 180]. They are not necessarily in numerical ascending order.

Version History

Introduced in R2012b

See Also

geoquadpt | geoquadline | outlinegeoquad

camheading

Set or query heading angle of camera for geographic globe

Syntax

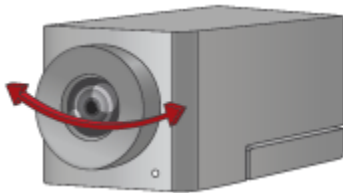
```
camheading(g,heading)  
camheading(g,'auto')  
camheading(g,'manual')
```

```
outHeading = camheading(g)  
outHeading = camheading( ___ )
```

Description

Set Heading and Mode

`camheading(g,heading)` sets the heading angle of the camera for the specified geographic globe. Setting the heading angle shifts the camera left or right. For more information about how camera rotations affect your view of the globe, see “How Camera Orientation Affects Globe View” on page 1-148.



`camheading(g,'auto')` sets the camera heading to automatic mode, enabling the geographic globe to determine the heading angle based on plotted data. The mode defaults to automatic when you create a geographic globe. If you interact with the globe using your mouse, then the mode switches to automatic.

`camheading(g,'manual')` sets the camera heading to manual mode, specifying that the geographic globe preserve the heading angle when the plotted data changes. If you change the heading angle using the `camheading` function, then the mode switches to manual.

Query Heading

`outHeading = camheading(g)` returns the heading angle of the camera.

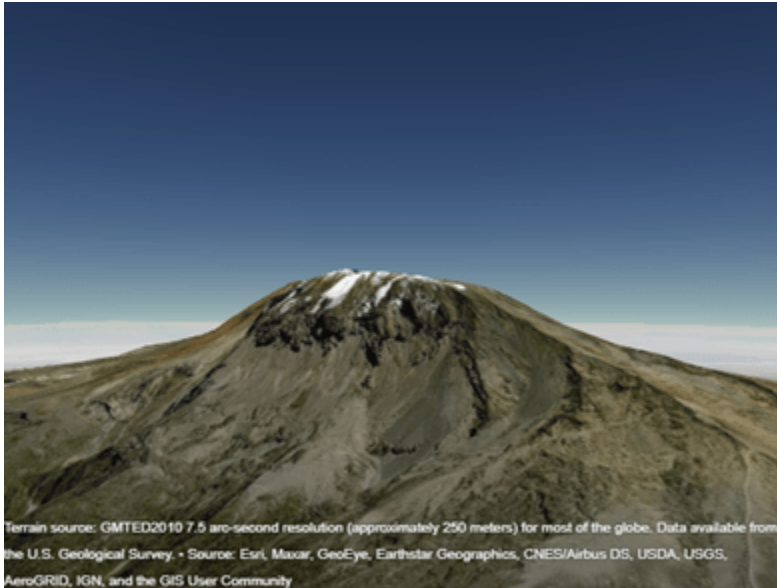
`outHeading = camheading(___)` sets the heading angle or mode and then returns the heading angle of the camera. You can return the heading angle using any combination of input arguments from the previous syntaxes.

Examples

Change Heading Angle of Camera

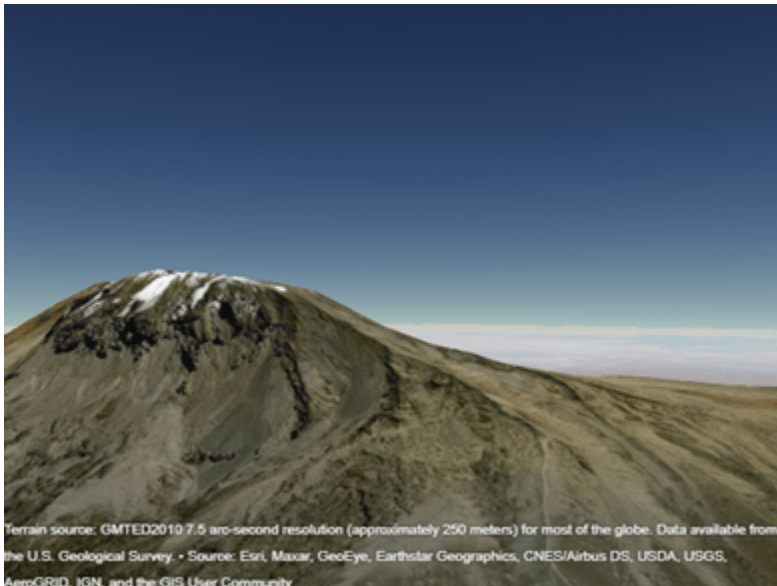
Create a geographic globe. Position the camera near Mount Kilimanjaro by specifying a latitude, longitude, and ellipsoidal height. Set the pitch angle to 0 degrees, so that the camera points across the summit.

```
uif = uifigure;  
g = geoglobe(uif);  
campos(g, -3.1519, 37.3561, 5500)  
campitch(g, 0)
```



By default, the heading angle is 360 degrees, which is equivalent to a heading angle of 0 degrees. Shift the camera to the right by changing the heading angle to 15 degrees.

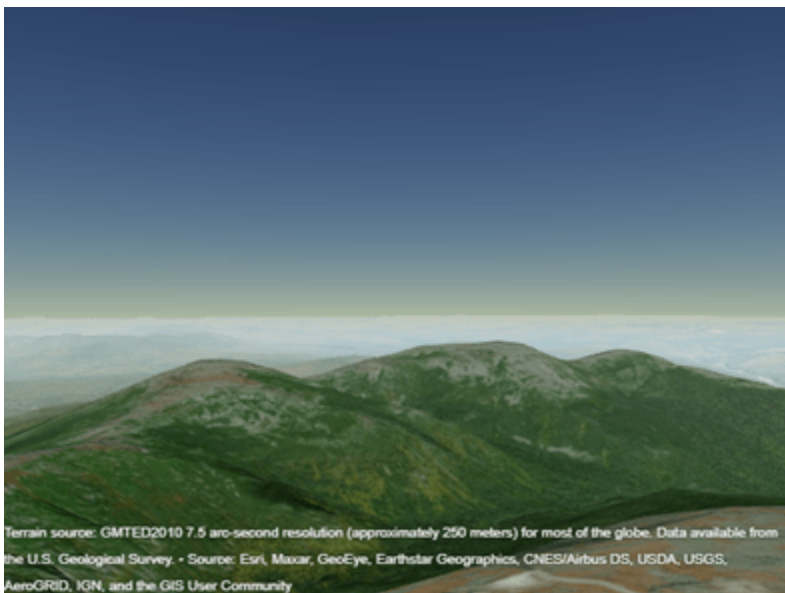
```
camheading(g, 15)
```



Animate Changes to Heading Angle

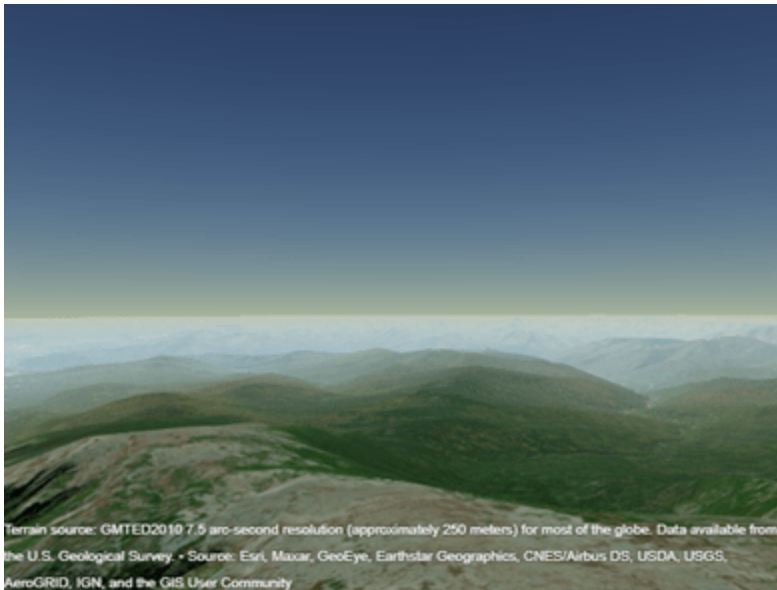
Create a geographic globe. Position the camera at the top of Mount Washington by specifying a latitude, longitude, and ellipsoidal height. Change the pitch angle so that the camera faces the horizon instead straight down.

```
uif = uifigure;  
g = geoglobe(uif);  
campos(g,44.2700,-71.3038,2000)  
campitch(g,0)
```



Animate the view by incrementally changing the heading angle. As the heading angle increases, the camera view shifts to the right.

```
for heading = 0:5:180  
    camheading(g,heading)  
    drawnow  
end
```



Get Information About Camera View

Get the position and the heading, pitch, and roll angles of the camera. Use this information to control the view of a different geographic globe or to automate navigation.

Create a geographic globe. Navigate to an area of interest using your mouse or gestures. For this example, navigate to an area around Hawaii.

```
uif = uifigure;  
g = geoglobe(uif);
```



Query the latitude, longitude, and ellipsoidal height of the camera, and assign each to a variable.

```
[camlat,camlon,camh] = campos(g)
```

```
camlat =  
    18.1781
```

```
camlon =  
   -155.9297
```

```
camh =  
    6.6664e+04
```

Query the heading, pitch, and roll angles of the camera, and assign each to a variable.

```
heading = camheading(g)  
pitch = campitch(g)  
roll = camroll(g)
```

```
heading =  
    16.7613
```

```
pitch =  
   -24.1507
```

```
roll =  
    359.9977
```

Use these values to control the view of a different geographic globe. For example, create a new geographic globe and programmatically set the view.

```
uif2 = uifigure;  
g2 = geoglobe(uif2);  
campos(g2,camlat,camlon,camh)  
camheading(g2,heading)  
campitch(g2,pitch)  
camroll(g2,roll)
```

Preserve Camera View

Preserve the position and the heading, pitch, and roll angles of the camera by setting the camera modes to manual. If you do not set the camera modes to manual, then the camera view resets when you plot new data.

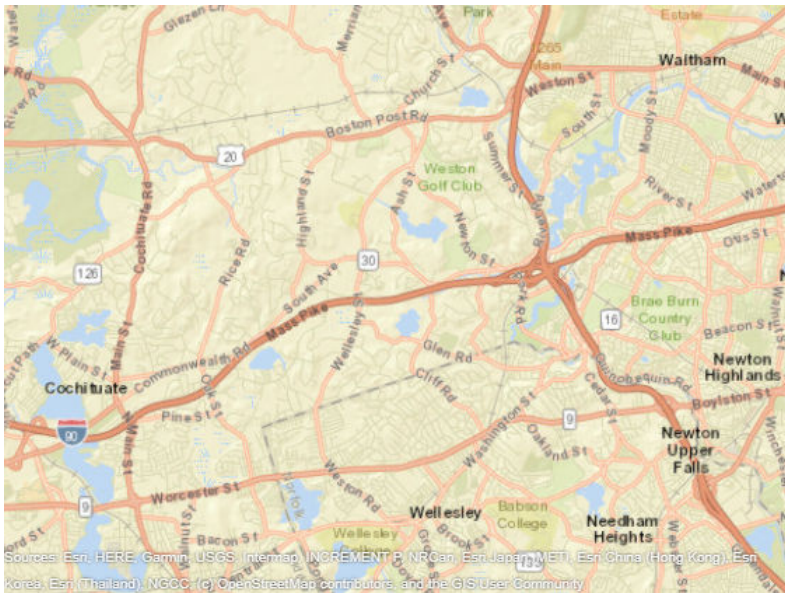
Import a sample route along roads in Massachusetts using the `gpxread` function. Create a geographic globe with a road map and no terrain data. Preserve the basemap and terrain settings by using the `hold` function. Then, navigate to an area near Eastern Massachusetts using your mouse.


```

track = gpxread('sample_tracks.gpx','Index',2);
lat = track.Latitude;
lon = track.Longitude;
height = track.Elevation;

uif = uifigure;
g = geoglobe(uif,'Basemap','streets','Terrain','none');
hold(g,'on')

```

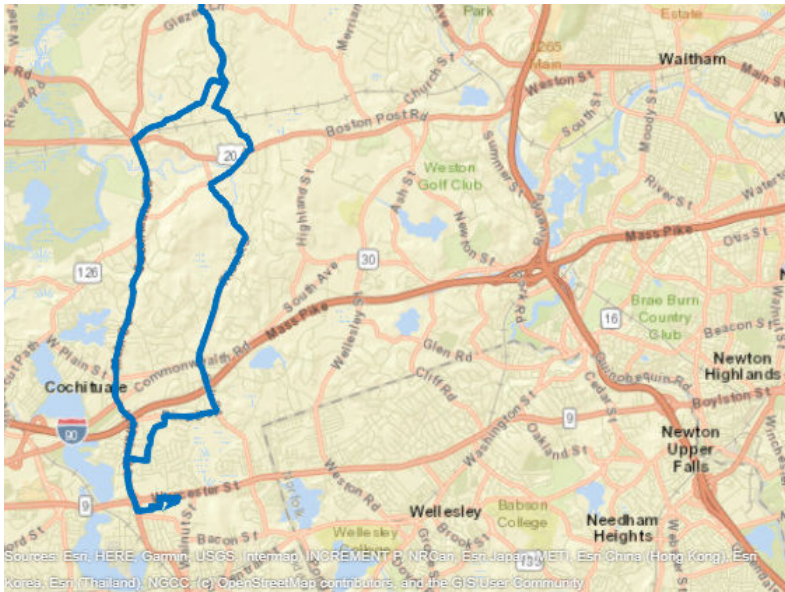


Set the camera modes to manual and plot the data. Note that the camera position does not change.

```

campos(g,'manual')
camheight(g,'manual')
camheading(g,'manual')
campitch(g,'manual')
camroll(g,'manual')
geoplot3(g,lat,lon,height,'LineWidth',3)

```



Input Arguments

g — **Geographic globe**
GeographicGlobe object

Geographic globe, specified as a GeographicGlobe object.²

heading — **Heading angle of camera**
360 (default) | scalar

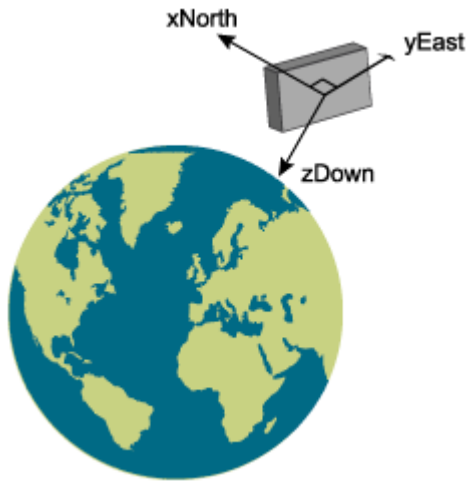
Heading angle of the camera, specified as a scalar value in the range [-360, 360] degrees.

More About

How Camera Orientation Affects Globe View

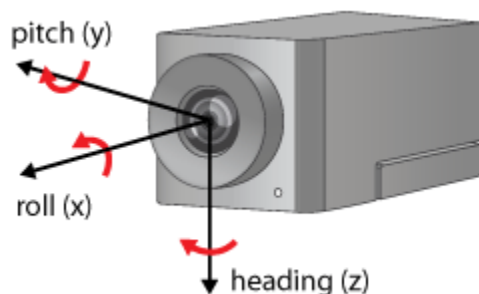
The values of the camera heading, pitch, and roll angles affect your view of a geographic globe. Mapping Toolbox references these values to the globe using a north-east-down (NED) coordinate system. As a result, when the heading, pitch, and roll angles of the camera are zero, the camera sits on a plane that is parallel to the tangent plane of the globe at the current latitude and longitude. For more information about NED coordinate systems, see “Comparison of 3-D Coordinate Systems”.

² Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.



Change your view of a geographic globe by changing the heading, pitch, and roll angles of the camera:

- Heading — Rotate the camera about its z-axis, which shifts the view left or right. Move the view to the right by increasing the heading angle.
- Pitch — Rotate the camera about its y-axis, which tilts the view up or down. Tilt the view up by increasing the pitch angle.
- Roll — Rotate the camera about its x-axis, which spins the camera around its lens. Spin the view counterclockwise by increasing the roll angle.



Tips

- When the pitch angle is near -90 (the default) or 90 degrees, the camera loses one rotational degree of freedom. As a result, when you change the roll angle, the heading angle may change instead. This phenomenon is called gimbal lock. To avoid the effects of gimbal lock, use the `camheading` function instead of the `camroll` function.

Version History

Introduced in R2020b

See Also

Functions

geoglobe | campos | camroll | camheight | campitch

Topics

“Visualize Aircraft Line-of-Sight over Terrain”

“Visualize UAV Flight Path on 2-D and 3-D Maps”

camheight

Set or query height of camera for geographic globe

Syntax

```
camheight(g,height)
camheight(g,'auto')
camheight(g,'manual')

heightOut = camheight(g)
heightOut = camheight( ___ )
```

Description

Set Height and Mode

`camheight(g,height)` sets the ellipsoidal height of the camera for the specified geographic globe.

`camheight(g,'auto')` sets the camera height to automatic mode, enabling the geographic globe to determine the height of the camera based on the plotted data. The mode defaults to automatic when you create a geographic globe. If you change the camera height using your mouse, then the mode switches to automatic.

`camheight(g,'manual')` sets the camera height to manual mode, specifying that the geographic globe preserve the height of the camera when the plotted data changes. If you change the camera height using the `camheight` function, then the mode switches to manual.

Query Height

`heightOut = camheight(g)` returns the ellipsoidal height of the camera.

`heightOut = camheight(___)` sets the height or mode and then returns the ellipsoidal height of the camera. You can return the camera height using any combination of input arguments from the previous syntaxes.

Examples

Change Camera Height

Create a geographic globe. Specify the latitude and longitude of the Eiffel Tower, and specify a height that is 700 meters above the WGS84 reference ellipsoid. Then, move the camera using the `campos` function.

```
uif = uifigure;
g = geoglobe(uif);

lat = 48.8584;
lon = 2.2945;
h = 700;
campos(g,lat,lon,h)
```



Change only the height of the camera by using the `camheight` function. Increase the camera height to 1500 meters above the WGS84 reference ellipsoid.

```
camheight(g,1500)
```



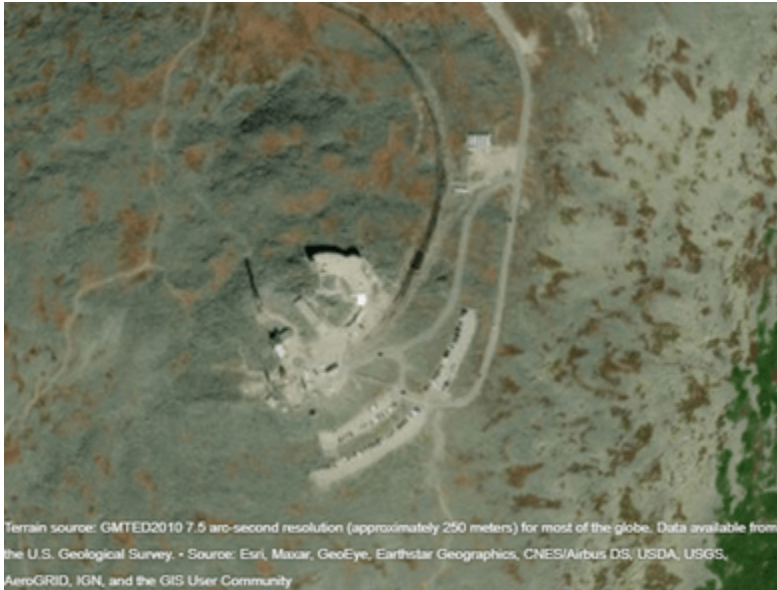
Animate Changes to Camera Height

Create a geographic globe. Position the camera above Mount Washington by specifying a latitude, longitude, and ellipsoidal height.

```
uif = uifigure;  
g = geoglobe(uif);
```

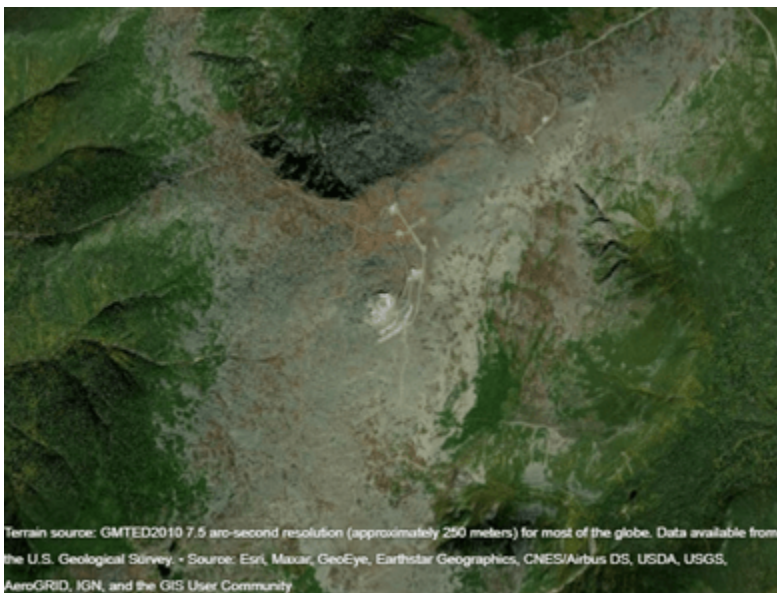


```
height0 = 2500;  
campos(g,44.2706, -71.3025,height0)
```



Animate the view by incrementally changing the camera height. As the camera height increases, the view zooms out.

```
for height = 2500:50:5000  
    camheight(g,height)  
    drawnow  
end
```



Get Height of Camera

Get the height of the camera. Use this information to control the view of a different geographic globe or to automate navigation.

Create a geographic globe. Zoom in on an area around Spain using your mouse or gestures.

```
uif = uifigure;  
g = geoglobe(uif);
```



Query the height of the camera and assign it to a variable.

```
outHeight = camheight(g)  
  
outHeight =  
  
    1.8803e+06
```

Use this value to control the camera height for a different geographic globe. For example, create a new geographic globe and programmatically set the camera height.

```
uif2 = uifigure;  
g2 = geoglobe(uif2);  
camheight(g2,outHeight)
```

Preserve Camera View

Preserve the position and the heading, pitch, and roll angles of the camera by setting the camera modes to manual. If you do not set the camera modes to manual, then the camera view resets when you plot new data.

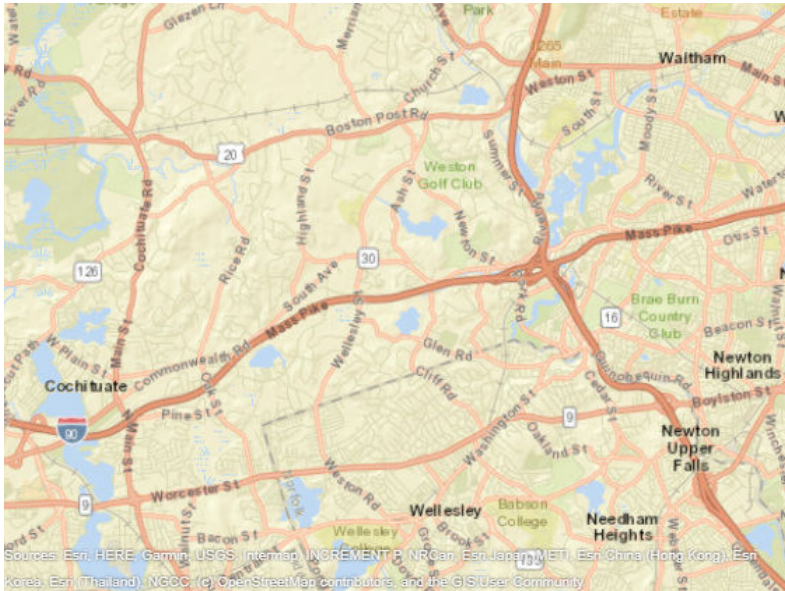
Import a sample route along roads in Massachusetts using the `gpxread` function. Create a geographic globe with a road map and no terrain data. Preserve the basemap and terrain settings by using the `hold` function. Then, navigate to an area near Eastern Massachusetts using your mouse.


```

track = gpxread('sample_tracks.gpx','Index',2);
lat = track.Latitude;
lon = track.Longitude;
height = track.Elevation;

uif = uifigure;
g = geoglobe(uif,'Basemap','streets','Terrain','none');
hold(g,'on')

```

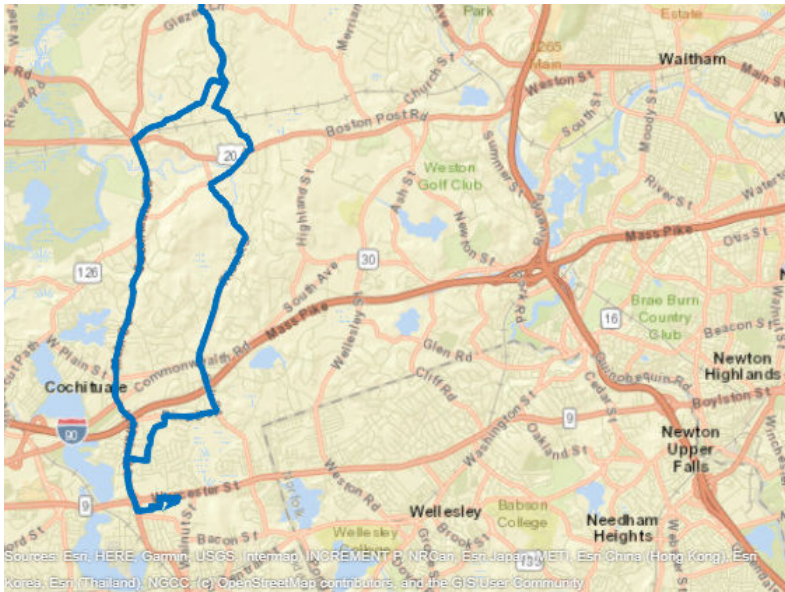


Set the camera modes to manual and plot the data. Note that the camera position does not change.

```

campos(g,'manual')
camheight(g,'manual')
camheading(g,'manual')
campitch(g,'manual')
camroll(g,'manual')
geoplot3(g,lat,lon,height,'LineWidth',3)

```



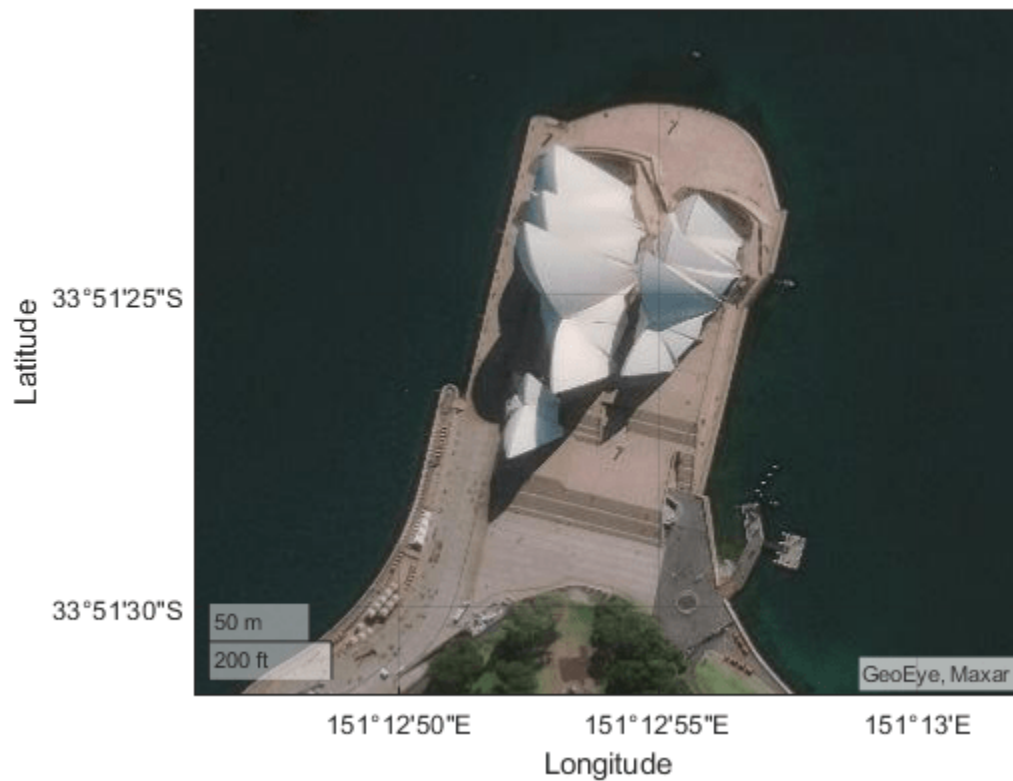
Convert Between Zoom Level and Camera Height

The strategies you use to programmatically zoom in and out of `GeographicGlobe` and `GeographicAxes` objects are different. For `GeographicGlobe` objects, you specify a camera height using the `camheight` function. For `GeographicAxes` objects, you specify a zoom level using the `ZoomLevel` property or specify latitude and longitude limits using the `geolimits` function. To create `GeographicGlobe` and `GeographicAxes` objects with similar map scales, approximate camera height and zoom level using the `heightToZoomLevel` and `zoomLevelToHeight` local functions (defined here).

You can verify the behavior of the `zoomLevelToHeight` local function by displaying `GeographicAxes` and `GeographicGlobe` objects using comparable magnification levels.

Specify the latitude and longitude of the Sydney Opera House. Create geographic axes with a basemap, map center, and zoom level that allows you to clearly see the building.

```
lat = -33.8572;
lon = 151.2150;
z = 17;
gx = geoaxes('Basemap', 'satellite', 'MapCenter', [lat lon], 'ZoomLevel', z);
```



Create a geographic globe. Position the camera above the Sydney Opera House using the `campos` function.

```
uif = uifigure;
g = geoglobe(uif);
campos(g,lat,lon)
```

Calculate an approximate camera height from the zoom level using the `zoomLevelToHeight` local function. Then, set the camera height using the `camheight` function. Note that the geographic axes and geographic globe displays are comparable.

```
h = zoomLevelToHeight(z,lat);
camheight(g,h)
```



To verify the behavior of the `heightToZoomLevel` function, calculate an approximate zoom level from the camera height.

```
z2 = heightToZoomLevel(h,lat)
```

```
z2 = 17
```

Note that `z` and `z2` are equal.

This code defines a local function called `zoomLevelToHeight` that approximates the camera height `h` for a `GeographicGlobe` object using the zoom level `z` and map center latitude `lat` of a `GeographicAxes` object.

```
function h = zoomLevelToHeight(z,lat)
    earthCircumference = 2*pi*6378137;
    h = (earthCircumference*cosd(lat)) / 2^(z-1);
end
```

This code defines a local function called `heightToZoomLevel` that approximates the zoom level `z` for a `GeographicAxes` object using the camera height `h` and latitude `lat` of a `GeographicGlobe` object.

```
function z = heightToZoomLevel(h,lat)
    earthCircumference = 2*pi*6378137;
    z = log2((earthCircumference*cosd(lat)) / h) + 1;
    z = max(0,z);
    z = min(19,z);
end
```

Input Arguments

g — **Geographic globe**
`GeographicGlobe` object

Geographic globe, specified as a `GeographicGlobe` object.³

height — Ellipsoidal height of camera

15000000 (default) | numeric scalar

Ellipsoidal height of the camera, specified as a numeric scalar in meters. Geographic globe objects use the WGS84 reference ellipsoid. For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

If you specify the height so that the camera is level with or below the terrain, then the `camheight` function sets the height to a value one meter above the terrain.

Version History

Introduced in R2020b

See Also

Functions

`geoglobe` | `campitch` | `campos` | `camroll` | `camheading`

Topics

“Visualize UAV Flight Path on 2-D and 3-D Maps”

“Visualize Aircraft Line-of-Sight over Terrain”

3 Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

campitch

Set or query pitch angle of camera for geographic globe

Syntax

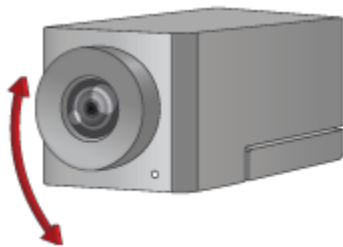
```
campitch(g,pitch)  
campitch(g,'auto')  
campitch(g,'manual')
```

```
outPitch = campitch(g)  
outPitch = campitch( ___ )
```

Description

Set Pitch and Mode

`campitch(g,pitch)` sets the pitch angle of the camera for the specified geographic globe. Setting the pitch angle tilts the camera up or down. For more information about how camera rotations affect your view of the globe, see “How Camera Orientation Affects Globe View” on page 1-166.



`campitch(g,'auto')` sets the camera pitch to automatic mode, enabling the geographic globe to determine the pitch angle based on plotted data. The mode defaults to automatic when you create a geographic globe. If you interact with the globe using your mouse, then the mode switches to automatic.

`campitch(g,'manual')` sets the camera pitch to manual mode, specifying that the geographic globe preserve the pitch angle when the plotted data changes. If you change the pitch angle using the `campitch` function, then the mode switches to manual.

Query Pitch

`outPitch = campitch(g)` returns the pitch angle of the camera.

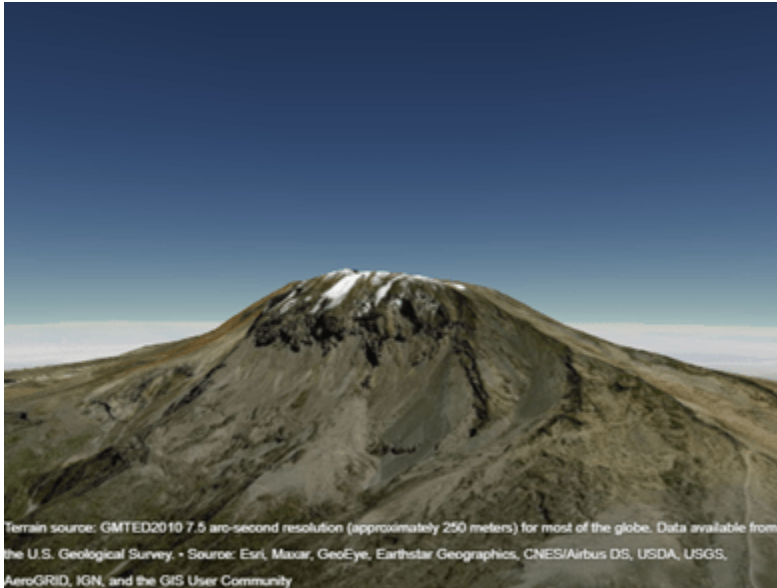
`outPitch = campitch(___)` sets the pitch angle or mode and then returns the pitch angle of the camera. You can return the pitch angle using any combination of input arguments from the previous syntaxes.

Examples

Change Pitch Angle of Camera

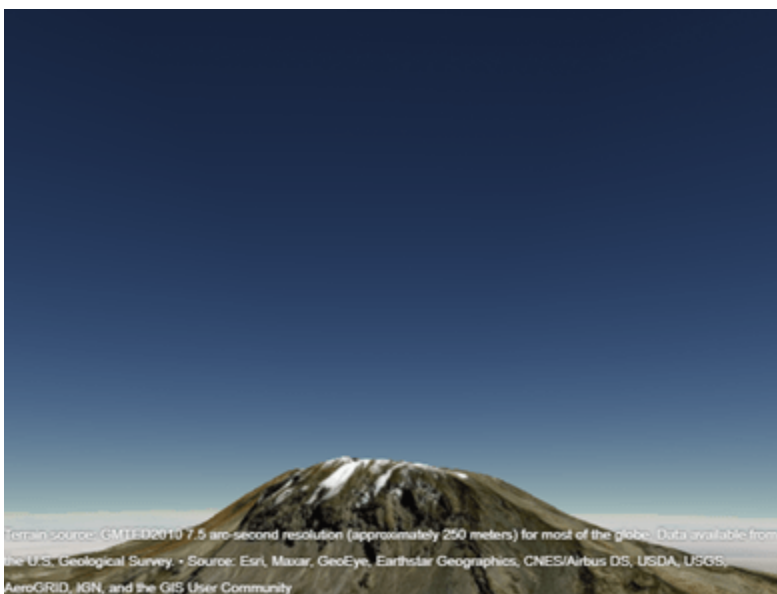
Create a geographic globe. Position the camera near Mount Kilimanjaro by specifying a latitude, longitude, and ellipsoidal height. Set the pitch angle to 0 degrees, so that the camera points across the summit.

```
uif = uifigure;  
g = geoglobe(uif);  
campos(g, -3.1519, 37.3561, 5500)  
campitch(g, 0)
```



Tilt the camera up by increasing the pitch angle to 15 degrees.

```
campitch(g, 15)
```



Animate Changes to Pitch Angle

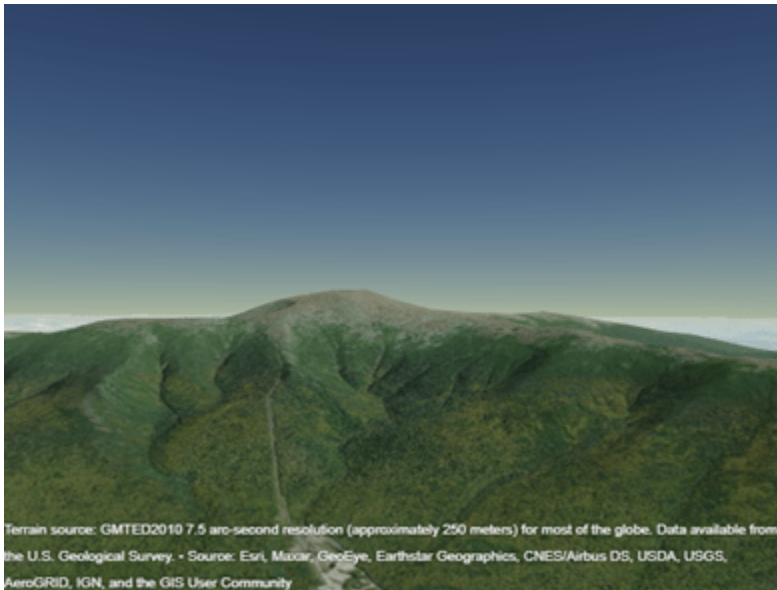
Create a geographic globe. Position the camera near Mount Washington by specifying a latitude, longitude, and ellipsoidal height. Change the heading angle so that the camera faces the mountain. By default, the pitch angle is -90 degrees, so that the camera points at the ground.

```
uif = uifigure;  
g = geoglobe(uif);  
  
campos(g,44.2668,-71.3849,1757)  
camheading(g,90)
```



Animate the view by incrementally changing the pitch angle. As the pitch angle increases, the camera changes from pointing at the ground to pointing at the sky. After the animation finishes, change the pitch angle to 0 degrees.

```
for pitch = -90:2:90  
    campitch(g,pitch)  
    drawnow  
end  
campitch(g,0)
```

Get Information About Camera View

Get the position and the heading, pitch, and roll angles of the camera. Use this information to control the view of a different geographic globe or to automate navigation.

Create a geographic globe. Navigate to an area of interest using your mouse or gestures. For this example, navigate to an area around Hawaii.

```
uif = uifigure;  
g = geoglobe(uif);
```



Query the latitude, longitude, and ellipsoidal height of the camera, and assign each to a variable.

```
[camlat,camlon,camh] = campos(g)
```

```
camlat =  
    18.1781
```

```
camlon =  
   -155.9297
```

```
camh =  
    6.6664e+04
```

Query the heading, pitch, and roll angles of the camera, and assign each to a variable.

```
heading = camheading(g)  
pitch = campitch(g)  
roll = camroll(g)
```

```
heading =  
    16.7613
```

```
pitch =  
   -24.1507
```

```
roll =  
    359.9977
```

Use these values to control the view of a different geographic globe. For example, create a new geographic globe and programmatically set the view.

```
uif2 = uifigure;  
g2 = geoglobe(uif2);  
campos(g2,camlat,camlon,camh)  
camheading(g2,heading)  
campitch(g2,pitch)  
camroll(g2,roll)
```

Preserve Camera View

Preserve the position and the heading, pitch, and roll angles of the camera by setting the camera modes to manual. If you do not set the camera modes to manual, then the camera view resets when you plot new data.

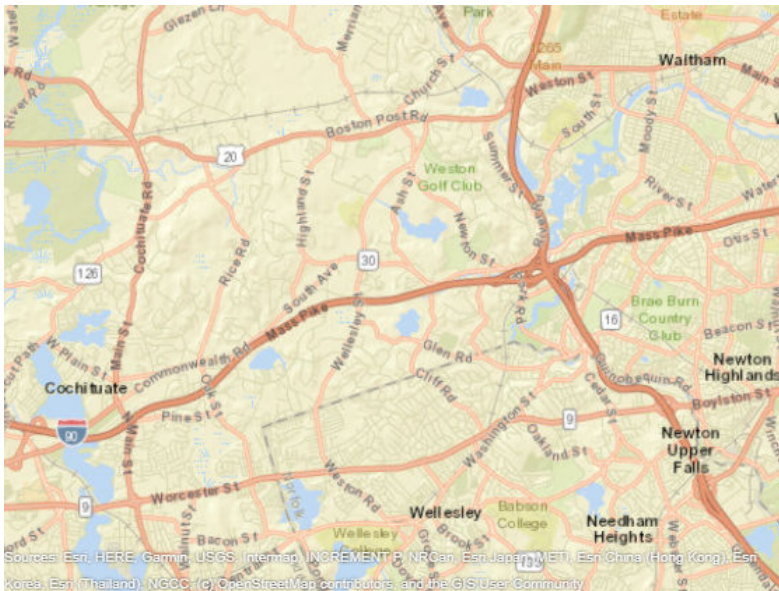
Import a sample route along roads in Massachusetts using the `gpxread` function. Create a geographic globe with a road map and no terrain data. Preserve the basemap and terrain settings by using the `hold` function. Then, navigate to an area near Eastern Massachusetts using your mouse.

```

track = gpxread('sample_tracks.gpx','Index',2);
lat = track.Latitude;
lon = track.Longitude;
height = track.Elevation;

uif = uifigure;
g = geoglobe(uif,'Basemap','streets','Terrain','none');
hold(g,'on')

```

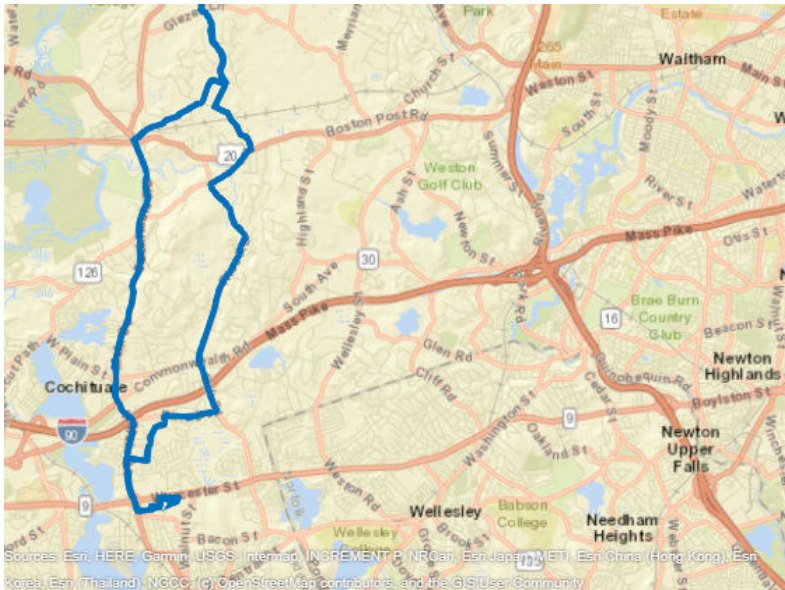


Set the camera modes to manual and plot the data. Note that the camera position does not change.

```

campos(g,'manual')
camheight(g,'manual')
camheading(g,'manual')
campitch(g,'manual')
camroll(g,'manual')
geoplot3(g,lat,lon,height,'LineWidth',3)

```



Input Arguments

g — **Geographic globe**
GeographicGlobe object

Geographic globe, specified as a GeographicGlobe object.⁴

pitch — **Pitch angle of camera**
-90 (default) | scalar

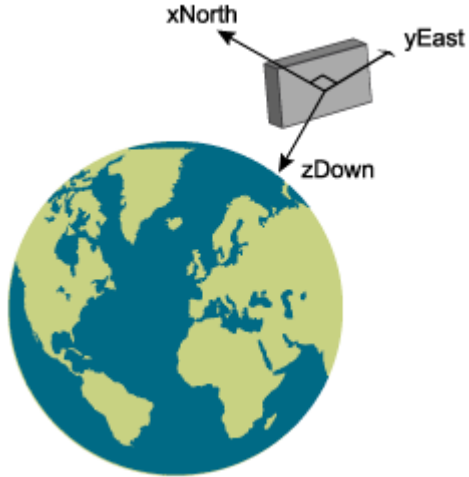
Pitch angle of the camera, specified as a scalar value in the range [-90, 90] degrees. By default, the pitch angle is -90 degrees, which means that camera points directly toward the surface of the globe.

More About

How Camera Orientation Affects Globe View

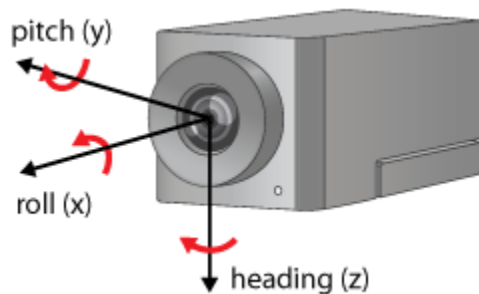
The values of the camera heading, pitch, and roll angles affect your view of a geographic globe. Mapping Toolbox references these values to the globe using a north-east-down (NED) coordinate system. As a result, when the heading, pitch, and roll angles of the camera are zero, the camera sits on a plane that is parallel to the tangent plane of the globe at the current latitude and longitude. For more information about NED coordinate systems, see “Comparison of 3-D Coordinate Systems”.

⁴ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.



Change your view of a geographic globe by changing the heading, pitch, and roll angles of the camera:

- Heading — Rotate the camera about its z-axis, which shifts the view left or right. Move the view to the right by increasing the heading angle.
- Pitch — Rotate the camera about its y-axis, which tilts the view up or down. Tilt the view up by increasing the pitch angle.
- Roll — Rotate the camera about its x-axis, which spins the camera around its lens. Spin the view counterclockwise by increasing the roll angle.



Tips

- When the pitch angle is near -90 (the default) or 90 degrees, the camera loses one rotational degree of freedom. As a result, when you change the roll angle, the heading angle may change instead. This phenomenon is called gimbal lock. To avoid the effects of gimbal lock, call the `camheading` function instead of the `camroll` function.

Version History

Introduced in R2020b

See Also

Functions

geoglobe | campos | camheight | camroll | camheading

Topics

“Visualize Aircraft Line-of-Sight over Terrain”

“Visualize UAV Flight Path on 2-D and 3-D Maps”

campos

Set or query position of camera for geographic globe

Syntax

```
campos(g, lat, lon)
campos(g, lat, lon, height)
```

```
campos(g, 'auto')
campos(g, 'manual')
```

```
campos(g)
[latOut, lonOut, heightOut] = campos( ___ )
```

Description

Set Position

`campos(g, lat, lon)` sets the latitude and longitude of the camera for the specified geographic globe.

`campos(g, lat, lon, height)` sets the latitude, longitude, and ellipsoidal height of the camera. If you want to set only the height of the camera, then use the `camheight` function instead.

Set Mode

`campos(g, 'auto')` sets the camera position to an automatic mode, enabling the geographic globe to determine the latitude and longitude of the camera based on the plotted data. The mode defaults to automatic when you create a geographic globe. If you change the camera position using your mouse, then the mode switches to automatic. To control the mode for the height of the camera, use the `camheight` function instead.

`campos(g, 'manual')` sets the camera position to a manual mode, specifying that the geographic globe preserve the latitude and longitude of the camera when the plotted data changes. If you change the camera position using the `campos` function, then the mode switches to manual.

Query Position

`campos(g)` displays the latitude, longitude, and ellipsoidal height of the camera as a three-element vector.

`[latOut, lonOut, heightOut] = campos(___)` sets the position or mode and then returns the latitude, longitude, and height of the camera. You can return the camera position using any of the previous syntaxes.

Examples

Change Camera Position

Create a geographic globe. Specify the latitude and longitude of the Eiffel Tower, and specify a height that is 400 meters above the WGS84 reference ellipsoid. Use these values to move the camera.

```
uif = uifigure;  
g = geoglobe(uif);  
  
lat = 48.8584;  
lon = 2.2945;  
h = 400;  
campos(g, lat, lon, h)
```



Get Information About Camera View

Get the position and the heading, pitch, and roll angles of the camera. Use this information to control the view of a different geographic globe or to automate navigation.

Create a geographic globe. Navigate to an area of interest using your mouse or gestures. For this example, navigate to an area around Hawaii.

```
uif = uifigure;  
g = geoglobe(uif);
```




Query the latitude, longitude, and ellipsoidal height of the camera, and assign each to a variable.

```
[camlat,camlon,camh] = campos(g)
```

```
camlat =
```

```
    18.1781
```

```
camlon =
```

```
   -155.9297
```

```
camh =
```

```
    6.6664e+04
```

Query the heading, pitch, and roll angles of the camera, and assign each to a variable.

```
heading = camheading(g)
```

```
pitch = campitch(g)
```

```
roll = camroll(g)
```

```
heading =
```

```
    16.7613
```

```
pitch =
```

```
   -24.1507
```

```
roll =
```

```
    359.9977
```

Use these values to control the view of a different geographic globe. For example, create a new geographic globe and programmatically set the view.

```
uif2 = uifigure;
g2 = geoglobe(uif2);
campos(g2,camlat,camlon,camh)
camheading(g2,heading)
campitch(g2,pitch)
camroll(g2,roll)
```

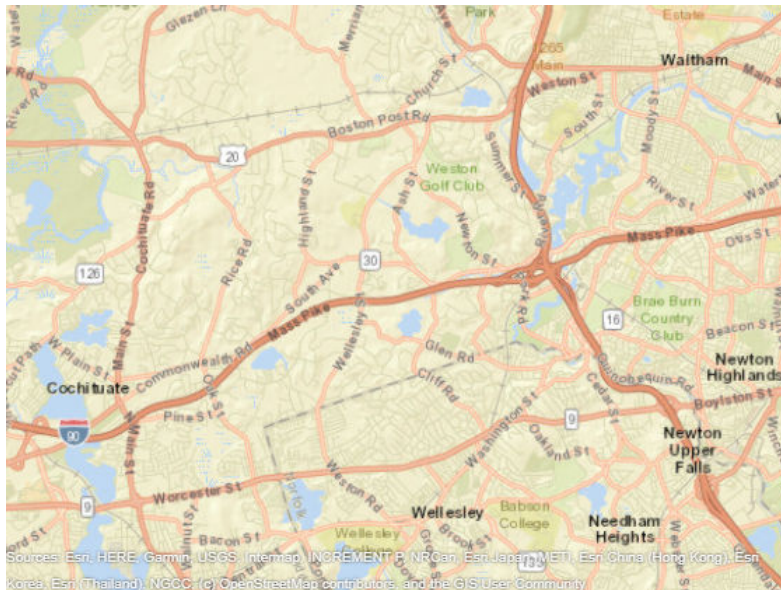
Preserve Camera View

Preserve the position and the heading, pitch, and roll angles of the camera by setting the camera modes to manual. If you do not set the camera modes to manual, then the camera view resets when you plot new data.

Import a sample route along roads in Massachusetts using the `gpxread` function. Create a geographic globe with a road map and no terrain data. Preserve the basemap and terrain settings by using the `hold` function. Then, navigate to an area near Eastern Massachusetts using your mouse.

```
track = gpxread('sample_tracks.gpx','Index',2);
lat = track.Latitude;
lon = track.Longitude;
height = track.Elevation;

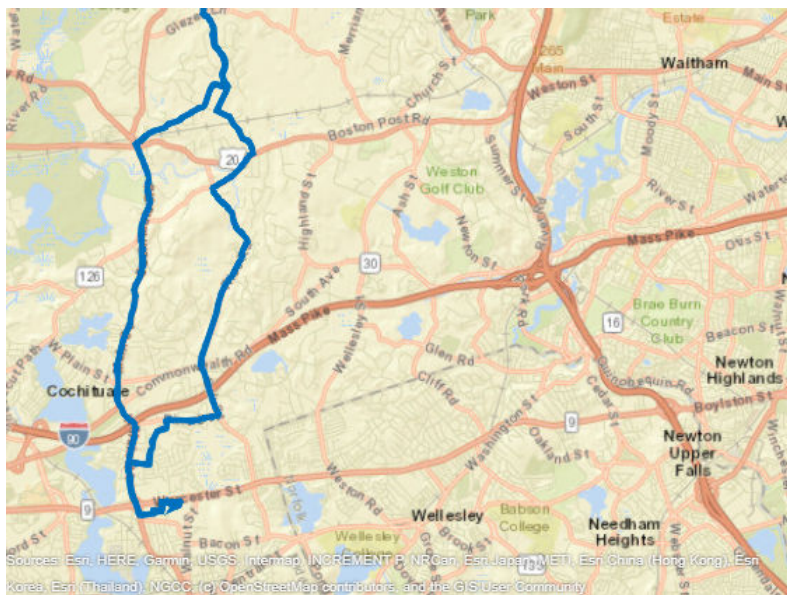
uif = uifigure;
g = geoglobe(uif,'Basemap','streets','Terrain','none');
hold(g,'on')
```



Set the camera modes to manual and plot the data. Note that the camera position does not change.

```
campos(g,'manual')
camheight(g,'manual')
camheading(g,'manual')
```

```
campitch(g, 'manual')
camroll(g, 'manual')
geoplot3(g, lat, lon, height, 'LineWidth', 3)
```



Input Arguments

g — Geographic globe

GeographicGlobe object

Geographic globe, specified as a GeographicGlobe object.⁵

lat — Geodetic latitude of camera

0 (default) | numeric scalar

Geodetic latitude of the camera, specified as a numeric scalar in the range [-90, 90] degrees.

lon — Geodetic longitude of camera

0 (default) | numeric scalar

Geodetic longitude of the camera, specified as a numeric scalar in the range [-360, 360].

height — Ellipsoidal height of camera

15000000 (default) | numeric scalar

Ellipsoidal height of the camera, specified as a numeric scalar in meters. Geographic globe objects use the WGS84 reference ellipsoid. For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

If you specify the height so that the camera is level with or below the terrain, then the campos function sets the height to a value one meter above the terrain.

⁵ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

Output Arguments

latOut — Geodetic latitude of camera

numeric scalar

Geodetic latitude of the camera, returned as a numeric scalar in degrees.

lonOut — Geodetic longitude of camera

numeric scalar

Geodetic longitude of the camera, returned as a numeric scalar in degrees.

heightOut — Ellipsoidal height of camera

numeric scalar

Ellipsoidal height of the camera, returned as a numeric scalar in meters. Geographic globe objects use the WGS84 reference ellipsoid. For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Version History

Introduced in R2020b

See Also

Functions

geoglobe | campitch | camheight | camroll | camheading

Topics

“Visualize Aircraft Line-of-Sight over Terrain”

“Visualize UAV Flight Path on 2-D and 3-D Maps”

camposm

Set camera position for axesm-based map using geographic coordinates

Syntax

```
camposm(lat, long, alt)
[x, y, z] = camposm(lat, long, alt)
```

Description

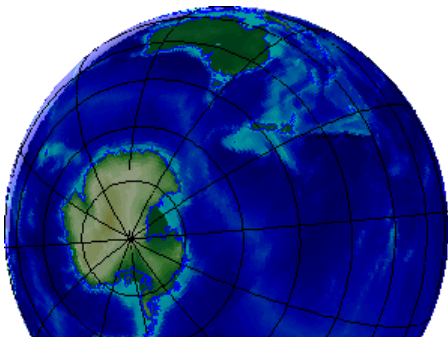
`camposm(lat, long, alt)` sets the axes `CameraPosition` property of the current axesm-based map to the position specified in geographic coordinates. The inputs `lat` and `long` are assumed to be in the angle units of the current axesm-based map.

`[x, y, z] = camposm(lat, long, alt)` returns the camera position in the projected Cartesian coordinate system.

Examples

Look at northern Australia from a point south and one Earth radius above New Zealand.

```
axesm('globe', 'galt', 0)
gridm('glinestyle', '-')
load topo60c
geoshow(topo60c, topo60cR, 'DisplayType', 'texturemap')
demcmap(topo60c)
camlight
material(0.6*[ 1 1 1])
plat = -50;
plon = 160;
tlat = -10;
tlon = 130;
camtargm(tlat, tlon, 0)
camposm(plat, plon, 1)
camupm(tlat, tlon)
set(gca, 'CameraViewAngle', 75)
land = shaperead('landareas.shp', 'UseGeoCoords', true);
linem([land.Lat], [land.Lon])
axis off
```



Version History

Introduced before R2006a

See Also

camtargm | camupm | campos | camva

camroll

Set or query roll angle of camera for geographic globe

Syntax

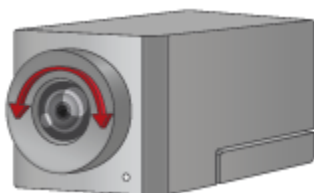
```
camroll(g,roll)
camroll(g,'auto')
camroll(g,'manual')

outRoll = camroll(g)
outRoll = camroll( ___ )
```

Description

Set Roll and Mode

`camroll(g,roll)` sets the roll angle of the camera for the specified geographic globe. Setting the roll angle rotates the camera around its lens. For more information about how camera rotations affect your view of the globe, see “How Camera Orientation Affects Globe View” on page 1-183.



`camroll(g,'auto')` sets the camera roll to automatic mode, enabling the geographic globe to determine the roll angle based on plotted data. The mode defaults to automatic when you create a geographic globe. If you interact with the globe using your mouse, then the mode switches to automatic.

`camroll(g,'manual')` sets a manual mode, specifying that the geographic globe preserve the roll angle when the plotted data changes. If you change the roll angle using the `camroll` function, then the mode switches to manual.

Query Roll

`outRoll = camroll(g)` returns the roll angle of the camera.

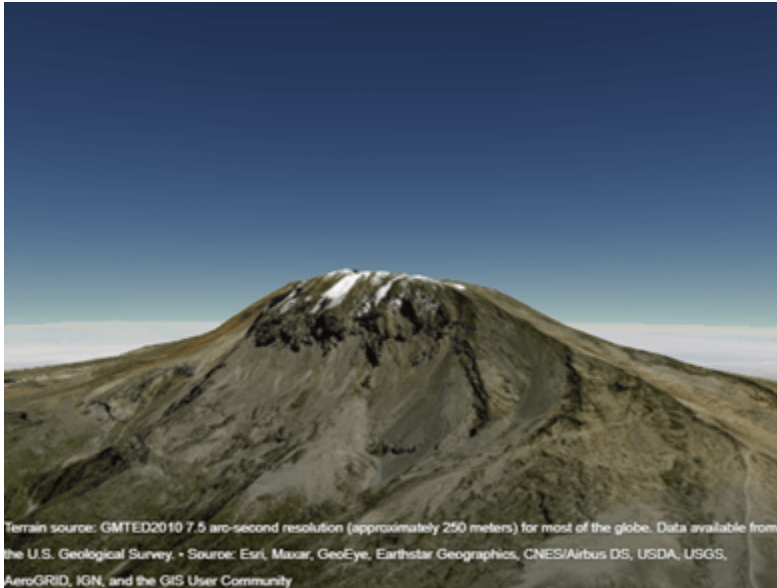
`outRoll = camroll(___)` sets the roll angle or mode and then returns the roll angle of the camera. You can return the roll angle using any combination of input arguments from the previous syntaxes.

Examples

Change Roll Angle of Camera

Create a geographic globe. Position the camera near Mount Kilimanjaro by specifying a latitude, longitude, and ellipsoidal height. Set the pitch angle to 0 degrees, so that the camera points across the summit.

```
uif = uifigure;  
g = geoglobe(uif);  
campos(g, -3.1519, 37.3561, 5500)  
campitch(g, 0)
```



By default, the roll angle is 0 degrees. Rotate the mountain in a counterclockwise direction by increasing the roll angle to 30 degrees.

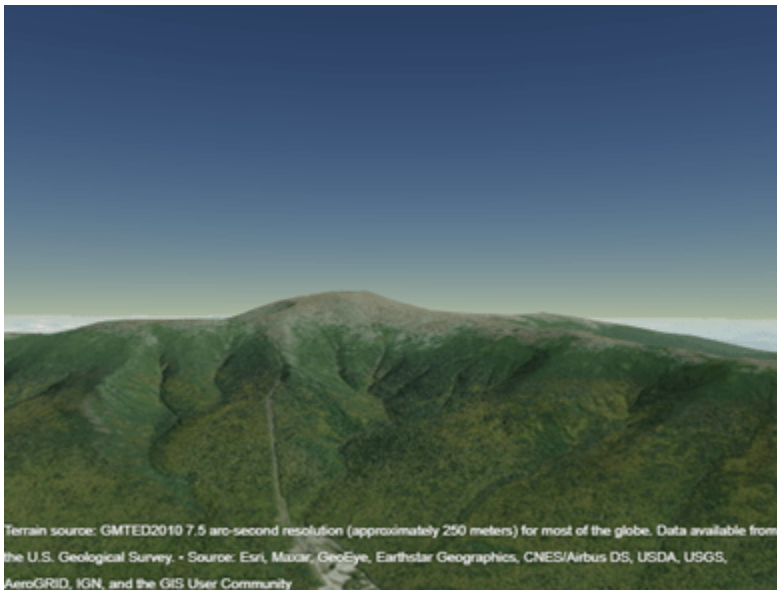
```
camroll(g, 30)
```



Animate Changes to Roll Angle

Create a geographic globe. Position the camera near Mount Washington by specifying a latitude, longitude, and ellipsoidal height. Change the heading and pitch angles so that the camera faces the mountain.

```
uif = uifigure;  
g = geoglobe(uif);  
  
campos(g,44.2668, -71.3849, 1757)  
camheading(g,90)  
campitch(g,0)
```



Animate the view by incrementally changing the roll angle. As the roll angle increases, the mountain rotates in a counterclockwise direction.

```
for roll = 0:5:180  
    camroll(g,roll)  
    drawnow  
end
```

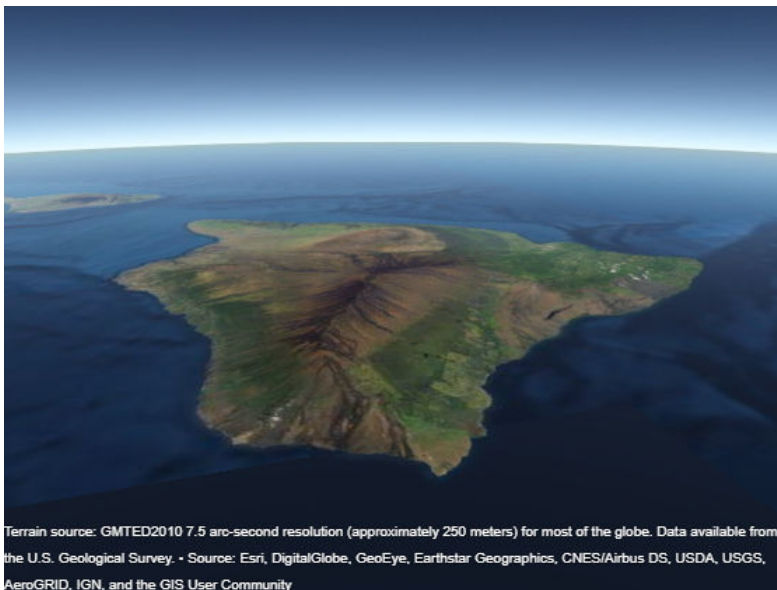


Get Information About Camera View

Get the position and the heading, pitch, and roll angles of the camera. Use this information to control the view of a different geographic globe or to automate navigation.

Create a geographic globe. Navigate to an area of interest using your mouse or gestures. For this example, navigate to an area around Hawaii.

```
uif = uifigure;  
g = geoglobe(uif);
```



Query the latitude, longitude, and ellipsoidal height of the camera, and assign each to a variable.

```
[camlat,camlon,camh] = campos(g)
```

```
camlat =
    18.1781
```

```
camlon =
   -155.9297
```

```
camh =
    6.6664e+04
```

Query the heading, pitch, and roll angles of the camera, and assign each to a variable.

```
heading = camheading(g)
pitch = campitch(g)
roll = camroll(g)
```

```
heading =
    16.7613
```

```
pitch =
   -24.1507
```

```
roll =
    359.9977
```

Use these values to control the view of a different geographic globe. For example, create a new geographic globe and programmatically set the view.

```
uif2 = uifigure;
g2 = geoglobe(uif2);
campos(g2,camlat,camlon,camh)
camheading(g2,heading)
campitch(g2,pitch)
camroll(g2,roll)
```

Preserve Camera View

Preserve the position and the heading, pitch, and roll angles of the camera by setting the camera modes to manual. If you do not set the camera modes to manual, then the camera view resets when you plot new data.

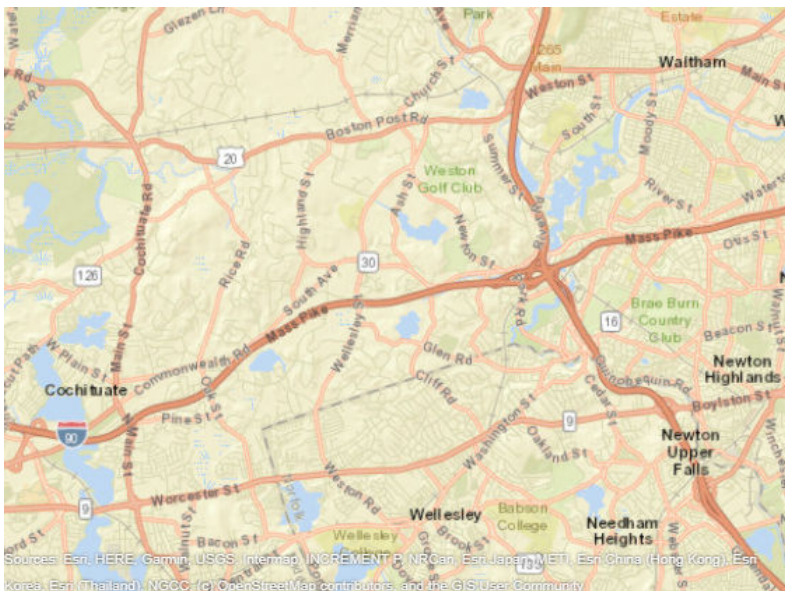
Import a sample route along roads in Massachusetts using the `gpxread` function. Create a geographic globe with a road map and no terrain data. Preserve the basemap and terrain settings by using the `hold` function. Then, navigate to an area near Eastern Massachusetts using your mouse.

```

track = gpxread('sample_tracks.gpx','Index',2);
lat = track.Latitude;
lon = track.Longitude;
height = track.Elevation;

uif = uifigure;
g = geoglobe(uif,'Basemap','streets','Terrain','none');
hold(g,'on')

```

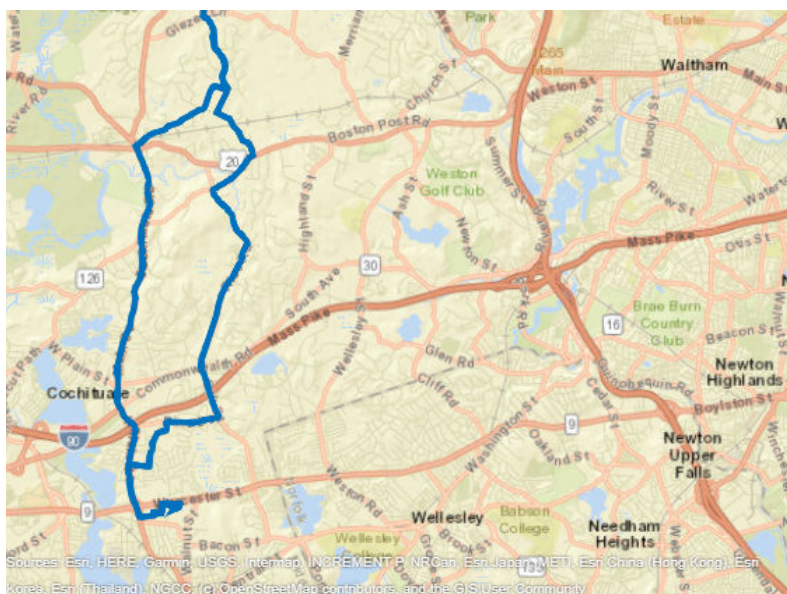


Set the camera modes to manual and plot the data. Note that the camera position does not change.

```

campos(g,'manual')
camheight(g,'manual')
camheading(g,'manual')
campitch(g,'manual')
camroll(g,'manual')
geoplot3(g,lat,lon,height,'LineWidth',3)

```



Input Arguments

g — Geographic globe

GeographicGlobe object

Geographic globe, specified as a GeographicGlobe object.⁶

roll — Roll angle of camera

0 (default) | scalar

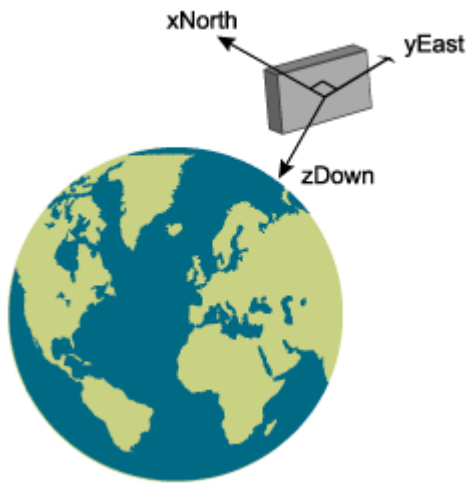
Roll angle of the camera, specified as a scalar value in the range [-360, 360] degrees.

More About

How Camera Orientation Affects Globe View

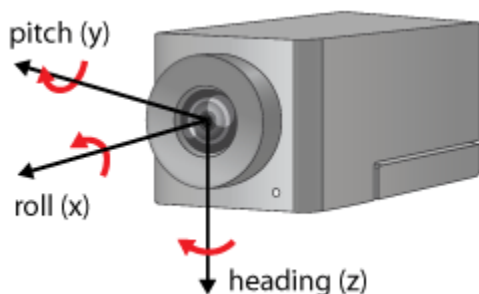
The values of the camera heading, pitch, and roll angles affect your view of a geographic globe. Mapping Toolbox references these values to the globe using a north-east-down (NED) coordinate system. As a result, when the heading, pitch, and roll angles of the camera are zero, the camera sits on a plane that is parallel to the tangent plane of the globe at the current latitude and longitude. For more information about NED coordinate systems, see “Comparison of 3-D Coordinate Systems”.

⁶ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.



Change your view of a geographic globe by changing the heading, pitch, and roll angles of the camera:

- Heading — Rotate the camera about its z-axis, which shifts the view left or right. Move the view to the right by increasing the heading angle.
- Pitch — Rotate the camera about its y-axis, which tilts the view up or down. Tilt the view up by increasing the pitch angle.
- Roll — Rotate the camera about its x-axis, which spins the camera around its lens. Spin the view counterclockwise by increasing the roll angle.



Tips

- When the pitch angle is near -90 (the default) or 90 degrees, the camera loses one rotational degree of freedom. As a result, when you change the roll angle, the heading angle may change instead. This phenomenon is called gimbal lock. To avoid the effects of gimbal lock, call the `camheading` function instead of the `camroll` function.

Version History

Introduced in R2020b

See Also

Functions

geoglobe | campos | camheading | camheight | campitch

Topics

“Visualize Aircraft Line-of-Sight over Terrain”

“Visualize UAV Flight Path on 2-D and 3-D Maps”

camtargm

Set camera target for axesm-based map using geographic coordinates

Syntax

```
camtargm(lat, long, alt)
[x, y, z] = camtargm(lat, long, alt)
```

Description

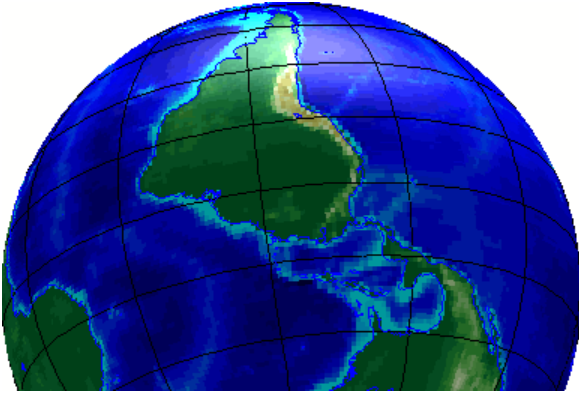
`camtargm(lat, long, alt)` sets the axes `CameraTarget` property of the current axesm-based map to the position specified in geographic coordinates. The inputs `lat` and `long` are assumed to be in the angle units of the current axesm-based map.

`[x, y, z] = camtargm(lat, long, alt)` returns the camera target in the projected Cartesian coordinate system.

Examples

Look down the spine of the Andes from a location three Earth radii above the surface.

```
axesm('globe', 'galt', 0)
gridm('linestyle', '-')
load topo60c
geoshow(topo60c, topo60cR, 'DisplayType', 'texturemap');
demcmap(topo60c)
lightm(-80, -180);
material(0.6*[ 1 1 1])
plat = 10;
plon = -65;
tlat = -30;
tlon = -70;
camtargm(tlat, tlon, 0);
camposm(plat, plon, 3);
camupm(tlat, tlon);
camva(20)
set(gca, 'CameraViewAngle', 30)
land = shaperead('landareas.shp', 'UseGeoCoords', true);
linem([land.Lat], [land.Lon])
axis off
```

Version History

Introduced before R2006a

See Also

camposm | camupm | camtarget | camva

camupm

Set camera up vector for axesm-based map using geographic coordinates

Syntax

```
camupm(lat, long)
[x, y, z] = camupm(lat, long)
```

Description

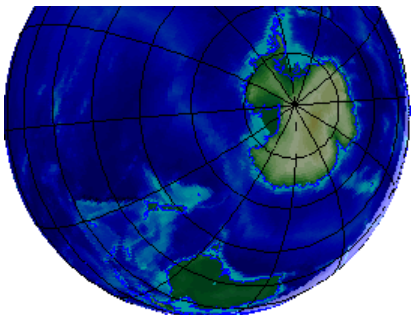
`camupm(lat, long)` sets the axes `CameraUpVector` property of the current axesm-based map to the position specified in geographic coordinates. The inputs `lat` and `long` are assumed to be in the angle units of the current axesm-based map.

`[x, y, z] = camupm(lat, long)` returns the camera position in the projected Cartesian coordinate system.

Examples

Look at northern Australia from a point south of and one Earth radius above New Zealand. Set `CameraUpVector` to the antipode of the camera target for that *down under* view.

```
axesm('globe', 'galt', 0)
gridm('glinestyle', '-')
load topo60c
geoshow(topo60c, topo60cR, 'DisplayType', 'texturemap');
demcmap(topo60c)
camlight
material(0.6*[ 1 1 1])
plat = -50;
plon = 160;
tlat = -10;
tlon = 130;
[alat, alon] = antipode(tlat, tlon);
camtargm(tlat, tlon, 0)
camposm(plat, plon, 1)
camupm(alat, alon)
set(gca, 'CameraViewAngle', 80)
land = shaperead('landareas.shp', 'UseGeoCoords', true);
linem([land.Lat], [land.Lon])
axis off
```



Version History

Introduced before R2006a

See Also

camtargm | camposm | camup | camva

cart2grn

Transform projected coordinates on axesm-based map to Greenwich system

Syntax

```
[lat,lon,alt] = cart2grn  
[lat,lon,alt] = cart2grn(hndl)  
[lat,lon,alt] = cart2grn(hndl,mstruct)
```

Description

When objects are projected and displayed on axesm-based maps, they are plotted in Cartesian coordinates appropriate for the selected projection. This function transforms those coordinates back into the Greenwich frame, in which longitude is measured positively East from Greenwich (longitude 0), England and negatively West from Greenwich.

[lat,lon,alt] = cart2grn returns the latitude, longitude, and altitude data in geographic coordinates of the current map object, removing any clips or trims introduced during the display process from the output data.

[lat,lon,alt] = cart2grn(hndl) specifies the displayed map object desired with its handle hndl. The default handle is gco.

[lat,lon,alt] = cart2grn(hndl,mstruct) specifies the map structure associated with the object. The map structure of the current axes is the default.

Version History

Introduced before R2006a

See Also

gcm | projinv | projfwd

cat

Concatenate geographic or planar vector

Syntax

```
v = cat(1,v1,v2,...)
```

Description

`v = cat(1,v1,v2,...)` concatenates the geographic or planar vectors `v1,v2`, and so on, along the first dimension. If the class type of any property is a cell array, then the resultant field in the output `v` is also a cell array.

Examples

Concatenate Two Geopoint Vectors

Create two geopoint vectors. The first vector has one feature, and the second vector has two features. The vectors have different dynamic properties.

```
gp1 = geopoint(52,-101, 'Weather', 'Cloudy');
gp2 = geopoint([42 42.2], [-110.5 -110.7], 'Temperature', [65.6 63.2]);
```

Concatenate the vectors into a single geopoint vector. Note that the first input argument must be 1.

```
p = cat(1,gp1,gp2)
```

```
p =
3x1 geopoint vector with properties:

Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
Feature properties:
    Latitude: [52 42 42.2000]
    Longitude: [-101 -110.5000 -110.7000]
    Weather: {'Cloudy' '' ''}
    Temperature: [0 65.6000 63.2000]
```

The concatenated vector has three features, and all features have all dynamic properties. Default property values are used when the value was not specified in the original geopoint vector. For example, the 'Temperature' value of the first feature is set to 0 since no 'Temperature' value was specified in `gp1`.

Input Arguments

v1,v2,... — Geographic or planar vectors to be concatenated
geopoint, geoshape, mappoint, or mapshape objects

Geographic or planar vectors to be concatenated, specified as `geopoint`, `geoshape`, `mappoint`, or `mapshape` objects. All of `v1`, `v2`,... are the same type of object.

Output Arguments

v — Concatenated geographic or planar vector

`geopoint`, `geoshape`, `mappoint`, or `mapshape` object

Concatenated geographic or planar vector, returned as a `geopoint`, `geoshape`, `mappoint`, or `mapshape` object. The object type of `v` matches the object type of `v1`, `v2`, ...

Version History

Introduced in R2012a

See Also

`vertcat`

changem

Replace values in array

Syntax

```
B = changem(A,new)
B = changem(A,new,old)
```

Description

`B = changem(A, new)` replaces all occurrences of 0 in array `A` with the specified scalar `new`. This function is useful for replacing values in classification grids.

`B = changem(A, new, old)` replaces all occurrences of `old` with `new`.

Examples

Replace Values in Land Cover Classification

Read a land cover classification of Oahu, Hawaii as an array, a map cells reference object, and a colormap. The elements of the array index into the colormap.

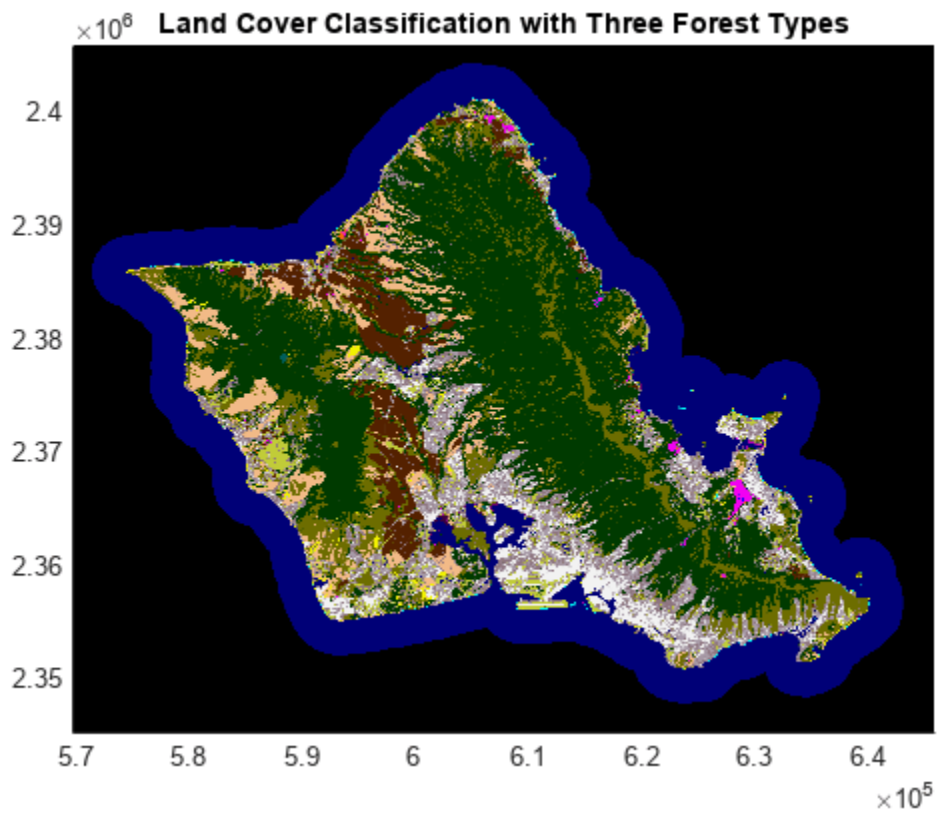
```
[A,R,cmap] = readgeoraster("oahu_landcover.img");
```

Deciduous forest, evergreen forest, and mixed forest are indicated by the values 9, 10, and 11 in the array, respectively. Create an array that uses the same color for all forests by replacing occurrences of 9 and 10 with 11.

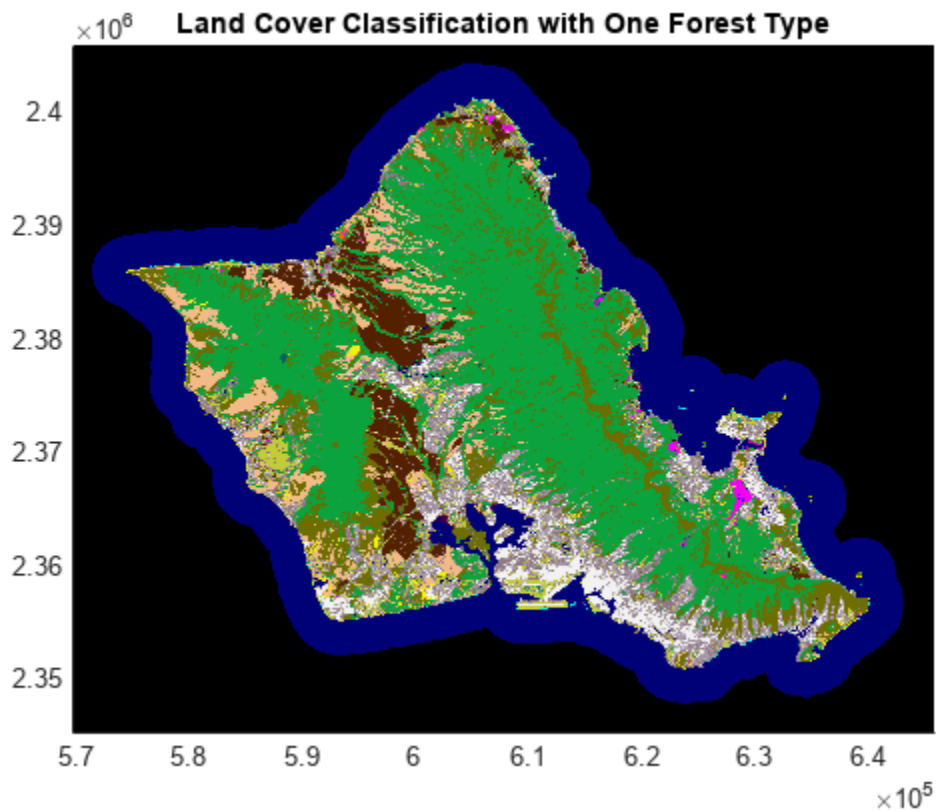
```
new = [11 11];
old = [9 10];
B = changem(A,new,old);
```

Display the old and new land cover classifications.

```
figure
mapshow(A,cmap,R)
title("Land Cover Classification with Three Forest Types")
```



```
figure  
mapshow(B,cmap,R)  
title("Land Cover Classification with One Forest Type")
```

Input Arguments

A — Input array

array

Input array.

new — New value

scalar | vector

New value, specified as a scalar or vector. When new and old are vectors, the function replaces occurrences of old(k) with new(k).

The size of new must match the size of old.

old — Value to replace

scalar | vector

Value to replace, specified as a scalar or vector. When new and old are vectors, the function replaces occurrences of old(k) with new(k).

The size of new must match the size of old.

Version History

Introduced before R2006a

See Also

Functions

replace | fillmissing | readgeoraster

circcirc

Find intersection of circles in Cartesian coordinates

Syntax

```
[xout,yout] = circcirc(centerx1,centery1,radius1,centerx2,centery2,radius2)
```

Description

`[xout,yout] = circcirc(centerx1,centery1,radius1,centerx2,centery2,radius2)` finds the intersection of two circles with the specified centers and radii, in Cartesian coordinates.

Examples

Find Intersection of Two Circles

Find the intersection of two circles. The first circle has its center at (-2, 3) and a radius of 4. The second circle has its center at (1, -5) and a radius of 6.

```
[xout,yout] = circcirc(-2,3,4,1,-5,6)
```

```
xout = 1×2
```

```
    1.4541    -3.2760
```

```
yout = 1×2
```

```
    0.9828   -0.7910
```

Input Arguments

centerx1 — x-coordinate of center of first circle

numeric scalar

x-coordinate of the center of the first circle, specified as a numeric scalar.

centery1 — y-coordinate of center of first circle

numeric scalar

y-coordinate of the center of the first circle, specified as a numeric scalar.

radius1 — Radius of first circle

positive scalar

Radius of the first circle, specified as a positive scalar.

centerx2 — x-coordinate of center of second circle

numeric scalar

x-coordinate of the center of the second circle, specified as a numeric scalar.

centery2 — y-coordinate of center of second circle

numeric scalar

y-coordinate of the center of the second circle, specified as a numeric scalar.

radius2 — Radius of second circle

positive scalar

Radius of the second circle, specified as a positive scalar.

Output Arguments**xout — x-coordinates of intersections**

two-element vector

x-coordinates of the intersections, returned as a two-element vector.

- When the circles are tangent, the elements of the vector are equal.
- When the circles do not intersect or are identical, both elements are NaN.

yout — y-coordinates of intersections

two-element vector

y-coordinates of the intersections, returned as a two-element vector.

- When the circles are tangent, the elements of the vector are equal.
- When the circles do not intersect or are identical, both elements are NaN.

Version History**Introduced before R2006a****See Also****Functions**

linecirc

clabelm

Label map contour plot

Syntax

```
clabelm(C,h)
clabelm(C,h,levels)
clabelm(C,h,"manual")
t = clabelm( ___ )
```

```
clabelm(C)
clabelm(C,levels)
clabelm(C,"manual")
tl = clabelm( ___ )
```

```
clabelm( ___ , "LabelSpacing", spacing)
```

Description

Rotated Labels

`clabelm(C,h)` labels the current map contour plot by inserting rotated text into each contour line. If a contour line is not long enough to fit the text, then the function does not insert the text.

The `clabelm` function supports only contour plots created using the `contourfm`, `contourm`, `contour3m`, or `geoshow` function. To label other contour plots, use the `clabel` function.

`clabelm(C,h,levels)` labels the contour levels specified by `levels`.

`clabelm(C,h,"manual")` labels the locations you select with the mouse. Click the mouse or press the space bar to label the contour closest to the center of the cursor. To finish labeling, while the cursor is within the figure, press **Enter**.

`t = clabelm(___)` returns the labels as text objects, using any combination of input arguments from the previous syntaxes in this group. Use `t` to modify properties of the text after creating it. For a list of properties, see [Text Properties](#).

Upright Labels

`clabelm(C)` labels the current contour plot by adding upright text next to each contour line. The function randomly selects the positions of the labels. This syntax displays plus symbols (+) on the contour lines next to the labels.

`clabelm(C,levels)` labels the contour levels specified by `levels`.

`clabelm(C,"manual")` labels the locations you select with the mouse. Click the mouse or press the space bar to label the contour closest to the center of the cursor. To finish labeling, while the cursor is within the figure, press **Enter**.

`tl = clabelm(___)` returns the labels as text objects and the plus symbols (+) as line objects, using any combination of input arguments from the previous syntaxes in this group.

Additional Options

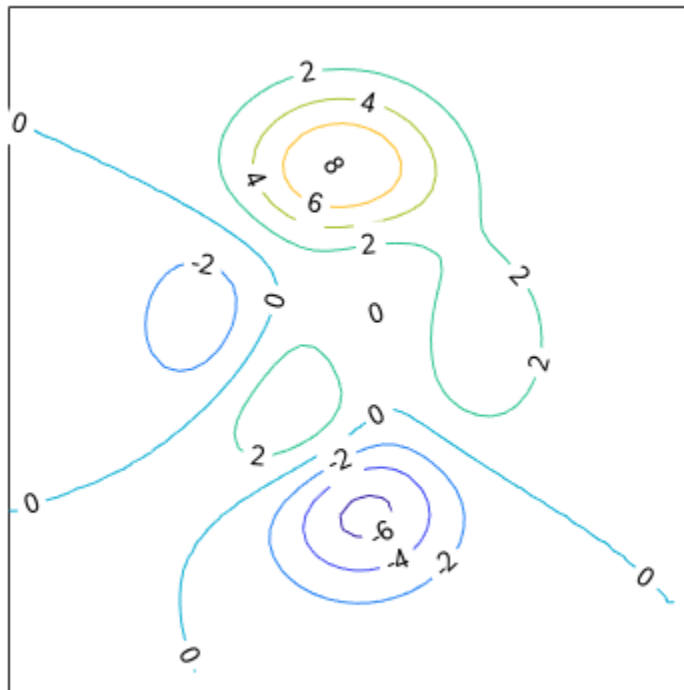
`clabelm(____, "LabelSpacing", spacing)` specifies the spacing between labels on the same contour line.

Examples

Add Labels to Contour Plot

Create a contour plot from sample map data. Obtain the contour matrix `C` and the contour patch `h`. Then, label the contour plot.

```
Z = peaks;  
R = georefcalls([-0.1 0],[0 0.1],size(Z));  
axesm miller  
[C,h] = contourm(Z,R);  
  
clabelm(C,h)
```

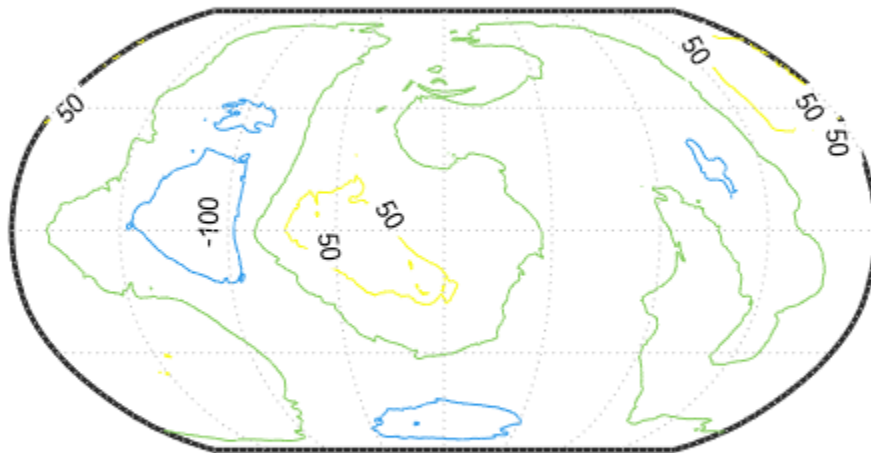


Label Specific Contour Levels

Create a contour plot using geoid heights from the Earth Gravitational Model of 1996 (EGM96). Label only the contours with contour levels -100 or 50.

```
[N,R] = egm96geoid;
worldmap(N,R)
plabel off
mlabel off

[C,h] = contourm(N,R,-100:50:100);
clabelm(C,h,[-100 50])
```



Set Contour Label Properties

Create an elevation map for a region surrounding the Korean peninsula.

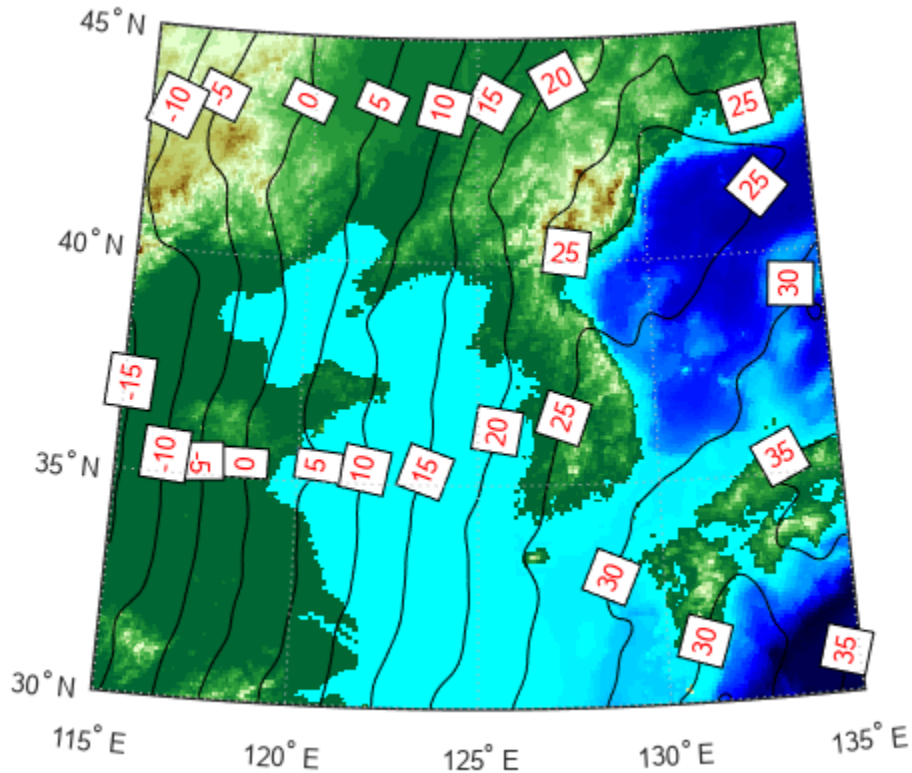
```
load korea5c
worldmap(korea5c,korea5cR)
geoshow(korea5c,korea5cR,"DisplayType","texturemap")
demcmap(korea5c)
```

Create a contour plot using geoid heights from the Earth Gravitational Model of 1996 (EGM96).

```
N = egm96geoid(korea5cR);
[C,h] = contourm(N,korea5cR,-100:5:100,"k");
```

Label the contours and return the text objects. Change the text color and the edge color by setting properties of the text objects.

```
t = clabelm(C,h);
set(t,"Color","r")
set(t,"EdgeColor","k")
```



Input Arguments

C — Contour matrix

two-row matrix

Contour matrix, specified as a two-row matrix returned by the `contourm`, `contourfm`, or `contour3m` function. This argument contains the data that defines the contour lines. The first row of the matrix contains longitude data and the second row of the matrix contains latitude data.

If you pass the contour object `h` to the `clabelm` function, then you can replace this argument with `[]`. For example, use `clabelm([],h)`.

h — Contour patches

Group object

Contour patches, specified as a Group object returned by the `contourm`, `contourfm`, `contour3m`, or `geoshow` function.

levels — Contour levels

vector

Contour levels, specified as a row or column vector of individual values.

Example: `[0, 10, 20]`

spacing – Label spacing

144 (default) | scalar

Label spacing along the contour lines, specified as a scalar value in points, where one point is 1/72 inch. Use this property to control the number of contour labels along the contour lines. Smaller values produce more labels.

If the length of a contour line is less than `spacing`, then the function displays one label on the line.

Output Arguments

t – Text objects

vector

Text objects, returned as a vector. The `UserData` properties of the text objects contain the contour values displayed.

tL – Text and line objects

vector

Text and line objects, returned as a vector. The `UserData` properties of the text objects contain the contour values displayed. The line objects correspond to the plus symbols (+).

Version History

Introduced before R2006a

See Also

Functions

`clegendm` | `contourm` | `contour3m` | `contourfm` | `clabel`

clegendm

Add legend labels to map contour display

Syntax

```
clegendm(C,h)
clegendm(C,h,loc)
clegendm( ____,unitstr)
clegendm( ____,labels)
hl = clegendm( ____)
```

Description

`clegendm(C,h)` adds a legend specifying the contour line heights, `C`, to the current map contour plot, `h`.

`clegendm(C,h,loc)` places the legend in a specified location.

`clegendm(____,unitstr)` appends a string `unitstr` to each entry in the legend.

`clegendm(____,labels)` uses the text specified in `labels` to label the legend.

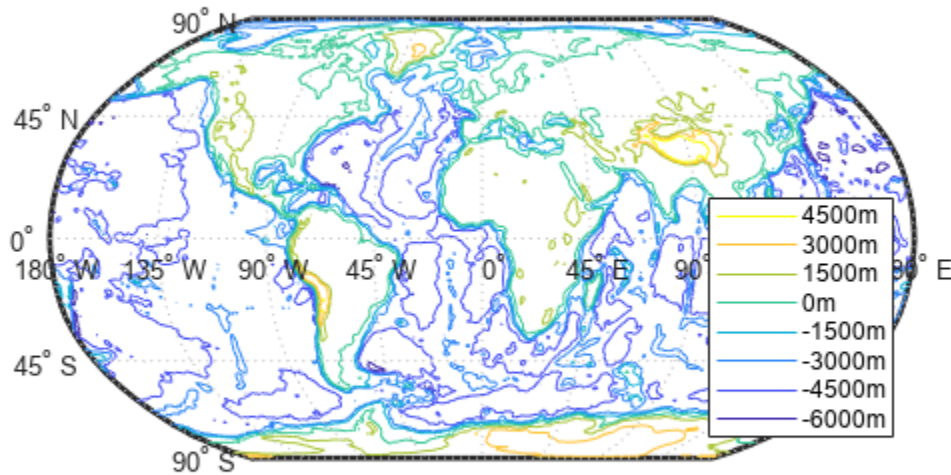
`hl = clegendm(____)` returns the handle to the legend object created.

Examples

Create Legend for Contour Display

Load elevation raster data and a geographic cells reference object. Display the data using a contour plot on a world map. Then, create a legend in the lower-right corner of the map. Specify the contour elevations as meters.

```
load topo60c
worldmap('world')
[c,h] = contourm(topo60c,topo60cR,-6000:1500:6000);
clegendm(c,h,4,'m')
```



Input Arguments

C – Contour matrix

numeric matrix

Contour matrix, specified as a matrix with two rows. The first row represents longitude data and the second row represents latitude data. You can create a contour matrix by using `contourm`, `contour3m`, or `contourfm`.

h – Handle of contour patches

hggroup

Handle to the contour patches displayed on the current axes, returned as an hggroup. You can get a handle to contour patches by using `contourm`, `contour3m`, or `contourfm`.

loc – Location

0 (default) | 1 | 2 | 3 | 4 | -1

Location to place legend, specified as one of the following integers.

Value	Placement
0	Automatic placement (default)
1	Upper right corner

Value	Placement
2	Upper left corner
3	Lower left corner
4	Lower right corner
-1	To the right of the plot

unitstr — Text to append

character vector | string scalar

Text to append to each entry in the legend, specified as a character vector or string scalar.

labels — Labels

cell array of character vectors | string array

Labels in the legend, specified as a string array or cell array of character vectors. `labels` must have the same number of entries as the line children of `h`.

Output Arguments**hL** — Handle to legend object

handle

Handle to legend object created by the `clegendm` function, returned as a handle.

Version History

Introduced before R2006a

See Also`clabelm` | `contourm` | `contour3m` | `contourfm` | `contourc` | `contourcbar`

clipdata

Clip data at $\pm\pi$ in longitude, $\pm\pi$ in latitude

Syntax

```
[lat,long,splitpts] = clipdata(lat,long,object)
```

Description

`[lat,long,splitpts] = clipdata(lat,long,object)` inserts NaNs at the appropriate locations in a map object so that a displayed map is clipped at the appropriate edges. It assumes that the clipping occurs at $\pm\pi/2$ radians in the latitude (y) direction and $\pm\pi$ radians in the longitude (x) direction.

The input data must be in radians and properly transformed for the particular aspect and origin so that it fits in the specified clipping range.

The output data is in radians, with NaNs placed at the proper locations. The output variable `splitpts` returns the row and column indices of the clipped elements (columns 1 and 2 respectively). These indices are necessary to restore the original data if the map parameters or projection are ever changed.

The `object` parameter can have any of the following values:

Object to clip	Description
'surface'	graticules
'light'	lights
'line'	lines
'patch'	patches
'text'	text object location points
'point'	point data
'none'	skip all clipping operations

Version History

Introduced before R2006a

See Also

`trimdata` | `undoclip` | `undotrim`

clma

Clear current axesm-based map

Syntax

```
clma  
clma all  
clma purge
```

Description

`clma` deletes all displayed map objects from the current axesm-based map, but leaves the frame if it is displayed.

`clma all` deletes all displayed map objects, including the frame, but it leaves the map structure intact, thereby retaining the axesm-based map.

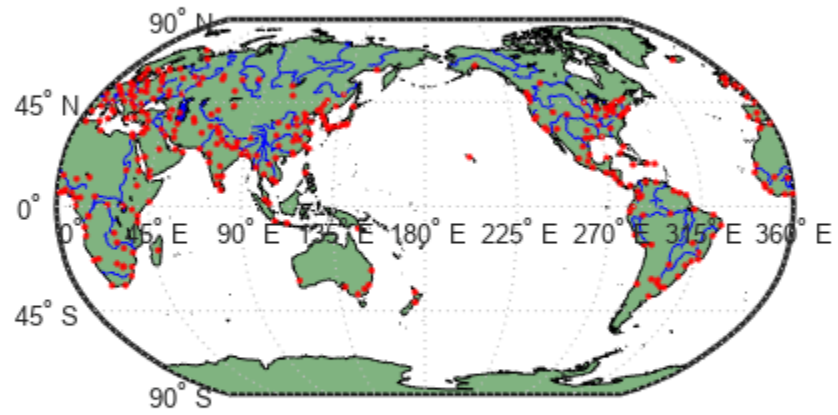
`clma purge` removes the map definition from the current axes, but leaves all objects projected on the axes intact.

Examples

Delete axesm-Based Map Without Frame

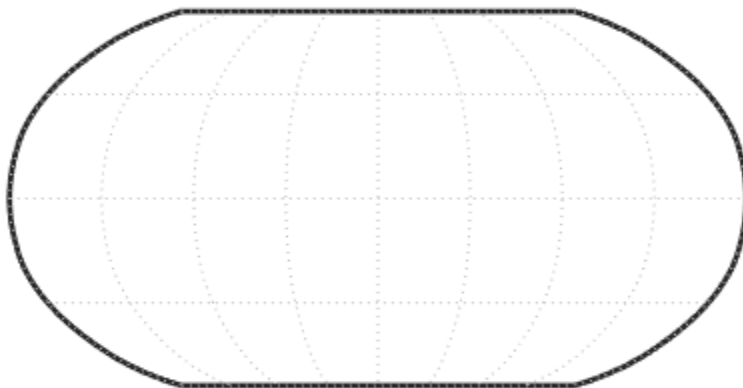
Read and display land areas, major lakes and rivers, cities, and populated places on a world map.

```
ax = worldmap("World");  
setm(ax,"Origin",[0 180 0])  
  
land = readgeotable("landareas.shp");  
geoshow(ax,land,"FaceColor",[0.5 0.7 0.5])  
  
lakes = readgeotable("worldlakes.shp");  
geoshow(lakes,"FaceColor","blue")  
  
rivers = readgeotable("worldrivers.shp");  
geoshow(rivers,"Color","blue")  
  
cities = readgeotable("worldcities.shp");  
geoshow(cities,"Marker",".", "Color","red")
```



Delete all displayed map objects from the current axesm-based map, but retain the frame .

clma



Delete axesm-Based Map Definition Keeping Objects Intact

Read and display land areas, major lakes and rivers, cities, and populated places on a world map.

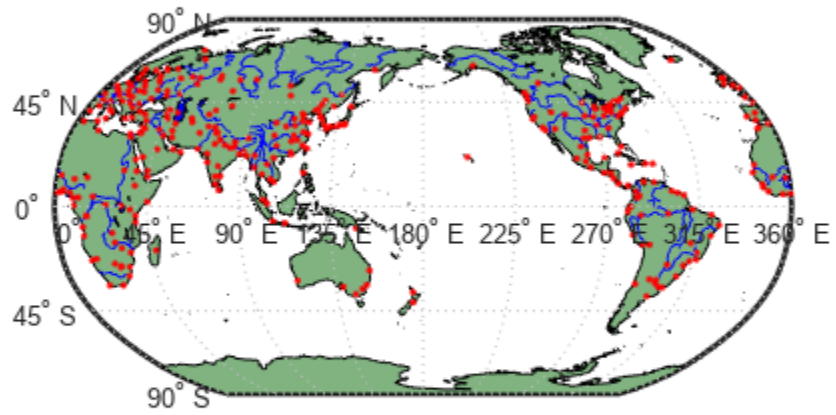
```
ax = worldmap("World");
setm(ax, "Origin", [0 180 0])

land = readgeotable("landareas.shp");
geoshow(ax, land, "FaceColor", [0.5 0.7 0.5])

lakes = readgeotable("worldlakes.shp");
geoshow(lakes, "FaceColor", "blue")

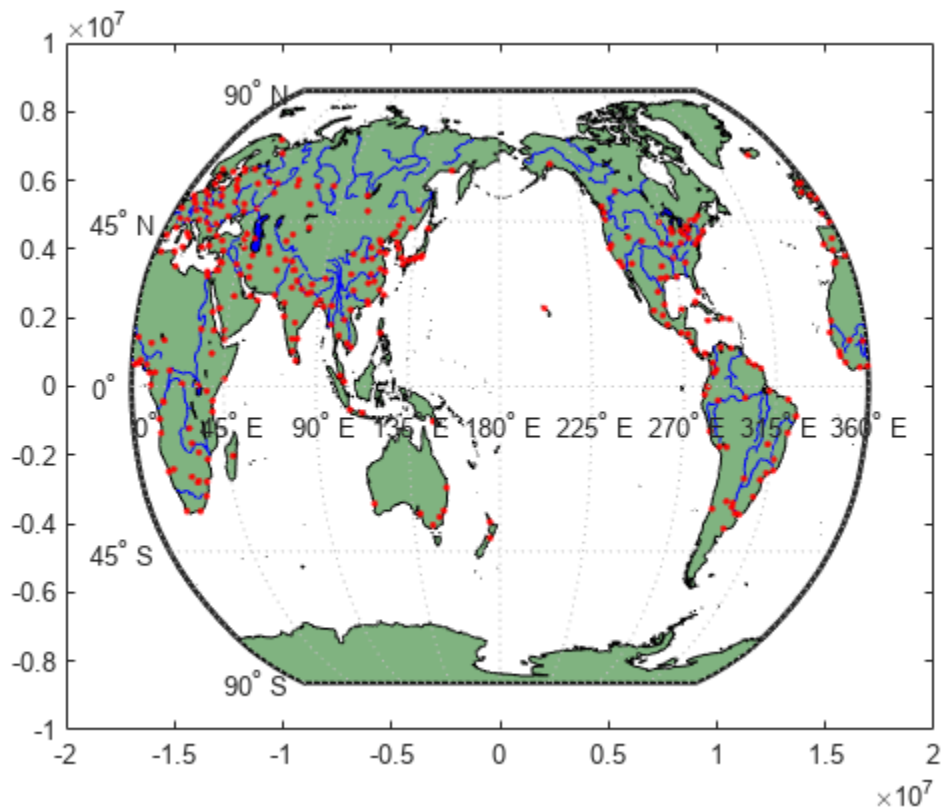
rivers = readgeotable("worldrivers.shp");
geoshow(rivers, "Color", "blue")

cities = readgeotable("worldcities.shp");
geoshow(cities, "Marker", ".", "Color", "red")
```

Delete the map definition from the current axes, but leave all objects projected on the axes intact.

clma [purge](#)



Version History

Introduced before R2006a

See Also

cla | clmo

clmo

Clear graphics objects from axesm-based map

Syntax

```
clmo  
clmo(obj)  
clmo(objType)
```

Description

`clmo` opens a dialog box that enables you to interactively select objects to clear from the current axes.

`clmo(obj)` clears the specified objects.

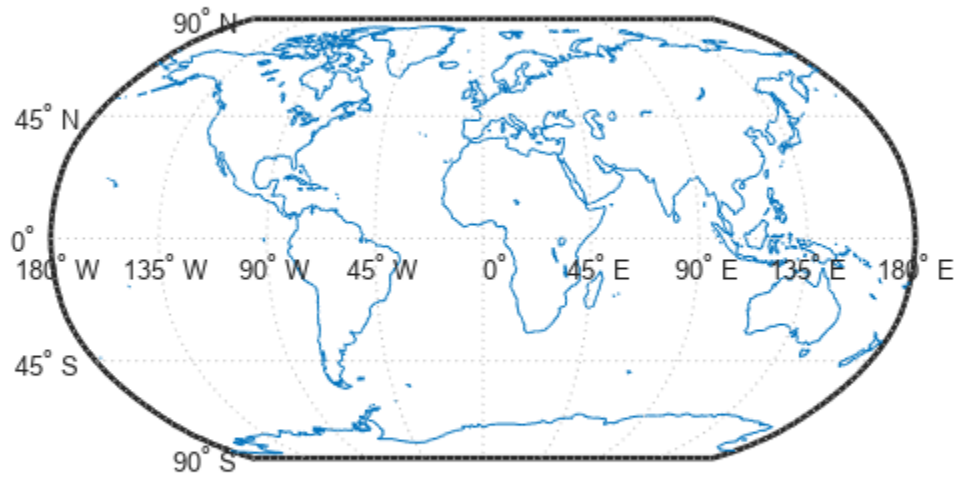
`clmo(objType)` clear objects of the specified type.

Examples

Clear Graphics Objects from Current Axes

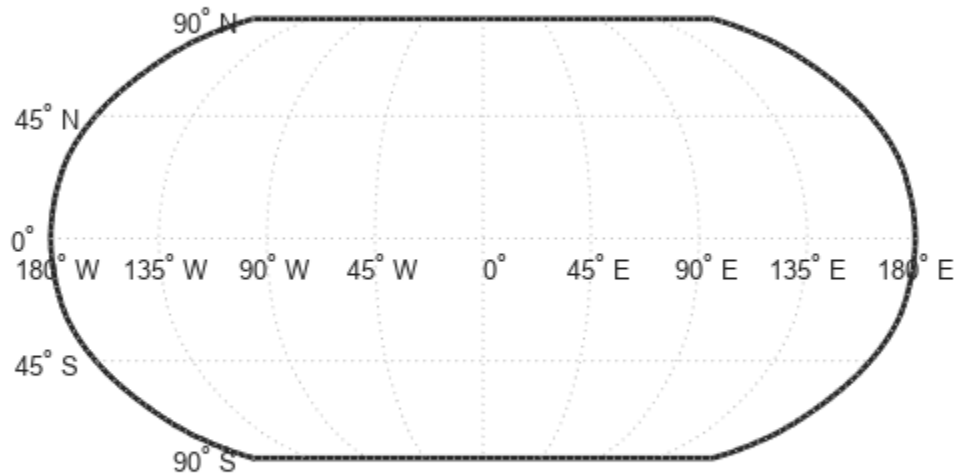
Load a MAT file containing the coordinates of global coastlines into the workspace. Create a world map and then plot the coastline data.

```
load coastlines  
figure  
worldmap("world")  
p = plotm(coastlat,coastlon);
```



Clear the plot from the current axes.

`clm(p)`



Input Arguments

obj – Objects to clear

array of graphics objects

Objects to clear, specified as an array of graphics objects.

objType – Type of graphics object to clear

"all" | "clabel" | "contour" | "fillcontour" | "frame" | ...

Type of graphics object to clear, specified as one of these options.

Option	Description
"all"	All children
"clabel"	Contour labels
"contour"	hggroup containing contours
"fillcontour"	hggroup containing filled contours
"frame"	Map frame
"grid"	Map grid lines
"hggroup"	All hggroup objects

Option	Description
"hidden"	Hidden objects
"image"	Untagged image objects
"light"	Untagged light objects
"line"	Untagged line objects
"map"	All objects on the map, excluding the frame and grid
"meridian"	Longitude grid lines
"mlabel"	Longitude labels
"parallel"	Latitude grid lines
"plabel"	Latitude labels
"patch"	Untagged patch objects
"scaleruler"	Scale rulers
"surface"	Untagged surface objects
"text"	Untagged text objects
"tissot"	Tissot indicatrices
"visible"	Visible objects

Data Types: char | string

Version History

Introduced before R2006a

See Also

clma | handlem | showm

closePolygonParts

Close all rings in multipart polygon

Syntax

```
[xdata, ydata] = closePolygonParts(xdata, ydata)
[lat, lon] = closePolygonParts(lat, lon, angleunits)
```

Description

`[xdata, ydata] = closePolygonParts(xdata, ydata)` ensures that each ring in a multipart (NaN-separated) polygon is “closed” by repeating the start point at the end of each ring, unless the start and end points are already identical. Coordinate vectors `xdata` and `ydata` must match in size and have identical NaN locations.

`[lat, lon] = closePolygonParts(lat, lon, angleunits)` works with latitude-longitude data and accounts for longitude wrapping with a period of 360 if `angleunits` is 'degrees' and 2π if `angleunits` is 'radians'. For a ring to be considered closed, the latitudes of its first and last vertices must match exactly, but their longitudes need only match modulo the appropriate period. Such rings are returned unaltered.

Examples

Close Polygon in Plane Coordinates

Create two vectors of planar coordinates.

```
xOpen = [1 0 2 NaN 0.5 0.5 1 1];
yOpen = [0 1 2 NaN 0.8 1 1 0.8];
```

Create a closed polygon from these coordinates.

```
[xClosed, yClosed] = closePolygonParts(xOpen, yOpen)
```

```
xClosed = 1x10
```

```
    1.0000    0    2.0000    1.0000    NaN    0.5000    0.5000    1.0000    1.0000    0.5000
```

```
yClosed = 1x10
```

```
    0    1.0000    2.0000    0    NaN    0.8000    1.0000    1.0000    0.8000    0.8000
```

Display all variables.

```
whos
```

Name	Size	Bytes	Class	Attributes
xClosed	1x10	80	double	

```
xOpen      1x8      64 double
yClosed    1x10     80 double
yOpen      1x8      64 double
```

Close Polygon in Latitude-Longitude Coordinates

Load coastline data from MAT-file.

```
load coastlines
```

Construct a two-part polygon based on the coastlines data. The first ring is Antarctica. The longitude of its first vertex is -180 and the longitude of its last vertex is 180. The second ring is a small island from which the last vertex, a replica of the first vertex, is removed.

```
[latparts, lonparts] = polysplit(coastlat, coastlon);
latparts{2}(end) = [];
lonparts{2}(end) = [];
latparts(3:end) = [];
lonparts(3:end) = [];
[lat, lon] = polyjoin(latparts, lonparts);
```

Examine how `closePolygonParts` treats the two rings. In both cases, the first and last vertices differ. However, Antarctica remains unchanged while the small island is closed back up.

```
[latClosed, lonClosed] = closePolygonParts(lat, lon, 'degrees');
[latpartsClosed, lonpartsClosed] = polysplit(latClosed, lonClosed);
lonpartsClosed{1}(end) - lonpartsClosed{1}(1) % Result is 360

ans = 360

lonpartsClosed{2}(end) - lonpartsClosed{2}(1) % Result is 0

ans = 0
```

Version History

Introduced in R2006a

See Also

`isShapeMultipart` | `removeExtraNanSeparators`

Topics

“Create and Display Polygons”

combntns

(Removed) All possible combinations of set of values

Note The `combntns` function has been removed. Use the `nchoosek` function instead. For more information, see “Compatibility Considerations”.

Syntax

`C = combntns(v,k)`

Description

`C = combntns(v,k)` returns all possible combinations of the set of values `v`, given combinations of length `k`.

Examples

All Combinations of Five Numbers Taken Three at a Time

Find all possible combinations of five numbers taken three at a time.

```
v = 1:5;
C = combntns(v,3)
```

C =

```

1     2     3
1     2     4
1     2     5
1     3     4
1     3     5
1     4     5
2     3     4
2     3     5
2     4     5
3     4     5
```

Input Arguments

v — Set of all choices

vector

Set of all choices, specified as a vector.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical` | `char`

Complex Number Support: Yes

k — Number of selected choices

nonnegative integer scalar

Number of selected choices, specified as a nonnegative integer scalar. This argument can be any numeric type, but must be real.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

Output Arguments**C — All combinations of v**

matrix

All combinations of *v*, returned as a matrix of the same data type as *v*. The number of columns in *C* is the same as the value of *k*.

Version History**Introduced before R2006a****R2022b: Removed***Errors starting in R2022b*

The `combntns` function has been removed. Use the `nchoosek` function instead. To update your code, replace instances of the `combntns` function with the `nchoosek` function.

R2014a: To be removed*Warns starting in R2014a*

The `combntns` function issues a warning that it will be removed in a future release.

See Also`nchoosek`

map.geodesy.ConformalLatitudeConverter

Convert between geodetic and conformal latitudes

Description

A `ConformalLatitudeConverter` object provides conversion methods between geodetic and conformal latitudes for an ellipsoid with a given eccentricity.

The conformal latitude maps an ellipsoid (oblate spheroid) to a sphere while preserving shapes and angles locally. (Curves that meet at a given angle on the ellipsoid meet at the same angle on the sphere.) Use conformal latitudes when implementing conformal map projections on the ellipsoid.

Creation

Syntax

```
converter = map.geodesy.ConformalLatitudeConverter
converter = map.geodesy.ConformalLatitudeConverter(spheroid)
```

Description

`converter = map.geodesy.ConformalLatitudeConverter` creates a `ConformalLatitudeConverter` object for a sphere and sets the `Eccentricity` property to 0.

`converter = map.geodesy.ConformalLatitudeConverter(spheroid)` creates a conformal latitude converter object and sets the `Eccentricity` property to match the specified spheroid object.

Input Arguments

spheroid — Reference spheroid

referenceEllipsoid object | oblateSpheroid object | referenceSphere object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

Properties

Eccentricity — Ellipsoid eccentricity

0 | numeric scalar

Ellipsoid eccentricity, specified as a numeric scalar. Eccentricity is in the interval [0, 0.5]. Eccentricities larger than 0.5 are possible in theory, but do not occur in practice and are not supported.

Data Types: double

Object Functions

`forward` Convert geodetic latitude to authalic, conformal, isometric, or rectifying latitude
`inverse` Convert authalic, conformal, isometric, or rectifying latitude to geodetic latitude

Examples

Create a Conformal Latitude Converter Object and Set Property

```
grs80 = referenceEllipsoid('GRS 80');  
  
conv1 = map.geodesy.ConformalLatitudeConverter;  
conv1.Eccentricity = grs80.Eccentricity  
  
conv1 =  
  
    ConformalLatitudeConverter with properties:  
  
    Eccentricity: 0.0818
```

Create a Conformal Latitude Converter Object Specifying a Spheroid

```
grs80 = referenceEllipsoid('GRS 80');  
  
conv2 = map.geodesy.ConformalLatitudeConverter(grs80)  
  
conv2 =  
  
    ConformalLatitudeConverter with properties:  
  
    Eccentricity: 0.0818
```

Version History

Introduced in R2013a

See Also

Functions

`geocentricLatitude` | `parametricLatitude`

Objects

`AuthalicLatitudeConverter` | `IsometricLatitudeConverter` | `RectifyingLatitudeConverter`

contains

Package: map.rasterref

Determine if geographic or map raster contains points

Syntax

```
tf = contains(R, lat, lon)
tf = contains(R, xWorld, yWorld)
```

Description

`tf = contains(R, lat, lon)` determines whether the points (lat, lon) in geographic coordinates fall within the bounds of geographic raster R.

`tf = contains(R, xWorld, yWorld)` determines whether the points (xWorld, yWorld) in the world coordinate system fall within the bounds of map raster R contains .

Examples

Check If Single Point Exists Within Bounds of Planar Raster

Create a MapPostingsReference raster reference object.

```
xWorldLimits = [207000 208000];
yWorldLimits = [912500 913000];
rasterSize = [11 21];
R = maprefpostings(xWorldLimits, yWorldLimits, rasterSize, 'ColumnsStartFrom', 'north')
```

R =

MapPostingsReference with properties:

```

    XWorldLimits: [207000 208000]
    YWorldLimits: [912500 913000]
    RasterSize: [11 21]
    RasterInterpretation: 'postings'
    ColumnsStartFrom: 'north'
    RowsStartFrom: 'west'
    SampleSpacingInWorldX: 50
    SampleSpacingInWorldY: 50
    RasterExtentInWorldX: 1000
    RasterExtentInWorldY: 500
    XIntrinsicLimits: [1 21]
    YIntrinsicLimits: [1 11]
    TransformationType: 'rectilinear'
    CoordinateSystemType: 'planar'
    ProjectedCRS: []
```

Check if the raster contains the point (207549,912753). The expected result is 1 (true) since the x-coordinate is within R.XWorldLimits and the y-coordinate is within R.YWorldLimits.

```
tf = contains(R,207549,912753)
```

```
tf = logical  
    1
```

Check If Multiples Points Exist Within Bounds of Geographic Raster

Create a GeographicCellsReference raster reference object.

```
latlim = [0 89];  
lonlim = [-180 179];  
rasterSize = [90 360];  
R = georefcells(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')
```

```
R =  
GeographicCellsReference with properties:  
  
    LatitudeLimits: [0 89]  
    LongitudeLimits: [-180 179]  
    RasterSize: [90 360]  
    RasterInterpretation: 'cells'  
    ColumnsStartFrom: 'north'  
    RowsStartFrom: 'west'  
    CellExtentInLatitude: 0.988888888888889  
    CellExtentInLongitude: 0.997222222222222  
    RasterExtentInLatitude: 89  
    RasterExtentInLongitude: 359  
    XIntrinsicLimits: [0.5 360.5]  
    YIntrinsicLimits: [0.5 90.5]  
    CoordinateSystemType: 'geographic'  
    GeographicCRS: []  
    AngleUnit: 'degree'
```

Check if points exist within the northern hemisphere.

```
pts_lat = [32 0 -10 32 212];  
pts_lon = [-80 0 80 360 -80];  
tf = contains(R,pts_lat,pts_lon)
```

```
tf = 1x5 logical array  
  
    1    1    0    1    0
```

The first point is in the northern hemisphere. The second point is the origin, and `tf(2)` indicates the origin exists within the bounds of the northern hemisphere. The third point is in the southern hemisphere. The fourth point is identical to the first point after longitude wrapping. The element `tf(4)` demonstrates that the geographic raster supports wrapping of longitude coordinates. The last element `tf(5)` indicates that the geographic raster does not support wrapping of latitude coordinates.

Input Arguments

R — Geographic or map raster

GeographicCellsReference, GeographicPostingsReference, MapCellsReference, or MapPostingsReference object

Geographic or map raster, specified as a GeographicCellsReference, GeographicPostingsReference, MapCellsReference, or MapPostingsReference object.

lat — Latitude coordinates

numeric scalar or vector

Latitude coordinates, specified as a numeric scalar or vector.

Data Types: `single` | `double`

lon — Longitude coordinates

numeric scalar or vector

Longitude coordinates, specified as a numeric scalar or vector. Elements of `lon` can be wrapped arbitrarily without affecting the result.

Data Types: `single` | `double`

xWorld — x-coordinates in the world coordinate system

numeric scalar or vector

x-coordinates in the world coordinate system, specified as a numeric scalar or vector.

Data Types: `single` | `double`

yWorld — y-coordinates in the world coordinate system

numeric scalar or vector

y-coordinates in the world coordinate system, specified as a numeric scalar or vector.

Data Types: `single` | `double`

Output Arguments

tf — Flag indicating geographic or map raster vector contains points in the world coordinate system

logical scalar or vector

Flag indicating geographic or map raster vector contains points in the world coordinate system, returned as a logical scalar or vector. The k th element of `tf` is `True` when `R` contains the point (`xWorld(k)`, `yWorld(k)`) in the world coordinate system.

Data Types: `logical`

Version History

Introduced in R2013b

contour3m

Project 3-D contour plot of map data

Syntax

```
contour3m(Z,R)
contour3m(lat,lon,Z)
contour3m( ____,levels)
contour3m( ____,LineStyle)
contour3m( ____,Name,Value)
C = contour3m( ____)
[C,h] = contour3m( ____)
```

Description

`contour3m(Z,R)` creates a 3-D contour plot of the regular data grid `Z` that is spatially referenced by the geographic raster reference object `R`. The function displays the lines for each contour level in the axes at the `z`-coordinate equal to the value of the contour level.

`contour3m(lat,lon,Z)` creates a 3-D contour plot of the geolocated data grid `Z` that is referenced to the latitude-longitude coordinates contained in `lat` and `lon`.

`contour3m(____,levels)` specifies the contour lines to display, in addition to any combination of arguments from the previous syntaxes.

`contour3m(____,LineStyle)` specifies the style and color of the contour lines.

`contour3m(____,Name,Value)` specifies additional options for the contour plot using one or more name-value arguments.

`C = contour3m(____)` returns the contour matrix `C`, which contains the latitude and longitude coordinates of the vertices at each level.

`[C,h] = contour3m(____)` returns the contour matrix and the contour patches `h`.

Examples

Create 3-D Contour Plot

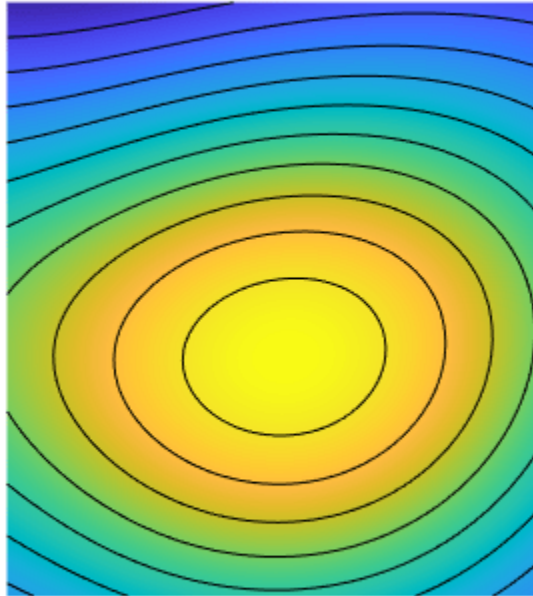
Display sample map data as a surface on a map. Then, display 3-D contours of the sample data on the same map.

```
R = georefpostings([10 50],[60 100],[100 100]);
Z = geopeaks(R);
```

```
figure
axesm miller
axis off
```

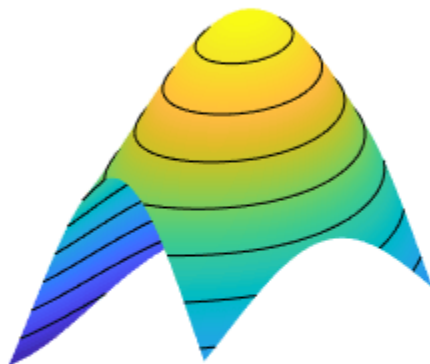


```
geoshow(Z,R,"DisplayType","surface")  
contour3m(Z,R,"k")
```



Exaggerate the z-axis of the axes. Then, view the map in 3-D.

```
daspect([1 1 5])  
view(3)
```



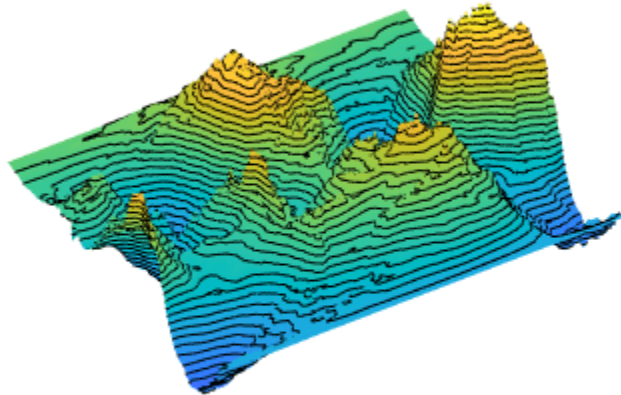
Specify Number of Contour Levels

Read geoid heights from the Earth Gravitational Model of 1996 (EGM96) into the workspace. Display the data as a surface on a map. Then, display contours at 40 levels of Z.

```
[Z,R] = egm96geoid;  
  
figure  
axesm miller  
axis off  
  
geoshow(Z,R,"DisplayType","surface")  
contour3m(Z,R,40,"k")
```

Exaggerate the z-axis of the axes. Then, view the map in 3-D.

```
daspect([1 1 50])  
view(3)
```



Specify Spacing Between Contour Lines

Load global elevation and bathymetry data. Crop the data to include an area around South Asia.

```
load topo60c
latlim = [0 50];
lonlim = [35 115];
[Z,R] = geocrop(topo60c,topo60cR,latlim,lonlim);
```

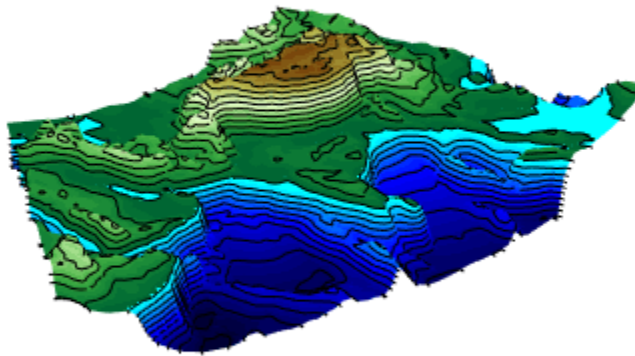
Display the data as a surface, using a colormap appropriate for elevation data. Then, create a 3-D contour plot on top of the surface. Display contour lines at increments of 500 meters.

```
figure
axesm("lambertstd","MapLatLimit",latlim,"MapLonLimit",lonlim)
axis off
tightmap

geoshow(Z,R,"DisplayType","surface")
demcmap(Z)
contour3m(Z,R,"k","LevelStep",500)
```

Exaggerate the z-axis of the axes. Then, view the map in 3-D.

```
daspect([1 1 40000])
view(3)
```



Input Arguments

Z — Regular or geolocated data grid

M-by-*N* matrix

Regular or geolocated data grid, specified as an *M*-by-*N* matrix.

The `contour3m` function does not display contour lines for elements of *Z* that have values of `NaN`.

R — Spatial reference

`GeographicCellsReference` object | `GeographicPostingsReference` object

Spatial reference for *Z*, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object. The `RasterSize` property of *R* must be consistent with `size(Z)`.

lat — Latitude coordinates

M-by-*N* matrix | *M*-element vector

Latitude coordinates, specified as an *M*-by-*N* matrix or an *M*-element vector.

This argument does not support `NaN` values. To indicate missing data, set the corresponding element of *Z* to a value of `NaN`, instead.

Lon — Longitude coordinates*M*-by-*N* matrix | *M*-element vector

Longitude coordinates, specified as an *M*-by-*N* matrix or an *M*-element vector.

This argument does not support NaN values. To indicate missing data, set the corresponding element of *Z* to a value of NaN, instead.

Levels — Contour levels

positive integer | numeric vector

Contour levels, specified as a positive integer or a numeric vector.


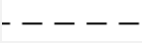
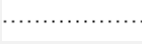

- To display contour lines at *n* automatically chosen levels, specify this argument as *n*. The function chooses levels based on the values in *Z*.
- To display contour lines at specific levels, specify this argument as a vector of increasing values.
- To display contour lines at a single level, *k*, specify this argument as a two-element row vector [*k* *k*].


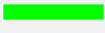






LineStyle — Line style and color

character vector | string scalar

Line style and color, specified as a character vector or string scalar containing characters and symbols. The characters and symbols can appear in any order. You can specify the line style, line color, or both. Marker symbols such as 'o' are ignored.

Example: '- - g' is a green dashed line.

Line Style	Description	Resulting Line
" - "	Solid line	
" - - "	Dashed line	
" : "	Dotted line	
" - . "	Dash-dotted line	

Color Name	Short Name	Appearance
'red'	'r'	
'green'	'g'	
'blue'	'b'	
'cyan'	'c'	
'magenta'	'm'	
'yellow'	'y'	
'black'	'k'	
'white'	'w'	

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `contour3m(Z,R,ShowText="on")` displays the contour line labels.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `contour3m(Z,R,"ShowText","on")` displays the contour line labels.

Note In addition to the name-value arguments in this section, you can use name-value arguments to specify values for the `HandleVisibility`, `Parent`, `Tag`, `UserData`, and `Visible` properties of the `Group` object returned by this function. For more information about these group object properties, see `Group`.

Fill — Fill between contour lines

"off" (default) | "on"

Fill between the contour lines, specified as one of these values:

- "off" — Do not fill the spaces between contour lines with a color.
- "on" — Fill the spaces between contour lines with color.

LabelSpacing — Label spacing

144 (default) | scalar

Label spacing along the contour lines, specified as a scalar value in points, where one point is 1/72 inch. Use this property to control the number of contour labels along the contour lines. Smaller values produce more labels.

You must specify `ShowText` as "on" for `LabelSpacing` to have an effect.

If the length of a contour line is less than `LabelSpacing`, then the function displays one label on the line.

LevelList — Contour levels

row vector of increasing values in Z

Contour levels, specified as a row vector of increasing values in Z. By default, the `contour3m` function chooses values that span the range of values in Z.

LevelStep — Spacing between contour lines

positive scalar

Spacing between the contour lines, specified as a positive scalar. For example, specify a value of 2 to display contour lines at increments of 2. By default, the `contour3m` function determines the spacing based on the values in Z. If you specify both `levels` and `LevelStep`, then the function ignores `LevelStep`.

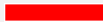




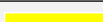


LineColor — Color of contour lines

"flat" (default) | RGB triplet | "r" | "g" | "b" | "none" | ...

Color of the contour lines, specified as "flat", a color name, a short name, an RGB triplet, or "none". The default value of "flat" selects a distinct color for lines at each contour level from the colormap of the figure in which the contours are drawn. The value "none" applies no color to the lines.

For a custom color, specify an RGB triplet. An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1]; for example, [0.4 0.6 0.7].




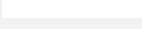
Alternatively, you can specify some common colors by name. This table lists the named color options and equivalent RGB triplets.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

LineStyle – Line style

"-" (default) | "--" | ":" | "-." | "none"

Line style, specified as one of the options listed in this table.

Line Style	Description	Resulting Line
"-"	Solid line	
--"	Dashed line	
:"	Dotted line	
-."	Dash-dotted line	
"none"	No line	No line

LineWidth – Line width

0.5 (default) | positive scalar

Contour line width, specified as a positive scalar in points. One point equals 1/72 inch.

ShowText – Contour line labels

"off" (default) | "on"

Contour line labels, specified as one of these values:

- "on" — Display the contour level along the contour lines.

- "off" — Do not label the contour lines.

Output Arguments

C — Contour matrix

matrix with two rows

Contour matrix, returned as a matrix with two rows. This argument contains the data that defines the contour lines. The first row of the matrix contains longitude data and the second row of the matrix contains latitude data.

h — Contour patches

Group object

Contour patches, returned as a Group object.

Tips

- When you use the `contour3m` function with an `axesm`-based map that contains a globe map frame, the `contour3m` function issues a warning.
- The `contour3m` function behaves the same as the `contourm` function, except the `contour3m` function displays the lines for each contour level at the *z*-coordinate equal to the value of the level.

Version History

Introduced before R2006a

R2022b: contour3m will not accept referencing vectors or referencing matrices as input

Not recommended starting in R2022b

The `contour3m` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.

- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

See Also

Functions

`contourcbar` | `contourm` | `contourfm` | `clabelm` | `geoshow`

contourcbar

Color bar for filled contour map display

Syntax

```
contourcbar
contourcbar(location)
contourcbar( ____,Name,Value)
contourcbar(ax, ____)
c = contourcbar( ____)

contourcbar("off")
contourcbar(ax,"off")
```

Description

Add Color Bar

`contourcbar` displays a vertical color bar to the right of the current axes. Color bars display the current colormap and indicate the mapping of data values into the colormap. If the current axes contains a contour object created by the `contourm`, `contourfm`, `contour3m`, or `geoshow` function, then the `contourcbar` function breaks the colormap into sections that correspond to the contour levels in the plot. Otherwise, the color bar displays the current colormap.

`contourcbar(location)` displays the color bar in a specific location, such as "northoutside".

`contourcbar(____,Name,Value)` modifies the color bar appearance using one or more name-value arguments, in addition to any combination of input arguments from the previous syntaxes. For example, "Direction", "reverse" reverses the color scale.

`contourcbar(ax, ____)` adds a color bar to the axes specified by `ax`. Specify the target axes as the first argument in any of the previous syntaxes.

`c = contourcbar(____)` returns the `ColorBar` object.

Remove Color Bar

`contourcbar("off")` deletes all color bars associated with the current axes.

`contourcbar(ax,"off")` deletes all color bars associated with the target axes.

Examples

Add Color Bar for Contoured Elevation Data

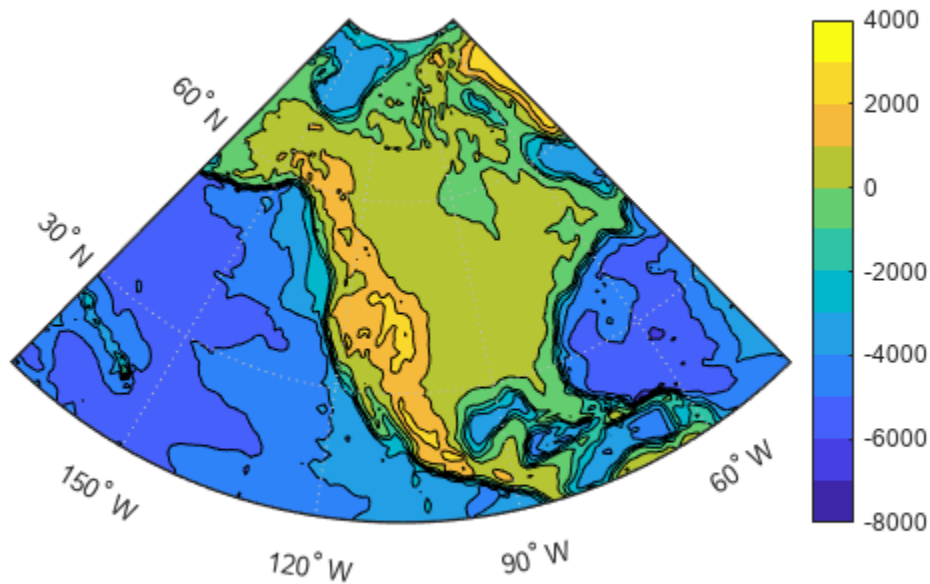
Create a filled contour plot of elevation and bathymetry data for North America. Specify a new contour level every 1000 meters.

```
load topo60c
worldmap("north america")
```

```
levels = -8000:1000:4000;
contourfm(topo60c, topo60cR, levels)
```

Set the colormap limits using the minimum and maximum contour levels. Then, add a color bar.

```
clim([min(levels) max(levels)])
contourcbar
```



Add Color Bar to Contour Plot with Non-Uniform Levels

Read spatially referenced geoid heights from the EGM96 geoid model. Display the data using a contour plot, specifying non-uniform contour levels.

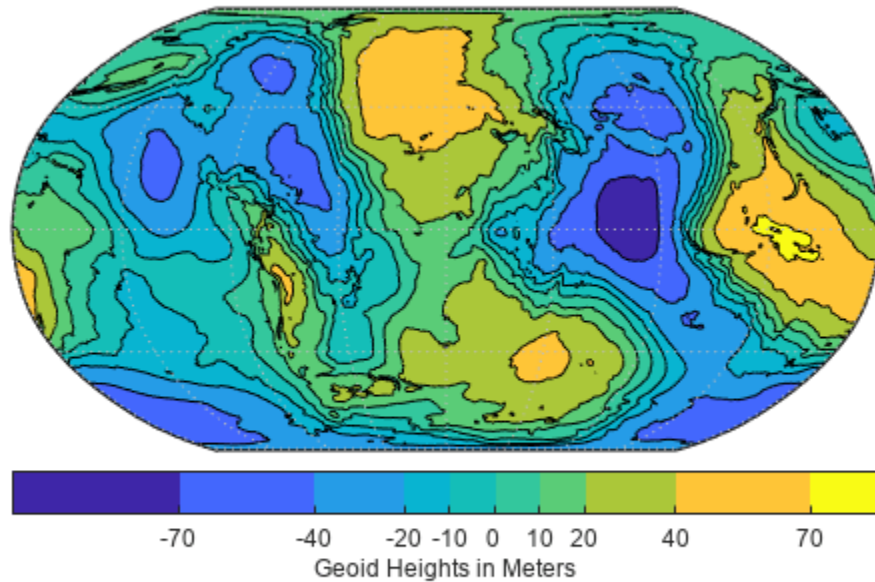
```
worldmap world
plabel off
mlabel off

[N,R] = egm96geoid;
levels = [-70 -40 -20 -10 0 10 20 40 70];
contourfm(N,R,levels)
```

Specify the colormap limits using the minimum and maximum geoid heights. Then, add a labeled colorbar below the contour plot. Change the tick mark locations so they match the contour levels.

```
clim([min(min(N)) max(max(N))])
cb = contourcbar("southoutside");
```

```
cb.XLabel.String = "Geoid Heights in Meters";
cb.Ticks = levels;
```



Input Arguments

location – Location

"eastoutside" (default) | "north" | "south" | "east" | "west" | "northoutside" | ...

Location of the color bar with respect to the axes, specified as one of the values in this table.

Value	Resulting Location	Resulting Orientation
"north"	Top of axes	Horizontal
"south"	Bottom of axes	Horizontal
"east"	Right side of axes	Vertical
"west"	Left side of axes	Vertical
"northoutside"	Top outside of axes	Horizontal
"southoutside"	Bottom outside of axes	Horizontal
"eastoutside"	Right outside of axes (default)	Vertical
"westoutside"	Left outside of axes	Vertical

If a color bar already exists in the specified location, then an updated color bar replaces the existing one. To ensure that the color bar does not overlap the graph, specify a location with the suffix `outside`.

You also can set the color bar location using the `Location` property. For example, `contourcbar("Location","northoutside")` is the same as `contourcbar("northoutside")`.

Example: `contourcbar("westoutside")`

ax — Target axes

Axes object

Target axes that contains the associated data visualization, specified as an `Axes` object. If you do not specify a target axes, then the function affects the current axes.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `contourcbar(FontSize=12,Direction="reverse")` sets the font size to 12 and reverses the direction of the color scale

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `contourcbar("FontSize",12,"Direction","reverse")` sets the font size to 12 and reverses the direction of the color scale

Note Use name-value arguments to specify values for the properties of the `ColorBar` object created by this function. The properties listed here are only a subset. For a complete list, see `Colorbar`.

Location — Location with respect to the axes

"eastoutside" (default) | "north" | "south" | "east" | "west" | "northoutside" | ...

Location with respect to the axes, specified as one of the values listed in this table.

Value	Resulting Location	Resulting Orientation
"north"	Top of axes	Horizontal
"south"	Bottom of axes	Horizontal
"east"	Right side of axes	Vertical
"west"	Left side of axes	Vertical
"northoutside"	Top outside of axes	Horizontal
"southoutside"	Bottom outside of axes	Horizontal
"eastoutside"	Right outside of axes (default)	Vertical
"westoutside"	Left outside of axes	Vertical
"manual"	Determined by <code>Position</code> property	Vertical

To display the color bar in a location that does not appear in the table, use the `Position` property to specify a custom location. If you specify the `Position` property, then MATLAB specifies the

Location property as "manual". The associated axes does not resize to accommodate the color bar when the Location property is specified as "manual".

TickLabels — Tick mark labels

cell array of character vectors | string array | numeric array | character vector | categorical array

Tick mark labels, specified as a cell array of character vectors, a string array, a numeric array, a character vector, or a categorical array. By default, the color bar labels the tick marks with numeric values. If you specify labels and do not specify enough labels for all the tick marks, then, for the remaining tick marks, MATLAB cycles through the specified labels.

If you specify this property as a categorical array, MATLAB uses the values in the array, not the categories.

Example: {"cold", "warm", "hot"}

Ticks — Tick mark locations

vector of increasing numeric values

Tick mark locations, specified as a vector of increasing numeric values. The values do not need to be equally spaced. If you do not want tick marks displayed, then set the property to the empty vector, [].

Example: [-1 0 1 2 3 4 5]

Data Types: single | double

Direction — Direction of color scale

"normal" (default) | "reverse"

Direction of the color scale, specified as one of these values:

- "normal" — Display the colormap and labels ascending from bottom to top for a vertical color bar, and ascending from left to right for a horizontal color bar.
- "reverse" — Display the colormap and labels descending from bottom to top for a vertical color bar, and descending from left to right for a horizontal color bar.

FontSize — Font size

positive scalar

Font size, specified as a positive scalar in point units. The default font size depends on the specific operating system and locale.

If you change the axes font size, then MATLAB automatically sets the font size of the color bar to 90% of the axes font size. If you manually set the font size of the color bar, then changing the axes font size does not affect the color bar font.

Tips

- The `contourcbar` function supports the same syntaxes and options as the `colorbar` function.
- If the axes contains multiple contour objects created by the `contourm`, `contourfm`, `contour3m`, or `geoshow` function, then the `contourcbar` function divides the color bar into sections using the first contour object it finds in the axes.
- To add a text description along the color bar, access the underlying text object using the `Label` property of the color bar.

```
c.Label.String = "My Colorbar Label";
```

To change the label appearance, such as the font style or color, set other text properties. For a list of properties, see `Text`. For example, this code changes the font size.

```
c.Label.FontSize = 12;
```

- Adding a color bar might resize the axes to accommodate the color bar.
- If an axes does not exist, then the `contourcbar` function creates a blank axes and displays a color bar with the default colormap.

Version History

Introduced in R2011b

R2014b: "peer" input is not recommended

Not recommended starting in R2014b

Starting in R2014b, `contourcbar("peer", ax)` is not recommended and might be removed in a future release. Use `contourcbar(ax)` instead.

See Also

Functions

`clegendm` | `colorbar` | `colormap`

Properties

`Colorbar`

Topics

"Creating Colorbars"

"Control Colormap Limits"

contourcmap

Contour colormap and color bar

Syntax

```
contourcmap(cmap)
contourcmap(cmap,cdelta)
contourcmap( ____,Name,Value)
h = contourcmap( ____)
```

Description

`contourcmap(cmap)` sets the colormap of the current figure (and current axes) to a predefined colormap. If the current axes contains a contour object created by the `contourm`, `contourfm`, `contour3m`, or `geoshow` function, then the number of colors in the colormap matches the number of contour intervals. Otherwise, the colormap contains 10 colors.

`contourcmap(cmap,cdelta)` updates the colormap of the current figure using the contour levels specified by `cdelta`. If the current axes contains a contour object created by the `contourm`, `contourfm`, `contour3m`, or `geoshow` function, then the `contourcmap` function ignores the value of `cdelta`.

`contourcmap(____,Name,Value)` specifies options for the color bar using name-value arguments, in addition to any combination of input arguments from the previous syntaxes. For example, display the color bar by specifying "Colorbar", "on".

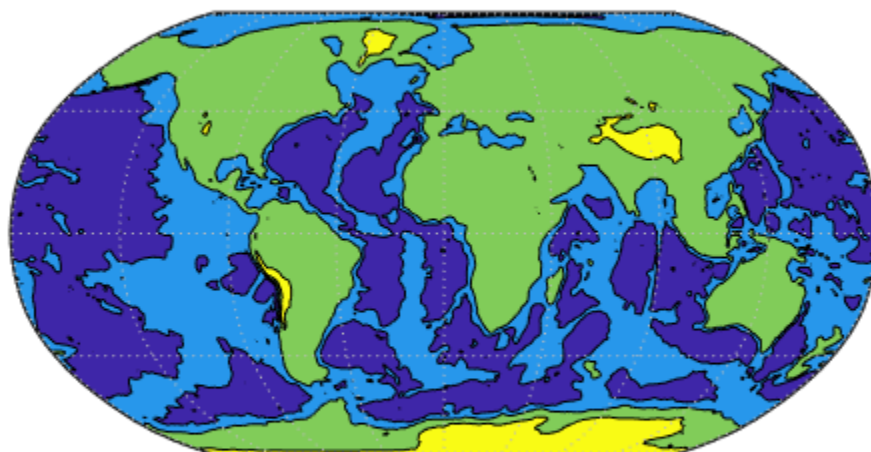
`h = contourcmap(____)` returns the color bar.

Examples

Change Colormap for Contoured World Elevations

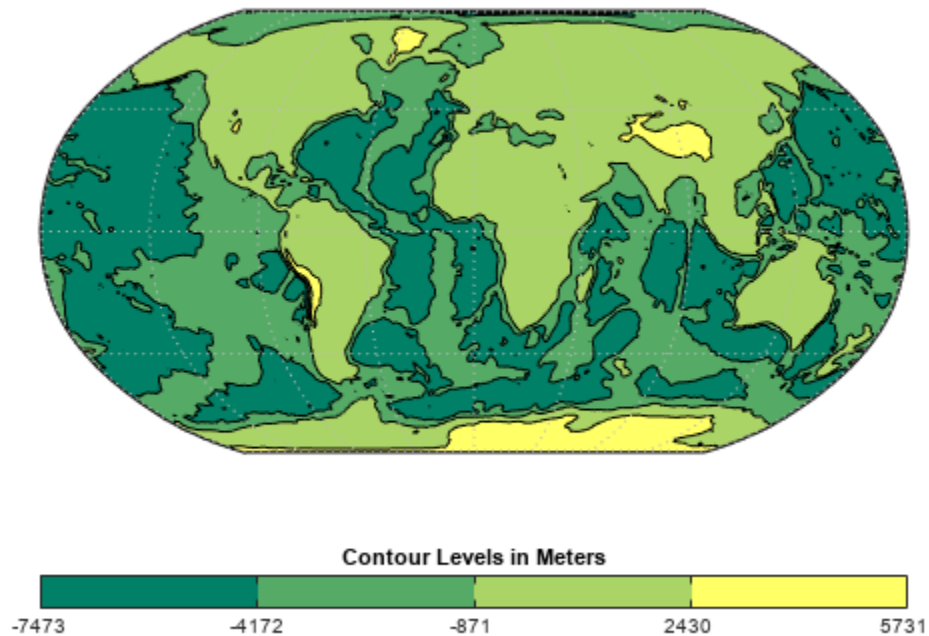
Create a filled contour plot of world elevations. Specify three contour levels (which creates four contour intervals).

```
load topo60c
worldmap world
contourfm(topo60c,topo60cR,3)
plabel off
mlabel off
```

Change the colormap and add a labeled color bar. Note that the colormap uses the same number of contour intervals.

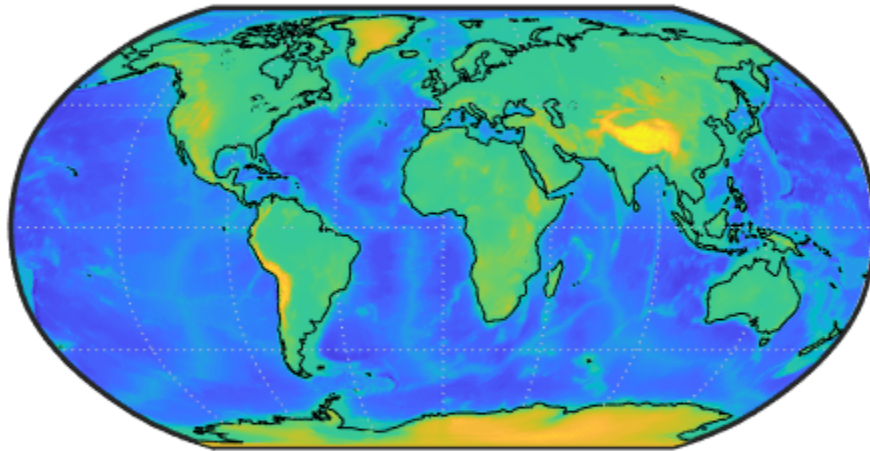
```
contourmap("summer", "Colorbar", "on", ...  
          "Location", "horizontal", "TitleString", "Contour Levels in Meters")
```



Specify Contour Levels

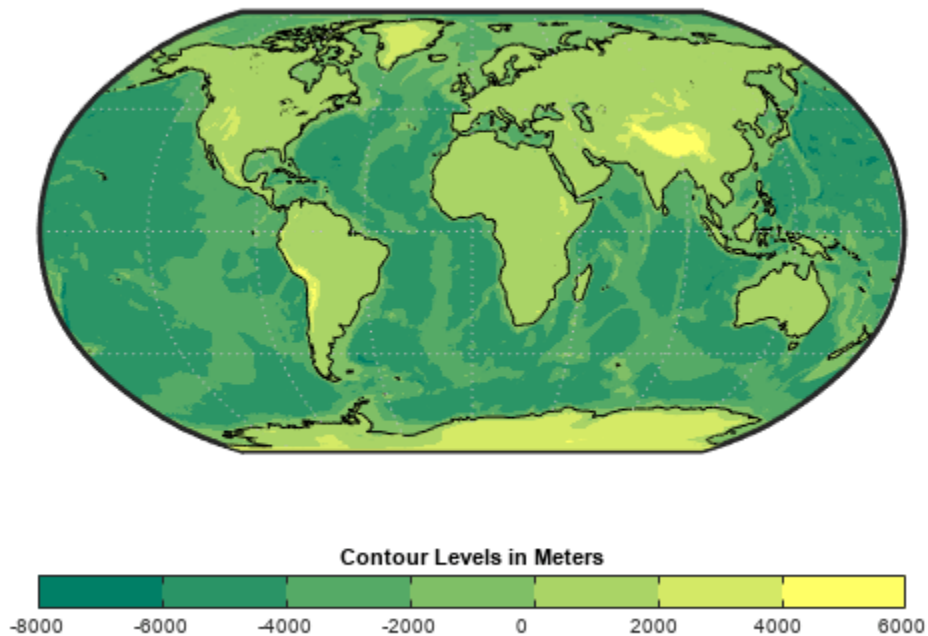
Create a world map containing elevation data and coastline data. Display the elevation data using a surface.

```
load topo60c
load coastlines
worldmap world
geoshow(topo60c,topo60cR,"DisplayType","surface")
geoshow(coastlat,coastlon,"Color","k")
mlabel off
plabel off
```



Change the colormap, specifying a new contour level every 2000 meters, and add a labeled color bar.

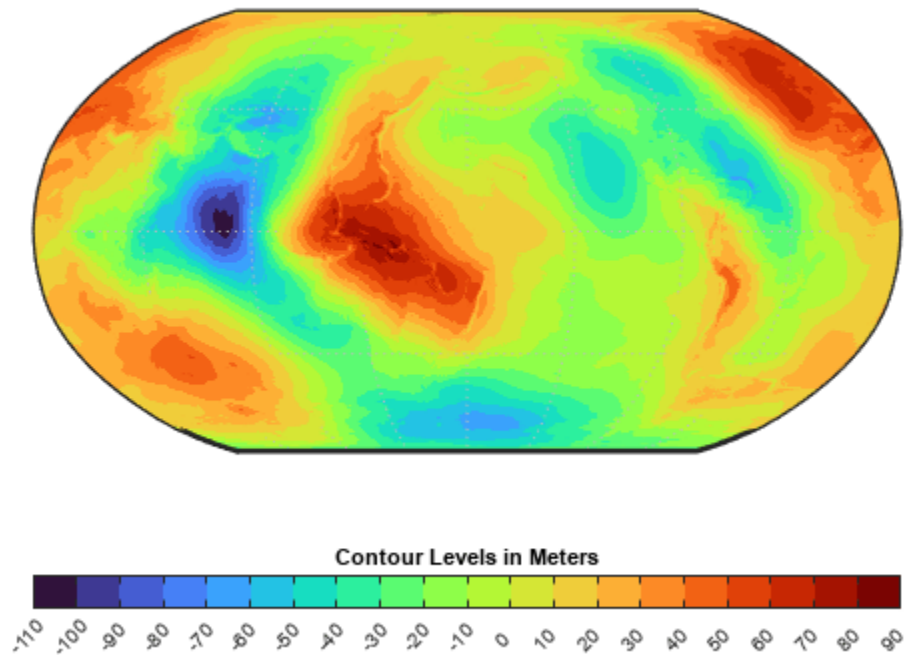
```
contourmap("summer",2000,"Colorbar","on", ...  
          "Location","horizontal", ...  
          "TitleString","Contour Levels in Meters")
```



Restrict Range of Colors

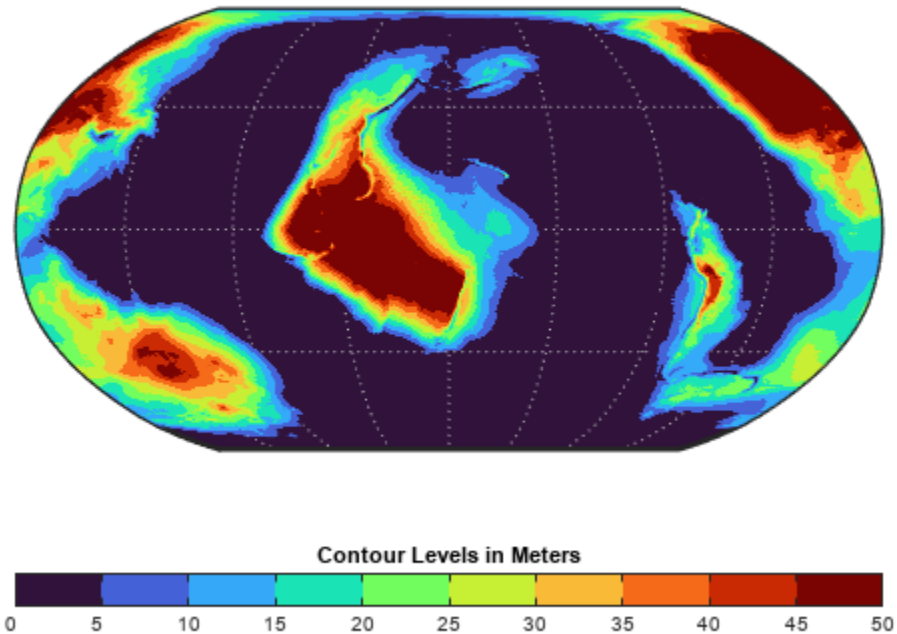
Read and display spatially referenced geoid heights from the EGM96 geoid model. Change the colormap, specifying a new contour level every 10 meters, and add a labeled color bar.

```
[N,R] = egm96geoid;  
worldmap(N,R)  
geoshow(N,R,"DisplayType","surface")  
plabel off  
mlabel off  
  
contourcmap("turbo",10,"Colorbar","on","Location","horizontal", ...  
            "TitleString","Contour Levels in Meters")
```



Change the colormap again. To restrict the range of colors, specify the contour levels using a vector of evenly-spaced values. The map displays geoid heights outside the range using the color associated with the nearest contour level.

```
range = 0:5:50;  
contourmap("turbo",range,"Colorbar","on","Location","horizontal", ...  
           "TitleString","Contour Levels in Meters")
```



Input Arguments

cmap — Colormap

"parula" | "turbo" | "hsv" | "hot" | "cool" | ...

Colormap, specified as one of the options in the table. This argument accepts any predefined colormap accepted by the `colormap` function.

Colormap Name	Color Scale
"parula"	
"turbo"	
"hsv"	
"hot"	
"cool"	
"spring"	
"summer"	
"autumn"	
"winter"	
"gray"	

Colormap Name	Color Scale
"bone"	
"copper"	
"pink"	
"jet"	
"lines"	
"colorcube"	
"prism"	
"flag"	
"white"	

Data Types: char | string

cdelta — Contour levels

numeric scalar | numeric vector of evenly spaced values

Contour levels, specified as a numeric scalar or a numeric vector of evenly spaced values.

- If `cdelta` is a scalar, then the function generates new contour levels at multiples of `cdelta`.
- If `cdelta` is a vector of evenly spaced values, then the function generates new contour levels at those values.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `contourmap("turbo", Colorbar="on")` changes the colormap of the figure to "turbo" and displays a color bar

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `contourmap("turbo", "Colorbar", "on")` changes the colormap of the figure to "turbo" and displays a color bar

Note In addition to the name-value arguments in this section, you can use name-value arguments to specify values for the properties of the Axes object returned by this function. For more information about the properties of Axes objects, see Axes Properties.

Colorbar — Visibility of color bar

"off" (default) | "on"

Visibility of the color bar, specified as one of these options:

- "on" — Display a color bar.
- "off" — Do not display a color bar.

Data Types: char | string

Location — Location of color bar with respect to axes`"vertical" (default) | "horizontal" | "none"`

Location of the color bar with respect to the axes, specified as one of these options:

- `"vertical"` — Display the color bar vertically and to the right of the axes.
- `"horizontal"` — Display the color bar horizontally and below the axes.
- `"none"` — Do not display a color bar.

Data Types: `char` | `string`

ColorAlignment — Alignment of labels in color bar`"center" | "ends"`

Alignment of the labels in the color bar, specified as one of these options:

- `"center"` — Center the labels on the color bands.
- `"ends"` — Center the labels on the color breaks.

If the figure contains contour objects created by the `contourm`, `contourfm`, `contour3m`, or `geoshow` function, the `contourcmap` function sets the value of this argument to `"center"` for contour lines and `"ends"` for filled contours, regardless of the option you specify.

Data Types: `char` | `string`

SourceObject — Graphics object that determines colormap limits`gca (default) | graphics object`

Graphics object that determines the colormap limits, specified as a graphics object.

TitleString — Title of color bar`character vector | string scalar`

Title of the color bar, specified as a character vector or string scalar.

Data Types: `char` | `string`

XLabelString — x-label of color bar`character vector | string scalar`

x-label of the color bar, specified as a character vector or string scalar.

Data Types: `char` | `string`

YLabelString — y-label of color bar`character vector | string scalar`

y-label of the color bar, specified as a character vector or string scalar.

Data Types: `char` | `string`

Output Arguments**h — Output color bar**`Axes object`

Output color bar, returned as an Axes object.

Version History

Introduced before R2006a

See Also

Functions

[clabelm](#) | [clegendm](#) | [contour3m](#) | [contourcbar](#) | [contourfm](#) | [contourm](#)

contourfm

Project filled 2-D contour plot of map data

Syntax

```
contourfm(Z,R)
contourfm(lat,lon,Z)
contourfm( ____,levels)
contourfm( ____,LineStyle)
contourfm( ____,Name,Value)
C = contourfm( ____)
[C,h] = contourfm( ____)
```

Description

`contourfm(Z,R)` creates a filled contour plot of the regular data grid `Z` that is spatially referenced by the geographic raster reference object `R`.

`contourfm(lat,lon,Z)` creates a filled contour plot of the geolocated data grid `Z` that is referenced to the latitude-longitude coordinates contained in `lat` and `lon`.

`contourfm(____, levels)` specifies the contour lines to display, in addition to any combination of arguments from the previous syntaxes.

`contourfm(____,LineStyle)` specifies the style and color of the contour lines.

`contourfm(____,Name,Value)` specifies additional options for the contour plot using one or more name-value arguments.

`C = contourfm(____)` returns the contour matrix `C`, which contains the latitude and longitude coordinates of the vertices at each level.

`[C,h] = contourfm(____)` returns the contour matrix and the contour patches `h`.

Examples

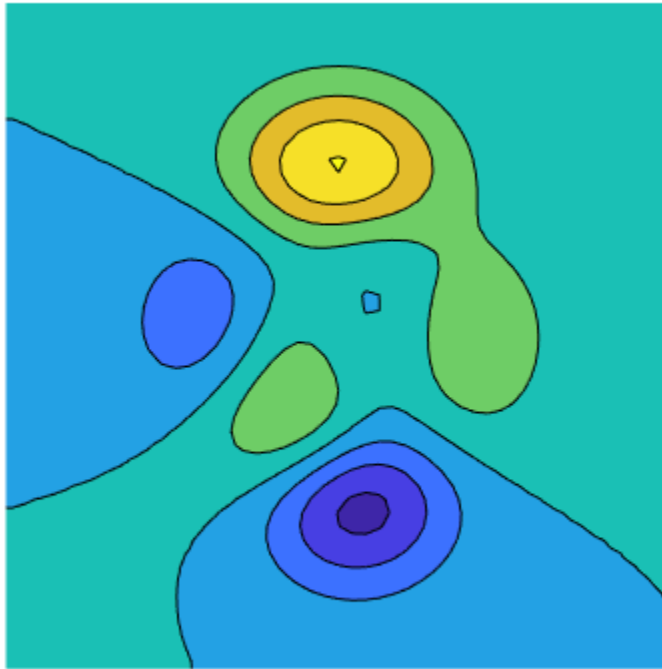
Create Filled Contour Plot

Create a sample data grid and geographic raster reference object. Then, display the data using a filled contour plot.

```
Z = peaks;
R = georefcalls([-0.1 0],[0 0.1],size(Z));
```

```
figure
axesm miller
axis off

contourfm(Z,R)
```



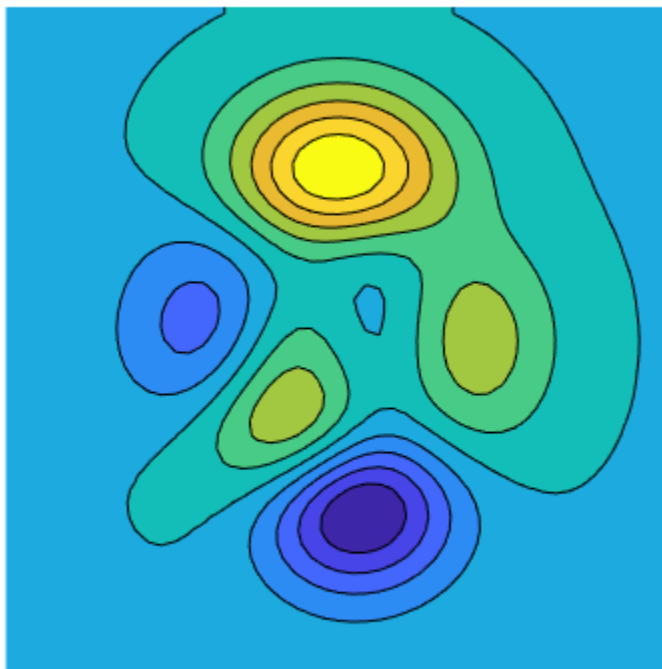
Specify Number of Contour Levels

Create a sample data grid and geographic raster reference object. Then, display contours at 10 levels of Z.

```
Z = peaks;  
R = georefcalls([-0.1 0],[0 0.1],size(Z));
```

```
figure  
axesm miller  
axis off
```

```
contourfm(Z,R,10)
```



Specify Contour Levels

Read global elevation data into the workspace. Crop the data to a region that includes North America.

```
load topo60c  
[Z,R] = geocrop(topo60c,topo60cR,[10 85],[-170 -45]);
```

Find the minimum and maximum elevations.

```
min(min(Z))
```

```
ans = -7258
```

```
max(max(Z))
```

```
ans = 3047
```

Display the data on a map using a filled contour plot. Specify the minimum and maximum contours using values that surround the minimum and maximum elevations, and specify a new contour level every 1000 meters.

```
worldmap(Z,R)
```

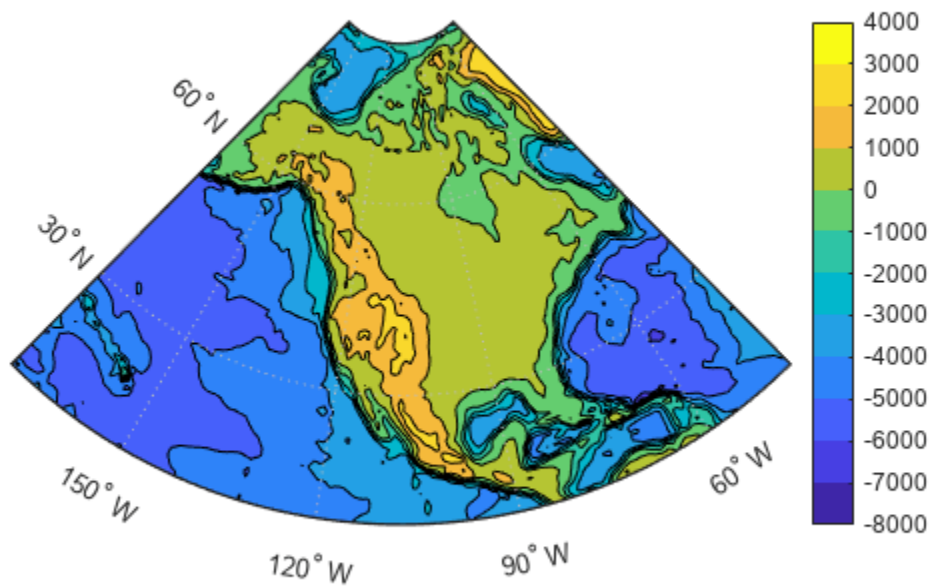
```
minL = -8000;
```

```
inc = 1000;
maxL = 4000;

levels = minL:inc:maxL;
contourfm(topo60c,topo60cR,levels)
```

Set the colormap limits and add a color bar.

```
clim([minL maxL])
c = contourbar;
c.Ticks = levels;
```



Input Arguments

Z — Regular or geolocated data grid

M-by-*N* matrix

Regular or geolocated data grid, specified as an *M*-by-*N* matrix.

The `contourfm` function does not display contour lines for elements of *Z* that have values of NaN.

R — Spatial reference

GeographicCellsReference object | GeographicPostingsReference object

Spatial reference for Z, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object. The `RasterSize` property of R must be consistent with `size(Z)`.

lat — Latitude coordinates

M-by-*N* matrix | *M*-element vector

Latitude coordinates, specified as an *M*-by-*N* matrix or an *M*-element vector.

This argument does not support NaN values. To indicate missing data, set the corresponding element of Z to a value of NaN, instead.

lon — Longitude coordinates

M-by-*N* matrix | *M*-element vector

Longitude coordinates, specified as an *M*-by-*N* matrix or an *M*-element vector.

This argument does not support NaN values. To indicate missing data, set the corresponding element of Z to a value of NaN, instead.

levels — Contour levels

positive integer | numeric vector

Contour levels, specified as a positive integer or a numeric vector.


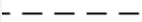
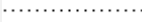
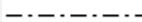
- To display contour lines at *n* automatically chosen levels, specify this argument as *n*. The function chooses levels based on the values in Z.
- To display contour lines at specific levels, specify this argument as a vector of increasing values.
- To display contour lines at a single level, *k*, specify this argument as a two-element row vector [*k* *k*].


LineStyle — Line style and color








character vector | string scalar

Line style and color, specified as a character vector or string scalar containing characters and symbols. The characters and symbols can appear in any order. You can specify the line style, line color, or both. Marker symbols such as 'o' are ignored.

Example: '- -g' is a green dashed line.

Line Style	Description	Resulting Line
"_"	Solid line	
"- -"	Dashed line	
":"	Dotted line	
"- ."	Dash-dotted line	

Color Name	Short Name	Appearance
'red'	'r'	

Color Name	Short Name	Appearance
'green'	'g'	
'blue'	'b'	
'cyan'	'c'	
'magenta'	'm'	
'yellow'	'y'	
'black'	'k'	
'white'	'w'	

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `contourfm(Z,R,ShowText="on")` displays the contour line labels.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `contourfm(Z,R,"ShowText","on")` displays the contour line labels.

Note In addition to the name-value arguments in this section, you can use name-value arguments to specify values for the `HandleVisibility`, `Parent`, `Tag`, `UserData`, and `Visible` properties of the `Group` object returned by this function. For more information about these group object properties, see `Group`.

LabelSpacing — Label spacing

144 (default) | scalar

Label spacing along the contour lines, specified as a scalar value in points, where one point is 1/72 inch. Use this property to control the number of contour labels along the contour lines. Smaller values produce more labels.

You must specify `ShowText` as "on" for `LabelSpacing` to have an effect.

If the length of a contour line is less than `LabelSpacing`, then the function displays one label on the line.

LevelList — Contour levels

row vector of increasing values in Z

Contour levels, specified as a row vector of increasing values in Z. By default, the `contourfm` function chooses values that span the range of values in Z.

LevelStep — Spacing between contour lines

positive scalar

Spacing between the contour lines, specified as a positive scalar. For example, specify a value of 2 to display contour lines at increments of 2. By default, the `contourfm` function determines the spacing based on the values in Z. If you specify both `levels` and `LevelStep`, then the function ignores `LevelStep`.








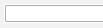
LineColor – Color of contour lines

"flat" (default) | RGB triplet | "r" | "g" | "b" | "none" | ...

Color of the contour lines, specified as "flat", a color name, a short name, an RGB triplet, or "none". The default value of "flat" selects a distinct color for lines at each contour level from the colormap of the figure in which the contours are drawn. The value "none" applies no color to the lines.

For a custom color, specify an RGB triplet. An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1]; for example, [0.4 0.6 0.7].



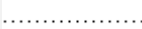
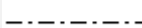
Alternatively, you can specify some common colors by name. This table lists the named color options and equivalent RGB triplets.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

LineStyle – Line style

"-" (default) | "--" | ":" | "-." | "none"

Line style, specified as one of the options listed in this table.

Line Style	Description	Resulting Line
"-"	Solid line	
"--"	Dashed line	
":"	Dotted line	
"-."	Dash-dotted line	
"none"	No line	No line

LineWidth – Line width

0.5 (default) | positive scalar

Contour line width, specified as a positive scalar in points. One point equals 1/72 inch.

ShowText – Contour line labels

"off" (default) | "on"

Contour line labels, specified as one of these values:

- "on" — Display the contour level along the contour lines.
- "off" — Do not label the contour lines.

Output Arguments

C — Contour matrix

matrix with two rows

Contour matrix, returned as a matrix with two rows. This argument contains the data that defines the contour lines. The first row of the matrix contains longitude data and the second row of the matrix contains latitude data.

h — Contour patches

Group object

Contour patches, returned as a Group object.

Tips

The `contourfm` function behaves the same as the `contourm` function, except the `contourfm` function fills the spaces between the contour lines with color. For each contour interval, the `contourfm` function selects a distinct color from the colormap for the figure. You can obtain the same result with the `contourm` function by specifying the `Fill` name-value argument as "on" and the `LineColor` name-value argument as "black".

Version History

Introduced before R2006a

R2022b: contourfm will not accept referencing vectors or referencing matrices as input

Not recommended starting in R2022b

The `contourfm` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.

- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

See Also

Functions

`contourcbar` | `contourm` | `contour3m` | `clabelm` | `geoshow`

contourm

Project 2-D contour plot of map data

Syntax

```
contourm(Z,R)
contourm(lat,lon,Z)
contourm( __ ,levels)
contourm( __ ,LineStyle)
contourm( __ ,Name,Value)
C = contourm( __ )
[C,h] = contourm( __ )
```

Description

`contourm(Z,R)` creates a contour plot of the regular data grid `Z` that is spatially referenced by the geographic raster reference object `R`.

`contourm(lat,lon,Z)` creates a contour plot of the geolocated data grid `Z` that is referenced to the latitude-longitude coordinates contained in `lat` and `lon`.

`contourm(__ ,levels)` specifies the contour lines to display, in addition to any combination of arguments from the previous syntaxes.

`contourm(__ ,LineStyle)` specifies the style and color for the contour lines.

`contourm(__ ,Name,Value)` specifies additional options for the contour plot using one or more name-value arguments.

`C = contourm(__)` returns the contour matrix `C`, which contains the latitude and longitude coordinates of the vertices at each level.

`[C,h] = contourm(__)` returns the contour matrix and the contour patches `h`.

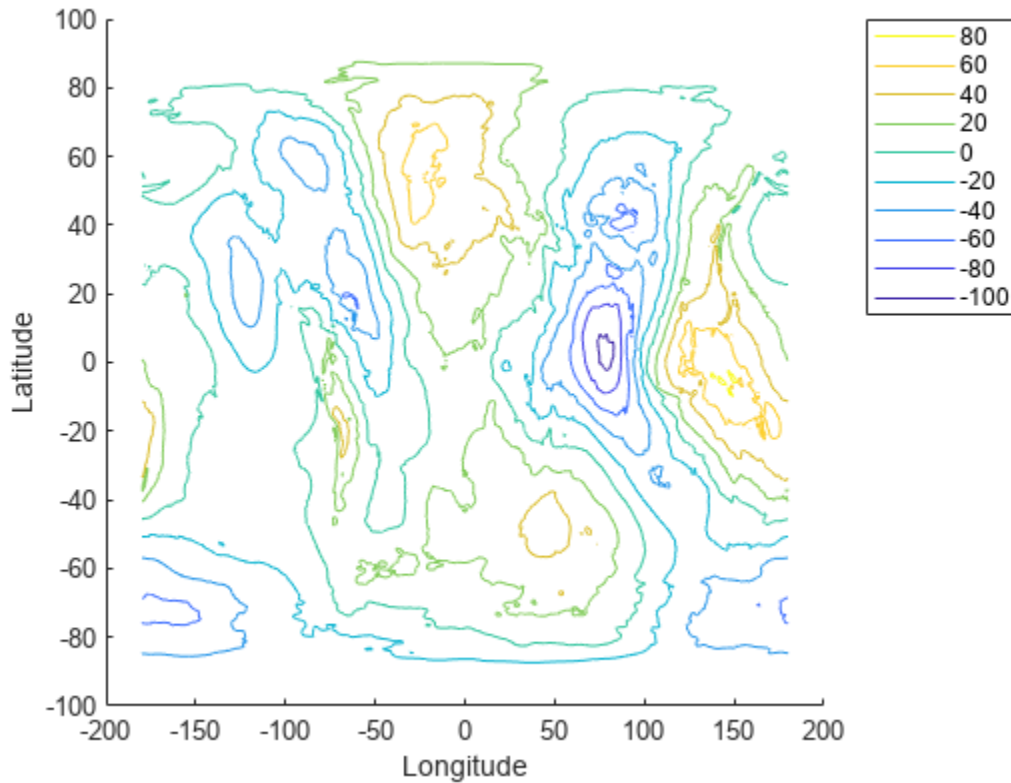
Examples

Create Contour Plot

Read geoid heights from the Earth Gravitational Model of 1996 (EGM96) into the workspace. Then, create a contour plot and add a legend.

```
[Z,R] = egm96geoid;

[C,h] = contourm(Z,R);
xlabel("Longitude")
ylabel("Latitude")
clegendm(C,h,-1)
```



Specify Contour Levels

Create an elevation map for a region surrounding the Korean peninsula.

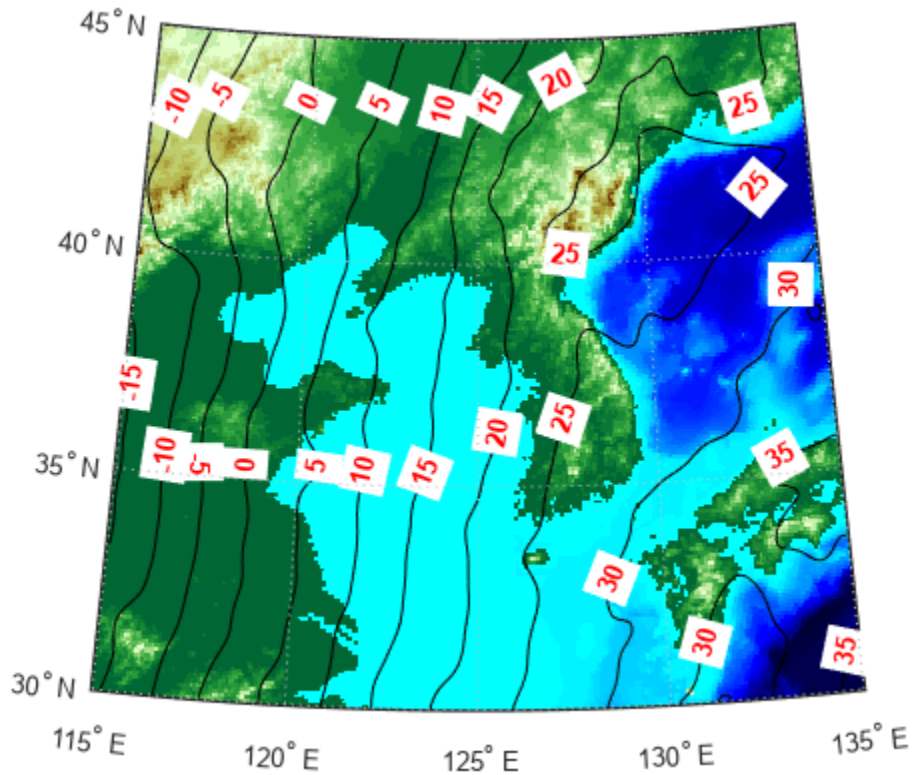
```
load korea5c
worldmap(korea5c,korea5cR)
geoshow(korea5c,korea5cR,"DisplayType","texturemap")
demcmap(korea5c)
```

Create a contour plot using geoid heights from the Earth Gravitational Model of 1996 (EGM96). Specify contour levels from -20 to 40 in increments of 5.

```
N = egm96geoid(korea5cR);
[C,h] = contourm(N,korea5cR,-20:5:40,"k");
```

Label the contours using white text boxes with red text.

```
t = clabelm(C,h);
set(t,"Color","r")
set(t,"BackgroundColor","white")
set(t,"FontWeight","bold")
```



Input Arguments

Z — Regular or geolocated data grid

M-by-*N* matrix

Regular or geolocated data grid, specified as an *M*-by-*N* matrix.

The `contourm` function does not display contour lines for elements of *Z* that have values of NaN.

R — Spatial reference

GeographicCellsReference object | GeographicPostingsReference object

Spatial reference for *Z*, specified as a GeographicCellsReference or GeographicPostingsReference object. The RasterSize property of *R* must be consistent with `size(Z)`.

lat — Latitude coordinates

M-by-*N* matrix | *M*-element vector

Latitude coordinates, specified as an *M*-by-*N* matrix or an *M*-element vector.

This argument does not support NaN values. To indicate missing data, set the corresponding element of *Z* to a value of NaN, instead.

lon — Longitude coordinates*M*-by-*N* matrix | *M*-element vector

Longitude coordinates, specified as an *M*-by-*N* matrix or an *M*-element vector.

This argument does not support NaN values. To indicate missing data, set the corresponding element of *Z* to a value of NaN, instead.

levels — Contour levels

positive integer | numeric vector

Contour levels, specified as a positive integer or a numeric vector.


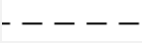
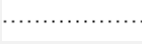

- To display contour lines at *n* automatically chosen levels, specify this argument as *n*. The function chooses levels based on the values in *Z*.
- To display contour lines at specific levels, specify this argument as a vector of increasing values.
- To display contour lines at a single level, *k*, specify this argument as a two-element row vector [*k* *k*].





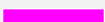



LineStyle — Line style and color

character vector | string scalar

Line style and color, specified as a character vector or string scalar containing characters and symbols. The characters and symbols can appear in any order. You can specify the line style, line color, or both. Marker symbols such as 'o' are ignored.

Example: '- - g' is a green dashed line.

Line Style	Description	Resulting Line
" - "	Solid line	
" - - "	Dashed line	
" : "	Dotted line	
" - . "	Dash-dotted line	

Color Name	Short Name	Appearance
'red'	'r'	
'green'	'g'	
'blue'	'b'	
'cyan'	'c'	
'magenta'	'm'	
'yellow'	'y'	
'black'	'k'	
'white'	'w'	

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `contourm(Z,R,ShowText="on")` displays the contour line labels.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `contourm(Z,R,"ShowText","on")` displays the contour line labels.

Note In addition to the name-value arguments in this section, you can use name-value arguments to specify values for the `HandleVisibility`, `Parent`, `Tag`, `UserData`, and `Visible` properties of the `Group` object returned by this function. For more information about these group object properties, see `Group`.

Fill — Fill between contour lines

"off" (default) | "on"

Fill between the contour lines, specified as one of these values:

- "off" — Do not fill the spaces between contour lines with a color.
- "on" — Fill the spaces between contour lines with color.

LabelSpacing — Label spacing

144 (default) | scalar

Label spacing along the contour lines, specified as a scalar value in points, where one point is 1/72 inch. Use this property to control the number of contour labels along the contour lines. Smaller values produce more labels.

You must specify `ShowText` as "on" for `LabelSpacing` to have an effect.

If the length of a contour line is less than `LabelSpacing`, then the function displays one label on the line.

LevelList — Contour levels

row vector of increasing values in Z

Contour levels, specified as a row vector of increasing values in Z. By default, the `contourm` function chooses values that span the range of values in Z.

LevelStep — Spacing between contour lines

positive scalar

Spacing between the contour lines, specified as a positive scalar. For example, specify a value of 2 to display contour lines at increments of 2. By default, the `contourm` function determines the spacing based on the values in Z. If you specify both `levels` and `LevelStep`, then the function ignores `LevelStep`.

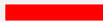




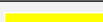


LineColor — Color of contour lines

"flat" (default) | RGB triplet | "r" | "g" | "b" | "none" | ...

Color of the contour lines, specified as "flat", a color name, a short name, an RGB triplet, or "none". The default value of "flat" selects a distinct color for lines at each contour level from the colormap of the figure in which the contours are drawn. The value "none" applies no color to the lines.

For a custom color, specify an RGB triplet. An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0,1]; for example, [0.4 0.6 0.7].





Alternatively, you can specify some common colors by name. This table lists the named color options and equivalent RGB triplets.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

LineStyle – Line style

"-" (default) | "--" | ":" | "-." | "none"

Line style, specified as one of the options listed in this table.

Line Style	Description	Resulting Line
"-"	Solid line	
--"	Dashed line	
:"	Dotted line	
-."	Dash-dotted line	
"none"	No line	No line

LineWidth – Line width

0.5 (default) | positive scalar

Contour line width, specified as a positive scalar in points. One point equals 1/72 inch.

ShowText – Contour line labels

"off" (default) | "on"

Contour line labels, specified as one of these values:

- "on" — Display the contour level along the contour lines.

- "off" — Do not label the contour lines.

Output Arguments

C — Contour matrix

matrix with two rows

Contour matrix, returned as a matrix with two rows. This argument contains the data that defines the contour lines. The first row of the matrix contains longitude data and the second row of the matrix contains latitude data.

h — Contour patches

Group object

Contour patches, returned as a Group object.

Version History

Introduced before R2006a

R2022b: contourm will not accept referencing vectors or referencing matrices as input

Not recommended starting in R2022b

The `contourm` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

See Also

Functions

`clabelm` | `clegendm` | `contour3m` | `contourfm` | `geoshow`

convertlat

Convert between geodetic and auxiliary latitudes

Syntax

```
latout = convertlat(ellipsoid,latin,from,to,units)
```

Description

`latout = convertlat(ellipsoid,latin,from,to,units)` converts latitude values in `latin` from type `from` to type `to`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form [`semimajor_axis` `eccentricity`].

`latin` is an array of input latitude values. `from` and `to` are each one of the latitude types listed below:

Latitude Type	Description
geodetic	The geodetic latitude is the angle that a line perpendicular to the surface of the ellipsoid at the given point makes with the equatorial plane.
authalic	The authalic latitude maps an ellipsoid to a sphere while preserving surface area. Authalic latitudes are used in place of the geodetic latitudes when projecting the ellipsoid using an equal area projection.
conformal	The conformal latitude maps an ellipsoid conformally onto a sphere. Conformal latitudes are used in place of the geodetic latitudes when projecting the ellipsoid with a conformal projection.
geocentric	The geocentric latitude is the angle that a line connecting a point on the surface of the ellipsoid to its center makes with the equatorial plane.
isometric	The isometric latitude is a nonlinear function of the geodetic latitude.
parametric	The parametric latitude of a point on the ellipsoid is the latitude on a sphere of radius a , where a is the semimajor axis of the ellipsoid, for which the parallel has the same radius as the parallel of geodetic latitude.
rectifying	The rectifying latitude is used to map an ellipsoid to a sphere in such a way that distance is preserved along meridians.

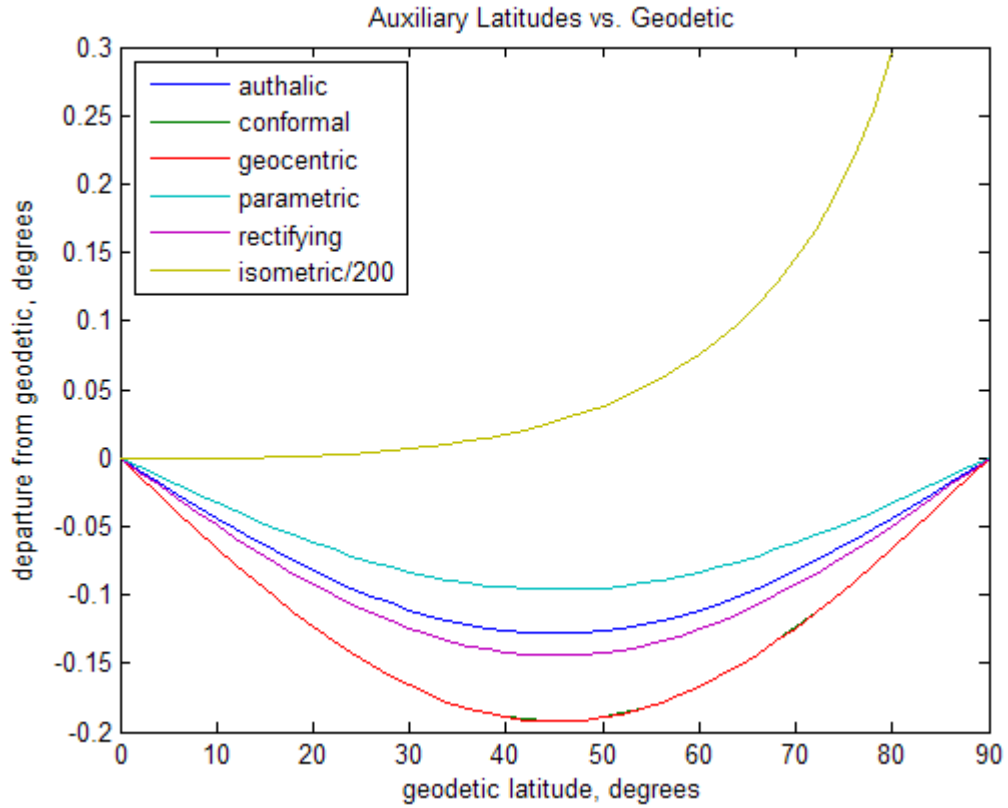
`latin` has the angle units specified by `units`: either 'degrees' or 'radians'. The output array, `latout`, has the same size and units as `latin`.

To properly project rectified latitudes, the radius must also be scaled to ensure the equal meridional distance property. This is accomplished by `rsphere`.

Examples

```
% Plot the difference between the auxiliary latitudes
% and geocentric latitude, from equator to pole,
% using the GRS 80 ellipsoid. Avoid the polar region with
```

```
% the isometric latitude, and scale down the difference
% by a factor of 200.
grs80 = referenceEllipsoid('grs80');
geodetic = 0:2:90;
authalic = ...
convertlat(grs80,geodetic,'geodetic','authalic','deg');
conformal = ...
convertlat(grs80,geodetic,'geodetic','conformal','deg');
geocentric = ...
convertlat(grs80,geodetic,'geodetic','geocentric','deg');
parametric = ...
convertlat(grs80,geodetic,'geodetic','parametric','deg');
rectifying = ...
convertlat(grs80,geodetic,'geodetic','rectifying','deg');
isometric = ...
convertlat(grs80,geodetic(1:end-5), ...
'geodetic','isometric','deg');
plot(geodetic, (authalic - geodetic),...
geodetic, (conformal - geodetic),...
geodetic, (geocentric - geodetic),...
geodetic, (parametric - geodetic),...
geodetic, (rectifying - geodetic),...
geodetic(1:end-5), (isometric - geodetic(1:end-5))/200);
title('Auxiliary Latitudes vs. Geodetic')
xlabel('geodetic latitude, degrees')
ylabel('departure from geodetic, degrees');
legend('authalic','conformal','geocentric', ...
'parametric','rectifying', 'isometric/200',...
'Location','NorthWest');
```



Version History

Introduced before R2006a

See Also

[referenceEllipsoid](#) | [referenceSphere](#) | [oblateSpheroid](#) | [rsphere](#)

crossfix

Intersection points for pairs of great circles or small circles

Syntax

```
[latIntersect,lonIntersect] = crossfix(lat,lon,az)
[latIntersect,lonIntersect] = crossfix(lat,lon,az_radius,ind)
[latIntersect,lonIntersect] = crossfix(lat,lon,az_radius,ind,latEstimate,
lonEstimate)
[latIntersect,lonIntersect] = crossfix( ___,units)
mat = crossfix( ___ )
```

Description

`[latIntersect,lonIntersect] = crossfix(lat,lon,az)` finds the intersection points of pairs of great circles. Define each great circle by specifying the latitude `lat` and longitude `lon` of a point on the circle and the azimuth `az` at that point.

`[latIntersect,lonIntersect] = crossfix(lat,lon,az_radius,ind)` enables you to find the intersection points of great circles and small circles. When an element of `ind` is `0`, the corresponding elements of `lat` and `lon` define the center of a small circle, and `az_radius` specifies the radius of the small circle. When an element of `ind` is `1`, the corresponding element of `lat` and `lon` define a point on a great circle, and `az_radius` specifies the azimuth.

`[latIntersect,lonIntersect] = crossfix(lat,lon,az_radius,ind,latEstimate,lonEstimate)` finds the intersection point closest to the point specified by `latEstimate` and `lonEstimate`.

`[latIntersect,lonIntersect] = crossfix(___,units)` specifies the angle units for the coordinates, azimuth, and radii, in addition to any combination of input arguments from the previous syntaxes.

`mat = crossfix(___)` returns the latitudes and longitudes of the intersection points as the matrix `mat`.

Examples

Find Intersections of Great Circles

Define three great circles by specifying a point on each circle and the azimuth at each point.

```
lat = [0 5 0];
lon = [0 5 10];
az = [80 240 310];
```

Find the intersections of the great circles.

```
[latIntersect,lonIntersect] = crossfix(lat,lon,az)
```

```
latIntersect = 3×2
    0.9022    -0.9022
    1.4526    -1.4526
   -4.6654     4.6654
```

```
lonIntersect = 3×2
   174.8759    -5.1241
    8.2683   -171.7317
  -175.5811     4.4189
```

Visualize the results. First, generate the latitude and longitude coordinates of each great circle.

```
[lat1,lon1] = track1(lat(1),lon(1),az(1));
[lat2,lon2] = track1(lat(2),lon(2),az(2));
[lat3,lon3] = track1(lat(3),lon(3),az(3));
```

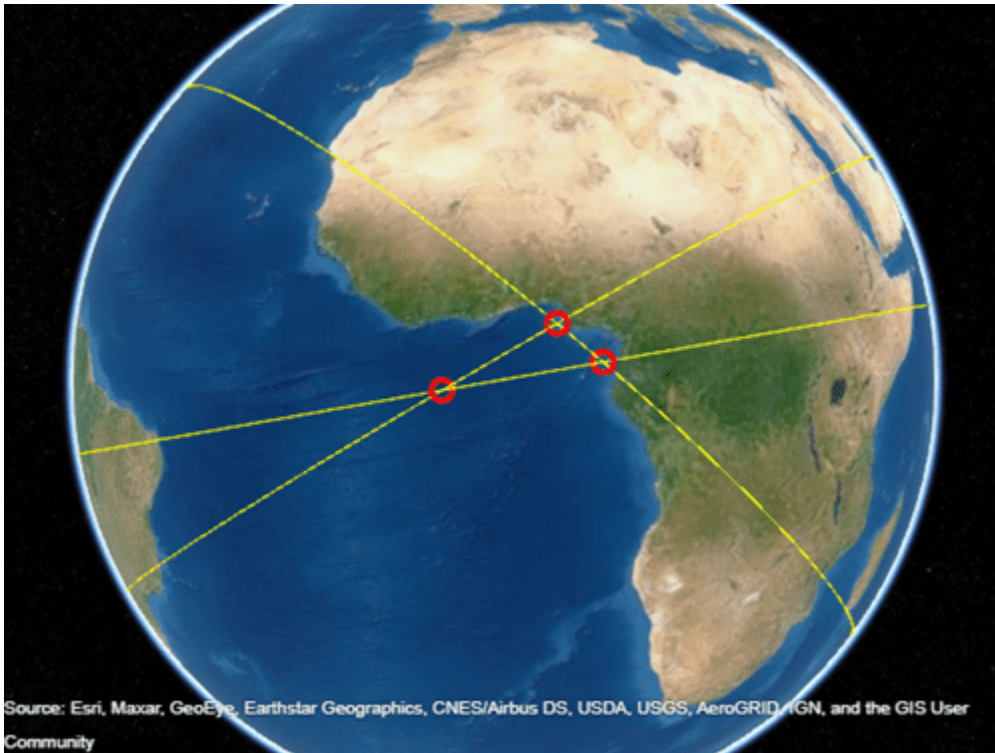
Display the great circles on a globe.

```
uif = uifigure;
g = geoglobe(uif,"Terrain","none");
hold(g,"on")
```

```
geoplot3(g,lat1,lon1,0,"y")
geoplot3(g,lat2,lon2,0,"y")
geoplot3(g,lat3,lon3,0,"y")
```

Display the intersection points. Note that there are three additional intersection points on the other side of the globe.

```
geoplot3(g,reshape(latIntersect,[6 1]),reshape(lonIntersect,[6 1]),0, ...
    "ro","LineWidth",3)
```



Find Intersections of Small Circles

Define three small circles by specifying their centers and radii. Specify the radii using spherical distances in degrees.

```
lat = [0 5 0];
lon = [0 5 10];
r = [8 8 8];
```

Find the intersections of the small circles. Indicate that the third argument contains radii (instead of azimuths) by specifying the fourth argument as a vector of 0 values.

```
ind = [0 0 0];
[latIntersect,lonIntersect] = crossfix(lat,lon,r,ind)
```

```
latIntersect = 3x2
```

```
7.5594 -2.5744
6.2529 -6.2529
7.5594 -2.5744
```

```
lonIntersect = 3x2
```

```
-2.6260 7.5770
5.0000 5.0000
12.6260 2.4230
```


Visualize the results on a map. First, generate the latitude and longitude coordinates of each small circle.

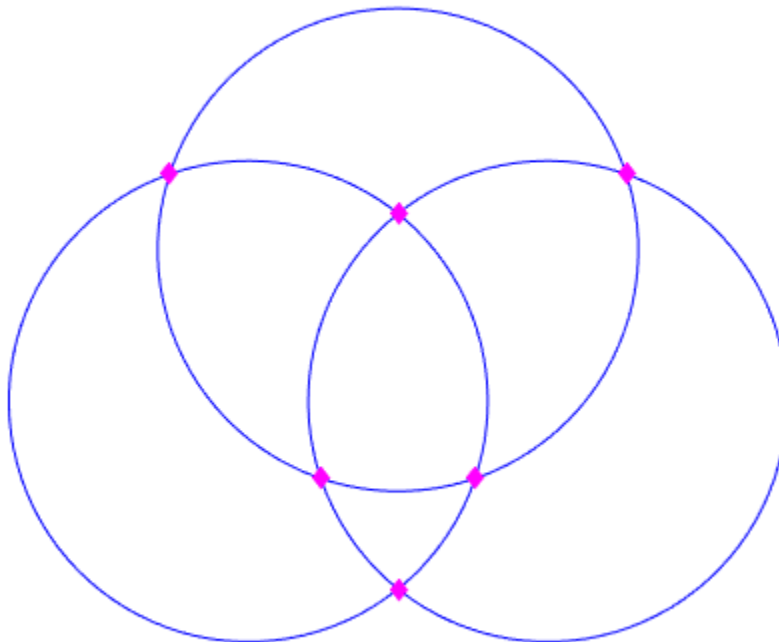
```
[lat1,lon1] = scircle1(lat(1),lon(1),r(1));
[lat2,lon2] = scircle1(lat(2),lon(2),r(2));
[lat3,lon3] = scircle1(lat(3),lon(3),r(3));
```

Display the small circles on a map.

```
figure
axesm("mercator","MapLatLim",[-10 15],"MapLonLim",[-10 20])
axis off
geoshow(lat1,lon1,"DisplayType","line","Color","b","LineStyle","-")
geoshow(lat2,lon2,"DisplayType","line")
geoshow(lat3,lon3,"DisplayType","line")
```

Display the intersection points using magenta diamond markers.

```
geoshow(reshape(latIntersect,[6 1]),reshape(lonIntersect,[6 1]), ...
        "DisplayType","point","Marker","d","MarkerEdgeColor","m","MarkerFaceColor","m")
```



Find Intersections Closest to Estimated Point

Define three small circles by specifying their centers and radii. Specify the radii using spherical distances in degrees.

```
lat = [0 5 0];  
lon = [0 5 10];  
r = [8 8 8];
```

Estimate an intersection point. Then, find the intersections of the small circles that are closest to the estimated point. Indicate that the third argument contains radii (instead of azimuths) by specifying the fourth argument as a vector of 0 values.

```
latEstimate = 0;  
lonEstimate = 5;  
ind = [0 0 0];  
[latIntersect,lonIntersect] = crossfix(lat,lon,r,ind,latEstimate,lonEstimate)
```

```
latIntersect = 3×1
```

```
-2.5744  
6.2529  
-2.5744
```

```
lonIntersect = 3×1
```

```
7.5770  
5.0000  
2.4230
```

Visualize the results on a map. First, generate the latitude and longitude coordinates of each small circle.

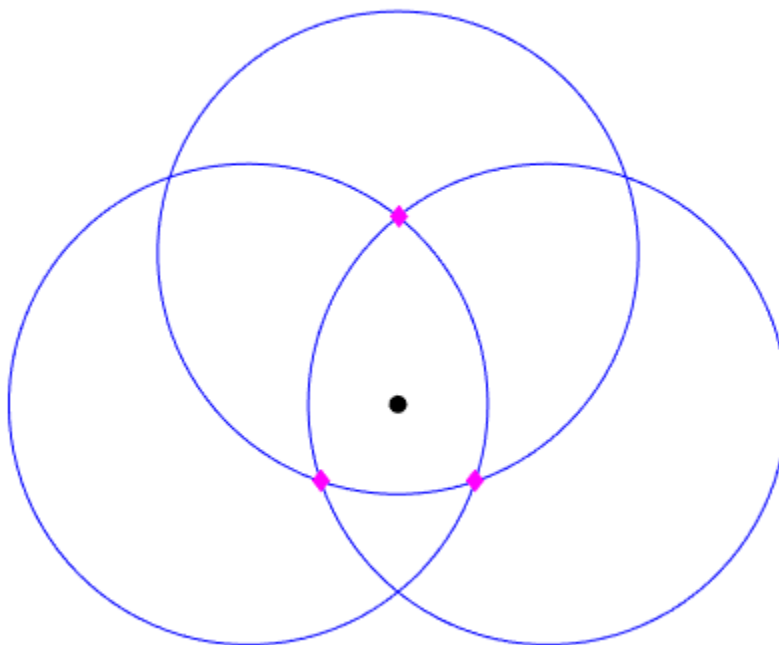
```
[lat1,lon1] = scircle1(lat(1),lon(1),r(1));  
[lat2,lon2] = scircle1(lat(2),lon(2),r(2));  
[lat3,lon3] = scircle1(lat(3),lon(3),r(3));
```

Display the small circles on a map.

```
figure  
axesm("mercator","MapLatLim",[-10 15],"MapLonLim",[-10 20])  
axis off  
geoshow(lat1,lon1,"DisplayType","line","Color","b","LineStyle","-")  
geoshow(lat2,lon2,"DisplayType","line")  
geoshow(lat3,lon3,"DisplayType","line")
```

Display the estimated point using a black circle marker. Display the intersection points that are closest to the estimated point using magenta diamond markers.

```
geoshow(latEstimate,lonEstimate, ...  
        "DisplayType","point","Marker","o","MarkerEdgeColor","k","MarkerFaceColor","k")  
geoshow(reshape(latIntersect,[3 1]),reshape(lonIntersect,[3 1]), ...  
        "DisplayType","point","Marker","d","MarkerEdgeColor","m","MarkerFaceColor","m")
```



Input Arguments

lat – Latitudes

n-element vector

Latitudes, specified as an *n*-element vector, where *n* is the number of circles. *n* must be greater than or equal to 2.

The `crossfix` function interprets each element of `lat` and `lon` depending on the corresponding element of `ind`.

- When an element of `ind` is 1, the corresponding elements of `lat` and `lon` define a point on a great circle. This is the default behavior.
- When an element of `ind` is 0, the corresponding elements of `lat` and `lon` define the center of a small circle.

The sizes of `lat`, `lon`, and `az` (or `az_radius` and `ind`) must match.

Data Types: `double`

lon – Longitudes

n-element vector

Longitudes, specified as an *n*-element vector, where *n* is the number of circles. *n* must be greater than or equal to 2.

The `crossfix` function interprets each element of `lat` and `lon` depending on the corresponding element of `ind`.

- When an element of `ind` is 1, the corresponding elements of `lat` and `lon` define a point on a great circle. This is the default behavior.
- When an element of `ind` is 0, the corresponding elements of `lat` and `lon` define the center of a small circle.

The sizes of `lat`, `lon`, and `az` (or `az_radius` and `ind`) must match.

Data Types: `double`

az — Great circle azimuths

n-element vector

Great circle azimuths, measured clockwise from north, specified as an *n*-element vector, where *n* is the number of circles. *n* must be greater than or equal to 2.

The sizes of `lat`, `lon`, and `az` must match.

Data Types: `double`

az_radius — Great circle azimuths or radii of small circles

n-element vector

Great circle azimuths or radii of small circles, specified as an *n*-element vector, where *n* is the number of circles. *n* must be greater than or equal to 2.

The `crossfix` function interprets each element of `az_radius` depending on the corresponding element of `ind`.

- When an element of `ind` is 1, the corresponding element of `az_radius` is a great circle azimuth. This is the default behavior.
- When an element of `ind` is 0, the corresponding element of `az_radius` is the radius of a small circle. Specify the radius using a spherical distance in degrees.

The sizes of `lat`, `lon`, `az_radius`, and `ind` must match.

Data Types: `double`

ind — Indicator for azimuths or radii

n-element vector

Indicator for azimuths or radii, specified as an *n*-element vector, where *n* is the number of circles. *n* must be greater than or equal to 2.

The `crossfix` function interprets each element of `lat`, `lon`, and `az_radius` depending on the corresponding element of `ind`.

- To indicate that `lat` and `lon` define a point along a great circle, and that `az_radius` is a great circle azimuth, specify the corresponding element of `ind` as 1. This is the default behavior.
- To indicate that `lat` and `lon` define the center of a small circle, and that `az_radius` the radius of the small circle, specify the corresponding element of `ind` as 0.

Data Types: `single` | `double`

latEstimate — Estimated latitude of intersection

scalar

Estimated latitude of intersection, specified as a scalar.

When you specify `latEstimate` and the `crossfix` function does not find an intersection, the function issues a warning.

Data Types: double

lonEstimate — Estimated longitude of intersection

scalar

Estimated longitude of intersection, specified as a scalar.

When you specify `lonEstimate` and the `crossfix` function does not find an intersection, the function issues a warning.

Data Types: double

units — Angle unit for coordinates

"degrees" (default) | "radians"

Angle unit for the coordinates, specified as one of these options:

- "degrees" — Degrees
- "radians" — Radians

Data Types: char | string

Output Arguments**latIntersect — Latitudes of intersection points**

two-column matrix | column vector

Latitudes of the intersection points, returned as a two-column matrix or a column vector.

- When you do not use `latEstimate` and `lonEstimate` as input arguments, `latIntersect` is a two-column matrix. Each row of the matrix contains the latitude of two intersections.
- When you use `latEstimate` and `lonEstimate` as input arguments, `latIntersect` is a column vector. Each element of the vector contains the latitude of the intersection closest to the estimated point.

The `crossfix` function finds the intersection of each pair of circles. As a result, the number of rows equals $n\text{choosek}(n, 2)$, where n is the size of `lat` and `lon`.

When a pair of circles has no intersection, the corresponding row contains NaN values.

lonIntersect — Longitudes of intersection points

two-column matrix | column vector

Longitudes of the intersection points, returned as a two-column matrix or a column vector.

- When you do not use `latEstimate` and `lonEstimate` as input arguments, `lonIntersect` is a two-column matrix. Each row of the matrix contains the longitude of two intersections.

- When you use `latEstimate` and `lonEstimate` as input arguments, `lonIntersect` is a column vector. Each element of the vector contains the longitude of the intersection closest to the estimated point.

The `crossfix` function finds the intersection of each pair of circles. As a result, the number of rows equals `nchoosek(n, 2)`, where n is the size of `lat` and `lon`.

When a pair of circles has no intersection, the corresponding row contains NaN values.

mat – Latitudes and longitudes of intersection points

two-column matrix

Latitudes and longitudes of the intersection points, returned as a two-column matrix or a four-column matrix equivalent to `[latIntersect lonIntersect]`.

Tips

- To find intersection points by using rhumb line azimuths and nautical mile distances, use the `navfix` function.

Version History

Introduced before R2006a

See Also

Functions

`gcxsc` | `gcxgc` | `scxsc` | `rhxrh` | `polyxpoly`

daspectm

Control vertical exaggeration of axesm-based map

Syntax

```
daspectm(zunits)
daspectm(zunits,vfac)
daspectm(zunits,vfac,lat,long)
daspectm(zunits,vfac,lat,long,az)
daspectm(zunits,vfac,lat,long,az,radius)
```

Description

`daspectm(zunits)` sets the 'DataAspectRatio' property of the axesm-based map so that the z-axis is in proportion to the x-and y-projected coordinates. This permits elevation data to be displayed without vertical distortion. The `zunits` parameter specifies the units of the elevation data, and can be any length units recognized by `unitsratio`.

`daspectm(zunits,vfac)` sets the 'DataAspectRatio' property so that the z-axis is vertically exaggerated by the factor `vfac`. If omitted, the default is no vertical exaggeration.

`daspectm(zunits,vfac,lat,long)` sets the aspect ratio based on the local map scale at the specified geographic location. If omitted, the default is the center of the map limits.

`daspectm(zunits,vfac,lat,long,az)` also specifies the direction along which the scale is computed. If omitted, 90 degrees (west) is assumed.

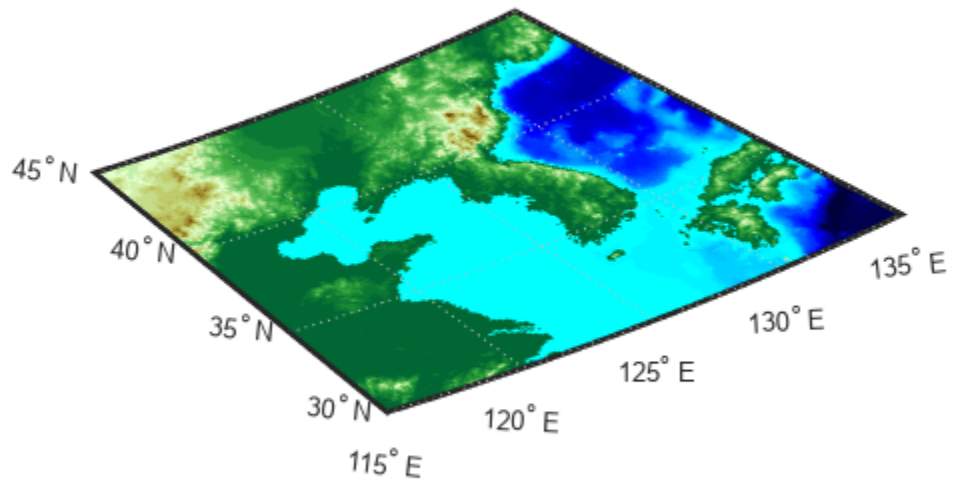
`daspectm(zunits,vfac,lat,long,az,radius)` specifies the radius of the sphere. `radius` can be one of the values supported by `km2deg`, or it can be the (numerical) radius of the desired sphere in `zunits`. If omitted, the default radius of the Earth is used.

Examples

Display Elevation Map with Vertical Exaggeration

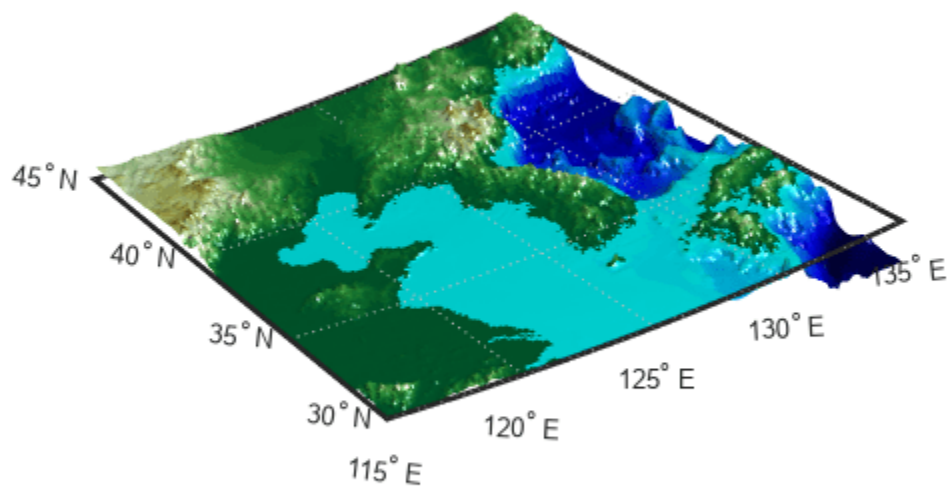
Load elevation data and a geographic cells reference object for the Korean peninsula. Create a world map with appropriate latitude and longitude limits, then display the data using `meshm`. Apply a colormap appropriate for elevation data using `demcmap`. Then, view the map in 3-D.

```
load korea5c
latlim = korea5cR.LatitudeLimits;
lonlim = korea5cR.LongitudeLimits;
worldmap(latlim,lonlim)
meshm(korea5c,korea5cR,korea5cR.RasterSize,korea5c)
demcmap(korea5c)
view(3)
```



Set the vertical exaggeration factor to 30 using `daspectm`. Add light using `camlight`.

```
daspectm('m',30)  
camlight
```

Limitations

The relationship between the vertical and horizontal coordinates holds only as long as the **geoid** or scale factor properties of the **axesm**-based map remain unchanged. If you change the scaling between geographic coordinates and projected axes coordinates, execute **daspectm** again.

Version History

Introduced before R2006a

See Also

daspect | paperscale

defaultm

Create or reset map projection structure

Syntax

```
mstruct = defaultm(projid)
mstruct = defaultm(mstructIn)
```

Description

`mstruct = defaultm(projid)` creates a map projection structure using the projection ID `projid`.

`mstruct = defaultm(mstructIn)` resets the map projection structure `mstructIn` by updating empty and dependent fields. The function updates the `origin`, `flatlimit`, `flonlimit`, `maplatlimit`, and `maplonlimit` fields so they are compatible with each other and with the `mapprojection` field. When the structure represents a UTM or UPS coordinate system, the function also updates the `zone` field.

Note To set up a map projection structure, you must use the `defaultm` function twice. These steps show how to set up a map projection structure.

- 1 Create a map projection structure with default values by using the syntax `defaultm(projid)`.
 - 2 Customize the map projection structure by specifying values for fields such as `origin`, `maplatlim`, and `maplonlim`.
 - 3 Update empty and dependent fields of the map projection structure by using the syntax `defaultm(mstructIn)`.
-

Examples

Create and Reset Map Projection Structure

Create a map projection structure using a Mercator projection. By default, many of the fields are empty.

```
mstruct = defaultm("mercator")

mstruct = struct with fields:
    mapprojection: 'mercator'
    zone: []
    angleunits: 'degrees'
    aspect: 'normal'
    falsenorthing: []
    falseeasting: []
    fixedorient: []
    geoid: [1 0]
    maplatlimit: []
```

```

maplonlimit: []
mapparallels: 0
nparallels: 1
  origin: []
scalefactor: []
  trimlat: [-86 86]
  trimlon: [-180 180]
  frame: []
  ffill: 100
fedgecolor: [0.1500 0.1500 0.1500]
ffacecolor: 'none'
flatlimit: []
flinewidth: 2
flonlimit: []
  grid: []
galtitude: Inf
  gcolor: [0.1500 0.1500 0.1500]
glinestyle: ':'
glinewidth: 0.5000
mlineexception: []
  mlinefill: 100
  mlinelimit: []
  mlinelocation: []
  mlinevisible: 'on'
plineexception: []
  plinefill: 100
  plinelimit: []
  plinelocation: []
  plinevisible: 'on'
  fontangle: 'normal'
  fontcolor: [0.1500 0.1500 0.1500]
  fontname: 'Helvetica'
  fontsize: 10
  fontunits: 'points'
  fontweight: 'normal'
  labelformat: 'compass'
labelrotation: 'off'
  labelunits: []
meridianlabel: []
mlabellocation: []
mlabelparallel: []
  mlabelround: 0
  parallellabel: []
plabellocation: []
plabelmeridian: []
  plabelround: 0

```

Specify the map origin. Then, update empty fields and fields that depend on the map origin, such as the map latitude and longitude limits, by using the `defaultm` function again.

```

mstruct.origin = [0 90 0];
mstruct = defaultm(mstruct)

mstruct = struct with fields:
  mapprojection: 'mercator'
    zone: []
  angleunits: 'degrees'

```

```
    aspect: 'normal'
falsenorthing: 0
falseeasting: 0
fixedorient: []
    geoid: [1 0]
maplatlimit: [-86 86]
maplonlimit: [-90 270]
mapparallels: 0
nparallels: 1
    origin: [0 90 0]
scalefactor: 1
    trimlat: [-86 86]
    trimlon: [-180 180]
    frame: 'off'
    ffill: 100
fedgecolor: [0.1500 0.1500 0.1500]
ffacecolor: 'none'
flatlimit: [-86 86]
flinewidth: 2
flonlimit: [-180 180]
    grid: 'off'
galtitude: Inf
gcolor: [0.1500 0.1500 0.1500]
glinestyle: ':'
glinewidth: 0.5000
mlineexception: []
    mlinefill: 100
    mlinelimit: []
    mlinelocation: 30
    mlinevisible: 'on'
plineexception: []
    plinefill: 100
    plinelimit: []
    plinelocation: 15
    plinevisible: 'on'
    fontangle: 'normal'
    fontcolor: [0.1500 0.1500 0.1500]
    fontname: 'Helvetica'
    fontsize: 10
    fontunits: 'points'
    fontweight: 'normal'
    labelformat: 'compass'
    labelrotation: 'off'
    labelunits: 'degrees'
meridianlabel: 'off'
mlabellocation: 30
mlabelparallel: 86
mlabelround: 0
parallellabel: 'off'
plabellocation: 15
plabelmeridian: -90
plabelround: 0
```

Project Coordinates Using Map Projection Structure

Project coordinates by using a map projection structure instead of an axesm-based map.

Create a map projection structure for a sinusoidal projection.

```
mstruct = defaultm("sinusoid");
```

Specify map limits and a reference ellipsoid for the map projection structure. Populate additional fields of the structure based on the map limits by using the defaultm function again.

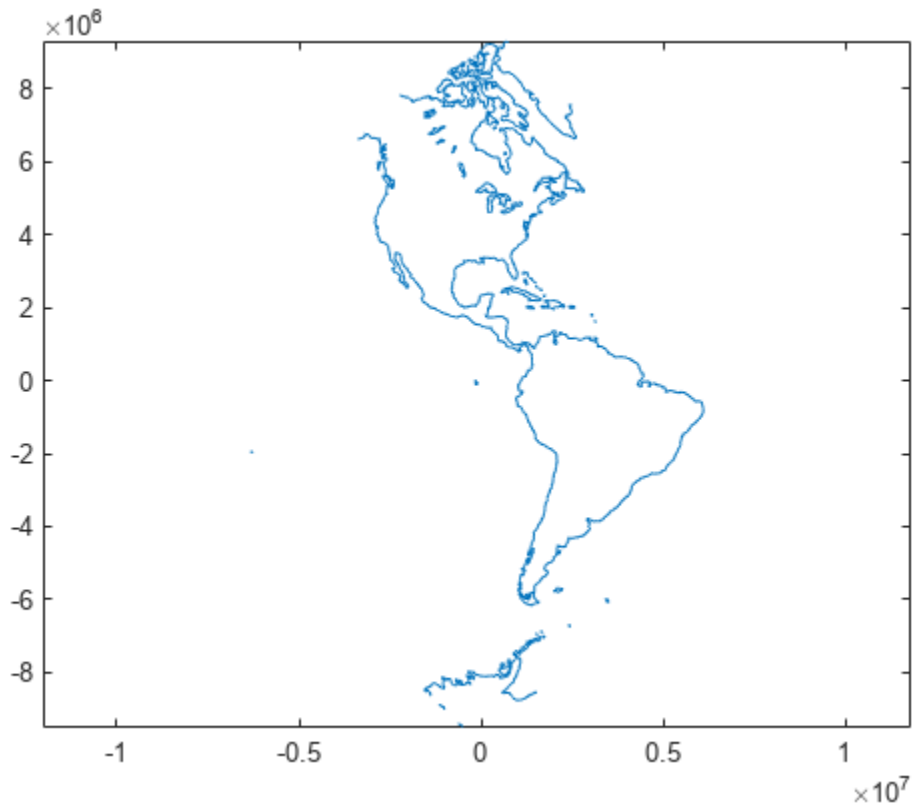
```
mstruct.maplonlimit = [-150 -30];  
mstruct.geoid = referenceEllipsoid("grs80","kilometers");  
mstruct = defaultm(mstruct);
```

Load coastline data and trim it to the map limits. Then, project the latitude and longitude coordinates by using the projfwd function and the map projection structure.

```
load coastlines  
[lat,lon] = maptriml(coastlat,coastlon,mstruct.maplatlimit,mstruct.maplonlimit);  
[x,y] = projfwd(mstruct,lat,lon);
```

Display the projected coordinates in a Cartesian axes.

```
figure  
plot(x,y)  
axis equal
```



Input Arguments

projid — Projection ID

character vector | string scalar

Projection ID, specified as a character vector or a string scalar.

This code shows how to list the supported projection IDs in the Command Window by using the `maps` function.

```
m = maps("idlist")
```

For more information about supported projection IDs, see “Summary and Guide to Projections”.

Data Types: `char` | `string`

mstructIn — Input map projection structure

structure

Input map projection structure, specified as a structure with fields identical to the properties of an `axesm`-based map. For more information about the properties of `axesm`-based maps, see `axesm`-Based Map Properties.

Output Arguments

mstruct — Map projection structure

structure

Map projection structure, returned as a structure with fields identical to the properties of an `axesm`-based map. Examples of map projection structure fields include the projection name, angle unit, origin, aspect, false easting, and false northing. For more information about the properties of `axesm`-based maps, see `axesm`-Based Map Properties.

A map projection structure enables you to project and unproject geographic coordinates without creating an `axesm`-based map. You can project coordinates by using a map projection structure as input with the `projfwd` or `vfwdtran` function. You can unproject coordinates by using a map projection structure as input with the `projinv` or `vinvtran` function.

Tips

- By default, the angle-valued fields of map projection structures are in degrees. If you must work in radians, update the `angleunits` field of the structure and then reset the structure. This code shows how to update your map projection structure to use radians.

```
mstruct = defaultm("mercator");  
mstruct.angleunits = "radians";  
mstruct = defaultm(mstruct);
```

Once you update a structure to use radians, you must use radians when you change angle-valued fields such as `origin`, `parallels`, `maplatlimit`, and `maplonlimit`.

- You can get a map projection structure from an `axesm`-based map by using the `gcm` function. This code shows how to create the same map projection structure by using the `defaultm` function as from an `axesm`-based map.

```
% Set longitude limits and define reference ellipsoid
lonlim = [-150 -30];
ref = referenceEllipsoid("grs80","kilometers");

% Create map projection structure using defaultm
mstruct1 = defaultm("sinusoid");
mstruct1.maplonlimit = lonlim;
mstruct1.geoid = ref;
mstruct1 = defaultm(mstruct1);

% Create map projection structure from axesm-based map
abm = axesm("sinusoid","maplonlimit",lonlim,"geoid",ref);
mstruct2 = gcm(abm);
f = gcf;
close(f)

% Compare map structures
isequal(mstruct1,mstruct2)
```

Version History

Introduced before R2006a

See Also

Functions

axesm | setm

Topics

“Work in UTM Without a Displayed Map”

deg2km

Convert spherical distance from degrees to kilometers

Syntax

```
km = deg2km(deg)
km = deg2km(deg, radius)
km = deg2km(deg, sphere)
```

Description

`km = deg2km(deg)` converts distances from degrees to kilometers, as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`km = deg2km(deg, radius)` converts distances from degrees to kilometers, as measured along a great circle on a sphere having the specified radius.

`km = deg2km(deg, sphere)` converts distances from degrees to kilometers, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Degrees to Kilometers on Earth

Find the circumference of the Earth in kilometers. By default, the `deg2km` function assumes your input is a measurement of the Earth, which is represented as a sphere with a radius of 6371 kilometers.

```
km = deg2km(360)
km = 4.0030e+04
```

Convert Degrees to Kilometers on Mars

Find the circumference of Mars in kilometers.

```
km = deg2km(360, 'mars')
km = 2.1300e+04
```

Input Arguments

deg — Distance in degrees

numeric array

Distance in degrees, specified as a numeric array.

Data Types: `single` | `double`

radius — Radius

6371 (default) | numeric scalar

Radius of sphere in units of kilometers, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments

km — Distance in kilometers

numeric array

Distance in kilometers, returned as a numeric array.

Data Types: `single` | `double`

Version History

Introduced in R2007a

See Also

`deg2nm` | `deg2sm` | `deg2rad` | `rad2deg` | `rad2km` | `km2deg`

deg2nm

Convert spherical distance from degrees to nautical miles

Syntax

```
nm = deg2nm(deg)
nm = deg2nm(deg, radius)
nm = deg2nm(deg, sphere)
```

Description

`nm = deg2nm(deg)` converts distances from degrees to nautical miles, as measured along a great circle on a sphere with a radius of 3440.065 nautical miles, the mean radius of the Earth.

`nm = deg2nm(deg, radius)` converts distances from degrees to nautical miles, as measured along a great circle on a sphere having the specified radius.

`nm = deg2nm(deg, sphere)` converts distances from degrees to nautical miles, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Arc Length to Nautical Miles

One degree of arc length is about 60 nautical miles, using a spherical model of the Earth.

```
deg2nm(1)
```

```
ans =
```

```
60.0405
```

This is not true on Mercury, of course.

```
deg2nm(1, 'mercury')
```

```
ans =
```

```
22.9852
```

Input Arguments

deg — Distance in degrees

numeric array

Distance in degrees, specified as a numeric array.

Data Types: `single` | `double`

radius — Radius

3440.065 (default) | numeric scalar

Radius of sphere in units of nautical miles, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments

nm — Distance in nautical miles

numeric array

Distance in nautical miles, returned as a numeric array.

Data Types: `single` | `double`

Version History

Introduced in R2007a

See Also

`deg2km` | `deg2sm` | `deg2rad` | `rad2deg` | `rad2nm` | `nm2deg`

deg2sm

Convert spherical distance from degrees to statute miles

Syntax

```
sm = deg2sm(deg)
sm = deg2sm(deg, radius)
sm = deg2sm(deg, sphere)
```

Description

`sm = deg2sm(deg)` converts distances from degrees to statute miles as measured along a great circle on a sphere with a radius of 3958.748 sm, the mean radius of the Earth.

`sm = deg2sm(deg, radius)` converts distances from degrees to statute miles as measured along a great circle on a sphere having the specified radius.

`sm = deg2sm(deg, sphere)` converts distances from degrees to statute miles, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Degrees to Statute Miles on Earth

Find the circumference of the Earth in statute miles. By default, the `deg2sm` function assumes your input is a measurement of the Earth, which is represented as a sphere with a radius of 3958.748 statute miles.

```
sm = deg2sm(360)
sm = 2.4874e+04
```

Convert Degrees to Statute Miles on Mars

Find the circumference of Mars in statute miles.

```
sm = deg2sm(360, 'mars')
sm = 1.3235e+04
```

Input Arguments

deg — Distance in degrees

numeric array

Distance in degrees, specified as a numeric array.

Data Types: single | double

radius — Radius

3958.748 (default) | numeric scalar

Radius of sphere in units of statute miles, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments

sm — Distance in statute miles

numeric array

Distance in statute miles, returned as a numeric array.

Data Types: single | double

Version History

Introduced in R2007a

See Also

deg2rad | rad2deg | deg2km | deg2nm | sm2deg | rad2sm

degrees2dm

Convert degrees to degrees-minutes

Syntax

```
DM = degrees2dm(angleInDegrees)
```

Description

`DM = degrees2dm(angleInDegrees)` converts angles from values in degrees which may include a fractional part (sometimes called “decimal degrees”) to degrees-minutes representation.

Examples

Convert Angle in Degrees to Degree-Minutes

```
angleInDegrees = [ 30.8457722555556; ...  
                  -82.0444189583333; ...  
                  -0.504756513888889; ...  
                  0.004116666666667];  
dm = degrees2dm(angleInDegrees)
```

```
dm = 4×2
```

```
    30.0000    50.7463  
   -82.0000     2.6651  
     0.0000   -30.2854  
     0.0000     0.2470
```

Input Arguments

angleInDegrees — Angle in degrees

n-element real-valued column vector

Angle in degrees, specified as an *n*-element real-valued column vector.

Output Arguments

DM — Angle in degrees-minutes representation

n-by-2 real-valued matrix

Angle in degrees-minutes representation, returned as an *n*-by-2 real-valued matrix. Each row specifies one angle, with the format [D M]:

- D contains the “degrees” element and is integer-valued.
- M contains the “minutes” element and may have a fractional part.

In any given row of DM, the sign of the first nonzero element indicates the sign of the overall angle. A positive number indicates north latitude or east longitude; a negative number indicates south latitude or west longitude. Any remaining element in that row has nonnegative values.

Version History

Introduced in R2007a

See Also

[dm2degrees](#) | [deg2rad](#) | [degrees2dms](#) | [rad2deg](#)

Topics

“Angle Representations and Angular Units”

degrees2dms

Convert degrees to degrees-minutes-seconds

Syntax

```
DMS = degrees2dms(angleInDegrees)
```

Description

`DMS = degrees2dms(angleInDegrees)` converts angles from values in degrees which may include a fractional part (sometimes called “decimal degrees”) to degrees-minutes-seconds representation.

Examples

Convert Angle in Degrees to Degree-Minute-Seconds

Convert an angle specified as a real-valued column vector to degrees-minutes-seconds representation. The output value is an n -by-3 real-valued matrix. Each row in the output specifies one angle, with the format [Degrees Minutes Seconds].

```
angleInDegrees = [ 30.8457722555556; ...
                  -82.0444189583333; ...
                  -0.504756513888889; ...
                   0.004116666666667];
dms = degrees2dms(angleInDegrees)
```

```
dms = 4x3
```

```
    30.0000    50.0000    44.7801
   -82.0000     2.0000    39.9082
         0   -30.0000    17.1235
         0         0    14.8200
```

Customize Degree-Minute-Seconds Display Format

Convert angles in degrees to degree-minute-second representation. Display the result using the default display provided by `angl2str`.

```
angleInDegrees = [ 30.8457722555556; ...
                  -82.0444189583333; ...
                  -0.504756513888889; ...
                   0.004116666666667];
angl2str(angleInDegrees, 'ns', 'degrees2dms')
```

```
ans = 4x25 char array
' 30^{\circ} 50' 44.78" N '
' 82^{\circ} 02' 39.91" S '
'  0^{\circ} 30' 17.12" S '
```



```
' 0^{\circ} 00' 14.82" N '
```

Alternatively, specify a custom display format by converting the angles to degree-minute-second representation and using `sprintf`. The result is a single string.

```
dms = degrees2dms(angleInDegrees)
```

```
dms = 4×3
```

```
    30.0000    50.0000    44.7801
   -82.0000     2.0000    39.9082
         0   -30.0000    17.1235
         0         0    14.8200
```

```
nonnegative = all((dms >= 0),2);
hemisphere = repmat('N', size(nonnegative));
hemisphere(~nonnegative) = 'S';
absvalues = num2cell(abs(dms'));
values = [absvalues; num2cell(hemisphere')];
sprintf('%2.0fd:%2.0fm:%7.5fs:%s\n',values{:})
```

```
ans =
    '30d:50m:44.78012s:N
     82d: 2m:39.90825s:S
      0d:30m:17.12345s:S
      0d: 0m:14.82000s:N
    '
```

Input Arguments

angleInDegrees — Angle in degrees

n-element real-valued column vector

Angle in degrees, specified as an *n*-element real-valued column vector.

Output Arguments

DMS — Angle in degrees-minutes-seconds representation

n-by-3 real-valued matrix

Angle in degrees-minutes-seconds representation, returned as an *n*-by-3 real-valued matrix. Each row specifies one angle, with the format [D M S]:

- D contains the “degrees” element and is integer-valued.
- M contains the “minutes” element and is integer-valued.
- S contains the “seconds” element and may have a fractional part.

In any given row of DMS, the sign of the first nonzero element indicates the sign of the overall angle. A positive number indicates north latitude or east longitude; a negative number indicates south latitude or west longitude. Any remaining elements in that row will have nonnegative values.

Version History

Introduced in R2007a

See Also

dms2degrees | deg2rad | degrees2dm | rad2deg

Topics

“Angle Representations and Angular Units”

deg2rad

(Not recommended) Convert angles from degrees to radians

Note deg2rad is not recommended. Use the deg2rad function instead. For more information, see “Compatibility Considerations”.

Syntax

```
angleInRadians = deg2rad(angleInDegrees)
```

Description

angleInRadians = deg2rad(angleInDegrees) converts angle units from degrees to radians.

Examples

Convert Degrees to Radians

Convert 90 degrees to radians.

```
angleInRadians = deg2rad(90)
```

```
angleInRadians =
```

```
    1.5708
```

Input Arguments

angleInDegrees — Angle in degrees

scalar | vector | matrix | N-D array

Angle in degrees, specified as a scalar, vector, matrix, or N-D array.

Version History

Introduced in R2009b

R2015b: deg2rad is not recommended

Not recommended starting in R2015b

The deg2rad function is not recommended. Use the deg2rad function instead.

To update your code, replace instances of the deg2rad function with the deg2rad function.

While the deg2rad function accepts input arguments of integer types such as uint8, the deg2rad function accepts only single- and double-precision types. You can convert integer types to single- or double-precision types by using the single or double function.

See Also
deg2rad

demcmap

Colormaps appropriate to terrain elevation data

Syntax

```
demcmap(Z)
demcmap(Z,ncolors)
demcmap(Z,ncolors,cmapsea,cmapland)

demcmap('inc',Z,deltaz)
demcmap('inc',Z,deltaz,cmapsea,cmapland)

[cmap,climits] = demcmap( ___ )
```

Description

`demcmap(Z)` sets the colormap and color axis limits based on the elevation data limits derived from input argument `Z`.

- The default colormap assigns shades of green and brown for positive elevations, and various shades of blue for negative elevation values below sea level.
- The number of colors assigned to land and to sea are in proportion to the ranges in terrain elevation and bathymetric depth and total 64 by default. The color axis limits are computed such that the interface between land and sea maps to the zero elevation contour.
- The colormap is applied to the current figure and the color axis limits are applied to the current axes.

`demcmap(Z,ncolors)` creates a colormap of length `ncolors`.

`demcmap(Z,ncolors,cmapsea,cmapland)` assigns `cmapsea` and `cmapland` to elevations below and above sea level respectively.

`demcmap('inc',Z,deltaz)` chooses number of colors and color axis limits such that each color approximately represents the increment of elevation `deltaz`.

- The literal `'inc'` signals `demcmap` that the first argument after `Z` will be `deltaz`.

`demcmap('inc',Z,deltaz,cmapsea,cmapland)` assigns `cmapsea` and `cmapland` to elevations below and above sea level respectively.

`[cmap,climits] = demcmap(___)` returns colormap `cmap` and color axis limit `climits`, using any of the above syntaxes, but does not apply them to figure or axes properties.

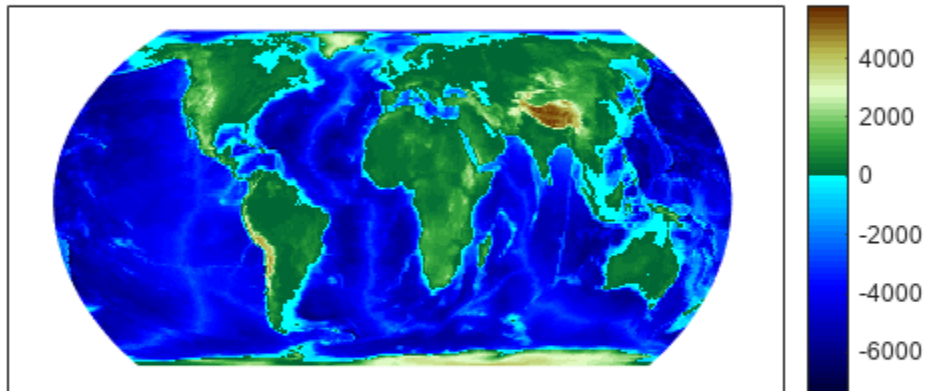
- Even if only one output argument is specified, no change occurs to figure or axes properties.

Examples

Displaying Elevation Data with Default Colormap

Load elevation raster data and a geographic cells reference object. Then, apply a colormap by specifying the maximum and minimum values of the data.

```
load topo60c
axesm hatano
meshm(topo60c,topo60cR)
zlimits = [min(topo60c(:)) max(topo60c(:))];
demcmap(zlimits)
colorbar
```

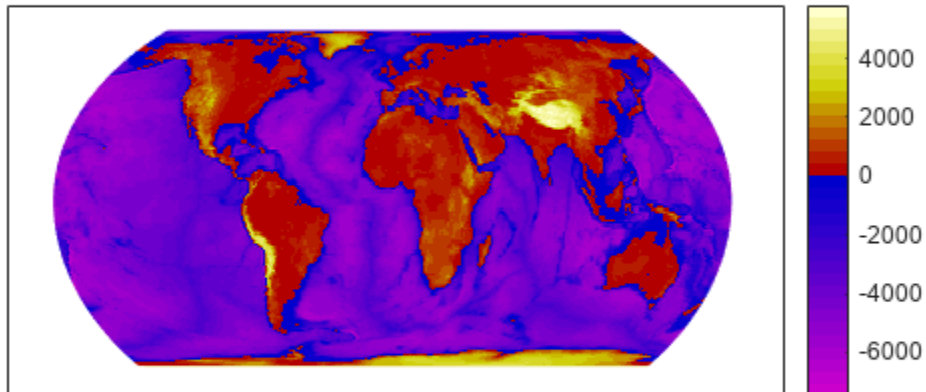


Defining Custom Land and Sea Colormaps

Custom RGB colormaps, for example `cmapsea` and `cmapland`, are used to populate figure colormaps by interpolation. The colors in each colormap map to the land and sea regions of the map. Fewer colors have been specified in total than the default number of 64. `demcmap` determines maximum and minimum elevation data limits internally as shown in the below example when the first argument is the elevation data grid.

```
load topo60c
axesm hatano
meshm(topo60c,topo60cR)
cmapsea = [0.8 0 0.8; 0 0 0.8];
```

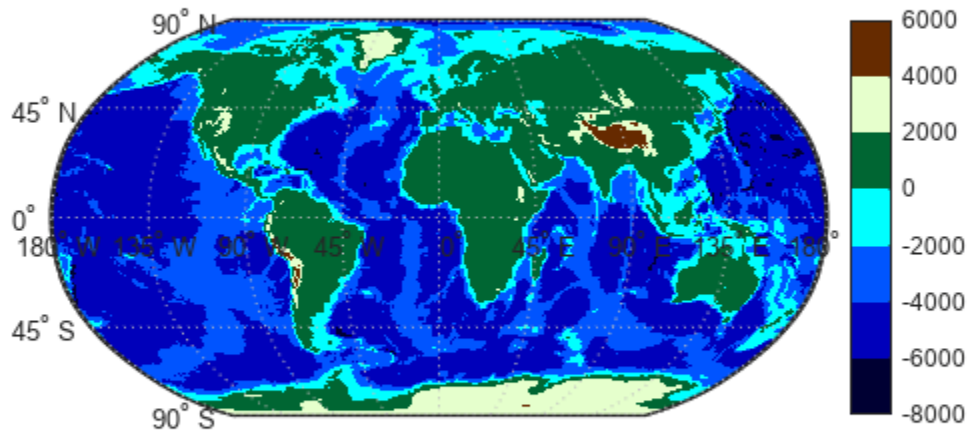
```
cmapland = [0.7 0 0; 0.8 0.8 0; 1 1 0.8 ];  
demcmap(topo60c,32,cmapsea,cmapland)  
colorbar
```



Colormap in Which Each Color Approximates a User Defined Increment

The following demcmap example controls the color quantization by choosing an optimal number of colors such that each color represents an elevation increment of approximately 2000 .

```
load topo60c  
worldmap('world')  
geoshow(topo60c,topo60cR,'DisplayType','texturemap')  
demcmap('inc',[max(topo60c(:)) min(topo60c(:))],2000);  
colorbar
```



Input Arguments

Z — Terrain elevation limits

vector | matrix

Terrain elevation limits specified as a vector or matrix. If **Z** is a 2 element vector, then it specifies the minimum and maximum limits of terrain elevation data; ordering is not important. If **Z** is a matrix, then it specifies an elevation grid in which positive and negative values represent points above and below sea level respectively. The above two syntaxes for `demcmap` are identical in their effect on the figure colormap and axes properties.

Data Types: `single` | `double` | `int8` | `int32` | `uint8` | `uint16` | `uint32`

ncolors — Number of colors in colormap

64 (default) | scalar

Number of colors in the colormap specified as a scalar. It defines the number of rows *m* in the *m*x3 RGB matrix of the figure colormap.

Data Types: `double`

cmapsea, **cmapland** — RGB colormap matrices

matrix

- RGB colormaps specified as $m \times 3$ arrays containing any number of rows. The two colormaps need not be equal in length. They serve as the basis set for populating the figure colormap by interpolation.
- `cmapsea` and `cmapland` replace the default colormap. The default colormap for land or sea can be retained by providing an empty matrix in place of either colormap matrix.

That part of the figure colormap assigned to negative elevations is derived from `cmapsea`; `cmapland` plays a similar role for positive elevations.

Data Types: `double`

deltaz — Increment of elevation

scalar

The increment of elevation specified as a scalar. The color quantization of the default or user supplied colormap is adjusted such that each discrete color approximately represents a `deltaz` increment in elevation.

Data Types: `double`

Output Arguments

cmap — RGB colormap

matrix

RGB colormap returned as a matrix constructed for the figure colormap. Supply output arguments when you want to obtain the colormap and color axis limits without applying them automatically to the figure or axes properties. These properties remain unchanged even if only one output (`cmap`) is specified.

Data Types: `double`

climits — Color axis limits

vector

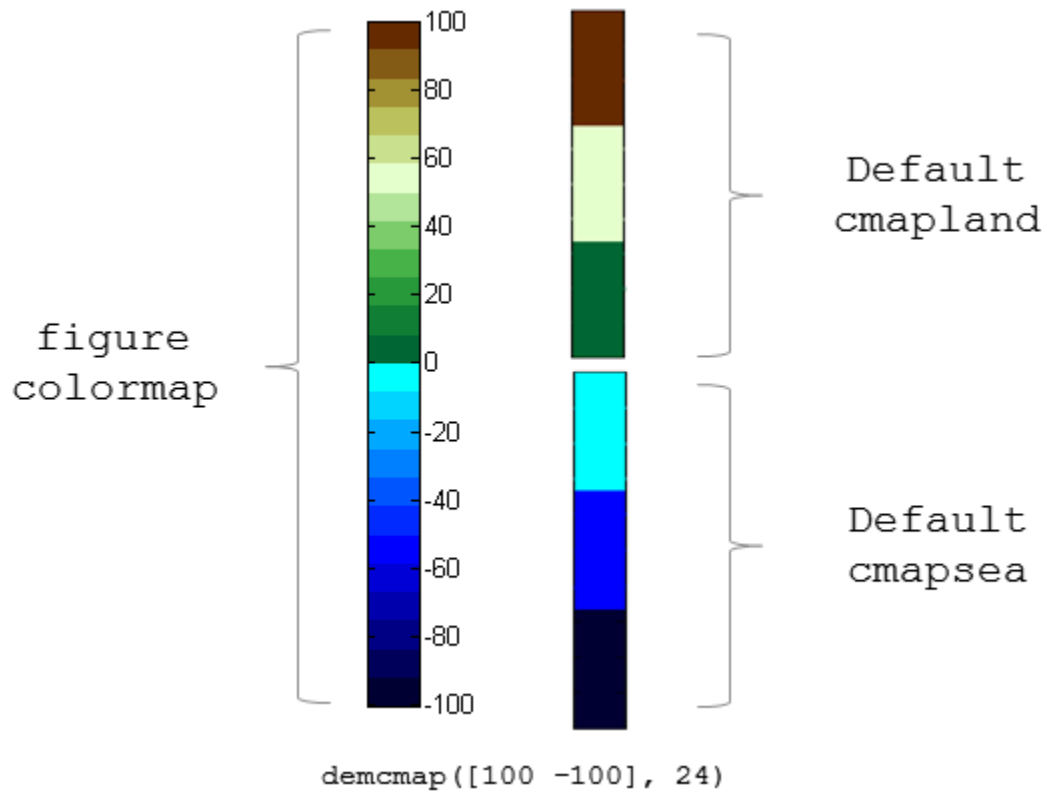
Color axis limits returned as a vector. `climits` may differ somewhat from those derived from input argument `Z` due to the quantization which results from fitting a limited number of colors over the range limit of the elevation data.

Supply output arguments when you want to obtain the colormap and color axis limits without applying them automatically to the figure or axes.

Data Types: `double`

Algorithms

If the elevation grid data contains both positive and negative values, then the computed colormap, `cmap`, has a "sea" partition of length `nsea` and "land" partition of length `nland`. The sum of `nsea` and `nland` equals the total number of entries in the computed colormap. The actual values of `nsea` and `nland` depend upon the number of entries and the relative range of the negative and positive limits of the elevation data. The sea partition consists of rows 1 through `nsea`, and the land partition consists of rows `nsea + 1` through `ncolors`. The sea and land partitions of the figure colormap are populated with colors interpolated from the basis RGB colormaps, `cmapsea` and `cmapland`. In the figure below, the sea and land 3×3 RGB colormaps shown are the default colors used by `demcmap` to populate the figure colormap when no user specified colormaps are provided.



If the elevation grid data contains only positive or negative values, then the figure colormap is derived solely from the corresponding sea or land colormap.

Version History

Introduced before R2006a

See Also

`colormap` | `meshlsrm` | `meshm` | `surflsrm` | `surfm`

departure

Departure of longitudes at specified latitudes

Syntax

```
d = departure(lon1,lon2,lat)
d = departure(lon1,lon2,lat,ellipsoid)
d = departure( ____,units)
```

Description

`d = departure(lon1,lon2,lat)` calculates the departure from `lon1` to `lon2` at the latitude `lat`. Departure is the distance along a specific parallel between two meridians. This syntax references the coordinates to the unit sphere and returns `d` as a spherical distance in degrees.

`d = departure(lon1,lon2,lat,ellipsoid)` specifies a reference ellipsoid for the coordinates. This syntax returns `d` in the units of the semimajor axis of the reference ellipsoid.

`d = departure(____,units)` specifies the angle units, in addition to any combination of input arguments from the previous syntaxes.

Examples

Calculate Departure of Longitudes

Calculate the departure distance between the longitudes 10°W and 20°W at the latitudes 10°N, 40°N, and 80°N. By default, the departure function returns spherical distances in degrees.

```
lon1 = 10;
lon2 = 20;
d1 = departure(lon1,lon2,10)

d1 = 9.8481

d2 = departure(lon1,lon2,40)

d2 = 7.6604

d3 = departure(lon1,lon2,80)

d3 = 1.7365
```

Calculate Departure of Longitudes on Ellipsoid

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of nautical miles.

```
wgs84 = wgs84Ellipsoid("nm");
```

Calculate the departure distance between the longitudes 10°W and 20°W at the latitudes 10°N, 40°N, and 80°N. Reference the coordinates to the ellipsoid. When you specify a reference ellipsoid as input to the `departure` function, the function returns linear distances in the units of the semimajor axis of the ellipsoid.

```
lon1 = 10;  
lon2 = 20;  
d1 = departure(lon1,lon2,10,wgs84)  
  
d1 = 592.0052  
  
d2 = departure(lon1,lon2,40,wgs84)  
  
d2 = 461.0899  
  
d3 = departure(lon1,lon2,80,wgs84)  
  
d3 = 104.7164
```

Input Arguments

lon1 — Longitude of first point

scalar | array

Longitude of the first point, specified as a scalar or array.

The sizes of `lon1`, `lon2`, and `lat` must match.

Data Types: `single` | `double`

lon2 — Longitude of second point

scalar | array

Longitude of the second point, specified as a scalar or array.

The sizes of `lon1`, `lon2`, and `lat` must match.

Data Types: `single` | `double`

lat — Latitude of points

scalar | array

Latitude of the points, specified as a scalar or array.

The sizes of `lon1`, `lon2`, and `lat` must match.

Data Types: `single` | `double`

ellipsoid — Reference ellipsoid

[1 0] (default) | `referenceSphere` object | `referenceEllipsoid` object | `oblateSpheroid` object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element vector of the form [`semimajor_axis` `eccentricity`], where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of [1 0] represents the unit sphere.

units — Angle unit

"degrees" (default) | "radians"

Angle unit, specified as one of these options:

- "degrees" — Degrees
- "radians" — Radians

If you do not specify a reference ellipsoid, this argument determines the angle units for the coordinates and the departure (as a spherical distance). If you specify a reference ellipsoid, this argument only determines the angle units for the coordinates.

Data Types: char | string

Output Arguments

d — Departure distance

scalar | array

Departure distance, returned as a scalar or an array of the same size as lon1, lon2, and lat.

- When you do not specify a reference ellipsoid as input, d is a spherical distance in degrees. You can return a spherical distance in radians by using the units input argument.
- When you specify a reference ellipsoid as input, d is a linear distance in the units of the semimajor axis of the ellipsoid.

More About

Departure

Departure is the distance along a parallel between two points. Whereas a degree of latitude is always the same distance, a degree of longitude is different in length at different latitudes. In practice, this distance is usually given in nautical miles.

Version History

Introduced before R2006a

See Also

Functions

distance | stdm

disp

Display geographic or planar vector

Syntax

```
disp(v)
```

Description

`disp(v)` prints the size of the geographic or planar vector `v`, and its properties and dynamic properties, if they exist.

If the command window is large enough, the values of the properties are also shown, otherwise only their size is shown. You can control the display of the numerical values using the `format` command.

Examples

Display a Geoshape Vector

Create a geoshape vector.

```
gs = geoshape(shaperead('worldcities.shp', 'UseGeoCoords', true));
```

Display the entire geoshape vector.

```
disp(gs)
```

```
318x1 geoshape vector with properties:
```

```
Collection properties:
```

```
    Geometry: 'point'
```

```
    Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(318 features concatenated with 317 delimiters)
```

```
    Latitude: [5.2985 NaN 24.6525 NaN 5.6106 NaN 37.0613 NaN 9.0235 NaN -34.6645 NaN 12.8767 NaN ...]
```

```
    Longitude: [-3.9509 NaN 54.7589 NaN -0.2121 NaN 35.3894 NaN 38.7575 NaN 138.8528 NaN 44.5408 NaN ...]
```

```
Feature properties:
```

```
    Name: {1x318 cell}
```

Display only the first two feature of the geoshape vector. Notice that the property values are shown because they are short enough to fit on the command window.

```
disp(gs(1:2));
```

```
2x1 geoshape vector with properties:
```

```
Collection properties:
```

```
    Geometry: 'point'
```

```
    Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(2 features concatenated with 1 delimiter)
```

```
Latitude: [5.2985 NaN 24.6525]
Longitude: [-3.9509 NaN 54.7589]
Feature properties:
  Name: {'Abidjan' 'Abu Dhabi'}
```

Input Arguments

v — Geographic or planar vector to be displayed

geopoint, geoshape, mappoint, or mapshape objects

Geographic or planar vector to be displayed, specified as a geopoint, geoshape, mappoint, or mapshape object.

Version History

Introduced in R2012a

See Also

format | fieldnames | length | properties

disp

Display properties of WMS layers or capabilities

Syntax

```
disp(layers,Name,Value,...)
disp(capabilities)
```

Description

`disp(layers,Name,Value,...)` displays the index number followed by the property names and property values of the Web map service layers, `layers`. You can specify additional options using one or more `Name,Value` pair arguments.

`disp(capabilities)` displays the properties of the Web map service capabilities document, `capabilities`. The function removes hyperlinks and expands character vector and cell array properties.

Examples

Display Specific Properties of WMS Layers

Search the WMS Database for layers that contain `srtm30`. Display the `LayerTitle` and `LayerName` properties without an `Index`.

```
layers = wmsfind('srtm30');
disp(layers(1:5),'Index', 'off', ...
      'Properties',{ 'layertitle', 'layername' })
```

```
5x1 WMSLayer
```

```
Properties:
```

```
LayerTitle: 'Estimated Seafloor Depth Gradients: srtm30plus (US West Coast) - magnitude_gra
LayerName: 'erdSrtm30plusSeafloorGradient:magnitude_gradient'
```

```
LayerTitle: 'Estimated Seafloor Depth Gradients: srtm30plus (US West Coast) - sea_floor_dep
LayerName: 'erdSrtm30plusSeafloorGradient:sea_floor_depth'
```

```
LayerTitle: 'Estimated Seafloor Depth Gradients: srtm30plus (US West Coast) - x_gradient'
LayerName: 'erdSrtm30plusSeafloorGradient:x_gradient'
```

```
LayerTitle: 'Estimated Seafloor Depth Gradients: srtm30plus (US West Coast) - y_gradient'
LayerName: 'erdSrtm30plusSeafloorGradient:y_gradient'
```

```
LayerTitle: 'SRTM30_PLUS Estimated Topography, 30 seconds, Global, v11 - z'
LayerName: 'srtm30plus:z'
```

Your results might be different because the WMS Database changes each release.

Sort and Display Properties of WMS Layers

Sort and display the LayerName property with an index.

Search the WMS Database for layers that contain information about elevation.

```
layers = wmsfind('elevation');
```

Sort the layers.

```
[layerNames,index] = sort({layers.LayerName});
```

Display the first five results.

```
layers = layers(index);
disp(layers(1:5),'Label','off','Properties','layername')
```

```
5x1 WMSLayer
Properties:
      Index: 1
'0'
      Index: 2
'133'
      Index: 3
'134'
      Index: 4
'141'
      Index: 5
'201'
```

Your results might be different because the WMS Database changes each release.

Display WMS Capabilities

Create a WMSCapabilities object from the contents of a downloaded capabilities file from the NASA SVS Image Server.

```
nasa = wmsfind('NASA SVS Image', 'SearchField', 'servertitle');
serverURL = nasa(1).ServerURL;
server = WebMapServer(serverURL);
capabilities = server.getCapabilities;
```

Display the properties of the capabilities document.

```
disp(capabilities)

WMSCapabilities
Properties:
  ServerTitle: 'NASA SVS Image Server'
  ServerURL: 'https://svs.gsfc.nasa.gov/cgi-bin/wms?'
```

```
    ServiceName: 'WMS'  
      Version: '1.3.0'  
    Abstract: 'Web Map Server maintained by the Scientific Visualization Studio at NASA'  
  OnlineResource: 'http://svs.gsfc.nasa.gov/'  
ContactInformation: [1x1 struct]  
  AccessConstraints: 'none'  
    Fees: 'none'  
  KeywordList: {}  
ImageFormats: {'image/png'}  
  LayerNames: {326x1 cell}  
    Layer: [326x1 WMSLayer]  
  AccessDate: '01-Apr-2021'
```

Methods

Your results might be different because the WMS Database changes each release.

Input Arguments

layers — Layers to display

array of WMSLayer objects

Layers to display, specified as an array of WMSLayer objects.

capabilities — WMS capabilities document to display

WMSCapabilities object

WMS capabilities document to display, specified as a WMSCapabilities object.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

You can abbreviate parameter names, and case does not matter.

Example: `'Properties',{'layertitle','layername'}`

Properties — Properties to display

'all' (default) | character vector or cell array of character vectors

Properties to display, specified as a character vector or cell array of character vectors. The properties are displayed in the same order as they are provided to `Properties`. Permissible values are: 'servertitle', 'servername', 'layertitle', 'layername', 'latlim', 'lonlim', 'abstract', 'coordrefsyscodes', 'details', or 'all'. To list all the properties, set `'Properties'` to 'all'.

Example: `{'coordrefsyscodes','latlim','lonlim'}`

Label — Flag to display property values

'on' (default) | 'off'

Flag to display property values, specified as the character vector 'on' or 'off'. The value is case-insensitive. If you set 'Label' to 'on', then the property name appears followed by its value. If you set 'Label' to 'off', then only the property value appears in the output.

Example: 'off'

Index — Flag to display property indices

'on' (default) | 'off'

Flag to display property indices, specified as the character vector 'on' or 'off'. The value is case-insensitive. If you set 'Index' to 'on', then `disp` lists the element's index in the output. If you set 'Index' to 'off', then `disp` does not list the index value in the output.

Example: 'off'

Version History

Introduced in R2009b

See Also

`getCapabilities` | `wmsfind`

displaym

Display geographic data from display structure on axesm-based map

Syntax

```
displaym(displaystruct)
displaym(displaystruct,str)
displaym(displaystruct,strings)
displaym(displaystruct,strings,searchmethod)
h = displaym(displaystruct)
```

Description

`displaym(displaystruct)` projects the data contained in the input `displaystruct`, a Version 1 Mapping Toolbox display structure, in the current axesm-based map. See the remarks about “Version 1 Display Structures” on page 1-319 below for details on the contents of display structures.

`displaym(displaystruct,str)` displays the vector data elements of `displaystruct` whose 'tag' fields contains character vectors beginning with 'str'. Vector data elements are those whose 'type' field is either 'line' or 'patch'. The match is case-insensitive.

`displaym(displaystruct,strings)` displays the vector data elements of `displaystruct` whose 'tag' field matches with one of the elements (or rows) of `strings`. `strings` is a cell array of character vectors (or a 2-D character array). In the case of character array, trailing blanks are stripped from each row before matching.

`displaym(displaystruct,strings,searchmethod)` controls the method used to match the values of the tag field in `displaystruct`, as follows:

- 'strmatch' — Search for matches at the beginning of the tag
- 'findstr' — Search within the tag
- 'exact' — Search for exact matches

Note that when `searchmethod` is specified the search is case-sensitive.

`h = displaym(displaystruct)` returns handles to the graphic objects created by `displaym`.

Note The type of *display structure* accepted by `displaym` is not the same as a *geographic data structure* (geostructs and mapstructs), introduced in Mapping Toolbox Version 2. Use `geoshow` or `mapshow` instead of `displaym` to display geostructs or mapstructs—created using `shaperead` and `gshhs`, for example. For more information, see “Geographic Data Structures”.

Tips

The following section documents the contents of display structures.

Version 1 Display Structures

A display structure is a MATLAB structure array with the following fields:

- A `tag` field names an individual feature or object
- A `type` field specifies a MATLAB graphics object type ('line', 'patch', 'surface', 'text', or 'light') or has the value 'regular', specifying a regular data grid
- `lat` and `long` fields contain coordinate vectors of latitudes and longitudes, respectively
- An `altitude` field contains a vector of vertical coordinate values
- A `string` property contains text to be displayed if `type` is 'text'
- MATLAB graphics properties are specified explicitly, on a per-feature basis, in an `otherproperty` field

The choice of options for the `type` field reveals that a display structure can contain

- Vector geodata (`type` is 'line' or 'patch')
- Raster geodata (`type` is 'surface' or 'regular')
- Graphic objects (`type` is 'text' or 'light')

The following table indicates which fields are used in the six types of display structures:

Field Name	Type 'light'	Type 'line'	Type 'patch'	Type 'regular'	Type 'surface'	Type 'text'
type	•	•	•	•	•	•
tag	•	•	•	•	•	•
lat	•	•	•		•	•
long	•	•	•		•	•
map				•	•	
maplegend				•		
meshgrat				•		
string						•
altitude	•	•	•	•	•	•
otherproperty	•	•	•	•	•	•

Some fields can contain empty entries, but each indicated field must exist for the objects in the structure array to be displayed correctly. For instance, the `altitude` field can be an empty matrix and the `otherproperty` field can be an empty cell array.

The `type` field must be one of the specified map object types: 'line', 'patch', 'regular', 'surface', 'text', or 'light'.

The `tag` field must be different from the `type` field usually containing the name or kind of map object. Its contents must not be equal to the name of the object type (i.e., line, surface, text, etc.).

The `lat`, `long`, and `altitude` fields can be scalar values, vectors, or matrices, as appropriate for the map object type.

The `map` field is a data grid. If `map` is a regular data grid, `maplegend` is its corresponding referencing vector, and `meshgrat` is a two-element vector specifying the graticule mesh size. If `map` is a geolocated data grid, `lat` and `long` are the matrices of latitude and longitude coordinates.

The `otherproperty` field is a cell array containing any additional display properties appropriate for the map object. Cell array entries can be a line specification, such as `'r+'`, or property name/property value pairs, such as `'color', 'red'`. If the `otherproperty` field is left as an empty cell array, default colors are used in the display of lines and patches based on the `tag` field.

Note In some cases you can use the `geoshow` function as a direct alternative to `displaym`. It accepts display structures of type `line` and `patch`.

Version History

Introduced before R2006a

See Also

`geoshow` | `mapshow` | `updategeostruct`

dist2str

Convert numeric distances to character array

Syntax

```
str = dist2str(dist)
str = dist2str(dist,format)
str = dist2str(dist,format,unit)
str = dist2str(dist,format,n)
str = dist2str(dist,format,unit,n)
```

Description

`str = dist2str(dist)` converts numeric distances in kilometers to a character array that represents the distances. This function is useful for displaying distances as text on maps.

`str = dist2str(dist,format)` specifies whether to add a plus sign (+) as a prefix to positive distances. To add a plus sign (+) as a prefix, specify `format` as "pm". The default for `format` is "none", which does not add a plus sign (+).

`str = dist2str(dist,format,unit)` includes the unit text of the specified unit in the character array.

`str = dist2str(dist,format,n)` specifies the number of decimal places to use in the character array. This syntax assumes the distances are in kilometers.

`str = dist2str(dist,format,unit,n)` specifies the unit and the number of decimal places to use in the character array.

Examples

Convert Distances in Kilometers to Character Array

Convert numeric distances to a character array. By default, the `dist2str` function assumes the distances are in kilometers.

```
dist = [-9.7 12.95 24];
str = dist2str(dist)
```

```
str = 3x8 char array
    '-9.70 km'
    '12.95 km'
    '24.00 km'
```

Convert the same distances to a character array and prefix a + sign to the positive distances.

```
strPlus = dist2str(dist,"pm")
```

```
strPlus = 3x9 char array
    '-9.70 km'
```

```
'+12.95 km'  
'+24.00 km'
```

Convert Distances in Specified Units to Character Array

Convert distances in nautical miles to a character array.

```
dist = [18.5 -9.48 16];  
str = dist2str(dist,"none","nm")  
  
str = 3x8 char array  
    '18.50 nm'  
    '-9.48 nm'  
    '16.00 nm'
```

Convert Distances to Character Array with Specified Number of Digits

Convert distances in meters to a character array. Round the distances to the nearest tenth.

```
dist = [8.523 -348.79 -418];  
str = dist2str(dist,"none","m",-1)  
  
str = 3x8 char array  
    ' 8.5 m'  
    '-348.8 m'  
    '-418.0 m'
```

Input Arguments

dist — Distances

numeric array

Distances, specified as a numeric array.

format — Plus sign for positive distances

"none" (default) | "pm"

Plus sign for positive distances, specified as one of these options:

- "pm" — Add a plus sign (+) as a prefix to positive distances.
- "none" — Do not add a plus sign (+) as a prefix to positive distances.

Data Types: char | string

unit — Unit text to include in character array

"kilometers" (default) | "feet" | "meters" | "nauticalmiles" | "statutemiles" | "degrees" | "radians" | ...

Unit text to include in the character array, specified as one of these options.

Option	Unit Text
"kilometers" or "km"	km
"feet" or "ft"	ft
"meters" or "m"	m
"nauticalmiles" or "nm"	nm
"statutemiles", "miles", or "mi"	mi Note that other Mapping Toolbox functions use <code>mi</code> to indicate international miles rather than statute miles.
"degrees" or "deg"	$\text{\textcircled{}}^{\circ}$, which is the LaTeX representation of $^{\circ}$.
"radians" or "rad"	R

Data Types: char | string

n — Number of digits to include in character array

-2 (default) | scalar integer

Number of digits to include in the character array, specified as an integer. When you specify `n`, the `dist2str` function rounds `dist` to the nearest multiple of 10^n .

The sign convention for this argument is opposite to the one used by the `round` function.

Example: `dist2str(3132.467, "none", -2)` returns '3132.47 km', which is 3132.467 rounded to the nearest hundredth.

Example: `dist2str(3132.467, "none", 0)` returns '3132 km', which is 3132.467 rounded to the nearest integer.

Output Arguments

str — Text representation of input distances

character array

Text representation of input distances, returned as a character array.

Data Types: char

Version History

Introduced before R2006a

See Also

Functions

`str2angle` | `angl2str` | `num2str`

distance

Distance between points on sphere or ellipsoid

Syntax

```
[arclen,az] = distance(lat1,lon1,lat2,lon2)
[arclen,az] = distance(pt1,pt2)
[arclen,az] = distance(lat1,lon1,lat2,lon2,ellipsoid)
[arclen,az] = distance(pt1,pt2,ellipsoid)
[arclen,az] = distance( ____,units)
[arclen,az] = distance(method, ____)
```

Description

`[arclen,az] = distance(lat1,lon1,lat2,lon2)` calculates the arc length `arclen` and azimuth `az` of the great circle arc from the starting point with coordinates `lat1` and `lon1` to the ending point with coordinates `lat2` and `lon2`. The function uses the shorter (minor) great circle arc. This syntax references the coordinates to a sphere and returns `arclen` and `az` as spherical distances in degrees.

`[arclen,az] = distance(pt1,pt2)` calculates the arc length and azimuth from the starting point with coordinates `pt1` and ending point with coordinates `pt2`.

This syntax is equivalent to `[arclen,az] = distance(pt1(:,1),pt1(:,2),pt2(:,1),pt2(:,2))`.

`[arclen,az] = distance(lat1,lon1,lat2,lon2,ellipsoid)` specifies a reference ellipsoid for the coordinates. This syntax returns `arclen` in the units of the semimajor axis of the reference ellipsoid.

`[arclen,az] = distance(pt1,pt2,ellipsoid)` specifies a reference ellipsoid for the coordinates. This syntax returns `arclen` in the units of the semimajor axis of the reference ellipsoid.

`[arclen,az] = distance(____,units)` specifies the angle units for the coordinates and azimuth, in addition to any combination of input arguments from the previous syntaxes.

`[arclen,az] = distance(method, ____,)`, where `method` is "rh", calculates the arc length and azimuth using a rhumb line. The default for `method` is "gc", which calculates the arc length and azimuth using a great circle arc (for a sphere) or a geodesic arc (for an ellipsoid).

Examples

Calculate Spherical Distance Between Two Points

Find the spherical distance between New York City and Paris. By default, the `distance` function calculates the great circle distance and returns the result as a spherical distance in degrees.

```
arclen1 = distance(40.71,-74.01,48.86,2.35)
```

```
arclen1 = 52.4971
```

Find the rhumb line distance between the same two points.

```
arclen2 = distance("rh",40.71,-74.01,48.86,2.35)
```

```
arclen2 = 54.6718
```

Calculate Linear Distance Between Two Points

You can return the arc length as a linear distance by specifying a reference ellipsoid as input to the `distance` function.

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of meters.

```
wgs84 = wgs84Ellipsoid("m");
```

Find the linear distance between New York City and Paris. When you specify a reference ellipsoid as input to the `distance` function, the function returns linear distances in the units of the semimajor axis of the ellipsoid.

```
d = distance(40.71,-74.01,48.86,2.35,wgs84)
```

```
d = 5.8531e+06
```

Input Arguments

lat1 — Latitude of start point

scalar | array

Latitude of the start point, specified as a scalar or array.

You can specify `lat1`, `lon1`, `lat2`, and `lon2` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

lon1 — Longitude of start point

scalar | array

Longitude of the start point, specified as a scalar or array.

You can specify `lat1`, `lon1`, `lat2`, and `lon2` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

lat2 — Latitude of end point

scalar | array

Latitude of the end point, specified as a scalar or array.

You can specify `lat1`, `lon1`, `lat2`, and `lon2` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

lon2 — Longitude of end point

scalar | array

Longitude of the end point, specified as a scalar or array.

You can specify `lat1`, `lon1`, `lat2`, and `lon2` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

pt1 — Latitude and longitude of start point

N-by-2 matrix

Latitude and longitude of the start point, specified as an *N*-by-2 numeric matrix of the form [`lat1` `lon1`], where `lat1` and `lon1` are column vectors.

Data Types: `single` | `double`

pt2 — Latitude and longitude of the end point

N-by-2 matrix

Latitude and longitude of the end point, specified as an *N*-by-2 numeric matrix of the form [`lat2` `lon2`], where `lat2` and `lon2` are column vectors.

Data Types: `single` | `double`

ellipsoid — Reference ellipsoid

`referenceSphere` object | `referenceEllipsoid` object | `oblateSpheroid` object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element vector of the form [`semimajor_axis` `eccentricity`], where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

units — Angle unit

`"degrees"` (default) | `"radians"`

Angle unit, specified as one of these options:

- `"degrees"` — Degrees
- `"radians"` — Radians

Data Types: `char` | `string`

method — Type of curve connecting start point and end point

`"gc"` (default) | `"rh"`

Type of curve connecting the start point and end point, specified as one of these options:

- "gc" — For spheres, calculate the arc length and azimuth using the great circle arc that connects the points. For ellipsoids, calculate the arc length and azimuth using the geodesic that connects the points.
- "rh" — Calculate the arc length and azimuth using the rhumb line that connects the points.

For more information about rhumb lines and great circles, see “Comparison of Rhumb Lines and Great Circles”.

Data Types: `char` | `string`

Output Arguments

arclen — Arc length

scalar | array

Arc length, returned as a scalar or array.

- When you specify the coordinates using `lat1`, `lon1`, `lat2`, and `lon2`, the size of this argument matches the size of the largest latitude or longitude input.
- When you specify the coordinates using `pt1` and `pt2`, this argument is a vector with length N .

The units of `arclen` depend on whether you specify a reference ellipsoid as input.

- When you do not specify a reference ellipsoid as input, `arclen` is a spherical distance in degrees. You can return a spherical distance in radians by using the `units` input argument.
- When you specify a reference ellipsoid as input, `arclen` is a linear distance in the units of the semimajor axis of the ellipsoid.

Data Types: `double`

az — Azimuth

scalar | array

Azimuth of the second point in each pair with respect to the first, returned as a scalar or array. The azimuth is the angle at which the arc crosses the meridian containing the first point. Azimuths are measured clockwise from north.

- When you specify the coordinates using `lat1`, `lon1`, `lat2`, and `lon2`, the size of this argument matches the size of the largest latitude or longitude input.
- When you specify the coordinates using `pt1` and `pt2`, this argument is a vector with length N .

This table shows the azimuths associated with cardinal and intercardinal compass directions.

Compass Direction	Azimuth
North	0° or 360°
Northeast	45°
East	90°
Southeast	135°
South	180°
Southwest	225°

Compass Direction	Azimuth
West	270°
Northwest	315°

Data Types: single | double

Tips

You can convert spherical distances to linear distances by using conversion functions such as `deg2km` and `deg2nm`.

Algorithms

The accuracy of geodesic azimuth calculations decreases as the distance between the points increases. Additionally, the calculations can break down when the points are nearly antipodal or close to the equator.

When you specify a reference ellipsoid and two points that are both close to the equator and nearly antipodal, the distance function issues a warning and returns both `arclen` and `az` as values of `NaN`.

Version History

Introduced before R2006a

See Also

Functions

`azimuth` | `ecef2aer` | `reckon` | `track` | `track1` | `track2`

Objects

`referenceEllipsoid` | `referenceSphere` | `oblateSpheroid`

Topics

“Comparison of Rhumb Lines and Great Circles”

distortcalc

Distortion parameters for map projections

Syntax

```
areascale = distortcalc(lat,lon)
areascale = distortcalc(mstruct,lat,lon)
[areascale,maxangdef,maxscale,minscale,merscale,parscale] = distortcalc( __ )
```

Description

`areascale = distortcalc(lat,lon)` calculates the area scale of the current map projection at the locations specified by `lat` and `lon`. Area scale is a standard way to quantify the local area distortion introduced by a map projection.

`areascale = distortcalc(mstruct,lat,lon)` uses the projection defined by the map projection structure `mstruct`.

`[areascale,maxangdef,maxscale,minscale,merscale,parscale] = distortcalc(__)` calculates the area scale, the maximum angular deformation, the maximum and minimum particular scale distortions, the particular scale along the meridian, and the particular scale along the parallel using any combinations of input arguments from previous syntaxes.

Examples

Calculate Distortion Parameters

Create a map projection structure for the Mercator projection. The Mercator projection is conformal, which means that it preserves angles.

```
mstruct = defaultm("mercator");
mstruct = defaultm(mstruct);
```

Calculate the area scale and maximum angular distortion for a point on the equator. At this location, the Mercator projection has no area distortion.

```
[areascale1,maxangdef1] = distortcalc(mstruct,0,0)
areascale1 = 1.0000
maxangdef1 = 0
```

Calculate the area scale and maximum angular distortion again, this time for a point 60 degrees north. At this location, the Mercator projection shows regions at 400% of their true area.

```
[areascale2,maxangdef2] = distortcalc(mstruct,60,0)
areascale2 = 4.0000
maxangdef2 = 0
```

For both calculations, the `distortcalc` function indicates no angular distortion. This result is expected for conformal projections.

Input Arguments

lat — Latitude coordinates

scalar | vector | array

Latitude coordinates, specified as a scalar, vector, or array. The size of `lat` must match the size of `lon`. Specify values using units that match the angle units of the map projection.

lon — Longitude coordinates

scalar | vector | array

Longitude coordinates, specified as a scalar, vector, or array. The size of `lon` must match the size of `lat`. Specify values using units that match the angle units of the map projection.

mstruct — Map projection structure

structure

Map projection structure, specified as a structure with fields identical to the properties of an `axesm`-based map. Map projection structure fields include, for example, the projection name, angle unit, origin, aspect, false easting, and false northing. For more information about the properties of `axesm`-based maps, see `axesm`-Based Map Properties.

Create a map projection structure by using the `defaultm` function, or extract the map projection structure from an `axesm`-based map by using the `gcm` function.

Output Arguments

areascale — Area scale

scalar | vector | array

Area scale, returned as a scalar, vector, or array of the same size as `lat` and `lon`.

The area scale is the ratio $pArea/sArea$, where $sArea$ is the area of an infinitesimal quadrangle on the spheroid and $pArea$ is the area of its projection in the map plane.

A value of 1 indicates no scale distortion.

maxangdef — Maximum angular deformation

scalar | vector | array

Maximum angular deformation, returned as a scalar, vector, or array of the same size as `lat` and `lon`. The units match the angle units of the map projection.

maxscale — Maximum particular scale distortion

scalar | vector | array

Maximum particular scale distortion, returned as a scalar, vector, or array of the same size as `lat` and `lon`. This value is unitless.

minscale — Minimum particular scale distortion

scalar | vector | array

Minimum particular scale distortion, returned as a scalar, vector, or array of the same size as `lat` and `lon`. This value is unitless.

merscale — Particular scale along meridian

scalar | vector | array

Particular scale along the meridian, returned as a scalar, vector, or array of the same size as `lat` and `lon`. This value is unitless.

parscale — Particular scale along parallel

scalar | vector | array

Particular scale along the parallel, returned as a scalar, vector, or array of the same size as `lat` and `lon`. This value is unitless.

More About

Distortion

Except in a few special locations, all map projections distort shapes when transforming the shapes from the globe to the plane. The amount and type of distortion depends on the projection, the location on the globe, and the values of the projection parameters. The `distortcalc` function enables you to quantify local distortions using various standard metrics.

Algorithms

- The `distortcalc` function uses a first difference technique.
- The function calculates the distortion parameters by slightly perturbing the input point locations in different directions and then projecting them.
- The results can contain a small amount of imprecision due to the function numerically computing derivatives.

Version History

Introduced before R2006a

See Also

Functions

`mdistort` | `tissot`

distdim

(Not recommended) Convert length units

Note The `distdim` function is not recommended. Use a different conversion function or the `unitsratio` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
distOut = distdim(distIn,originalUnit,targetUnit)
distOut = distdim(distIn,originalUnit,targetUnit,r)
distOut = distdim(distIn,originalUnit,targetUnit,refSphere)
```

Description

`distOut = distdim(distIn,originalUnit,targetUnit)` converts the distance `distIn` from the units specified by `originalUnit` to the units specified by `targetUnit`. This function assumes that `distIn` is along a great circle path on a reference sphere. If `originalUnit` or `targetUnit` is an angular unit, then this syntax uses a reference sphere with a radius of 6371 kilometers.

`distOut = distdim(distIn,originalUnit,targetUnit,r)` when either `originalUnit` or `targetUnit` is a length unit, and the other is an angular unit, converts the distance using a reference sphere with radius `r`. The function ignores `r` when `originalUnit` and `targetUnit` are both angular units or both length units.

`distOut = distdim(distIn,originalUnit,targetUnit,refSphere)` when either `originalUnit` or `targetUnit` is a length unit, and the other is an angular unit, converts the distance using the reference sphere `refSphere`. The function ignores `refSphere` when `originalUnit` and `targetUnit` are both angular units or both length units.

Examples

Convert Kilometers to Nautical Miles

Convert 100 kilometers to nautical miles.

```
distIn = 100;
distdim(distIn,"km","nm")
```

ans =

```
53.9957
```

Calculate the same conversion using the `unitsratio` function.

```
distIn * unitsratio("nm","km")
```

ans =

```
53.9957
```

Calculate the same conversion using the `km2nm` function.

```
km2nm(distIn)
```

```
ans =
```

```
53.9957
```

Input Arguments

distIn – Distance in original units

numeric array

Distance in original units, specified as a numeric array.

originalUnit – Original unit of measure

"kilometers" | "km" | "degrees" | "deg" | ...

Original unit of measure, specified as one of these options:

- These angular units.

Value	Unit Name
"degrees", "deg"	Degrees
"radians", "rad"	Radians

- These length units.

Value	Unit Name
"km", "kilometers"	Kilometers
"m", "meters"	Meters
"nm", "nauticalmiles"	Nautical miles
"ft", "feet"	U.S. survey feet
"mi", "sm", "miles", "statutemiles"	Statute miles

This argument is case insensitive.

Data Types: char | string

targetUnit – Target unit of measure

"kilometers" | "km" | "degrees" | "deg" | ...

Target unit of measure, specified as one of these options:

- These angular units.

Value	Unit Name
"degrees", "deg"	Degrees
"radians", "rad"	Radians

- These length units.

Value	Unit Name
"km", "kilometers"	Kilometers
"m", "meters"	Meters
"nm", "nauticalmiles"	Nautical miles
"ft", "feet"	U.S. survey feet
"mi", "sm", "miles", "statutemiles"	Statute miles

This argument is case insensitive.

Data Types: `char` | `string`

r – Radius of reference sphere

numeric scalar

Radius of the reference sphere, specified as a numeric scalar. Specify `r` using the length unit indicated by `originalUnit` or `targetUnit`.

refSphere – Reference sphere

"earth" (default) | "sun" | "moon" | "mercury" | "venus" | ...

Reference sphere, specified as "earth", "sun", "moon", "mercury", "venus", "mars", "jupiter", "saturn", "uranus", "neptune", or "pluto".

This argument is case insensitive.

Data Types: `char` | `string`

Output Arguments

distOut – Distance in target units

numeric array

Distance in target units, returned as a numeric array of the same size as `distIn`.

Version History

Introduced before R2006a

R2007b: `distdim` is not recommended

Not recommended starting in R2007b

The `distdim` function is not recommended. The replacement functionality depends on whether you know the original and target units before run time.

If you know the units before run time, then you can replace the `distdim` function with a conversion function. This table shows the supported conversion functions.

Original Unit	Conversion Functions
Degrees	<ul style="list-style-type: none"> • deg2km — Convert degrees to kilometers • deg2nm — Convert degrees to nautical miles • deg2sm — Convert degrees to statute miles • deg2rad — Convert degrees to radians
Radians	<ul style="list-style-type: none"> • rad2km — Convert radians to kilometers • rad2nm — Convert radians to nautical miles • rad2sm — Convert radians to statute miles • rad2deg — Convert radians to degrees
Kilometers	<ul style="list-style-type: none"> • km2nm — Convert kilometers to nautical miles • km2sm — Convert kilometers to statute miles • km2deg — Convert kilometers to degrees • km2rad — Convert kilometers to radians
Meters	None
Nautical miles	<ul style="list-style-type: none"> • nm2km — Convert nautical miles to kilometers • nm2sm — Convert nautical miles to statute miles • nm2deg — Convert nautical miles to degrees • nm2rad — Convert nautical miles to radians
U.S. survey feet	None
Statute miles	<ul style="list-style-type: none"> • sm2km — Convert statute miles to kilometers • sm2nm — Convert statute miles to nautical miles • sm2deg — Convert statute miles to degrees • sm2rad — Convert statute miles to radians

This table shows typical replacement patterns to use when updating your code to use a conversion function.

Not Recommended	Recommended
<code>distdim(distIn, "deg", "rad")</code>	<code>deg2rad(distIn)</code>
<code>distdim(distIn, "km", "deg", r)</code>	<code>km2deg(distIn, r)</code>
<code>distdim(distIn, "deg", "nm", refSphere)</code>	<code>deg2nm(distIn, refSphere)</code>

If you do not know the units before run time, or if a conversion function does not exist, then you can replace the `distdim` function with the `unitsratio` function. To convert between a length unit and an angle unit, use both the `unitsratio` function and a conversion function. This table shows typical replacement patterns to use when updating your code.

Not Recommended	Recommended
<code>distdim(distIn, originalUnit, targetUnit)</code>	<code>distIn * unitsratio(targetUnit, originalUnit)</code>
<code>distdim(distIn, "deg", "m")</code>	<code>unitsratio("m", "km") * deg2km(distIn)</code>

Not Recommended	Recommended
<code>distdim(distIn, "deg", "m", "mars")</code>	<code>unitsratio("m", "km") * deg2km(distIn, "mars")</code>

To indicate U.S. survey feet using the `unitsratio` function, specify "surveyfeet" or "sf" instead of "feet" or "ft". To indicate statute miles using the `unitsratio` function, specify "statute miles" or "sm" instead of "miles" or "mi".

See Also

`unitsratio` | `distance`

dm2degrees

Convert degrees-minutes to degrees

Syntax

```
angleInDegrees = dm2degrees(DM)
```

Description

`angleInDegrees = dm2degrees(DM)` converts angles from degrees-minutes representation to values in degrees which may include a fractional part (sometimes called “decimal degrees”).

Examples

Convert Angle in Degree-Minutes to Degrees

```
dm = [ ...
      30 44.78012; ...
     -82 39.90825; ...
       0 -17.12345; ...
       0 14.82000];
format long g
angleInDegrees = dm2degrees(dm)

angleInDegrees = 4×1

    30.74633533333333
   -82.6651375
  -0.2853908333333333
     0.247
```

Input Arguments

DM — Angle in degrees-minutes representation

n-by-2 real-valued matrix

Angle in degrees-minutes representation, specified as an *n*-by-2 real-valued matrix. Each row specifies one angle, with the format [D M]:

- D contains the “degrees” element and must be integer-valued.
- M contains the “minutes” element and may have a fractional part. The absolute value of M must be less than 60.

For an angle that is positive (north latitude or east longitude) or equal to zero, all elements in the row must be nonnegative. For a negative angle (south latitude or west longitude), the first nonzero element in the row must be negative and the remaining value, if any, is nonnegative.

Output Arguments

angleInDegrees — Angle in degrees

n-element column vector

Angle in degrees, returned as an n-element column vector. The k^{th} element corresponds to the k^{th} row of DM.

Algorithms

For an input row with value [D M], with integer-valued D and real M, the output value will be

$$\text{SGN} * (\text{abs}(D) + \text{abs}(M)/60)$$

where SGN is 1 if D and M are both nonnegative and -1 if the first nonzero element of [D M] is negative. An error results if a nonzero D is followed by a negative M.

Version History

Introduced in R2007a

See Also

degrees2dm | deg2rad | dms2degrees | str2angle

Topics

“Angle Representations and Angular Units”

dms2degrees

Convert degrees-minutes-seconds to degrees

Syntax

```
angleInDegrees = dms2degrees(DMS)
```

Description

`angleInDegrees = dms2degrees(DMS)` converts angles from degrees-minutes-seconds representation to values in degrees which may include a fractional part (sometimes called “decimal degrees”).

Examples

Convert Angle in Degree-Minute-Seconds to Degrees

```
dms = [ ...
        30 50 44.78012; ...
       -82  2 39.90825; ...
         0 -30 17.12345; ...
         0  0 14.82000];
format long g
angleInDegrees = dms2degrees(dms)

angleInDegrees = 4×1

    30.8457722555556
   -82.0444189583333
   -0.504756513888889
    0.00411666666666667
```

Input Arguments

DMS — Angle in degrees-minutes-seconds representation

n-by-3 real-valued matrix

Angle in degrees-minutes-seconds representation, specified as an *n*-by-3 real-valued matrix. Each row specifies one angle, with the format [D M S]:

- D contains the “degrees” element and must be integer-valued.
- M contains the “minutes” element and must be integer-valued. The absolute value of M must be less than 60.
- S contains the “seconds” element and may have a fractional part. The absolute value of S must be less than 60.

For an angle that is positive (north latitude or east longitude) or equal to zero, all elements in the row must be nonnegative. For a negative angle (south latitude or west longitude), the first nonzero element in the row must be negative and the remaining values are nonnegative.

Output Arguments

angleInDegrees — Angle in degrees

n-element column vector

Angle in degrees, returned as an n-element column vector. The k^{th} element corresponds to the k^{th} row of DMS.

Algorithms

For an input row with value [D M S], the output value will be

$$\text{SGN} * (\text{abs}(D) + \text{abs}(M)/60 + \text{abs}(S)/3600)$$

where SGN is 1 if D, M, and S are all nonnegative and -1 if the first nonzero element of [D M S] is negative. An error results if a nonzero element is followed by a negative element.

Version History

Introduced in R2007a

See Also

[degrees2dm](#) | [deg2rad](#) | [dm2degrees](#) | [str2angle](#)

Topics

“Angle Representations and Angular Units”

double

Package: map.geotiff

Convert TIFF tag property values to row vector of doubles

Syntax

```
tiffTagValue = double(rpctag)
```

Description

`tiffTagValue = double(rpctag)` returns a 92-element row vector of class `double`, representing the values of the TIFF tag. This is the format required to write the property values to a TIFF file.

Examples

Convert RPCCoefficientTag Properties to 92-Element Vector

Create an `RPCCoefficientTag` object and view the object summary display.

```
rpctag = map.geotiff.RPCCoefficientTag

rpctag =
  RPCCoefficientTag with properties:
      BiasErrorInMeters: -1
      RandomErrorInMeters: -1
           LineOffset: 0
          SampleOffset: 0
  GeodeticLatitudeOffset: 0
  GeodeticLongitudeOffset: 0
  GeodeticHeightOffset: 0
           LineScale: 1
          SampleScale: 1
  GeodeticLatitudeScale: 1
  GeodeticLongitudeScale: 1
  GeodeticHeightScale: 1
  LineNumeratorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
  LineDenominatorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
  SampleNumeratorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
  SampleDenominatorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
```

Call the `RPCCoefficientTag` class method `double` to convert the object into a vector of doubles. View the result.

```
tifftagvalues = double(rpctag)
```

```
tifftagvalues = 1×92
```

```
-1    -1     0     0     0     0     0     1     1     1     1     1     0     0     0     0
```

Input Arguments

rpctag — Rational Polynomial Coefficients (RPC) TIFF tag property values

RPCCoefficientTag object

Rational Polynomial Coefficients (RPC) TIFF tag property values, specified as an RPCCoefficientTag object.

Example: `tifftagvalues = double(rpctag);`

Output Arguments

tiffTagValue — Rational Polynomial Coefficients (RPC) TIFF tag property values

92-element vector

Rational Polynomial Coefficients (RPC) TIFF tag property values, returned as 92-element vector of class `double`.

Version History

Introduced in R2015b

See Also

RPCCoefficientTag | `geotiffinfo` | `geotiffwrite`

dreckon

Dead reckoning positions for track

Syntax

```
[drlat,drlong,drtime] = dreckon(waypoints,time,speed)
[drlat,drlong,drtime] = dreckon (waypoints,time,speed,spdtimes)
```

Description

`[drlat,drlong,drtime] = dreckon(waypoints,time,speed)` returns the positions and times of required dead reckoning (DR) points for the input track that starts at the input time. The track should be in navigational track format (two columns, latitude then longitude, in order of traversal). These waypoints are the starting and ending points of each leg of the track. There is one fewer track leg than waypoints, as the last point included is the end of the track. In navigation, the first waypoint would be a navigational fix, taken at `time`. The `speed` input can be a scalar, in which case a constant speed is used throughout, or it can be a vector in which one speed is given for each track leg (that is, speed changes coincide with course changes).

`[drlat,drlong,drtime] = dreckon (waypoints,time,speed,spdtimes)` allows speed changes to occur independent of course changes. The elements of the `speed` vector must have a one-to-one correspondence with the elements of the `spdtimes` vector. This latter variable consists of the time interval after `time` at which each speed order *ends*. For example, if `time` is 6.75, and the first element of `spdtimes` is 1.35, then the first `speed` element is in effect from 6.75 to 8.1 hours. When this syntax is used, the last output DR is the *earlier* of the final `spdtimes` time or the final `waypoints` point.

Background

This is a navigational function. It assumes that all latitudes and longitudes are in degrees, all distances are in nautical miles, all times are in hours, and all speeds are in knots, that is, nautical miles per hour.

Dead reckoning is an estimation of position at various times based on courses, speeds, and times elapsed from the last certain position, or fix. In navigational practice, a dead reckoning position, or DR, must be plotted at every course change, every speed change, and at every hour, on the hour. Navigators also DR at other times that are not relevant to this function.

Often in practice, when two events occur that require DRs within a very short time, only one DR is generated. This function mimics that practice by setting a tolerance of 3 minutes (0.05 hours). No two DRs will fall closer than that.

Examples

Assume that a navigator gets a fix at noon, 1200Z, which is (10.3°N, 34.67°W). He's in a hurry to make a 1330Z rendezvous with another ship at (9.9°N, 34.5°W), so he plans on a speed of 25 knots. After the rendezvous, both ships head for (0°, 37°W). The engineer wants to take an engine off line for maintenance at 1430Z, so at that time, speed must be reduced to 15 knots. At 1530Z, the maintenance will be done. Determine the DR points up to the end of the maintenance.

```
waypoints = [10.1 -34.6; 9.9 -34.5; 0 -37]

waypoints =
    10.1000 -34.6000 % Fix at noon
     9.9000 -34.5000 % Rendezvous point
     0 -37.0000 % Ultimate destination

speed = [25; 15];
spdtimes = [2.5; 3.5]; % Elapsed times after fix
noon = 12;
[drlat,drlong,dertime] = dreckon(waypoints,noon,speed,spdtimes);
[drlat,drlong,dertime]

ans =
    9.8999 -34.4999 12.5354 % Course change at waypoint
    9.7121 -34.5478 13.0000 % On the hour
    9.3080 -34.6508 14.0000 % On the hour
    9.1060 -34.7022 14.5000 % Speed change to 15 kts
    8.9847 -34.7330 15.0000 % On the hour
    8.8635 -34.7639 15.5000 % Stop at final spdtime, last
% waypoint has not been reached
```

Version History

Introduced before R2006a

See Also

[legs](#) | [navfix](#) | [track](#)

driftcorr

Heading to correct for wind or current drift

Syntax

```
heading = driftcorr(course,airspeed,windfrom,windspeed)
[heading,groundspeed,windcorrangle] = driftcorr(...)
```

Description

`heading = driftcorr(course,airspeed,windfrom,windspeed)` computes the heading that corrects for drift due to wind (for aircraft) or current (for watercraft). `course` is the desired direction of movement (in degrees), `airspeed` is the speed of the vehicle relative to the moving air or water mass, `windfrom` is the direction facing into the wind or current (in degrees), and `windspeed` is the speed of the wind or current (in the same units as `airspeed`).

`[heading,groundspeed,windcorrangle] = driftcorr(...)` also returns the ground speed and wind correction angle. The wind correction angle is positive to the right, and negative to the left.

Examples

An aircraft cruising at a speed of 160 knots plans to fly to an airport due north of its current position. If the wind is blowing from 310 degrees at 45 knots, what heading should the aircraft fly to remain on course?

```
course=0; airspeed=160;windfrom=310; windspeed = 45;
[heading,groundspeed,windcorrangle] =
driftcorr(course,airspeed,windfrom,windspeed)
```

```
heading =
```

```
    347.56
```

```
groundspeed =
```

```
    127.32
```

```
windcorrangle =
```

```
   -12.442
```

The required heading is 348 degrees, which amounts to a wind correction angle of 12 degrees to the left of course. The headwind component reduces the aircraft's ground speed to 127 knots.

Version History

Introduced before R2006a

See Also
driftvel

driftvel

Wind or current from heading, course, and speeds

Syntax

```
[windfrom,windspeed] = driftvel (course,groundspeed,heading,airspeed)
```

Description

[windfrom,windspeed] = driftvel (course,groundspeed,heading,airspeed) computes the wind (for aircraft) or current (for watercraft) from course, heading, and speeds. `course` and `groundspeed` are the direction and speed of movement relative to the ground (in degrees), `heading` is the direction in which the vehicle is steered, and `airspeed` is the speed of the vehicle relative to the air mass or water. The output `windfrom` is the direction facing into the wind or current (in degrees), and `windspeed` is the speed of the wind or current (in the same units as `airspeed` and `groundspeed`).

Examples

An aircraft is cruising at a true air speed of 160 knots and a heading of 10 degrees. From the Global Positioning System (GPS) receiver, the pilot determines that the aircraft is progressing over the ground at 155 knots in a northerly direction. What is the wind aloft?

```
course = 0; groundspeed = 155; heading = 10; airspeed = 160;  
[windfrom,windspeed] =  
driftvel(course,groundspeed,heading,airspeed)
```

```
windfrom =  
    84.717
```

```
windspeed =  
    27.902
```

The wind is blowing from the right, 085 degrees at 28 knots.

Version History

Introduced before R2006a

See Also

driftcorr

dted

(To be removed) Read U.S. Department of Defense Digital Terrain Elevation Data (DTED)

Note `dted` will be removed in a future release. Use `readgeoraster` instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z, refvec] = dted
[Z, refvec] = dted(filename)
[Z, refvec] = dted(filename, samplefactor)
[Z, refvec] = dted(filename, samplefactor, latlim, lonlim)
[Z, refvec] = dted(foldername, samplefactor, latlim, lonlim)
[Z, refvec, UHL, DSI, ACC] = dted(...)
```

Description

`[Z, refvec] = dted` returns all of the elevation data in a DTED file as a regular data grid, `Z`, with elevations in meters. The file is selected interactively. This function reads the DTED elevation files, which generally have file names ending in `.dtN`, where `N` is 0,1,2,3,... `refvec` is the associated three-element referencing vector that geolocates `Z`.

`[Z, refvec] = dted(filename)` returns all of the elevation data in the specified DTED file. The file must be found on the MATLAB path. If not found, the file may be selected interactively.

`[Z, refvec] = dted(filename, samplefactor)` subsamples data from the specified DTED file. `samplefactor` is a scalar integer. When `samplefactor` is 1 (the default), DTED reads the data at its full resolution. When `samplefactor` is an integer `n` greater than one, every `n`th point is read.

`[Z, refvec] = dted(filename, samplefactor, latlim, lonlim)` reads the data for the part of the DTED file within the latitude and longitude limits. The limits must be two-element vectors in units of degrees.

`[Z, refvec] = dted(foldername, samplefactor, latlim, lonlim)` reads and concatenates data from multiple files within a DTED CD-ROM or folder structure. The `foldername` input is a string scalar or character vector with the name of a folder containing the DTED folder. Within the DTED folder are subfolders for each degree of longitude, each of which contain files for each degree of latitude. For DTED CD-ROMs, `foldername` is the device name of the CD-ROM drive.

`[Z, refvec, UHL, DSI, ACC] = dted(...)` returns structures containing the DTED User Header Label (UHL), Data Set Identification (DSI) and Accuracy metadata records.

Background

The U. S. Department of Defense, through the National Geospatial Intelligence Agency, produces several kinds of digital cartographic data. One is digital elevation data, in a series called DTED, for

Defense Digital Terrain Elevation Data. The data is available as 1-by-1 degree quadrangles at horizontal resolutions ranging from about 1 kilometer to 1 meter. The lowest resolution data is available to the public. Certain higher resolution data is restricted to the U.S. Department of Defense and its contractors.

DTED Level 0 files have 121-by-121 points. DTED Level 1 files have 1201-by-1201. The edges of adjacent tiles have redundant records. Maps extend a half a cell outside the requested map limits. The 1 kilometer data and some higher-resolution data is available online, as are product specifications and documentation. DTED files are binary. No line ending conversion or byte-swapping is required when downloading a DTED file.

Examples

Read and Display DTED Data

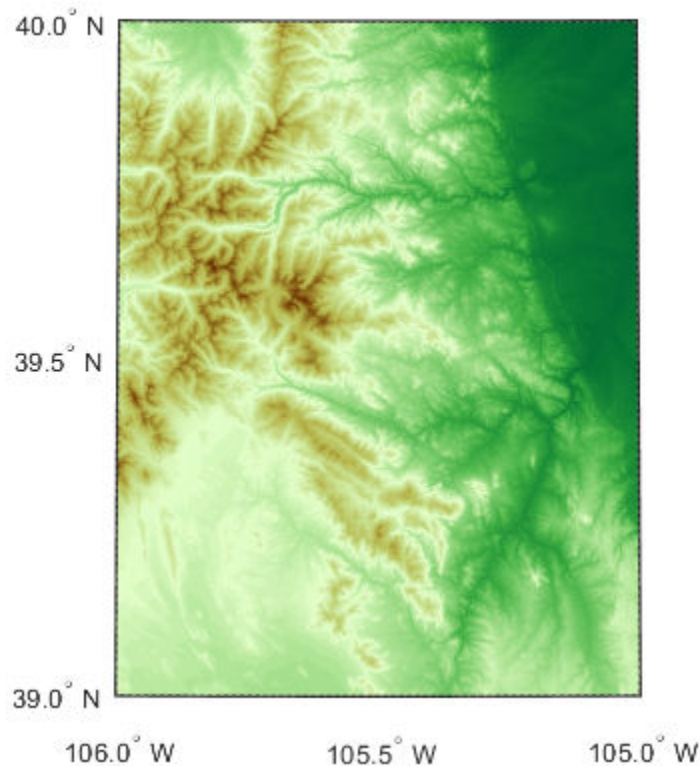
Read and display DTED data for an area around South Boulder Peak in Colorado.

First, import the elevation data. Replace unused output arguments with a tilde character (~). Associate the elevation data with geographic locations by creating a geographic postings reference object. To create a reference object, specify the latitude limits, longitude limits, and size of the elevation data grid.

```
[Z,~] = dted('n39_w106_3arc_v2.dt1');  
  
latlim = [39 40];  
lonlim = [-106 -105];  
R = georefpostings(latlim,lonlim,size(Z));
```

Create a map, then plot the data using geoshow. Display a colormap appropriate for elevation data using demcmap.

```
usamap(latlim,lonlim);  
geoshow(Z,R,'DisplayType','surface')  
demcmap(Z)
```



The DTED file used in this example is courtesy of the US Geological Survey.

Tips

Latitude-Dependent Sampling

In DTED files north of 50° North and south of 50° South, where the meridians have converged significantly relative to the equator, the longitude sampling interval is reduced to half of the latitude sampling interval. In order to retain square output cells, this function reduces the latitude sampling to match the longitude sampling. For example, it will return a 121-by-121 elevation grid for a DTED file covering from 49 to 50 degrees north, but a 61-by-61 grid for a file covering from 50 to 51 degrees north. When you supply a folder name instead of a file name, and `latLim` spans either 50° North or 50° South, an error results.

Snapping Latitude and Longitude Limits

If you call `dted` specifying arbitrary latitude-longitude limits for a region of interest, the grid and referencing vector returned will not exactly honor the limits you specified unless they fall precisely on grid cell boundaries. Because grid cells are discrete and cannot be arbitrarily divided, the data grid returned will include all areas between your latitude-longitude limits and the next row or column of cells, potentially in all four directions.

Data Sources and Information

DTED files contain digital elevation maps covering 1-by-1-degree quadrangles at horizontal resolutions ranging from about 1 kilometer to 1 meter. For details on locating DTED for download over the Internet, see “Find Geospatial Data Online”.

Null Data Values

Some DTED Level 1 and higher data tiles contain null data cells, coded with value -32767. When encountered, these null data values are converted to NaN.

Nonconforming Data Encoding

DTED files from some sources may depart from the specification by using two's complement encoding for binary elevation files instead of “sign-bit” encoding. This difference affects the decoding of negative values, and incorrect decoding usually leads to nonsensical elevations.

Thus, if the DTED function determines that all the (nonnull) negative values in a file would otherwise be less than -12,000 meters, it issues a warning and assumes two's complement encoding.

Version History

Introduced before R2006a

R2020a: To be removed

Not recommended starting in R2020a

Raster reading functions that return referencing vectors will be removed, including `dted`. Instead, use `readgeoraster`, which returns a geographic postings reference object. Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see `GeographicPostingsReference`.
- You can manipulate the limits of rasters associated with geographic reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with geographic reference objects using the `georesize` function.
- Most functions that accept referencing vectors as input also accept reference objects.

Get metadata about DTED files by accessing properties of the reference object or by using the `georasterinfo` function.

This table shows some typical usages of `dted` and how to update your code to use `readgeoraster` and `georasterinfo`. The `readgeoraster` function requires you to specify a file extension. For example, use `[Z,R] = readgeoraster('n39_w106_3arc_v2.dtl')`.

Will Be Removed	Recommended
<code>[Z,refvec] = dted(filename);</code>	<code>[Z,R] = readgeoraster(filename);</code>
<code>[Z,refvec] = dted(filename,samplefactor);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>[Z,R] = georesize(Z,R,1/samplefactor);</code>

Will Be Removed	Recommended
<code>[Z,refvec] = dted(filename,samplefactor,latlim,lonlim);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>[Z,R] = geocrop(Z,R,latlim,lonlim);</code> <code>[Z,R] = geosize(Z,R,1/samplefactor);</code>
<code>[Z,refvec,UHL,DSI,ACC] = dted(filename);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>info = georasterinfo(filename);</code> <code>meta = info.Metadata;</code>

The `readgeoraster` function returns data using the native data type embedded in the file. Return a different data type by specifying the 'OutputType' name-value pair. For example, use `[Z,R] = readgeoraster(filename, 'OutputType', 'double')`.

The `readgeoraster` function does not automatically replace missing data with NaN values. If your data set uses large negative numbers to indicate missing data, replace them with NaN values using the `standardizeMissing` function.

```
[Z,R] = readgeoraster('MtWashington-ft.grd');
info = georasterinfo('MtWashington-ft.grd');
m = info.MissingDataIndicator;
Z = standardizeMissing(Z,m);
```

Reading and concatenating multiple DTED files from a folder using the `readgeoraster` function is not supported. Find the standard names of the DTED files required to cover a region by using the `dteds` function. Then read the individual files by using the `readgeoraster` function. For information about concatenating raster tiles, see “Mosaic Spatially Referenced Raster Tiles”.

See Also

[readgeoraster](#) | [georasterinfo](#) | [dteds](#)

dteds

DTED file names for latitude-longitude quadrangle

Syntax

```
fname = dteds(latlim,lonlim)
fname = dteds(latlim,lonlim,level)
```

Description

`fname = dteds(latlim,lonlim)` returns Level 0 DTED file names (folder and name) required to cover the geographic region specified by `latlim` and `lonlim`. This function constructs the file names for a given geographic region based on the file-naming convention established by the Defense Digital Terrain Elevation Data (DTED) database.

`fname = dteds(latlim,lonlim,level)` controls the level for which the file names are generated. Valid inputs for the `level` of the DTED files include 0, 1, or 2.

Background

The U. S. Department of Defense produces several kinds of digital cartographic data. One is digital elevation data, in a series called DTED, for Defense Digital Terrain Elevation Data. The data is available as 1-by-1 degree quadrangles at horizontal resolutions ranging from about 1 kilometer to 1 meter. The lowest resolution data is available to the public. Higher resolution data is restricted to the U.S. Department of Defense and its contractors.

Determining the files needed to cover a particular region requires knowledge of the DTED database naming conventions. This function constructs the file names for a given geographic region based on these conventions.

Examples

Which files are needed for Cape Cod?

```
latlim = [ 41.15 42.22];
lonlim = [-70.94 -69.68];
dteds(latlim,lonlim,1)
```

```
ans =
```

```
4×1 cell array
```

```
{'dted\w071\n41.dt1'}
{'dted\w070\n41.dt1'}
{'dted\w071\n42.dt1'}
{'dted\w070\n42.dt1'}
```

Version History

Introduced before R2006a

See Also

readgeoraster

earthRadius

Mean radius of planet Earth

Syntax

```
R = earthRadius
R = earthRadius(lengthUnit)
```

Description

`R = earthRadius` returns the scalar value 6,371,000, the mean radius of the Earth in meters.

`R = earthRadius(lengthUnit)` returns the mean radius of the Earth using the length unit specified by `lengthUnit`.

Examples

Earth Radius in Meters

View the mean radius of the Earth using the default units, meters.

```
earthRadius
ans = 6371000
```

Earth Radius in Specified Units

View the mean radius of the Earth, specifying the units as kilometers.

```
earthRadius("km")
ans = 6371
```

Input Arguments

lengthUnit — Length unit of measure

'meter' (default) | string scalar | character vector

Length unit of measure, specified as a string scalar or character vector. You can specify any length unit accepted by the `validateLengthUnit` function.

Value	Unit Name
"m", "meter", "meters", "metre", "metres"	Meters

Value	Unit Name
"cm", "centimeter", "centimeters", "centimetre", "centimetres"	Centimeters
"mm", "millimeter", "millimeters", "millimetre", "millimetres"	Millimeters
"micron", "microns"	Microns
"km", "kilometer", "kilometers", "kilometre", "kilometers"	Kilometers
"nm", "naut mi", "nautical mile", "nautical miles"	Nautical miles
"ft", "international ft", "foot", "international foot", "feet", "international feet"	Feet
"in", "inch", "inches"	Inches
"yd", "yds", "yard", "yards"	Yards
"mi", "mile", "miles", "international mile", "international miles"	Miles
"sf", "survey ft", "US survey ft", "U.S. survey ft", "survey foot", "US survey foot", "U.S. survey foot", "survey feet", "US survey feet", "U.S. survey feet"	U.S. survey feet
"sm", "survey mile", "survey miles", "statute mile", "statute miles", "US survey mile", "US survey miles", "U.S. survey mile(s)", "U.S. survey miles"	U.S. survey miles (statute miles)
"Clarke's foot", "Clarkes foot"	Clarke's feet
"German legal metre", "German legal meter"	German legal metres
"Indian foot"	Indian feet

Data Types: char | string

Version History

Introduced in R2010b

See Also

unitsratio | validateLengthUnit

ecc2flat

Flattening of ellipse from eccentricity

Syntax

```
f = ecc2flat(ecc)
```

Description

`f = ecc2flat(ecc)` computes the flattening `f` of an ellipse or an ellipsoid of revolution given its eccentricity `ecc`.

Examples

Flattening of Ellipse from Eccentricity

Find the flattening of an ellipse from the eccentricity.

```
f = ecc2flat(0.0818)
```

```
f = 0.0034
```

Input Arguments

ecc — Eccentricity of ellipse

numeric scalar

Eccentricity of the ellipse, specified as a numeric scalar. The value of `ecc` must be in the range `[0, 1]`.

Data Types: `single` | `double`

Output Arguments

f — Flattening

numeric scalar

Flattening, returned as a numeric scalar.

Version History

Introduced before R2006a

R2013b: Only numeric scalars will be accepted as input

Not recommended starting in R2013b

The `ecc2flat` function will not accept vectors or matrices as input in a future release. To update your code, specify a numeric scalar instead.

See Also

`ecc2n` | `flat2ecc` | `majaxis` | `minaxis`

ecc2n

Third flattening of ellipse from eccentricity

Syntax

```
n = ecc2n(ecc)
```

Description

`n = ecc2n(ecc)` computes the third flattening n of an ellipse or an ellipsoid of revolution given its eccentricity `ecc`.

Examples

Third Flattening of Ellipse from Eccentricity

Find the third flattening of an ellipse from the eccentricity.

```
n = ecc2n(0.0818)
```

```
n = 0.0017
```

Input Arguments

ecc — Eccentricity of ellipse

numeric scalar

Eccentricity of the ellipse, specified as a numeric scalar. The value of `ecc` must be in the range $[0, 1]$.

Data Types: `single` | `double`

Output Arguments

n — Third flattening of ellipse

numeric scalar

Third flattening of the ellipse, returned as a numeric scalar. The output n is defined as $(a-b)/(a+b)$, where a is the semimajor axis and b is the semiminor axis.

Version History

Introduced before R2006a

R2013b: Only numeric scalars will be accepted as input

Not recommended starting in R2013b

The `ecc2n` function will not accept vectors or matrices as input in a future release. To update your code, specify a numeric scalar instead.

See Also

`ecc2flat` | `majaxis` | `minaxis` | `n2ecc`

ecef2aer

Transform geocentric Earth-centered Earth-fixed coordinates to local spherical

Syntax

```
[az,elev,slantRange] = ecef2aer(X,Y,Z,lat0,lon0,h0,spheroid)
[ ___ ] = ecef2aer( ___ ,angleUnit)
```

Description

[az,elev,slantRange] = ecef2aer(X,Y,Z,lat0,lon0,h0,spheroid) transforms the geocentric Earth-centered Earth-fixed (ECEF) Cartesian coordinates specified by X, Y, and Z to the local azimuth-elevation-range (AER) spherical coordinates specified by az, elev, and slantRange. Specify the origin of the local AER system with the geodetic coordinates lat0, lon0, and h0. Each coordinate input argument must match the others in size or be scalar. Specify spheroid as the reference spheroid for the geodetic coordinates.

[___] = ecef2aer(___ ,angleUnit) specifies the units for latitude, longitude, azimuth, and elevation. Specify angleUnit as 'degrees' (the default) or 'radians'.

Examples

Calculate AER Coordinates from ECEF Coordinates

Find the AER coordinates of a satellite with respect to a satellite dish, using the ECEF coordinates of the satellite and the geodetic coordinates of the satellite dish.

First, specify the reference spheroid as WGS84 with length units measured in kilometers. For more information about WGS84, see “Comparison of Reference Spheroids”. The units for the ellipsoidal height, slant range, and ECEF coordinates must match the units specified by the LengthUnit property of the reference spheroid.

```
wgs84 = wgs84Ellipsoid('kilometers');
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is the satellite dish. Specify h0 as ellipsoidal height in kilometers.

```
lat0 = 42.3221;
lon0 = -71.3576;
h0 = 0.0847;
```

Specify the ECEF coordinates of the point of interest. In this example, the point of interest is the satellite.

```
x = 10766.0803;
y = 14143.6070;
z = 33992.3880;
```

Then, calculate the AER coordinates of the satellite with respect to the satellite dish. In this example, slantRange displays in scientific notation.

```
[az,elev,slantRange] = ecef2aer(x,y,z,lat0,lon0,h0,wgs84)
```

```
az = 24.8012
```

```
elev = 14.6185
```

```
slantRange = 3.6272e+04
```

Reverse the transformation using the `aer2ecef` function. In this example, the results display in scientific notation.

```
[x,y,z] = aer2ecef(az,elev,slantRange,lat0,lon0,h0,wgs84)
```

```
x = 1.0766e+04
```

```
y = 1.4144e+04
```

```
z = 3.3992e+04
```

Input Arguments

X — ECEF x-coordinates

scalar | vector | matrix | N-D array

ECEF x-coordinates of one or more points in the geocentric ECEF system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the spheroid argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: single | double

Y — ECEF y-coordinates

scalar | vector | matrix | N-D array

ECEF y-coordinates of one or more points in the geocentric ECEF system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the spheroid argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: single | double

Z — ECEF z-coordinates

scalar | vector | matrix | N-D array

ECEF z-coordinates of one or more points in the geocentric ECEF system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the spheroid argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: single | double

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as 'radians'.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h0 — Ellipsoidal height of local origin

scalar | vector | matrix | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the spheroid object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

az — Azimuth angles

scalar | vector | matrix | N-D array

Azimuth angles of one or more points in the local AER system, returned as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Values are specified in degrees within the half-open interval [0 360). To use values in radians, specify the `angleUnit` argument as `'radians'`.

elev — Elevation angles

scalar | vector | matrix | N-D array

Elevation angles of one or more points in the local AER system, returned as a scalar, vector, matrix, or N-D array. Elevations are measured with respect to a plane that is perpendicular to the normal of the spheroid surface. If the local origin is on the surface of the spheroid ($h_0 = 0$), then the plane is tangent to the spheroid.

Values are specified in degrees within the closed interval [-90 90]. To use values in radians, specify the `angleUnit` argument as 'radians'.

slantRange — Distances from local origin

scalar | vector | matrix | N-D array

Distances from the local origin, returned as a scalar, vector, matrix, or N-D array. Each distance is calculated along a straight, 3-D, Cartesian line. Units are specified by the `LengthUnit` property of the spheroid argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `ecef2aer` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`ecef2enu` | `ecef2ned` | `aer2ecef` | `geodetic2aer`

Topics

“Comparison of 3-D Coordinate Systems”

ecef2enu

Transform geocentric Earth-centered Earth-fixed coordinates to local east-north-up

Syntax

```
[xEast,yNorth,zUp] = ecef2enu(X,Y,Z,lat0,lon0,h0,spheroid)
[ ___ ] = ecef2enu( ___ ,angleUnit)
```

Description

[xEast,yNorth,zUp] = ecef2enu(X,Y,Z,lat0,lon0,h0,spheroid) transforms the geocentric Earth-centered Earth-fixed (ECEF) Cartesian coordinates specified by X, Y, and Z to the local east-north-up (ENU) Cartesian coordinates specified by xEast, yNorth, and zUp. Specify the origin of the local ENU system with the geodetic coordinates lat0, lon0, and h0. Each coordinate input argument must match the others in size or be scalar. Specify spheroid as the reference spheroid for the geodetic coordinates.

[___] = ecef2enu(___ ,angleUnit) specifies the units for latitude and longitude. Specify angleUnit as 'degrees' (the default) or 'radians'.

Examples

Calculate ENU Coordinates from ECEF Coordinates

Find the ENU coordinates of orbital debris with respect to a satellite, using the ECEF coordinates of the debris and the geodetic coordinates of the satellite.

First, specify the reference spheroid as WGS84 with length units measured in kilometers. For more information about WGS84, see “Comparison of Reference Spheroids”. The units for the ellipsoidal height, ECEF coordinates, and ENU coordinates must match the units specified by the LengthUnit property of the reference spheroid.

```
wgs84 = wgs84Ellipsoid('kilometer');
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is the satellite. Specify h0 as ellipsoidal height in kilometers.

```
lat0 = 45.9132;
lon0 = 36.7484;
h0 = 1877.7532;
```

Specify the ECEF coordinates of the point of interest. In this example, the point of interest is the orbital debris.

```
x = 5507.5289;
y = 4556.2241;
z = 6012.8208;
```

Then, calculate the ENU coordinates of the debris with respect to the satellite. In this example, zUp displays in scientific notation.

```
[xEast,yNorth,zUp] = ecef2enu(x,y,z,lat0,lon0,h0,wgs84)
```

```
xEast = 355.6013
```

```
yNorth = -923.0832
```

```
zUp = 1.0410e+03
```

Reverse the transformation using the `enu2ecef` function. In this example, the results display in scientific notation.

```
[x,y,z] = enu2ecef(xEast,yNorth,zUp,lat0,lon0,h0,wgs84)
```

```
x = 5.5075e+03
```

```
y = 4.5562e+03
```

```
z = 6.0128e+03
```

Input Arguments

X — ECEF x-coordinates

scalar | vector | matrix | N-D array

ECEF x-coordinates of one or more points in the geocentric ECEF system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the spheroid argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: `single` | `double`

Y — ECEF y-coordinates

scalar | vector | matrix | N-D array

ECEF y-coordinates of one or more points in the geocentric ECEF system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the spheroid argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: `single` | `double`

Z — ECEF z-coordinates

scalar | vector | matrix | N-D array

ECEF z-coordinates of one or more points in the geocentric ECEF system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the spheroid argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: `single` | `double`

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as 'radians'.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h0 — Ellipsoidal height of local origin

scalar | vector | matrix | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

xEast — ENU x-coordinates

scalar | vector | matrix | N-D array

ENU x-coordinates of one or more points in the local ENU system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

yNorth — ENU y-coordinates

scalar | vector | matrix | N-D array

ENU y-coordinates of one or more points in the local ENU system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument.

For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

zUp — ENU z-coordinates

scalar | vector | matrix | N-D array

ENU z-coordinates of one or more points in the local ENU system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Tips

To transform vectors instead of coordinate locations, use the `ecef2enuv` function.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `ecef2enu` function supports code generation.

Extended Capabilities**C/C++ Code Generation**

Generate C and C++ code using MATLAB® Coder™.

See Also

`ecef2ned` | `ecef2aer` | `enu2ecef` | `geodetic2enu`

Topics

“Comparison of 3-D Coordinate Systems”

ecef2enuv

Rotate geocentric Earth-centered Earth-fixed vector to local east-north-up

Syntax

```
[uEast,vNorth,wUp] = ecef2enuv(U,V,W,lat0,lon0)
[ ___ ] = ecef2enuv( ___,angleUnit)
```

Description

[uEast,vNorth,wUp] = ecef2enuv(U,V,W,lat0,lon0) returns vector components uEast, vNorth, and wUp in a local east-north-up (ENU) system corresponding to vector components U, V, and W in a geocentric Earth-centered Earth-fixed (ECEF) system. Specify the origin of the system with the geodetic coordinates lat0 and lon0. Each coordinate input argument must match the others in size or be scalar.

[___] = ecef2enuv(___,angleUnit) specifies the units for latitude and longitude. Specify angleUnit as 'degrees' (the default) or 'radians'.

Examples

Calculate ENU Vector Components from ECEF Components

Find the ENU velocity components of a ground vehicle using its ECEF velocity components.

Specify the geodetic coordinates of the vehicle in degrees and the ECEF velocity components in kilometers per hour.

```
lat0 = 17.4114;
lon0 = 78.2700;
```

```
U = 27.9799;
V = -1.0990;
W = -15.7723;
```

Calculate the ENU components of the vehicle. The units for the ENU components match the units for the ECEF components. Thus, the ENU components are returned in kilometers per hour. The rotation performed by ecef2enuv does not affect the speed of the vehicle.

```
[uEast,vNorth,wUp] = ecef2enuv(U,V,W,lat0,lon0)
```

```
uEast = -27.6190
```

```
vNorth = -16.4298
```

```
wUp = -0.3186
```

Reverse the rotation using the enu2ecefv function.

```
[U,V,W] = enu2ecefv(uEast,vNorth,wUp,lat0,lon0)
```

U = 27.9799
V = -1.0990
W = -15.7723

Input Arguments

U — ECEF x-components

scalar value | vector | matrix | N-D array

ECEF x-components of one or more vectors, specified as a scalar value, vector, matrix, or N-D array.

Data Types: single | double

V — ECEF y-components

scalar value | vector | matrix | N-D array

ECEF y-components of one or more vectors, specified as a scalar value, vector, matrix, or N-D array.

Data Types: single | double

W — ECEF z-components

scalar value | vector | matrix | N-D array

ECEF z-components of one or more vectors, specified as a scalar value, vector, matrix, or N-D array.

Data Types: single | double

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as 'radians'.

Data Types: single | double

lon0 — Geodetic longitude of local origin

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as 'radians'.

Data Types: single | double

angleUnit — Angle units

'degrees' (default) | 'radians'

Angle units, specified as 'degrees' (the default) or 'radians'.

Output Arguments

uEast — ENU x-components

scalar value | vector | matrix | N-D array

ENU x-components of one or more vectors, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by U, V, and W.

vNorth — ENU y-components

scalar value | vector | matrix | N-D array

ENU y-components of one or more vectors, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by U, V, and W.

wUp — ENU z-components

scalar value | vector | matrix | N-D array

ENU z-components of one or more vectors, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by U, V, and W.

Tips

To transform coordinate locations instead of vectors, use the `ecef2enu` function.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `ecef2enuv` function supports code generation.

Extended Capabilities**C/C++ Code Generation**

Generate C and C++ code using MATLAB® Coder™.

See Also**Functions**

`enu2ecefv` | `ecef2nedv` | `ned2ecefv`

Topics

“Vectors in 3-D Coordinate Systems”

ecef2geodetic

Transform geocentric Earth-centered Earth-fixed coordinates to geodetic

Syntax

```
[lat,lon,h] = ecef2geodetic(spheroid,X,Y,Z)
```

```
[lat,lon,h] = ecef2geodetic( ____,angleUnit)
```

```
[lat,lon,h] = ecef2geodetic(X,Y,Z,spheroid)
```

Description

`[lat,lon,h] = ecef2geodetic(spheroid,X,Y,Z)` transforms the geocentric Earth-Centered Earth-Fixed (ECEF) Cartesian coordinates specified by `X`, `Y`, and `Z` to the geodetic coordinates specified by `lat`, `lon`, and `h`. Specify `spheroid` as the reference spheroid for the geodetic coordinates.

`[lat,lon,h] = ecef2geodetic(____,angleUnit)` specifies the units for latitude and longitude. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

`[lat,lon,h] = ecef2geodetic(X,Y,Z,spheroid)` is supported but not recommended. Unlike the previous syntaxes, this syntax returns `lat` and `lon` in radians. Specify `spheroid` as either a reference spheroid or an ellipsoid vector of the form `[semimajor_axis, eccentricity]`. Specify `X`, `Y`, and `Z` in the same units as the length unit of the `spheroid` argument. Additionally, the output `h` returns in the same units as the length unit of the `spheroid` argument.

Examples

Calculate Geodetic Coordinates from ECEF Coordinates

Find the geodetic coordinates of Paris, France, using its ECEF coordinates.

First, specify the reference spheroid as WGS84 with length units measured in kilometers. For more information about WGS84, see "Comparison of Reference Spheroids". The units for the ECEF coordinates and ellipsoidal height must match the units specified by the `LengthUnit` property of the reference spheroid.

```
wgs84 = wgs84Ellipsoid('kilometer');
```

Specify the ECEF coordinates of Paris in kilometers.

```
x = 4201;  
y = 172.46;  
z = 4780.1;
```

Then, calculate the geodetic coordinates of Paris. The result `h` is ellipsoidal height in kilometers.

```
[lat,lon,h] = ecef2geodetic(wgs84,x,y,z)
```

```
lat = 48.8562
```

```
lon = 2.3508
```

```
h = 0.0674
```

Reverse the transformation using the `geodetic2ecef` function. In this example, `x` and `z` display in scientific notation.

```
[x,y,z] = geodetic2ecef(wgs84,lat,lon,h)
```

```
x = 4.2010e+03
```

```
y = 172.4600
```

```
z = 4.7801e+03
```

Input Arguments

spheroid — Reference spheroid

referenceEllipsoid object | oblateSpheroid object | referenceSphere object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

X — ECEF x-coordinates

scalar | vector | matrix | N-D array

ECEF `x`-coordinates of one or more points in the geocentric ECEF system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: `single` | `double`

Y — ECEF y-coordinates

scalar | vector | matrix | N-D array

ECEF `y`-coordinates of one or more points in the geocentric ECEF system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: `single` | `double`

Z — ECEF z-coordinates

scalar | vector | matrix | N-D array

ECEF `z`-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

angleUnit — Angle units

'degrees' (default) | 'radians'

Angle units, specified as 'degrees' (the default) or 'radians'.

Output Arguments**lat — Geodetic latitude**

scalar | vector | matrix | N-D array

Geodetic latitude of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in degrees within the interval $[-90\ 90]$. To use values in radians, specify the `angleUnit` argument as 'radians'.

lon — Geodetic longitude

scalar | vector | matrix | N-D array

Geodetic longitude of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in degrees within the interval $[-180\ 180]$. To use values in radians, specify the `angleUnit` argument as 'radians'.

h — Ellipsoidal height

scalar | vector | matrix | N-D array

Ellipsoidal height of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in units that match the `LengthUnit` property of the spheroid object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Tips

- The geocentric Cartesian (ECEF) coordinate system is fixed with respect to the Earth, with its origin at the center of the spheroid and its positive X-, Y-, and Z axes intersecting the surface at the following points:

	Latitude	Longitude	Notes
X-axis	0	0	Equator at the Prime Meridian
Y-axis	0	90	Equator at 90-degrees East
Z-axis	90	0	North Pole

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `ecef2geodetic` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

[geodetic2ecef](#) | [ecef0ffset](#) | [ecef2aer](#) | [ecef2ned](#) | [ecef2enu](#)

Topics

“Comparison of 3-D Coordinate Systems”

ecef2lv

(Removed) Convert geocentric (ECEF) to local vertical coordinates

Note The `ecef2lv` function has been removed. Use the `ecef2enu` function instead. By default, the `ecef2enu` function assumes that the latitude and longitude of the local origin are in degrees. When you update your code, you can specify the `angleUnit` input argument as `'radians'`.

Syntax

```
[xl,yl,zl] = ecef2lv(x,y,z,phi0,lambda0,h0,ellipsoid)
```

Description

`[xl,yl,zl] = ecef2lv(x,y,z,phi0,lambda0,h0,ellipsoid)` converts geocentric point locations specified by the coordinate arrays `x`, `y`, and `z` to the local vertical coordinate system, with its origin at geodetic latitude `phi0`, longitude `lambda0`, and ellipsoidal height `h0`. The arrays `x`, `y`, and `z` may be of any shape, as long as they all match in size. `phi0`, `lambda0`, and `h0` must be scalars. `ellipsoid` is a `referenceEllipsoid` (`oblateSpheroid`) object, a `referenceSphere` object, or a vector of the form `[semimajor axis, eccentricity]`. `x`, `y`, `z`, and `h0` must have the same length units as the semimajor axis. `phi0` and `lambda0` must be in radians. The output coordinate arrays, `xl`, `yl`, and `zl` are the local vertical coordinates of the input points. They have the same size as `x`, `y`, and `z` and have the same length units as the semimajor axis.

In the local vertical Cartesian system defined by `phi0`, `lambda0`, `h0`, and `ellipsoid`, the `xl` axis is parallel to the plane tangent to the ellipsoid at `(phi0,lambda0)` and points due east. The `yl` axis is parallel to the same plane and points due north. The `zl` axis is normal to the ellipsoid at `(phi0,lambda0)` and points outward into space. The local vertical system is sometimes referred to as east-north-up or ENU.

More About

Local Vertical System

In the local vertical Cartesian system defined by `phi0`, `lambda0`, `h0`, and `ellipsoid`, the `xl` axis is parallel to the plane tangent to the ellipsoid at `(phi0,lambda0)` and points due east. The `yl` axis is parallel to the same plane and points due north. The `zl` axis is normal to the ellipsoid at `(phi0,lambda0)` and points outward into space. The local vertical system is sometimes referred to as East-North-Up or ENU.

Geocentric System

The geocentric Cartesian coordinate system, also known as Earth-Centered, Earth-Fixed (ECEF), is fixed with respect to the Earth, with its origin at the center of the spheroid and its positive X-, Y-, and Z axes intersecting the surface at the following points:

	Latitude	Longitude	Notes
X-axis	0	0	Equator at the Prime Meridian

	Latitude	Longitude	Notes
Y-axis	0	90	Equator at 90-degrees East
Z-axis	90	0	North Pole

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `ecef2lv` function has been removed. Use the `ecef2enu` function instead. By default, the `ecef2enu` function assumes that the latitude and longitude of the local origin are in degrees. When you update your code, you can specify the `angleUnit` input argument as `'radians'`.

R2022a: Warns

Warns starting in R2022a

The `ecef2lv` function issues a warning that it will be removed in a future release.

R2012b: To be removed

Not recommended starting in R2012b

The `ecef2lv` function runs without warning but will be removed in a future release.

See Also

`ecef2enu` | `enu2ecef`

ecef2ned

Transform geocentric Earth-centered Earth-fixed coordinates to local north-east-down

Syntax

```
[xNorth,yEast,zDown] = ecef2ned(X,Y,Z,lat0,lon0,h0,spheroid)
[ ___ ] = ecef2ned( ___ ,angleUnit)
```

Description

`[xNorth,yEast,zDown] = ecef2ned(X,Y,Z,lat0,lon0,h0,spheroid)` transforms the geocentric Earth-centered Earth-fixed (ECEF) Cartesian coordinates specified by `X`, `Y`, and `Z` to the local north-east-down (NED) Cartesian coordinates specified by `xNorth`, `yEast`, and `zDown`. Specify the origin of the local NED system with the geodetic coordinates `lat0`, `lon0`, and `h0`. Each coordinate input argument must match the others in size or be scalar. Specify `spheroid` as the reference spheroid for the geodetic coordinates.

`[___] = ecef2ned(___ ,angleUnit)` specifies the units for latitude and longitude. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate NED Coordinates from ECEF Coordinates

Find the NED coordinates of Mount Mansfield with respect to a nearby aircraft, using the ECEF coordinates of Mount Mansfield and the geodetic coordinates of the aircraft.

First, specify the reference spheroid as WGS84 with length units measured in kilometers. For more information about WGS84, see "Comparison of Reference Spheroids". The units for the ellipsoidal height, ECEF coordinates, and NED coordinates must match the units specified by the `LengthUnit` property of the reference spheroid.

```
wgs84 = wgs84Ellipsoid('kilometer');
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is the aircraft. Specify `h0` as ellipsoidal height in kilometers.

```
lat0 = 44.532;
lon0 = -72.782;
h0 = 1.699;
```

Specify the ECEF coordinates of the point of interest. In this example, the point of interest is Mount Mansfield.

```
x = 1345.660;
y = -4350.891;
z = 4452.314;
```

Then, calculate the NED coordinates of Mount Mansfield with respect to the aircraft. Since the ellipsoidal height of the aircraft is greater than the height of Mount Mansfield, a passenger needs to

look down to see the mountaintop. The z-axis of an NED coordinate system points down. Thus, the value of zDown is positive.

```
[xNorth,yEast,zDown] = ecef2ned(x,y,z,lat0,lon0,h0,wgs84)
```

```
xNorth = 1.3343
```

```
yEast = -2.5444
```

```
zDown = 0.3600
```

Reverse the transformation using the ned2ecef function. In this example, the results display in scientific notation.

```
[x,y,z] = ned2ecef(xNorth,yEast,zDown,lat0,lon0,h0,wgs84)
```

```
x = 1.3457e+03
```

```
y = -4.3509e+03
```

```
z = 4.4523e+03
```

Input Arguments

X — ECEF x-coordinates

scalar | vector | matrix | N-D array

ECEF x-coordinates of one or more points in the geocentric ECEF system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: single | double

Y — ECEF y-coordinates

scalar | vector | matrix | N-D array

ECEF y-coordinates of one or more points in the geocentric ECEF system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: single | double

Z — ECEF z-coordinates

scalar | vector | matrix | N-D array

ECEF z-coordinates of one or more points in the geocentric ECEF system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: single | double

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h0 — Ellipsoidal height of local origin

scalar | vector | matrix | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

xNorth — NED x-coordinates

scalar | vector | matrix | N-D array

NED x-coordinates of one or more points in the local NED system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

yEast — NED y-coordinates

scalar | vector | matrix | N-D array

NED y-coordinates of one or more points in the local NED system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

zDown — NED z-coordinates

scalar | vector | matrix | N-D array

NED z-coordinates of one or more points in the local NED system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Tips

To transform vectors instead of coordinate locations, use the `ecef2nedv` function.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `ecef2ned` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`ecef2enu` | `ecef2aer` | `ned2ecef` | `geodetic2ned`

Topics

“Comparison of 3-D Coordinate Systems”

ecef2nedv

Rotate geocentric Earth-centered Earth-fixed vector to local north-east-down

Syntax

```
[uNorth,vEast,wDown] = ecef2nedv(U,V,W,lat0,lon0)
[ ___ ] = ecef2nedv( ___ ,angleUnit)
```

Description

[uNorth,vEast,wDown] = ecef2nedv(U,V,W,lat0,lon0) returns vector components uNorth, vEast, and wDown in a local north-east-down (NED) system corresponding to vector components U, V, and W in a geocentric Earth-centered Earth-fixed (ECEF) system. Specify the origin of the system with the geodetic coordinates lat0 and lon0. Each coordinate input argument must match the others in size or be scalar.

[___] = ecef2nedv(___ ,angleUnit) specifies the units for latitude and longitude. Specify angleUnit as 'degrees' (the default) or 'radians'.

Examples

Calculate NED Vector Components from ECEF Components

Find the NED velocity components of an aircraft using its ECEF components.

Specify the geodetic coordinates of the aircraft in degrees and the ECEF velocity components in kilometers per hour.

```
lat0 = 61.64;
lon0 = 30.70;
```

```
U = 530.2445;
V = 492.1283;
W = 396.3459;
```

Calculate the NED components of the aircraft. The units for the NED components match the units for the ECEF components. Thus, the NED components are returned in kilometers per hour. The negative value of wDown means the aircraft is ascending.

```
[uNorth,vEast,wDown] = ecef2nedv(U,V,W,lat0,lon0)
```

```
uNorth = -434.0403
```

```
vEast = 152.4451
```

```
wDown = -684.6964
```

Reverse the rotation using the ned2ecefv function.

```
[U,V,W] = ned2ecefv(uNorth,vEast,wDown,lat0,lon0)
```

U = 530.2445

V = 492.1283

W = 396.3459

Input Arguments

U — ECEF x-components

scalar value | vector | matrix | N-D array

ECEF x-components of one or more vectors, specified as a scalar value, vector, matrix, or N-D array.

Data Types: single | double

V — ECEF y-components

scalar value | vector | matrix | N-D array

ECEF y-components of one or more vectors, specified as a scalar value, vector, matrix, or N-D array.

Data Types: single | double

W — ECEF z-components

scalar value | vector | matrix | N-D array

ECEF z-components of one or more vectors, specified as a scalar value, vector, matrix, or N-D array.

Data Types: single | double

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as 'radians'.

Data Types: single | double

lon0 — Geodetic longitude of local origin

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as 'radians'.

Data Types: single | double

angleUnit — Angle units

'degrees' (default) | 'radians'

Angle units, specified as 'degrees' (the default) or 'radians'.

Output Arguments

uNorth — NED x-components

scalar value | vector | matrix | N-D array

NED *x*-components of one or more vectors in the local NED system, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by *U*, *V*, and *W*.

vEast — NED *y*-components

scalar value | vector | matrix | N-D array

NED *y*-components of one or more vectors in the local NED system, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by *U*, *V*, and *W*.

wDown — NED *z*-components

scalar value | vector | matrix | N-D array

NED *z*-components of one or more vectors in the local NED system, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by *U*, *V*, and *W*.

Tips

To transform coordinate locations instead of vectors, use the `ecef2ned` function.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `ecef2nedv` function supports code generation.

Extended Capabilities**C/C++ Code Generation**

Generate C and C++ code using MATLAB® Coder™.

See Also

`ecef2enuv` | `ned2ecefv` | `enu2ecefv`

Topics

“Vectors in 3-D Coordinate Systems”

ecefOffset

Cartesian ECEF offset between geodetic coordinates

Syntax

```
[deltaX,deltaY,deltaZ] = ecefOffset(spheroid,lat1,lon1,h1,lat2,lon2,h2)
[] = ecefOffset( ____,angleUnit)
```

Description

`[deltaX,deltaY,deltaZ] = ecefOffset(spheroid,lat1,lon1,h1,lat2,lon2,h2)` returns the Earth-Centered Earth-Fixed (ECEF) Cartesian offset between the geodetic coordinates specified by `lat1`, `lon1`, and `h1` and the coordinates specified by `lat2`, `lon2`, and `h2`. Specify `spheroid` as the reference spheroid for the geodetic coordinates.

`[] = ecefOffset(____,angleUnit)`, where `angleUnit` is 'radians', specifies the units for latitude and longitude as radians. If you do not specify an angle unit, then latitude and longitude are in degrees.

Examples

Calculate Cartesian ECEF Offset Between Geodetic Positions

Find the ECEF offset between Paris, France and Miami, Florida.

First, specify the reference spheroid as WGS 84. For more information about WGS84, see “Comparison of Reference Spheroids”. The units for the ellipsoidal height and offset vector must match the units specified by the `LengthUnit` property of the reference spheroid. The default length unit for the reference spheroid created by `wgs84Ellipsoid` is 'meter'.

```
wgs84 = wgs84Ellipsoid;
```

Specify the geodetic coordinates of Paris and Miami. Specify `hParis` and `hMiami` as ellipsoidal height in meters. The value of `hMiami` is negative because Miami is below the surface of the reference spheroid.

```
latParis = 48.8567;
lonParis = 2.3508;
hParis = 80;
```

```
latMiami = 25.7753;
lonMiami = -80.2089;
hMiami = -25;
```

Calculate the ECEF offset between the two geodetic positions. The values `dx`, `dy`, and `dz` are specified in meters. For this example, the results display in scientific notation.

```
[dx,dy,dz] = ecefOffset(wgs84,latParis,lonParis,hParis,latMiami,lonMiami,hMiami)
```

```
dx = -3.2236e+06
```

```
dy = -5.8359e+06
```

```
dz = -2.0235e+06
```

Calculate the straight-line, 3-D Cartesian distance from Paris to Miami.

```
d = norm([dx dy dz])
```

```
d = 6.9674e+06
```

Input Arguments

spheroid — Reference spheroid

referenceEllipsoid object | oblateSpheroid object | referenceSphere object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

lat — Geodetic latitude

scalar | vector

Geodetic latitude of one or more points, specified as a scalar or vector. Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon — Geodetic longitude

scalar | vector

Geodetic longitude of one or more points, specified as a scalar or vector. Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h — Ellipsoidal height

scalar | vector

Ellipsoidal height of one or more points, specified as a scalar or vector. Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

angleUnit — Units of the latitude and longitude coordinates

`'degrees'` | `'radians'`

Units of the latitude and longitude coordinates, specified as `'degrees'` or `'radians'`.

Data Types: `char`

Output Arguments

deltaX — ECEF offset in x-axis direction

scalar | vector

ECEF offset in the x-axis direction, returned as a scalar or vector. Units are specified by the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

deltaY — ECEF offset in y-axis direction

scalar | vector

ECEF offset in the y-axis direction, returned as a scalar or vector. Units are specified by the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

deltaZ — ECEF offset in z-axis direction

scalar | vector

ECEF offset in the z-axis direction, returned as a scalar or vector. Units are specified by the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `ecefOffset` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`geodetic2ecef` | `ecef2geodetic` | `oblateSpheroid` | `referenceEllipsoid` | `referenceSphere`

egm96geoid

Geoid height from Earth Gravitational Model 1996 (EGM96)

Note Syntaxes of the `egm96geoid` function that return referencing vectors will be removed in a future release. Use a syntax that returns a reference object instead (*requires R2020a or later*). For more information, see “Compatibility Considerations”.

Syntax

```
N = egm96geoid(lat,lon)
N = egm96geoid(R)
[N,globalR] = egm96geoid
```

Description

`N = egm96geoid(lat,lon)` returns the height in meters of the geoid at the specified latitude and longitude from the “Earth Gravitational Model of 1996 (EGM96)” on page 1-391. Specify latitude and longitude in degrees. (*since R2019b*)

`N = egm96geoid(R)` returns geoid heights at the cell center or posting locations specified by the geographic postings reference or geographic cells reference object `R`. (*since R2020a*)

`[N,globalR] = egm96geoid` returns geoid heights for the entire globe as a 721-by-1441 matrix spaced at 15-minute intervals with latitude limits `[-90 90]` and longitude limits `[0 360]`. The function also returns a geographic postings reference object that contains spatial referencing information for the geoid heights. (*since R2020a*)

Examples

Geoid Height from Latitude and Longitude

Find geoid heights from EGM96 by specifying latitude and longitude values in degrees. The result is returned in meters.

```
lat = 27.988056;
lon = 86.925278;
N = egm96geoid(lat,lon)
```

```
N = -28.7444
```

Geoid Heights within Limits

View geoid heights from EGM96 for an area including Europe.

First, create a `GeographicPostingsReference` object. Specify the latitude and longitude limits of the area in degrees. Specify the raster size as the number of rows and columns for the grid of geoid

heights. Then, return the grid of geoid heights for the area by calling `egm96geoid` on the reference object.

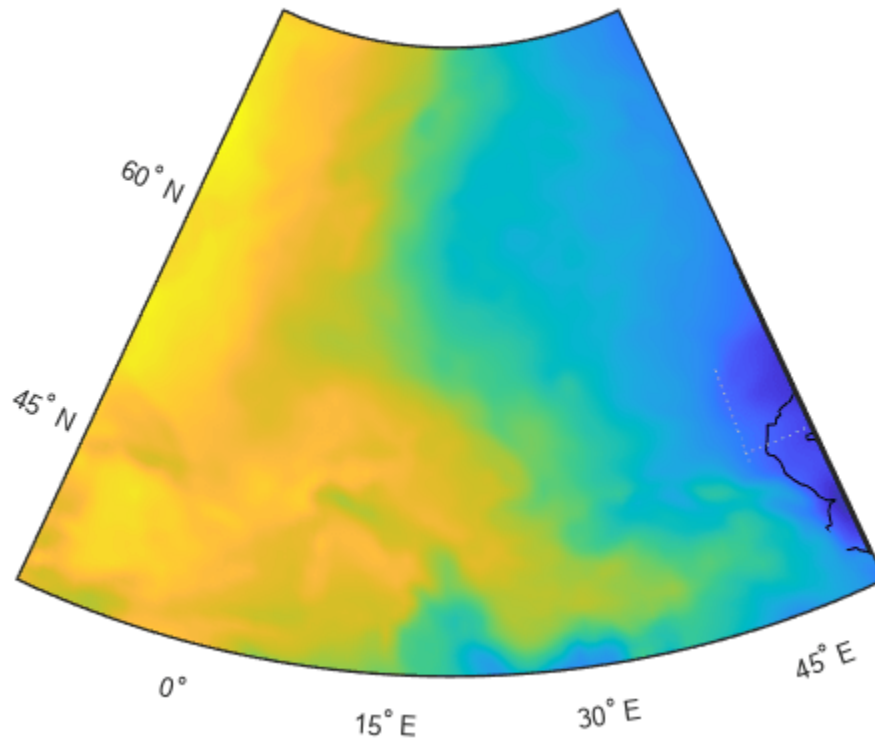
```
latlim = [35 72];  
lonlim = [-12 51];  
rasterSize = [100 100];  
R = georefpostings(latlim,lonlim,rasterSize);  
N = egm96geoid(R);
```

Note that the size of `N` matches the raster size of `R`.

```
size(N)  
ans = 1×2  
    100    100
```

Load coastline latitude and longitude data into the workspace. Then, plot the geoid height and coastline data on a map.

```
load coastlines  
worldmap(latlim,lonlim)  
geoshow(N,R,'DisplayType','surface')  
geoshow(coastlat,coastlon,'Color','k')
```

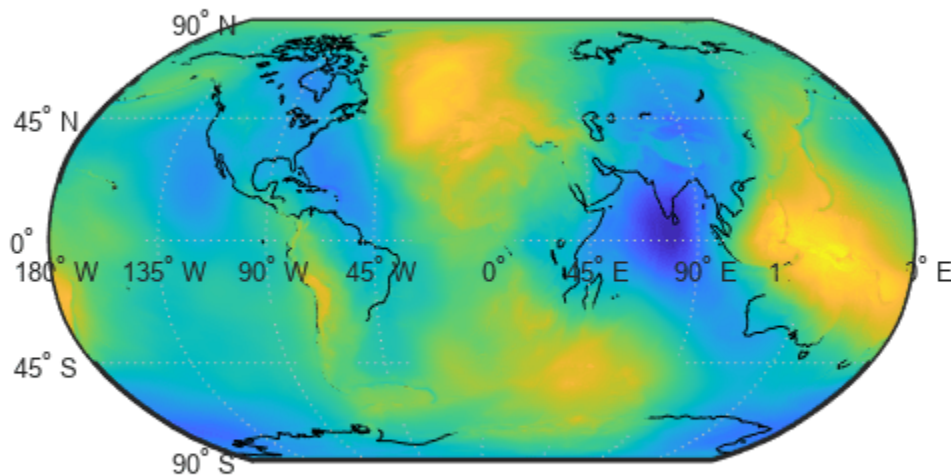


Geoid Heights for Entire Globe

View geoid heights from EGM96 for the entire globe.

First, return the geoid heights and a referencing object for the globe. The geoid heights are spaced at 15-minute intervals. Load coastline latitude and longitude data into the workspace. Then, plot the geoid heights and coastline data on a world map.

```
[N,R] = egm96geoid;  
load coastlines  
  
worldmap('World')  
geoshow(N,R,'DisplayType','surface')  
geoshow(coastlat,coastlon,'Color','k')
```



Input Arguments

lat — Latitude

scalar | vector | matrix

Latitude in degrees, specified as a scalar, vector, or matrix. The dimension of `lat` depends on the dimension of the geoid heights you want to find.

- To find a single geoid height, specify `lat` and `lon` as scalars.

- To find several geoid heights, specify `lat` and `lon` as vectors of the same length.
- To find a p -by- q grid of geoid heights, specify `lat` and `lon` as p -by- q matrices.

Data Types: `single` | `double`

lon — Longitude

`scalar` | `vector` | `matrix`

Longitude in degrees, specified as a scalar, vector, or matrix. The dimension of `lon` depends on the dimension of the geoid heights you want to find.

- To find a single geoid height, specify `lat` and `lon` as scalars.
- To find several geoid heights, specify `lat` and `lon` as vectors of the same length.
- To find a p -by- q grid of geoid heights, specify `lat` and `lon` as p -by- q matrices.

Data Types: `single` | `double`

R — Geographic reference

`GeographicPostingsReference` object | `GeographicCellsReference` object

Geographic reference, specified as a `GeographicPostingsReference` object or a `GeographicCellsReference` object that contains geospatial referencing information for `N`. The `RasterSize` property of the geographic reference object determines the size of the data grid, `size(N)`.

Output Arguments

N — Geoid height

`scalar` | `vector` | `matrix`

Geoid height in meters, returned as a scalar, vector, or matrix.

The size of `N` depends on the syntax:

Syntax	Size of N
<code>N = egm96geoid(lat,lon)</code>	Size of <code>lat</code> and <code>lon</code>
<code>N = egm96geoid(R)</code>	<code>R.RasterSize</code>
<code>[N,globalR] = egm96geoid</code>	721-by-1441 matrix

Data Types: `double`

globalR — Geographic reference

`GeographicPostingsReference` object

Geographic reference, returned as a `GeographicPostingsReference` object of size 721-by-1441 with latitude limits `[-90 90]` and longitude limits `[0 360]`.

More About

Earth Gravitational Model of 1996 (EGM96)

The geoid is an equipotential surface of the Earth's gravity field that approximates global mean sea level. You can visualize the geoid as the surface of the ocean without effects such as weather, waves,

and land. The Earth Gravitational Model of 1996 (EGM96) is based on the ellipsoid specified by the World Geodetic System of 1984 (WGS84), so the `egm96geoid` function returns heights above or below the surface of the WGS84 ellipsoid.

Version History

Introduced before R2006a

R2022a: Syntaxes that return referencing vectors warn

Warns starting in R2022a

Syntaxes of the `egm96geoid` function that return referencing vectors issue a warning that they will be removed in a future release. Use a syntax that returns a geographic raster reference object instead. Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `GeographicPostingsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` function.
- Most functions that accept referencing vectors as inputs also accept reference objects.

This table shows the syntaxes of the `egm96geoid` function that return referencing vectors and how to update your code to use syntaxes that return reference objects instead.

Will Be Removed	Recommended
<code>[N,refvec] = egm96geoid(samplefactor);</code>	<code>[~,globalR] = egm96geoid; latlim = globalR.LatitudeLimits; lonlim = globalR.LongitudeLimits; globalSize = globalR.RasterSize; rasterSize = 1 + ceil((globalSize-1)/samplefactor); R = georefpostings(latlim,lonlim,rasterSize); N = egm96geoid(R);</code>
<code>[N,refvec] = egm96geoid(samplefactor,latlim,lonlim);</code>	<code>[~,globalR] = egm96geoid; spacing = samplefactor ... * globalR.SampleSpacingInLatitude; R = georefpostings(latlim,lonlim,spacing,spacing); N = egm96geoid(R);</code>

R2020b: Syntaxes that return referencing vectors will be removed

Not recommended starting in R2020b

Syntaxes of the `egm96geoid` function that return referencing vectors will be removed in a future release.

R2020a: Return geoid heights referenced to geographic reference object

Return geoid heights from EGM96 that are referenced to a geographic raster reference object. You can specify `GeographicCellsReference` or `GeographicPostingsReference` objects, or return geoid heights and a reference object for the entire globe spaced at 15-minute intervals.

R2019b: Return geoid heights at specified latitudes and longitudes

Return geoid heights from EGM96 by specifying latitude and longitude in degrees. For example, find the geoid height at a latitude of 42.3601 degrees and a longitude of -71.589 degrees:

```
N = egm96geoid(42.3601, -71.589);
```

R2019b: Improved performance

In previous releases, `egm96geoid` accessed geoid heights using `WW15MGH.GRD`, a file that you downloaded from the Internet. Starting in R2019b, a grid of geoid heights from EGM96 is included with Mapping Toolbox, and `egm96geoid` no longer reads data from `WW15MGH.GRD`.

As a result, the `egm96geoid` function shows improved performance. For example, this code shows about a 15x speed-up when you return the entire grid of geoid heights:

```
function timingTest
N = egm96geoid(1);
end
```

The approximate execution times are:

- **R2019a:** 0.1838 s
- **R2019b:** 0.0121 s

This code was timed on a Windows® 10 test system with a 3.6-GHz Intel® Xeon® W-2133 CPU using the `timeit` function:

```
timeit(@timingTest)
```

See Also

Functions

`GeographicPostingsReference` | `GeographicCellsReference` | `geoshow` | `ndgrid`

Topics

“Shape of the Earth”

“Find Ellipsoidal Height from Orthometric and Geoid Height”

“Georeferenced Raster Data”

elevation

(Removed) Local vertical elevation angle, range, and azimuth

Note The `elevation` function has been removed. Use the `geodetic2aer` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[elevationangle,slanrange,azimuthangle] = ...
    elevation(lat1,lon1,alt1,lat2,lon2,alt2)
[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...
    angleunits)
[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...
    angleunits,distanceunits)
[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...
    angleunits,ellipsoid)
```

Description

```
[elevationangle,slanrange,azimuthangle] = ...
    elevation(lat1,lon1,alt1,lat2,lon2,alt2)
```

computes the elevation angle, slant range, and azimuth angle of point 2 (with geodetic coordinates `lat2`, `lon2`, and `alt2`) as viewed from point 1 (with geodetic coordinates `lat1`, `lon1`, and `alt1`). The coordinates `alt1` and `alt2` are ellipsoidal heights. The elevation angle is the angle of the line of sight above the local horizontal at point 1. The slant range is the three-dimensional Cartesian distance between point 1 and point 2. The azimuth is the angle from north to the projection of the line of sight on the local horizontal. Angles are in units of degrees; altitudes and distances are in meters. The figure of the earth is the default ellipsoid (GRS 80).

Inputs can be vectors of points, or arrays of any shape, but must match in size, with the following exception: Elevation, range, and azimuth from a single point to a set of points can be computed very efficiently by providing scalar coordinate inputs for point 1 and vectors or arrays for point 2.

```
[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...
    angleunits)
```

where `angleunits` specifies the units of the input and output angles. If you omit `angleunits`, 'degrees' is assumed.

```
[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...
    angleunits,distanceunits)
```

where `distanceunits` specifies the altitude and slant-range units. If you omit `distanceunits`, 'meters' is the default. Any units value recognized by `unitsratio` may be used.

```
[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...
    angleunits,ellipsoid)
```

uses `ellipsoid` to specify the ellipsoid. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form [`semimajor_axis` `eccentricity`]. If `ellipsoid` is supplied, the altitudes must be in the same units as the semimajor axis, and the slant range will be returned in these units. If `ellipsoid` is omitted, the default is a unit sphere. Distances are in meters unless otherwise specified.

Note The line-of-sight azimuth angles returned by `elevation` will generally differ slightly from the corresponding outputs of `azimuth` and `distance`, except for great circle azimuths on a spherical earth.

Examples

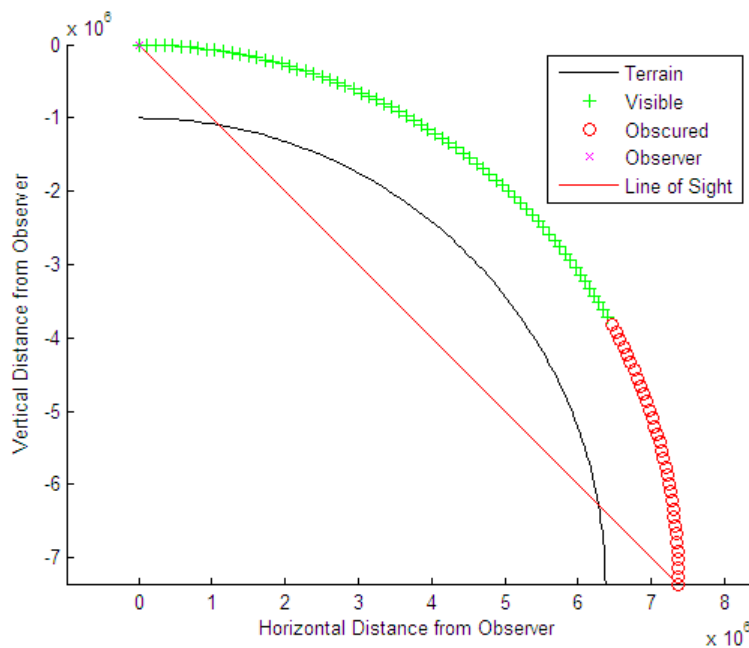
Find the elevation angle of a point 90 degrees from an observer assuming that the observer and the target are both 1000 km above the Earth.

```
lat1 = 0; lon1 = 0; alt1 = 1000*1000;
lat2 = 0; lon2 = 90; alt2 = 1000*1000;
elevang = elevation(lat1,lon1,alt1,lat2,lon2,alt2)
```

```
elevang =
    -45
```

Visually check the result using the `los2` line of sight function. Construct a data grid of zeros to represent the Earth's surface. The `los2` function with no output arguments creates a figure displaying the geometry.

```
Z = zeros(180,360);
refvec = [1 90 -180];
los2(Z,refvec,lat1,lon1,lat2,lon2,alt1,alt1);
```



Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `elevation` function has been removed. Use the `geodetic2aer` function instead.

The reference point comes second in the `geodetic2aer` argument list, and the outputs are ordered differently. The replacement pattern is:

```
[azimuthangle, elevationangle, slantrange] = geodetic2aer(lat2, lon2, alt2,  
lat1, lon1, alt1, spheroid, ...)
```

Unlike `elevation`, `geodetic2aer` requires a `spheroid` input, and it must be an `oblateSpheroid`, `referenceEllipsoid`, or `referenceSphere` object, not a 2-by-1 ellipsoid vector.

You can use the following steps to convert an ellipsoid vector, `ellipsoid`, to an `oblateSpheroid` object, `spheroid`:

- `spheroid = oblateSpheroid;`
- `spheroid.SemimajorAxis = ellipsoid(1);`
- `spheroid.Eccentricity = ellipsoid(2);`

When `elevation` is called with only 6 inputs, the GRS 80 reference ellipsoid, in meters, is used by default. To replace this usage, use `referenceEllipsoid('GRS80', 'meters')` as the `spheroid` input for `geodetic2aer`.

If an `angleunits` input is included, it must follow the `spheroid` input in the call to `geodetic2aer`, rather than preceding it.

You can specify the `lengthunits` parameter when calling `elevation`, but `geodetic2aer` has no such input. Instead, set the `LengthUnit` property of the input `spheroid` to the desired value. In this case a `referenceEllipsoid` or `referenceSphere` object must be used (not an `oblateSpheroid` object).

R2022a: Warns

Warns starting in R2022a

The `elevation` function issues a warning that it will be removed in a future release.

R2012b: To be removed

Not recommended starting in R2012b

The `elevation` function runs without warning but will be removed in a future release.

See Also

`geodetic2aer`

ellipse1

Geographic ellipse from center, semimajor axis, eccentricity, and azimuth

Syntax

```
[lat,lon] = ellipse1(lat0,lon0,ellipse)
[lat,lon] = ellipse1(lat0,lon0,ellipse,offset)
[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az)
[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,ellipsoid)
[lat,lon] = ellipse1( ____,units)
[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,ellipsoid,units,npts)
[lat,lon] = ellipse1(method, ____)
mat = ellipse1( ____)
```

Description

`[lat,lon] = ellipse1(lat0,lon0,ellipse)` finds the latitude and longitude coordinates of an ellipse. Specify the geographic coordinates of the center of the ellipse using `lat0` and `lon0`. Specify the semimajor axis and the eccentricity of the ellipse using `ellipse`. This syntax assumes that the semimajor axis is a spherical distance in degrees. This syntax orients the ellipse so that the semimajor axis goes from north to south.

`[lat,lon] = ellipse1(lat0,lon0,ellipse,offset)` rotates the ellipse using the azimuth `offset`.

`[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az)` finds coordinates for the section of the ellipse specified by `az`.

`[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,ellipsoid)` specifies the reference ellipsoid `ellipsoid` to use for the coordinates. This syntax assumes that the semimajor axis of `ellipse` is a linear measurement in the same units as the semimajor axis of `ellipsoid`.

`[lat,lon] = ellipse1(____,units)` specifies the angle units `units` of the inputs and outputs. You can use this syntax with any of the previous syntaxes, except `ellipse1(lat0,lon0,ellipse)`.

`[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,ellipsoid,units,npts)` specifies the number of points `npts` to include in the ellipse.

`[lat,lon] = ellipse1(method, ____,)`, where `method` is "rh", specifies that distances from the center of the small circle are rhumb line distances. The default for `method` is "gc", which specifies that distances from the center of the small circle are great circle distances (for a sphere) or geodesic distances (for an ellipsoid).

`mat = ellipse1(____,)` returns the latitude and longitude coordinates of the ellipse in the matrix `mat`.

Examples

Find Coordinates of Ellipse

Find the latitude and longitude coordinates of an ellipse centered on Ottawa with a semimajor axis of 4° and a semiminor axis of 2° . Find the eccentricity of the ellipse by using the `axes2ecc` function.

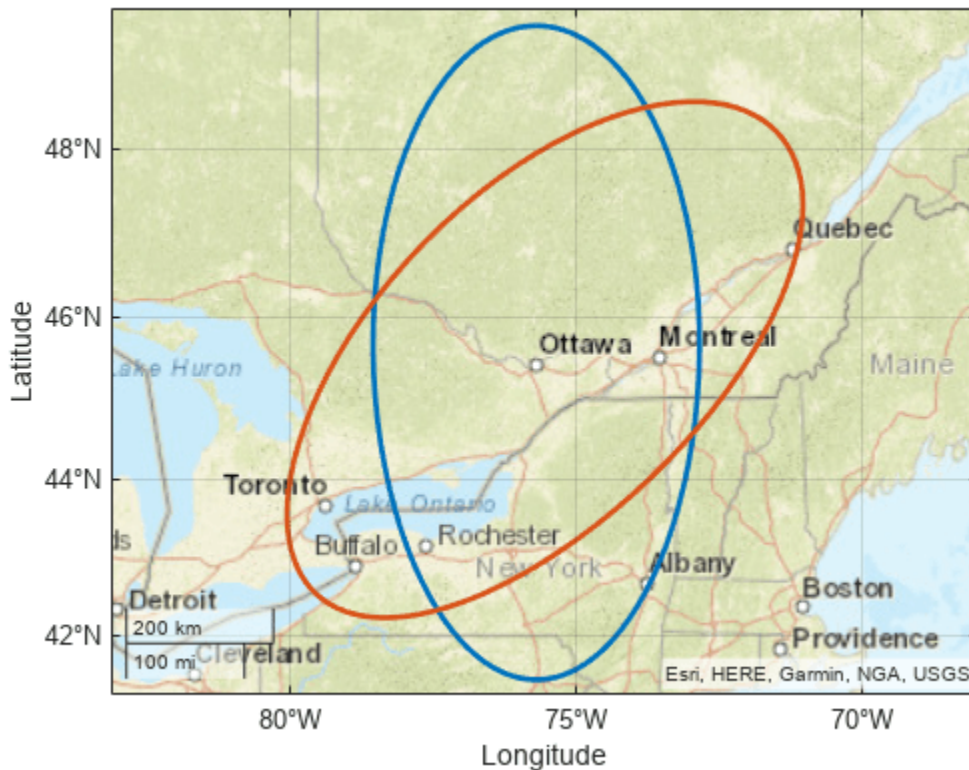
```
lat0 = 45.4215;
lon0 = -75.6972;
semimajor = 4;
ecc = axes2ecc(semimajor,2);
[lat1,lon1] = ellipse1(lat0,lon0,[semimajor ecc]);
```

Find the latitude coordinates of the same ellipse, this time with the semimajor axis rotated 45° from north.

```
[lat2,lon2] = ellipse1(lat0,lon0,[semimajor ecc],45);
```

Plot both ellipses on a map using thick lines.

```
geoplot(lat1,lon1,"LineWidth",2)
hold on
geoplot(lat2,lon2,"LineWidth",2)
geobasemap streets
```



Find Coordinates of Partial Ellipse

Find the latitude and longitude coordinates of a full ellipse centered on Tokyo with a semimajor axis of 5° and a semiminor axis of 2° . Find the eccentricity of the ellipse by using the `axes2ecc` function.

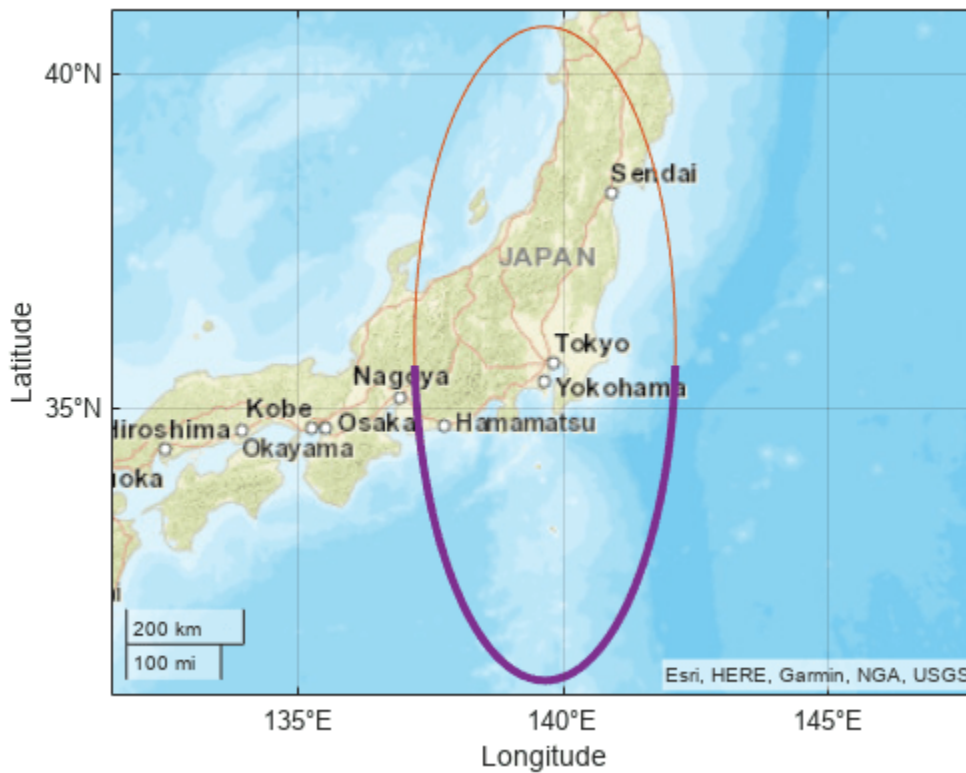
```
lat0 = 35.6762;
lon0 = 139.6503;
semimajor = 5;
ecc = axes2ecc(semimajor,2);
[lat1,lon1] = ellipse1(lat0,lon0,[semimajor ecc]);
```

Find the coordinates of a partial ellipse, in this case the section of the ellipse between 90° from north and 270° from north. Avoid rotating the ellipse by specifying the fourth argument as `[]`.

```
az = [90 270];
[lat2,lon2] = ellipse1(lat0,lon0,[semimajor ecc],[],az);
```

Display both the full ellipse and the partial ellipse on a map. Use a thick line for the partial ellipse.

```
geoplot(lat1,lon1,"Color",[0.8500 0.3250 0.0980])
hold on
geoplot(lat2,lon2,"Color",[0.4940 0.1840 0.5560],"LineWidth",3)
geobasemap streets
```



Find Coordinates of Ellipse on Reference Ellipsoid

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of kilometers.

```
wgs84 = wgs84Ellipsoid("km");
```

Find the latitude and longitude coordinates of an ellipse centered on Boston with a semimajor axis of 100 kilometers and a semiminor axis of 50 kilometers. Avoid rotating the ellipse and find the coordinates of the full ellipse by specifying the fourth and fifth arguments as []. Find the eccentricity of the ellipse by using the axes2ecc function.

```
lat0 = 42.3601;
lon0 = -71.0589;
semimajor = 100;
ecc = axes2ecc(100,50);
[lat,lon] = ellipse1(lat0,lon0,[semimajor ecc],[],[],wgs84);
```

Plot the ellipse on a map using a thick black line.

```
geoplot(lat,lon,"k","LineWidth",2)
geobasemap streets
```



Find Coordinates of Multiple Ellipses

You can use the `ellipse1` function to find the coordinates of multiple ellipses with the same center or with different centers.

Multiple Ellipses with Same Center

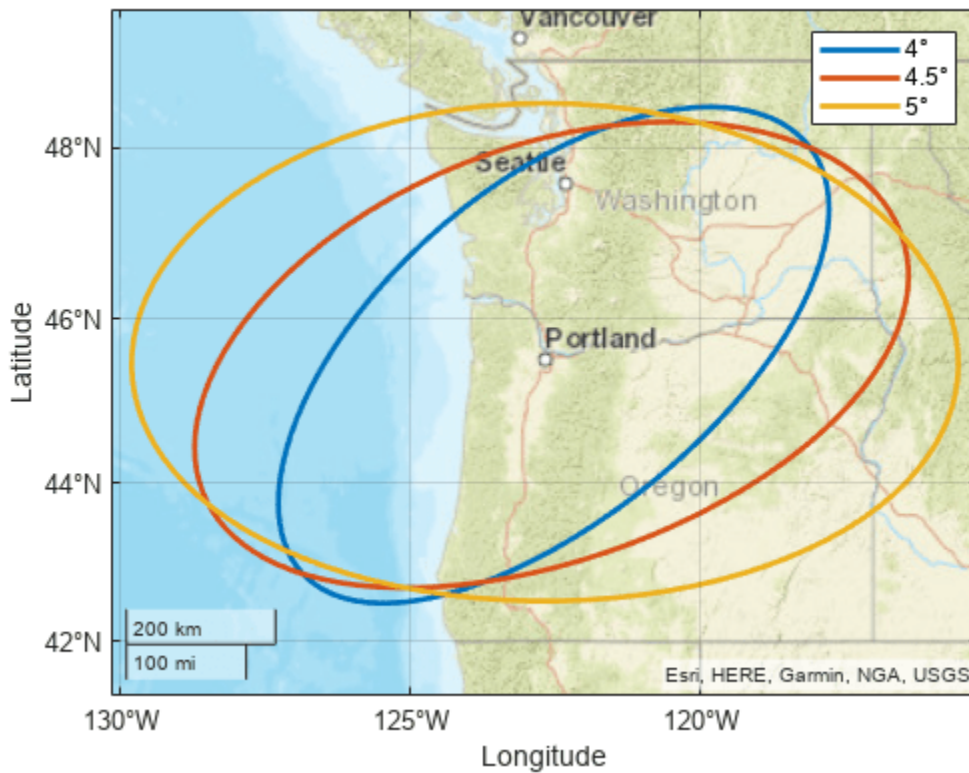
Find the coordinates of three ellipses centered on Portland, Oregon.

- The first ellipse has a semimajor axis of 4° and a semiminor axis of 2° . Rotate the semimajor axis 50° from north.
- The second ellipse has a semimajor axis of 4.5° and a semiminor axis of 2.5° . Rotate the semimajor axis 70° from north.
- The third ellipse has a semimajor axis of 5° and a semiminor axis of 3° . Rotate the semimajor axis 90° from north.

```
lat0 = 45.5152;
lon0 = -122.6784;
semimajor = [4 4.5 5];
ecc = axes2ecc(semimajor,[2 2.5 3]);
[lat,lon] = ellipse1(lat0,lon0,[semimajor' ecc'],[50 70 90]');
```

Display the ellipses on a map using thick lines. Differentiate the ellipses by including the semimajor axes in a legend.

```
geobasemap streets
hold on
for i=1:size(lat,2)
    geoplot(lat(:,i),lon(:,i),"LineWidth",2,"DisplayName",string(semimajor(i))+char(176))
end
legend
```



Multiple Ellipses with Different Centers

Find the coordinates of three ellipses with different centers.

- Center the first ellipse on Boston. Specify the semimajor axis as 4° and the semiminor axis as 2° . Rotate the semimajor axis 50° from north.
- Center the second ellipse on New York City. Specify the semimajor axis as 4.5° and the semiminor axis as 2.5° . Rotate the semimajor axis 120° from north.
- Center the third ellipse on Chicago. Specify the semimajor axis as 5° and the semiminor axis as 3° . Rotate the semimajor axis 90° from north.

```
lat0 = [42.3601 40.7128 41.8781]';
lon0 = [-71.0589 -74.0060 -87.6298]';
cities = ["Boston" "New York City" "Chicago"];
semimajor = [4 4.5 5];
ecc = axes2ecc(semimajor,[2 2.5 3]);
[lat,lon] = ellipse1(lat0,lon0,[semimajor' ecc'],[50 120 90]');
```

Display the ellipses on a map using thick lines. Differentiate the ellipses by including the city names in a legend.

```
figure
geobasemap streets
hold on
for i=1:size(lat,2)
    geoplot(lat(:,i),lon(:,i),"LineWidth",2,"DisplayName",cities(i))
```


end
legend



Input Arguments

lat0 — Latitude of center of ellipse

scalar | column vector

Latitude of the center of the ellipse, specified as a scalar or a column vector.

- To find the coordinates of multiple ellipses with the same center, specify `lat0` and `lon0` as scalars and specify `ellipse` as a two-column matrix. The number of rows in the matrix is the number of ellipses.
- To find the coordinates of multiple ellipses with different centers, specify `lat0` and `lon0` as column vectors and specify `ellipse` as a two-column matrix. The number of elements in `lat0` and `lon0` must match the number of rows in `ellipse`.

The sizes of `lat0` and `lon0` must match.

Data Types: double

lon0 — Longitude of center of ellipse

scalar | column vector

Longitude of the center of the ellipse, specified as a scalar or a column vector.

- To find the coordinates of multiple ellipses with the same center, specify `lat0` and `lon0` as scalars and specify `ellipse` as a two-column matrix. The number of rows in the matrix is the number of ellipses.
- To find the coordinates of multiple ellipses with different centers, specify `lat0` and `lon0` as column vectors and specify `ellipse` as a two-column matrix. The number of elements in `lat0` and `lon0` must match the number of rows in `ellipse`.

The sizes of `lat0` and `lon0` must match.

Data Types: `single` | `double`

ellipse — Ellipse

two-column matrix

Ellipse, specified as a two-column matrix. Each row of the matrix defines an ellipse and has the form `[semimajor_axis eccentricity]`, where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity.

When `lat0` and `lon0` are column vectors, the number of rows in `ellipse` must match the number of elements in `lat0` and `lon0`.

Data Types: `single` | `double`

offset — Azimuth offset of semimajor axis

`[]` (default) | scalar | column vector

Azimuth offset of the semimajor axis, specified as a scalar or a column vector. Azimuths are measured clockwise from north. The default value of `[]` indicates that the semimajor axis goes from north to south.

Unless `offset` is `[]`, the size of `offset` must match the number of ellipses.

Data Types: `single` | `double`

az — Azimuth indicating section of ellipse to find

`[]` (default) | column vector | two-column matrix

Azimuth indicating the section of the ellipse to find, specified as one of these options:

- A column vector — Find coordinates of the ellipse from north to the specified azimuth. Each element of `az` corresponds to a row of `ellipse`. The size of `az` must match the number of ellipses.
- A two-column matrix — Find coordinates of the ellipse between the azimuth in the first column and the azimuth in the second column. Each row of `az` corresponds to a row of `ellipse`. The number of rows in `az` must match the number of ellipses.

Azimuths are measured clockwise from north.

The default value of `[]` specifies a full ellipse.

Data Types: `single` | `double`

ellipsoid — Reference ellipsoid

`[1 0]` (default) | `referenceSphere` object | `referenceEllipsoid` object | `oblateSpheroid` object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element numeric vector of the form `[semimajor_axis eccentricity]`, where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of `[1 0]` represents the unit sphere.

units — Angle unit

`"degrees"` (default) | `"radians"`

Angle unit, specified as one of these options:

- `"degrees"` — Degrees
- `"radians"` — Radians

If you do not specify a reference ellipsoid, this argument determines the angle units for the coordinates, `offset`, `az`, and the semimajor axis of `ellipse`. If you specify a reference ellipsoid, this argument determines the angle units for only the coordinates, `offset`, and `az`.

Data Types: `char` | `string`

npts — Number of points

`100` (default) | `scalar`

Number of points to include in the ellipse, specified as a scalar. If you specify more than one ellipse, then the function finds `npts` points per ellipse.

Data Types: `single` | `double`

method — Type of distance from center of ellipse

`"gc"` (default) | `"rh"`

Type of distance from the center of the ellipse, specified as one of these options:

- `"gc"` — Use the great circle distance.
- `"rh"` — Use the rhumb line distance.

Data Types: `char` | `string`

Output Arguments

lat — Latitude coordinates of ellipse

`column vector` | `matrix`

Latitude coordinates of the ellipse, returned as a column vector with `npts` elements or a matrix of size `npts-by-m`, where `m` is the number of ellipses.

lon — Longitude coordinates of ellipse

`column vector` | `matrix`

Longitude coordinates of the ellipse, returned as a column vector with `npts` elements or a matrix of size `npts-by-m`, where `m` is the number of ellipses.

mat — Latitude and longitude coordinates of ellipse

`matrix`

Latitude and longitude coordinates of the ellipse, returned as a matrix equivalent to [lat lon].

Version History

Introduced before R2006a

See Also

Functions

axes2ecc | scircle1 | track1

encodem

Fill in regular data grid from seed values and locations

Syntax

```
newgrid = encodem(Z,seedmat)
newgrid = encodem(Z,seedmat,stopvals)
```

Description

`newgrid = encodem(Z,seedmat)` fills in regions of the input data grid, `Z`, with desired new values. The boundary consists of the edges of the matrix and any entries with the value 1. The *seeds*, or starting points, and the values associated with them, are specified by the three-column matrix `seedmat`, the rows of which have the form `[row column value]`.

`newgrid = encodem(Z,seedmat,stopvals)` allows you to specify a vector, `stopvals`, of stopping values. Any value that is an element of `stopvals` will act as a boundary.

This function *fills in* regions of data grids with desired values. If a *boundary* exists, the new value replaces all entries in all four directions until the boundary is reached. The boundary is made up of selected stopping values and the edges of the matrix. The new value tries to flood the region exhaustively, stopping only when no new spaces can be reached by moving up, down, left, or right without hitting a stopping value.

Examples

For this imaginary map, fill in the upper right region with 7s and the lower left region with 3s:

```
Z = eye(4)
```

```
Z =
     1     0     0     0
     0     1     0     0
     0     0     1     0
     0     0     0     1
```

```
newgrid = encodem(Z,[4,1,3; 1,4,7])
```

```
newgrid =
     1     7     7     7
     3     1     7     7
     3     3     1     7
     3     3     3     1
```

Version History

Introduced before R2006a

See Also
imbedm

enu2aer

Transform local east-north-up coordinates to local spherical

Syntax

```
[az,elev,slantRange] = enu2aer(xEast,yNorth,zUp)
[ ___ ] = enu2aer( ___ ,angleUnit)
```

Description

[az,elev,slantRange] = enu2aer(xEast,yNorth,zUp) transforms the local east-north-up (ENU) Cartesian coordinates specified by xEast, yNorth, and zUp to the local azimuth-elevation-range (AER) spherical coordinates specified by az, elev, and slantRange. Both coordinate systems use the same local origin. Each input argument must match the others in size or be scalar.

[___] = enu2aer(___ ,angleUnit) specifies the units for azimuth and elevation. Specify angleUnit as 'degrees' (the default) or 'radians'.

Examples

Calculate AER Coordinates from ENU Coordinates

Find the AER coordinates of a ground vehicle with respect to a parking gate, using the ENU coordinates of the vehicle with respect to the same gate.

First, specify the ENU coordinates of the vehicle. For this example, specify the coordinates in meters.

```
xEast = 8.4504;
yNorth = 12.4737;
zUp = 1.1046;
```

Then, calculate the AER coordinates of the vehicle. The azimuth and elevation are specified in degrees. The units for the slant range match the units specified by the ENU coordinates. Thus, the slant range is specified in meters.

```
[az,elev,slantRange] = enu2aer(xEast,yNorth,zUp)

az = 34.1160
elev = 4.1931
slantRange = 15.1070
```

Reverse the transformation using the aer2enu function.

```
[xEast,yNorth,zUp] = aer2enu(az,elev,slantRange)

xEast = 8.4504
yNorth = 12.4737
zUp = 1.1046
```

Input Arguments

xEast — ENU x-coordinates

scalar | vector | matrix | N-D array

ENU x-coordinates of one or more points in the local ENU system, specified as a scalar, vector, matrix, or N-D array.

Data Types: `single` | `double`

yNorth — ENU y-coordinates

scalar | vector | matrix | N-D array

ENU y-coordinates of one or more points in the local ENU system, specified as a scalar, vector, matrix, or N-D array.

Data Types: `single` | `double`

zUp — ENU z-coordinates

scalar value | vector | matrix | N-D array

ENU z-coordinates of one or more points in the local ENU system, specified as a scalar, vector, matrix, or N-D array.

Data Types: `single` | `double`

angleUnit — Angle units

'degrees' (default) | 'radians'

Angle units, specified as 'degrees' (the default) or 'radians'.

Output Arguments

az — Azimuth angles

scalar | vector | matrix | N-D array

Azimuth angles of one or more points in the local AER system, returned as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Values are specified in degrees within the half-open interval [0 360). To use values in radians, specify the `angleUnit` argument as 'radians'.

elev — Elevation angles

scalar | vector | matrix | N-D array

Elevation angles of one or more points in the local AER system, returned as a scalar, vector, matrix, or N-D array. Elevations are calculated with respect to the `xEast-yNorth` plane that contains the local origin. If the local origin is on the surface of the spheroid, then the `xEast-yNorth` plane is tangent to the spheroid.

Values are specified in degrees within the closed interval [-90 90]. Positive elevations correspond to positive `zUp` values, and negative elevations correspond to negative `zUp` values. An elevation of 0 indicates that the point lies in the `xEast-yNorth` plane. To use values in radians, specify the `angleUnit` argument as 'radians'.

sLantRange — Distances from local origin

scalar | vector | matrix | N-D array

Distances from the local origin, returned as a scalar, vector, matrix, or N-D array. Each distance is calculated along a straight, 3-D, Cartesian line. Values are returned in the units specified by `xEast`, `yNorth`, and `zUp`.

Version History**Introduced in R2012b****R2021a: Generate C and C++ code using MATLAB Coder**

The `enu2aer` function supports code generation.

Extended Capabilities**C/C++ Code Generation**

Generate C and C++ code using MATLAB® Coder™.

See Also

`aer2enu` | `ned2aer` | `enu2ecef` | `enu2geodetic`

Topics

“Comparison of 3-D Coordinate Systems”

enu2ecef

Transform local east-north-up coordinates to geocentric Earth-centered Earth-fixed

Syntax

```
[X,Y,Z] = enu2ecef(xEast,yNorth,zUp,lat0,lon0,h0,spheroid)
[ ___ ] = enu2ecef( ___ ,angleUnit)
```

Description

`[X,Y,Z] = enu2ecef(xEast,yNorth,zUp,lat0,lon0,h0,spheroid)` transforms the local east-north-up (ENU) Cartesian coordinates specified by `xEast`, `yNorth`, and `zUp` to the geocentric Earth-centered Earth-fixed (ECEF) Cartesian coordinates specified by `X`, `Y`, and `Z`. Specify the origin of the local ENU system with the geodetic coordinates `lat0`, `lon0`, and `h0`. Each coordinate input argument must match the others in size or be scalar. Specify `spheroid` as the reference spheroid for the geodetic coordinates.

`[___] = enu2ecef(___ ,angleUnit)` specifies the units for latitude and longitude. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate ECEF Coordinates from ENU Coordinates

Find the ECEF coordinates of orbital debris, using the ENU coordinates of the debris relative to the geodetic coordinates of a satellite.

First, specify the reference spheroid as WGS84 with length units measured in kilometers. For more information about WGS84, see “Comparison of Reference Spheroids”. The units for the ellipsoidal height, ENU coordinates, and ECEF coordinates must match the units specified by the `LengthUnit` property of the reference spheroid.

```
wgs84 = wgs84Ellipsoid('kilometer');
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is the satellite. Specify `h0` as ellipsoidal height in kilometers.

```
lat0 = 45.9132;
lon0 = 36.7484;
h0 = 1877.7532;
```

Specify the ENU coordinates of the point of interest. In this example, the point of interest is the orbital debris.

```
xEast = 355.6013;
yNorth = -923.0832;
zUp = 1041.0164;
```

Then, calculate the ECEF coordinates of the debris. In this example, the results display in scientific notation.

```
[x,y,z] = enu2ecef(xEast,yNorth,zUp,lat0,lon0,h0,wgs84)
```

```
x = 5.5075e+03
```

```
y = 4.5562e+03
```

```
z = 6.0128e+03
```

Reverse the transformation using the `ecef2enu` function. In this example, `zUp` displays in scientific notation.

```
[xEast,yNorth,zUp] = ecef2enu(x,y,z,lat0,lon0,h0,wgs84)
```

```
xEast = 355.6013
```

```
yNorth = -923.0832
```

```
zUp = 1.0410e+03
```

Input Arguments

xEast — ENU x-coordinates

scalar | vector | matrix | N-D array

ENU *x*-coordinates of one or more points in the local ENU system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Data Types: `single` | `double`

yNorth — ENU y-coordinates

scalar | vector | matrix | N-D array

ENU *y*-coordinates of one or more points in the local ENU system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Data Types: `single` | `double`

zUp — ENU z-coordinates

scalar | vector | matrix | N-D array

ENU *z*-coordinates of one or more points in the local ENU system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Data Types: `single` | `double`

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

`scalar` | `vector` | `matrix` | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h0 — Ellipsoidal height of local origin

`scalar` | `vector` | `matrix` | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

X — ECEF x-coordinates

`scalar` | `vector` | `matrix` | N-D array

ECEF x-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Y — ECEF y-coordinates

`scalar` | `vector` | `matrix` | N-D array

ECEF y-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid`

argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Z — ECEF z-coordinates

scalar | vector | matrix | N-D array

ECEF *z*-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Tips

To transform vectors instead of coordinate locations, use the `enu2ecefv` function.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `enu2ecef` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`ned2ecef` | `aer2ecef` | `ecef2enu` | `enu2geodetic`

Topics

“Comparison of 3-D Coordinate Systems”

enu2ecefv

Rotate local east-north-up vector to geocentric Earth-centered Earth-fixed

Syntax

```
[U,V,W] = enu2ecefv(uEast,vNorth,wUp,lat0,lon0)
[ ___ ] = enu2ecefv( ___,angleUnit)
```

Description

`[U,V,W] = enu2ecefv(uEast,vNorth,wUp,lat0,lon0)` returns vector components `U`, `V`, and `W` in a geocentric Earth-centered Earth-fixed (ECEF) system corresponding to vector components `uEast`, `vNorth`, and `wUp` in a local east-north-up (ENU) system. Specify the origin of the system with the geodetic coordinates `lat0` and `lon0`. Each coordinate input argument must match the others in size or be scalar.

`[___] = enu2ecefv(___,angleUnit)` specifies the units for latitude and longitude. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate ECEF Vector Components from ENU Components

Find the ECEF velocity components of a ground vehicle using its ENU velocity components.

Specify the geodetic coordinates of the vehicle in degrees and the ENU velocity components in kilometers per hour.

```
lat0 = 17.41;
lon0 = 78.27;
```

```
uEast = -27.6190;
vNorth = -16.4298;
wUp = -0.3186;
```

Calculate the ECEF components of the vehicle. The units for the ECEF components match the units for the ENU components. Thus, the ECEF components are returned in kilometers per hour. The rotation performed by `enu2ecefv` does not affect the speed of the vehicle.

```
[U,V,W] = enu2ecefv(uEast,vNorth,wUp,lat0,lon0)
```

```
U = 27.9798
```

```
V = -1.0993
```

```
W = -15.7724
```

Reverse the rotation using the `ecef2enuv` function.

```
[uEast,vNorth,wUp] = ecef2enuv(U,V,W,lat0,lon0)
```

uEast = -27.6190

vNorth = -16.4298

wUp = -0.3186

Input Arguments

uEast — ENU x-components

scalar value | vector | matrix | N-D array

ENU x-components of one or more vectors, specified as a scalar value, vector, matrix, or N-D array.

Data Types: single | double

vNorth — ENU y-components

scalar value | vector | matrix | N-D array

ENU y-components of one or more vectors, specified as a scalar value, vector, matrix, or N-D array.

Data Types: single | double

wUp — ENU z-components

scalar value | vector | matrix | N-D array

ENU z-components of one or more vectors, specified as a scalar value, vector, matrix, or N-D array.

Data Types: single | double

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as 'radians'.

Data Types: single | double

lon0 — Geodetic longitude of local origin

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as 'radians'.

Data Types: single | double

angleUnit — Angle units

'degrees' (default) | 'radians'

Angle units, specified as 'degrees' (the default) or 'radians'.

Output Arguments

U — ECEF x-components

scalar value | vector | matrix | N-D array

ECEF x-components of one or more vectors, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by `uEast`, `vNorth`, and `wUp`.

V — ECEF y-components

scalar value | vector | matrix | N-D array

ECEF y-components of one or more vectors, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by `uEast`, `vNorth`, and `wUp`.

W — ECEF z-components

scalar value | vector | matrix | N-D array

ECEF z-components of one or more vectors, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by `uEast`, `vNorth`, and `wUp`.

Tips

To transform coordinate locations instead of vectors, use the `enu2ecef` function.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `enu2ecefv` function supports code generation.

Extended Capabilities**C/C++ Code Generation**

Generate C and C++ code using MATLAB® Coder™.

See Also

`ned2ecefv` | `ecef2enuv` | `ecef2nedv`

Topics

“Vectors in 3-D Coordinate Systems”

enu2geodetic

Transform local east-north-up coordinates to geodetic

Syntax

```
[lat,lon,h] = enu2geodetic(xEast,yNorth,zUp,lat0,lon0,h0,spheroid)
[ ___ ] = enu2geodetic( ___,angleUnit)
```

Description

`[lat,lon,h] = enu2geodetic(xEast,yNorth,zUp,lat0,lon0,h0,spheroid)` transforms the local east-north-up (ENU) Cartesian coordinates specified by `xEast`, `yNorth`, and `zUp` to the geodetic coordinates specified by `lat`, `lon`, and `h`. Specify the origin of the local ENU system with the geodetic coordinates `lat0`, `lon0`, and `h0`. Each coordinate input argument must match the others in size or be scalar. Specify `spheroid` as the reference spheroid for the geodetic coordinates.

`[___] = enu2geodetic(___,angleUnit)` specifies the units for latitude and longitude. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate Geodetic Coordinates from ENU Coordinates

Find the geodetic coordinates of the Matterhorn, using the ENU coordinates of the Matterhorn with respect to the geodetic coordinates of Zermatt, Switzerland.

First, specify the reference spheroid as WGS84. For more information about WGS84, see "Comparison of Reference Spheroids". The units for ellipsoidal height and ENU coordinates must match the units specified by the `LengthUnit` property of the reference spheroid. The default length unit for the reference spheroid created by `wgs84Ellipsoid` is 'meter'.

```
wgs84 = wgs84Ellipsoid;
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is Zermatt. Specify `h0` as ellipsoidal height in meters.

```
lat0 = 46.017;
lon0 = 7.750;
h0 = 1673;
```

Specify the ENU coordinates of the point of interest. In this example, the point of interest is the Matterhorn.

```
xEast = -7134.8;
yNorth = -4556.3;
zUp = 2852.4;
```

Then, calculate the geodetic coordinates of the Matterhorn. The result `h` is the ellipsoidal height of the mountain in meters. To view the results in standard notation, specify the display format as `shortG`.

```
format shortG
[lat,lon,h] = enu2geodetic(xEast,yNorth,zUp,lat0,lon0,h0,wgs84)

lat =
    45.976

lon =
    7.658

h =
    4531
```

Reverse the transformation using the `geodetic2enu` function.

```
[xEast,yNorth,zUp] = geodetic2enu(lat,lon,h,lat0,lon0,h0,wgs84)

xEast =
   -7134.8

yNorth =
   -4556.3

zUp =
    2852.4
```

Input Arguments

xEast — ENU x-coordinates

scalar | vector | matrix | N-D array

ENU x-coordinates of one or more points in the local ENU system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: `single` | `double`

yNorth — ENU y-coordinates

scalar | vector | matrix | N-D array

ENU y-coordinates of one or more points in the local ENU system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: `single` | `double`

zUp — ENU z-coordinates

scalar | vector | matrix | N-D array

ENU z-coordinates of one or more points in the local ENU system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid`

argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Data Types: `single` | `double`

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h0 — Ellipsoidal height of local origin

scalar | vector | matrix | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term `reference spheroid` is used synonymously with `reference ellipsoid`. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

lat — Geodetic latitude

scalar | vector | matrix | N-D array

Geodetic latitude of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in degrees within the interval $[-90\ 90]$. To use values in radians, specify the `angleUnit` argument as `'radians'`.

lon — Geodetic longitude

scalar | vector | matrix | N-D array

Geodetic longitude of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in degrees within the interval $[-180\ 180]$. To use values in radians, specify the `angleUnit` argument as `'radians'`.

h — Ellipsoidal height

scalar | vector | matrix | N-D array

Ellipsoidal height of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `enu2geodetic` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`aer2geodetic` | `enu2ecef` | `geodetic2enu` | `ned2geodetic`

Topics

“Comparison of 3-D Coordinate Systems”

epsm

(Removed) Accuracy in angle units for certain map computations

Note The epsm function has been removed. For information about updating your code, see “Compatibility Considerations”.

Syntax

```
epsm
epsm(units)
```

Description

epsm is the limit of map angular precision. It is useful in avoiding trigonometric singularities, among other things.

epsm(units) returns the same angle in units corresponding to any valid angle units character vector. The default is 'degrees'.

Examples

The value of epsm is 10⁻⁶ degrees. To put this in perspective, in terms of an angular arc length, the distance is

```
epsmkm = deg2km(epsm)

epsmkm =
    1.1119e-04    % kilometers
```

This is about 11 centimeters, a very small distance on a global scale.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The epsm function has been removed. To update your code, use these replacement patterns.

To Be Removed	Recommended
epsm()	1.0E-6
epsm('deg')	1.0E-6
epsm('rad')	deg2rad(1.0E-6)

R2022a: Warns

Warns starting in R2022a

The `epsm` function issues a warning that it will be removed in a future release.

R2013a: To be removed

Not recommended starting in R2013a

The `epsm` function runs without warning but will be removed in a future release.

See Also

`round`

eqa2grn

Convert from equal area to Greenwich coordinates

Syntax

```
[lat,lon] = eqa2grn(x,y)
[lat,lon] = eqa2grn(x,y,origin)
[lat,lon] = eqa2grn(x,y,origin,ellipsoid)
[lat,lon] = eqa2grn(x,y,origin,units)
mat = eqa2grn(x,y,origin...)
```

Description

`[lat,lon] = eqa2grn(x,y)` converts the equal-area coordinate points `x` and `y` to the Greenwich (standard geographic) coordinates `lat` and `lon`.

`[lat,lon] = eqa2grn(x,y,origin)` specifies the location in the Greenwich system of the `x-y` origin (0,0). The two-element vector `origin` must be of the form `[latitude longitude]`. The default places the origin at the Greenwich coordinates (0°,0°).

`[lat,lon] = eqa2grn(x,y,origin,ellipsoid)` specifies the ellipsoidal model of the figure of the Earth using `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The `ellipsoid` is a unit sphere by default.

`[lat,lon] = eqa2grn(x,y,origin,units)` specifies the units for the outputs, where `units` is any valid angle units value. The default value is `'degrees'`.

`mat = eqa2grn(x,y,origin...)` packs the outputs into a single variable.

This function converts data from equal-area `x-y` coordinates to geographic (latitude-longitude) coordinates. The opposite conversion can be performed with `grn2eqa`.

Examples

```
[lat,lon] = eqa2grn(.5,.5)
```

```
lat =
    30.0000
lon =
    28.6479
```

Version History

Introduced before R2006a

See Also

`grn2eqa` | `hista`

etopo

(To be removed) Read gridded global relief data (ETOPO products)

Note `etopo` will be removed in a future release. Use `readgeoraster` instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z, refvec] = etopo
[Z, refvec] = etopo(samplefactor)
[Z, refvec] = etopo(samplefactor, latlim, lonlim)
[Z, refvec] = etopo(folder, ...)
[Z, refvec] = etopo(filename, ...)
[Z, refvec] = etopo({'etopo5.northern.bat', 'etopo5.southern.bat'}, ...)
```

Description

`[Z, refvec] = etopo` reads the ETOPO data for the entire world from the ETOPO data in the current folder. The `etopo` function searches the current folder first for ETOPO1c binary data, then ETOPO2V2c binary data, then ETOPO2 (2001) binary data, then ETOPO5 binary data, and finally ETOPO5 ASCII data. Once the function finds a case-insensitive file name match, it reads the data. See “Tips” on page 1-428 for a list of possible file names. The `etopo` function returns the data grid, `Z`, as an array of elevations. Data values, in whole meters, represent the elevation of the center of each cell. `refvec`, the associated three-element referencing vector, geolocates `Z`.

`[Z, refvec] = etopo(samplefactor)` reads the data for the entire world, downsampling the data by `samplefactor`. The scalar integer `samplefactor` when equal to 1 gives the data at its full resolution (10800 by 21600 values for ETOPO1 data, 5400 by 10800 values for ETOPO2 data, and 2160 by 4320 values for ETOPO5 data). When `samplefactor` is an integer n greater than one, the `etopo` function returns every n^{th} point. If you omit `samplefactor` or leave it empty, it defaults to 1. (If the `etopo` function reads an older, ASCII ETOPO5 data set, then `samplefactor` must divide evenly into the number of rows and columns of the data file.)

`[Z, refvec] = etopo(samplefactor, latlim, lonlim)` reads the data for the part of the world within the specified latitude and longitude limits. Specify the limits of the desired data as two-element vectors of latitude, `latlim`, and longitude, `lonlim`, in degrees. Specify the elements of `latlim` and `lonlim` in ascending order. Specify `lonlim` in the range `[0 360]` for ETOPO5 data and `[-180 180]` for ETOPO2 and ETOPO1 data. If `latlim` is empty, the latitude limits are `[-90 90]`. If `lonlim` is empty, the file type determines the longitude limits.

`[Z, refvec] = etopo(folder, ...)` allows you to use the variable `folder` to specify the path for the ETOPO data file. Otherwise, the `etopo` function searches the current folder for the data.

`[Z, refvec] = etopo(filename, ...)` reads the ETOPO data from the file specified by the case-insensitive string scalar or character vector `filename`. The name of the ETOPO file is as

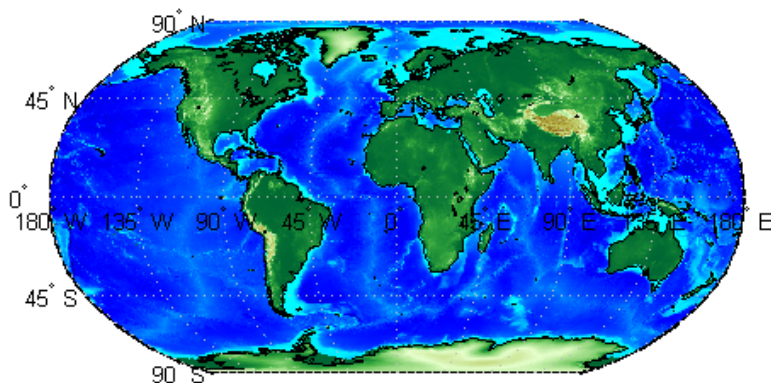
referenced in the ETOPO data file names table. Include the folder name in `filename` or place the file in the current folder or in a folder on the MATLAB path.

`[Z, refvec] = etopo({'etopo5.northern.bat', 'etopo5.southern.bat'}, ...)` reads the ETOPO data from the specified case-insensitive ETOPO5 ASCII data files. Place the files in the current folder or in a folder on the MATLAB path.

Examples

Read and display ETOPO2V2c data from the file 'ETOP02V2c_i2_LSB.bin' downsampled to half-degree cell size and display the boundary of the land areas.

```
samplefactor = 15;
[Z, refvec] = etopo('ETOP02V2c_i2_LSB.bin', samplefactor);
figure
worldmap world
geoshow(Z, refvec, 'DisplayType', 'texturemap');
demcmap(Z, 256);
geoshow('landareas.shp', 'FaceColor', 'none', ...
        'EdgeColor', 'black');
```



More About

ETOPO Models

According to the National Geophysical Data Center (NGDC) Web site, ETOPO models combine regional and global land topography and ocean bathymetry data from many data sources. ETOPO1, the most recent model, has an Ice Surface version showing the top of the Antarctic and Greenland ice sheets and a Bedrock version showing the bedrock below the ice sheets. For detailed information about the data sources used to create the ETOPO1 model, see the NGDC Web site. NGDC lists the ETOPO2 and ETOPO5 models as deprecated but still available.

Model	Cell Size	Date Available
ETOPO1	1-arc-minute	March 2009
ETOPO2v2	2-minute	2006

Model	Cell Size	Date Available
ETOPO2	2-minute	2001
ETOPO5	5-minute	1988

Tips

The `etopo` function supports these ETOPO data files.

Format	File Names
ETOPO1c (cell)	<ul style="list-style-type: none"> • <code>etopo1_ice_c.flt</code> • <code>etopo1_bed_c.flt</code> • <code>etopo1_ice_c_f4.flt</code> • <code>etopo1_bed_c_f4.flt</code> • <code>etopo1_ice_c_i2.bin</code> • <code>etopo1_bed_c_i2.bin</code>
ETOPO2V2c (cell)	<ul style="list-style-type: none"> • <code>ETOP02V2c_i2_MSB.bin</code> • <code>ETOP02V2c_i2_LSB.bin</code> • <code>ETOP02V2c_f4_MSB.flt</code> • <code>ETOP02V2c_f4_LSB.flt</code> • <code>ETOP02V2c.hdf</code>
ETOPO2 (2001)	<ul style="list-style-type: none"> • <code>ETOP02.dos.bin</code> • <code>ETOP02.raw.bin</code>
ETOPO5 (binary)	<ul style="list-style-type: none"> • <code>ETOP05.DOS</code> • <code>ETOP05.DAT</code>
ETOPO5 (ASCII)	<ul style="list-style-type: none"> • <code>etopo5.northern.bat</code> • <code>etopo5.southern.bat</code>

Version History

Introduced before R2006a

R2021b: Warns

Warns starting in R2021b

Support for reading most ETOPO data files will be removed in a future release. In addition, raster reading functions that return referencing vectors issue a warning that they will be removed in a future release, including `etopo`. Instead, use a supported data file and return a raster reference object using `readgeoraster`.

Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see `GeographicCellsReference` and `GeographicPostingsReference`.

- You can manipulate the limits of rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` function.
- Most functions that accept referencing vectors as input also accept reference objects.

You can find supported ETOPO data files on the ETOPO1 Global Relief Model website. The `readgeoraster` function does not support netCDF data files. Depending on which version of the ETOPO file you want to use, there are different ways to update your code.

- Older ETOPO data files contain cell-referenced data. To continue using cell-referenced data, download the cells-referenced GeoTIFF file and use these replacement patterns. This option is useful when you want to avoid updating your code that analyzes or displays the data.

Will Be Removed	Recommended
<code>[Z,refvec] = etopo(filename);</code>	<code>filename = "ETOPO1_Ice_c_geotiff.tif";</code> <code>[Z,R] = readgeoraster(filename, ...</code> <code> "CoordinateSystemType","geographic");</code>
<code>[Z,refvec] = etopo(filename,samplefactor);</code>	<code>filename = "ETOPO1_Ice_c_geotiff.tif";</code> <code>[Z,R] = readgeoraster(filename, ...</code> <code> "CoordinateSystemType","geographic");</code> <code>[Z,R] = georesize(Z,R,1/samplefactor);</code>
<code>[Z,refvec] = etopo(filename,samplefactor,latitude,lon);</code>	<code>filename = "ETOPO1_Ice_c_geotiff.tif";</code> <code>[Z,R] = readgeoraster(filename, ...</code> <code> "CoordinateSystemType","geographic");</code> <code>[Z,R] = geocrop(Z,R,latlim,lonlim);</code> <code>[Z,R] = georesize(Z,R,1/samplefactor);</code>

- Modern elevation models typically contain grid-referenced data (also known as postings-referenced data). To use grid-referenced data, download the grid-referenced GeoTIFF file and use these replacement patterns. This option can require you to update your code that analyzes or displays the data.

Will Be Removed	Recommended
<code>[Z,refvec] = etopo(filename);</code>	<code>filename = "ETOPO1_Ice_g_geotiff.tif";</code> <code>[Z,~] = readgeoraster(filename, ...</code> <code> "CoordinateSystemType","geographic");</code> <code>R = georefpostings([-90 90],[-180 180], ...</code> <code> size(Z),"ColumnsStartFrom","north");</code>
<code>[Z,refvec] = etopo(filename,samplefactor);</code>	<code>filename = "ETOPO1_Ice_g_geotiff.tif";</code> <code>[Z,~] = readgeoraster(filename, ...</code> <code> "CoordinateSystemType","geographic");</code> <code>R = georefpostings([-90 90],[-180 180], ...</code> <code> size(Z),"ColumnsStartFrom","north");</code> <code>[Z,R] = georesize(Z,R,1/samplefactor);</code>
<code>[Z,refvec] = etopo(filename,samplefactor,latitude,lon);</code>	<code>filename = "ETOPO1_Ice_g_geotiff.tif";</code> <code>[Z,~] = readgeoraster(filename, ...</code> <code> "CoordinateSystemType","geographic");</code> <code>R = georefpostings([-90 90],[-180 180], ...</code> <code> size(Z),"ColumnsStartFrom","north");</code> <code>[Z,R] = geocrop(Z,R,latlim,lonlim);</code> <code>[Z,R] = georesize(Z,R,1/samplefactor);</code>

Unlike `etopo`, the `readgeoraster` function does not support the ETOPO2 or ETOPO5 models. Instead, read the cell-referenced ETOPO1 model stored in the GeoTIFF format, and specify a geographic coordinate system type. For example, use `[Z,R] = readgeoraster(filename, 'CoordinateSystemType', 'geographic')`. To obtain the resolution of the ETOPO2 or ETOPO5 models, resize the full-resolution ETOPO1 model using the `georesize` function with a scale of 1/2 or 1/5, respectively.

The `readgeoraster` function returns data using the native data type embedded in the file. Return a different data type by specifying the `'OutputType'` name-value pair. For example, use `[Z,R] = readgeoraster(filename, 'OutputType', 'double')`.

The `readgeoraster` function does not automatically replace missing data with NaN values. Replace missing data with NaN values using the `standardizeMissing` function.

```
filename = "ETOP01_Ice_c_geotiff.tif";  
[Z,R] = readgeoraster(filename, "CoordinateSystemType", "geographic");  
info = georasterinfo(filename);  
m = info.MissingDataIndicator;  
Z = standardizeMissing(Z,m);
```

R2020a: To be removed

Not recommended starting in R2020a

The `etopo` function runs without warning but will be removed in a future release.

References

- [1] "2-minute Gridded Global Relief Data (ETOPO2v2)," U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Geophysical Data Center, 2006.
- [2] Amante, C. and B. W. Eakins, "ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis," *NOAA Technical Memorandum NESDIS NGDC-24*, March 2009.
- [3] "Digital Relief of the Surface of the Earth," *Data Announcement 88-MGG-02*, NOAA, National Geophysical Data Center, Boulder, Colorado, 1988.
- [4] "ETOPO2v2 Global Gridded 2-minute Database," National Geophysical Data Center, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce.

See Also

`readgeoraster` | `georasterinfo`

Topics

"Find Geospatial Raster Data"

extractfield

Field values from structure array

Syntax

```
a = extractfield(S,name)
```

Description

`a = extractfield(S,name)` returns the field values specified by the field name of structure `S`.

Examples

Extract Fields From Structure

Load a structure that contains information about roads in Concord, MA.

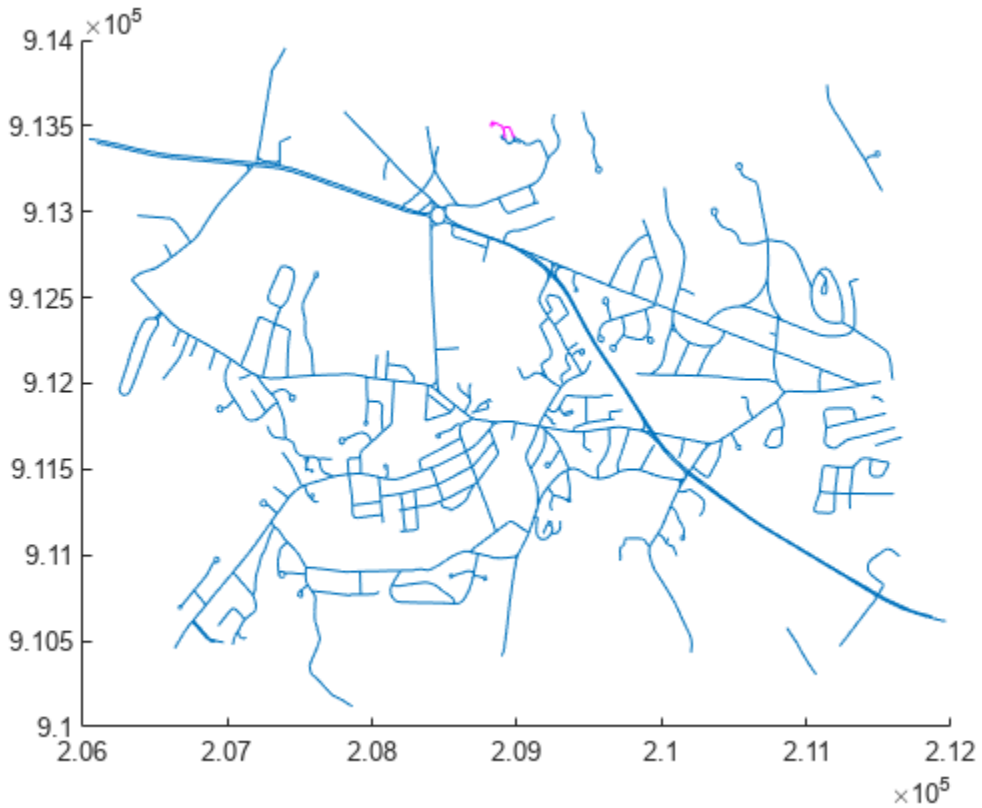
```
roads = shaperead('concord_roads.shp');  
r = roads(1:5)
```

r=5x1 struct array with fields:

```
Geometry  
BoundingBox  
X  
Y  
STREETNAME  
RT_NUMBER  
CLASS  
ADMIN_TYPE  
LENGTH
```

Get the x- and y-coordinates of the roads. Display the map, and highlight the first few elements using the color magenta.

```
hold on  
plot(extractfield(roads,'X'),extractfield(roads,'Y'));  
plot(extractfield(r,'X'),extractfield(r,'Y'),'m');
```



Extract the names of the roads, stored in the field `STREETNAME`. The field values are character vectors, so the result is returned in a cell array.

```
names = extractfield(r, 'STREETNAME')
```

```
names = 1x5 cell
      {0x0 char}  {'WRIGHT FARM'}  {'WRIGHT FARM'}  {'WRIGHT FARM'}  {'WRIGHT FARM'}
```

Extract the `X` field from the structure and examine the format of the returned values. All values have the same numeric data type (`double`), so the result is returned in a vector.

```
uniformType = extractfield(r, 'X')
```

```
uniformType = 1x42
10^5 x
      2.0884      2.0884      2.0884      2.0883      2.0883      2.0882      2.0882      2.0882      2.0882      2.0882
```

For illustrative purposes, change the `X` field value in one of the elements to have a different data type. This command converts the second element to data type `single`.

```
r(2).X = single(r(2).X);
```

Extract the `X` field values again. This time, the values have different data types, so the result is returned in a cell array.

```
mixedType = extractfield(r, 'X')
```

```
mixedType=1x5 cell array
```

```
{[2.0884e+05 2.0884e+05 2.0884e+05 2.0883e+05 2.0883e+05 2.0882e+05 2.0882e+05 2.0882e+05 2.
```

Input Arguments

S — Structure

structure

Structure, specified as a structure.

name — Field name

string scalar | character vector

Field name, specified as a case-sensitive string scalar or character vector.

Output Arguments

a — Extracted field values

1-by-*n* numeric vector | 1-by-*n* cell array

Extracted field values, returned as a 1-by-*n* numeric vector or cell array. *n* is the total number of elements in the field name of structure *S*, that is, $n = \text{numel}([S(:)].(\text{name}))$. *a* is a cell array if any field values in the field name contain a character vector or if the field values are not uniform in type; otherwise *a* is the same type as the field values. The shape of the input field is not preserved in *a*.

Version History

Introduced before R2006a

See Also

struct | shaperead

extractm

(Removed) Coordinate data from line or patch display structure

Note The `extractm` function has been removed. Use geospatial tables instead. For more information about geospatial tables, see “Create Geospatial Tables”.

Syntax

```
[lat,lon] = extractm(display_struct,object_str)
[lat,lon] = extractm(display_struct,object_strings)
[lat,lon] = extractm(display_struct,object_strings,searchmethod)
[lat,lon] = extractm(display_struct)
[lat,lon,indx] = extractm(...)
mat = extractm(...)
```

Description

`[lat,lon] = extractm(display_struct,object_str)` extracts latitude and longitude coordinates from those elements of `display_struct` having 'tag' fields that begin with the string scalar or character vector specified by `object_str`. `display_struct` is a Mapping Toolbox display structure in which the 'type' field has a value of either 'line' or 'patch'. The output `lat` and `lon` vectors include NaNs to separate the individual map features. The comparison of 'tag' values is not case-sensitive.

`[lat,lon] = extractm(display_struct,object_strings)` selects features with 'tag' fields matching any of several different string scalar or character vectors. `object_strings` is a string scalar, character vector, cell array of character vectors, or character array. `extractm` strips trailing spaces from features listed in character arrays before matching.

`[lat,lon] = extractm(display_struct,object_strings,searchmethod)` specifies the method used to match the values of the 'tag' field in `display_struct`. `searchmethod` can be one of these values:

'strmatch'	Search for matches at the beginning of the tag
'findstr'	Search within the tag
'exact'	Search for exact matches. Note that when <i>searchmethod</i> is specified the search is case-sensitive.

`[lat,lon] = extractm(display_struct)` extracts all vector data from the input map structure.

`[lat,lon,indx] = extractm(...)` also returns the vector `indx` identifying which elements of `display_struct` met the selection criteria.

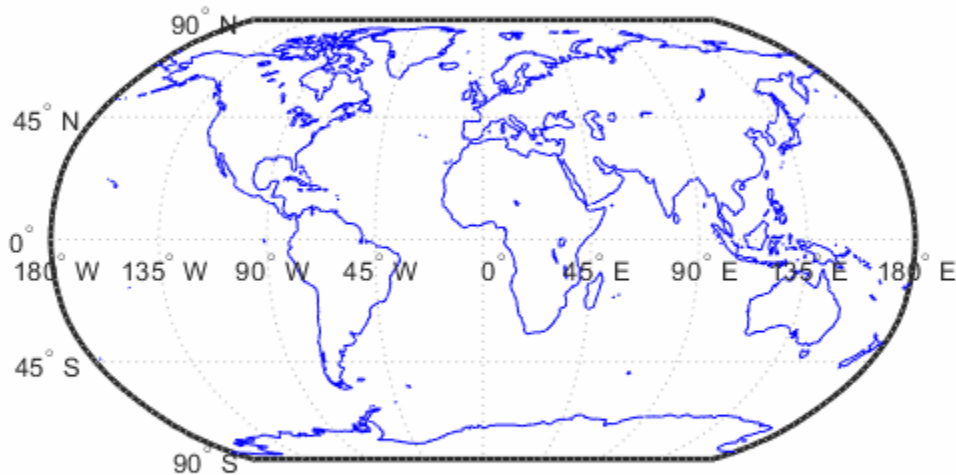
`mat = extractm(...)` returns the vector data in a single matrix, where `mat = [lat lon]`.

Examples

Create a sample display structure from coastline coordinates. Extract the latitude and longitude coordinates from the structure, then display the data.

```
load coastlines
S = struct('lat',coastlat,'long',coastlon,'tag','coastlines', ...
    'type','line','altitude',[]);
[lat,lon] = extractm(S,'coastlines');
```

```
figure
worldmap('world')
geoshow(lat,lon)
```



Tips

A Version 1 display structure is a MATLAB structure that can contain line, patch, text, regular data grid, geolocated data grid, and certain other objects and fixed attributes. In Mapping Toolbox Version 2, a new data structure for vector geodata was introduced (called a mapstruct or a geostruct, depending on whether coordinates it contains are projected or unprojected). Geostructs and mapstructs have few required fields and can include any number of user-defined fields, giving them much greater flexibility to represent vector geodata. For information about the contents and format of display structures, see “Version 1 Display Structures” on page 1-319 in the reference page for `displaym`. For information about converting display structures to geographic data structures, see the reference page for `updategeostruct`, which performs such conversions.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `extractm` function has been removed. Use geospatial tables instead. For more information about geospatial tables, see “Create Geospatial Tables”.

R2022a: Warns

Warns starting in R2022a

The `extractm` function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The `extractm` function runs without warning but will be removed in a future release.

See Also

Functions

`displaym` | `extractfield` | `geoshow` | `mapshow` | `updategeostruct`

Objects

`geoshape`

Topics

“Create Geospatial Tables”

fieldnames

Return dynamic property names of geographic or planar vector

Syntax

```
names = fieldnames(v)
```

Description

`names = fieldnames(v)` returns the names of the dynamic properties of geographic or planar vector `v`.

Examples

View Dynamic Properties of a Mapshape Vector

Create a mapshape vector.

```
ms = mapshape(shaperead('tsunamis.shp'));
```

Display all dynamic properties of the mapshape vector. The displayed properties exclude the Collection properties `Geometry` and `Metadata` and the required mapshape Vertex properties `X` and `Y`.

```
fieldnames(ms)
```

```
ans = 18x1 cell
    {'Year'      }
    {'Month'     }
    {'Day'       }
    {'Hour'      }
    {'Minute'    }
    {'Second'    }
    {'Val_Code'  }
    {'Validity'  }
    {'Cause_Code'}
    {'Cause'     }
    {'Eq_Mag'   }
    {'Country'  }
    {'Location'  }
    {'Max_Height'}
    {'Iida_Mag'  }
    {'Intensity' }
    {'Num_Deaths'}
    {'Desc_Deaths'}
```

Input Arguments

v — Geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Geographic or planar vector, specified as a geopoint, geoshape, mappoint, or mapshape object.

Output Arguments

names — Names of dynamic properties

cell array

Names of dynamic properties of vector v, returned as a cell array.

Version History

Introduced in R2012a

See Also

disp | properties

fill3m

Project filled 3-D patches on axesm-based map

Syntax

```
h = fill3m(lat,lon,z,cdata)
h = fill3m(lat,lon,z,PropertyName,PropertyValue,...)
```

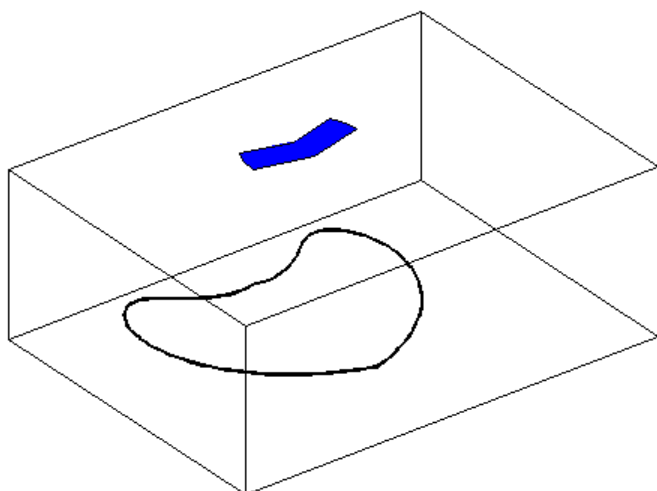
Description

`h = fill3m(lat,lon,z,cdata)` projects and displays any patch object with vertices defined by vectors `lat` and `lon` to the current axesm-based map. The scalar `z` indicates the altitude plane at which the patch is displayed. The input `cdata` defines the patch face color. The patch handle or handles, `h`, can be returned.

`h = fill3m(lat,lon,z,PropertyName,PropertyValue,...)` allows any property name/property value pair supported by `patch` to be assigned to the `fill3m` object.

Examples

```
lat = [30 15 0 0 0 15 30 30]';
lon = [-60 -60 -60 0 60 60 60 0]';
axesm bonne; framem
view(3)
fill3m(lat,lon,2,'b')
```



Version History

Introduced before R2006a

See Also

fillm | patchesm | patchm

fillm

Project filled 2-D patches on axesm-based map

Syntax

```
h = fillm(lat,lon,cdata)
h = fillm(lat,lon,'PropertyName',PropertyValue,...)
```

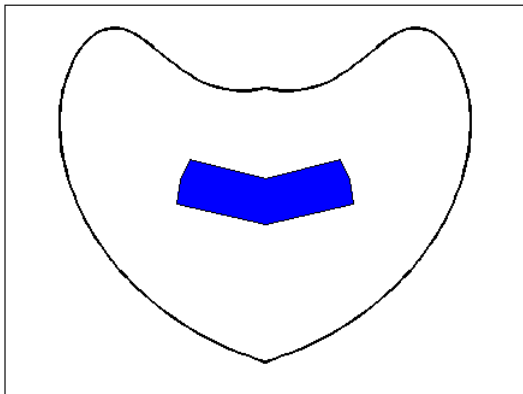
Description

`h = fillm(lat,lon,cdata)` projects and displays any patch object with vertices defined by the vectors `lat` and `lon` to the current axesm-based map. The input `cdata` defines the patch face color. The patch handle or handles, `h`, can be returned.

`h = fillm(lat,lon,'PropertyName',PropertyValue,...)` allows any property name/property value pair supported by `patch` to be assigned to the `fillm` object.

Examples

```
lat = [30 15 0 0 0 15 30 30]';
lon = [-60 -60 -60 0 60 60 60 0]';
axesm bonne; framem
fillm(lat,lon,'b')
```



Version History

Introduced before R2006a

See Also

`fill3m` | `patchesm` | `patchm`

filterm

Filter latitudes and longitudes based on underlying data grid

Syntax

```
[latout,lonout] = filterm(lat,lon,Z,R,allowed)
[latout,lonout,indx] = filterm(____)
```

Description

`[latout,lonout] = filterm(lat,lon,Z,R,allowed)` filters a set of latitudes and longitudes to include only those data points which have a corresponding value in `Z` equal to `allowed`. `R` is a geographic raster reference object.

`[latout,lonout,indx] = filterm(____)` filters a set of latitudes and longitudes, returning indices of the included points in `indx`.

Examples

Filter Elevation Data

Display points along the equator that are above sea level.

First, load elevation raster data and a geographic cells reference object. The raster contains terrain heights relative to mean sea level. Then, specify the coordinates of evenly spaced points along the equator.

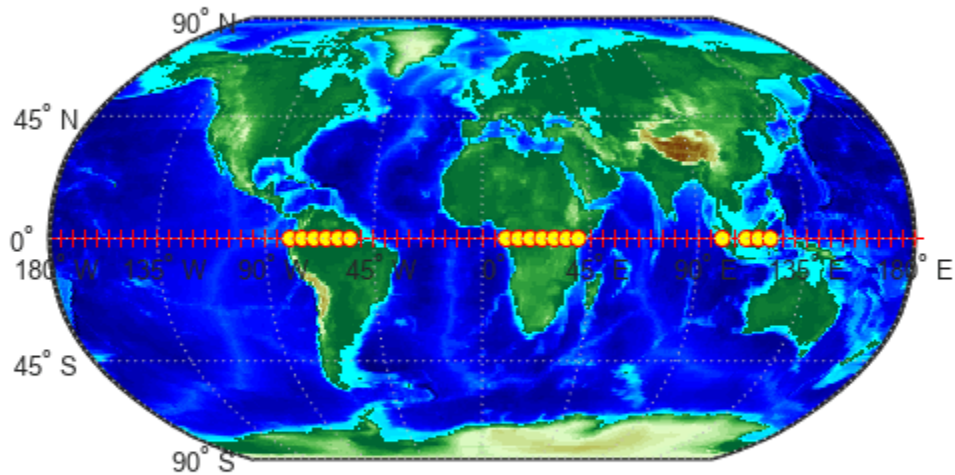
```
load topo60c
lon = (0:5:360)';
lat = zeros(size(lon));
```

Create a logical array representing the terrain above sea level. Then, filter the points along the equator to include only the elements that contain `true`.

```
topoASL = topo60c > 0;
[newlat,newlon] = filterm(lat,lon,topoASL,topo60cR,1);
```

Create a world map and display the elevation data. Display the all of the points along the equator using red markers. Then, display the points that are above sea level using yellow circles.

```
worldmap world
geoshow(topo60c,topo60cR,'DisplayType','texturemap')
demcmap(topo60c)
geoshow(lat,lon,'DisplayType','point','MarkerEdgeColor','r')
geoshow(newlat,newlon,'DisplayType','point','Marker','o',...
        'MarkerFaceColor','y')
```

Input Arguments

lat — Latitude values

numeric array

Latitude values, specified as a numeric array.

Data Types: single | double

lon — Longitude values

numeric array

Longitude values, specified as a numeric array.

Data Types: single | double

Z — Filter

numeric array

Filter, specified as a numeric array.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64 | logical

R — Spatial referencing information

GeographicCellsReference object | GeographicPostingsReference object

Spatial referencing information, specified as a `GeographicCellsReference` object or a `GeographicPostingsReference` object. The `RasterSize` property of `R` must be consistent with `size(Z)`.

Data Types: `double`

allowed — Allowed values

numeric array or character vector

Allowed values, specified as a numeric array or character vector.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical` | `char`

Output Arguments

latout — Latitudes of filtered points

numeric array

Latitudes of filtered points, returned as a numeric array.

lonout — Longitudes of filtered points

numeric array

Longitudes of filtered points, returned as a numeric array.

indx — Indices of filtered points

numeric array

Indices of filtered points, returned as a numeric array.

Version History

Introduced before R2006a

R2022b: `filterm` will not accept referencing vectors or referencing matrices as input

Not recommended starting in R2022b

The `filterm` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

See Also

`imbedm` | `hista` | `histr`

findm

Latitudes and longitudes of nonzero data grid elements

Syntax

```
[lat,lon] = findm(Z,R)
[lat,lon] = findm(latz,lonz,Z)
[lat,lon,val] = findm(...)
mat = findm(...)
```

Description

`[lat,lon] = findm(Z,R)` computes the latitudes and longitudes of the nonzero elements of a regular data grid, `Z`. Specify `R` as a `GeographicCellsReference` or `GeographicPostingsReference` object. The `RasterSize` property of `R` must be consistent with `size(Z)`.

`[lat,lon] = findm(latz,lonz,Z)` returns the latitudes and longitudes of the nonzero elements of a geolocated data grid `Z`, which is an M-by-N logical or numeric array. Typically `latz` and `lonz` are M-by-N latitude-longitude arrays, but `latz` may be a latitude vector of length M and `lonz` may be a longitude vector of length N.

`[lat,lon,val] = findm(...)` returns the values of the nonzero elements of `Z`, in addition to their locations.

`mat = findm(...)` returns a single output, where `mat = [lat lon]`.

This function works in two modes: with a regular data grid and with a geolocated data grid.

Examples

The data grid can be the result of a logical operation. For example, load elevation raster data and a geographic cells reference object. Then, find all locations with elevations greater than 5500 meters.

```
load topo60c
[lat,lon] = findm((topo60c > 5500),topo60cR);
[lat lon]
```

```
ans =
    34.5000    79.5000
    34.5000    80.5000
    30.5000    84.5000
    28.5000    86.5000
```

These points are in the Himalayas. Find the grid values at these locations using the `geographicToDiscrete` and `sub2ind` functions.

```
[row,col] = geographicToDiscrete(topo60cR,lat,lon);
indx = sub2ind(size(topo60c),row,col);
heights = topo60c(indx)
```

```
heights =  
    5559  
    5515  
    5523  
    5731
```

Version History

Introduced before R2006a

R2022b: findm will not accept referencing vectors or referencing matrices as input

Not recommended starting in R2022b

The `findm` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

See Also

`find` | `geographicToDiscrete`

firstCornerX

Package: map.rasterref

Return world x-coordinate of map raster index (1,1)

Syntax

```
x = firstCornerX(R)
```

Description

`x = firstCornerX(R)` returns the world x-coordinate of the outermost corner of the first element (1,1) of map raster R.

Examples

Find x-Coordinate of First Corner

Import a GeoTIFF image [1] on page 1-448 of Boston as an array and a `MapCellsReference` object. Find the world x-coordinate of the outermost corner of the first cell.

```
[Z,R] = readgeoraster('boston.tif');  
x = firstCornerX(R)
```

```
x = 7.6432e+05
```

[1] The data used in this example includes material copyrighted by GeoEye, all rights reserved.

Input Arguments

R — Map raster

`MapCellsReference` or `MapPostingsReference` object

Map raster, specified as a `MapCellsReference` or `MapPostingsReference` object.

Output Arguments

x — World x-coordinate

numeric scalar

World x-coordinate, returned as a numeric scalar.

Data Types: double

Version History

Introduced in R2013b

See Also

firstCornerY

firstCornerY

Package: map.rasterref

Return world y-coordinate of map raster index (1,1)

Syntax

```
y = firstCornerY(R)
```

Description

`y = firstCornerY(R)` returns the world y-coordinate of the outermost corner of the first element (1,1) of map raster R.

Examples

Find y-Coordinate of First Corner

Import a GeoTIFF image [1] on page 1-450 of Boston as an array and a `MapCellsReference` object. Find the world y-coordinate of the outermost corner of the first cell.

```
[Z,R] = readgeoraster('boston.tif');  
y = firstCornerY(R)
```

```
y = 2.9606e+06
```

[1] The data used in this example includes material copyrighted by GeoEye, all rights reserved.

Input Arguments

R — Map raster

`MapCellsReference` or `MapPostingsReference` object

Map raster, specified as a `MapCellsReference` or `MapPostingsReference` object.

Output Arguments

y — World y-coordinate

numeric scalar

World y-coordinate, returned as a numeric scalar.

Data Types: double

Version History

Introduced in R2013b

See Also

firstCornerX

flat2ecc

Eccentricity of ellipse from flattening

Syntax

```
ecc = flat2ecc(f)
```

Description

`ecc = flat2ecc(f)` computes the eccentricity of an ellipse or an ellipsoid of revolution given the flattening `f`.

Examples

Eccentricity of Ellipse from Flattening

Find the eccentricity of an ellipse from the flattening.

```
ecc = flat2ecc(0.0034)
```

```
ecc = 0.0824
```

Input Arguments

f – Flattening

numeric scalar

Flattening, specified as a numeric scalar.

Data Types: `single` | `double`

Output Arguments

ecc – Eccentricity of ellipse

numeric scalar

Eccentricity of the ellipse, returned as a numeric scalar in the range [0, 1].

Version History

Introduced before R2006a

R2013b: Only numeric scalars will be accepted as input

Not recommended starting in R2013b

The `flat2ecc` function will not accept vectors or matrices as input in a future release. To update your code, specify a numeric scalar instead.

See Also

Functions

[axes2ecc](#) | [ecc2flat](#) | [n2ecc](#)

flatearthpoly

Clip polygon to world limits

Syntax

```
[latf,lonf] = flatearthpoly(lat,lon)
[latf,lonf] = flatearthpoly(lat,lon,longitudeOrigin)
```

Description

`[latf,lonf] = flatearthpoly(lat,lon)` trims NaN-separated polygons specified by the latitude and longitude vectors `lat` and `lon` to the limits `[-180 180]` in longitude and `[-90 90]` in latitude, inserting straight segments along the ± 180 -degree meridians and at the poles. Inputs and outputs are in degrees.

Display functions automatically cut and trim geographic data when required by the map projection. Use the `flatearthpoly` function only when performing set operations on polygons.

`[latf,lonf] = flatearthpoly(lat,lon,longitudeOrigin)` centers the longitude limits on the longitude specified by the scalar longitude `longitudeOrigin`.

Examples

Clip Polygon to World Limits

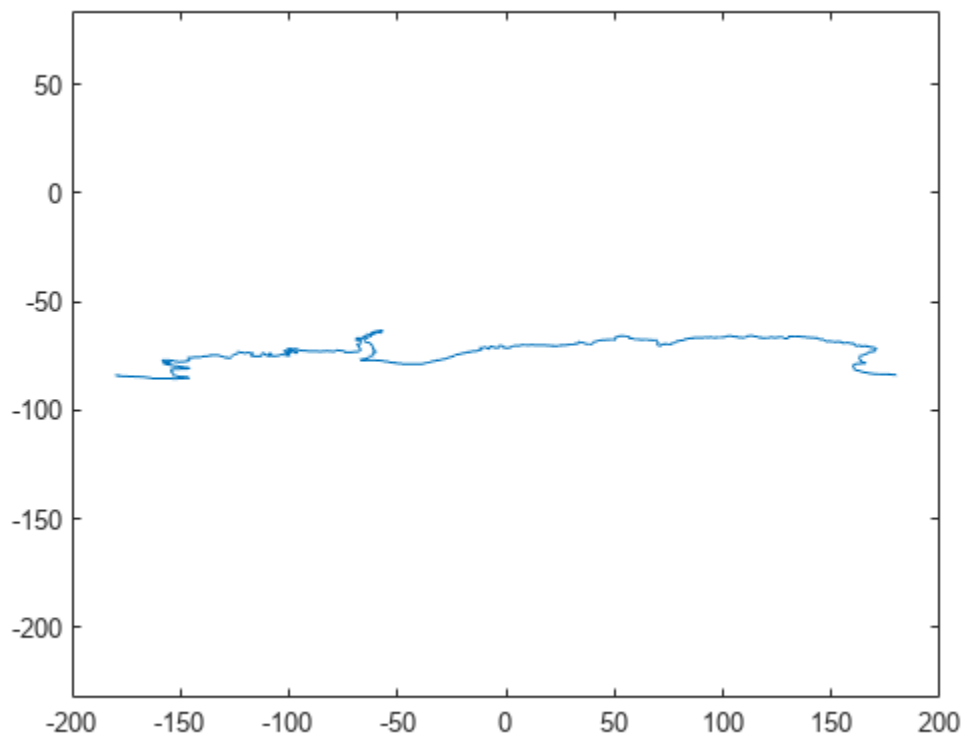
Vector data for geographic objects that encompass a pole must encounter or cross the Antimeridian. While the toolbox properly displays such polygons, they can cause problems for functions that work with Cartesian coordinates, such as polygon intersection and Boolean operations. When these polygons are treated as Cartesian coordinates, the Antimeridian crossing results in a spurious line segment, and the polygon displayed as a patch does not have the interior filled correctly. You can reformat such polygons by using the `flatearthpoly` function.

Load the coordinates of global coastlines. Extract the coordinates of the first polygon, which represents Antarctica.

```
load coastlines
firstnan = find(isnan(coastlat),1,"first");
lat = coastlat(1:firstnan);
lon = coastlon(1:firstnan);
```

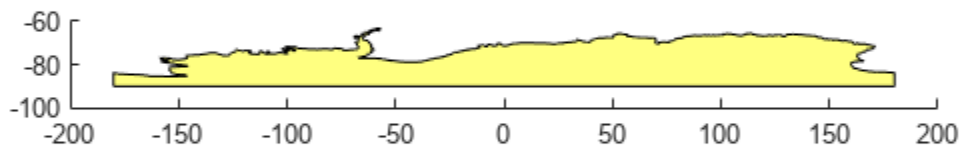
Plot the coordinates that make up the polygon boundary. Note that the boundary is not closed.

```
plot(lon,lat)
xlim([-200 200])
axis equal
```



Convert the coastline so that it uses planar polygon topology and plot the result. The polygon boundary meets the Antimeridian, drops down to the pole, sweeps across the longitudes at the pole, and follows the Antimeridian up to the other side of the Antimeridian crossing.

```
[latf,lonf] = flatearthpoly(lat,lon);  
figure  
mapshow(lonf,latf,"DisplayType","polygon")  
ylim([-100 -60])
```



Cut Lines and Polygons at the Antimeridian

Longitude coordinate discontinuities at the Antimeridian can confuse set operations on polygons. To prepare geographic data for use with `polybool` or for patch rendering, cut the polygons at the Antimeridian with the `flatearthpoly` function. The `flatearthpoly` function returns a polygon with points inserted to follow the Antimeridian up to the pole, traverse the longitudes at the pole, and return to the Antimeridian along the other edge of the Antimeridian.

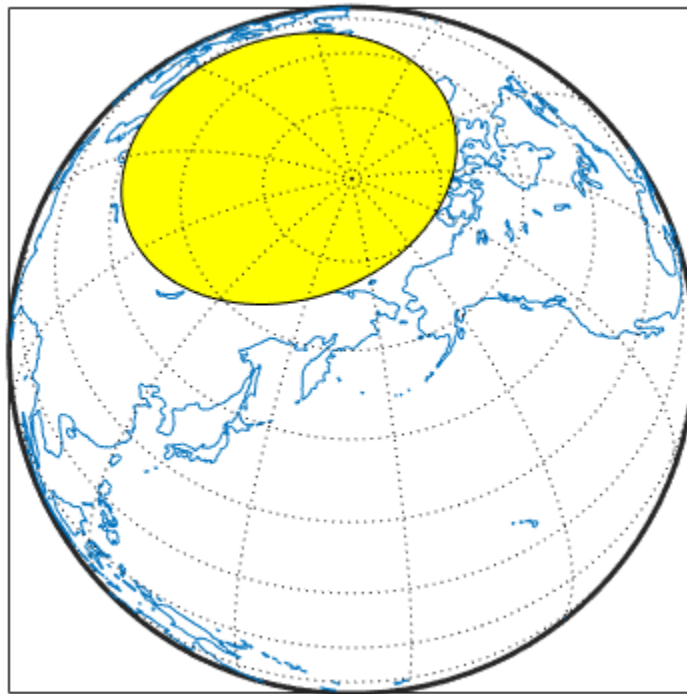
Create an orthographic view of the Earth and plot the coastlines on it.

```
axesm ortho
setm(gca,'Origin',[60 170]); framem on; gridm on
load coastlines
plotm(coastlat,coastlon)
```



Generate a small circle that encompasses the North Pole and color it yellow.

```
[latc,lonc] = scircle1(75,45,30);  
patchm(latc,lonc,'y')
```

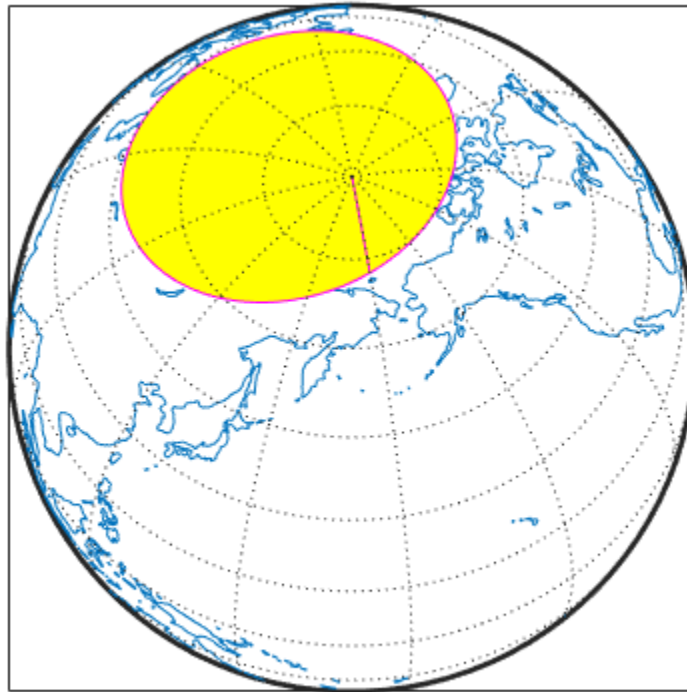


Flatten the small circle using the `flatearthpoly` function.

```
[latf,lonf] = flatearthpoly(latc,lonc);
```

Plot the cut circle that you just generated as a magenta line.

```
plotm(latf,lonf,'m')
```

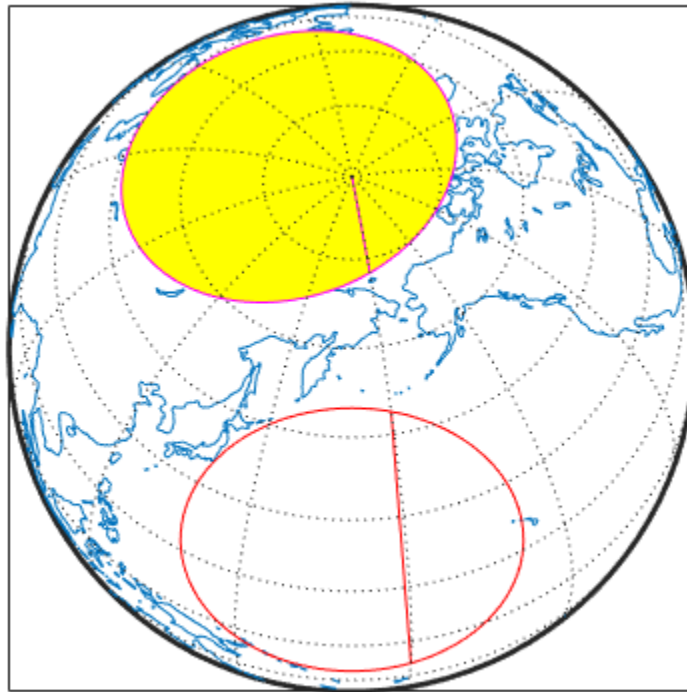



Generate a second small circle that does not include a pole.

```
[latc1, lonc1] = scircle1(20, 170, 30);
```

Flatten the circle and plot it as a red line. Note that the second small circle, which does not cover a pole, is clipped into two pieces along the Antimeridian. The polygon for the first small circle is plotted in plane coordinates to illustrate its flattened shape. The `flatearthpoly` function assumes that the interior of the polygon being flattened is in the hemisphere that contains most of its edge points. Thus a polygon produced by `flatearthpoly` does not cover more than a hemisphere.

```
[latf1,lonf1] = flatearthpoly(latc1,lonc1);  
plotm(latf1,lonf1,'r')
```



Tips

The polygon defined by `lat` and `lon` must be well-formed:

- The boundaries must not intersect.
- The vertices of outer boundaries must be in a clockwise order and the vertices of inner boundaries must be in a counterclockwise order, such that the interior of the polygon is always to the right of the boundary.

For more information, see “Create and Display Polygons”.

Version History

Introduced before R2006a

See Also

`mapclip` | `geoclip` | `maptrim` | `ispolycw` | `poly2cw` | `poly2ccw`

forward

Package: map.geodesy

Convert geodetic latitude to authalic, conformal, isometric, or rectifying latitude

Syntax

```
lat = forward(converter,phi)
lat = forward(converter,phi,angleUnit)
```

Description

`lat = forward(converter,phi)` returns the authalic, conformal, isometric, or rectifying latitude coordinates corresponding to geodetic latitude coordinates `phi`.

`lat = forward(converter,phi,angleUnit)` specifies the units of input `phi`.

Examples

Convert Geodetic Latitude to Authalic Latitude

Specify geodetic latitude coordinates and create an authalic latitude converter. Then, convert the coordinates.

```
phi = [-90 -67.5 -45 -22.5 0 22.5 45 67.5 90];
conv = map.geodesy.AuthalicLatitudeConverter(wgs84Ellipsoid);
beta = forward(conv,phi)

beta = 1×9

-90.0000 -67.4092 -44.8717 -22.4094      0  22.4094  44.8717  67.4092  90.0000
```

Convert Geodetic Latitude to Isometric Latitude

Specify geodetic latitude coordinates and create an isometric latitude converter. Then, convert the coordinates.

```
phi = [-90 -67.5 -45 -22.5 0 22.5 45 67.5 90];
conv = map.geodesy.IsometricLatitudeConverter(wgs84Ellipsoid);
psi = forward(conv,phi)

psi = 1×9

-Inf -1.6087 -0.8766 -0.4006      0  0.4006  0.8766  1.6087  Inf
```

Convert Geodetic Latitude to Rectifying Latitude Using Radians

Specify geodetic latitude coordinates and convert them to radians. Create a rectifying latitude converter. Then, convert the coordinates by specifying the angle unit as 'radians'.

```
phi = [-90 -67.5 -45 -22.5 0 22.5 45 67.5 90];
phirad = deg2rad(phi);
conv = map.geodesy.RectifyingLatitudeConverter(wgs84Ellipsoid);
mu = forward(conv,phirad,'radians')
```

```
mu = 1×9
```

```
-1.5708 -1.1763 -0.7829 -0.3909 0 0.3909 0.7829 1.1763 1.5708
```

Input Arguments

converter — Latitude converter

`AuthalicLatitudeConverter`, `ConformalLatitudeConverter`, `IsometricLatitudeConverter`, or `RectifyingLatitudeConverter` object

Latitude converter, specified as an `AuthalicLatitudeConverter`, `ConformalLatitudeConverter`, `IsometricLatitudeConverter`, or `RectifyingLatitudeConverter` object.

phi — Geodetic latitude coordinates

numeric scalar, vector, matrix, or N-D array

Geodetic latitude coordinates, specified as a numeric scalar value, vector, matrix, or N-D array. If `angleUnit` is not supplied, `phi` is in degrees. Otherwise, values of `phi` must be consistent with the units of `angleUnit`.

Data Types: `single` | `double`

angleUnit — Unit of geodetic latitude coordinates

'degrees' (default) | 'radians'

Units of geodetic latitude coordinates, specified as 'degrees' or 'radians'.

Output Arguments

lat — Converted latitude coordinates

numeric scalar, vector, matrix, or N-D array

Converted latitude coordinates, returned as a numeric scalar, vector, matrix, or N-D array. `lat` is the same size as `phi`.

The interpretation of `lat` depends on the latitude converter. If the conversion is:

- `authalic`, `lat` represents the variable β (beta), and has the same units as `phi`.
- `conformal`, `lat` represents χ (chi), and has the same units as `phi`.
- `isometric`, `lat` represents ψ (psi). `lat` is a dimensionless number and does not have an angle unit.

- rectifying, `lat` represents μ (mu), and has the same units as `phi`.

Version History

Introduced in R2013a

See Also

`inverse`

framem

Control frame of axesm-based map

Syntax

```
framem
framem('on')
framem('off')
framem('reset')
framem(linespec)
framem(PropertyName,PropertyValue,...)
```

Description

`framem` toggles the visibility of the map frame by setting the axesm-based map property `Frame` to 'on' or 'off'. The default setting for axesm-based maps is 'off'.

`framem('on')` sets the axesm-based map property `Frame` to 'on'.

`framem('off')` sets the axesm-based map property `Frame` to 'off'. When called with the value 'off', the axesm-based map property `Frame` is set to 'off'.

`framem('reset')` resets the entire frame using the current properties. This is essentially a *refresh* option.

`framem(linespec)` sets the axesm-based map `FEdgeColor` property to the color component of any MATLAB `linespec`.

`framem(PropertyName,PropertyValue,...)` sets the appropriate axesm-based map properties to the desired values. These property names and values are described on the axesm reference page.

Tips

- You can also create or alter map frame properties using the `axesm` or `setm` functions.
- By default the `Clipping` property is set to 'off'. Override this setting with the following code:

```
hgrat = gridm('on');
set(hgrat,'Clipping','on')
```

Version History

Introduced before R2006a

See Also

`axesm` | `setm`

fromDegrees

Convert angles from degrees

Syntax

```
[A1,...,An] = fromDegrees(toUnits,D1,...,Dn)
```

Description

[A1,...,An] = fromDegrees(toUnits,D1,...,Dn) converts the angles specified by D1,...,Dn from degrees to the units specified by toUnits. This function is useful for converting angles from degrees when you do not know the output units until run-time.

Examples

Convert From Degrees to Radians

Convert several values from degrees to radians.

```
[A1,A2,A3,A4] = fromDegrees("radians",45,90,135,180)
```

```
A1 = 0.7854
```

```
A2 = 1.5708
```

```
A3 = 2.3562
```

```
A4 = 3.1416
```

Convert the same values from degrees by specifying an array.

```
D = [45 90 135 180];
```

```
A = fromDegrees("radians",D)
```

```
A = 1×4
```

```
    0.7854    1.5708    2.3562    3.1416
```

Input Arguments

toUnits — Output unit

"degrees" | "radians"

Output unit, specified as "degrees" or "radians". You can also specify abbreviations such as "deg" and "rad".

Data Types: char | string

D1, ..., Dn — Angles in degrees

numeric array

Angles in degrees, specified as one or more numeric arrays.

Output Arguments

A1, ..., An — Angles in degrees or radians

numeric array

Angles in degrees or radians, returned as the same number of numeric arrays as in D_1, \dots, D_n . The size of each output array matches the size of the corresponding input array.

Version History

Introduced in R2007b

See Also

Functions

`fromRadians` | `deg2rad` | `toDegrees` | `toRadians`

fromRadians

Convert angles from radians

Syntax

```
[A1,...,An] = fromRadians(toUnits,R1,...,Rn)
```

Description

[A1,...,An] = fromRadians(toUnits,R1,...,Rn) converts the angles specified by R1,...,Rn from radians to the units specified by toUnits. This function is useful for converting angles from radians when you do not know the output units until run-time.

Examples

Convert from Radians to Degrees

Convert several values from radians to degrees.

```
[A1,A2,A3,A4] = fromRadians("degrees",pi/2,pi,3*pi/2,2*pi)
```

```
A1 = 90
```

```
A2 = 180
```

```
A3 = 270
```

```
A4 = 360
```

Convert the same values from radians by specifying an array.

```
R = [pi/2 pi 3*pi/2 2*pi];
A = fromRadians("degrees",R)
```

```
A = 1×4
```

```
    90    180    270    360
```

Input Arguments

toUnits — Output unit

"degrees" | "radians"

Output unit, specified as "degrees" or "radians". You can also specify abbreviations such as "deg" and "rad".

Data Types: char | string

R1,...,Rn — Angles in radians

numeric array

Angles in radians, specified as one or more numeric arrays.

Output Arguments

A1, ..., An — Angles in degrees or radians

numeric array

Angles in degrees or radians, returned as the same number of numeric arrays as in R_1, \dots, R_n . The size of each output array matches the size of the corresponding input array.

Version History

Introduced in R2007b

See Also

Functions

fromDegrees | rad2deg | toDegrees | toRadians

gc2sc

Center and radius of great circle

Syntax

```
[lat,lon,radius] = gc2sc(lat0,lon0,az)
[lat,lon,radius] = gc2sc(lat0,lon0,az,angleunits)
mat = gc2sc(...)
```

Description

`[lat,lon,radius] = gc2sc(lat0,lon0,az)` converts a great circle from great circle notation (i.e., lat, lon, azimuth, where (lat, lon) is on the circle) to small circle notation (i.e., lat, lon, radius, where (lat, lon) is the center of the circle and the radius is 90 degrees, which is a definition of a great circle). A great circle has two centers and one is chosen arbitrarily. The other is its antipode. All inputs and outputs are in units of degrees.

`[lat,lon,radius] = gc2sc(lat0,lon0,az,angleunits)` where `angleunits` specifies the units of the inputs and outputs, either 'degrees' or 'radians'.

`mat = gc2sc(...)` returns a single output, where `mat = [lat lon radius]`.

Examples

Represent a great circle passing through (25°S,70°W) on an azimuth of 45° as a small circle:

```
[lat,lon,radius] = gc2sc(-25,-70,45)
```

```
lat =
    -39.8557
```

```
lon =
    42.9098
```

```
radius =
    90
```

A great circle always bisects the sphere. As a demonstration of this statement, consider the Equator, which passes through any point with a latitude of 0° and proceeds on an azimuth of 90° or 270°.

Represent the Equator as a small circle:

```
[lat,lon,radius] = gc2sc(0,-70,270)
```

```
lat =
    90
```

```
lon =
    0
```

radius =

90

Not surprisingly, the small circle is centered on the North Pole. As always at the poles, the longitude is arbitrary because of the convergence of the meridians.

Note that the center coordinates returned by this function always lead to one of two possibilities. Since the great circle bisects the sphere, the antipode of the returned point is also a center with a radius of 90°. In the above example, the South Pole would also be a suitable center for the Equator in a small circle.

More About

Great and Small Circles

A *small circle* is the intersection of a plane with the surface of a sphere. A *great circle* is a small circle with a radius of 90°.

Version History

Introduced before R2006a

See Also

[antipode](#) | [crossfix](#) | [gcxgc](#) | [gcxsc](#) | [rhxrh](#)

gcm

Query projection structure of current axesm-based map

Syntax

```
mstruct = gcm  
mstruct = gcm(abm)
```

Description

`mstruct = gcm` returns the map projection structure of the current axesm-based map, which contains the settings for all the current axesm-based map properties.

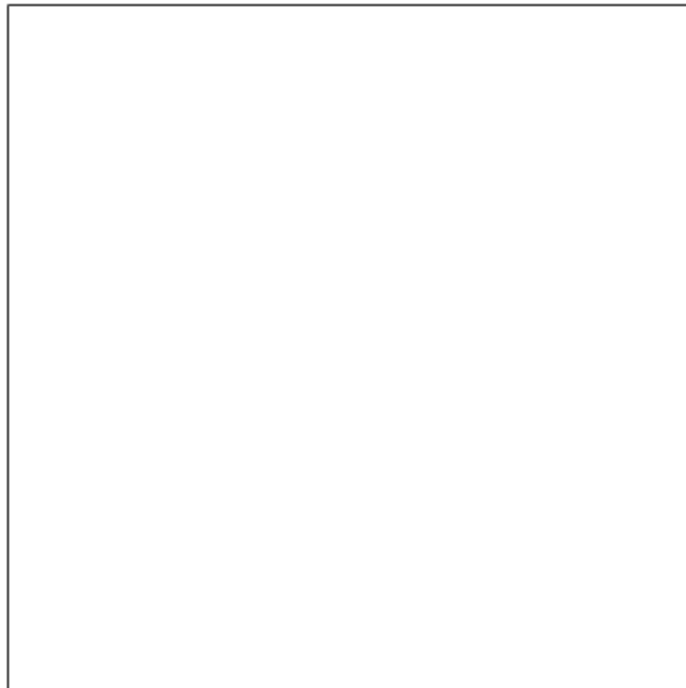
`mstruct = gcm(abm)` returns the map projection structure for the specified axesm-based map.

Examples

Query Projection Structure of axesm-Based Map

Establish an axesm-based map with default values, then look at the structure.

```
axesm mercator
```



```
mstruct = gcm

mstruct = struct with fields:
  mapprojection: 'mercator'
    zone: []
    angleunits: 'degrees'
    aspect: 'normal'
  falsenorthing: 0
  falseeastng: 0
  fixedorient: []
    geoid: [1 0]
  maplatlimit: [-86 86]
  maplonlimit: [-180 180]
  mapparallels: 0
    nparallels: 1
    origin: [0 0 0]
  scalefactor: 1
    trimlat: [-86 86]
    trimlon: [-180 180]
    frame: 'off'
    ffill: 100
  fedgecolor: [0.1500 0.1500 0.1500]
  ffacecolor: 'none'
  flatlimit: [-86 86]
  flinewidth: 2
  flonlimit: [-180 180]
    grid: 'off'
  galtitude: Inf
    gcolor: [0.1500 0.1500 0.1500]
  glinestyle: ':'
  glinewidth: 0.5000
  mlineexception: []
    mlinefill: 100
    mlinelimit: []
  mlinelocation: 30
  mlinevisible: 'on'
  plineexception: []
    plinefill: 100
    plinelimit: []
  plinelocation: 15
  plinevisible: 'on'
    fontangle: 'normal'
    fontcolor: [0.1500 0.1500 0.1500]
    fontname: 'Helvetica'
    fontsize: 10
    fontunits: 'points'
    fontweight: 'normal'
  labelformat: 'compass'
  labelrotation: 'off'
    labelunits: 'degrees'
  meridianlabel: 'off'
  mlabellocation: 30
  mlabelparallel: 86
    mlabelround: 0
  parallellabel: 'off'
  plabellocation: 15
  plabelmeridian: -180
```

```
plabelround: 0
```

Input Arguments

abm — axesm-based map

map created using `axesm`, `worldmap`, or `usamap`

axesm-based map, specified as a map created using the `axesm`, `worldmap`, or `usamap` function.

Output Arguments

mstruct — Map projection structure

structure

Map projection structure, returned as a structure with fields identical to the properties of an axesm-based map. Examples of map projection structure fields include the projection name, angle unit, origin, aspect, false easting, and false northing. For more information about the properties of axesm-based maps, see [axesm-Based Map Properties](#).

Tips

- You can query specific properties of axesm-based maps by using the `getm` function.
- You can modify specific properties of axesm-based maps by using the `setm` function.

Version History

Introduced before R2006a

See Also

`axesm` | `getm` | `setm`

gcpmap

Identify current point on axesm-based map using mouse

Syntax

```
pt = gcpmap  
pt = gcpmap(hndl)
```

Description

`pt = gcpmap` returns the current point (the location of last button click) of the current axesm-based map in the form `[latitude longitude z-altitude]`.

`pt = gcpmap(hndl)` specifies the axesm-based map in question by its handle.

Examples

Set up an axesm-based map with a graticule and display a world map:

```
axesm robinson  
gridm on  
geoshow('landareas.shp')
```

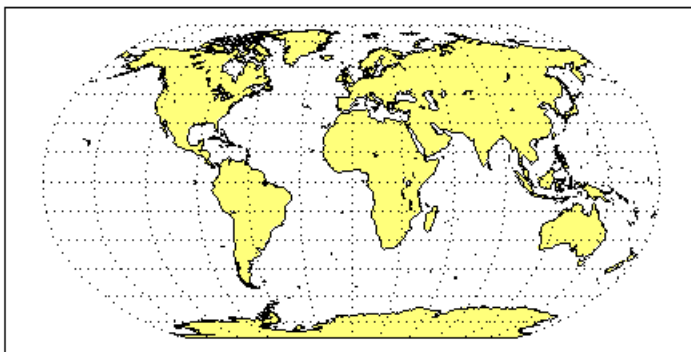
Click somewhere near Boston, Massachusetts to obtain a current point:

```
pt = gcpmap
```

```
pt =  
    44.171    -69.967         2  
    44.171    -69.967         0
```

```
whos
```

Name	Size	Bytes	Class	Attributes
pt	2x3	48	double array	



Tips

`gcpmap` works much like the standard MATLAB function `get(gca, 'CurrentPoint')`, except that the returned matrix is in `[lat lon z]`, not `[x y z]`.

You must use `view(2)` and an ordinary projection (not the Globe projection) when working with the `gcpmap` function.

The `CurrentPoint` property is updated whenever a button-click event occurs in a MATLAB figure window. The pointer does not have to be within the axes, or even the figure window. Coordinates with respect to the requested axes are returned regardless of the pointer location. Likewise, `gcpmap` will return values that may look reasonable whether the current point is within the graticule bounds or not, and thus must be used with care.

Version History

Introduced before R2006a

See Also

`inputm`

gcwaypts

Equally spaced waypoints along great circle

Syntax

```
[lat,lon] = gcwaypts(lat1,lon1,lat2,lon2)
[lat,lon] = gcwaypts(lat1,lon1,lat2,lon2,nlegs)
pts = gcwaypts(lat1,lon1,lat2,lon2...)
```

Description

`[lat,lon] = gcwaypts(lat1,lon1,lat2,lon2)` returns the coordinates of equally spaced points along a great circle path connecting two endpoints, `(lat1,lon1)` and `(lat2,lon2)`.

`[lat,lon] = gcwaypts(lat1,lon1,lat2,lon2,nlegs)` specifies the number of equal-length track legs to calculate. `nlegs+1` output points are returned, since a final endpoint is required. The default number of legs is 10.

`pts = gcwaypts(lat1,lon1,lat2,lon2...)` packs the outputs, which are otherwise two-column vectors, into a two-column matrix of the form `[latitude longitude]`. This format for successive waypoints along a navigational track is called *navigational track format* in this guide. See the `navigational track format` reference page in this section for more information.

Background

This is a navigational function. It assumes that all latitudes and longitudes are in degrees.

In navigational practice, great circle paths are often approximated by rhumb line segments. This is done to come reasonably close to the shortest distance between points without requiring course changes too frequently. The `gcwaypts` function provides an easy means of finding waypoints along a great circle path that can serve as endpoints for rhumb line segments (track legs).

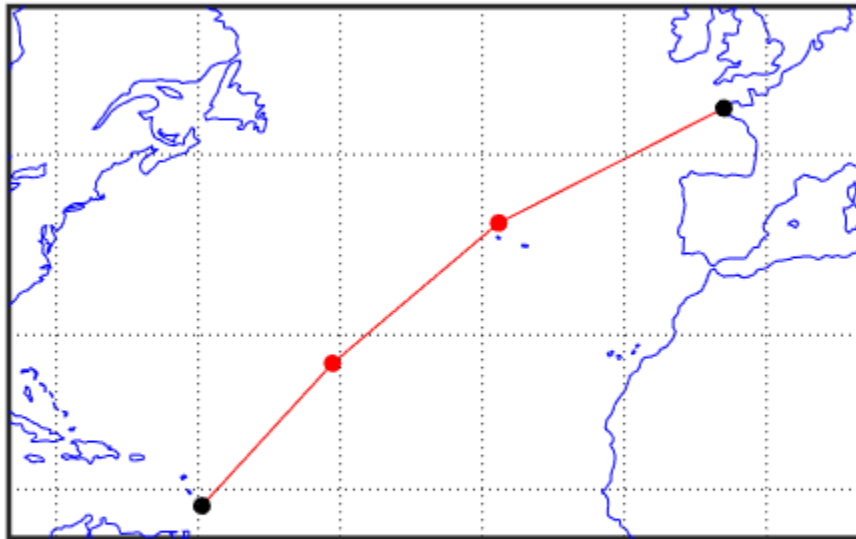
Examples

Determine Equally Spaced Points Along a Great Circle Path

Imagine you own a sailing yacht and are planning a voyage from North Point, Barbados (13.33° N,59.62°W), to Brest, France (48.36°N,4.49°W). Divide the track into three equal-length segments.

```
figure('color','w');
ha = axesm('mapproj','mercator',...
    'maplatlim',[10 55],'maplonlim',[-80 10],...
    'MLineLocation',15,'PLineLocation',15);
axis off, gridm on, framem on;
% Load coastline data and plot it in the figure.
load coastlines;
hg = geoshow(coastlat,coastlon,'displaytype','line','color','b');
% Define point locations for Barbados and Brest
barbados = [13.33 -59.62];
```

```
brest = [48.36 -4.49];  
% Calculate the waypoints along the path.  
[l,g] = gcwaypts(barbados(1),barbados(2),brest(1),brest(2),3);  
geoshow(l,g,'displaytype','line','color','r',...  
         'markeredgecolor','r','markerfacecolor','r','marker','o');  
geoshow(barbados(1),barbados(2),'DisplayType','point',...  
         'markeredgecolor','k','markerfacecolor','k','marker','o')  
geoshow(brest(1),brest(2),'DisplayType','point',...  
         'markeredgecolor','k','markerfacecolor','k','marker','o')
```



Version History

Introduced before R2006a

See Also

[dreckon](#) | [legs](#) | [navfix](#) | [track](#)

gcxgc

Intersection points for pairs of great circles

Syntax

```
[lat,lon] = gcxgc(lat1,lon1,az1,lat2,lon2,az2)
[lat,lon] = gcxgc(lat1,lon1,az1,lat2,lon2,az2,units)
latlon = gcxgc(____)
```

Description

`[lat,lon] = gcxgc(lat1,lon1,az1,lat2,lon2,az2)` returns in `lat` and `lon` the locations where pairs of great circles intersect. The great circles are defined using *great circle notation*, which consists of a point on the great circle and the azimuth at that point along which the great circle proceeds. For example, the first great circle in a pair would pass through the point `(lat1,lon1)` with an azimuth of `az1` (in angular units).

For any pair of great circles, there are two possible intersection conditions: the circles are identical or they intersect exactly twice on the sphere.

`[lat,lon] = gcxgc(lat1,lon1,az1,lat2,lon2,az2,units)` specifies the angular units used for all inputs, where `units` is any valid angular unit.

`latlon = gcxgc(____)` returns a single output consisting of the concatenated latitude and longitude coordinates of the great circle intersection points.

Examples

Find Intersection Points of Two Great Circles

Given a great circle passing through $(10^{\circ}\text{N}, 13^{\circ}\text{E})$ and proceeding on an azimuth of 10° , where does it intersect with a great circle passing through $(0^{\circ}, 20^{\circ}\text{E})$, on an azimuth of -23° (that is, 337°)?

```
[newlat,newlon] = gcxgc(10,13,10,0,20,-23)
```

```
newlat =
```

```
    14.3105  -14.3105
```

```
newlon =
```

```
    13.7838  -166.2162
```

Note that the two intersection points are always antipodes of each other. As a simple example, consider the intersection points of two meridians, which are just great circles with azimuths of 0° or 180° :

```
[newlat,newlon] = gcxgc(10,13,0,0,20,180)
```

```
newlat =
```

```

    -90    90
newlon =
    0    180

```

The two meridians intersect at the North and South Poles, which is exactly correct.

Input Arguments

lat1, lon1 — Coordinate of point on first great circle

numeric scalar | n -element numeric vector

Latitude or longitude coordinate of a point on the first great circle in each pair, specified as one of these values.

- A numeric scalar to find the intersection of a single pair of great circles.
- A n -element numeric vector to find the intersection of n pairs of great circles.

`lat1` and `lon1` must have the same length.

Example: 10

Example: [-10 20 90 -45]

az1 — Azimuth of first great circle

positive numeric scalar | n -element vector of positive numbers

Azimuth of the first great circle of each pair, in angular units, specified as one of these values.

- A positive numeric scalar to find the intersection of a single pair of great circles.
- A n -element vector of positive numbers to find the intersection of n pairs of great circles. The length of `az1` matches the length of `lat1` and `lon1`.

Example: 20

Example: [20 10 45 45]

lat2, lon2 — Coordinate of point on second great circle

numeric scalar | numeric vector

Latitude or longitude coordinate of a point on the second great circle in each pair, specified as one of these values.

- A numeric scalar to find the intersection of a single pair of great circles.
- A n -element numeric vector to find the intersection of n pairs of great circles.

`lat2` and `lon2` must have the same length as `lat1` and `lon1`.

Example: 3

Example: [3 30 85 -45]

az2 — Azimuth of second great circle

positive numeric scalar | n -element vector of positive numbers

Azimuth of the second great circle of each pair, in angular units, specified as one of these values.

- A positive numeric scalar to find the intersection of a single pair of great circles.
- A n -element vector of positive numbers to find the intersection of n pairs of great circles. The length of `az2` matches the length of `lat2` and `lon2`.

Example: 15

Example: [15 15 45 50]

units – Angular units

'degrees' (default) | 'radians'

Angular units, specified as 'degrees' or 'radians'.

Output Arguments

lat, lon – Coordinates of great circle intersections

2-element vector | n -by-2 matrix

Coordinates of great circle intersections, returned as one of the following.

- 2-element vector when you find the intersection of a single pair of great circles.
- n -by-2 matrix when you find the intersection of n pairs of great circles.

If a pair of great circles are identical, then `gcxgc` displays a warning and returns NaNs for the latitude and longitude coordinates of the intersection points.

latlon – Concatenated coordinates of great circle intersections

4-element vector | n -by-4 matrix

Concatenated coordinates of great circle intersections, returned as one of the following. This output is identical to [`lat` `lon`].

- 4-element vector when you find the intersection of a single pair of great circles.
- n -by-4 matrix when you find the intersection of n pairs of great circles.

If a pair of great circles are identical, then `gcxgc` displays a warning and returns NaNs for the latitude and longitude coordinates of the intersection points.

Version History

Introduced before R2006a

See Also

`antipode` | `gc2sc` | `scxsc` | `gcxsc` | `rhxrh` | `crossfix` | `polyxpoly`

gcxsc

Intersection points for great and small circle pairs

Syntax

```
[newlat,newlon] = gcxsc(gclat,gclon,gcaz,sclat,sclon,scrangle)
[newlat,newlon] = gcxsc(..., units)
```

Description

[newlat,newlon] = gcxsc(gclat,gclon,gcaz,sclat,sclon,scrangle) returns the points of intersection of a great circle in *great circle notation* followed by a small circle in *small circle notation*. For multiple pairings, the inputs must be column vectors. The results are two-column matrices with the coordinates of the intersection points. If the circles do not intersect, or are identical, two NaNs are returned and a warning is displayed. If the two circles are tangent, the single intersection point is repeated twice.

[newlat,newlon] = gcxsc(..., units) where units specifies the standard angle unit. The default value is 'degrees'.

For a pairing of a great circle with a small circle, there are four possible intersection conditions: the circles are identical (possible because great circles are a subset of small circles), they do not intersect, they are tangent to each other (the small circle interior to the great circle) and hence they intersect once, or they intersect twice.

Great circle notation consists of a point on the great circle and the azimuth at that point along which the great circle proceeds.

Small circle notation consists of a center point and a radius in units of angular arc length.

Examples

Given a great circle passing through (43°N,0°) and proceeding on an azimuth of 10°, where does it intersect with a small circle centered at (47°N,3°E) with an arc length radius of 12°?

```
[newlat,newlon] = gcxsc(43,0,10,47,3,12)
```

```
newlat =
    35.5068    58.9143
```

```
newlon =
   -1.6159    5.4039
```

Version History

Introduced before R2006a

See Also

[gc2sc](#) | [gcxgc](#) | [scxsc](#) | [rhxrh](#) | [crossfix](#) | [polyxpoly](#)

geocentric2geodeticLat

(Removed) Convert geocentric to geodetic latitude

Note The `geocentric2geodeticLat` function has been removed. Use the `geodeticLatitudeFromGeocentric` function instead.

Syntax

```
phiI = geocentric2geodeticlat(ecc, phi_g)
```

Description

`phiI = geocentric2geodeticlat(ecc, phi_g)` converts an array of geocentric latitude in radians, `phi_g`, to geodetic latitude in radians, `phiI`, on a reference ellipsoid with first eccentricity `ecc`.

Version History

Introduced in R2006b

R2023a: Removed

Errors starting in R2023a

The `geocentric2geodeticLat` function has been removed. Use the `geodeticLatitudeFromGeocentric` function instead.

R2022a: Warns

Warns starting in R2022a

The `geocentric2geodeticLat` function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The `geocentric2geodeticLat` function runs without warning but will be removed in a future release.

See Also

`geodeticLatitudeFromGeocentric`

geocentricLatitude

Convert geodetic to geocentric latitude

Syntax

```
psi = geocentricLatitude(phi,F)
psi = geocentricLatitude(phi,F,angleUnit)
```

Description

`psi = geocentricLatitude(phi,F)` returns the geocentric latitude corresponding to geodetic latitude `phi` on an ellipsoid with flattening `F`.

`psi = geocentricLatitude(phi,F,angleUnit)` specifies the units of input `phi` and output `psi`.

Examples

Convert Geodetic Latitude to Geocentric Latitude

Create a reference ellipsoid and then convert the geodetic latitude to geocentric latitude. The reference ellipsoid contains a flattening factor.

```
s = wgs84Ellipsoid;
geocentricLatitude(45, s.Flattening)

ans =

    44.8076
```

Convert Geodetic Latitude Expressed in Radians to Geocentric Latitude

Create a reference ellipsoid and then convert a geodetic latitude expressed in radians to geocentric latitude. The reference ellipsoid contains a flattening factor.

```
s = wgs84Ellipsoid;
geocentricLatitude(pi/3, s.Flattening, 'radians')

ans =

    1.0443
```

Input Arguments

phi — Geodetic latitude of one or more points

scalar value, vector, matrix, or N-D array

Geodetic latitude of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types: `single` | `double`

F — Flattening of reference spheroid

scalar

Flattening of reference spheroid, specified as a scalar value.

Data Types: `single` | `double`

angleUnit — Unit of measurement for angle

'degrees' (default) | 'radians'

Unit of measurement for angle, specified as either 'degrees' or 'radians'.

Data Types: `char`

Output Arguments

psi — Geocentric latitudes of one or more points

scalar value, vector, matrix, or N-D array

Geocentric latitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Values are in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Version History

Introduced in R2013a

See Also

Functions

`parametricLatitude` | `geodeticLatitudeFromGeocentric`

Objects

`AuthalicLatitudeConverter` | `ConformalLatitudeConverter` | `IsometricLatitudeConverter` | `RectifyingLatitudeConverter`

geoclip

Clip geographic shape to latitude-longitude limits

Syntax

```
clipped = geoclip(shape,latlim,lonlim)
```

Description

`clipped = geoclip(shape,latlim,lonlim)` clips the geographic point, line, or polygon shapes in `shape` to the latitude and longitude limits in `latlim` and `lonlim`, respectively.

To crop raster data that is represented by an array and a geographic raster reference object, use the `geocrop` function instead.

Examples

Clip Shapes in Geographic Coordinates

Read worldwide land areas as a geospatial table. Extract the polygon shapes.

```
land = readgeotable("landareas.shp");  
shape = land.Shape
```

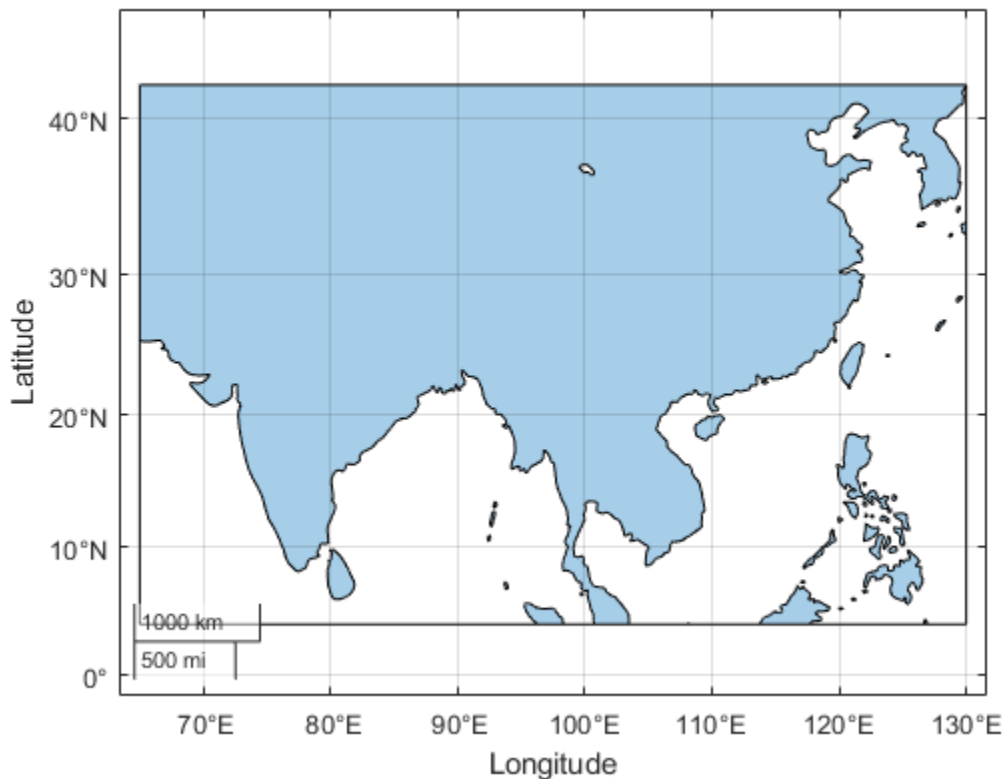
```
shape=537x1 object  
16x1 geoplyshape array with properties:  
  
    NumRegions: [16x1 double]  
    NumHoles: [16x1 double]  
    Geometry: "polygon"  
    CoordinateSystemType: "geographic"  
    GeographicCRS: [1x1 geocrs]  
    :
```

Specify the latitude and longitude limits for an area containing part of Asia. Then, clip the shapes.

```
latlim = [4 42];  
lonlim = [65 130];  
clipped = geoclip(shape,latlim,lonlim);
```

Display the clipped shapes on a map with no basemap. Display the bounding box as a rectangle.

```
figure  
geobasemap none  
hold on  
geoplot(clipped)  
geoplot(latlim([1 2 2 1 1]),lonlim([1 1 2 2 1]),"k")
```



Remove Shapes with No Coordinate Data from Output

Read the names and locations of world cities as a geospatial table. Extract the point shapes.

```
cities = readgeotable("worldcities.shp");
shape = cities.Shape

shape =
    318x1 geopointshape array with properties:

        NumPoints: [318x1 double]
        Latitude: [318x1 double]
        Longitude: [318x1 double]
        Geometry: "point"
    CoordinateSystemType: "geographic"
    GeographicCRS: [1x1 geocrs]
```

Specify the latitude and longitude limits for an area containing part of Asia. Then, clip the shapes.

```
latlim = [4 42];
lonlim = [65 130];
clipped = geoclip(shape,latlim,lonlim);
```

When a point shape lies outside the specified limits, the clipped shape has no coordinate data and the `NumPoints` property is 0. Remove shapes with no coordinate data from the clipped shapes.

```
idx = clipped.NumPoints ~= 0;
clipped = clipped(idx)

clipped =
  57x1 geopointshape array with properties:

      NumPoints: [57x1 double]
      Latitude: [57x1 double]
      Longitude: [57x1 double]
      Geometry: "point"
  CoordinateSystemType: "geographic"
      GeographicCRS: [1x1 geocrs]
```

When a line or polygon shape has no coordinate data, its respective `NumParts` or `NumRegions` property is 0.

Shift Longitude Limits

Create a line shape in geographic coordinates from global coastline data. The longitude coordinates are in the range of -180 to 180 degrees.

```
load coastlines
coast = geolineshape(coastlat,coastlon)

coast =
  geolineshape with properties:

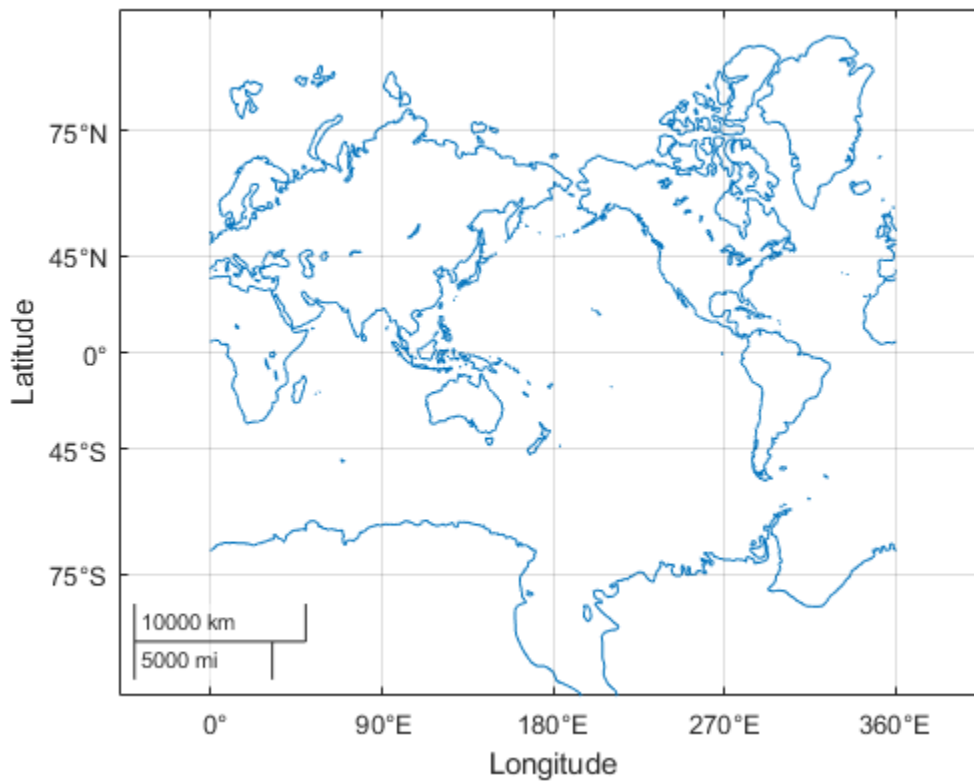
      NumParts: 241
      Geometry: "line"
  CoordinateSystemType: "geographic"
      GeographicCRS: []
```

Shift the longitude coordinates so they are in the range of 0 to 360 degrees.

```
coastShift = geoclip(coast,[-90 90],[0 360]);
```

Display the shifted line shape on a map.

```
figure
geobasemap none
hold on
geoplot(coastShift)
```



Input Arguments

shape — Shape

geopointshape, geolineshape, or geopolyshape object | array of geopointshape, geolineshape, or geopolyshape objects

Shape, specified as a geopointshape, geolineshape, or geopolyshape object or as an array of geopointshape, geolineshape, or geopolyshape objects. When you specify an array, you can include a combination of point, line, and polygon shape objects.

latlim — Latitude limits

two-element vector

Latitude limits, specified as a two-element vector of the form `[slat nlat]`, where `slat` is the southern limit in degrees and `nlat` is the northern limit in degrees.

lonlim — Longitude limits

two-element vector

Longitude limits, specified as a two-element vector of the form `[wlon elon]`, where `wlon` is the western limit in degrees and `elon` is the eastern limit in degrees.

Output Arguments

clipped — Clipped shape

geopointshape, geolineshape, or geopolyshape object | array of geopointshape, geolineshape, or geopolyshape objects

Clipped shape, returned as a geopointshape, geolineshape, or geopolyshape object or as an array of geopointshape, geolineshape, or geopolyshape objects.

clipped has the same type and size as shape.

If an element of shape lies completely outside the specified limits, then the corresponding element of clipped does not contain coordinate data. When a point, line, or polygon shape does not contain coordinate data, its respective NumPoints, NumParts, or NumRegions property is 0.

Tips

- If you clip a shape within a geospatial table, the function does not modify any attributes of the table.
- If you do not know the latitude and longitude limits you want, you can open and explore a geographic axes by using the `geoaxes` function. Return the limits of the axes by using the `geolimits` function or interactively select the southwest and northeast corners of a bounding box by using the `ginput` function.

Version History

Introduced in R2022a

See Also

Functions

mapclip | geocrop

Topics

“Create Geospatial Tables”

geocontourxy

Contour grid in local system with latitude-longitude results

Syntax

```
[contourLines, contourPolygons] = geocontourxy(X,Y,Z,lat0,lon0,h0)
[ ___ ] = geocontourxy( ___,Name,Value)
```

Description

[contourLines, contourPolygons] = geocontourxy(X,Y,Z,lat0,lon0,h0) returns line and polygon geoshapes containing contour lines and contour fill polygons, respectively. This function is non-graphical. You can plot the return values using `geoshow`, if desired.

[___] = geocontourxy(___,Name,Value) specifies name-value pairs that control aspects of the operation. Parameter names can be abbreviated and are case-insensitive.

Examples

Calculate Contour Lines and Polygons for Area Near Hawaii

Define a set of *X* and *Y* coordinates and create contour lines and contour polygons.

```
X = -150000:10000:150000;
Y = 0:10000:300000;
[xmesh, ymesh] = meshgrid(X/50000, (Y - 150000)/50000);
Z = 8 + peaks(xmesh, ymesh);
lat0 = dm2degrees([ 21 18]);
lon0 = dm2degrees([-157 49]);
h0 = 300;
levels = 0:2:18;
```

```
[contourLines, contourPolygons] = geocontourxy(X,Y,Z,lat0,lon0,h0, ...
    'LevelList',levels, 'XYRotation',120)
```

```
contourLines =
    8x1 geoshape vector with properties:
```

```
Collection properties:
```

```
    Geometry: 'line'
```

```
    Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(8 features concatenated with 7 delimiters)
```

```
    Latitude: [21.1171 21.0296 20.9819 20.9814 20.9880 21.0702 21.1122 21.1431 21.1671 21.1631]
```

```
    Longitude: [-158.5364 -158.5053 -158.4015 -158.3987 -158.3903 -158.3425 -158.3542 -158.3815]
```

```
    Height: [769.9110 771.5545 686.9961 684.5002 672.2181 584.6248 578.2085 599.1402 650.4110]
```

```
Feature properties:
```

```
    ContourLevel: [2 4 6 8 10 12 14 16]
```

```
contourPolygons =
```

```
    9x1 geoshape vector with properties:
```

```

Collection properties:
    Geometry: 'polygon'
    Metadata: [1x1 struct]
Vertex properties:
(9 features concatenated with 8 delimiters)
    Latitude: [21.1171 21.1630 21.1671 21.1431 21.1122 21.0702 20.9880 20.9814 20.9819 2
    Longitude: [-158.5364 -158.5114 -158.4450 -158.3876 -158.3542 -158.3425 -158.3903 -15
    Height: [769.9110 725.7670 650.4579 599.1402 578.2085 584.6248 672.2181 684.5002 6
Feature properties:
    LowerContourLevel: [0 2 4 6 8 10 12 14 16]
    UpperContourLevel: [2 4 6 8 10 12 14 16 18]

```

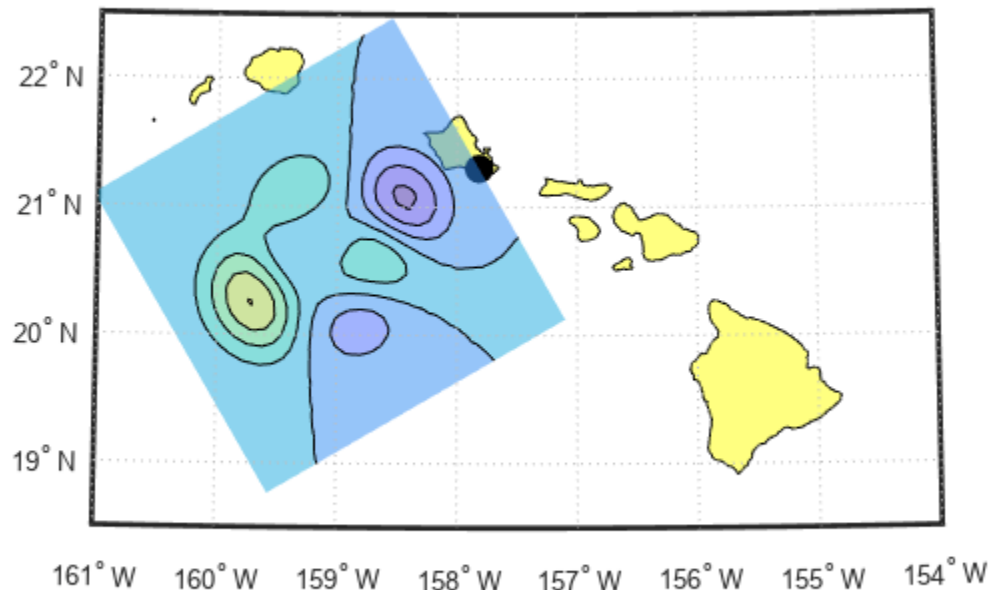
Display Hawaii on a map, add a marker, and then display the polygons returned by `geocontourxy` on the map.

```

figure
usamap([18.5 22.5],[-161 -154])
hawaii = shaperead('usastatehi.shp', 'UseGeoCoords', true,...
    'Selector',{@(name) strcmpi(name,'Hawaii'), 'Name'});
geoshow(hawaii)
geoshow(lat0,lon0,'DisplayType','point','Marker','o',...
    'MarkerEdgeColor','k','MarkerFaceColor','k','MarkerSize',10)

cmap = parula(1 + length(levels));
for k = 1:length(contourPolygons)
    lat = contourPolygons(k).Latitude;
    lon = contourPolygons(k).Longitude;
    geoshow(lat,lon,'Display','polygon', ...
        'FaceColor',cmap(k,:), 'FaceAlpha',0.5, 'EdgeColor','none')
end
geoshow(contourLines.Latitude,contourLines.Longitude,'Color','black')

```



Input Arguments

X — X-component of a mesh that locates each element of Z in a local x-y plane

vector or matrix

X-component of a mesh that locates each element of Z in a local x-y plane, specified as a vector or matrix. `geocontourxy` assumes that units are meters unless you provide a `Spheroid` input, in which case the units of your input must match the `LengthUnit` property of the `Spheroid` object.

Data Types: `single` | `double`

Y — Y-component of a mesh that locates each element of Z in a local x-y plane

vector or matrix

Y-component of a mesh that locates each element of Z in a local x-y plane. specified as a vector or matrix. `geocontourxy` assumes that units are meters unless you provide a `Spheroid` input, in which case the units of your input must match the `LengthUnit` property of the `Spheroid` object.

Data Types: `single` | `double`

Z — Data to be contoured

2-D array

Data to be contoured, specified as a 2-D array.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

lat0 — Geodetic latitude of local origin (reference) point

scalar value in units of degrees

Geodetic latitude of local origin (reference) point, specified as a scalar value in units of degrees.

Data Types: `single` | `double`**lon0 — Geodetic longitude of local origin (reference) point**

scalar value in units of degrees

Geodetic longitude of local origin (reference) point, specified as a scalar value in units of degrees.

Data Types: `single` | `double`**h0 — Ellipsoidal height of local origin (reference) point**

scalar value

Ellipsoidal height of local origin (reference) point, specified as a scalar value. `geocontourxy` assumes that units are meters unless you provide a `Spheroid` input, in which case the units of your input must match the unit specified in the `LengthUnit` property of the `Spheroid` object.Data Types: `single` | `double`**Name-Value Pair Arguments**Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.*Before R2021a, use commas to separate each name and value, and enclose Name in quotes.*Example: `[contourLines, contourPolygons] = geocontourxy(X,Y,Z,lat0,lon0,h0,'LevelList',levels,'XYRotation',120)`**LevelList — Contour levels**

vector of Z-values

Contour levels, specified as a vector of Z-values. By default, the `geocontourxy` function chooses levels that span the range of values.Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`**XYRotation — Rotation angle of the local x-y system**

0 (default) | scalar value in units of degrees

Rotation angle of the local x-y system, measured counterclockwise from the *xEast-yNorth* system, specified as a scalar value in units of degrees.Data Types: `single` | `double`**Spheroid — Reference spheroid**WGS84 reference ellipsoid (default) | `referenceEllipsoid` | `oblateSpheroid` | `referenceSphere`Reference spheroid, specified as a `referenceEllipsoid`, `oblateSpheroid`, or `referenceSphere` object. Use the constructor for one of these three classes, or the `wgs84Ellipsoid` function, to construct a Mapping Toolbox spheroid object. (You cannot directly pass in to `geocontourxy` the name of your spheroid. Instead, pass that name to `referenceEllipsoid` or `referenceSphere` and

use the resulting object.) By default, `geocontourxy` uses the WGS84 reference ellipsoid with units of meters.

Output Arguments

contourLines — Contour lines

line geoshape

Contour lines, returned as a line `geoshape` with one element per contour level. `Latitude` and `Longitude` properties contain contour line vertices in degrees. The contour level value of the k -th element is stored in the `ContourLevel` feature property of `contourLines(k)`. A third vertex property, `Height`, contains the ellipsoidal height of each vertex. In combination with `Latitude` and `Longitude`, it completes the definition of the 3-D location of the contour line in the plane that contains the local origin and is parallel to the tangent plane at the origin latitude and longitude.

contourPolygons — Contour polygons

polygon geoshape

Contour polygons, returned as a polygon `geoshape` with one element (contour fill polygon) per contour interval. `Latitude` and `Longitude` properties contain the vertices of the contour fill polygons, specified in degrees. The `LowerContourLevel` and `UpperContourLevel` properties of `contourPolygons(k)` store the limits of the k -th contour interval. As in the case of lines, a third vertex property, `Height`, is included.

Version History

Introduced in R2016a

See Also

`contourm` | `contourfm` | `geodetic2enu` | `enu2geodetic`

Topics

“Create and Display Polygons”

geocrop

Crop geographic raster

Syntax

```
[B,RB] = geocrop(A,RA,latlim,lonlim)
```

Description

`[B,RB] = geocrop(A,RA,latlim,lonlim)` crops the raster specified by `A` and raster reference `RA` and returns the cropped raster `B` and raster reference `RB`. The returned raster is cropped to geographic limits in degrees close to those specified by `latlim` and `lonlim`.

To clip vector data represented by a point, line, or polygon shape in geographic coordinates, use the `geoclip` function instead.

Examples

Crop Geographic Raster

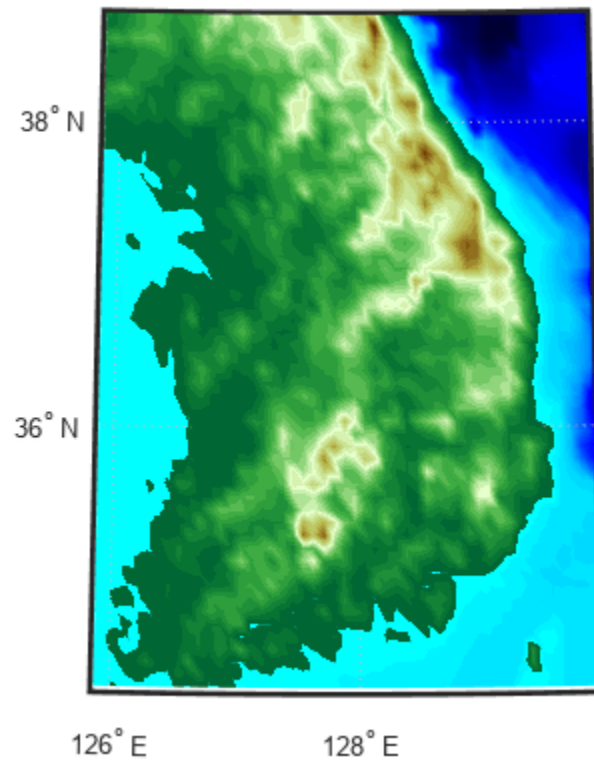
Crop a geographic raster and display the cropped raster on a map.

First, load elevation raster data and a geographic cells reference object for the Korean peninsula. Then, crop the raster to the limits specified by `latlim` and `lonlim`.

```
load korea5c
latlim = [34.25 38.72];
lonlim = [125.85 129.92];
[B,RB] = geocrop(korea5c,korea5cR,latlim,lonlim);
```

Display the cropped raster as a surface on a map. Apply a colormap appropriate for elevation data using the `demcmap` function.

```
worldmap(latlim,lonlim)
geoshow(B,RB,'DisplayType','surface')
demcmap(B)
```



Shift Longitude Limits

Shift the longitude limits of a raster with limits that span 360 degrees using the `geocrop` function. Then, display the shifted data as a surface on a map.

First, load elevation raster data for the world and a geographic cells reference object. Then, shift the longitude limits of the raster from `[0, 360]` to `[-180, 180]`.

```
load topo60c
latlim = topo60cR.LatitudeLimits;
[B,RB] = geocrop(topo60c,topo60cR,latlim,[-180 180]);
```

Compare the rasters by querying their `LongitudeLimits` properties.

```
topo60cR.LongitudeLimits
```

```
ans = 1×2
      0   360
```

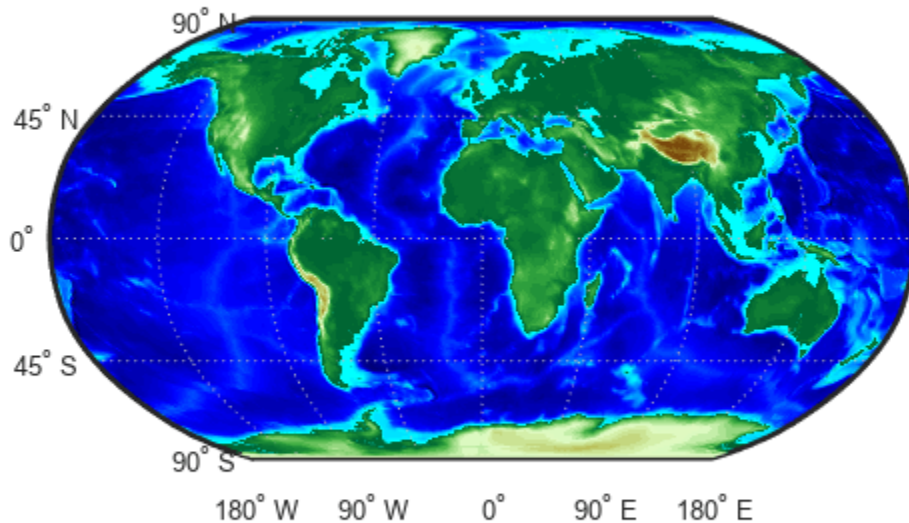
```
RB.LongitudeLimits
```

```
ans = 1×2
```

```
-180 180
```

Display the shifted data as a surface on a map. Move the meridian labels to the bottom of the map using the `mLabel` function. Specify meridian labels to display using the `MLabelLocation` property. Then, apply a colormap appropriate for topographic data using the `demcmap` function. Note that the shifted longitude limits appear at the edges of the map.

```
worldmap(RB.LatitudeLimits,RB.LongitudeLimits)  
geoshow(B,RB,'DisplayType','surface')  
mlabel('south')  
setm(gca,'MLabelLocation',-180:90:180)  
demcmap(B)
```



Input Arguments

A — Geographic raster

array

Geographic raster, specified as an *M*-by-*N* or *M*-by-*N*-by-*P* numeric or logical array.

RA — Raster reference

GeographicCellsReference object | GeographicPostingsReference object

Raster reference for A, specified as a GeographicCellsReference object or GeographicPostingsReference object.

latlim — Latitude limits

two-element vector

Latitude limits, specified as a two-element numeric vector of the form `[slat nlat]`, where `slat` is the southernmost limit in degrees and `nlat` is the northernmost limit in degrees.

lonlim — Longitude limits

two-element vector

Longitude limits, specified as a two-element numeric vector of the form `[wlon elon]`, where `wlon` is the westernmost limit in degrees and `elon` is the easternmost limit in degrees.

Output Arguments**B — Cropped geographic raster**

array

Cropped geographic raster, returned as a numeric or logical array. The data type and size of B matches the data type and size of A.

If the limits specified by `latlim` and `lonlim` do not intersect the raster specified by A and RA, then B is empty.

RB — Raster reference

GeographicCellsReference object | GeographicPostingsReference object

Raster reference for B, returned as a `GeographicCellsReference` object or `GeographicPostingsReference` object. The object type of RB matches the object type of RA.

The exact latitude and longitude limits of RB do not match the limits specified by `latlim` and `lonlim`, unless they coincide with a cell boundary or posting location. Otherwise, the limits of RB are slightly larger than `latlim` and `lonlim`.

If the limits specified by `latlim` and `lonlim` do not intersect the raster specified by A and RA, then RB is empty.

Version History

Introduced in R2020a

See Also

mapcrop | geoclip | georesize

geocrs

Geographic coordinate reference system object

Description

A geographic coordinate reference system (CRS) provides information that assigns latitude, longitude, and height coordinates to physical locations. Geographic CRSs consist of a datum, a prime meridian, and an angular unit of measurement.

Projected CRSs consist of a geographic CRS and several parameters that are used to transform coordinates to and from the geographic CRS. For more information about projected CRSs, see `projcrs`.

Creation

You can create a geographic CRS object in several ways:

- Import raster data using functions such as `readgeoraster` or `wmsread`, and then query the `GeographicCRS` property of the returned raster reference object.
- Import vector data by using the `readgeotable` function, and then query the `GeographicCRS` property of the shape objects in the returned geospatial table.
- Get information about a shapefile using the `shapeinfo` function, and then query the `CoordinateReferenceSystem` field of the returned structure.
- Access the geographic CRS of a projected CRS by querying the `GeographicCRS` property of a `projcrs` object.
- Use the `geocrs` function (described here).

Syntax

```
g = geocrs(code)
g = geocrs(code, "Authority", authority)
g = geocrs(wkt)
```

Description

`g = geocrs(code)` creates a geographic CRS object using the EPSG code specified by `code`.

`g = geocrs(code, "Authority", authority)` creates a geographic CRS object using the specified code and authority.

`g = geocrs(wkt)` creates a geographic CRS object using a specified well-known text (WKT) string representation.

Input Arguments

code — Geographic CRS code

positive integer | string scalar | character vector

Geographic CRS code, specified as a positive integer, string scalar, or character vector. By default, the `geocrs` function assumes the `code` argument refers to an EPSG code. To specify other types of codes, use the "Authority" name-value pair.

To refer to an EPSG or ESRI code, specify this argument as a positive integer. To refer to an IGNF code, specify this argument as a string scalar or character vector.

For information on valid EPSG codes, see the EPSG home page.

authority — Organization that manages definition of CRS

"EPSG" (default) | "ESRI" | "IGNF"

Organization that manages the definition of the CRS, specified as "EPSG", "ESRI", or "IGNF". Each organization maintains a list of codes associated with specific CRSs.

If you do not specify an authority, then the `geocrs` function uses "EPSG".

wkt — Well-known text

string scalar | character vector

Well-known text (WKT), specified as a string scalar or character vector. You can use well-known text in either the WKT 1 or WKT 2 standard.

Properties

Name — CRS name

string scalar

This property is read-only.

CRS name, returned as a string scalar.

Data Types: `string`

Datum — Datum name

string scalar

This property is read-only.

Datum name, returned as a string scalar.

Data Types: `string`

Spheroid — Reference spheroid

`referenceEllipsoid` object | `referenceSphere` object | `oblateSpheroid` object

This property is read-only.

Reference spheroid used by the datum, returned as a `referenceEllipsoid` object, `referenceSphere` object, or `oblateSpheroid` object.

Data Types: `string`

PrimeMeridian — Longitude origin offset from Greenwich

double

This property is read-only.

Longitude origin offset from Greenwich, returned as a double. The units of the PrimeMeridian property match the value of the AngleUnit property.

Data Types: double

AngleUnit — Angle unit

string scalar

This property is read-only.

Angle unit, returned as a string scalar. The typical values are "degree" and "radian".

Data Types: string

Object Functions

wktstring Well-known text string

isequal Compare two projcrs or geocrs objects for equivalence

Examples

Get Geographic CRS from EPSG Code

Create a geographic CRS object by specifying an EPSG code.

```
g = geocrs(6668)
g =
  geocrs with properties:
      Name: "JGD2011"
      Datum: "Japanese Geodetic Datum 2011"
      Spheroid: [1x1 referenceEllipsoid]
      PrimeMeridian: 0
      AngleUnit: "degree"
```

Get Geographic CRS from ESRI Code

Create a geographic CRS object from an ESRI code by using the Authority name-value argument.

```
g = geocrs(37220, "Authority", "ESRI")
g =
  geocrs with properties:
      Name: "GCS_Guam_1963"
      Datum: "D_Guam_1963"
      Spheroid: [1x1 referenceEllipsoid]
      PrimeMeridian: 0
      AngleUnit: "degree"
```

Get Geographic CRS from IGNF Code

Create a geographic CRS object from an IGNF code by using the Authority name-value argument. Specify the code using a string scalar or character vector.

```
g = geocrs("RGFG95G", "Authority", "IGNF")

g =
  geocrs with properties:
      Name: "RGFG95 geographiques (dms)"
      Datum: "Reseau Geodesique Francais Guyane 1995"
      Spheroid: [1x1 referenceEllipsoid]
      PrimeMeridian: 0
      AngleUnit: "degree"
```

Get Geographic CRS from Projection File

Import a WKT projection file as a character vector using the `fileread` function. Then, create a geographic CRS object by specifying the vector.

```
wkt = fileread('landareas.prj');
g = geocrs(wkt)

g =
  geocrs with properties:
      Name: "WGS 84"
      Datum: "World Geodetic System 1984"
      Spheroid: [1x1 referenceEllipsoid]
      PrimeMeridian: 0
      AngleUnit: "degree"
```

Get Geographic CRS from Imported Raster Data

Import raster data as an array and a geographic reference object using the `readgeoraster` function. Then, get the geographic CRS by querying the `GeographicCRS` property of the reference object.

```
[Z,R] = readgeoraster('n39_w106_3arc_v2.dt1');
R.GeographicCRS

ans =
  geocrs with properties:
      Name: "WGS 84"
      Datum: "World Geodetic System 1984"
      Spheroid: [1x1 referenceEllipsoid]
      PrimeMeridian: 0
      AngleUnit: "degree"
```

Alternatively, return information about the same file as a `RasterInfo` object using the `georasterinfo` function. Then, get the geographic CRS by querying the `CoordinateReferenceSystem` property of the object.

```
info = georasterinfo('n39_w106_3arc_v2.dt1');  
info.CoordinateReferenceSystem
```

```
ans =  
geocrs with properties:  
  
    Name: "WGS 84"  
    Datum: "World Geodetic System 1984"  
    Spheroid: [1x1 referenceEllipsoid]  
    PrimeMeridian: 0  
    AngleUnit: "degree"
```

Find Reference Ellipsoid for Geographic CRS

Find the reference ellipsoid for a geographic CRS by creating a `geocrs` object and accessing its `Spheroid` property.

```
g = geocrs(4957);  
g.Spheroid
```

```
ans =  
referenceEllipsoid with defining properties:
```

```
    Code: 7019  
    Name: 'GRS 1980'  
    LengthUnit: 'meter'  
    SemimajorAxis: 6378137  
    SemiminorAxis: 6356752.31414036  
    InverseFlattening: 298.257222101  
    Eccentricity: 0.0818191910428158
```

```
and additional properties:
```

```
    Flattening  
    ThirdFlattening  
    MeanRadius  
    SurfaceArea  
    Volume
```

Version History

Introduced in R2020b

See Also

Functions

`fileread`

Objects

projcrs | referenceEllipsoid

Topics

“Comparison of Reference Spheroids”

External Websites

EPSG home page

geodetic2aer

Transform geodetic coordinates to local spherical

Syntax

```
[az,elev,slantRange] = geodetic2aer(lat,lon,h,lat0,lon0,h0,spheroid)
[az,elev,slantRange] = geodetic2aer( ____,angleUnit)
```

Description

`[az,elev,slantRange] = geodetic2aer(lat,lon,h,lat0,lon0,h0,spheroid)` transforms the geodetic coordinates specified by `lat`, `lon`, and `h` to the local azimuth-elevation-range (AER) spherical coordinates specified by `az`, `elev`, and `slantRange`. Specify the origin of the local AER system with the geodetic coordinates `lat0`, `lon0`, and `h0`. Each coordinate input argument must match the others in size or be scalar. Specify `spheroid` as the reference spheroid for the geodetic coordinates.

`[az,elev,slantRange] = geodetic2aer(____,angleUnit)` specifies the units for latitude, longitude, azimuth, and elevation. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate AER Coordinates from Geodetic Coordinates

Find the AER coordinates of the Matterhorn with respect to Zermatt, Switzerland, using the geodetic coordinates of Zermatt and the Matterhorn.

First, specify the reference spheroid as WGS 84. For more information about WGS 84, see “Comparison of Reference Spheroids”. The units for ellipsoidal height and slant range must match the units specified by the `LengthUnit` property of the reference spheroid. The default length unit for the reference spheroid created by `wgs84Ellipsoid` is 'meter'.

```
wgs84 = wgs84Ellipsoid;
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is Zermatt. Specify `h0` as ellipsoidal height in meters.

```
lat0 = 46.017;
lon0 = 7.750;
h0 = 1673;
```

Specify the geodetic coordinates of the point of interest. In this example, the point of interest is the Matterhorn. Specify `h` as ellipsoidal height in meters.

```
lat = 45.977;
lon = 7.658;
h = 4531;
```

Then, calculate the AER coordinates of the Matterhorn with respect to Zermatt. To view the results in standard notation, specify the display format as `shortG`.


```
format shortG
[az,elev,slantRange] = geodetic2aer(lat,lon,h,lat0,lon0,h0,wgs84)

az =
    238.08

elev =
    18.744

slantRange =
    8876.8
```

Reverse the transformation using the `aer2geodetic` function.

```
[lat,lon,h] = aer2geodetic(az,elev,slantRange,lat0,lon0,h0,wgs84)

lat =
    45.977

lon =
    7.658

h =
    4531
```

Input Arguments

lat — Geodetic latitude

scalar | vector | matrix | N-D array

Geodetic latitude of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon — Geodetic longitude

scalar | vector | matrix | N-D array

Geodetic longitude of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h — Ellipsoidal height

scalar | vector | matrix | N-D array

Ellipsoidal height of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

lat0 — Geodetic latitude of local origin

`scalar` | `vector` | `matrix` | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

`scalar` | `vector` | `matrix` | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h0 — Ellipsoidal height of local origin

`scalar` | `vector` | `matrix` | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments**az — Azimuth angles**

`scalar` | `vector` | `matrix` | N-D array

Azimuth angles of one or more points in the local AER system, returned as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Values are specified in degrees within the half-open interval [0 360). To use values in radians, specify the `angleUnit` argument as 'radians'.

elev — Elevation angles

scalar | vector | matrix | N-D array

Elevation angles of one or more points in the local AER system, returned as a scalar, vector, matrix, or N-D array. Elevations are measured with respect to a plane that is perpendicular to the normal of the spheroid surface. If the local origin is on the surface of the spheroid ($h_0 = 0$), then the plane is tangent to the spheroid.

Values are specified in degrees within the closed interval [-90 90]. To use values in radians, specify the `angleUnit` argument as 'radians'.

sLantRange — Distances from local origin

scalar | vector | matrix | N-D array

Distances from the local origin, returned as a scalar, vector, matrix, or N-D array. Each distance is calculated along a straight, 3-D, Cartesian line. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `geodetic2aer` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`aer2geodetic` | `ecef2aer` | `geodetic2enu` | `geodetic2ned`

Topics

“Comparison of 3-D Coordinate Systems”

geodetic2ecef

Transform geodetic coordinates to geocentric Earth-centered Earth-fixed

Syntax

```
[X,Y,Z] = geodetic2ecef(spheroid,lat,lon,h)
```

```
[X,Y,Z] = geodetic2ecef( ____,angleUnit)
```

```
[X,Y,Z] = geodetic2ecef(lat,lon,h,spheroid)
```

Description

`[X,Y,Z] = geodetic2ecef(spheroid,lat,lon,h)` transforms the geodetic coordinates specified by `lat`, `lon`, and `h` to the geocentric Earth-Centered Earth-Fixed (ECEF) Cartesian coordinates specified by `X`, `Y`, and `Z`. Specify `spheroid` as the reference spheroid for the geodetic coordinates.

`[X,Y,Z] = geodetic2ecef(____,angleUnit)` specifies the units for latitude and longitude. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

`[X,Y,Z] = geodetic2ecef(lat,lon,h,spheroid)` is supported but not recommended. Unlike the previous syntaxes, specify `lat` and `lon` in radians. Specify `spheroid` as either a reference spheroid or an ellipsoid vector of the form `[semimajor_axis, eccentricity]`. Specify `h` in the same units as the length unit of the `spheroid` argument. Additionally, the outputs `X`, `Y`, and `Z` return in the same units as the length unit of the `spheroid` argument.

Examples

Calculate ECEF Coordinates Using Geodetic Coordinates

Find the ECEF coordinates of Paris, France, using its geodetic coordinates.

First, specify the reference spheroid as WGS84 with length units measured in kilometers. For more information about WGS84, see "Comparison of Reference Spheroids". The units for the ellipsoidal height and ECEF coordinates must match the units specified by the `LengthUnit` property of the reference spheroid.

```
wgs84 = wgs84Ellipsoid('kilometer');
```

Specify the geodetic coordinates of Paris. Specify `h` as ellipsoidal height in kilometers.

```
lat = 48.8562;  
lon = 2.3508;  
h = 0.0674;
```

Then, calculate the ECEF coordinates of Paris. In this example, `x` and `y` display in scientific notation.

```
[x,y,z] = geodetic2ecef(wgs84,lat,lon,h)
```

```
x = 4.2010e+03
```

```
y = 172.4603
z = 4.7801e+03
```

Reverse the transformation using the `ecef2geodetic` function.

```
[lat,lon,h] = ecef2geodetic(wgs84,x,y,z)
lat = 48.8562
lon = 2.3508
h = 0.0674
```

Input Arguments

spheroid — Reference spheroid

referenceEllipsoid object | oblateSpheroid object | referenceSphere object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

lat — Geodetic latitude

scalar | vector | matrix | N-D array

Geodetic latitude of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon — Geodetic longitude

scalar | vector | matrix | N-D array

Geodetic longitude of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h — Ellipsoidal height

scalar | vector | matrix | N-D array

Ellipsoidal height of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as 'degrees' (the default) or 'radians'.

Output Arguments

X — ECEF x-coordinates

scalar | vector | matrix | N-D array

ECEF x-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Y — ECEF y-coordinates

scalar | vector | matrix | N-D array

ECEF y-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Z — ECEF z-coordinates

scalar | vector | matrix | N-D array

ECEF z-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Tips

- The geocentric Cartesian (ECEF) coordinate system is fixed with respect to the Earth, with its origin at the center of the spheroid and its positive x-, y-, and z-axes intersecting the surface at the following points:

	Latitude	Longitude	Notes
x-axis	0	0	Equator at the Prime Meridian
y-axis	0	90	Equator at 90-degrees East
z-axis	90	0	North Pole

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `geodetic2ecef` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

[ecef2geodetic](#) | [ecef0ffset](#) | [geodetic2aer](#) | [geodetic2ned](#) | [geodetic2enu](#) | [ecef2enu](#)

Topics

“Comparison of 3-D Coordinate Systems”

geodetic2enu

Transform geodetic coordinates to local east-north-up

Syntax

```
[xEast,yNorth,zUp] = geodetic2enu(lat,lon,h,lat0,lon0,h0,spheroid)
[xEast,yNorth,zUp] = geodetic2enu( ____,angleUnit)
```

Description

`[xEast,yNorth,zUp] = geodetic2enu(lat,lon,h,lat0,lon0,h0,spheroid)` transforms the geodetic coordinates specified by `lat`, `lon`, and `h` to the local east-north-up (ENU) Cartesian coordinates specified by `xEast`, `yNorth`, and `zDown`. Specify the origin of the local ENU system with the geodetic coordinates `lat0`, `lon0`, and `h0`. Each coordinate input argument must match the others in size or be scalar. Specify `spheroid` as the reference spheroid for the geodetic coordinates.

`[xEast,yNorth,zUp] = geodetic2enu(____,angleUnit)` specifies the units for latitude and longitude. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate ENU Coordinates from Geodetic Coordinates

Find the ENU coordinates of the Matterhorn with respect to Zermatt, Switzerland, using their geodetic coordinates.

First, specify the reference spheroid as WGS84. For more information about WGS84, see “Comparison of Reference Spheroids”. The units for ellipsoidal height and ENU coordinates must match the units specified by the `LengthUnit` property of the reference spheroid. The default length unit for the reference spheroid created by `wgs84Ellipsoid` is 'meter'.

```
wgs84 = wgs84Ellipsoid;
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is Zermatt, Switzerland. Specify `h0` as ellipsoidal height in meters.

```
lat0 = 46.017;
lon0 = 7.750;
h0 = 1673;
```

Specify the geodetic coordinates of the point of interest. In this example, the point of interest is the Matterhorn. Specify `h` as ellipsoidal height in meters.

```
lat = 45.976;
lon = 7.658;
h = 4531;
```

Then, calculate the ENU coordinates of the Matterhorn with respect to Zermatt. View the results in standard notation by specifying the display format as `shortG`.


```
format shortG
[xEast,yNorth,zUp] = geodetic2enu(lat,lon,h,lat0,lon0,h0,wgs84)

xEast =
    -7134.8

yNorth =
    -4556.3

zUp =
    2852.4
```

Reverse the transformation using the `enu2geodetic` function.

```
[lat,lon,h] = enu2geodetic(xEast,yNorth,zUp,lat0,lon0,h0,wgs84)

lat =
    45.976

lon =
    7.658

h =
    4531
```

Input Arguments

lat — Geodetic latitude

scalar | vector | matrix | N-D array

Geodetic latitude of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon — Geodetic longitude

scalar | vector | matrix | N-D array

Geodetic longitude of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h — Ellipsoidal height

scalar | vector | matrix | N-D array

Ellipsoidal height of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

lat0 — Geodetic latitude of local origin

`scalar` | `vector` | `matrix` | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

`scalar` | `vector` | `matrix` | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h0 — Ellipsoidal height of local origin

`scalar` | `vector` | `matrix` | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments**xEast — ENU x-coordinates**

`scalar` | `vector` | `matrix` | N-D array

ENU x-coordinates of one or more points in the local ENU system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument.

For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

yNorth — ENU y-coordinates

scalar | vector | matrix | N-D array

ENU y-coordinates of one or more points in the local ENU system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

zUp — ENU z-coordinates

scalar | vector | matrix | N-D array

ENU z-coordinates of one or more points in the local ENU system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `geodetic2enu` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`ecef2enu` | `enu2geodetic` | `geodetic2aer` | `geodetic2ned`

Topics

“Comparison of 3-D Coordinate Systems”

geodetic2ned

Transform geodetic coordinates to local north-east-down

Syntax

```
[xNorth,yEast,zDown] = geodetic2ned(lat,lon,h,lat0,lon0,h0,spheroid)
[ ___ ] = geodetic2ned( ___ ,angleUnit)
```

Description

`[xNorth,yEast,zDown] = geodetic2ned(lat,lon,h,lat0,lon0,h0,spheroid)` transforms the geodetic coordinates specified by `lat`, `lon`, and `h` to the local north-east-down (NED) Cartesian coordinates specified by `xNorth`, `yEast`, and `zDown`. Specify the origin of the local NED system with the geodetic coordinates `lat0`, `lon0`, and `h0`. Each coordinate input argument must match the others in size or be scalar. Specify `spheroid` as the reference spheroid for the geodetic coordinates.

`[___] = geodetic2ned(___ ,angleUnit)` specifies the units for latitude and longitude. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate NED Coordinates from Geodetic Coordinates

Find the NED coordinates of Mount Mansfield with respect to a nearby aircraft, using their geodetic coordinates.

First, specify the reference spheroid as WGS 84. For more information about WGS 84, see "Comparison of Reference Spheroids". The units for the ellipsoidal height and NED coordinates must match the units specified by the `LengthUnit` property of the reference spheroid. The default length unit for the reference spheroid created by `wgs84Ellipsoid` is 'meter'.

```
wgs84 = wgs84Ellipsoid;
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is the aircraft. Specify `h0` as ellipsoidal height in meters.

```
lat0 = 44.532;
lon0 = -72.782;
h0 = 1699;
```

Specify the geodetic coordinates of the point of interest. In this example, the point of interest is Mount Mansfield. Specify `h` as ellipsoidal height in meters.

```
lat = 44.544;
lon = -72.814;
h = 1340;
```

Then, calculate the NED coordinates of Mount Mansfield with respect to the aircraft. Since the ellipsoidal height of the aircraft is greater than the height of Mount Mansfield, a passenger needs to look down to see the mountaintop. The `z`-axis of an NED coordinate system points down. Thus, the

value of `zDown` is positive. View the results in standard notation by specifying the display format as `shortG`.

```
format shortG
[xNorth,yEast,zDown] = geodetic2ned(lat,lon,h,lat0,lon0,h0,wgs84)

xNorth =
    1334.3

yEast =
   -2543.6

zDown =
    359.65
```

Reverse the transformation using the `ned2geodetic` function.

```
[lat,lon,h] = ned2geodetic(xNorth,yEast,zDown,lat0,lon0,h0,wgs84)

lat =
    44.544

lon =
   -72.814

h =
    1340
```

Input Arguments

lat — Geodetic latitude

scalar | vector | matrix | N-D array

Geodetic latitude of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon — Geodetic longitude

scalar | vector | matrix | N-D array

Geodetic longitude of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h — Ellipsoidal height

scalar | vector | matrix | N-D array

Ellipsoidal height of one or more points, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the spheroid object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h0 — Ellipsoidal height of local origin

scalar | vector | matrix | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

xNorth — NED x-coordinates

scalar | vector | matrix | N-D array

NED *x*-coordinates of one or more points in the local NED system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

yEast — NED y-coordinates

scalar | vector | matrix | N-D array

NED *y*-coordinates of one or more points in the local NED system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

zDown — NED z-coordinates

scalar | vector | matrix | N-D array

NED *z*-coordinates of one or more points in the local NED system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `geodetic2ned` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`ecef2ned` | `ned2geodetic` | `geodetic2aer` | `geodetic2enu`

Topics

“Comparison of 3-D Coordinate Systems”

geodetic2geocentricLat

(Removed) Convert geodetic to geocentric latitude

Note The `geodetic2geocentricLat` function has been removed. Use the `geocentricLatitude` function instead.

Syntax

```
phi_g = geodetic2geocentriclat(ecc, phi)
```

Description

`phi_g = geodetic2geocentriclat(ecc, phi)` converts an array of geodetic latitude in radians, `phi`, to geocentric latitude in radians, `phi_g`, on a reference ellipsoid with first eccentricity `ecc`.

Version History

Introduced in R2006b

R2023a: Removed

Errors starting in R2023a

The `geodetic2geocentricLat` function has been removed. Use the `geocentricLatitude` function instead.

R2022a: Warns

Warns starting in R2022a

The `geodetic2geocentricLat` function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The `geodetic2geocentricLat` function runs without warning but will be removed in a future release.

See Also

`geocentricLatitude`

geodeticLatitudeFromGeocentric

Convert geocentric to geodetic latitude

Syntax

```
phi = geodeticLatitudeFromGeocentric(psi,F)
phi = geodeticLatitudeFromGeocentric(psi,F,angleUnit)
```

Description

`phi = geodeticLatitudeFromGeocentric(psi,F)` returns the geodetic latitude corresponding to geocentric latitude `psi` on an ellipsoid with flattening `F`.

`phi = geodeticLatitudeFromGeocentric(psi,F,angleUnit)` specifies the units of input `psi` and output `phi`.

Examples

Convert Geocentric Latitude to Geodetic Latitude

Create a reference ellipsoid.

```
s = wgs84Ellipsoid;
```

Convert the geocentric latitude to geodetic latitude. The reference ellipsoid contains a flattening factor.

```
geodeticLatitudeFromGeocentric(45, s.Flattening)
ans = 45.1924
```

Convert Geocentric Latitude Expressed in Radians to Geodetic Latitude

Create a reference ellipsoid.

```
s = wgs84Ellipsoid;
```

Convert a geocentric latitude expressed in radians to geodetic latitude. The reference ellipsoid contains a flattening factor.

```
geodeticLatitudeFromGeocentric(pi/3, s.Flattening, 'radians')
ans = 1.0501
```

Input Arguments

psi — Geocentric latitude of one or more points

scalar value, vector, matrix, or N-D array

Geocentric latitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Values are in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types: `single` | `double`

F — Flattening of reference spheroid

scalar

Flattening of reference spheroid, specified as a scalar value.

Data Types: `double`

angleUnit — Unit of measurement for angle

'degrees' (default) | 'radians'

Unit of measurement for angle, specified as either 'degrees' or 'radians'.

Data Types: `char`

Output Arguments

phi — Geodetic latitude of one or more points

scalar value, vector, matrix, or N-D array

Geodetic latitude of one or more points, returned as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Version History

Introduced in R2013a

See Also

Functions

`geodeticLatitudeFromParametric` | `geocentricLatitude`

Objects

`AuthalicLatitudeConverter` | `ConformalLatitudeConverter` | `IsometricLatitudeConverter` | `RectifyingLatitudeConverter`

geodeticLatitudeFromParametric

Convert parametric to geodetic latitude

Syntax

```
phi = geodeticLatitudeFromParametric(beta,F)
phi = geodeticLatitudeFromParametric(beta,F,angleUnit)
```

Description

`phi = geodeticLatitudeFromParametric(beta,F)` returns the geodetic latitude corresponding to parametric latitude `beta` on an ellipsoid with flattening `F`.

`phi = geodeticLatitudeFromParametric(beta,F,angleUnit)` specifies the units of input `beta` and output `phi`.

Examples

Convert Parametric Latitude to Geodetic Latitude

Create a reference ellipsoid and then convert the parametric latitude to geodetic latitude. The reference ellipsoid contains a flattening factor.

```
s = wgs84Ellipsoid;
geodeticLatitudeFromParametric(45, s.Flattening)
ans =
    45.0962
```

Convert Parametric Latitude Expressed in Radians to Geodetic Latitude

Create a reference ellipsoid and then convert a parametric latitude expressed in radians to geodetic latitude. The reference ellipsoid contains a flattening factor.

```
s = wgs84Ellipsoid;
geodeticLatitudeFromParametric(pi/3, s.Flattening, 'radians')
ans =
    1.0487
```

Input Arguments

beta — Parametric latitude of one or more points

scalar value, vector, matrix, or N-D array

Parametric latitude of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types: `single` | `double`

F — Flattening of reference spheroid

scalar

Flattening of reference spheroid, specified as a scalar value.

Data Types: `double`

angleUnit — Unit of measurement for angle

'degrees' (default) | 'radians'

Unit of measurement for angle, specified as either 'degrees' or 'radians'.

Data Types: `char`

Output Arguments

phi — Geodetic latitudes of one or more points

scalar value, vector, matrix, or N-D array

Geodetic latitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Values are in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Version History

Introduced in R2013a

See Also

Functions

`geodeticLatitudeFromGeocentric` | `parametricLatitude`

Objects

`AuthalicLatitudeConverter` | `ConformalLatitudeConverter` |
`IsometricLatitudeConverter` | `RectifyingLatitudeConverter`

geoglobe

Create geographic globe

Syntax

```
geoglobe(parent)
geoglobe(parent,Name,Value)
g = geoglobe( ___ )
```

Description

`geoglobe(parent)` creates a geographic globe in the specified figure, panel, or tab group. The figure must be created using the `ui figure` function. For information about navigating the globe, see “Geographic Globe Navigation” on page 1-535.

The geographic globe requires hardware graphics support for WebGL™.

`geoglobe(parent,Name,Value)` specifies additional options for the globe using one or more name-value pair arguments. Specify the options after all other input arguments. For a list of options, see `GeographicGlobe`.

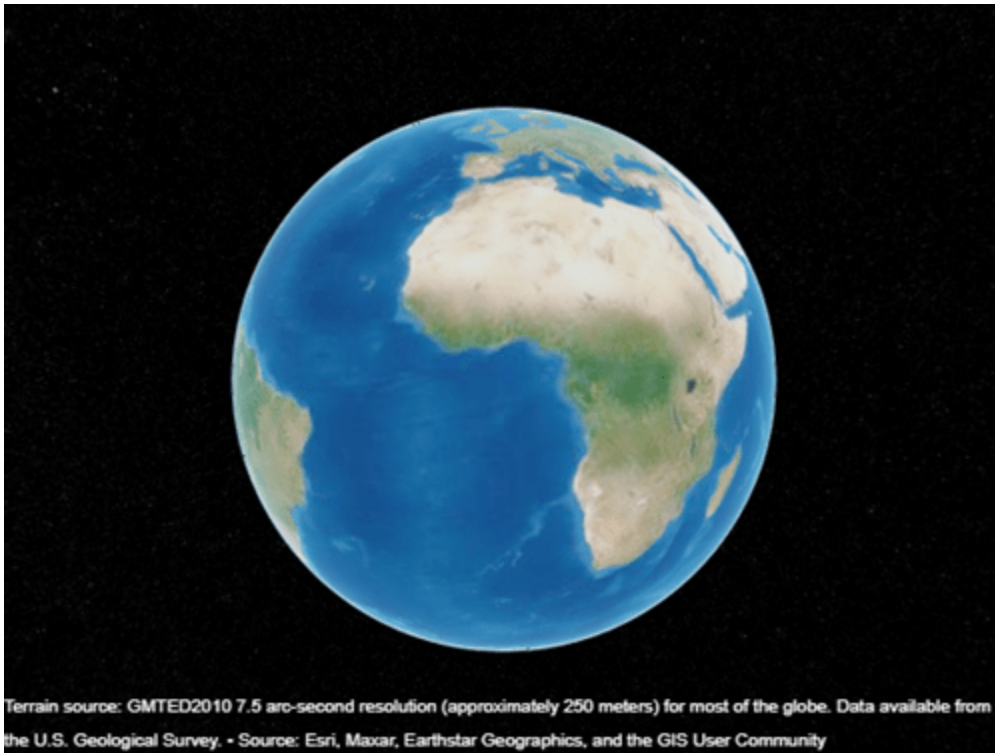
`g = geoglobe(___)` returns a `GeographicGlobe` object. This syntax is useful for controlling the properties of the geographic globe.

Examples

Display Geographic Globe

Display a geographic globe in a figure created using the `ui figure` function.

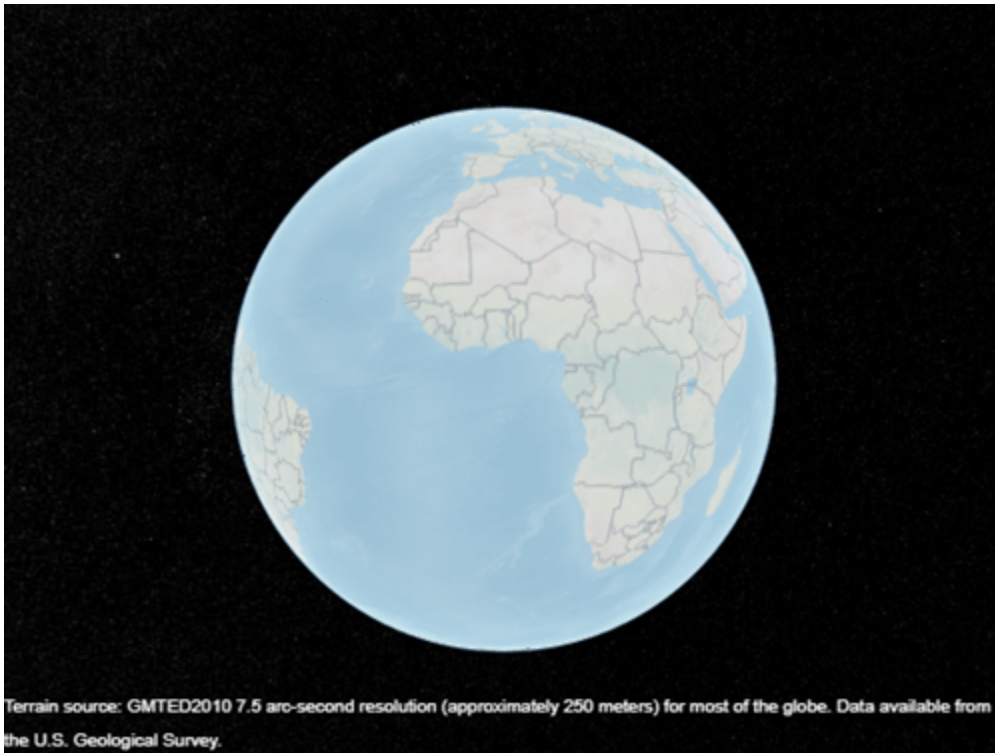
```
uif = uifigure;
g = geoglobe(uif);
```



Specify and Change Basemap

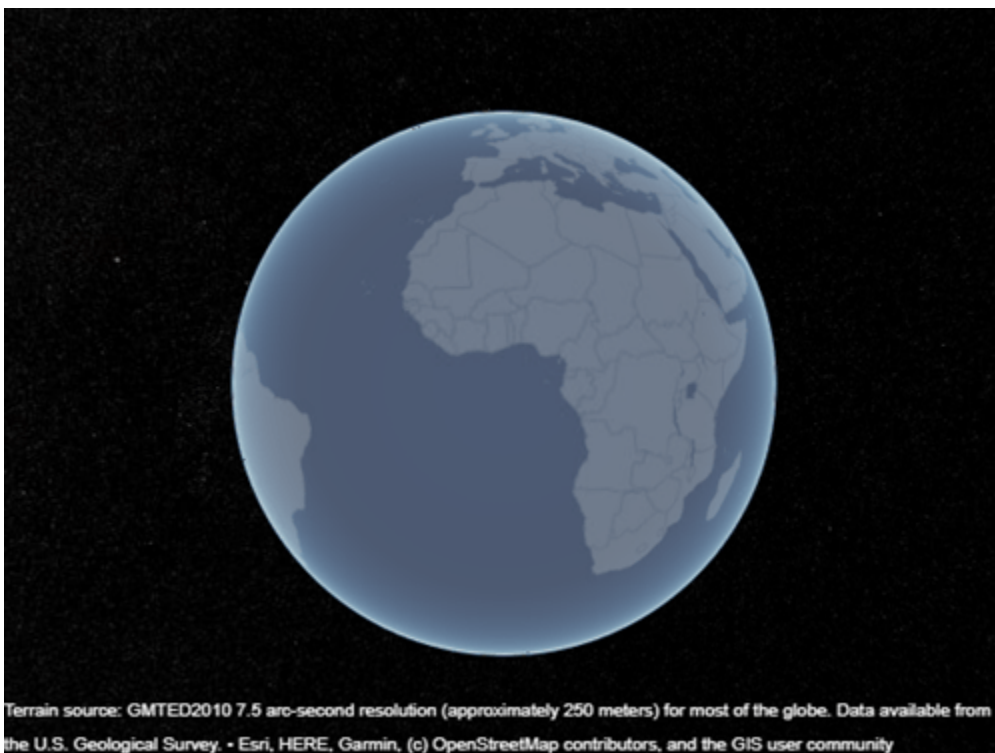
Create a geographic globe. Specify the basemap using name-value arguments.

```
uif = uifigure;  
g = geoglobe(uif, "Basemap", "landcover");
```



Change the basemap of an existing geographic globe by using the geobasemap function.

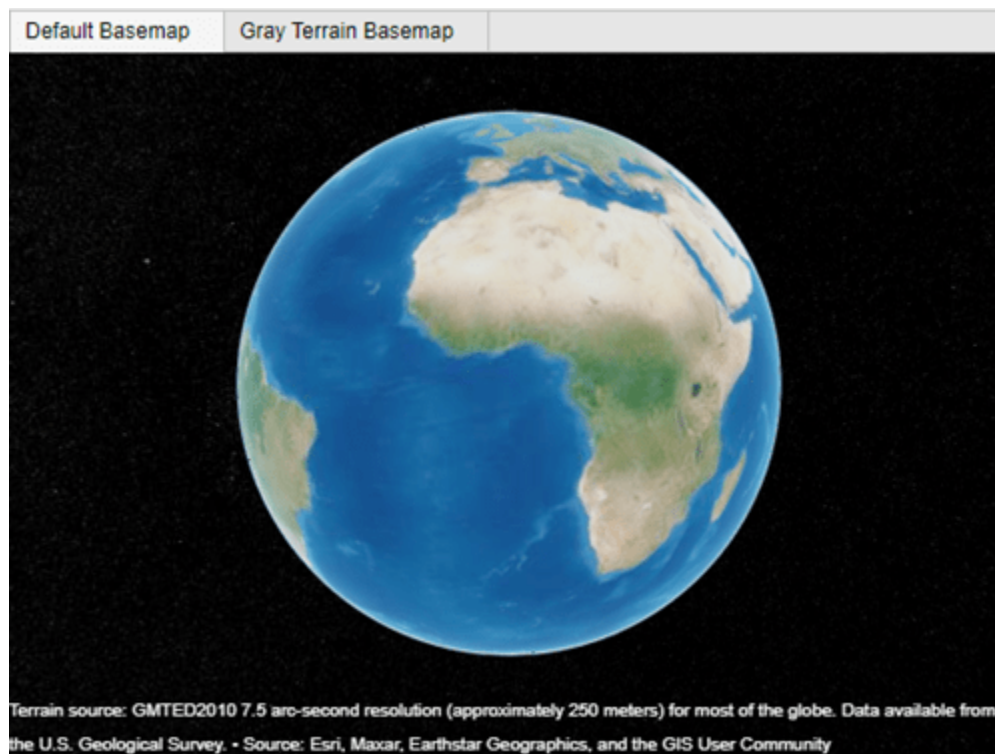
`geobasemap(g, "streets-dark")`



Display Geographic Globes in Tabs

Create a tab group that fills an entire figure. To make the group fill the figure, specify the width and height of the group as the width and height of the figure. Then, display a geographic globe in each tab.

```
uif = uifigure;  
pos = [0 0 uif.Position(3) uif.Position(4)];  
tgroup = uitabgroup(uif,"Position",pos);  
  
tab1 = uitab(tgroup,"Title","Default Basemap");  
g1 = geoglobe(tab1);  
  
tab2 = uitab(tgroup,"Title","Gray Terrain Basemap");  
g2 = geoglobe(tab2,"Basemap","grayterrain");
```



Input Arguments

parent — Parent container

Figure object created using `uifigure` | Panel object | Tab object

Parent container, specified as a Figure object created using the `uifigure` function, a Panel object, or a Tab object.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.


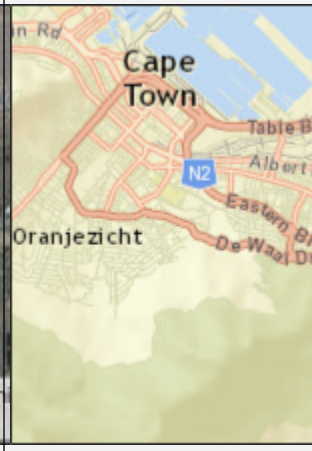

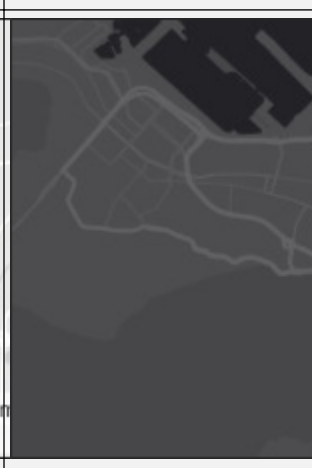
Example: `geoglobe(uif, 'Basemap', 'streets')` sets the basemap of the geographic globe

Note The properties listed here are only a subset. For a full list, see `GeographicGlobe`.


Basemap — Map to plot data on

'satellite' (default) | 'streets' | 'streets-light' | 'streets-dark' | custom basemap | ...

Map on which to plot data, specified as one of the values listed in the table. Six of the basemaps in the table are tiled data sets created using Natural Earth. Five of the basemaps are high-zoom-level maps hosted by Esri.

	<p>'satellite' (default)</p> <p>Full global basemap composed of high-resolution satellite imagery.</p> <p>Hosted by Esri.</p> <p>Earthstar Geograph CNES/Airbus DS</p>		<p>'streets'</p> <p>General-purpose road map that emphasizes accurate, legible styling of roads and transit networks.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, NGA, USGS</p>
	<p>'streets-light'</p> <p>Map designed to provide geographic context while highlighting user data on a light background.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, NGA, USGS</p>		<p>'streets-dark'</p> <p>Map designed to provide geographic context while highlighting user data on a dark background.</p> <p>Hosted by Esri.</p> <p>Esri, HERE, Garmin, NGA, USGS</p>

	<p>'topographic'</p> <p>General-purpose map with styling to depict topographic features.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, USGS, NGA</p>		<p>'landcover'</p> <p>Map that combines satellite-derived land cover data, shaded relief, and ocean-bottom relief. The light, natural palette is suitable for thematic and reference maps.</p> <p>Created using Natural Earth.</p>
	<p>'colorterrain'</p> <p>Shaded relief map blended with a land cover palette. Humid lowlands are green and arid lowlands are brown.</p> <p>Created using Natural Earth.</p>		<p>'grayterrain'</p> <p>Terrain map in shades of gray. Shaded relief emphasizes both high mountains and micro-terrain found in lowlands.</p> <p>Created using Natural Earth.</p>
	<p>'bluegreen'</p> <p>Two-tone, land-ocean map with light green land areas and light blue water areas.</p> <p>Created using Natural Earth.</p>		<p>'grayland'</p> <p>Two-tone, land-ocean map with gray land areas and white water areas.</p> <p>Created using Natural Earth.</p>

	<p>'darkwater'</p> <p>Two-tone, land-ocean map with light gray land areas and dark gray water areas. This basemap is installed with MATLAB.</p> <p>Created using Natural Earth.</p>	<p>Not applicable.</p>	<p>Custom basemap added using the <code>addCustomBasemap</code> function.</p>
---	--	------------------------	---

All basemaps except 'darkwater' require Internet access. The 'darkwater' basemap is included with MATLAB and Mapping Toolbox.

If you do not have consistent access to the Internet, you can download the basemaps created using Natural Earth onto your local system by using the Add-On Explorer. The basemaps hosted by Esri are not available for download. For more about downloading basemaps and changing the default basemap on your local system, see “Access Basemaps and Terrain for Geographic Globe”.

The basemaps hosted by Esri update periodically. As a result, you might see differences in your visualizations over time.

Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

Example: `g = geoglobe(uifigure,'Basemap','bluegreen')`

Example: `g.Basemap = 'bluegreen'`

Data Types: `char` | `string`

Terrain — Terrain data

`'gmted2010'` (default) | `'none'` | `string scalar` | `character vector`

Terrain data, specified as one of these values:

- `'gmted2010'` - Tiled global terrain derived from the GMTED2010 model by the U.S. Geological Survey (USGS) and National Geospatial-Intelligence Agency (NGA) and hosted by MathWorks. Internet access is required to use `'gmted2010'`.
- `'none'` - No terrain.
- `string scalar` or `character vector` - Name of custom terrain added using the `addCustomTerrain` function.

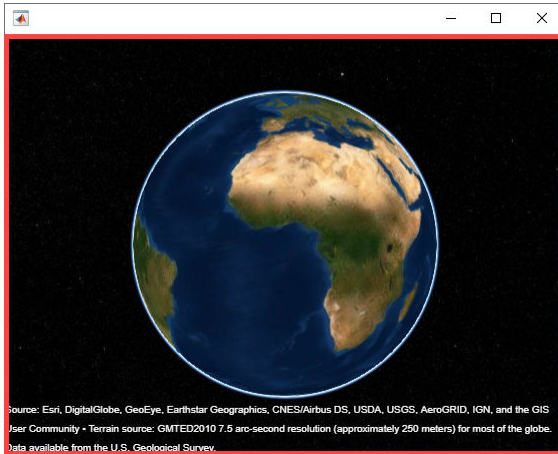
Position — Size and location

`[0 0 1 1]` (default) | `four-element vector of form [left bottom width height]`

Size and location, specified as a four-element vector of the form `[left bottom width height]`. By default, MATLAB measures the values in units normalized to the container. To change the units, set the `Units` property.

- The `left` and `bottom` elements define the distance from the lower-left corner of the container figure, panel, or tab to the lower-left corner of the position boundary.
- The `width` and `height` elements are the position boundary dimensions.

This red line in this figure shows the position boundary of the geographic globe.



Units – Position units

'normalized' (default) | 'inches' | 'centimeters' | 'points' | 'pixels' | 'characters'

Position units, specified as one of these values.

Units	Description
'normalized' (default)	Units normalized with respect to the container, which is typically the figure or a panel. The lower left corner of the container is (0,0) and the upper right corner is (1,1).
'inches'	Inches.
'centimeters'	Centimeters.
'characters'	Units based on the default <code>uicontrol</code> font of the graphics root object: <ul style="list-style-type: none"> • The character width is the width of the letter <code>x</code>. • The character height is the distance between the baselines of two lines of text.
'points'	Typography points. One point equals 1/72 inch.

Units	Description
'pixels'	<p data-bbox="865 300 943 321">Pixels.</p> <p data-bbox="865 359 1422 447">Distances in pixels are independent of your system resolution on Windows and Macintosh systems.</p> <ul data-bbox="865 478 1463 682" style="list-style-type: none"> <li data-bbox="865 478 1438 537">• On Windows systems, a pixel is 1/96th of an inch. <li data-bbox="865 552 1463 611">• On Macintosh systems, a pixel is 1/72nd of an inch. <li data-bbox="865 625 1390 682">• On Linux[®] systems, the size of a pixel is determined by your system resolution.

When specifying the units as a name-value pair during object creation, specify the `Units` name-value pair before specifying name-value pairs that use those units, for example `Position`.

Limitations

- In the Live Editor, geographic globes appear in a separate window instead of within the live script.
- Deploying geographic globes using MATLAB Compiler is not supported on Linux.
- If multiple windows requiring WebGL are open at once, then the geographic globe might display this error:

```
Globe Viewer needs to close because the WebGL context has been lost.
```

More About

Geographic Globe Navigation

Interactively navigate the globe using your mouse.

- Pan by left-clicking and dragging.
- Zoom by scrolling or by right-clicking and dragging.
- Tilt and rotate by holding **Ctrl** and dragging or by middle-clicking and dragging.

On a touch screen, navigate the globe using gestures.

- Pan by dragging one finger.
- Zoom by pinching two fingers.
- Tilt by dragging two fingers in the same direction.
- Rotate by dragging two fingers in a circle.

To programmatically navigate the globe, use the `campos`, `camheight`, `camheading`, `campitch`, and `camroll` object functions.

Tips

- If you create a geographic globe with no output argument, then you can assign the globe to a variable later by using the `findall` function. If there is more than one geographic globe, then `findall` returns a vector of globe objects.

```
uif = uifigure;  
geoglobe(uif)  
g = findall(groot, 'Type', 'globe');
```

If there is more than one geographic globe, then `findall` returns a vector of globe objects.

```
uif = uifigure;  
geoglobe(uif)  
uif2 = uifigure;  
geoglobe(uif2)  
g = findall(groot, 'Type', 'globe')
```

```
g =
```

```
2×1 GeographicGlobe array:
```

```
GeographicGlobe  
GeographicGlobe
```

Version History

Introduced in R2020a

R2021a: Use geographic globes in MATLAB Online

Create, plot data on, and manipulate your view of geographic globes in MATLAB Online.

See Also

Functions

`geoplot3`

Objects

`GeographicGlobe`

GeographicCellsReference

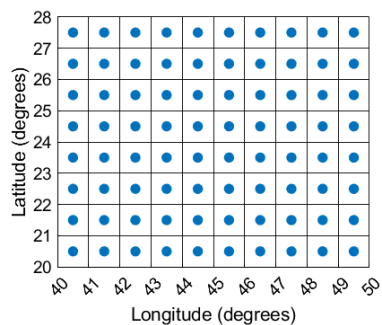
Reference raster cells to geographic coordinates

Description

A geographic cells raster reference object contains information that describes the relationship between a geographic coordinate system and an intrinsic coordinate system on page 1-542 that is anchored to the columns and rows of a 2-D spatially referenced raster grid or image of cells.

In order to reference a raster of cells to geographic coordinates by using a `GeographicCellsReference` object, the raster must be sampled regularly in latitude and longitude, and its columns and rows must be aligned with meridians and parallels, respectively. The sample spacing from row to row need not equal the sample spacing from column to column.

This image illustrates a 8-by-10 geographic raster of cells. The raster cells have an extent of 1 degree in latitude and longitude, cover longitude values in the range [40,50] in degrees, and cover latitude values in the range [20,28] in degrees. The boundary of the raster of cells is made up of the outermost boundaries of the outermost cells.



To reference a raster of postings to geographic coordinates, use a `GeographicPostingsReference` object instead.

Creation

You can use these functions to create `GeographicCellsReference` objects:

- `readgeoraster` — Import a raster data file as an array and a reference object.
- `wmsread` — Import a raster map from a Web Map Service (WMS) server as an array and a reference object.
- `georefcells` — Create a geographic raster reference object by specifying the latitude and longitude limits of the raster and either the size of the raster or the extent of the cells.
- `georasterref` — Convert a world file to a geographic raster reference object.
- `refmatToGeoRasterReference` — Convert a referencing matrix to a geographic raster reference object.
- `refvecToGeoRasterReference` — Convert a referencing vector to a geographic raster reference object.

Properties

LatitudeLimits — Latitude limits of the geographic quadrangle bounding the georeferenced raster

[0.5 2.5] (default) | two-element vector

Latitude limits of the geographic quadrangle bounding the georeferenced raster, specified as a two-element vector of the form [southern_limit northern_limit].

Example: [-90 90]

Data Types: double

LongitudeLimits — Longitude limits of the geographic quadrangle bounding the georeferenced raster

[0.5 2.5] (default) | two-element vector

Longitude limits of the geographic quadrangle bounding the georeferenced raster, specified as a two-element vector of the form [western_limit eastern_limit].

Example: [-100 180]

Data Types: double

RasterSize — Number of rows and columns of the raster or image associated with the referencing object

[2 2] (default) | two-element vector of positive integers

Number of rows and columns of the raster or image associated with the referencing object, specified as a two-element vector, [m n], where m represents the number of rows and n the number of columns. For convenience, you can assign a size vector having more than two elements. This enables assignments like R.RasterSize = size(RGB), where RGB is m-by-n-by-3. In cases like this, the object stores only the first two elements of the size vector and ignores the higher (nonspatial) dimensions.

Example: [200 300]

Data Types: double

RasterInterpretation — Geometric nature of the raster

'cells' (default)

This property is read-only.

Geometric nature of the raster, specified as 'cells'. The value 'cells' indicates that the raster comprises a grid of quadrangular cells, and is bounded on all sides by cell edges. For an m-by-n raster, points with an intrinsic x-coordinate of 1 or n or an intrinsic y-coordinate of 1 or m fall within the raster, not on its edges.

Data Types: char

AngleUnit — Unit of measurement used for angle-valued properties

'degree' (default)

Unit of measurement used for angle-valued properties, specified as 'degree'.

Cannot be set.

Data Types: char

ColumnsStartFrom — Edge from which column indexing starts

'south' (default) | 'north'

Edge from which column indexing starts, specified as 'south' or 'north'.

Example: 'south'

Data Types: char

RowsStartFrom — Edge from which row indexing starts

'west' (default) | 'east'

Edge from which row indexing starts, specified as 'west' or 'east'.

Example: 'east'

Data Types: char

CellExtentInLatitude — Extent in latitude of individual cells

1 (default) | positive numeric scalar

Extent in latitude of individual cells, specified as a positive numeric scalar. Distance, in units of latitude, between the northern and southern limits of a single raster cell. The value is the same for all cells in the raster.

Example: 2.5

Data Types: double

CellExtentInLongitude — Extent in longitude of individual cells

1 (default) | positive numeric scalar

Extent in longitude of individual cells, specified as a positive numeric scalar. Distance, in units of longitude, between the western and eastern limits of a single raster cell. The value is always positive, and is the same for all cells in the raster.

Example: 2.5

Data Types: double

RasterExtentInLatitude — Latitude extent ("height") of the quadrangle covered by the raster

2 (default) | positive numeric scalar

This property is read-only.

Latitude extent ("height") of the quadrangle covered by the raster, specified as a positive numeric scalar.

Example: 2

Data Types: double

RasterExtentInLongitude — Longitude extent ("width") of the quadrangle covered by the raster

2 (default) | positive numeric scalar

This property is read-only.

Longitude extent ("width") of the quadrangle covered by the raster, specified as a positive numeric scalar.

Data Types: double

XIntrinsicLimits — Raster limits in intrinsic x coordinates

[0.5 2.5] (default) | two-element row vector of positive integers

This property is read-only.

Raster limits in intrinsic x coordinates, specified as a two-element row vector of positive integers, [xMin xMax]. For an m -by- n raster, XIntrinsicLimits equals [0.5, $m+0.5$], because the RasterInterpretation is 'cells'.

Example: [0.5 2.5]

Data Types: double

YIntrinsicLimits — Raster limits in intrinsic y coordinates

[0.5 2.5] (default) | two-element row vector of positive integers

This property is read-only.

Raster limits in intrinsic y coordinates, specified as a two-element row vector of positive integers, [yMin yMax]. For an m -by- n raster, YIntrinsicLimits equals [0.5, $n+0.5$], because the RasterInterpretation is 'cells'.

Data Types: double

CoordinateSystemType — Type of coordinate system to which the image or raster is referenced

'geographic' (default)

This property is read-only.

Type of coordinate system to which the image or raster is referenced, specified as 'geographic'.

Data Types: char

GeographicCRS — Geographic coordinate reference system

[] (default) | geocrs object

Geographic coordinate reference system (CRS), specified as a geocrs object. A geographic CRS consists of a datum (including its ellipsoid), prime meridian, and angular unit of measurement.

Object Functions

contains	Determine if geographic or map raster contains points
geographicGrid	Geographic coordinates of raster elements
geographicToDiscrete	Transform geographic to discrete coordinates
geographicToIntrinsic	Transform geographic to intrinsic coordinates
intrinsicToGeographic	Transform intrinsic to geographic coordinates
intrinsicXToLongitude	Convert from intrinsic x to longitude coordinates
intrinsicYToLatitude	Convert from intrinsic y to latitude coordinates
latitudeToIntrinsicY	Convert from latitude to intrinsic y coordinates
longitudeToIntrinsicX	Convert from longitude to intrinsic x coordinates

sizesMatch	Determine if geographic or map raster object and image or raster are size-compatible
worldFileMatrix	Return world file parameters for transformation

Examples

Display Geographic Raster with Regularly Spaced Cell Centers

Import a GeoTIFF image as an array and a GeographicCellsReference object by using the `readgeoraster` function.

```
[Z,R] = readgeoraster('katrina.tif');
```

View the properties of the GeographicCellsReference object.

R

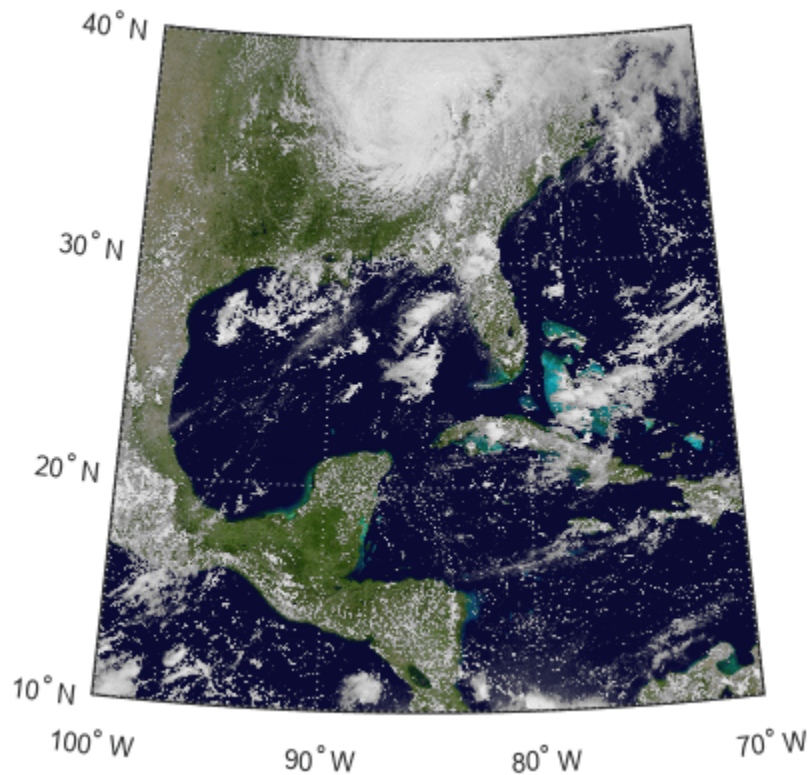
```
R =
  GeographicCellsReference with properties:
```

```

    LatitudeLimits: [10 40]
    LongitudeLimits: [-100 -70]
    RasterSize: [1024 1024]
    RasterInterpretation: 'cells'
    ColumnsStartFrom: 'north'
    RowsStartFrom: 'west'
    CellExtentInLatitude: 0.029296875
    CellExtentInLongitude: 0.029296875
    RasterExtentInLatitude: 30
    RasterExtentInLongitude: 30
    XIntrinsicLimits: [0.5 1024.5]
    YIntrinsicLimits: [0.5 1024.5]
    CoordinateSystemType: 'geographic'
    GeographicCRS: [1x1 geocrs]
    AngleUnit: 'degree'
```

Create a world map with limits that match the limits of the reference object. Then, display the image.

```
worldmap(Z,R)
geoshow(Z,R)
```



More About

Intrinsic Coordinate System

A 2-D Cartesian system with its x-axis running parallel to the rows of a raster or image and its y-axis running parallel to the columns. x increases by 1 from column to column, and y increases by 1 from row to row.

Mapping Toolbox and Image Processing Toolbox™ use the convention for the location of the origin relative to the raster cells or sampling points such that, at a sample location or at the center of a cell, x has an integer value equal to the column index. Likewise, at a sample location or at the center of a cell, y has an integer value equal to the row index. For details, see Image Coordinate Systems (Image Processing Toolbox).

Version History

Introduced in R2013b

See Also

Functions

`georefcells` | `georasterref` | `readgeoraster` | `wmsread`

Objects

GeographicPostingsReference | MapCellsReference | MapPostingsReference

Topics

“Spatially Reference Imported Rasters”

GeographicGlobe

Control geographic globe appearance and behavior

Description

Use a geographic globe to plot 3-D lines and markers over basemaps and terrain.

Creation

Create a geographic globe object using the `geoglobe` function.


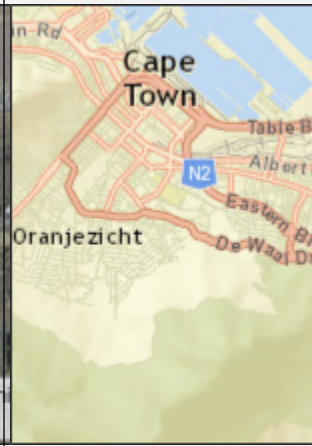
Properties

Maps




Basemap — Map to plot data on

'satellite' (default) | 'streets' | 'streets-light' | 'streets-dark' | custom basemap | ...

Map on which to plot data, specified as one of the values listed in the table. Six of the basemaps in the table are tiled data sets created using Natural Earth. Five of the basemaps are high-zoom-level maps hosted by Esri.

	<p>'satellite' (default)</p> <p>Full global basemap composed of high-resolution satellite imagery.</p> <p>Hosted by Esri.</p> <p>Earthstar Geographi CNES/Airbus DS</p>		<p>'streets'</p> <p>General-purpose road map that emphasizes accurate, legible styling of roads and transit networks.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, NGA, USGS</p>
---	---	--	--

	<p>'streets-light'</p> <p>Map designed to provide geographic context while highlighting user data on a light background.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, NGA, USGS</p>		<p>'streets-dark'</p> <p>Map designed to provide geographic context while highlighting user data on a dark background.</p> <p>Hosted by Esri.</p> <p>Esri, HERE, Garmin, NGA, USGS</p>
	<p>'topographic'</p> <p>General-purpose map with styling to depict topographic features.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, USGS, NGA</p>		<p>'landcover'</p> <p>Map that combines satellite-derived land cover data, shaded relief, and ocean-bottom relief. The light, natural palette is suitable for thematic and reference maps.</p> <p>Created using Natural Earth.</p>
	<p>'colorterrain'</p> <p>Shaded relief map blended with a land cover palette. Humid lowlands are green and arid lowlands are brown.</p> <p>Created using Natural Earth.</p>		<p>'grayterrain'</p> <p>Terrain map in shades of gray. Shaded relief emphasizes both high mountains and micro-terrain found in lowlands.</p> <p>Created using Natural Earth.</p>

	<p>'bluegreen'</p> <p>Two-tone, land-ocean map with light green land areas and light blue water areas.</p> <p>Created using Natural Earth.</p>		<p>'grayland'</p> <p>Two-tone, land-ocean map with gray land areas and white water areas.</p> <p>Created using Natural Earth.</p>
	<p>'darkwater'</p> <p>Two-tone, land-ocean map with light gray land areas and dark gray water areas. This basemap is installed with MATLAB.</p> <p>Created using Natural Earth.</p>	<p>Not applicable.</p>	<p>Custom basemap added using the addCustomBasemap function.</p>

All basemaps except 'darkwater' require Internet access. The 'darkwater' basemap is included with MATLAB and Mapping Toolbox.

If you do not have consistent access to the Internet, you can download the basemaps created using Natural Earth onto your local system by using the Add-On Explorer. The basemaps hosted by Esri are not available for download. For more about downloading basemaps and changing the default basemap on your local system, see “Access Basemaps and Terrain for Geographic Globe”.

The basemaps hosted by Esri update periodically. As a result, you might see differences in your visualizations over time.

Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

Example: `g = geoglobe(uifigure,'Basemap','bluegreen')`

Example: `g.Basemap = 'bluegreen'`

Data Types: `char` | `string`

Terrain — Terrain data

'gmted2010' (default) | 'none' | `string scalar` | `character vector`

Terrain data, specified as one of these values:


- 'gmted2010' - Global terrain derived from the GMTED2010 model created by the U.S. Geological Survey (USGS) and National Geospatial-Intelligence Agency (NGA).
- 'none' - No terrain.
- string scalar or character vector - Name of custom terrain added using the `addCustomTerrain` function.

Multiple Plots

ColorOrder — Color order

seven predefined colors (default) | three-column matrix of RGB triplets

Color order for lines plotted on the globe, specified as a three-column matrix of RGB triplets. This property defines the palette of colors MATLAB uses to create plot objects such as lines. Each row of the array is an RGB triplet. An RGB triplet is a three-element vector whose elements specify the intensities of the red, green, and blue components of a color. The intensities must be in the range [0, 1]. This table lists the default colors.

Colors	ColorOrder Matrix
	<pre>[0 0.4470 0.7410 0.8500 0.3250 0.0980 0.9290 0.6940 0.1250 0.4940 0.1840 0.5560 0.4660 0.6740 0.1880 0.3010 0.7450 0.9330 0.6350 0.0780 0.1840]</pre>

MATLAB assigns colors to objects according to their order of creation. For example, when plotting lines, the first line uses the first color, the second line uses the second color, and so on. If there are more lines than colors, then the cycle repeats.

Change the color order in either of the following ways:

- Call the `colororder` function to change the color order for all globe objects in a UI figure. The colors of existing plots in the UI figure update immediately. If you place additional globe objects into the figure, those globe objects also use the new color order. If you continue to call plotting commands, those commands also use the new colors.
- Set the `ColorOrder` property on the globe, call the `hold` function to set the globe hold state to 'on', and then call the desired plotting functions. This is like calling the `colororder` function, but in this case you are setting the color order for the specific globe, not the entire UI figure. Setting the `hold` state to 'on' is necessary to ensure that subsequent plotting commands do not reset the globe to use the default color order.

NextSeriesIndex — SeriesIndex value for next object

whole number

This property is read-only.

`SeriesIndex` value for the next plot object added to the globe, returned as a whole number greater than or equal to 0. This property is useful when you want to track how the objects cycle through the

colors in the color order. This property maintains a count of the objects in the globe that have a `SeriesIndex` property. MATLAB uses it to assign the value of the `SeriesIndex` property for each new object. The count starts at 1 when you create the globe, and it increases by 1 for each additional object. Thus, the count is typically $n+1$, where n is the number of objects in the globe.

NextPlot — Properties to reset

'replace' (default) | 'add' | 'replacechildren' | 'replaceall'

Properties to reset when adding a new plot to the globe, specified as one of these values:

- 'add' — Add new plots to the existing globe. Do not delete existing plots or reset globe properties before displaying the new plot.
- 'replacechildren' — Delete existing plots before displaying the new plot. Reset the `ColorOrderIndex` property to 1, but do not reset other globe properties. The next plot added to the globe uses the first color based on the `ColorOrder` property.
- 'replace' — Delete existing plots and reset globe properties, except `Position`, `Units`, `Basemap`, and `Terrain`, to their default values before displaying the new plot.
- 'replaceall' — Delete existing plots and reset globe properties, except `Position` and `Units`, to their default values before displaying the new plot.

Position

Position — Size and location

[0 0 1 1] (default) | four-element vector of form [left bottom width height]

Size and location, specified as a four-element vector of the form [left bottom width height]. By default, MATLAB measures the values in units normalized to the container. To change the units, set the `Units` property.

- The `left` and `bottom` elements define the distance from the lower left corner of the container UI figure, panel, or tab to the lower left corner of the position boundary.
- The `width` and `height` elements are the position boundary dimensions.

Units — Position units

'normalized' (default) | 'inches' | 'centimeters' | 'points' | 'pixels' | 'characters'

Position units, specified as one of these values.

Units	Description
'normalized' (default)	Units normalized with respect to the container, which is typically the figure or a panel. The lower left corner of the container is (0,0) and the upper right corner is (1,1).
'inches'	Inches.
'centimeters'	Centimeters.

Units	Description
'characters'	Units based on the default <code>uicontrol</code> font of the graphics root object: <ul style="list-style-type: none"> • The character width is the width of the letter <code>x</code>. • The character height is the distance between the baselines of two lines of text.
'points'	Typography points. One point equals 1/72 inch.
'pixels'	<p>Pixels.</p> <p>Distances in pixels are independent of your system resolution on Windows and Macintosh systems.</p> <ul style="list-style-type: none"> • On Windows systems, a pixel is 1/96th of an inch. • On Macintosh systems, a pixel is 1/72nd of an inch. • On Linux systems, the size of a pixel is determined by your system resolution.

When specifying the units as a name-value pair during object creation, specify the `Units` name-value pair before specifying name-value pairs that use those units, for example `Position`.

Interactivity

Visible — State of visibility

'on' (default) | on/off logical value

State of visibility, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to `true`, and 'off' is equivalent to `false`. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Display the object.
- 'off' — Hide the object without deleting it. You still can access the properties of an invisible object.

Parent/Child

Parent — Parent container

Figure object created using `uifigure` | Panel object | Tab object

Parent container, specified as a Figure object created using the `uifigure` function, a Panel object within a UI figure, or a Tab object within a UI figure.

Children — Children

empty `GraphicsPlaceholder` array | array of Line objects

Children, returned as an array of graphics objects. Use this property to view a list of the children or to reorder the children by setting the property to a permutation of itself.

You cannot add or remove children using the `Children` property. To add a child to this list, set the `Parent` property of the child graphics object to the `GeographicGlobe` object.

HandleVisibility — Visibility of object handle

'on' (default) | 'off' | 'callback'

Visibility of the object handle in the `Children` property of the parent, specified as one of these values:

- 'on' — Object handle is always visible.
- 'off' — Object handle is invisible at all times. This option is useful for preventing unintended changes by another function. Set the `HandleVisibility` to 'off' to temporarily hide the handle during the execution of that function.
- 'callback' — Object handle is visible from within callbacks or functions invoked by callbacks, but not from within functions invoked from the command line. This option blocks access to the object at the command line, but permits callback functions to access it.

If the object is not listed in the `Children` property of the parent, then functions that obtain object handles by searching the object hierarchy or querying handle properties cannot return it. Examples of such functions include the `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close` functions.

Hidden object handles are still valid. Set the root `ShowHiddenHandles` property to 'on' to list all object handles regardless of their `HandleVisibility` property setting.

Identifiers

Type — Type of graphics object

'globe'

This property is read-only.

Type of graphics object returned as 'globe'.

Tag — Object identifier

'' (default) | character vector | string scalar

Object identifier, specified as a character vector or string scalar. You can specify a unique `Tag` value to serve as an identifier for an object. When you need access to the object elsewhere in your code, you can use the `findobj` function to search for the object based on the `Tag` value.

UserData — User data

[] (default) | array

User data, specified as any MATLAB array. For example, you can specify a scalar, vector, matrix, cell array, character array, table, or structure. Use this property to store arbitrary data on an object.

If you are working in App Designer, create public or private properties in the app to share data instead of using the `UserData` property. For more information, see “Share Data Within App Designer Apps”.

Object Functions

Change Hold State and Basemap

hold	<p>These hold syntaxes are supported for geographic globe objects:</p> <ul style="list-style-type: none"> • <code>hold(g, 'on')</code> retains plots in the globe <code>g</code> so that new plots do not delete existing plots. New plots use the next color based on the <code>ColorOrder</code> property of the globe. MATLAB adjusts the camera line of sight to display the full range of data. • <code>hold(g, 'off')</code> sets the hold state to off so that new plots added to the globe clear existing plots and reset all globe properties, excluding terrain and basemaps, to their default values. The next plot added to the globe uses the first color based on the <code>ColorOrder</code> property of the globe. This option is the default behavior. • <code>hold(g)</code> toggles the hold state between on and off.
geobasemap	<p>This geobasemap syntax is supported for geographic globe objects:</p> <ul style="list-style-type: none"> • <code>geobasemap(g, basemap)</code> sets the basemap for the globe specified by <code>g</code>. For example, <code>geobasemap(g, 'topographic')</code> sets the basemap to a general-purpose map with styling to depict topographic features. For a list of basemaps, see the <code>Basemap</code> property.

Change View

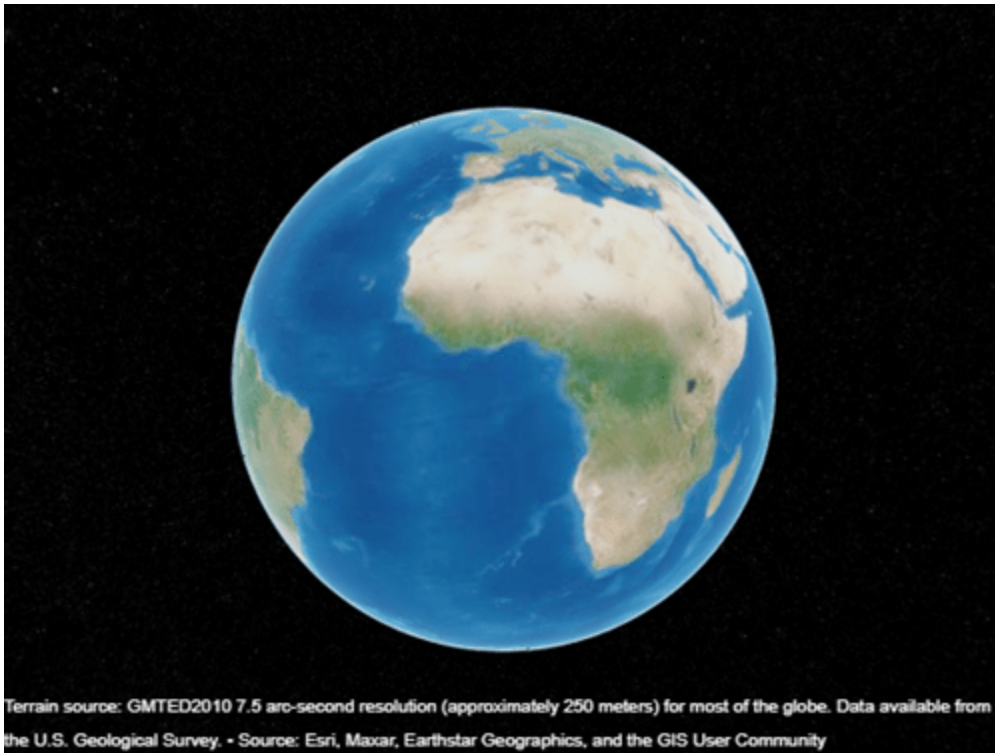
<code>campos</code>	Set or query position of camera for geographic globe
<code>camheight</code>	Set or query height of camera for geographic globe
<code>camheading</code>	Set or query heading angle of camera for geographic globe
<code>campitch</code>	Set or query pitch angle of camera for geographic globe
<code>camroll</code>	Set or query roll angle of camera for geographic globe

Examples

Display Geographic Globe

Display a geographic globe in a figure created using the `uifigure` function.

```
uif = uifigure;
g = geoglobe(uif);
```



Version History

Introduced in R2020a

R2022b: When NextPlot is 'replace', adding new plots to geographic globe does not reset basemap or terrain

Behavior changed in R2022b

When the value of the NextPlot property is 'replace', adding new plots does not reset the Basemap or Terrain properties. As a result, when you add a plot to a geographic globe by using the geoplot3 function, MATLAB does not reset the basemap or terrain. In R2022a and earlier releases, the basemap and terrain reset when you add new plots.

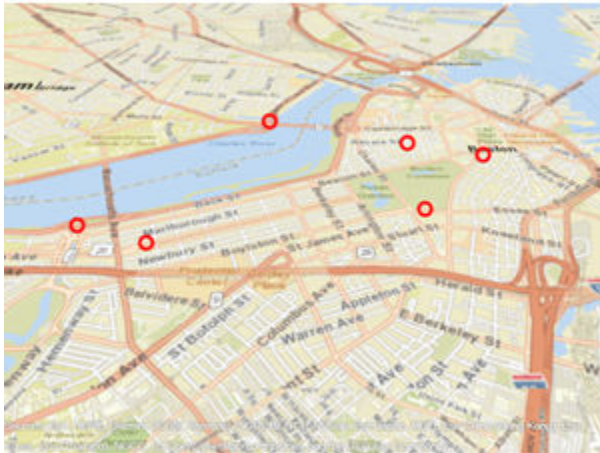
As a result, you can specify the basemap or terrain and then visualize data without using the hold function. For example, this code creates a globe using the "streets" basemap and no terrain data. Then, it displays a plot and adjusts the camera view. In R2022b, the basemap and terrain do not reset. In R2022a and earlier releases, the basemap reset to the default "satellite" and the terrain reset to the default "gmted2010".

```
lat = [42.3501 42.3515 42.3598 42.3584 42.3529 42.3626];
lon = [-71.0870 -71.0926 -71.0662 -71.0598 -71.0662 -71.0789];

uif = uifigure;
g = geoglobe(uif,Basemap="streets",Terrain="none");

p = geoplot3(g,lat,lon,0,"ro",LineWidth=3);
campos(g,42.33,-71.0756,2113)
campitch(g,-42.2458)
```

R2022b



R2022a



This change does not affect existing code that sets the hold state to "on" between commands.

To reset the basemap and terrain, set the `Basemap` and `Terrain` properties to the defaults after you create the plot.

```
g.Basemap = "satellite";  
g.Terrain = "gmted2010";
```

For more information about changing the basemap and terrain of geographic globes, see “Access Basemaps and Terrain for Geographic Globe”.

See Also

geoglobe | geoplot3

geographicGrid

Package: map.rasterref

Geographic coordinates of raster elements

Syntax

```
[lat,lon] = geographicGrid(R)
[lat,lon] = geographicGrid(R,gridOption)
```

Description

[lat,lon] = geographicGrid(R) returns the geographic coordinates of raster elements as the 2-D arrays lat and lon. The coordinates of raster element (i,j) are (lat(i,j),lon(i,j)).

[lat,lon] = geographicGrid(R,gridOption), where gridOption is 'gridvectors', returns lat and lon as vectors. The coordinates of raster element (i,j) are (lat(i),lon(j)). The default for gridOption is 'fullgrid', which returns lat and lon as 2-D arrays.

Examples

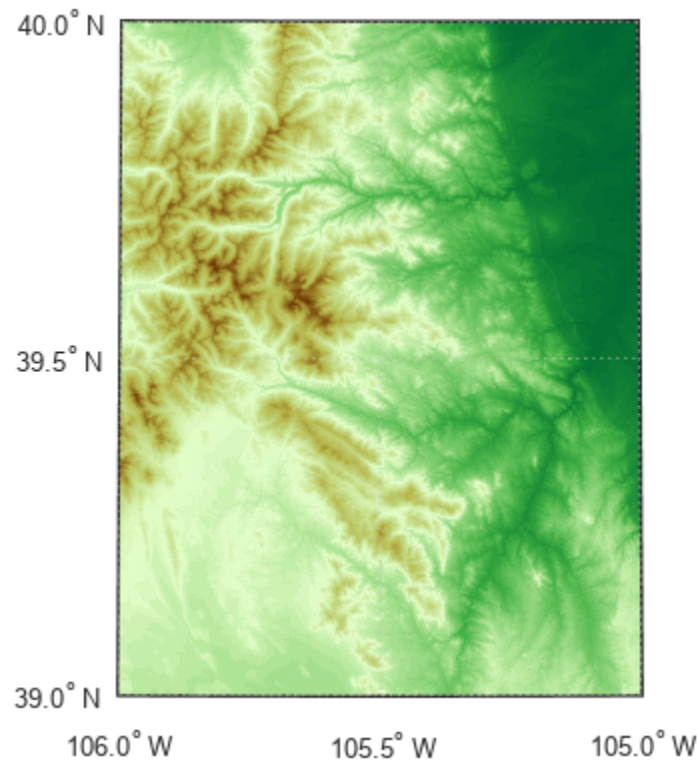
Find Coordinates of Raster Elements

Import elevation data [1] on page 1-555 for an area around South Boulder Peak in Colorado as an array and a geographic postings reference object. Find the coordinates of each element in the array.

```
[Z,R] = readgeoraster('n39_w106_3arc_v2.dt1');
[lat,lon] = geographicGrid(R);
```

Create a map with latitude and longitude limits that match the limits of the data. Display the data using an appropriate colormap.

```
usamap(R.LatitudeLimits,R.LongitudeLimits)
surfm(lat,lon,Z)
demcmap(Z)
```

[1] The elevation data used in this example is courtesy of the U.S. Geological Survey.

Get Vectors Instead of Arrays

Create a geographic cells reference object for a 3-by-4 raster with latitude values in the range [0, 30] degrees and longitude values in the range [-20, 20] degrees. Get the coordinates of the raster elements and return them as row vectors.

```
R = georefcells([0 30],[-20 20],[3 4]);
[lat,lon] = geographicGrid(R,'gridvectors')
```

```
lat = 1×3
```

```
    5    15    25
```

```
lon = 1×4
```

```
   -15    -5     5    15
```

If you do not specify the second argument as 'gridvectors', then the geographicGrid function returns 2-D arrays by default.

```
[latFull,lonFull] = geographicGrid(R)
```

```
latFull = 3×4
```

```
    5    5    5    5
   15   15   15   15
   25   25   25   25
```

```
lonFull = 3×4
```

```
  -15   -5    5   15
  -15   -5    5   15
  -15   -5    5   15
```

Input Arguments

R — Spatial reference

GeographicCellsReference object | GeographicPostingsReference object

Spatial reference, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object.

If `R` is a `GeographicCellsReference` object, then `lat` and `lon` are cell centers. If `R` is a `GeographicPostingsReference` object, then `lat` and `lon` are posting points.

gridOption — Grid option

'fullgrid' (default) | 'gridvectors'

Grid option, specified as one of these values:

- 'fullgrid' — Return `lat` and `lon` as 2-D arrays, where each column of `lat` is identical and each row of `lon` is identical. This is the default behavior.
- 'gridvectors' — Return `lat` and `lon` as row vectors. Use this option when you want to reduce memory usage and when 2-D arrays are unnecessary, such as when plotting large data sets with the `surf` function.

This table shows the difference between 'fullgrid' and 'gridvectors'.

'fullgrid'	'gridvectors'
<pre>R = georefcells([0 30],[-20 20],[3 4]); [lat,lon] = geographicGrid(R)</pre>	<pre>R = georefcells([0 30],[-20 20],[3 4]); [lat,lon] = geographicGrid(R,'gridvectors')</pre>
lat = <pre> 5 5 5 5 15 15 15 15 25 25 25 25</pre>	lat = <pre> 5 15 25</pre>
lon = <pre> -15 -5 5 15 -15 -5 5 15 -15 -5 5 15</pre>	lon = <pre> -15 -5 5 15</pre>

Data Types: char | string

Output Arguments

lat — Latitudes

2-D array (default) | row vector

Latitudes, returned as a 2-D array or a row vector. By default, `lat` is a 2-D array. To return `lat` as a row vector, specify `gridOption` as `'gridvectors'`.

By default, and when `gridOption` is `'fullgrid'`, the sizes of `lat` and `lon` each equal the `RasterSize` property of `R`. When `gridOption` is `'gridvectors'`, the lengths of `lat` and `lon` equal the first and second elements of the `RasterSize` property of `R`, respectively.

lon — Longitudes

2-D array (default) | row vector

Longitudes, returned as a 2-D array or a row vector. By default, `lon` is a 2-D array. To return `lon` as a row vector, specify `gridOption` as `'gridvectors'`.

By default, and when `gridOption` is `'fullgrid'`, the sizes of `lat` and `lon` each equal the `RasterSize` property of `R`. When `gridOption` is `'gridvectors'`, the lengths of `lat` and `lon` equal the first and second elements of the `RasterSize` property of `R`, respectively.

Version History

Introduced in R2021a

See Also

Functions

`ndgrid` | `meshgrid` | `intrinsicToGeographic` | `worldGrid`

Objects

`GeographicCellsReference` | `GeographicPostingsReference`

GeographicPostingsReference

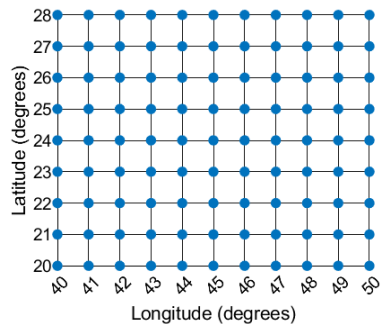
Reference raster postings to geographic coordinates

Description

A geographic postings raster reference object contains information that describes the relationship between a geographic coordinate system and an intrinsic coordinate system on page 1-563 that is anchored to the columns and rows of a 2-D spatially referenced grid of point samples (or postings).

In order to reference a raster of postings to geographic coordinates by using a `GeographicPostingsReference` object, the raster must be sampled regularly in latitude and longitude, and its columns and rows must be aligned with meridians and parallels, respectively. The sample spacing from row to row need not equal the sample spacing from column to column.

This image illustrates a 9-by-11 geographic raster of postings. The postings are spaced 1 degree apart in latitude and longitude, cover longitude values in the range [40,50] in degrees, and cover latitude values in the range [20,28] in degrees. The boundary of the raster of postings is a geographic quadrangle with edges that pass through the outermost postings.



To reference a raster of cells to geographic coordinates, use a `GeographicCellsReference` object instead.

Creation

You can use these functions to create `GeographicPostingsReference` objects:

- `readgeoraster` — Import a raster data file as an array and a reference object.
- `georefpostings` — Create a geographic raster reference object by specifying the latitude and longitude limits of the raster and either the size of the raster or the spacing of the postings.
- `georasterref` — Convert a world file to a geographic raster reference object.
- `refmatToGeoRasterReference` — Convert a referencing matrix to a geographic raster reference object.

Properties

LatitudeLimits — Latitude limits of the geographic quadrangle bounding the georeferenced raster

[0.5 1.5] (default) | two-element vector

Latitude limits of the geographic quadrangle bounding the georeferenced raster, specified as a two-element vector of the form [southern_limit northern_limit].

Example: [-20 70]

Data Types: double

LongitudeLimits — Longitude limits of the geographic quadrangle bounding the georeferenced raster

[0.5 1.5] (default) | two-element vector

Longitude limits of the geographic quadrangle bounding the georeferenced raster, specified as a two-element vector of the form [western_limit eastern_limit].

Example: [-100 180]

Data Types: double

RasterSize — Number of rows and columns of the raster or image associated with the referencing object

[2 2] (default) | two-element vector of positive integers

Number of rows and columns of the raster or image associated with the referencing object, specified as a two-element vector, [m n], where *m* represents the number of rows and *n* the number of columns. For convenience, you can assign a size vector having more than two elements. This enables assignments like `R.RasterSize = size(RGB)`, where RGB is *m*-by-*n*-by-3. In cases like this, the object stores only the first two elements of the size vector and ignores the higher (nonspatial) dimensions.

Example: [200 300]

Data Types: double

RasterInterpretation — Geometric nature of the raster

'postings' (default)

This property is read-only.

Geometric nature of the raster, specified as 'postings'.

The value 'postings' indicates that the raster comprises a grid of sample points, where rows or columns of samples run along the edge of the grid. For an *m*-by-*n* raster, points with an intrinsic *x*-coordinate of 1 or *n* and/or an intrinsic *y*-coordinate of 1 or *m* fall right on an edge (or corner) of the raster.

Data Types: char

AngleUnit — Unit of measurement used for angle-valued properties

'degree' (default)

This property is read-only.

Unit of measurement used for angle-valued properties, specified as 'degree'.

Data Types: char

ColumnsStartFrom — Edge from which column indexing starts

'south' (default) | 'north'

Edge from which column indexing starts, specified as 'south' or 'north'.

Example: 'south'

Data Types: char

RowsStartFrom — Edge from which row indexing starts

'west' (default) | 'east'

Edge from which row indexing starts, specified as 'west' or 'east'.

Example: 'east'

Data Types: char

SampleSpacingInLatitude — North-south distance in latitude between adjacent samples in the raster

1 (default) | positive numeric scalar

North-south distance in latitude between adjacent samples (postings) in the raster, specified as a positive numeric scalar. The value is always positive, and is the constant throughout the raster.

Example: 2.5

Data Types: double

SampleSpacingInLongitude — East-west distance in longitude between adjacent samples in the raster

1 (default) | positive numeric scalar

East-west distance in longitude between adjacent samples (postings) in the raster, specified as a positive numeric scalar. The value is always positive, and is the constant throughout the raster.

Example: 2.5

Data Types: double

RasterExtentInLatitude — Latitude extent ("height") of the quadrangle covered by the raster

1 (default) | positive numeric scalar

This property is read-only.

Latitude extent ("height") of the quadrangle covered by the raster, specified as a positive numeric scalar.

Data Types: double

RasterExtentInLongitude — Longitude extent ("width") of the quadrangle covered by the raster

1 (default) | positive numeric scalar

This property is read-only.

Longitude extent ("width") of the quadrangle covered by the raster, specified as a positive numeric scalar.

Data Types: double

XIntrinsicLimits — Raster limits in intrinsic x coordinates

[1 2] (default) | two-element row vector of positive integers

This property is read-only.

Raster limits in intrinsic *x* coordinates, specified as a two-element row vector of positive integers, [xMin xMax]. For an *m*-by-*n* raster, XIntrinsicLimits equals [1 *m*], because the RasterInterpretation is 'postings'.

Data Types: double

YIntrinsicLimits — Raster limits in intrinsic y coordinates

[1 2] (default) | two-element row vector of positive integers

This property is read-only.

Raster limits in intrinsic *y* coordinates, specified as a two-element row vector of positive integers, [yMin yMax]. For an *m*-by-*n* raster, YIntrinsicLimits equals [1 *m*], because the RasterInterpretation is 'postings'.

Data Types: double

CoordinateSystemType — Type of coordinate system to which the image or raster is referenced

'geographic' (default) | two-element row vector of positive integers

This property is read-only.

Type of coordinate system to which the image or raster is referenced, specified as 'geographic'.

Data Types: char

GeographicCRS — Geographic coordinate reference system

[] (default) | geocrs object

Geographic coordinate reference system (CRS), specified as a geocrs object. A geographic CRS consists of a datum (including its ellipsoid), prime meridian, and angular unit of measurement.

Object Functions

contains	Determine if geographic or map raster contains points
geographicGrid	Geographic coordinates of raster elements
geographicToDiscrete	Transform geographic to discrete coordinates
geographicToIntrinsic	Transform geographic to intrinsic coordinates
intrinsicToGeographic	Transform intrinsic to geographic coordinates
intrinsicXToLongitude	Convert from intrinsic <i>x</i> to longitude coordinates
intrinsicYToLatitude	Convert from intrinsic <i>y</i> to latitude coordinates
latitudeToIntrinsicY	Convert from latitude to intrinsic <i>y</i> coordinates
longitudeToIntrinsicX	Convert from longitude to intrinsic <i>x</i> coordinates
sizesMatch	Determine if geographic or map raster object and image or raster are size-compatible

worldFileMatrix Return world file parameters for transformation

Examples

Display Geographic Raster of Regularly Spaced Posting Points

Import elevation data as an array and a `GeographicPostingsReference` object by using the `readgeoraster` function. Prepare the data for plotting by specifying the output type as `'double'`.

```
[Z,R] = readgeoraster('n39_w106_3arc_v2.dt1','OutputType','double');
```

View the properties of the `GeographicPostingsReference` object.

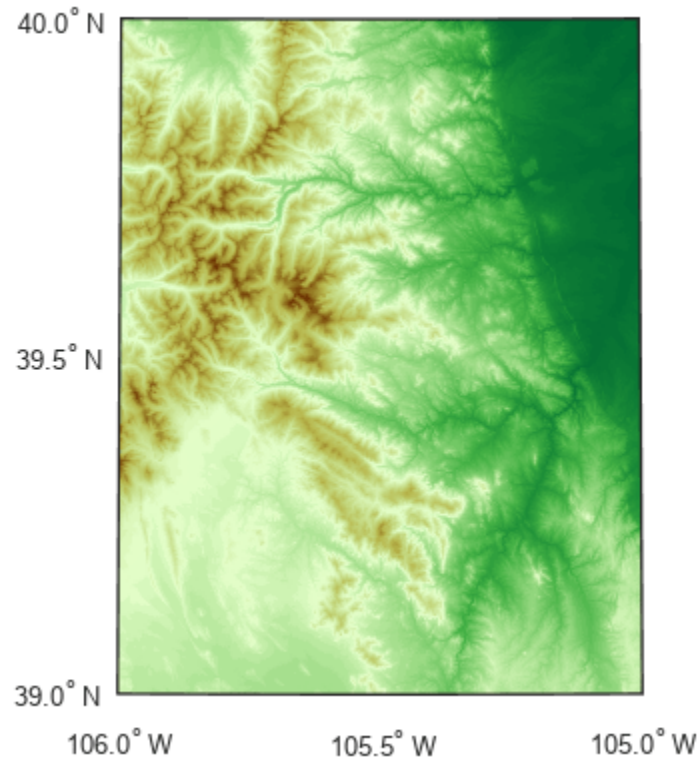
R

```
R =  
GeographicPostingsReference with properties:
```

```
LatitudeLimits: [39 40]  
LongitudeLimits: [-106 -105]  
RasterSize: [1201 1201]  
RasterInterpretation: 'postings'  
ColumnsStartFrom: 'north'  
RowsStartFrom: 'west'  
SampleSpacingInLatitude: 1/1200  
SampleSpacingInLongitude: 1/1200  
RasterExtentInLatitude: 1  
RasterExtentInLongitude: 1  
XIntrinsicLimits: [1 1201]  
YIntrinsicLimits: [1 1201]  
CoordinateSystemType: 'geographic'  
GeographicCRS: [1x1 geocrs]  
AngleUnit: 'degree'
```

Create a map with limits that match the limits of the reference object. Display the elevation data as a surface. Apply a colormap that is appropriate for elevation data.

```
usamap(R.LatitudeLimits,R.LongitudeLimits)  
geoshow(Z,R,'DisplayType','surface')  
demcmmap(Z)
```

More About

Intrinsic Coordinate System

A 2-D Cartesian system with its x-axis running parallel to the rows of a raster or image and its y-axis running parallel to the columns. x increases by 1 from column to column, and y increases by 1 from row to row.

Mapping Toolbox and Image Processing Toolbox use the convention for the location of the origin relative to the raster cells or sampling points such that, at a sample location or at the center of a cell, x has an integer value equal to the column index. Likewise, at a sample location or at the center of a cell, y has an integer value equal to the row index. For details, see Image Coordinate Systems (Image Processing Toolbox).

Version History

Introduced in R2013b

See Also

Functions

`georefcells` | `georasterref` | `readgeoraster`

Objects

GeographicCellsReference | MapCellsReference | MapPostingsReference

Topics

“Spatially Reference Imported Rasters”

geographicToDiscrete

Package: `map.rasterref`

Transform geographic to discrete coordinates

Syntax

```
[I,J] = geographicToDiscrete(R,lat,lon)
```

Description

`[I,J] = geographicToDiscrete(R,lat,lon)` returns the indices corresponding to geographic coordinates `lat` and `lon` in geographic raster `R`. If `R.RasterInterpretation` is:

- `'cells'`, then `I` and `J` are the row and column subscripts of the raster cells (or image pixels)
- `'postings'`, then `I` and `J` refer to the nearest sample point (posting)

Examples

Find Indices of Nearest Posting Point from Geographic Coordinates

Import elevation data [1] on page 1-565 for a region in Colorado as an array and a `GeographicPostingsReference` object. Find the indices of the posting point nearest to the latitude and longitude of South Boulder Peak, which are `39.9539` and `-105.2992` degrees, respectively.

```
[Z,R] = readgeoraster('n39_w106_3arc_v2.dt1');
[I,J] = geographicToDiscrete(R,39.9539,-105.2992)
```

```
I = 56
```

```
J = 842
```

The result means that the posting point closest to the geographic coordinates is in row 56 and column 842 of the array.

[1] The elevation data used in this example is from the U.S. Geological Survey.

Input Arguments

R — Geographic raster

`GeographicCellsReference` or `GeographicPostingsReference` object

Geographic raster, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object.

lat — Latitude coordinates

numeric array

Latitude coordinates, specified as a numeric array.

Data Types: `single` | `double`

lon — Longitude coordinates

numeric array

Longitude coordinates, specified as a numeric array. `lon` is the same size as `lat`.

Data Types: `single` | `double`

Output Arguments**I — Longitude indices**

array of integers

Longitude indices, returned as an array of integers. `I` is the same size as `lat`.

For an m -by- n raster, $1 \leq I \leq m$, except for points (`lat(k)`, `lon(k)`) that fall outside the bounds of the raster as defined by the function `contains`. In this case `I(k)` and `J(k)` are NaN.

Data Types: `double`

J — Latitude indices

array of integers

Latitude indices, returned as an array of integers. `J` is the same size as `lat`.

For an m -by- n raster, $1 \leq J \leq n$ except for points (`lat(k)`, `lon(k)`) that fall outside the bounds of the raster as defined by the function `contains`. In this case `I(k)` and `J(k)` are NaN.

Data Types: `double`

Version History

Introduced in R2013b

See Also

`contains` | `geographicToIntrinsic` | `latitudeToIntrinsicY` | `longitudeToIntrinsicX` | `worldToDiscrete`

geographicToIntrinsic

Package: map.rasterref

Transform geographic to intrinsic coordinates

Syntax

```
[xIntrinsic,yIntrinsic] = geographicToIntrinsic(R,lat,lon)
```

Description

[xIntrinsic,yIntrinsic] = geographicToIntrinsic(R,lat,lon) returns the intrinsic coordinates corresponding to geographic coordinates lat and lon in geographic raster R.

Examples

Find Intrinsic Coordinates from Geographic Coordinates

Find the intrinsic coordinates of a cell within a raster by specifying a raster reference object and geographic coordinates.

First, load a geographic cells reference object for the Korean peninsula. To do this, load the korea5cR variable from the korea5c MAT-file. Then, specify the geographic coordinates of Seoul.

```
load korea5c korea5cR
lat = 37.57;
lon = 126.98;
```

Find the intrinsic coordinates.

```
[xIntrinsic,yIntrinsic] = geographicToIntrinsic(korea5cR,lat,lon)

xIntrinsic = 144.2600
yIntrinsic = 91.3400
```

The result means that the geographic coordinates are in the cell in column 144 and row 91 of the raster.

You can reverse the operation by using the intrinsicToGeographic function.

```
[lat,lon] = intrinsicToGeographic(korea5cR,xIntrinsic,yIntrinsic)

lat = 37.5700
lon = 126.9800
```

Input Arguments

R — Geographic raster

GeographicCellsReference or GeographicPostingsReference object

Geographic raster, specified as a GeographicCellsReference or GeographicPostingsReference object.

lat — Latitude coordinates

numeric array

Latitude coordinates, specified as a numeric array. Valid values of `lat` are in the range [-90, 90] degrees or are NaN. `lat` coordinates can be outside the bounds of the raster R.

Data Types: `single` | `double`

lon — Longitude coordinates

numeric array

Longitude coordinates, specified as a numeric array. `lon` is the same size as `lat`. `lon` coordinates can be outside the bounds of the raster R.

Data Types: `single` | `double`

Output Arguments

xIntrinsic — x-coordinates in intrinsic coordinate system

numeric array

x-coordinates in intrinsic coordinate system, returned as a numeric array. `xIntrinsic` is the same size as `lat`.

When `lon(k)` is outside the bounds of raster R, `xIntrinsic(k)` is extrapolated in the intrinsic coordinate system.

Data Types: `double`

yIntrinsic — y-coordinates in intrinsic coordinate system

numeric array

y-coordinates in intrinsic coordinate system, returned as a numeric array. `yIntrinsic` is the same size as `lat`.

When `lat(k)` is valid and outside the bounds of raster R, `yIntrinsic(k)` is extrapolated in the intrinsic coordinate system.

Data Types: `double`

Version History

Introduced in R2013b

See Also

`intrinsicToGeographic` | `latitudeToIntrinsicY` | `longitudeToIntrinsicX` |
`geographicToDiscrete` | `worldToIntrinsic`

geointerp

Geographic raster interpolation

Syntax

```
Vq = geointerp(V,R,latq,longq)
Vq = geointerp( ____,method)
```

Description

`Vq = geointerp(V,R,latq,longq)` interpolates the geographically referenced raster `V`, using bilinear interpolation. The function returns a value in `Vq` for each of the query points in arrays `latq` and `longq`. `R` is a geographic raster reference object that specifies the location and extent of data in `V`.

`Vq = geointerp(____,method)` specifies alternate interpolation methods.

Examples

Interpolate Values at Specific Latitudes and Longitudes

Load elevation raster data and a geographic cells reference object.

```
load topo60c
```

Specify the latitude and longitude values you want to interpolate. Then, interpolate the values.

```
latq = [-40 -20 20 40];
longq = [42 54 38 62];
Vq = geointerp(topo60c,topo60cR,latq,longq)
```

```
Vq = 1×4
103 ×
```

```
    -2.8327    -4.3855    -0.7125     0.1700
```

Input Arguments

V — Georeferenced raster grid

numeric or logical array

Georeferenced raster grid, specified as numeric or logical array.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

R — Geographic raster

`GeographicCellsReference` or `GeographicPostingsReference` object

Geographic raster, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object.

To convert a referencing matrix to a geographic raster reference object, use `refmatToGeoRasterReference`. To convert a referencing vector to a geographic raster reference object, use `refvecToGeoRasterReference`.

Latq — Latitude of query point coordinates

numeric array

Latitude of query point coordinates, specified as a numeric array.

Data Types: `single` | `double`

Longq — Longitude of query point coordinates,

numeric array

Longitude of query point coordinates, specified as a numeric array.

Data Types: `single` | `double`

method — Interpolation methods

'linear' (default) | 'nearest' | 'cubic' | 'spline'

Interpolation methods, specified as one of the following values.

Method	Description
'nearest'	Nearest neighbor interpolation
'linear'	Bilinear interpolation
'cubic'	Bicubic interpolation
'spline'	Spline interpolation

Data Types: `char` | `string`

Output Arguments

Vq — Interpolated values

numeric array

Interpolated values, returned as a numeric array.

Version History

Introduced in R2017a

See Also

`mapinterp` | `interp2` | `griddedInterpolant`

geoloc2grid

Convert geolocated data array to regular data grid

Syntax

```
[Z,R] = geoloc2grid(lat,lon,A,cellsize)
```

Description

`[Z,R] = geoloc2grid(lat,lon,A,cellsize)` converts the geolocated data array `A`, given geolocation points in `lat` and `lon`, to produce a regular data grid, `Z`, and the corresponding raster reference object `R`. `cellsize` is a scalar that specifies the width and height of data cells in the regular data grid, using the same angular units as `lat` and `lon`. Data cells in `Z` falling outside the area covered by `A` are set to `NaN`.

Examples

Display Geolocated and Regular Data Grids

Load the geolocated data array `map1` and grid it to $\frac{1}{2}$ -degree cells.

```
load mapmtx
cellsize = 0.5;
[Z,R] = geoloc2grid(lt1,lg1,map1,cellsize);
```

Create a figure.

```
f = figure;
[cmap,clim] = demcmap(map1);
set(f,'Colormap',cmap,'Color','w')
```

Define map limits.

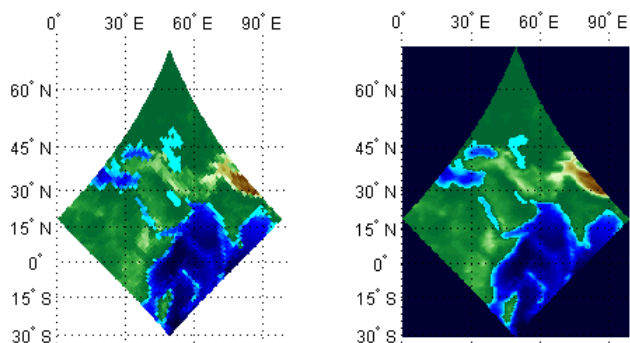
```
latlim = [-35 70];
lonlim = [0 100];
```

Display `map1` as a geolocated data array and `Z` as a regular data grid using subplots.

```
subplot(1,2,1)
ax = axesm('mercator','MapLatLimit',latlim,...
    'MapLonLimit',lonlim,'Grid','on',...
    'MeridianLabel','on','ParallelLabel','on');
set(ax,'Visible','off')
geoshow(lt1,lg1,map1,'DisplayType','texturemap');

subplot(1,2,2)
ax = axesm('mercator','MapLatLimit',latlim,...
    'MapLonLimit',lonlim,'Grid','on',...
    'MeridianLabel','on','ParallelLabel','on');
```

```
set(ax, 'Visible', 'off')
geoshow(Z,R, 'DisplayType', 'texturemap');
```



Tips

geoloc2grid provides an easy-to-use alternative to gridding geolocated data arrays with `imbedm`. There is no need to preallocate the output map; there are no data gaps in the output (even if cellsize is chosen to be very small), and the output map is smoother.

Version History

Introduced before R2006a

R2021a: geoloc2grid returns raster reference objects instead of referencing vectors

Behavior changed in R2021a

Starting in R2021a, the `geoloc2grid` function returns a raster reference object instead of a referencing vector. This change is unlikely to affect your existing code because most Mapping Toolbox functions that accept referencing vectors as input also accept raster reference objects.

See Also

Functions

`imbedm`

Objects

`GeographicCellsReference` | `GeographicPostingsReference` | `MapPostingsReference` | `MapCellsReference`

geopeaks

Generate synthetic data set on sphere

Syntax

```
Z = geopeaks(lat,lon)
Z = geopeaks(R)
Z = geopeaks( ____,spheroid)
```

Description

`Z = geopeaks(lat,lon)` evaluates a "peaks-like" function at specific latitudes and longitudes on the surface of a sphere, returning the synthetic data set `Z`. The function is continuous and smooth at all points, including the poles. Reminiscent of the MATLAB `peaks` function, `geopeaks` undulates gently between values of -10 and 8, with about a half dozen local extrema.

`Z = geopeaks(R)` evaluates the `geopeaks` function at cell centers or sample posting points defined by a geographic raster reference object, `R`.

`Z = geopeaks(____,spheroid)` evaluates the function on a specific spheroid. The choice of spheroid makes very little difference. This option exists mainly to support formal testing. If you do not specify `spheroid` and the `GeographicCRS` property of `R` is not empty, then `geopeaks` uses the spheroid contained in the `Spheroid` property of the `geocrs` object in the `GeographicCRS` property of `R`.

Examples

Generate Profile Along Meridian

Define latitude and longitude values along meridian that includes Paris, France.

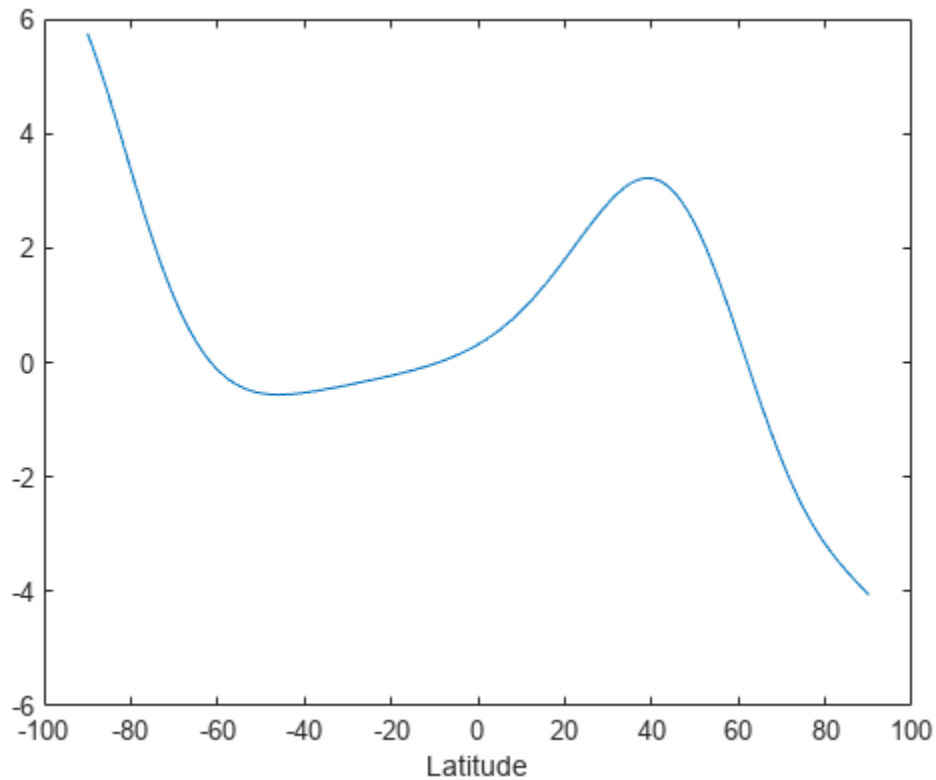
```
lon = dms2degrees([2 21 3]);
lat = -90:0.5:90;
```

Generate a data set, specifying a spheroid.

```
z = geopeaks(lat, lon, wgs84Ellipsoid);
```

Display the profile.

```
figure
plot(lat,z)
xlabel('Latitude')
```



Generate Global Raster and Display Results on World Map

Create a raster reference object for a 181-by-361 grid of postings.

```
latlim = [-90 90];
lonlim = [-180 180];
sampleSpacing = 1;
R = georefpostings(latlim,lonlim,sampleSpacing,sampleSpacing)
```

```
R =
  GeographicPostingsReference with properties:
```

```
    LatitudeLimits: [-90 90]
    LongitudeLimits: [-180 180]
    RasterSize: [181 361]
    RasterInterpretation: 'postings'
    ColumnsStartFrom: 'south'
    RowsStartFrom: 'west'
    SampleSpacingInLatitude: 1
    SampleSpacingInLongitude: 1
    RasterExtentInLatitude: 180
    RasterExtentInLongitude: 360
    XIntrinsicLimits: [1 361]
    YIntrinsicLimits: [1 181]
    CoordinateSystemType: 'geographic'
```

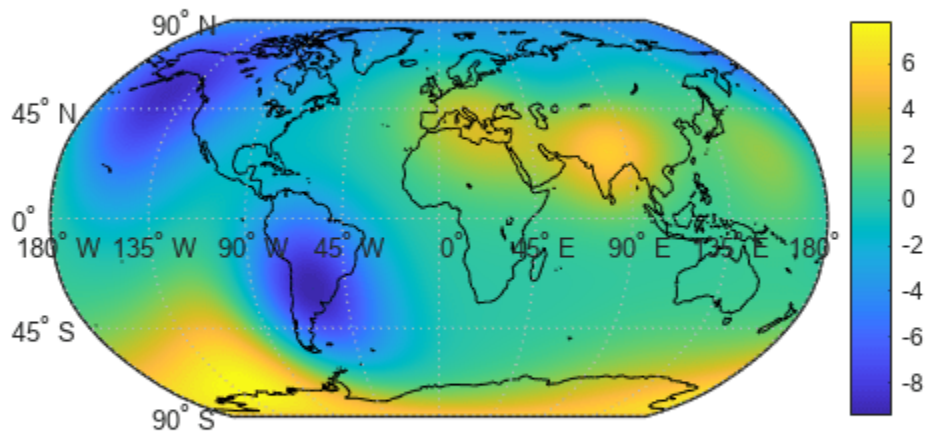
```
GeographicCRS: []  
AngleUnit: 'degree'
```

Generate a data set.

```
Z = geopeaks(R);
```

Display the resultant data set on a map.

```
figure  
worldmap world  
geoshow(Z,R,'DisplayType','surface','CData',Z,'ZData',zeros(size(Z)))  
load coastlines  
geoshow(coastlat,coastlon,'Color','k')  
colorbar
```



Input Arguments

lat — Geodetic latitude of one or more points

scalar, vector, or matrix

Geodetic latitude of one or more points, specified as a scalar value, vector, or matrix. Values must be in degrees.

The `lat` input argument must match the `lon` input argument in size unless either value is scalar (in which case it will expand in size to match the other), or `lat` is a column vector and `lon` is a row vector (they will expand to form a plaid latitude-longitude mesh).

Example: `lat = -90:0.5:90`

Data Types: `single` | `double`

lon — Geodetic longitude of one or more points

scalar, vector, or matrix

Geodetic longitude of one or more points, specified as a scalar value, vector, or matrix. Values must be in degrees.

The `lon` input argument must match the `lat` input argument in size unless either value is scalar (in which case it will expand in size to match the other), or `lon` is a column vector and `lat` is a row vector (they will expand to form a plaid latitude-longitude mesh).

Example: `lon = -180:0.5:180`

Data Types: `single` | `double`

R — Geographic raster

`GeographicCellsReference` or `GeographicPostingsReference` object

Geographic raster, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object. The geographic raster stores the latitude and longitude of points.

Example: `R = georefcells([0 80], [-140 60], 0.25, 0.25)`

spheroid — Reference spheroid

`referenceEllipsoid` | `oblateSpheroid` | `referenceSphere`

Reference spheroid, specified as a `referenceEllipsoid`, `oblateSpheroid`, or `referenceSphere` object.

Example: `spheroid = referenceEllipsoid('GRS80')`

Output Arguments

Z — Synthetic data set

scalar value, vector, or matrix

Synthetic data set, returned as a scalar value, vector, or matrix of class `single` or `double`, depending on the class of the input. The function is evaluated at each element of `lat` and `lon` (following expansion as noted above), or at each cell center or posting point defined by `R`.

Version History

Introduced in R2015b

R2020b: geopeaks uses reference ellipsoid information in raster reference objects

The `geopeaks` function uses the reference ellipsoid within the geographic raster reference object `R`. To find the reference ellipsoid for a geographic raster reference object, `R`, first get its geographic

coordinate reference system as a `geocrs` object. Then, query the `Spheroid` property of the `geocrs` object.

```
g = R.GeographicCRS;  
g.Spheroid
```

To use `geopeaks` with a different spheroid, specify the `spheroid` argument.

See Also

`peaks`

geoplot3

Geographic globe plot

Syntax

```
geoplot3(g,lat,lon,h)
geoplot3( ____,LineStyle)
geoplot3( ____,Name,Value)
p = geoplot3( ____)
```

Description

`geoplot3(g,lat,lon,h)` plots a 3-D line in the geographic globe specified by `g` at the vertices specified by `lat`, `lon`, and `h`.

`geoplot3(____,LineStyle)` sets the line style, marker, and color.

`geoplot3(____,Name,Value)` specifies additional options for the line using one or more name-value pair arguments. Specify the options after all other input arguments. For a list of options, see [Line Properties](#).

`p = geoplot3(____)` returns a `Line` object. This syntax is useful for controlling the properties of the line.

Examples

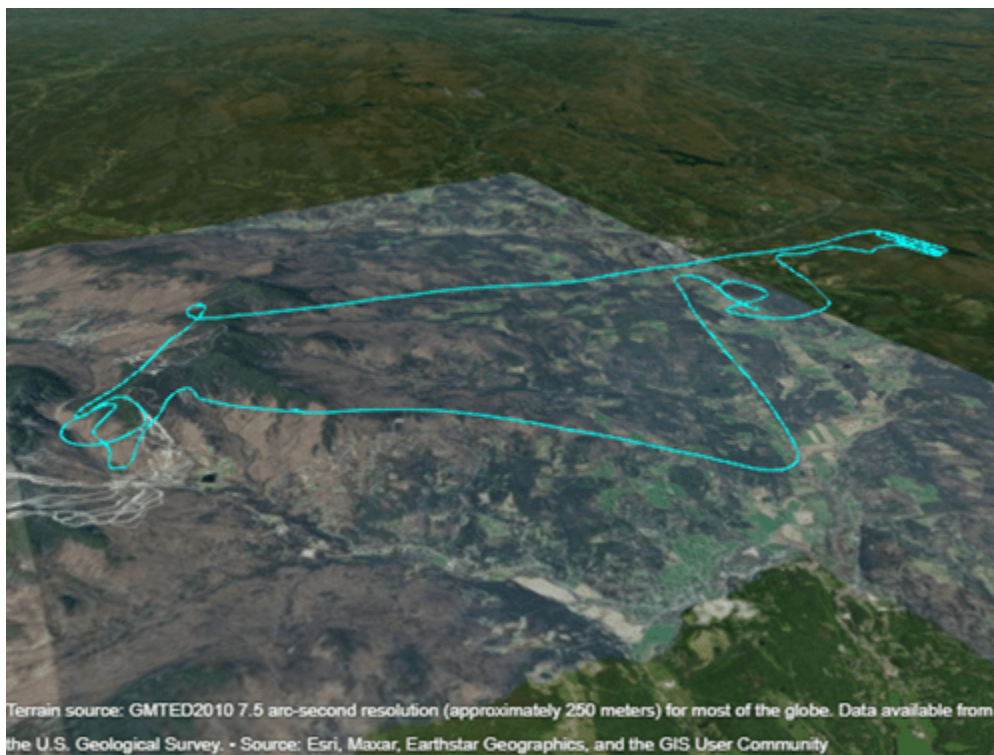
Plot Line over Local Region

Plot the path of a glider above a local region. First, import sample data representing the path. Get the latitude, longitude, and geoid height values.

```
trk = readgeotable("sample_mixed.gpx","Layer","track_points");
lat = trk.Shape.Latitude;
lon = trk.Shape.Longitude;
h = trk.Elevation;
```

Create a geographic globe. Then, plot the path as a line. By default, the view is directly above the data. Tilt the view by holding **Ctrl** and dragging.

```
uif = uifigure;
g = geoglobe(uif);
geoplot3(g,lat,lon,h,"c")
```

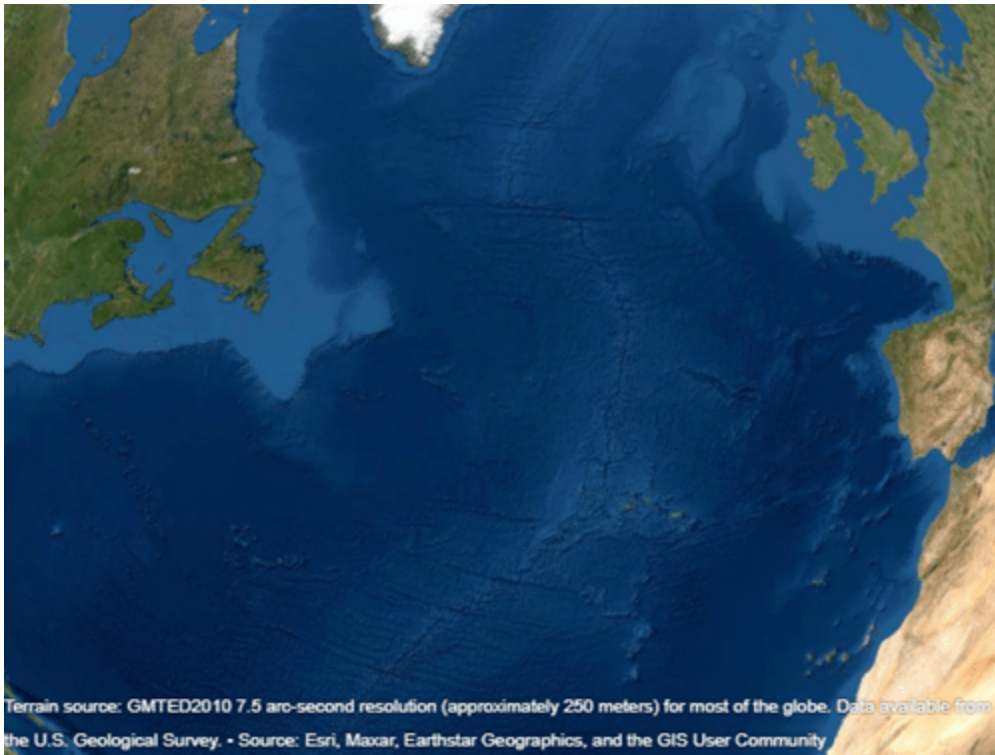


Plot Line Between Distant Points

When you plot a line between points that are far apart, the data may be obscured because the line passes through the Earth. View the entire line by inserting points between the specified data points.

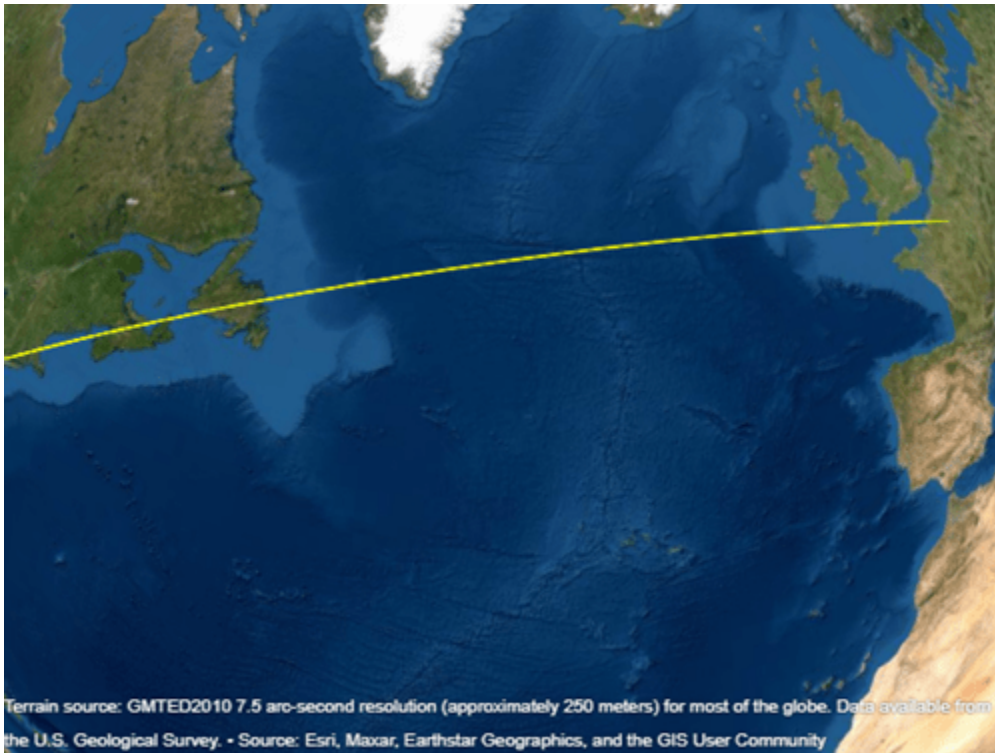
For example, specify the coordinates of New York City and Paris. Then, plot a line between them. Indicate there is no height data by specifying the fourth argument of `geoplot3` as an empty array. Note that you cannot see the line because it passes through the Earth.

```
lat = [40.71 48.86];  
lon = [-74.01 2.35];  
uif = uifigure;  
g = geoglobe(uif);  
geoplot3(g,lat,lon,[],"y","LineWidth",2)
```



To see the line, insert points along a great circle using the `interp` function. Then, plot the line again. Note that the line is visible.

```
[latI,lonI] = interp(lat,lon,0.1,"gc");  
geoplot3(g,latI,lonI,[],"y","LineWidth",2)
```

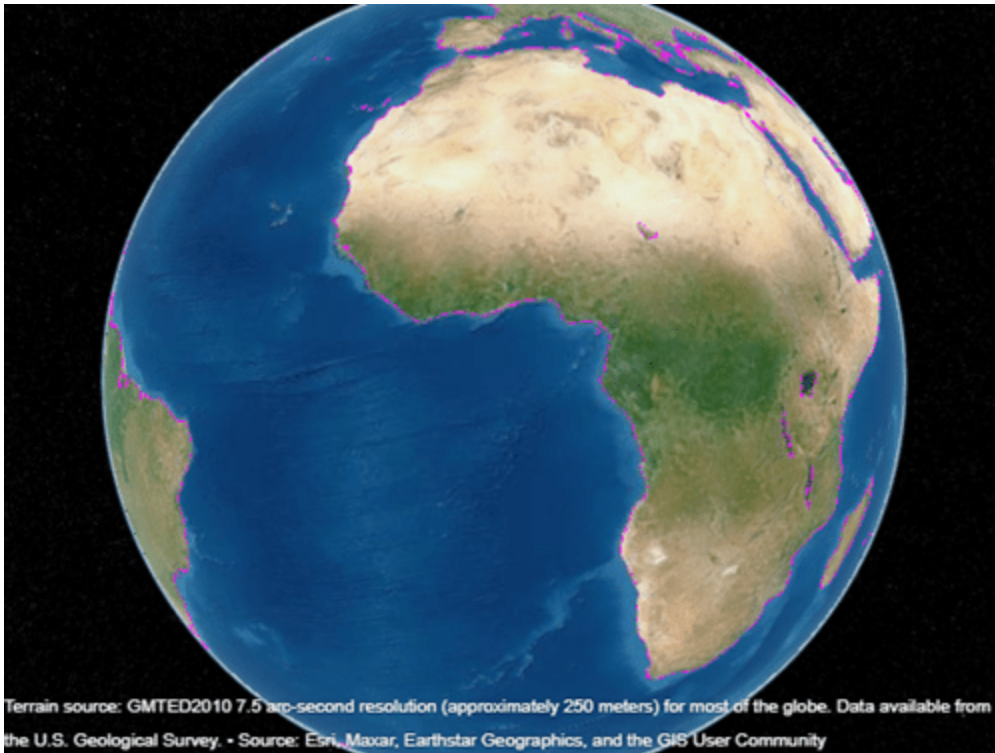


Plot Line over Global Region

When you plot a line over a large region such as a state or country, part of the line may be obscured because it passes through terrain. View the entire line by removing the terrain data from the globe.

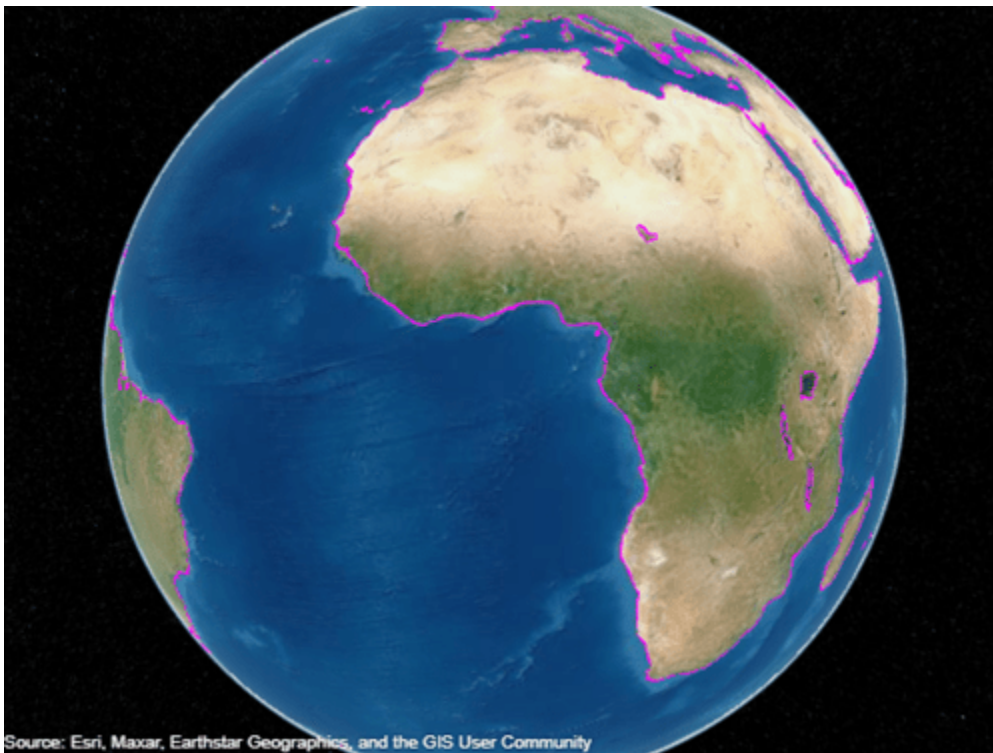
For example, import sample coastline data and plot it on a geographic globe. By default, the globe includes terrain data derived from the GMTED2010 model. Note that the line appears broken.

```
load coastlines
uif = uifigure;
g = geoglobe(uif);
p = geoplot3(g, coastlat, coastlon, [], "m");
```



To see the line, set the Terrain property of the globe to "none". Indicate the plotted data sits on the WGS84 reference ellipsoid by setting the HeightReference property of the line to "ellipsoid". Note that the line is visible over the basemap.

```
g.Terrain = "none";  
p.HeightReference = "ellipsoid";
```

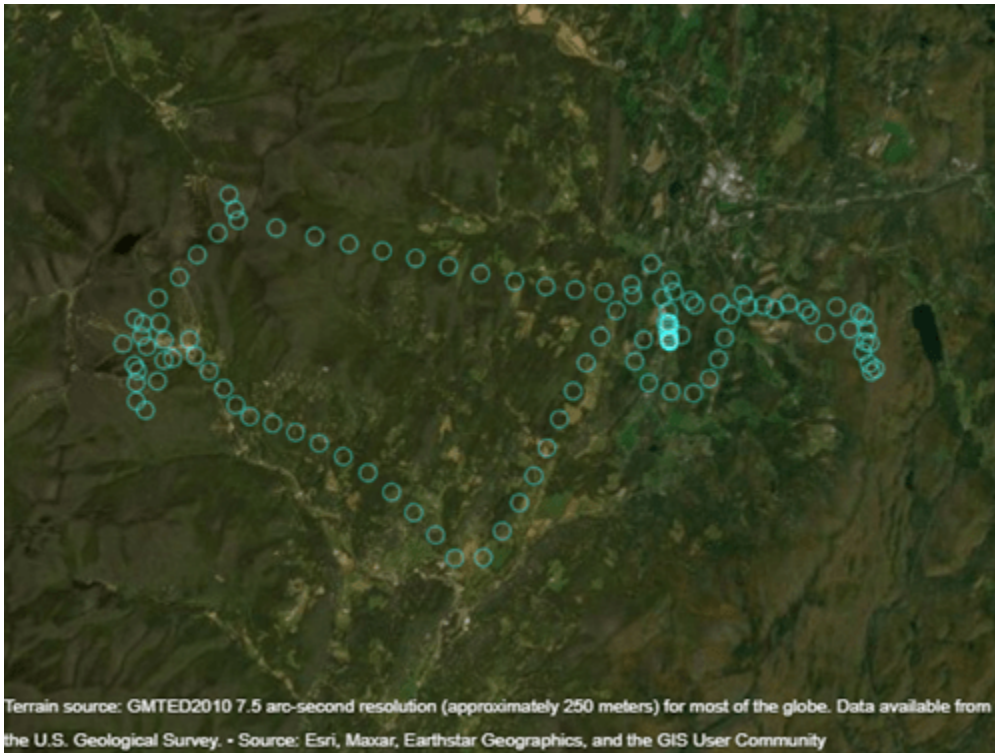
Plot Circle Markers Instead of Line

Import sample data representing the path of a glider. Get the latitude, longitude, and geoid height values.

```
trk = readgeotable("sample_mixed.gpx", "Layer", "track_points");  
lat = trk.Shape.Latitude;  
lon = trk.Shape.Longitude;  
h = trk.Elevation;
```

Create a geographic globe. Then, plot the data using circle markers. Plot a marker at every 25th data point by setting the `MarkerIndices` property.

```
uif = uifigure;  
g = geoglobe(uif);  
mskip = 1:25:length(lat);  
geoplot3(g, lat, lon, h, "co", "MarkerIndices", mskip)
```



Plot Data with Height Referenced to Terrain

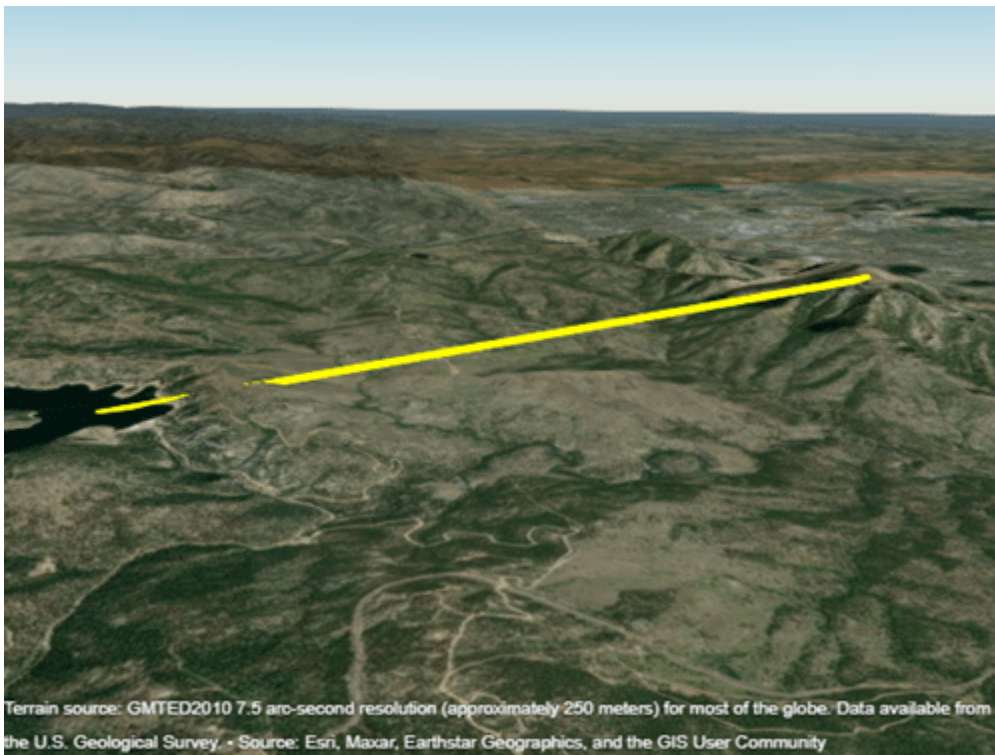
Plot a line from the surface of Gross Reservoir to a point above South Boulder Peak.

Specify the latitude, longitude, and height of the two endpoints. Specify the heights relative to the terrain, so that 0 represents ground level and not sea level.

```
lat = [39.95384 39.95];
lon = [-105.29916 -105.3608];
hTerrain = [10 0];
```

Plot the line on a geographic globe. Indicate that height values are referenced to the terrain using the `HeightReference` property. By default, the view is directly above the data. Tilt the view by holding **Ctrl** and dragging.

```
uif = uifigure;
g = geoglobe(uif);
geoplot3(g,lat,lon,hTerrain,"y","HeightReference","terrain","LineWidth",3)
```



Input Arguments

g — Geographic globe

GeographicGlobe object

Geographic globe, specified as a GeographicGlobe object.⁷

lat — Geodetic latitudes

vector

Geodetic latitudes in degrees, specified as a vector.

lat and lon must be the same size.

Data Types: single | double

lon — Geodetic longitudes

vector

Geodetic longitudes in degrees, specified as a vector.

lat and lon must be the same size.

Data Types: single | double

⁷ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

h – Heights

vector

Heights in meters, specified as a vector. By default, height values are referenced to the geoid, or mean sea level.

Reference height values to the WGS84 reference ellipsoid by setting the `HeightReference` property of the line to `'ellipsoid'`. Reference height values to the terrain, or ground, by setting the `HeightReference` property to `'terrain'`.

`h` must be either a scalar or a vector of the same size as `lat` and `lon`. If `h` is a scalar, then every point is plotted at the same height.

Data Types: `single` | `double`

LineStyle – Line style, marker, and color

character vector | string scalar

Line style, marker, and color, specified as a character vector or string containing symbols. The symbols can appear in any order. You do not need to specify all three characteristics (line style, marker, and color). For example, if you omit the line style and specify the marker, then the plot shows only the marker and no line.

Example: `'-o'` is a red solid line with circle markers

Line Style and Marker	Description
-	Solid line (default)
o	Circle marker

Color	Description
y	yellow
m	magenta
c	cyan
r	red
g	green
b	blue
w	white
k	black

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `geoplot3(g, 1:10, 1:10, 1:10, 'Color', 'r')` changes the color of the line

Note The properties listed here are only a subset. For a full list, see [Line Properties](#).

HeightReference – Height reference

'geoid' (default) | 'terrain' | 'ellipsoid'

Height reference, specified as one of these values:

- 'geoid' - Height values are relative to the geoid (mean sea level).
- 'terrain' - Height values are relative to the ground.
- 'ellipsoid' - Height values are relative to the WGS84 reference ellipsoid.

For more information about terrain, geoid, and ellipsoid height, see “Find Ellipsoidal Height from Orthometric and Geoid Height”.

Color – Line color


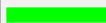


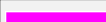
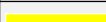


[0 0.4470 0.7410] (default) | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...

Line color, specified as an RGB triplet, a hexadecimal color code, a color name, or a short name.





RGB triplets and hexadecimal color codes are useful for specifying custom colors.




- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1]; for example, [0.4 0.6 0.7].
- A hexadecimal color code is a character vector or a string scalar that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Thus, the color codes '#FF8800', '#ff8800', '#F80', and '#f80' are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	

RGB Triplet	Hexadecimal Color Code	Appearance
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

Example: 'blue'


Example: [0 0 1]

Example: '#0000FF'

LineStyle – Line style

'-' (default) | 'none'

Line style, specified as one of these options:

Line Style	Description	Resulting Line
'-'	Solid line (default)	
'none'	No line	No line

Marker – Marker symbol

'none' (default) | 'o'

Marker symbol, specified as 'none' or 'o'. By default, the line does not display markers. Specify 'o' to display circle markers at each data point or vertex.

Markers do not tilt or rotate as you navigate the globe.

Limitations

- Unlike most Line objects, lines created using `geoplot3` cannot have their parent changed to any object except a geographic globe.

Version History

Introduced in R2020a

R2022b: Adding new plot to geographic globe does not reset basemap or terrain

Behavior changed in R2022b

When you add a plot to a geographic globe by using the `geoplot3` function, MATLAB does not reset the basemap or terrain. In R2022a and earlier releases, the basemap and terrain reset when you add new plots.

As a result, you can specify the basemap or terrain and then visualize data without using the `hold` function. For example, this code creates a globe using the "streets" basemap and no terrain data. Then, it displays a plot and adjusts the camera view. In R2022b, the basemap and terrain do not reset. In R2022a and earlier releases, the basemap reset to the default "satellite" and the terrain reset to the default "gmted2010".

```
lat = [42.3501 42.3515 42.3598 42.3584 42.3529 42.3626];
lon = [-71.0870 -71.0926 -71.0662 -71.0598 -71.0662 -71.0789];
```

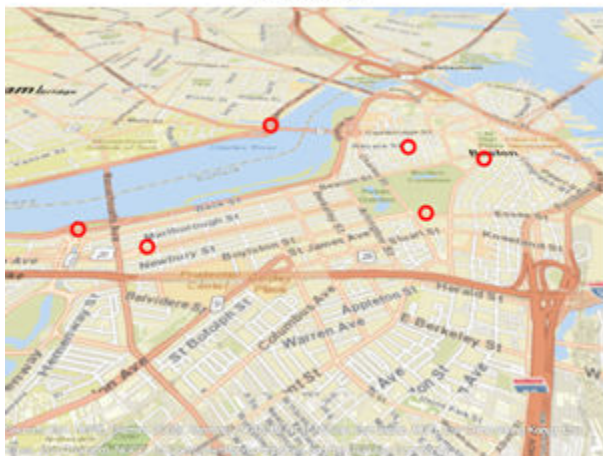
```

uif = uifigure;
g = geoglobe(uif,Basemap="streets",Terrain="none");

p = geoplot3(g,lat,lon,0,"ro",LineWidth=3);
campos(g,42.33,-71.0756,2113)
campitch(g,-42.2458)

```

R2022b



R2022a



This change does not affect existing code that sets the hold state to "on" between commands.

To reset the basemap and terrain, set the Basemap and Terrain properties to the defaults after you create the plot.

```

g.Basemap = "satellite";
g.Terrain = "gmted2010";

```

For more information about changing the basemap and terrain of geographic globes, see "Access Basemaps and Terrain for Geographic Globe".

See Also

geoglobe | Line Properties

geopoint

Geographic point vector

Description

A geopoint vector is a container object that holds geographic point coordinates and attributes. The points are coupled, such that the size of the latitude and longitude coordinate arrays are always equal and match the size of any dynamically added attribute arrays. Each entry of a coordinate pair and associated attributes, if any, represents a discrete element in the geopoint vector.

To create a geographic point shape for use with a geospatial table, create a `geopointshape` object instead.

Creation

Syntax

```
p = geopoint()
p = geopoint(latitude, longitude)
p = geopoint(latitude, longitude, Name, Value)
p = geopoint(structArray)
p = geopoint(latitude, longitude, structArray)
```

Description

`p = geopoint()` constructs an empty geopoint vector with these default property settings:

`p =`

```
0x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: []
  Longitude: []
```

`p = geopoint(latitude, longitude)` sets the `Latitude` and `Longitude` properties of geopoint vector `p`

`p = geopoint(latitude, longitude, Name, Value)` sets the `Latitude` and `Longitude` properties, then adds dynamic properties to the geopoint vector using `Name, Value` argument pairs. You can specify several name-value pair arguments in any order as `Name1, Value1, ..., NameN, ValueN`.

`p = geopoint(structArray)` constructs a new geopoint vector from the fields of the structure, `structArray`.

- If `structArray` contains the field `Lat`, and does not contain a field `Latitude`, then the `Lat` values are assigned to the `Latitude` property. Similar behavior occurs when `structArray` contains the field `Lon`, and does not contain the field `Longitude`.
- If `structArray` contains both `Lat` and `Latitude` fields, then both field values are assigned to `p`. Similar behavior occurs for `Lon` and `Longitude` fields when both are present in `structArray`.
- Other fields of `structArray` are assigned to `p` and become dynamic properties. Field values in `structArray` that are not numeric data types, string scalars, string arrays, character vectors, or cell arrays of numeric data types or character vectors are ignored.

`p = geoint(latitude, longitude, structArray)` sets the `Latitude` and `Longitude` properties, and sets dynamic properties from the field values of the structure, `structArray`.

- If `structArray` contains the fields `Lat`, `Latitude`, `Lon`, or `Longitude`, then those field values are ignored.

Properties

Each element in a geoint vector is considered a feature. For more about the property types in `geoint`, see “Collection Properties” on page 1-608 and “Feature Properties” on page 1-608.

Dynamic properties are new features that are added to a geoint vector and that apply to each individual feature in the geoint vector. You can attach new dynamic Feature properties to the object during construction with a `Name, Value` pair or after construction using dot (`.`) notation. This is similar to adding dynamic fields to a structure. For an example of adding dynamic Feature properties, see “Construct Geoint Vector Using Name-Value Pairs” on page 1-597.

Geometry — Type of geometry

`'point'`

Type of geometry, specified as `'point'`. For `geoint`, `Geometry` is always `'point'`.

Data Types: `char` | `string`

Latitude — Latitude coordinates

numeric row or column vector

Latitude coordinates, specified as a numeric row or column vector.

Data Types: `double` | `single`

Longitude — Longitude coordinates

numeric row or column vector

Longitude coordinates, specified as a numeric row or column vector.

Data Types: `double` | `single`

Metadata — Information for the entire set of geoint vector elements

scalar structure

Information for the entire set of geoint vector elements, specified as a scalar structure. You can add any data type to the structure.

- If `Metadata` is provided as a dynamic property `Name` in the constructor, and the corresponding `Value` is a scalar structure, then `Value` is copied to the `Metadata` property. Otherwise, an error is issued.
- If a `Metadata` field is provided by `structArray`, and both `Metadata` and `structArray` are scalar structures, then the `Metadata` field value is copied to the `Metadata` property value. If `structArray` is a scalar but the `Metadata` field is not a structure, then an error is issued. If `structArray` is not scalar, then the `Metadata` field is ignored.

Data Types: `struct`

Object Functions

<code>append</code>	Append features to geographic or planar vector
<code>cat</code>	Concatenate geographic or planar vector
<code>disp</code>	Display geographic or planar vector
<code>fieldnames</code>	Return dynamic property names of geographic or planar vector
<code>isempty</code>	Determine if geographic or planar vector is empty
<code>isfield</code>	Determine if dynamic property exists in geographic or planar vector
<code>isprop</code>	Determine if property exists in geographic or planar vector
<code>length</code>	Return number of elements in geographic or planar vector
<code>properties</code>	Return property names of geographic or planar vector
<code>rmfield</code>	Remove dynamic property from geographic or planar vector
<code>rmprop</code>	Remove property from geographic or planar vector
<code>size</code>	Return size of geographic or planar vector
<code>struct</code>	Convert geographic or planar vector to scalar structure
<code>vertcat</code>	Vertically concatenate geographic or planar vectors

Examples

Construct Geopoint Vector and Display It

This example shows how to create a `geopoint` vector, specifying latitude and longitude coordinates, and display it.

Create Geopoint Containing Single Point and Display It

Create a `geopoint` vector using the latitude and longitude of Paris, France, and display it. When using a `geopoint` vector, the geometry of the constructed object is always `'point'`.

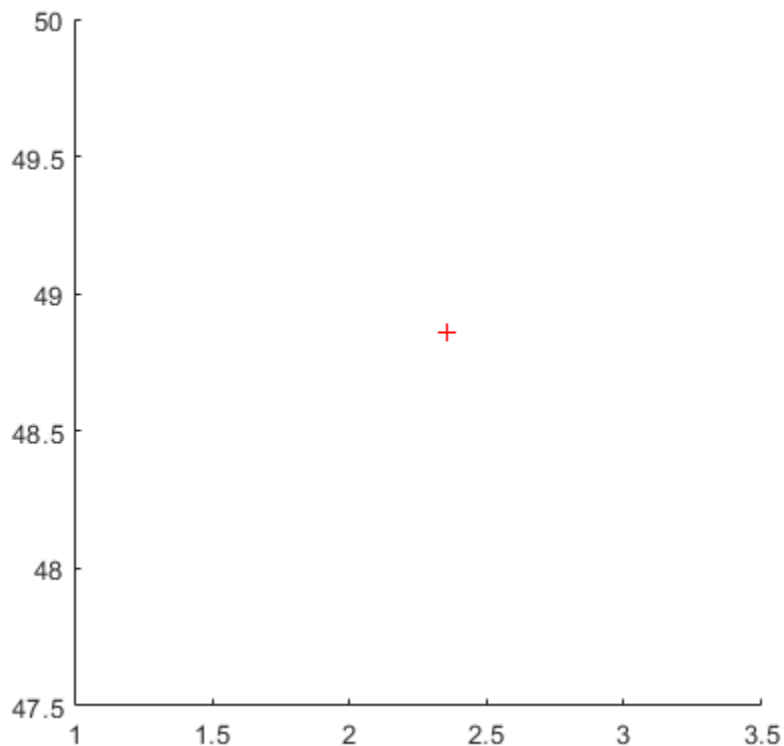
```
lat = 48.8566;
lon = 2.3522;
p = geopoint(lat,lon)

p =
    1×1 geopoint vector with properties:

    Collection properties:
        Geometry: 'point'
        Metadata: [1×1 struct]
    Feature properties:
        Latitude: 48.8566
        Longitude: 2.3522
```

Display the point in a plot. You can pass a `geopoint` vector directly to the `geoshow` command. `geoshow` can read the latitude and longitude values from the `geopoint` vector and also reads the geometry type.

```
geoshow(p)
```

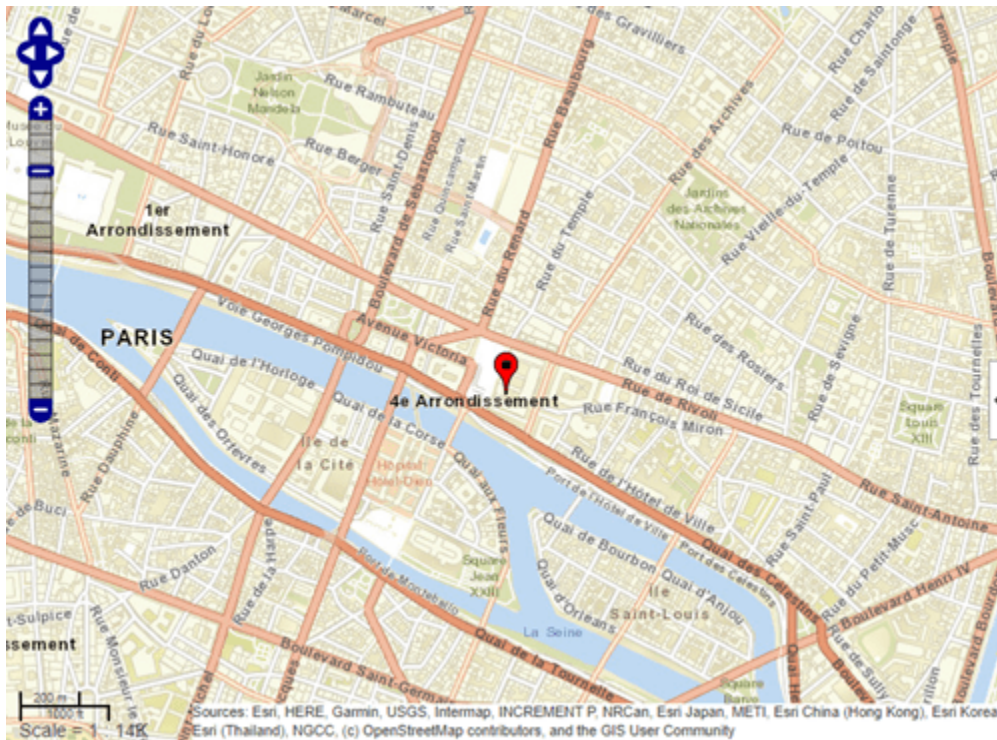


Display Point on a Map

To display your point with more context, plot your point over a map using the web map display function `wmmarker`. You can pass a `geopoint` vector directly to the `wmmarker` command.

```
wmmarker(p)
```

The `wmmarker` function opens a web map and displays the point on the map.



Construct Geopoint Vector from File

Import data from a text file with the latitudes and longitudes of some European capitals. The latitude coordinates are in the first column and the longitude coordinates are in the second column. The coordinates are separated by single space character.

```
data = importdata('european_capitals.txt');
```

Create a geopoint vector containing the latitude and longitude data.

```
p = geopoint(data(:,1),data(:,2))
```

```
p =  
13x1 geopoint vector with properties:
```

```
Collection properties:
```

```
Geometry: 'point'
```

```
Metadata: [1x1 struct]
```

```
Feature properties:
```

```
Latitude: [48.8566 51.5074 40.4168 41.9028 52.5200 52.3680 52.2297 47.4979 44.4268 50.0755 4
```

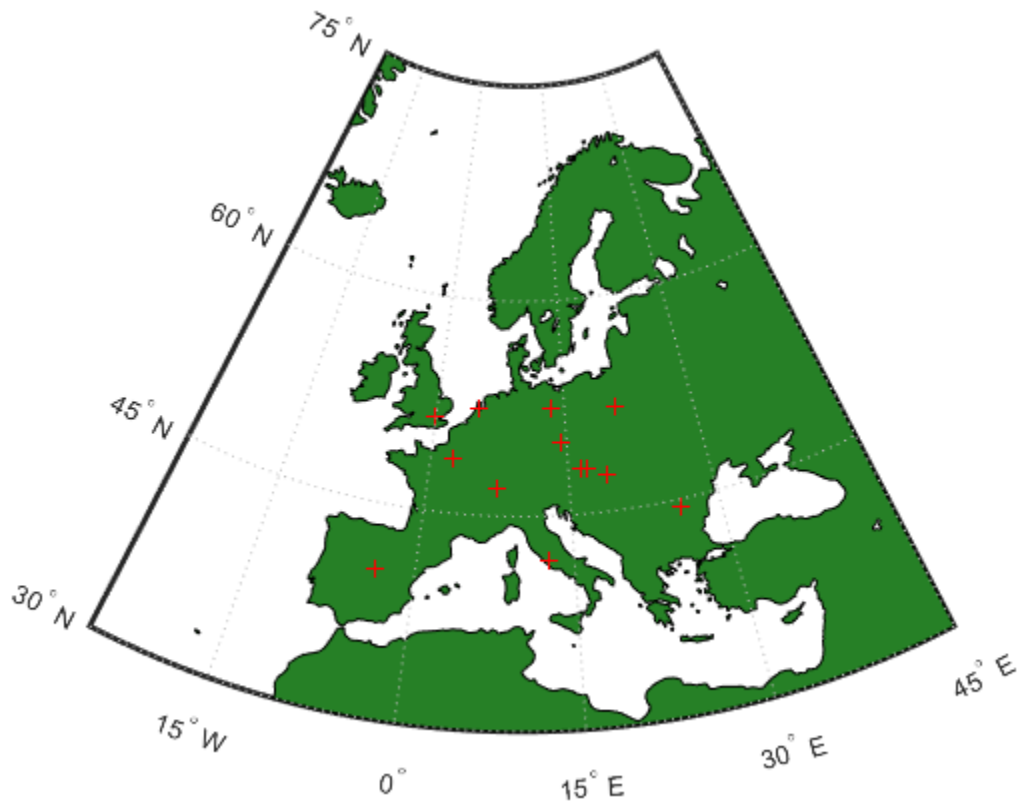
```
Longitude: [2.3522 -0.1278 -3.7038 12.4964 13.4050 4.9036 21.0122 19.0402 26.1025 14.4378 17
```

Plot the points on a map showing the landmass of Europe.

```
worldmap europe
```

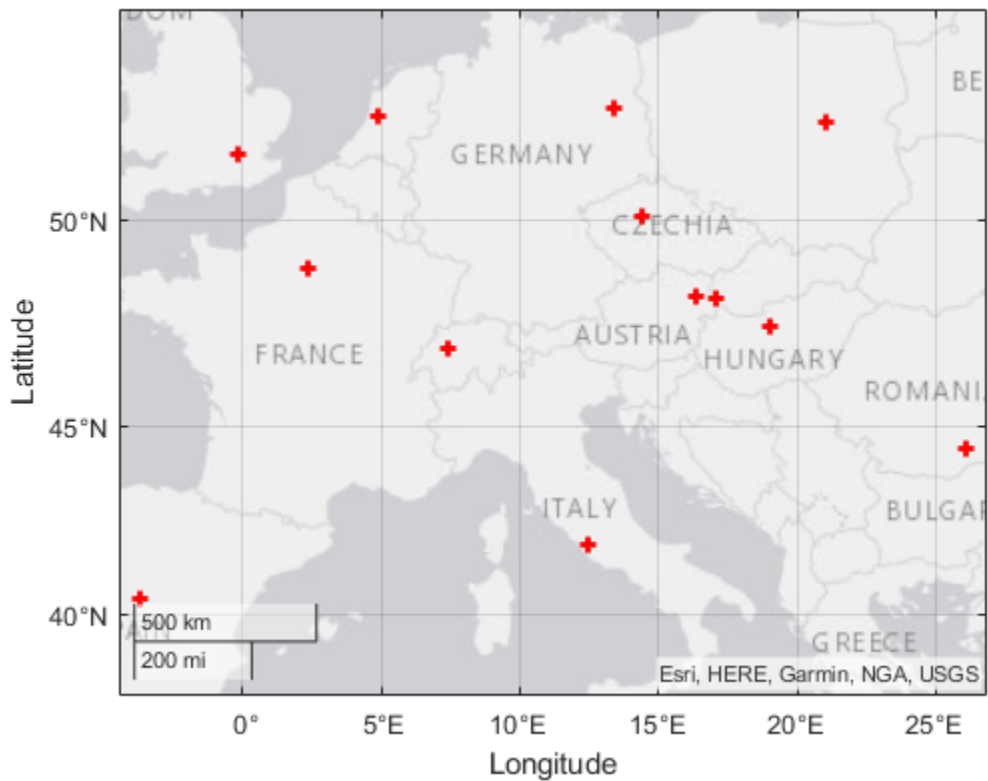
```
geoshow('landareas.shp','FaceColor',[0.15 0.5 0.15])
```

```
geoshow(p)
```



Alternatively, you can also plot these points over a map using the `geoplot` function. This example includes a line specification parameter to specify a plus sign marker and the color red. The example also increases the line width for better visibility of the markers.

```
figure  
geoplot(p.Latitude,p.Longitude,'+r','LineWidth',2)
```



Construct Geopoint Vector Using Name-Value Pairs

Create a geopoint vector, specifying Latitude, Longitude, and Temperature, where Temperature is part of a Name-Value pair.

```
point = geopoint(42, -72, 'Temperature', 89)
```

```
point =
```

```
1x1 geopoint vector with properties:
```

```
Collection properties:
```

```
Geometry: 'point'
```

```
Metadata: [1x1 struct]
```

```
Feature properties:
```

```
Latitude: 42
```

```
Longitude: -72
```

```
Temperature: 89
```

Construct a geopoint object specifying names.

```
p = geopoint([51.519 48.871], [-.13 2.4131],...
    'Name', {"London", "Paris"})
```

```
p =
```

```
2x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [51.5190 48.8710]
  Longitude: [-0.1300 2.4131]
  Name: {'London' 'Paris'}
```

Construct Geopoint Vector From a Structure Array

Read shape data into a geostruct (a structure array containing Lat and Lon fields).

```
S = shaperead('worldcities.shp', 'UseGeoCoords', true)
```

```
S =
```

```
318x1 struct array with fields:
```

```
  Geometry
  Lon
  Lat
  Name
```

Create a geopoint vector specifying the geostruct.

```
p = geopoint(S)
```

```
p =
```

```
318x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [1x318 double]
  Longitude: [1x318 double]
  Name: {1x318 cell}
```

Add a Filename field to the Metadata structure. The Metadata property pertains to all elements of a geopoint vector.

```
p.Metadata.Filename = 'worldcities.shp';
```

```
m = p.Metadata
```

```
ans =
```

```
  Filename: 'worldcities.shp'
```

Construct a Geopoint Vector Using Numeric Arrays and a Structure Array

Create a structure array.

```
[structArray, A] = shaperead('worldcities.shp', 'UseGeoCoords', true)
```

```
structArray =
```

```
318x1 struct array with fields:
    Geometry
    Lon
    Lat
```

```
A =
```

```
318x1 struct array with fields:
    Name
```

Use the numeric arrays and the structure containing the list of names to construct a geopoint vector.

```
p = geopoint([structArray.Lat], [structArray.Lon], A)
```

```
p =
```

```
318x1 geopoint vector with properties:
```

```
Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
Feature properties:
    Latitude: [1x318 double]
    Longitude: [1x318 double]
    Name: {1x318 cell}
```

Add Coordinate and Dynamic Properties

Generate an empty geopoint vector using the default constructor, then populate the geopoint vector using dot notation with properties from data fields in structure `structArray`.

```
structArray = shaperead('worldcities.shp', 'UseGeoCoords', true);
```

```
p = geopoint();
```

```
p.Latitude = [structArray.Lat];
```

```
p.Longitude = [structArray.Lon];
```

```
p.Name = structArray.Name;
```

```
p
```

```
p =
```

```
318x1 geopoint vector with properties:
```

```
Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
Feature properties:
    Latitude: [1x318 double]
    Longitude: [1x318 double]
    Name: {1x318 cell}
```

Add New Values to Existing geopoint Vector

This example shows how to add new values to an existing geopoint vector. The example appends data about Paderborn Germany to the geopoint vector of data about world cities.

Read world cities data using the `shaperead` command. `shaperead` returns a structure array.

```
structArray = shaperead('worldcities.shp', 'UseGeoCoords', true);
```

Create a geopoint vector from the structure array. Display the last of the 318 elements in the vector.

```
p = geopoint(structArray);
p(end)

ans =
  1x1 geopoint vector with properties:

  Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
  Feature properties:
    Latitude: 34.8519
    Longitude: 113.8061
    Name: 'Zhengzhou'
```

Add the Paderborn data to the end of the geopoint vector. Display the last of the existing elements and the new element.

```
lat = 51.715254;
lon = 8.75213;
p = append(p, lat, lon, 'Name', 'Paderborn');
p(end-1:end)

ans =
  2x1 geopoint vector with properties:

  Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
  Feature properties:
    Latitude: [34.8519 51.7153]
    Longitude: [113.8061 8.7521]
    Name: {'Zhengzhou' 'Paderborn'}
```

Another way to add a point at the end of a vector is to use linear indexing. For example, add data about Arlington, Massachusetts to the end of the world cities vector. Notice how, after the initial assignment statement appends a value to the Latitude property vector, using `end+1`, all other property vectors automatically expand by one element. Display the last of the existing elements and the new element.

```
p(end+1).Latitude = 42.417060

p =
  320x1 geopoint vector with properties:

  Collection properties:
```

```

    Geometry: 'point'
    Metadata: [1x1 struct]
    Feature properties:
      Latitude: [5.2985 24.6525 5.6106 37.0613 9.0235 -34.6645 12.8767 22.7778 31.3044 36.7870 43.
      Longitude: [-3.9509 54.7589 -0.2121 35.3894 38.7575 138.8528 44.5408 72.2474 30.4098 3.0397
      Name: {1x320 cell}

p(end).Longitude = -71.170200;
p(end).Name = 'Arlington';
p(end-1:end)

ans =
    2x1 geopoint vector with properties:

    Collection properties:
      Geometry: 'point'
      Metadata: [1x1 struct]
    Feature properties:
      Latitude: [51.7153 42.4171]
      Longitude: [8.7521 -71.1702]
      Name: {'Paderborn' 'Arlington'}

```

Manipulate a Geopoint Vector

Construct a geopoint vector containing two features and then add two dynamic properties.

```

lat = [51.519 48.871];
lon = [-.13 2.4131];
p = geopoint(lat, lon);

p.Name = {'London', 'Paris'}; % Add character feature dynamic property
p.ID = [1 2] % Add numeric feature dynamic property

p =

    2x1 geopoint vector with properties:

    Collection properties:
      Geometry: 'point'
      Metadata: [1x1 struct]
    Feature properties:
      Latitude: [51.5190 48.8710]
      Longitude: [-0.1300 2.4131]
      Name: {'London' 'Paris'}
      ID: [1 2]

```

Add the coordinates for a third feature.

```

p(3).Latitude = 45.472;
p(3).Longitude = 9.184

p =

    3x1 geopoint vector with properties:

```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [51.5190 48.8710 45.4720]
  Longitude: [-0.1300 2.4131 9.1840]
  Name: {'London' 'Paris' ''}
  ID: [1 2 0]
```

Note that lengths of all feature properties are synchronized with default values.

Set the values for the ID feature dynamic property with more values than contained in `Latitude` or `Longitude`.

```
p.ID = 1:4
```

```
p =
```

```
4x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [51.5190 48.8710 45.4720 0]
  Longitude: [-0.1300 2.4131 9.1840 0]
  Name: {'London' 'Paris' '' ''}
  ID: [1 2 3 4]
```

Note that all feature properties are expanded to match in size.

Set the values for the ID feature dynamic property with fewer values than contained in the `Latitude` or `Longitude` properties.

```
p.ID = 1:2
```

```
p =
```

```
4x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [51.5190 48.8710 45.4720 0]
  Longitude: [-0.1300 2.4131 9.1840 0]
  Name: {'London' 'Paris' '' ''}
  ID: [1 2 0 0]
```

The ID property values expand to match the length of the `Latitude` and `Longitude` property values.

Set the value of either coordinate property (`Latitude` or `Longitude`) with fewer values.

```
p.Latitude = [51.519 48.871]
```

```
p =
```


2x1 geopoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [51.5190 48.8710]
  Longitude: [-0.1300 2.4131]
  Name: {'London' 'Paris'}
  ID: [1 2]
```

All properties shrink to match in size.

Remove the ID property by setting its value to [].

```
p.ID = []
```

```
p =
```

2x1 geopoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [51.5190 48.8710]
  Longitude: [-0.1300 2.4131]
  Name: {'London' 'Paris'}
```

Remove all dynamic properties and set the object to empty by setting a coordinate property value to [].

```
p.Latitude = []
```

```
p =
```

0x1 geopoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: []
  Longitude: []
```

Sort Dynamic Properties and Extract Subsets

Read data from shapefile. Initially the field names of the class are in random order.

```
structArray = shaperead('tsunamis.shp', 'UseGeoCoords', true);
% Field names in random order
p = geopoint(structArray)
```

```
p =
```

162x1 geopoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [1x162 double]
  Longitude: [1x162 double]
  Year: [1x162 double]
  Month: [1x162 double]
  Day: [1x162 double]
  Hour: [1x162 double]
  Minute: [1x162 double]
  Second: [1x162 double]
  Val_Code: [1x162 double]
  Validity: {1x162 cell}
  Cause_Code: [1x162 double]
  Cause: {1x162 cell}
  Eq_Mag: [1x162 double]
  Country: {1x162 cell}
  Location: {1x162 cell}
  Max_Height: [1x162 double]
  Iida_Mag: [1x162 double]
  Intensity: [1x162 double]
  Num_Deaths: [1x162 double]
  Desc_Deaths: [1x162 double]
```

Using the method `fieldnames` and typical MATLAB vector notation, the field names in the `geopoint` vector are alphabetically sorted.

```
p = p(:, sort(fieldnames(p)))
```

```
p =
```

```
162x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [1x162 double]
  Longitude: [1x162 double]
  Cause: {1x162 cell}
  Cause_Code: [1x162 double]
  Country: {1x162 cell}
  Day: [1x162 double]
  Desc_Deaths: [1x162 double]
  Eq_Mag: [1x162 double]
  Hour: [1x162 double]
  Iida_Mag: [1x162 double]
  Intensity: [1x162 double]
  Location: {1x162 cell}
  Max_Height: [1x162 double]
  Minute: [1x162 double]
  Month: [1x162 double]
  Num_Deaths: [1x162 double]
  Second: [1x162 double]
  Val_Code: [1x162 double]
  Validity: {1x162 cell}
  Year: [1x162 double]
```

Using typical MATLAB vector notation, extract a subset of data from the base geopoint vector into a geopoint vector albeit smaller in size.

```
subp = p(20:40,{'Location','Country','Year'}) % get subset of data
```

```
subp =
```

```
21x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [1x21 double]
  Longitude: [1x21 double]
  Location: {1x21 cell}
  Country: {1x21 cell}
  Year: [1x21 double]
```

Note that the coordinate properties `Latitude` and `Longitude`, and the Collection properties, are retained in this subset of geopoint vectors.

Set, Get, and Remove Dynamic Property Values

To set property values, use the `()` operator, or assign array values to corresponding fields, or use dot `.'` notation (`object.property`) to assign new property values.

```
pts = geopoint();
pts.Latitude = [42 44 45];
pts.Longitude = [-72 -72.1 -71];
pts
```

```
pts =
```

```
3x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [42 44 45]
  Longitude: [-72 -72.1000 -71]
```

Use `()` to assign values to fields.

```
pts(3).Latitude = 45.5;
pts
```

```
pts =
```

```
3x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
```

```
Latitude: [42 44 45.5000]
Longitude: [-72 -72.1000 -71]
```

Use dot notation to create new dynamic properties

```
pts.Name = {'point1', 'point2', 'point3'}
```

```
pts =
```

```
3x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [42 44 45.5000]
  Longitude: [-72 -72.1000 -71]
  Name: {'point1' 'point2' 'point3'}
```

Get property values

```
pts.Name
```

```
ans =
```

```
'point1' 'point2' 'point3'
```

Remove dynamic properties. To delete or remove dynamic properties, set them to [] or set the **Latitude** or **Longitude** property to [].

```
pts.Temperature = 1:3
```

```
pts =
```

```
3x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [42 44 45.5000]
  Longitude: [-72 -72.1000 -71]
  Name: {'point1' 'point2' 'point3'}
  Temperature: [1 2 3]
```

By setting the **Temperature** property to [], this dynamic property is deleted.

```
pts.Temperature = []
```

```
pts =
```

```
3x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [42 44 45.5000]
```

```
Longitude: [-72 -72.1000 -71]
Name: {'point1' 'point2' 'point3'}
```

To clear all fields in the `geopoint` vector, set the `Latitude` or `Longitude` property to `[]`.

```
pts.Latitude = []
```

```
pts =
```

```
0x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: []
  Longitude: []
```

Modify geopoint Object and Its Metadata

If you typically store latitude and longitude coordinates in an N -by-2 or 2-by- M array, you can assign these numeric values to a `geopoint` vector. If the coordinates are N -by-2, the first column is assigned to the `Latitude` property and the second column to the `Longitude` property. If the coordinates are 2-by- M , then the first row is assigned to the `Latitude` property and the second row to the `Longitude` property.

```
load coastlines;
ltn = [coastlat coastlon];           % 9865x2 array
pts = geopoint;                     % null constructor
pts(1:numel(coastlat)) = ltn;       % assign array
pts.Metadata.Name = 'coastline';
pts

pts =
9865x1 geopoint vector with properties:

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: [-83.8300 -84.3300 -84.5000 -84.6700 -84.9200 -85.4200 -85.4200 -85.5800 -85.3300
  Longitude: [-180 -178 -174 -170 -166.0000 -163 -158 -152 -146 -147 -151 -153.5000 -153 -154.]
```

```
pts.Metadata
```

```
ans = struct with fields:
  Name: 'coastline'
```

More About

Collection Properties

Collection properties contain only one value per class instance. In contrast, the Feature property type has attribute values associated with each feature. `Geometry` and `Metadata` are the only two Collection properties.

Feature Properties

Feature properties contain one value (a scalar number, a scalar string, or a character vector) for each feature in a geopoint vector. They are suitable for properties such as name, owner, serial number, or age, that describe a given feature (an element of a geopoint vector) as a whole. The `Latitude` and `Longitude` coordinate properties are feature properties as there is one value for each element in the geopoint vector.

Feature properties can be added after construction using dot notation. This is similar to adding dynamic fields to a structure.

Tips

- If `Latitude`, `Longitude`, or a dynamic property is set with more values than features in the geopoint vector, then all other properties expand in size using 0 for numeric values and an empty character vector (' ') for cell values. See “Manipulate a Geopoint Vector” on page 1-601 for examples of these behaviors.
- If a dynamic property is set with fewer values than the number of features, then this dynamic property expands to match the size of the other properties by inserting a 0, if the value is numeric, or an empty character vector (' '), if the value is a cell array.
- If the `Latitude` or `Longitude` property of the geopoint vector is set with fewer values than contained in the object, then all other properties shrink in size.
- If either `Latitude` or `Longitude` are set to [], then both coordinate properties are set to [] and all dynamic properties are removed.
- If a dynamic property is set to [], then it is removed from the object.

Version History

Introduced in R2012a

See Also

Functions

`gpxread` | `shaperead`

Objects

`geoshape` | `mappoint` | `mapshape`

geopointshape

Point shape in geographic coordinates

Description

A `geopointshape` object represents a point or multipoint in geographic coordinates. A multipoint is an individual point shape that contains a set of point locations.

To represent a point or multipoint in planar coordinates, use a `mappointshape` object instead.

Creation

To create `geopointshape` objects, either:

- Import point data in geographic coordinates as a geospatial table using the `readgeotable` function, and then query the `Shape` variable of the table.
- Use the `geopointshape` function (described here).

Syntax

```
shape = geopointshape(lat,lon)
```

Description

`shape = geopointshape(lat,lon)` creates a `geopointshape` object or array of `geopointshape` objects with the specified latitude and longitude coordinates. The sizes of `lat`, `lon`, and the `geopointshape` object array `shape` match.

Input Arguments

lat — Latitude coordinates

numeric array | cell array of numeric arrays

Latitude coordinates, specified as a numeric array or a cell array of numeric arrays.

- Create a point by specifying a scalar, such as `39`.
- Create a multipoint by specifying an array within a cell, such as `{[38 -30 29]}`.
- Create an array of points by specifying an array, such as `[38 -30 29]`.
- Create an array of points and multipoints by specifying a cell array of numeric arrays, such as `{39,[38 -30 29]}`.

Create placeholders for points with missing data by including `NaN` values. The `NaN` values in `lat` must correspond to the `NaN` values in `lon`.

The size of `lat` must match the size of `lon`. For cell arrays, the size of the array in each cell of `lat` must match the size of the array in the corresponding cell of `lon`.

Data Types: `double` | `cell`

lon — Longitude coordinates

numeric array | cell array of numeric arrays

Longitude coordinates, specified as a numeric array or a cell array of numeric arrays.

- Create a point by specifying a scalar, such as `-113`.
- Create a multipoint by specifying an array within a cell, such as `{[-66 -31 42]}`.
- Create an array of points by specifying an array, such as `[-66 -31 42]`.
- Create an array of points and multipoints by specifying a cell array of numeric arrays, such as `{-113, [-66 -31 42]}`.

Create placeholders for points with missing data by including NaN values. The NaN values in `lat` must correspond to the NaN values in `lon`.

The size of `lat` must match the size of `lon`. For cell arrays, the size of the array in each cell of `lat` must match the size of the array in the corresponding cell of `lon`.

Data Types: `double` | `cell`

Properties**NumPoints — Number of points**

array of nonnegative integers

This property is read-only.

Number of points, returned as an array of nonnegative integers.

For a `geopointshape` scalar, the value of `NumPoints` is 1 when the `geopointshape` object represents a single point and more than 1 when the object represents a multipoint.

For a `geopointshape` array, the size of `NumPoints` matches the size of the array.

Data Types: `double`

Latitude — Latitude coordinates

array

Latitude coordinates, specified as an array.

For a `geopointshape` scalar, the size of `Latitude` matches the value of `NumPoints`.

For a `geopointshape` array, the size of `Latitude` matches the size of `NumPoints`. If the array contains `geopointshape` objects with multipoints, then accessing the `Latitude` property of the array is not supported. Instead, access the `Latitude` property of individual objects within the array. You can determine whether a `geopointshape` array contains multipoints by using the `ismultipoint` function.

This property is read-only for arrays when any element of `NumPoints` is greater than 1.

`Latitude` and `Longitude` must be the same size.

Data Types: `double`

Longitude — Longitude coordinates

array

Longitude coordinates, specified as an array.

For a `geopointshape` scalar, the size of `Longitude` matches the value of `NumPoints`.

For a `geopointshape` array, the size of `Longitude` matches the size of `NumPoints`. If the array contains `geopointshape` objects with multipoints, then accessing the `Longitude` property of the array is not supported. Instead, access the `Longitude` property of individual elements within the array. You can determine whether a `geopointshape` array contains multipoints by using the `ismultipoint` function.

This property is read-only for arrays when any element of `NumPoints` is greater than 1.

Latitude and Longitude must be the same size.

Data Types: `double`

Geometry — Geometric type

"point" (default)

This property is read-only.

Geometric type, returned as "point".

Data Types: `string`

CoordinateSystemType — Coordinate system type

"geographic" (default)

This property is read-only.

Coordinate system type, returned as "geographic".

Data Types: `string`

GeographicCRS — Geographic coordinate reference system[] (default) | `geocrs` object

Geographic coordinate reference system (CRS), specified as a `geocrs` object. A geographic CRS consists of a datum (including its ellipsoid), prime meridian, and angular unit of measurement.

Object Functions

<code>geoplot</code>	Plot points, lines, and polygons on map
<code>geoclip</code>	Clip geographic shape to latitude-longitude limits
<code>ismultipoint</code>	Determine which array elements are multipoint shapes

Examples**Get Information About Imported Geographic Points**

Import a GPX file containing the coordinates of locations in Boston as a geospatial table. The GPX file represents the locations using points. Get information about the points by querying the `Shape` variable of the table.

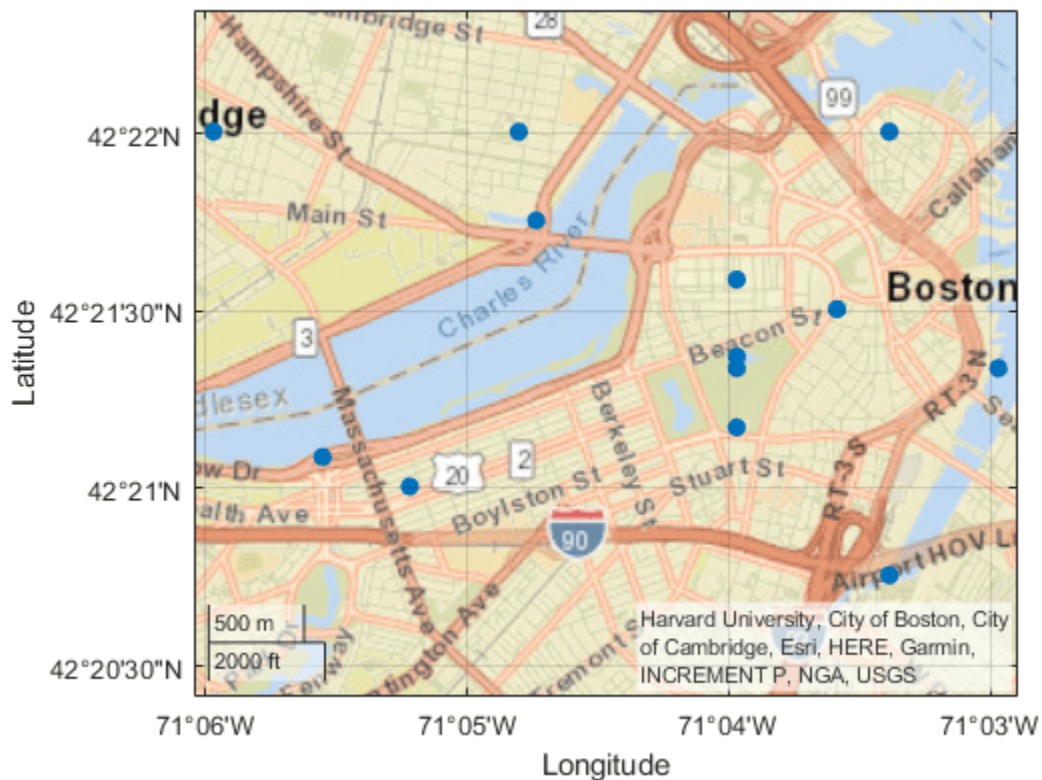
```
GT = readgeotable("boston_placenames.gpx");
GT.Shape
```

```
ans =
    13x1 geopointshape array with properties:

        NumPoints: [13x1 double]
        Latitude: [13x1 double]
        Longitude: [13x1 double]
        Geometry: "point"
        CoordinateSystemType: "geographic"
        GeographicCRS: [1x1 geocrs]
```

Display the locations on a road map by passing the geospatial table to the `geoplot` function.

```
figure
geoplot(GT,"o",MarkerFaceColor="#0072BD")
geobasemap streets
```



Create Geographic Points and Multipoints

Create an individual point as a `geopointshape` scalar. Specify the geographic CRS as the World Geodetic System of 1984, which has the EPSG code 4326.

```

point = geointshape(39,-113);
g = geocrs(4326);
point.GeographicCRS = g

point =
  geointshape with properties:

      NumPoints: 1
      Latitude: 39
      Longitude: -113
      Geometry: "point"
  CoordinateSystemType: "geographic"
      GeographicCRS: [1x1 geocrs]

```

Create a multipoint as a geointshape scalar.

```

multipoint = geointshape({[38 -30 29]},{[-66 -31 42]});
multipoint.GeographicCRS = g

multipoint =
  geointshape with properties:

      NumPoints: 3
      Latitude: [38 -30 29]
      Longitude: [-66 -31 42]
      Geometry: "point"
  CoordinateSystemType: "geographic"
      GeographicCRS: [1x1 geocrs]

```

Create three individual points as a 1-by-3 geointshape vector.

```

pointVector = geointshape([38 -20 29],[-66 -31 42]);
pointVector.GeographicCRS = g

pointVector =
  1x3 geointshape array with properties:

      NumPoints: [1 1 1]
      Latitude: [38 -20 29]
      Longitude: [-66 -31 42]
      Geometry: "point"
  CoordinateSystemType: "geographic"
      GeographicCRS: [1x1 geocrs]

```

Create one individual point and one multipoint as a 1-by-2 geointshape vector.

```

pointMultipoint = geointshape({39,[38 -30 29]},{-113,[-66 -31 42]});
pointMultipoint.GeographicCRS = g

pointMultipoint =
  1x2 geointshape array with properties:

      NumPoints: [1 3]
      Geometry: "point"
  CoordinateSystemType: "geographic"
      GeographicCRS: [1x1 geocrs]

```

Version History

Introduced in R2021b

R2022a: Points with missing coordinate data have some changed property values

Behavior changed in R2022a

When a point shape has missing coordinate data, its `NumPoints` property has a value of 0 and its `Latitude` and `Longitude` properties each have a value of NaN.

- When you create a point by specifying both coordinates as NaN values, its `NumPoints` property has a value of 0. In the previous release, the property had a value of 1.
- When a point has no coordinate data, its `Latitude` and `Longitude` properties each have a value of NaN. In the previous release, the properties were each empty double values.

These changes make it easier to create and access the properties of `geopointshape` arrays when the input coordinates contain missing data. For example, you can now access the coordinates of a `geopointshape` array when the array contains a combination of points with coordinate data (`NumPoints` is 1) and without coordinate data (`NumPoints` is 0). In the previous release, MATLAB issued an error.

See Also

Functions

`readgeotable`

Objects

`geolineshape` | `geopolyshape` | `mappointshape`

Topics

“Create Geospatial Tables”

geolineshape

Line shape in geographic coordinates

Description

A `geolineshape` object represents a line or multiline in geographic coordinates. A *multiline* is an individual line shape that contains a set of separate lines.

To represent a line or multiline in planar coordinates, use a `maplineshape` object instead.

Creation

To create `geolineshape` objects, either:

- Import line data in geographic coordinates as a geospatial table using the `readgeotable` function, and then query the `Shape` variable of the table.
- Use the `geolineshape` function (described here).

Syntax

```
shape = geolineshape(lat,lon)
```

Description

`shape = geolineshape(lat,lon)` creates a `geolineshape` object or array of `geolineshape` objects with vertices at the specified latitude and longitude coordinates. The sizes of `lat`, `lon`, and the `geolineshape` object array `shape` match.

Input Arguments

lat — Latitude coordinates

numeric vector | cell array of numeric vectors

Latitude coordinates, specified as a numeric vector or a cell array of numeric vectors.

- Create a line by specifying a vector, such as `[65 62 53 66]`.
- Create a multiline by specifying a vector and including line breaks as `NaN` values, such as `[55 34 18 NaN 14 19 42 26]`.
- Create an array of lines and multilines by specifying a cell array of vectors, such as `{[55 34 18],[14 19 NaN 42 26 31]}`.

The `NaN` values in `lat` must correspond to the `NaN` values in `lon`.

The size of `lat` must match the size of `lon`. For cell arrays, the size of the vector in each cell of `lat` must match the size of the vector in the corresponding cell of `lon`.

Data Types: `double` | `cell`

lon — Longitude coordinates

numeric vector | cell array of numeric vectors

Longitude coordinates, specified as a numeric vector or a cell array of numeric vectors.

- Create a line by specifying a vector, such as [4 59 121 98].
- Create a multiline by specifying a vector and including line breaks as NaN values, such as [78 56 63 NaN 83 106 104 126].
- Create an array of lines and multilines by specifying a cell array of vectors, such as {[78 56 63],[83 106 NaN 104 126 131]}.

The NaN values in `lat` must correspond to the NaN values in `lon`.

The size of `lat` must match the size of `lon`. For cell arrays, the size of the vector in each cell of `lat` must match the size of the vector in the corresponding cell of `lon`.

Data Types: `double` | `cell`

Properties**NumParts — Number of line parts**

array of nonnegative integers

This property is read-only.

Number of line parts, returned as an array of nonnegative integers.

For a `geolineshape` scalar, the value of `NumParts` is 1 when the `geolineshape` object represents a single line and more than 1 when the object represents a multiline.

For a `geolineshape` array, the size of `NumParts` matches the size of the array.

Data Types: `double`

Geometry — Geometric type`"line"` (default)

This property is read-only.

Geometric type, returned as `"line"`.

Data Types: `string`

CoordinateSystemType — Coordinate system type`"geographic"` (default)

This property is read-only.

Coordinate system type, returned as `"geographic"`.

Data Types: `string`

GeographicCRS — Geographic coordinate reference system`[]` (default) | `geocrs` object

Geographic coordinate reference system (CRS), specified as a `geocrs` object. A geographic CRS consists of a datum (including its ellipsoid), prime meridian, and angular unit of measurement.

Object Functions

`geoplot` Plot points, lines, and polygons on map
`geoclip` Clip geographic shape to latitude-longitude limits
`ismultipoint` Determine which array elements are multipoint shapes

Examples

Get Information About Imported Geographic Lines

Import the `tracks` layer of a GPX file containing routes in Massachusetts as a geospatial table. The `tracks` layer represents the routes using lines. Get information about the line in the second track by querying the `Shape` variable of the table.

```
GT = readgeotable("sample_tracks.gpx", Layer="tracks");  
GT.Shape(2)
```

```
ans =  
  geolineshape with properties:  
      NumParts: 5  
      Geometry: "line"  
  CoordinateSystemType: "geographic"  
      GeographicCRS: [1x1 geocrs]
```

Create a subtable that contains the second track. Display the second track on a road map.

```
GT2 = GT(2, :);  
geoplot(GT2, LineWidth=2)  
geobasemap streets
```



Create Geographic Lines and Multilines

Create an individual line as a `geolineshape` scalar. Specify the geographic CRS as the World Geodetic System of 1984, which has the EPSG code 4326.

```
lat = [65 62 53 66];
lon = [4 59 121 98];
lineshp = geolineshape(lat,lon);

g = geocrs(4326);
lineshp.GeographicCRS = g

lineshp =
    geolineshape with properties:
        NumParts: 1
        Geometry: "line"
        CoordinateSystemType: "geographic"
        GeographicCRS: [1x1 geocrs]
```

Create a multiline as a `geolineshape` scalar.

```
lat = [55 34 18 NaN 14 19 42 26];
lon = [78 56 63 NaN 83 106 104 126];
```



```

multiline = geolineshape(lat,lon);
multiline.GeographicCRS = g

multiline =
  geolineshape with properties:

      NumParts: 2
      Geometry: "line"
  CoordinateSystemType: "geographic"
      GeographicCRS: [1x1 geocrs]

```

Create one individual line and one multiline as a 1-by-2 geolineshape array.

```

lat = {[55 34 18],[14 19 NaN 42 26 37]};
lon = {[78 56 63],[83 106 NaN 104 126 113]};
lineMultiline = geolineshape(lat,lon);
lineMultiline.GeographicCRS = g

lineMultiline=1x2 object
  1x2 geolineshape array with properties:

      NumParts: [1 2]
      Geometry: "line"
  CoordinateSystemType: "geographic"
      GeographicCRS: [1x1 geocrs]

```

Version History

Introduced in R2021b

See Also

Functions

readgeotable

Objects

geopointshape | geopolyshape | maplineshape

Topics

“Create Geospatial Tables”

geoplot

Plot points, lines, and polygons on map

Syntax

```
geoplot(GT)
geoplot(shape)
geoplot( ____, LineSpec)

geoplot(lat, lon)
geoplot(lat, lon, LineSpec)
geoplot(lat1, lon1, ..., latN, lonN)
geoplot(lat1, lon1, LineSpec1, ..., latN, lonN, LineSpecN)

geoplot(tbl, latvar, lonvar)

geoplot( ____, Name=Value)
geoplot(ax, ____)
h = geoplot( ____)
```

Description

Mapping Toolbox extends the functionality of the `geoplot` (MATLAB) function. It adds support for displaying points, lines, and polygons with coordinates in any supported geographic or projected coordinate reference system (CRS). Depending on the type of axes, the function displays data into different map projections.

- Geographic axes — A Web Mercator projection
- Map axes — The projection specified by the `ProjectedCRS` property of the map axes

If you do not have Mapping Toolbox installed, then see `geoplot`.

Geospatial Table and Shape Data

`geoplot(GT)` plots the point, line, or polygon shape objects within the `Shape` variable of the geospatial table `GT`. If the current axes is not a geographic or map axes, or if there is no current axes, then the function plots the line in a new geographic axes.

`geoplot(shape)` plots the point, line, or polygon shape objects in `shape`.

`geoplot(____, LineSpec)` sets the style, marker symbol, and color for the plotted shapes. You can use the `LineSpec` argument with either the `GT` or `shape` argument.

Numeric Vector Data

`geoplot(lat, lon)` plots a line with vertices at the latitudes and longitudes in `lat` and `lon`, respectively.

`geoplot(lat, lon, LineSpec)` sets the style, marker symbol, and color for the line.

`geoplot(lat1, lon1, ..., latN, lonN)` plots multiple pairs of latitude and longitude coordinates on the same set of axes.

`geoplot(lat1,lon1,LineSpec1,...,latN,lonN,LineSpecN)` assigns specific line styles, markers, and colors to each latitude-longitude pair.

Numeric Table Data

`geoplot(tbl,latvar,lonvar)` plots the variables `latvar` and `lonvar` from the table `tbl`. To plot one data set, specify one variable for `latvar` and one variable for `lonvar`. To plot multiple data sets, specify multiple variables for `latvar`, `lonvar`, or both. If both arguments specify multiple variables, they must specify the same number of variables. (Since R2022b)

Additional Options

`geoplot(____,Name=Value)` specifies options for the plot using one or more name-value arguments, in addition to any combination of input arguments from the previous syntaxes.

`geoplot(ax, ____)` plots in the geographic axes or map axes specified by `ax`.

`h = geoplot(____)` returns a `Point`, `Line`, or `Polygon` object. The type of object depends on the type of input. Use `h` to modify the properties of the plot object.

Examples

Plot Shapes from Geospatial Table

Import a shapefile containing road data for Concord, MA, into the workspace as a geospatial table. The table represents roads using line shapes in projected coordinates.

```
GT = readgeotable("concord_roads.shp");
GT.Shape

ans=609x1 object
16x1 maplineshape array with properties:

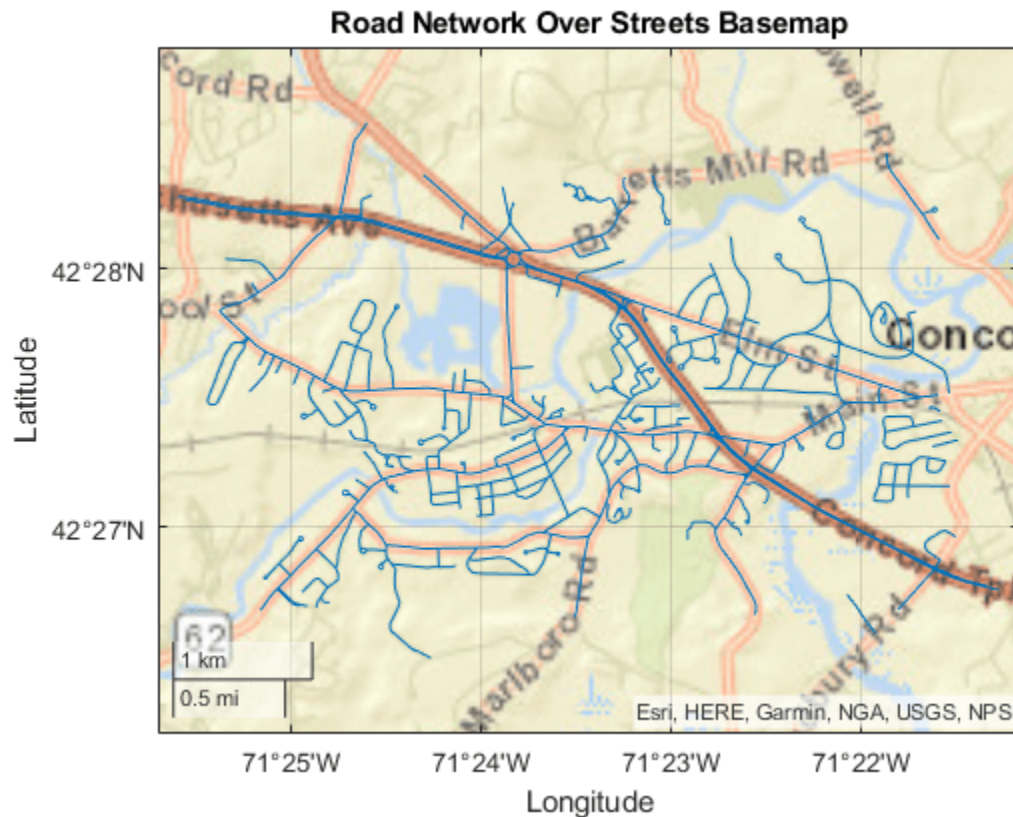
    NumParts: [16x1 double]
    Geometry: "line"
    CoordinateSystemType: "planar"
    ProjectedCRS: [1x1 projcrs]
    :
```

Display the line shapes by passing the table to the `geoplot` function.

```
figure
geoplot(GT)
```

Change the basemap and add a title.

```
geobasemap streets
title("Road Network Over Streets Basemap")
```



Plot from Geospatial Table Using Custom Colors

One way to plot data from a geospatial table and customize the colors is to set the `ColorVariable` property. You can set this property by using a name-value argument when you call the `geoplot` function, or you can set it on the plot object later.

Read a shapefile containing tsunami events into the workspace as a geospatial table. The table represents the tsunami events using point shapes in geographic coordinates.

```
GT = readgeotable("tsunamis.shp",CoordinateSystemType="geographic");
```

Create a subtable containing events for a region surrounding Southeast Asia.

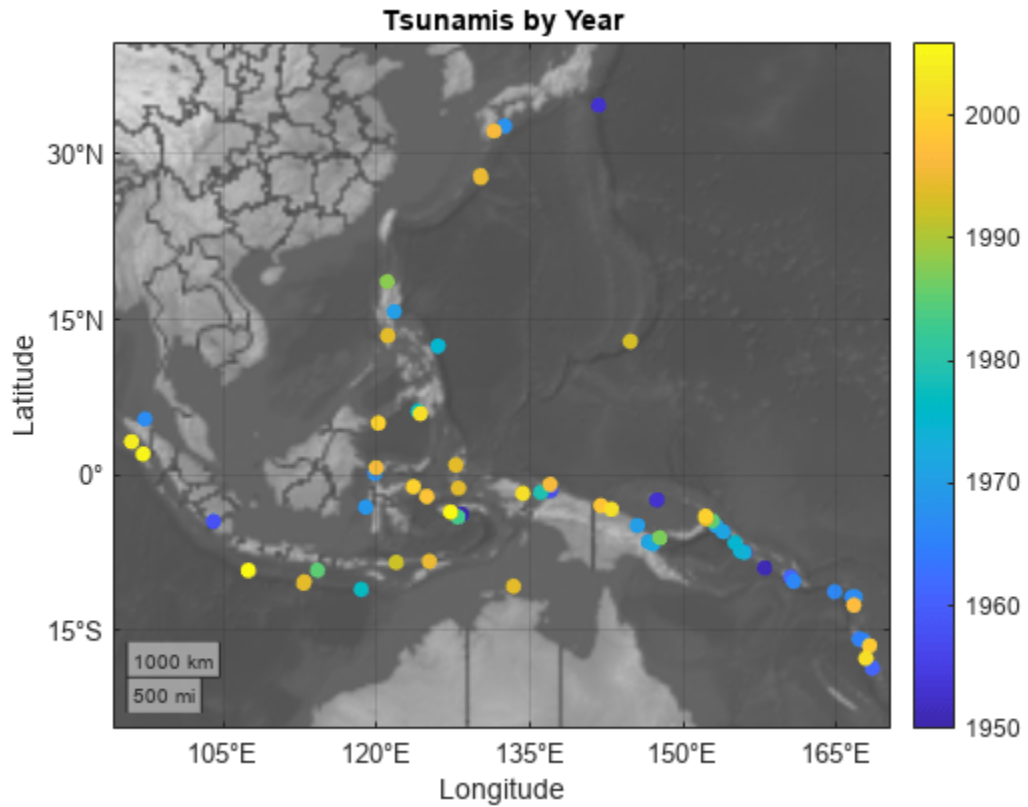
```
bbox = geopolyshape([-25 35 35 -25 -25],[90 90 170 170 90]);
inpoly = isinterior(bbox,GT.Shape);
GT2 = GT(inpoly,:);
```

Display the point shapes within the table. Vary the marker colors by specifying the `ColorVariable` name-value argument as a table variable. Return the `Point` object as `h`, so you can change the `ColorVariable` property later.

```
figure
h = geoplot(GT2,ColorVariable="Year",MarkerSize=20);
```

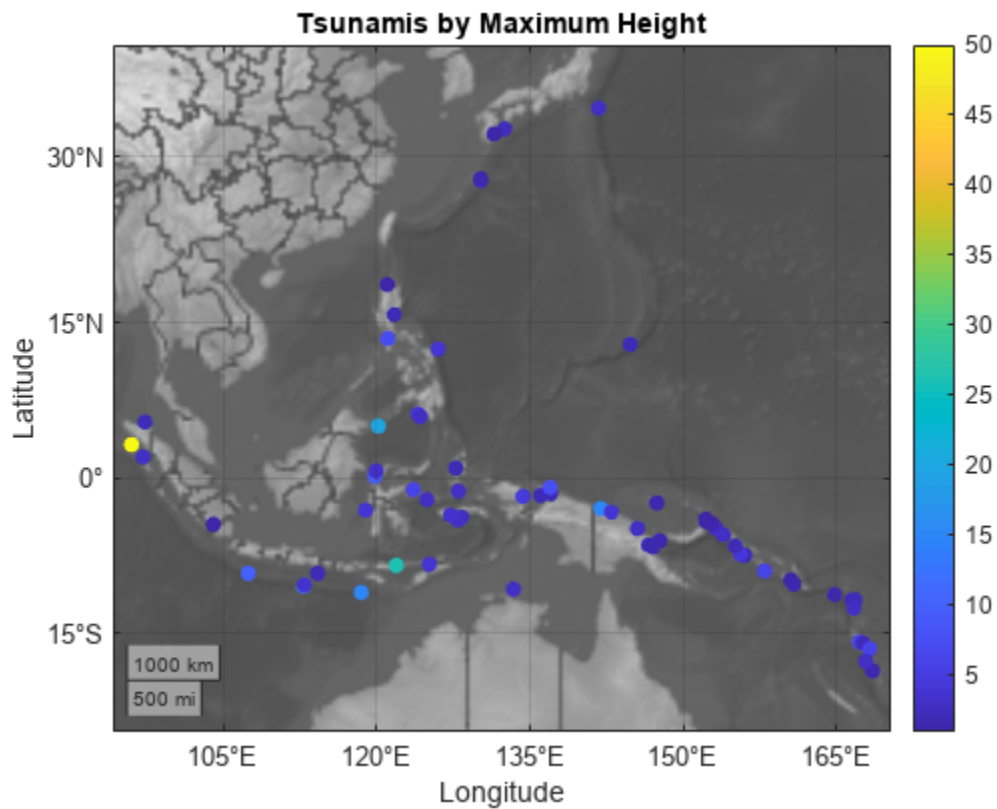
Change the basemap, add a colorbar, and add a title.

```
geobasemap grayterrain  
colorbar  
title("Tsunamis by Year")
```



Change the marker colors again by setting the ColorVariable property to a different table variable.

```
h.ColorVariable = "Max_Height";  
title("Tsunamis by Maximum Height")
```



Plot Shapes in Geographic Coordinates

Read a shapefile containing world cities into the workspace as a geospatial table. The table represents the cities using point shapes in geographic coordinates.

```
GT = readgeotable("worldcities.shp");
shape = GT.Shape
```

```
shape =
  318x1 geopointshape array with properties:
```

```
    NumPoints: [318x1 double]
    Latitude: [318x1 double]
    Longitude: [318x1 double]
    Geometry: "point"
    CoordinateSystemType: "geographic"
    GeographicCRS: [1x1 geocrs]
```

Clip the shapes to a region containing part of Europe.

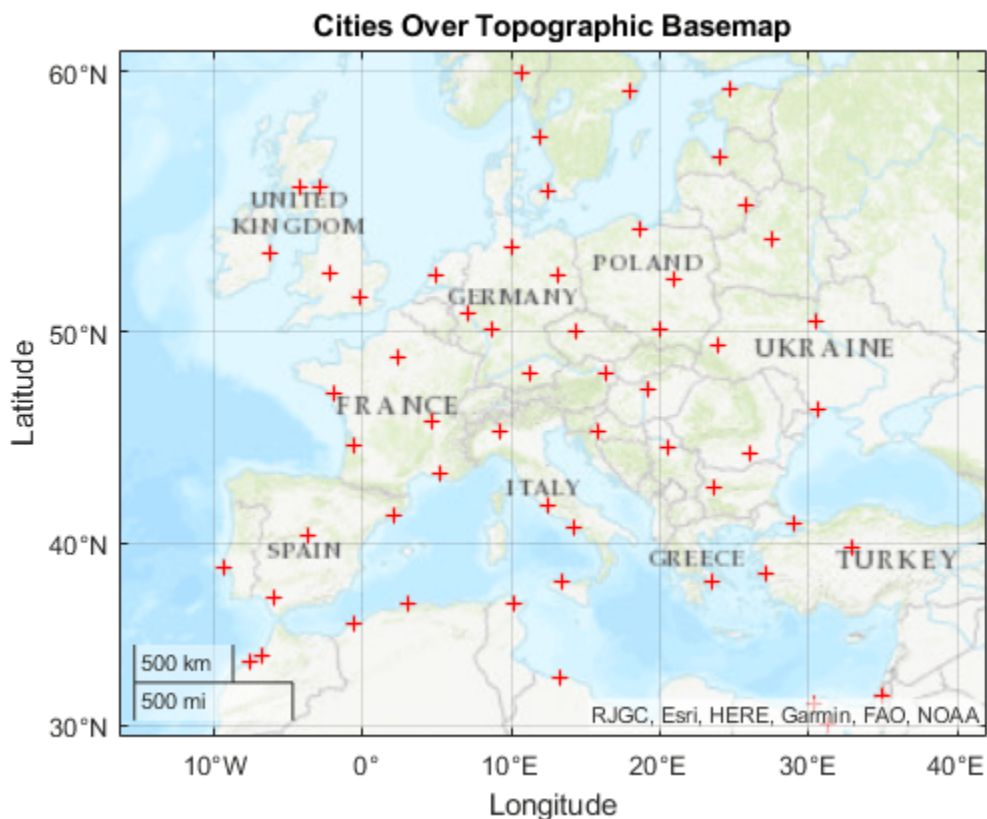
```
clipped = geoclip(shape,[30 60],[-20 35]);
```

Display the shapes using red plus sign markers over a topographic basemap.

```

figure
geoplot(clipped,"r+")
geobasemap topographic
title("Cities Over Topographic Basemap")

```



Plot Shapes in Projected Coordinates

Read hydrography data into the workspace as a geospatial table. The table represents the data using polygon shapes in projected coordinates. Extract the polygon shape for a pond.

```

GT = readgeotable("concord_hydro_area.shp");
shape = GT.Shape(14)

```

```

shape =
  mappolyshape with properties:
    NumRegions: 1
    NumHoles: 3
    Geometry: "polygon"
    CoordinateSystemType: "planar"
    ProjectedCRS: [1x1 projcrs]

```

To plot shapes in projected coordinates using the `geoplot` function, the `ProjectedCRS` property of the shape must not be empty. View the contents of the `ProjectedCRS` property.

```
shape.ProjectedImage
```

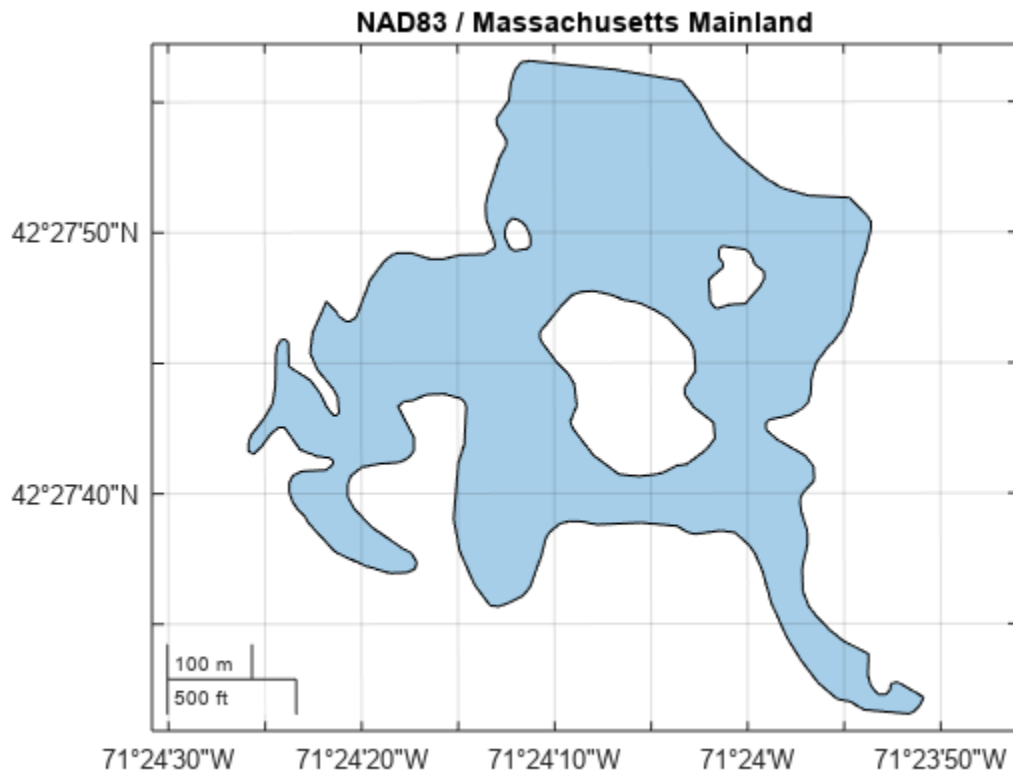
```
ans =  
  projcrs with properties:  
      Name: "NAD83 / Massachusetts Mainland"  
      GeographicCRS: [1x1 geocrs]  
      ProjectionMethod: "Lambert Conic Conformal (2SP)"  
      LengthUnit: "meter"  
      ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

Create a new map that uses the same projected CRS as the pond polygon. Then, display the pond polygon.

```
figure  
newmap(shape.ProjectedImage)  
geoplot(shape)
```

Title the map using the name of the projected CRS.

```
title(shape.ProjectedImage.Name)
```



Plot Shapes Using Custom Colors

Read a shapefile of US states into the workspace as a geospatial table. The table represents the states using polygon shapes in geographic coordinates.

```
GT = readgeotable("usastatehi.shp");  
shape = GT.Shape;
```

Clip the shapes to a region containing the conterminous US.

```
clipped = geoclip(shape, [17 56], [-127 -65]);
```

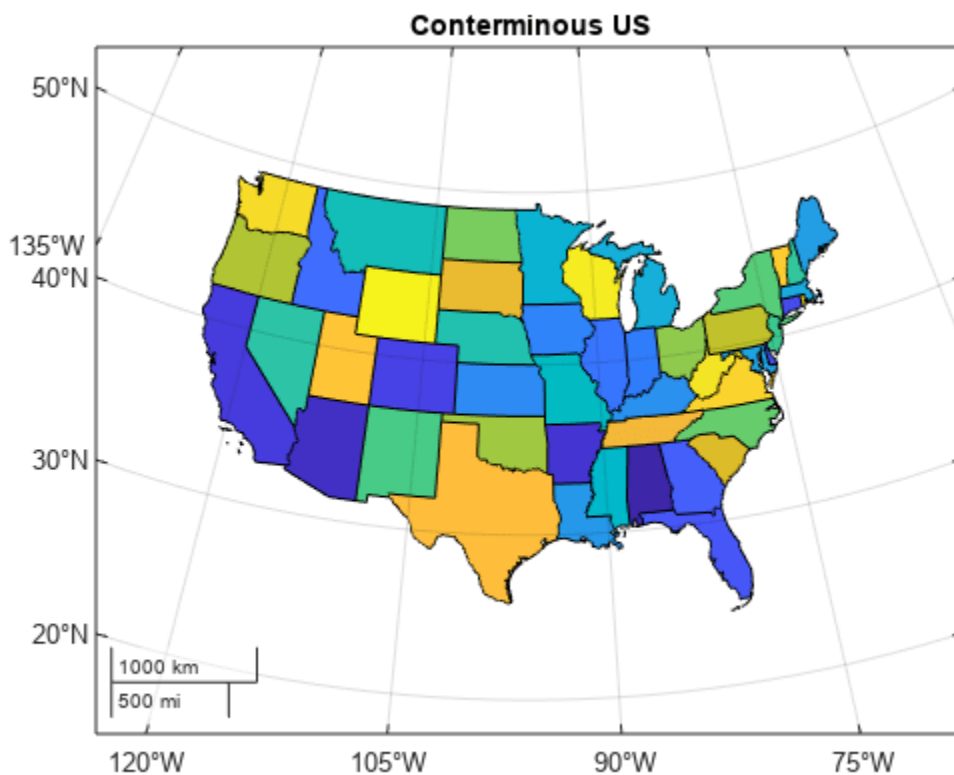
Create a new map that uses a North America Albers Equal Area Conic projection. Then, display the shapes. Vary the colors by using the ColorData name-value argument.

```
figure  
proj = projcrs(102008, Authority="ESRI");  
newmap(proj)
```

```
c = 1:length(clipped);  
geoplot(clipped, ColorData=c)
```

Add a title.

```
title("Conterminous US")
```



Plot Points and Lines from Numeric Vector Data

Load a MAT file containing the coordinates of global coastlines into the workspace. The variables within the MAT file, `coastlat` and `coastlon`, specify numeric latitude and longitude coordinates, respectively. Display the coordinates using a blue line over a topographic basemap.

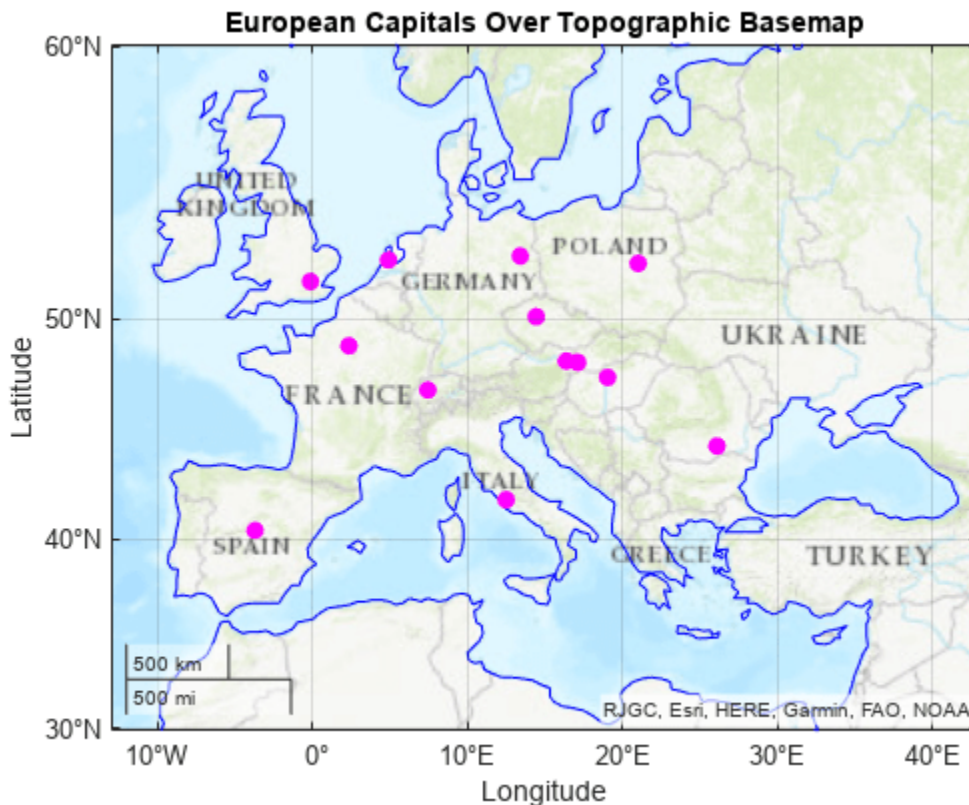
```
load coastlines
figure
geoplot(coastlat,coastlon,"b")
geobasemap topographic
```

Read the geographic coordinates of European capitals into the workspace. Display the capitals using magenta circle markers on the same map.

```
[lat,lon] = readvars("european_capitals.txt");
hold on
geoplot(lat,lon,"om",MarkerFaceColor="m")
title("European Capitals Over Topographic Basemap")
```

Center the map over Europe by changing its limits.

```
geolimits([30 60],[-13 43])
```



Plot Point, Line, and Polygon Shapes on Same Axes

Import several shapefiles into the workspace as geospatial tables.

- `landareas.shp` contains world land areas. The table represents the areas using polygon shapes in geographic coordinates (`geopolyshape` objects).
- `worldrivers.shp` contains world rivers. The table represents the rivers using line shapes in geographic coordinates (`geolineshape` objects).
- `worldcities.shp` contains world cities. The table represents the cities using point shapes in geographic coordinates (`geopointshape` objects).

```
land = readgeotable("landareas.shp");  
rivers = readgeotable("worldrivers.shp");  
cities = readgeotable("worldcities.shp");
```

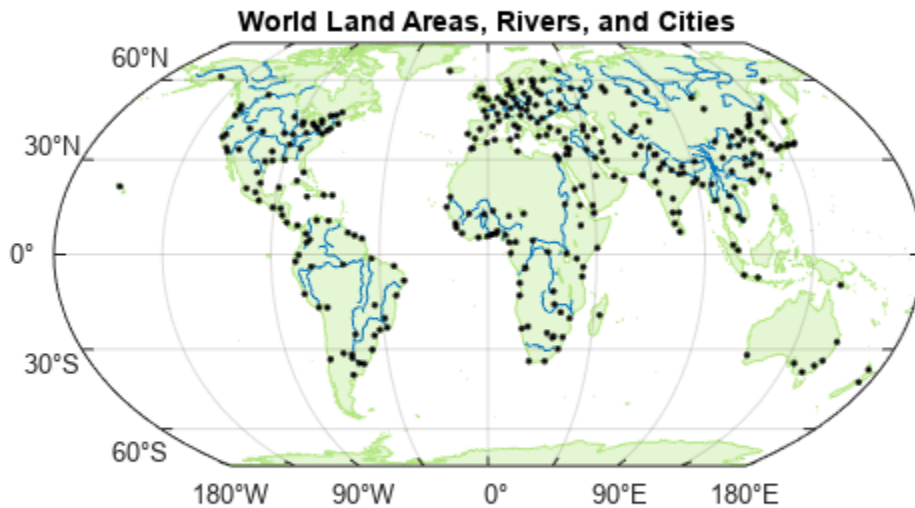
Set up a new map. By default, map axes use an Equal Earth map projection. Then, display each set of shapes using separate calls to the `geoplot` function. Different shapes support different name-value arguments.

- Display the land areas using green polygons.
- Display the rivers using blue lines.
- Display the cities using black points.

```
figure  
newmap  
hold on  
  
geoplot(land,FaceColor=[0.7 0.9 0.5],EdgeColor=[0.7 0.9 0.5])  
geoplot(rivers,Color=[0 0.4470 0.7410])  
geoplot(cities,"k")
```

Add a title.

```
title("World Land Areas, Rivers, and Cities")
```



Specify Geographic Axes

Create multiple geographic axes in a single figure by using a tiled chart layout.

Create a 1-by-2 tiled chart layout.

```
t = tiledlayout(1,2);
```

Load a MAT file containing the coordinates of global coastlines into the workspace. The variables within the MAT file, `coastlat` and `coastlon`, specify numeric latitude and longitude coordinates, respectively.

```
load coastlines
```

Place a geographic axes in the first tile. Plot the coordinates as a line on the axes.

```
gx1 = geoaxes(t);  
geoplot(gx1,coastlat,coastlon)  
title(gx1,"Coastline Coordinates")
```

Read a shapefile containing world land areas into the workspace as a geospatial table. The table represents the land areas using polygon shapes in geographic coordinates.

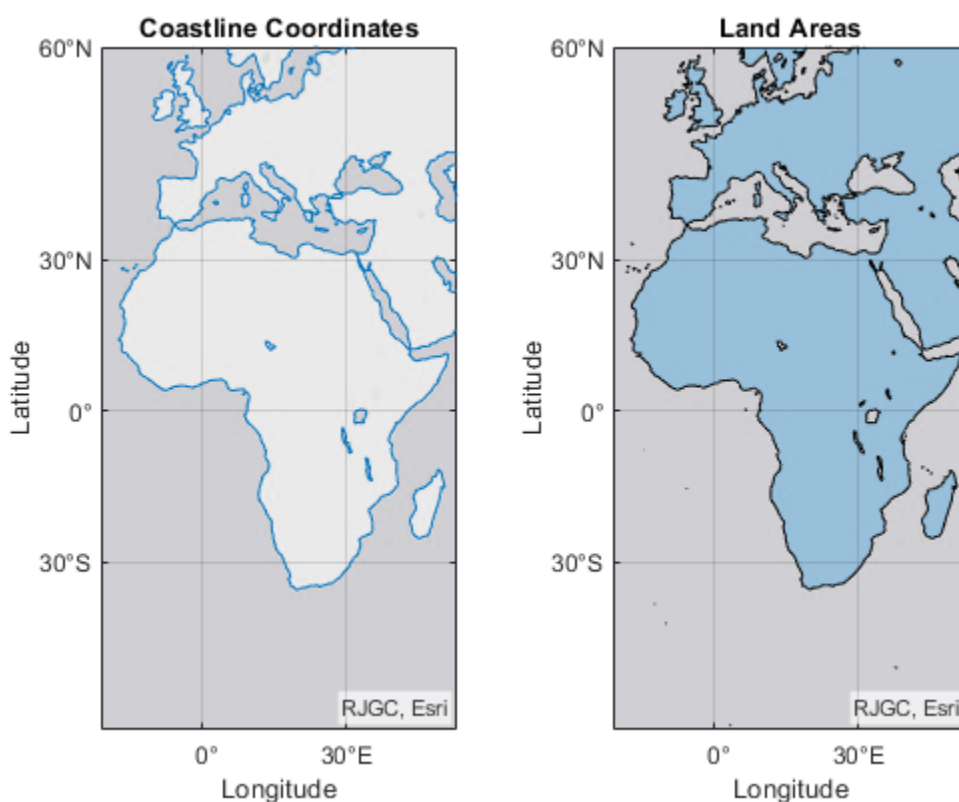
```
GT = readgeotable("landareas.shp");
```

Place a new geographic axes in the second tile. Plot the land areas as a polygon on the new axes.

```
gx2 = geoaxes(t);
gx2.Layout.Tile = 2;
geoplot(gx2,GT)
title(gx2,"Land Areas")
```

Zoom both axes to a region containing Africa.

```
latlim = [-55 60];
lonlim = [-21 53];
geolimits(gx1,latlim,lonlim)
geolimits(gx2,latlim,lonlim)
```



Modify Point, Line, or Polygon After Creation

Import several shapefiles into the workspace as geospatial tables.

- `landareas.shp` contains world land areas. The table represents the areas using polygon shapes in geographic coordinates (`geopolyshape` objects).
- `worldrivers.shp` contains world rivers. The table represents the rivers using line shapes in geographic coordinates (`geolineshape` objects).
- `worldcities.shp` contains world cities. The table represents the cities using point shapes in geographic coordinates (`geopointshape` objects).

```
land = readgeotable("landareas.shp");
rivers = readgeotable("worldrivers.shp");
cities = readgeotable("worldcities.shp");
```

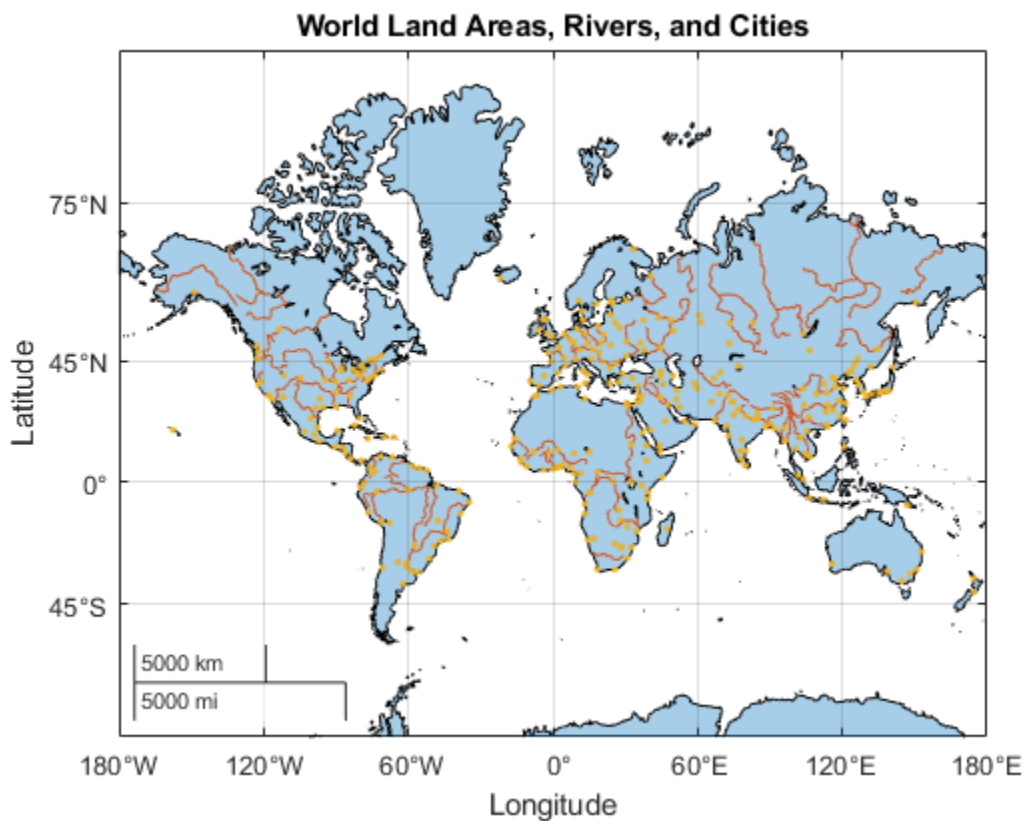
Display each set of shapes by using separate calls to the `geoplot` function.

- Display the land areas and return the polygon in `h1`. The polygon in `h1` represents multiple polygon shapes in `land`.
- Display the rivers and return the line in `h2`. The line in `h2` represents multiple line shapes in `rivers`.
- Display the cities and return the point in `h3`. The point in `h3` represents multiple point shapes in `cities`.

```
figure
h1 = geoplot(land);
hold on
h2 = geoplot(rivers);
h3 = geoplot(cities);
```

Change the geographic limits of the map, add a title, and remove the basemap.

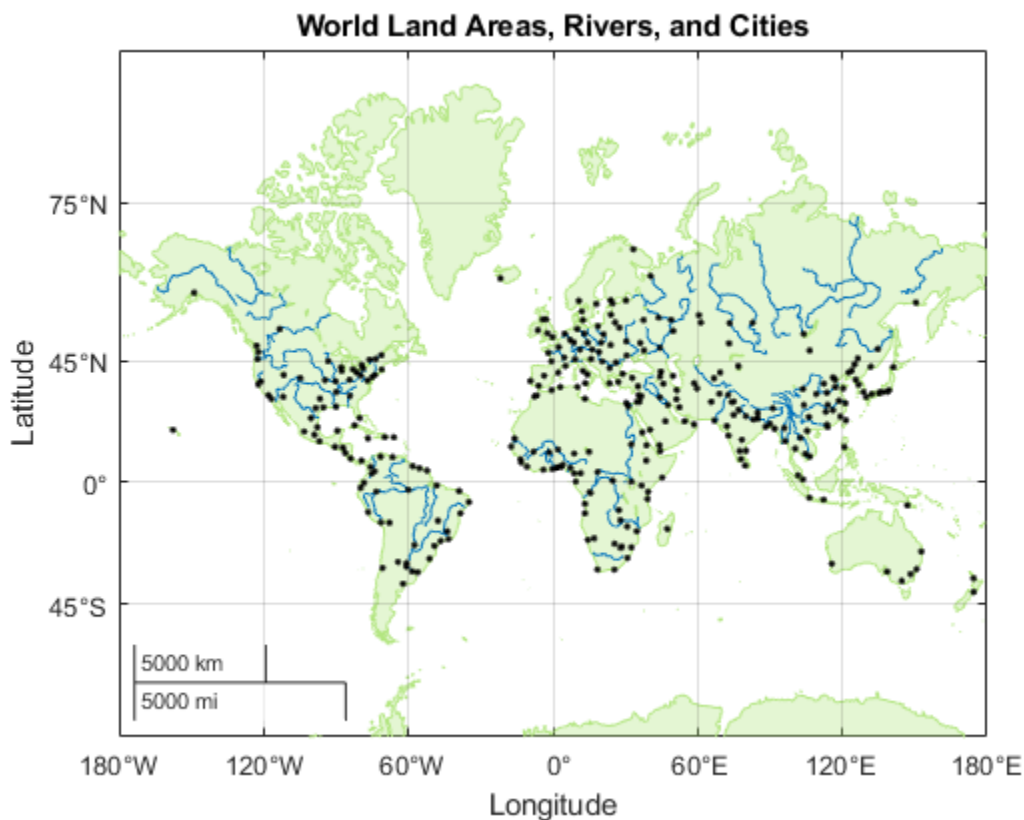
```
geolimits([-72 85],[-180 180])
title("World Land Areas, Rivers, and Cities")
geobasemap none
```



Update properties of the polygon, point, and line objects. Each object supports different properties.

- Change the fill and outline colors of the polygons to green.
- Change the color of the lines to blue.
- Change the color of the markers to black.

```
h1.FaceColor = [0.7 0.9 0.5];
h1.EdgeColor = [0.7 0.9 0.5];
h2.Color = [0 0.4470 0.7410];
h3.MarkerEdgeColor = "k";
```



Input Arguments

GT — Geospatial table

geospatial table

Geospatial table. A geospatial table is a `table` or `timetable` object with a `Shape` variable that contains point, line, or polygon shapes. For more information about geospatial tables, see “Create Geospatial Tables”.

The `Shape` variable of the table must contain only one type of shape.

The `ProjectedCRS` property of `mappointshape`, `maplineshape`, and `mappolyshape` objects within the `Shape` variable must not be empty.

If the `GeographicCRS` property of a `geopointshape`, `geolineshape`, or `geopolyshape` object within the `Shape` variable is empty, then the function assumes the geographic CRS based on the type of axes:

- Geographic axes — The WGS84 coordinate reference system.
- Map axes — The geographic CRS specified by the `ProjectedCRS` property of the map axes. To find the geographic CRS, access the projected CRS in the `ProjectedCRS` property. Then, access the `GeographicCRS` property of the projected CRS. For example, to find the geographic CRS for a map axes `mx`, query `mx.ProjectedCRS.GeographicCRS`.

shape — Point, line, or polygon shapes

vector of `geopointshape` objects | vector of `geolineshape` objects | vector of `geopolyshape` objects | vector of `mappointshape` objects | vector of `maplineshape` objects | vector of `mappolyshape` objects

Point, line, or polygon shapes, specified as one of these options:

- A vector of `geopointshape` objects — Point shapes in geographic coordinates
- A vector of `geolineshape` objects — Line shapes in geographic coordinates
- A vector of `geopolyshape` objects — Polygon shapes in geographic coordinates
- A vector of `mappointshape` objects — Point shapes in projected coordinates
- A vector of `maplineshape` objects — Line shapes in projected coordinates
- A vector of `mappolyshape` objects — Polygon shapes in projected coordinates

You can also specify this argument as a scalar point, line, or polygon shape.

The `ProjectedCRS` property of `mappointshape`, `maplineshape`, and `mappolyshape` objects must not be empty.

If the `GeographicCRS` property of a `geopointshape`, `geolineshape`, or `geopolyshape` object within the `Shape` variable is empty, then the function assumes the geographic CRS based on the type of axes:

- Geographic axes — The WGS84 coordinate reference system.
- Map axes — The geographic CRS specified by the `ProjectedCRS` property of the map axes. To find the geographic CRS, access the projected CRS in the `ProjectedCRS` property. Then, access the `GeographicCRS` property of the projected CRS. For example, to find the geographic CRS for a map axes `mx`, query `mx.ProjectedCRS.GeographicCRS`.

lat — Latitude coordinates in degrees

vector

Latitude coordinates in degrees, specified as a vector. The vector can contain NaN values.

Depending on the type of axes, the `geoplot` function references numeric coordinates to different geographic CRSs.

- Geographic axes — The WGS84 coordinate reference system. To plot points or lines with coordinates in a different CRS, use the coordinates to create a `geopointshape` or `geolineshape` object and set its `GeographicCRS` property. Then, pass the object you created to the `geoplot` function.

- Map axes — The geographic CRS specified by the `ProjectedCRS` property of the map axes. To find the geographic CRS, access the projected CRS in the `ProjectedCRS` property. Then, access the `GeographicCRS` property of the projected CRS. For example, to find the geographic CRS for a map axes `mx`, query `mx.ProjectedCRS.GeographicCRS`.

`lat` must be the same size as `lon`.

Example: `[43.0327 38.8921 44.0435]`

Data Types: `single` | `double`

lon — Longitude coordinates in degrees

vector

Longitude coordinates in degrees, specified as a vector. The vector can contain NaN values.

Depending on the type of axes, the `geoplot` function references numeric coordinates to different geographic CRSs.

- Geographic axes — The WGS84 coordinate reference system. To plot points or lines with coordinates in a different CRS, use the coordinates to create a `geopointshape` or `geolineshape` object and set its `GeographicCRS` property. Then, pass the object you created to the `geoplot` function.
- Map axes — The geographic CRS specified by the `ProjectedCRS` property of the map axes. To find the geographic CRS, access the projected CRS in the `ProjectedCRS` property. Then, access the `GeographicCRS` property of the projected CRS. For example, to find the geographic CRS for a map axes `mx`, query `mx.ProjectedCRS.GeographicCRS`.

`lon` must be the same size as `lat`.

Example: `[-107.5556 -77.0269 -72.5565]`

Data Types: `single` | `double`


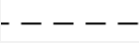
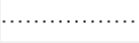

LineStyle — Line style, marker, and color
















character vector | string scalar

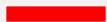


Line style, marker, and color, specified as a character vector or string scalar containing symbols. You can specify the symbols in any order. Different types of input support different characteristics (line, marker style, and color).






Type of Input	Supported Characteristics	Example
GT or shape contains <code>geopointshape</code> or <code>mappointshape</code> objects	Marker and color	'ro' specifies red circle markers
GT or shape contains <code>geolineshape</code> or <code>maplineshape</code> objects	Line style and color	'r--' specifies red dashed lines
GT or shape contains <code>geopolyshape</code> or <code>mappolyshape</code> objects	Line style and color	'r--' specifies red dashed lines
<code>lat</code> and <code>lon</code> contain numeric data	Line style, marker, and color	'--or' specifies red dashed lines with circle markers

You do not need to specify all supported characteristics. For example, if you plot a line from numeric data and specify only the marker, then the plot shows only the marker and no line.

Line Style	Description	Resulting Line
"_"	Solid line	
"_ _"	Dashed line	
":"	Dotted line	
"_ ."	Dash-dotted line	

Marker	Description	Resulting Marker
"o"	Circle	
"+"	Plus sign	
"*"	Asterisk	
","	Point	
"x"	Cross	
"_"	Horizontal line	
" "	Vertical line	
"square"	Square	
"diamond"	Diamond	
"^"	Upward-pointing triangle	
"v"	Downward-pointing triangle	
">"	Right-pointing triangle	
"<"	Left-pointing triangle	
"pentagram"	Pentagram	
"hexagram"	Hexagram	

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	

Color Name	Short Name	RGB Triplet	Appearance
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

tbl — Source table

table | timetable

Source table containing the data to plot, specified as a table or a timetable.

latvar — Table variables containing latitude coordinates

string array | character vector | cell array | pattern | numeric scalar or vector | logical vector | vartype()

Table variables containing the latitude coordinates, specified using one of the indexing schemes from the table.

Indexing Scheme	Examples
Variable names: <ul style="list-style-type: none"> A string, character vector, or cell array. A pattern object. 	<ul style="list-style-type: none"> "A" or 'A' — A variable called A ["A", "B"] or {'A', 'B'} — Two variables called A and B "Var"+digitsPattern(1) — Variables named "Var" followed by a single digit
Variable index: <ul style="list-style-type: none"> An index number that refers to the location of a variable in the table. A vector of numbers. A logical vector. Typically, this vector is the same length as the number of variables, but you can omit trailing 0 or false values. 	<ul style="list-style-type: none"> 3 — The third variable from the table [2 3] — The second and third variables from the table [false false true] — The third variable
Variable type: <ul style="list-style-type: none"> A vartype subscript that selects variables of a specified type. 	<ul style="list-style-type: none"> vartype("categorical") — All the variables containing categorical values

Regardless of the variable name, the axis label on the plot is always `Latitude`.

The variables you specify must contain numeric data of type `single` or `double`. The data must be in the range (-90, 90).

If `latvar` and `lonvar` both specify multiple variables, the number of variables must be the same.

Example: `geoplot(tbl, ["lat1", "lat2"], "lon")` specifies the table variables named `lat1` and `lat2` for the latitude coordinates.

Example: `geoplot(tbl, 2, "lon")` specifies the second variable for the latitude coordinates.

Example: `geoplot(tbl,vartype("numeric"),"lon")` specifies all numeric variables for the latitude coordinates.

lonvar — Table variables containing longitude coordinates

string array | character vector | cell array | pattern | numeric scalar or vector | logical vector | `vartype()`

Table variables containing the longitude coordinates, specified using one of the indexing schemes from the table.

Indexing Scheme	Examples
Variable names: <ul style="list-style-type: none"> A string, character vector, or cell array. A pattern object. 	<ul style="list-style-type: none"> "A" or 'A' — A variable called A ["A","B"] or {'A','B'} — Two variables called A and B "Var"+<code>digitsPattern(1)</code> — Variables named "Var" followed by a single digit
Variable index: <ul style="list-style-type: none"> An index number that refers to the location of a variable in the table. A vector of numbers. A logical vector. Typically, this vector is the same length as the number of variables, but you can omit trailing 0 or false values. 	<ul style="list-style-type: none"> 3 — The third variable from the table [2 3] — The second and third variables from the table [false false true] — The third variable
Variable type: <ul style="list-style-type: none"> A <code>vartype</code> subscript that selects variables of a specified type. 	<ul style="list-style-type: none"> <code>vartype("categorical")</code> — All the variables containing categorical values

Regardless of the variable name, the axis label on the plot is always **Longitude**.

The variables you specify must contain numeric data of type `single` or `double`.

If `latvar` and `lonvar` both specify multiple variables, the number of variables must be the same.

Example: `geoplot(tbl,"lat",["lon1","lon2"])` specifies the table variables named `lon1` and `lon2` for the longitude coordinates.

Example: `geoplot(tbl,"lat",2)` specifies the second variable for the longitude coordinates.

Example: `geoplot(tbl,"lat",vartype("numeric"))` specifies all numeric variables for the longitude coordinates.

ax — Target axes

GeographicAxes object | MapAxes object

Target axes, specified as a `GeographicAxes` object⁸ or `MapAxes` object. If you do not specify this argument, then the `geoplot` function plots into the current axes, provided that the current axes is a geographic or map axes object.

8 Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `geoplot(47, -122, Marker="*", Color="m")` displays a magenta star marker at the specified latitude and longitude.

Specify properties for the plot by using name-value arguments. The supported name-value arguments depend on the type of input.

Type of Input	Supported Name-Value Arguments
GT or shape contains <code>geopointshape</code> or <code>mappointshape</code> objects	See Point Properties
GT or shape contains <code>geolineshape</code> or <code>maplineshape</code> objects	See Line Properties
GT or shape contains <code>geopolyshape</code> or <code>mappolyshape</code> objects	See Polygon Properties
<code>lat</code> and <code>lon</code> contain numeric data	See Line Properties

Output Arguments

h — Plot object

geographic Point object | geographic chart Line object | geographic Polygon object | column vector of chart Line objects

Plot object. The value of `h` depends on the type of input you pass to the `geoplot` function.

Type of Input	Value of h
GT or shape contains <code>geopointshape</code> or <code>mappointshape</code> objects	A geographic Point object. A Point object can represent multiple <code>geopointshape</code> or <code>mappointshape</code> objects.
GT or shape contains <code>geolineshape</code> or <code>maplineshape</code> objects	A geographic chart Line object. A Line object can represent multiple <code>geolineshape</code> or <code>maplineshape</code> objects.
GT or shape contains <code>geopolyshape</code> or <code>mappolyshape</code> objects	A geographic Polygon object. A Polygon object can represent multiple <code>geopolyshape</code> or <code>mappolyshape</code> objects.
<code>lat</code> and <code>lon</code> contain numeric data	A column vector of chart Line objects. Each object corresponds to a vector of latitude-longitude pairs.

Version History

Introduced in R2022a

R2022b: Pass tables containing numeric coordinates directly to `geoplot`

Create a plot by passing a table containing numeric coordinate data to the `geoplot` function followed by the coordinate variables you want to plot.

R2022b: Adding new plots to geographic axes does not reset basemap

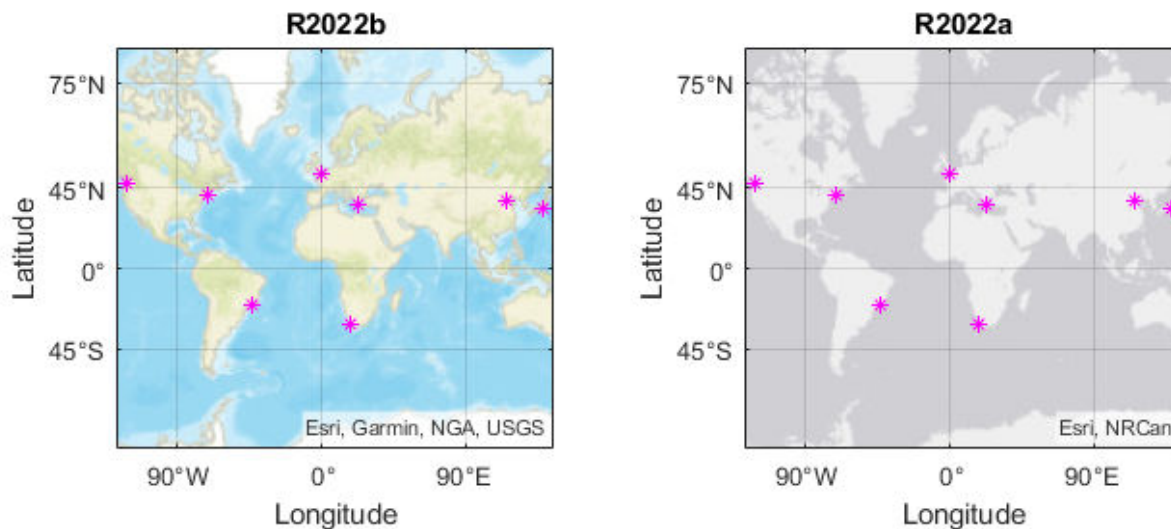
Behavior changed in R2022b

When you plot into geographic axes by using functions such as `geoplot` or `geoscatter`, MATLAB does not reset the basemap. In R2022a and earlier releases, the basemap resets when you add new plots.

As a result, you can specify a basemap and then visualize data without using the `hold` function between commands. For example, this code creates a map using the `streets` basemap. Then it displays a plot over the basemap. In R2022b, the basemap does not reset. In R2022a and earlier releases, the basemap resets to the default `streets-light`.

```
lat = [35 -22 51 39 37 42 47 -33];
lon = [139 -43 0 116 23 -71 -122 18];
```

```
figure
geobasemap streets
geoplot(lat,lon,"m*")
```



This change does not affect existing code that sets the `hold` state to "on" between commands.

To reset the basemap when you add a new plot, use the `cla reset` syntax of the `cla` function before you create the plot. For example, to update the preceding code, use `cla reset` between the calls to `geobasemap` and `geoplot`.

```
lat = [35 -22 51 39 37 42 47 -33];
lon = [139 -43 0 116 23 -71 -122 18];
```

```
figure
geobasemap streets
cla reset
geoplot(lat,lon,"m*")
```

Alternatively, you can change the basemap to the default `streets-light` by using the `geobasemap` function. For more information about changing the basemap of geographic axes, see “Access Basemaps for Geographic Axes and Charts”.

See Also

Functions

`geobasemap` | `geolimits` | `geoaxes` | `geoplot3`

Properties

`GeographicAxes` Properties | `MapAxes` Properties

Topics

“Create Choropleth Map from Table Data”

“Create Classification Map from Table Data”

geopolyshape

Polygon in geographic coordinates

Description

A `geopolyshape` object represents a polygon or multipolygon in geographic coordinates. A polygon is a region bounded by a closed curve and can include interior holes. A multipolygon is an individual polygon shape that includes multiple nonintersecting regions.

To represent a polygon or multipolygon in planar coordinates, use a `mappolyshape` object instead.

Creation

To create `geopolyshape` objects, either:

- Import polygon data in geographic coordinates as a geospatial table using the `readgeotable` function, and then query the `Shape` variable of the table.
- Use the `geopolyshape` function (described here).

Syntax

```
shape = geopolyshape(lat, lon)
```

Description

`shape = geopolyshape(lat, lon)` creates a `geopolyshape` object or array of `geopolyshape` objects with vertices at the specified latitude and longitude coordinates. The sizes of `lat`, `lon`, and the `geopolyshape` object array `shape` match.

The `geopolyshape` function assumes that `lat` and `lon` define polygons with valid topology. A polygon has valid topology when:

- Region interiors are to the right as you trace boundaries from vertex to vertex.
- The boundaries have no self-intersections.

In general, the outer boundaries of polygons with valid topology have vertices in clockwise order and the interior holes have vertices in counterclockwise order.

Input Arguments

lat — Latitude coordinates

numeric vector | cell array of numeric vectors

Latitude coordinates, specified as a numeric vector or a cell array of numeric vectors.

- Create a polygon by specifying a vector, such as `[39 45 19 39]`.

- Create a polygon with holes or a multipolygon by specifying a vector and including breaks between the hole and region boundaries as NaN values, such as [37 46 31 20 37 NaN 45 49 35 32 45 NaN 35 40 42 35].
- Create an array of polygons and multipolygons by specifying a cell array of vectors, such as {[37 46 31 20 37],[45 49 35 32 45 NaN 35 40 42 35]}.

The NaN values in `lat` must correspond to the NaN values in `lon`.

The size of `lat` must match the size of `lon`. For cell arrays, the size of the vector in each cell of `lat` must match the size of the vector in the corresponding cell of `lon`.

Data Types: `double` | `cell`

lon — Longitude coordinates

numeric vector | cell array of numeric vectors

Longitude coordinates, specified as a numeric vector or a cell array of numeric vectors.

- Create a polygon by specifying a vector, such as [-113 -49 -100 -113].
- Create a polygon with holes or a multipolygon by specifying a vector and including breaks between the hole and region boundaries as NaN values, such as [69 90 105 79 69 NaN 6 52 43 14 6 NaN 18 32 22 18].
- Create an array of polygons and multipolygons by specifying a cell array of vectors, such as {[69 90 105 79 69],[6 52 43 14 6 NaN 18 32 22 18]}.

The NaN values in `lat` must correspond to the NaN values in `lon`.

The size of `lat` must match the size of `lon`. For cell arrays, the size of the vector in each cell of `lat` must match the size of the vector in the corresponding cell of `lon`.

Data Types: `double` | `cell`

Properties

NumRegions — Number of polygon regions

array of nonnegative integers

This property is read-only.

Number of polygon regions, returned as an array of nonnegative integers. A region is a connected area such that any two points within the area can be connected by a path entirely within the area. Regions may contain holes.

For a `geopolyshape` scalar, the value of `NumRegions` is 1 when the `geopolyshape` object represents a single polygon and more than 1 when the object represents a multipolygon.

For a `geopolyshape` array, the size of `NumRegions` matches the size of the array.

Data Types: `double`

NumHoles — Number of holes

array of nonnegative integers

This property is read-only.

Number of holes in the polygon or multipolygon, returned as an array of nonnegative integers.

For a `geopolyshape` array, the size of `NumHoles` matches the size of the array.

Data Types: `double`

Geometry — Geometric type

"`polygon`" (default)

This property is read-only.

Geometric type, returned as "`polygon`".

Data Types: `string`

CoordinateSystemType — Coordinate system type

"`geographic`" (default)

This property is read-only.

Coordinate system type, returned as "`geographic`".

Data Types: `string`

GeographicCRS — Geographic coordinate reference system

`[]` (default) | `geocrs` object

Geographic coordinate reference system (CRS), specified as a `geocrs` object. A geographic CRS consists of a datum (including its ellipsoid), prime meridian, and angular unit of measurement.

Object Functions

<code>geoplot</code>	Plot points, lines, and polygons on map
<code>geoclip</code>	Clip geographic shape to latitude-longitude limits
<code>isinterior</code>	Query geographic or planar points in polygon
<code>ismultipoint</code>	Determine which array elements are multipoint shapes

Examples

Get Information About Imported Geographic Polygons

Import a shapefile containing worldwide land areas as a geospatial table. The shapefile represents the land areas using polygons.

```
GT = readgeotable("landareas.shp");
```

Create a subtable that contains the polygon representing Africa, Europe, and Asia. Get information about the polygon by querying the `Shape` variable of the table.

```
row = GT.Name == "Africa and Eurasia";  
rowGT = GT(row, :);  
rowGT.Shape
```

```
ans =  
    geopolyshape with properties:
```

```

    NumRegions: 2
    NumHoles: 22
    Geometry: "polygon"
    CoordinateSystemType: "geographic"
    GeographicCRS: [1x1 geocrs]

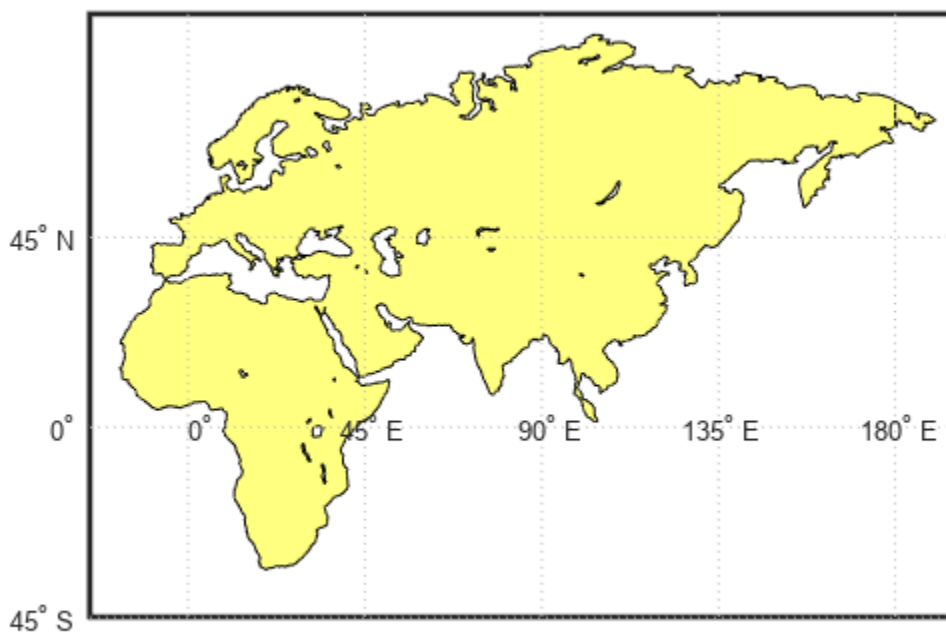
```

Display the polygon on a world map.

```

worldmap([-45 80],[-25 195])
geoshow(rowGT)

```



Create Geographic Polygons and Multipolygons

Create an individual polygon with no holes as a `geopolyshape` scalar. Specify the geographic CRS as the World Geodetic System of 1984, which has the EPSG code 4326.

```

lat = [39 45 19 39];
lon = [-113 -49 -100 -113];
polyshp = geopolyshape(lat,lon);

```

```

g = geocrs(4326);
polyshp.GeographicCRS = g

```

```

polyshp =
    geopolyshape with properties:

```

```
        NumRegions: 1
        NumHoles: 0
        Geometry: "polygon"
CoordinateSystemType: "geographic"
        GeographicCRS: [1x1 geocrs]
```

Create a multipolygon with two regions and one hole as a `geopolyshape` scalar.

```
lat = [37 46 31 20 37 NaN 45 49 35 32 45 NaN 35 40 42 35];
lon = [69 90 105 79 69 NaN 6 52 43 14 6 NaN 18 32 22 18];
multipolygon = geopolyshape(lat,lon);
multipolygon.GeographicCRS = g
```

```
multipolygon =
    geopolyshape with properties:
```

```
        NumRegions: 2
        NumHoles: 1
        Geometry: "polygon"
CoordinateSystemType: "geographic"
        GeographicCRS: [1x1 geocrs]
```

Create two individual polygons as a 1-by-2 `geopolyshape` array. The second polygon contains a hole.

```
lat = {[37 46 31 20 37],[45 49 35 32 45 NaN 35 40 42 35]};
lon = {[69 90 105 79 69],[6 52 43 14 6 NaN 18 32 22 18]};
polyArray = geopolyshape(lat,lon);
polyArray.GeographicCRS = g
```

```
polyArray=1x2 object
    1x2 geopolyshape array with properties:
```

```
        NumRegions: [1 1]
        NumHoles: [0 1]
        Geometry: "polygon"
CoordinateSystemType: "geographic"
        GeographicCRS: [1x1 geocrs]
```

Version History

Introduced in R2021b

See Also

Functions

`readgeotable`

Objects

`geointshape` | `geolineshape` | `mappolyshape`

Topics

“Create Geospatial Tables”

geoquadline

Geographic quadrangle bounding multi-part line

Syntax

```
[latlim,lonlim] = geoquadline(lat,lon)
```

Description

`[latlim,lonlim] = geoquadline(lat,lon)` returns the limits of the tightest possible geographic quadrangle that bounds a line connecting vertices with geographic coordinates specified by `lat` and `lon`.

Examples

Bounding Quadrangle for the Brahmaputra River

Read shape data and then create a bounding box around the line.

```
brahmaputra = shaperead('worldrivers.shp','Selector', ...  
    {@(name) strcmp(name,'Brahmaputra'),'Name'}, 'UseGeoCoords',true);  
[latlim, lonlim] = geoquadline(brahmaputra.Lat, brahmaputra.Lon)
```

```
latlim =
```

```
    23.8285    30.3831
```

```
lonlim =
```

```
    81.8971    95.4970
```

Input Arguments

lat — Latitudes along a line

vector

Latitudes along a line, specified as a vector representing an ordered sequences of vertices, in units of degrees. The line may be broken into multiple parts, delimited by values of `NaN`.

Data Types: `single` | `double`

lon — Longitudes along a line

vector

Longitudes along a line, specified as a vector representing an ordered sequences of vertices, in units of degrees. The line may be broken into multiple parts, delimited by values of `NaN`.

Data Types: `single` | `double`

Output Arguments

latlim — Latitude limits

1-by-2 vector

Latitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form `[southern_limit northern_limit]`, in units of degrees. The elements are in ascending order, and both lie in the closed interval `[-90 90]`.

lonlim — Longitude limits

1-by-2 vector

Longitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form `[western_limit eastern_limit]`, in units of degrees. The limits are wrapped to the interval `[-180 180]`. They are not necessarily in numerical ascending order.

Version History

Introduced in R2012b

See Also

`bufgeoquad` | `geoquadpt` | `outlinegeoquad` | `ingeoquad`

geoquadpt

Geographic quadrangle bounding scattered points

Syntax

```
[latlim,lonlim] = geoquadpt(lat,lon)
```

Description

[latlim,lonlim] = geoquadpt(lat,lon) returns the limits of the tightest possible geographic quadrangle that bounds a set of points with geographic coordinates lat and lon.

In most cases, tf = ingeoquad(lat,lon,latlim,lonlim) will return true, but tf may be false for points on the edges of the quadrangle, due to round off. tf will also be false for elements of lat that fall outside the interval [-90 90] and elements of lon that are not finite.

Examples

Bounding Quadrangle Including Tokyo and Honolulu

In this case the output quadrangle straddles the 180-degree meridian, hence the elements of lonlim are in descending numerical order, although they are ordered from west to east.

Read a set of points and then create a bounding box around the points.

```
cities = shaperead('worldcities.shp','Selector', ...
    {@(name) any(strcmp(name,{'Tokyo','Honolulu'})),'Name'}, ...
    'UseGeoCoords',true);
[latlim,lonlim] = geoquadpt([cities.Lat],[cities.Lon])
```

```
latlim =
```

```
    21.3178    35.7082
```

```
lonlim =
```

```
   139.6401  -157.8291
```

Input Arguments

lat — Point latitudes

vector | matrix | N-D array

Point latitudes, specified as a vector, matrix, or N-D array, in units of degrees.

Data Types: single | double

lon — Point longitudes

vector | matrix | N-D array

Point longitudes, specified as a vector, matrix, or N-D array, in units of degrees.

Data Types: `single` | `double`

Output Arguments

latlim — Latitude limits

1-by-2 vector

Latitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form `[southern_limit northern_limit]`, in units of degrees. The elements are in ascending order, and both lie in the closed interval `[-90 90]`.

lonlim — Longitude limits

1-by-2 vector

Longitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form `[western_limit eastern_limit]`, in units of degrees. The limits are wrapped to the interval `[-180 180]`. They are not necessarily in numerical ascending order.

Version History

Introduced in R2012b

See Also

`bufgeoquad` | `geoquadline` | `outlinegeoquad` | `ingeoquad`

georasterinfo

Information about geospatial raster data file

Syntax

```
info = georasterinfo(filename)
```

Description

`info = georasterinfo(filename)` returns a `RasterInfo` object for the geographic or projected raster data file specified by `filename`. Supported file formats include Esri Binary Grid, Esri GridFloat, GeoTIFF, and DTED. For a full list of supported formats, see “Supported Formats and Extensions” on page 1-653.

Examples

Get Information About Geospatial Raster Data

Get information about a geospatial raster data file by creating a `RasterInfo` object.

```
info = georasterinfo('boston.tif');
```

Access individual properties of the `RasterInfo` object using dot notation.

```
info.NativeFormat
```

```
ans =  
"uint8"
```

Get DTED Metadata

Get information about a DTED file by creating a `RasterInfo` object. Get metadata specific to DTED files by accessing the `Metadata` property of the `RasterInfo` object.

```
info = georasterinfo('n39_w106_3arc_v2.dt1');  
md = info.Metadata
```

```
md = struct with fields:  
    AREA_OR_POINT: "Point"  
    DTED_CompilationDate: "0002"  
    DTED_DataEdition: "02"  
    DTED_DigitizingSystem: "SRTM"  
    DTED_HorizontalAccuracy: "0013"  
    DTED_HorizontalDatum: "WGS84"  
    DTED_MaintenanceDate: "0000"  
    DTED_MaintenanceDescription: "0000"  
    DTED_MatchMergeDate: "0000"  
    DTED_MatchMergeVersion: "A"
```

```

        DTED_NimaDesignator: "DTED1"
        DTED_OriginLatitude: "0390000N"
        DTED_OriginLongitude: "1060000W"
    DTED_PartialCellIndicator: "00"
        DTED_Producer: "USCNIMA "
    DTED_RelHorizontalAccuracy: "NA "
        DTED_RelVerticalAccuracy: "0006"
        DTED_SecurityCode_DSI: "U"
        DTED_SecurityCode_UHL: "U "
        DTED_UniqueRef_DSI: "G19 107 "
        DTED_UniqueRef_UHL: "G19 107 "
    DTED_VerticalAccuracy_ACC: "0006"
    DTED_VerticalAccuracy_UHL: "0006"
        DTED_VerticalDatum: "E96"

```

Find the coordinates of the lower-left corner of the data by accessing the `DTED_OriginLatitude` and `DTED_OriginLongitude` fields of the metadata structure. The coordinates are stored as strings. Convert the strings to angles.

```

latS = md.DTED_OriginLatitude;
lonS = md.DTED_OriginLongitude;
latA = str2angle(latS)

```

```
latA = 39
```

```
lonA = str2angle(lonS)
```

```
lonA = -106
```

The DTED file used in this example is courtesy of the US Geological Survey.

Input Arguments

filename — Name of raster data file

character vector | string scalar

Name of the raster data file, specified as a character vector or string scalar. The form of `filename` depends on the location of your file.

- If the file is in your current folder or in a folder on the MATLAB path, then specify the name of the file, such as `'myFile.dem'`.
- If the file is not in the current folder or in a folder on the MATLAB path, then specify the full or relative path name, such as `'C:\myfolder\myFile.tif'` or `'dataDir\myFile.dat'`.

For a list of supported file formats, see “Supported Formats and Extensions” on page 1-653.

Data Types: `char` | `string`

More About

Supported Formats and Extensions

The `readgeoraster` and `georasterinfo` functions support these file formats and extensions. In some cases, you can read supported file formats using extensions other than the ones listed.

File Format	Extension
GeoTIFF	.tif or .tiff
Esri Binary Grid	.adf
Esri ASCII Grid	.asc or .grd
Esri GridFloat	.flt
DTED	.dt0, .dt1, or .dt2
SDTS	.DDF
USGS DEM	.dem
ER Mapper ERS	.ers
ENVI	.dat
ERDAS IMAGINE	.img
Vertical Mapper Numeric Grid	.grd
Vertical Mapper Classified Grid	.grc
SRTM Height	.hgt

Some file formats consist of a data file and multiple supporting files. For example, Esri GridFloat files may have supporting header files (.hdr). When you read a data file with supporting files using `readgeoraster` or `georasterinfo`, specify the extension of the data file.

File formats may be referred to using different names. For example, the Esri GridFloat format may also be referred to as Esri .hdr Labelled or ITT ESRI .hdr RAW Raster. The Esri Binary Grid format may also be referred to as ArcGrid Binary, Esri ArcGIS Binary Grid, or Esri ArcInfo Grid.

Version History

Introduced in R2020a

R2021b: Get information about SRTM Height data

The `georasterinfo` function can get information about SRTM Height data files with extension .hgt.

R2021a: Get information about data in Vertical Mapper Grid formats

The `georasterinfo` function can get information about data in the Vertical Mapper Numeric Grid and Vertical Mapper Classified Grid formats.

See Also

Functions

`readgeoraster`

Objects

`RasterInfo`

Topics

“Find Geospatial Raster Data”

georasterref

(Not recommended) Create geographic raster reference object

Note The `georasterref` function is not recommended, except when creating a raster reference object from a world file matrix. To specify options using name-value arguments, use the `georefcells` or `georefpostings` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
R = georasterref(W, rasterSize)
R = georasterref(W, rasterSize, rasterInterpretation)
R = georasterref(Name, Value)
```

Description

`R = georasterref(W, rasterSize)` creates a reference object for a raster of quadrangular cells referenced to geographic coordinates using the world file matrix `W` and raster size `rasterSize`.

`R = georasterref(W, rasterSize, rasterInterpretation)` specifies the geometric nature of the raster. When the raster contains posting point samples referenced to geographic coordinates, specify `rasterInterpretation` as "postings". The default for `rasterInterpretation` is "cells", which specifies a raster of quadrangular cells.

`R = georasterref(Name, Value)` specifies options using name-value arguments.

Examples

Create Geographic Reference Object from World File Matrix

Create a reference object for a global raster of cells with size 180-by-360, latitude extents of 1 degree, and longitude extents of 1 degree. Orient the raster using a convention typical for imagery, where image rows run from west to east and image columns run from north to south.

Specify the world file matrix using these values:

Value	Explanation
1	The rows of the raster start from the west and each cell is one degree in longitude.
-179.5	The longitude of the first cell center.
-1	The columns of the raster start from the north and each cell is one degree in latitude.
89.5	The latitude of the first cell center.

```
W = [1 0 -179.5; 0 -1 89.5];
```

Create the reference object.

```
R = georasterref(W, [180 360], "cells")
```

R =

GeographicCellsReference with properties:

```

    LatitudeLimits: [-90 90]
    LongitudeLimits: [-180 180]
    RasterSize: [180 360]
    RasterInterpretation: 'cells'
    ColumnsStartFrom: 'north'
    RowsStartFrom: 'west'
    CellExtentInLatitude: 1
    CellExtentInLongitude: 1
    RasterExtentInLatitude: 180
    RasterExtentInLongitude: 360
    XIntrinsicLimits: [0.5 360.5]
    YIntrinsicLimits: [0.5 180.5]
    CoordinateSystemType: 'geographic'
    GeographicCRS: []
    AngleUnit: 'degree'

```

Input Arguments

W — World file matrix

2-by-3 numeric array

World file matrix, specified as a 2-by-3 numeric array of the form `[lonspacing 0 lon; 0 latspacing lat]`, where:

- `lonspacing` determines the `RowsStartFrom` and the `CellExtentInLongitude` or `SampleSpacingInLongitude` properties of R.
 - When `lonspacing` is positive, `RowsStartFrom` is 'west'. When `lonspacing` is negative, `RowsStartFrom` is 'east'.
 - `CellExtentInLongitude` or `SampleSpacingInLongitude` is `abs(lonspacing)`.
- `latspacing` determines the `ColumnsStartFrom` and the `CellExtentInLatitude` or `SampleSpacingInLatitude` properties of R.
 - When `latspacing` is positive, `ColumnsStartFrom` is 'south'. When `latspacing` is negative, `ColumnsStartFrom` is 'north'.
 - `CellExtentInLatitude` or `SampleSpacingInLatitude` is `abs(latspacing)`.
- `lat` and `lon` are the latitude and longitude coordinates of the first cell center or posting point, respectively. For a spatially referenced raster A, the first cell center or posting point is the spatial location associated with `A(1, 1, :)`.
- The 0 values indicate a rectilinear relationship between the intrinsic and geographic coordinates.

A world file matrix defines a transformation that maps intrinsic coordinates to geographic coordinates.

rasterSize — Number of rows and columns

two-element vector

Number of rows and columns of the raster, specified as a two-element vector of the form `[m n]`, where `m` is the number of rows and `n` is the number of columns.

For convenience, you can specify this argument as a vector with more than two elements, such as the size of an RGB image (*m-by-n-by-3*). The `georasterref` function uses only the first two elements of the size vector.

rasterInterpretation — Geometric nature of raster

`"cells"` (default) | `"postings"`

Geometric nature of the raster, specified as one of these options:

- `"cells"` — The raster is a grid of quadrangular cells. The boundary of the raster is made up of the outermost boundaries of the outermost cells.
- `"postings"` — The raster is a grid of posting point samples. The boundary of the raster is made up of sampling points along the edge of the raster.

For more information about cells and posting points, see “Spatially Reference Imported Rasters”.

The corresponding property of the reference object, `RasterInterpretation`, is read-only after you create the object.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `georasterref("LatitudeLimits", [-90 90], "LongitudeLimits", [-180 180])` creates a geographic cells reference object with latitudes in the range `[-90, 90]` degrees and longitudes in the range `[-180, 180]` degrees.

LatitudeLimits — Latitude limits

`[0.5 2.5]` (default) | two-element vector

Latitude limits of the geographic quadrangle that bounds the georeferenced raster, specified as a two-element vector of the form `[southern_limit northern_limit]`.

LongitudeLimits — Longitude limits

`[0.5 2.5]` (default) | two-element vector

Longitude limits of the geographic quadrangle that bounds the georeferenced raster, specified as a two-element vector of the form `[western_limit eastern_limit]`.

RasterSize — Number of rows and columns

`[2 2]` (default) | two-element vector of positive integers

Number of rows and columns of the raster, specified as a two-element vector of the form `[m n]`, where `m` is the number of rows and `n` is the number of columns.

For convenience, you can specify `RasterSize` as a vector with more than two elements, such as the size of an RGB image (*m-by-n-by-3*). The `georasterref` function uses only the first two elements of the size vector.

RasterInterpretation — Geometric nature of raster`"cells" (default) | "postings"`

Geometric nature of the raster, specified as one of these options:

- `"cells"` — The raster is a grid of quadrangular cells. The boundary of the raster is made up of the outermost boundaries of the outermost cells.
- `"postings"` — The raster is a grid of posting point samples. The boundary of the raster is made up of sampling points along the edge of the raster.

For more information about cells and posting points, see “Spatially Reference Imported Rasters”.

The corresponding property of the raster reference object is read-only after you create the object.

Data Types: `char` | `string`

ColumnsStartFrom — Edge from which column indexing starts`"south" (default) | "north"`

Edge from which column indexing starts, specified as `"south"` or `"north"`.

Data Types: `char` | `string`

RowsStartFrom — Edge from which row indexing starts`"west" (default) | "east"`

Edge from which row indexing starts, specified as `"west"` or `"east"`.

Data Types: `char` | `string`

Output Arguments**R — Geographic raster reference object**

`GeographicCellsReference` object | `GeographicPostingsReference` object

Geographic raster reference object, returned as a `GeographicCellsReference` or `GeographicPostingsReference` object. The value of R depends on the value of the `rasterInterpretation` argument or `RasterInterpretation` name-value argument.

rasterInterpretation or RasterInterpretation	R
<code>"cells"</code>	<code>GeographicCellsReference</code> object
<code>"postings"</code>	<code>GeographicPostingsReference</code> object

Version History

Introduced in R2011a

R2015b: georasterref is not recommended

Not recommended starting in R2015b

The `georasterref` function is not recommended, except when creating a reference object from a world file matrix. To specify options using name-value arguments, use the `georefcells` or `georefpostings` function instead.

- Create a reference object for a grid of quadrangular cells referenced to geographic latitude and longitude coordinates by using the `georefcells` function.
- Create a reference object for a grid of posting point samples referenced to geographic coordinates by using the `georefpastings` function.

See Also

Functions

`worldfileread` | `georefcells` | `georefpastings` | `maprasterref` | `worldFileMatrix`

Topics

“Spatially Reference Imported Rasters”

georefpostings

Reference raster postings to geographic coordinates

Syntax

```
R = georefpostings()
R = georefpostings(latlim,lonlim,rasterSize)
R = georefpostings(latlim,lonlim,latspacing,lonspacing)
R = georefpostings(latlim,lonlim,___,Name,Value)
```

Description

`R = georefpostings()` returns a default referencing object for a raster of regularly posted samples in geographic coordinates.

`R = georefpostings(latlim,lonlim,rasterSize)` constructs a referencing object for a raster spanning the specified limits in latitude and longitude, with the numbers of rows and columns specified by `rasterSize`.

`R = georefpostings(latlim,lonlim,latspacing,lonspacing)` allows the geographic sample spacings to be set precisely. The geographic limits will be adjusted slightly, if necessary, to ensure an integer number of samples in each dimension.

`R = georefpostings(latlim,lonlim,___,Name,Value)` allows the directions of the columns and rows to be specified via name-value pairs.

Examples

Construct Geographic Referencing Object for Global Raster

Define latitude and longitude limits and the dimensions of the raster.

```
latlim = [-90 90];
lonlim = [-180 180];
rasterSize = [181 361];
```

Create the referencing object specifying the raster size.

```
R = georefpostings(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')
```

```
R =
  GeographicPostingsReference with properties:
    LatitudeLimits: [-90 90]
    LongitudeLimits: [-180 180]
    RasterSize: [181 361]
    RasterInterpretation: 'postings'
    ColumnsStartFrom: 'north'
    RowsStartFrom: 'west'
    SampleSpacingInLatitude: 1
```

```
SampleSpacingInLongitude: 1
RasterExtentInLatitude: 180
RasterExtentInLongitude: 360
  XIntrinsicLimits: [1 361]
  YIntrinsicLimits: [1 181]
CoordinateSystemType: 'geographic'
  GeographicCRS: []
  AngleUnit: 'degree'
```

Obtain the same result by specifying the sample spacing.

```
spacing = 1;
```

```
R = georefpostings(latlim,lonlim,spacing,spacing,'ColumnsStartFrom','north')
```

```
R =
  GeographicPostingsReference with properties:
```

```
LatitudeLimits: [-90 90]
LongitudeLimits: [-180 180]
RasterSize: [181 361]
RasterInterpretation: 'postings'
ColumnsStartFrom: 'north'
RowsStartFrom: 'west'
SampleSpacingInLatitude: 1
SampleSpacingInLongitude: 1
RasterExtentInLatitude: 180
RasterExtentInLongitude: 360
  XIntrinsicLimits: [1 361]
  YIntrinsicLimits: [1 181]
CoordinateSystemType: 'geographic'
  GeographicCRS: []
  AngleUnit: 'degree'
```

Input Arguments

latlim — Latitude limits in degrees

[0.5 2.5] (default) | 1-by-2 numeric vector

Latitude limits in degrees, specified as a 1-by-2 numeric vector. The number of rows in the resulting raster is specified by `rasterSize`.

Example: `latlim = [-90 90];`

lonlim — Longitude limits in degrees

[0.5 2.5] (default) | 1-by-2 numeric vector

Longitude limits in degrees, specified as a 1-by-2 numeric vector. The number of columns in the resulting raster is specified by `rasterSize`.

Example: `lonlim = [-180 180];`

rasterSize — Size of the raster

[2 2] (default) | 1-by-2 numeric vector

Size of the raster, specified as a 1-by-2 numeric vector.

Example: `rasterSize = [180 360];`**latspacing — Vertical spacing of posting**

1 (default) | numeric scalar

Vertical spacing of posting, specified as a numeric scalar. The value of `latspacing` determines the `SampleSpacingInLatitude` property of `R`.Example: `latspacing = 1.5`**lonspacing — Horizontal spacing of postings**

1 (default) | numeric scalar

Horizontal spacing of postings, specified as a numeric scalar. The value of `lonspacing` determines the `SampleSpacingInLongitude` property of `R`.Example: `lonspacing = 1.5`**Name-Value Pair Arguments**Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.*Before R2021a, use commas to separate each name and value, and enclose Name in quotes.*Example: `R = georefpostings(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')`**ColumnsStartFrom — Edge from which column indexing starts**

'south' (default) | 'north'

Edge from which column indexing starts, specified as either 'north' or 'south'.

Example: `R = georefpostings(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')`Data Types: `char` | `string`**RowsStartFrom — Edge from which row indexing starts**

'west' (default) | 'east'

Edge from which column indexing starts, specified as either 'east' or 'west'.

Example: `R = georefpostings(latlim,lonlim,rasterSize,'RowsStartFrom','east')`Data Types: `char` | `string`**Output Arguments****R — Object that references raster postings to geographic coordinates**`GeographicPostingsReference` raster reference object

Object that references raster postings to geographic coordinates, returned as a `GeographicPostingsReference` raster reference object.

Tips

- To construct a geographic raster reference object from a world file matrix, use the `georasterref` function.

Version History

Introduced in R2015b

See Also

`georefcells` | `GeographicPostingsReference` | `maprefpostings`

georefcells

Reference raster cells to geographic coordinates

Syntax

```
R = georefcells()
R = georefcells(latlim,lonlim,rasterSize)
R = georefcells(latlim,lonlim,latcellextent,loncellextent)
R = georefcells(latlim,lonlim,___,Name,Value)
```

Description

`R = georefcells()` returns a default referencing object for a regular raster of cells in geographic coordinates.

`R = georefcells(latlim,lonlim,rasterSize)` constructs a referencing object for a raster of cells spanning the specified limits in latitude and longitude, with the numbers of rows and columns specified by `rasterSize`.

`R = georefcells(latlim,lonlim,latcellextent,loncellextent)` allows the geographic cell extents to be set precisely. If necessary, `georefcells` adjusts the geographic limits slightly to ensure an integer number of cells in each dimension.

`R = georefcells(latlim,lonlim,___,Name,Value)` allows the directions of the columns and rows to be specified via name-value pairs.

Examples

Construct Referencing Object for Global Raster

Construct a referencing object for a global raster comprising a grid of 180-by-360 one-degree cells, with rows that start at longitude -180, and with the first cell located in the northwest corner.

```
latlim = [-90 90];
lonlim = [-180 180];
rasterSize = [180 360];
```

Create a raster referencing object by specifying the raster size.

```
R = georefcells(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')
```

```
R =
  GeographicCellsReference with properties:
```

```
    LatitudeLimits: [-90 90]
    LongitudeLimits: [-180 180]
    RasterSize: [180 360]
  RasterInterpretation: 'cells'
    ColumnsStartFrom: 'north'
    RowsStartFrom: 'west'
```

```
    CellExtentInLatitude: 1
    CellExtentInLongitude: 1
    RasterExtentInLatitude: 180
    RasterExtentInLongitude: 360
        XIntrinsicLimits: [0.5 360.5]
        YIntrinsicLimits: [0.5 180.5]
    CoordinateSystemType: 'geographic'
        GeographicCRS: []
        AngleUnit: 'degree'
```

Obtain the same result by specifying cell extents.

```
extent = 1;
```

```
R = georefcells(latlim,lonlim,extent,extent,'ColumnsStartFrom','north')
```

```
R =
    GeographicCellsReference with properties:
```

```
        LatitudeLimits: [-90 90]
        LongitudeLimits: [-180 180]
        RasterSize: [180 360]
    RasterInterpretation: 'cells'
        ColumnsStartFrom: 'north'
        RowsStartFrom: 'west'
    CellExtentInLatitude: 1
    CellExtentInLongitude: 1
    RasterExtentInLatitude: 180
    RasterExtentInLongitude: 360
        XIntrinsicLimits: [0.5 360.5]
        YIntrinsicLimits: [0.5 180.5]
    CoordinateSystemType: 'geographic'
        GeographicCRS: []
        AngleUnit: 'degree'
```

Input Arguments

latlim — Latitude limits in degrees

[0.5 2.5] (default) | 1-by-2 numeric vector

Latitude limits in degrees, specified as a 1-by-2 numeric vector. The number of rows in the resulting raster is specified by `rasterSize`.

Example: `latlim = [-90 90];`

lonlim — Longitude limits in degrees

[0.5 2.5] (default) | 1-by-2 numeric vector

Longitude limits in degrees, specified as a 1-by-2 numeric vector. The number of columns in the resulting raster is specified by `rasterSize`.

Example: `lonlim = [-180 180];`

rasterSize — Size of the raster

[2 2] (default) | 1-by-2 numeric vector

Size of the raster, specified as a 1-by-2 numeric vector.

Example: `rasterSize = [180 360];`**latcellextent — Height of cells**

1 (default) | numeric scalar

Height of cells, specified as a numeric scalar. The value of `latcellextent` determines the `CellExtentInLatitude` property of `R`.Example: `latcellextent = 1.5`**loncellextent — Width of cells**

1 (default) | numeric scalar

Width of cells, specified as a numeric scalar. The value of `loncellextent` determines the `CellExtentInLongitude` property of `R`.Example: `loncellextent = 1.5`**Name-Value Pair Arguments**Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.*Before R2021a, use commas to separate each name and value, and enclose `Name` in quotes.*Example: `R = georefcells(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')`**ColumnsStartFrom — Edge from which column indexing starts**

'south' (default) | 'north'

Edge from which column indexing starts, specified as either 'north' or 'south'.

Example: `R = georefcells(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')`

Data Types: char | string

RowsStartFrom — Edge from which row indexing starts

'west' (default) | 'east'

Edge from which row indexing starts, specified as either 'east' or 'west'.

Example: `R = georefcells(latlim,lonlim,rasterSize,'RowsStartFrom','east')`

Data Types: char | string

Output Arguments**R — Object that references raster cells to geographic coordinates**

GeographicCellsReference raster reference object

Object that references raster cells to geographic coordinates, returned as a `GeographicCellsReference` raster reference object.

Tips

- To construct a geographic raster reference object from a world file matrix, use the `georasterref` function.

Version History

Introduced in R2015b

See Also

`georefpostings` | `GeographicCellsReference` | `maprefcells`

georesize

Resize geographic raster

Syntax

```
[B,RB] = georesize(A,RA,scale)
[B,RB] = georesize(A,RA,latscale,lonscale)
[B,RB] = georesize( ____,method)
[B,RB] = georesize( ____, 'Antialiasing',TF)
```

Description

`[B,RB] = georesize(A,RA,scale)` returns the raster `B` that is `scale` times the size of the raster `A`. `RA` is a geographic raster reference object that specifies the location and extent of data in `A`. `georesize` returns the raster reference object `RB` that is associated with the returned raster `B`. By default, `georesize` uses cubic interpolation.

`georesize` preserves the limits of the raster. If the `scale` specified divides evenly into the numbers of cells in each dimension, or the number of samples in each dimension minus 1, the limits of the output are the same as the input. Otherwise, `georesize` adjusts the output limits by a fraction of the cell extents or sample spacing values.

`[B,RB] = georesize(A,RA,latscale,lonscale)` returns the raster `B` that is `latscale` times the size of `A` in column (north-south) direction and `lonscale` times the size of `A` in the row (east-west) direction.

`[B,RB] = georesize(____,method)` returns a resized raster where `method` specifies the interpolation method.

`[B,RB] = georesize(____, 'Antialiasing',TF)` specifies whether to perform antialiasing when shrinking a raster. The default depends on the type of interpolation. For nearest-neighbor interpolation, the default value is `false`. For all other interpolation methods, the default is `true`.

Examples

Resize Geographic Raster

Import a sample geographic raster and geographic cells reference object.

```
[Z,R] = readgeoraster('raster_sample2.tif');
```

Resize the raster using `georesize`. Double the length and width of the raster by specifying the `scale` as 2. Use nearest neighbor interpolation by specifying the interpolation method as `'nearest'`.

```
[Z2,R2] = georesize(Z,R,2,'nearest');
```

You can also resize the input raster by specifying different scales for the north-south and east-west directions.

```
[Z3,R3] = georesize(Z,R,3,2,'nearest');  
R3.RasterSize
```

```
ans = 1×2  
     6     4
```

Verify the raster has been resized by comparing the size of the original raster with the size of the updated rasters.

```
R.RasterSize
```

```
ans = 1×2  
     2     2
```

```
R2.RasterSize
```

```
ans = 1×2  
     4     4
```

```
R3.RasterSize
```

```
ans = 1×2  
     6     4
```

If the rasters are small, you can compare them directly.

```
Z
```

```
Z = 2×2  
     1     2  
     3     4
```

```
Z2
```

```
Z2 = 4×4  
     1     1     2     2  
     1     1     2     2  
     3     3     4     4  
     3     3     4     4
```

```
Z3
```

```
Z3 = 6×4  
     1     1     2     2  
     1     1     2     2  
     1     1     2     2  
     3     3     4     4
```

```
3 3 4 4
3 3 4 4
```

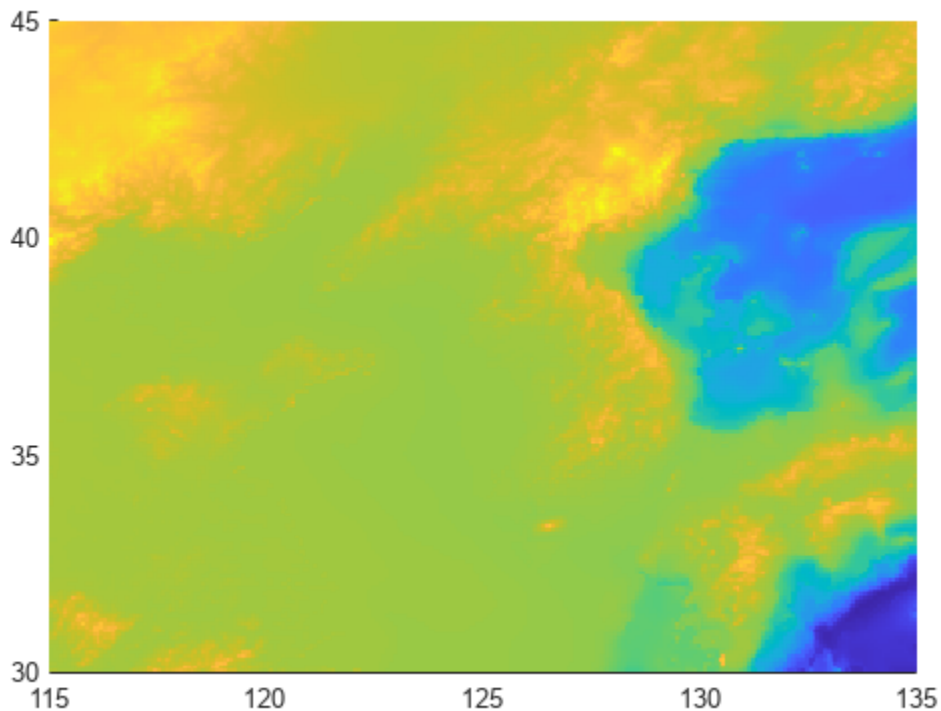
Resize Geographic Raster Data Set

Load a raster data set showing land elevations and bathymetry for the region around the Korean peninsula, at a resolution of 12 cells per degree. The data includes a raster image, `korea5c`, and an associated geographic raster reference object, `korea5cR`.

```
load korea5c
```

View the raster data set, using `geoshow`, specifying the associated raster reference object.

```
geoshow(korea5c, korea5cR, 'DisplayType', 'texturemap')
```

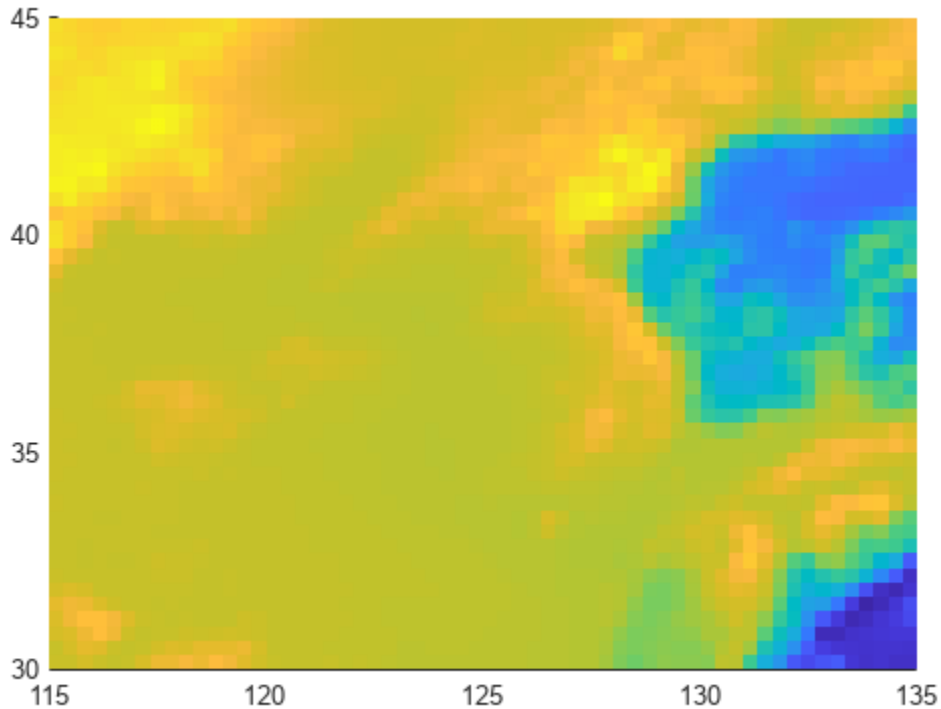


Resize the raster to be a quarter of its original size.

```
[resizedKorea, resizedKoreaR] = georesize(korea5c, korea5cR, 0.25);
```

View the resized raster. Note that `geoshow` preserves the original limits of the map in the display so that, at first glance, the resized raster appears to be the same size as the original. A closer look reveals that the size of pixels in the resized raster are larger than the pixels in the original.

```
figure  
geoshow(resizedKorea, resizedKoreaR, 'DisplayType', 'texturemap')
```



Input Arguments

A — Raster to be resized

numeric or logical array

Raster to be resized, specified as a numeric or logical array. If A has more than two dimensions, such as with a color raster in RGB format, `georesize` only resizes the first two dimensions.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

RA — Information about location and extent of raster

raster reference object

Information about location and extent of raster, specified as a raster reference object. To convert a referencing vector or referencing matrix into a raster reference object, use the `refvecToGeoRasterReference` or `refmatToGeoRasterReference`.

scale — Amount of resizing

numeric scalar

Amount of resizing, specified as numeric scalar. If `scale` is in the range `[0 1]`, B is smaller than A. If `scale` is greater than 1, B is larger than A.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

latscale — Amount of resizing in north-south direction

numeric scalar

Amount of resizing in north-south direction, specified as numeric scalar. If `latscale` is in the range `[0 1]`, B is smaller than A. If `latscale` is greater than 1, B is larger than A.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

lonscale — Amount of resizing in east-west direction

numeric scalar

Amount of resizing in east-west direction, specified as numeric scalar. If `lonscale` is in the range `[0 1]`, B is smaller than A. If `lonscale` is greater than 1, B is larger than A.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

method — Interpolation method

'cubic' (default) | 'nearest' | 'bilinear'

Interpolation method, specified as one of the following values:

Value	Description
'nearest'	Nearest-neighbor interpolation
'bilinear'	Bilinear interpolation
'cubic'	Cubic interpolation

Data Types: `char` | `string`

Output Arguments

B — Resized raster

numeric or logical array

Resized raster, returned as a numeric or logical array.

RB — Information about location and extent of raster

geographic raster reference object

Information about location and extent of the raster, returned as a geographic raster reference object.

Tips

- Use `georesize` with raster data in latitude and longitude coordinates. To work with projected raster data, in x- and y-coordinates, use `mapresize`.

Version History

Introduced in R2019a

See Also

[geointerp](#) | [georefcells](#) | [georefpostings](#) | [mapresize](#)

geoshape

Geographic shape vector

Description

A geoshape vector is an object that represents geographic vector features with either point, line, or polygon topology. The features consist of latitude and longitude coordinates and associated attributes.

Attributes that vary spatially are termed Vertex properties. These elements of the geoshape vector are coupled such that the length of the latitude and longitude coordinate property values are always equal in length to any additional dynamic Vertex properties.

Attributes that only pertain to the overall feature (point, line, polygon) are termed Feature properties. Feature properties are not linked to the autosizing mechanism of the Vertex properties. Both property types can be added to a geoshape vector during construction or by using standard dot (.) notation after construction.

To create a geographic point, line, or polygon shape for use with a geospatial table, create a `geopointshape`, `geolineshape`, or `geopolyshape` object instead.

Creation

Syntax

```
s = geoshape()
s = geoshape(latitude, longitude)
s = geoshape(latitude, longitude, Name, Value)
s = geoshape(structArray)
s = geoshape(latitude, longitude, structArray)
```

Description

`s = geoshape()` constructs an empty geoshape vector, `s`, with these default property settings.

`s =`

```
0x1 geoshape vector with properties:
```

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  Latitude: []
  Longitude: []
```

`s` is always a column vector.

`s = geoshape(latitude, longitude)` sets the `Latitude` and `Longitude` properties of `geoshape` vector `s`.

`s = geoshape(latitude, longitude, Name, Value)` sets the `Latitude` and `Longitude` properties, then adds dynamic properties to the `geoshape` vector using `Name, Value` argument pairs. You can specify several name-value pair arguments in any order as `Name1, Value1, ..., NameN, ValueN`.

`s = geoshape(structArray)` constructs a `geoshape` vector from the fields of the structure array, `structArray`.

- If `structArray` contains the field `Lat`, and does not contain the field `Latitude`, then the `Latitude` property values are set equal to the `Lat` field values. Similar behavior occurs when `structArray` contains the field `Lon` and does not contain the field `Longitude`.
- If `structArray` contains both `Lat` and `Latitude` fields, then the `Latitude` property values are set equal to the `Latitude` field values. Also, a `Lat` dynamic property is created and its values are set equal to the `Lat` field values. Similar behavior occurs for `Lon` and `Longitude` fields when both are present in `structArray`.
- Other `structArray` fields are assigned to `s` and become dynamic properties. Field values in `structArray` that are not numeric values, string scalars, string arrays, character vectors, logical, or cell arrays of numeric values, logical, or character vectors are ignored. You can specify vectors within cell arrays as either row or column vectors.

`s = geoshape(latitude, longitude, structArray)` sets the `Latitude` and `Longitude` properties, and sets dynamic properties from the field values of `structArray`.

- If `structArray` contains the fields `Lat`, `Latitude`, `Lon` or `Longitude`, then those field values are ignored since the `latitude` and `longitude` input vectors set the `Latitude` and `Longitude` property values.

Properties

The `geoshape` class is a general class that represents various geographic features. This class permits features to have more than one vertex and can thus represent lines and polygons in addition to multipoints. For more about the property types in `geoshape`, see “Collection Properties” on page 1-688, “Vertex Properties” on page 1-688, and “Feature Properties” on page 1-688.

Dynamic properties are new features and vertices that are added to a `geoshape` vector. You can attach dynamic properties to a `geoshape` vector during construction using a `Name, Value` argument, or after construction using dot (`.`) notation. This is similar to adding new fields to a structure. For an example of adding dynamic Feature properties, see “Construct a Geoshape Vector with Dynamic Properties” on page 1-678.

Geometry — Shape of every feature in the `geoshape` vector

`'line' (default) | 'point' | 'polygon'`

Shape of every feature in the `geoshape` vector, specified as `'line'`, `'point'`, or `'polygon'`. `Geometry` is a Collection property so there can be only one value per object instance and its purpose is purely informational. The three allowable values for `Geometry` do not change class behavior. The class does not validate line or polygon topologies.

Data Types: `char` | `string`

Latitude — Latitude coordinates

numeric row or column vector

Latitude coordinates, specified as a numeric row or column vector. `Latitude` is stored as a row vector. `Latitude` is a Vertex property.

Data Types: `double` | `single`**Longitude — Longitude coordinates**

numeric row or column vector

Longitude coordinates, specified as a row or column vector. `Longitude` is stored as a row vector. `Longitude` is a Vertex property.

Data Types: `double` | `single`**Metadata — Information for every feature**

scalar structure

Information for every feature, specified as a scalar structure. You can add any data type to the structure. `Metadata` is a Collection property, so only one instance per object is allowed.

- If 'Metadata' is provided as a dynamic property name in the constructor, and the corresponding value is a scalar structure, then the `Value` is copied to the `Metadata` property. Otherwise, an error is issued.
- If a `Metadata` field is provided by `structArray`, and both `Metadata` and `structArray` are scalar structures, then the `Metadata` field value is copied to the `Metadata` property value. If `structArray` is a scalar but the `Metadata` field is not a structure, then an error is issued. If `structArray` is not scalar, then the `Metadata` field is ignored.

Data Types: `struct`**Object Functions**

<code>append</code>	Append features to geographic or planar vector
<code>cat</code>	Concatenate geographic or planar vector
<code>disp</code>	Display geographic or planar vector
<code>fieldnames</code>	Return dynamic property names of geographic or planar vector
<code>isempty</code>	Determine if geographic or planar vector is empty
<code>isfield</code>	Determine if dynamic property exists in geographic or planar vector
<code>isprop</code>	Determine if property exists in geographic or planar vector
<code>length</code>	Return number of elements in geographic or planar vector
<code>properties</code>	Return property names of geographic or planar vector
<code>rmfield</code>	Remove dynamic property from geographic or planar vector
<code>rmprop</code>	Remove property from geographic or planar vector
<code>size</code>	Return size of geographic or planar vector
<code>struct</code>	Convert geographic or planar vector to scalar structure
<code>vertcat</code>	Vertically concatenate geographic or planar vectors

Examples**Construct a Default Geoshape Vector, Then Add Properties**

Construct an empty geoshape vector.

```
s = geoshape()
s =
0x1 geoshape vector with properties:
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  Latitude: []
  Longitude: []
```

Set the **Latitude** and **Longitude** property values using dot notation.

```
s.Latitude = 0:45:90;
s.Longitude = [10 10 10];
```

Display the updated geoshape vector.

```
s
s =
1x1 geoshape vector with properties:
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  Latitude: [0 45 90]
  Longitude: [10 10 10]
```

Construct Geoshape Vector Specifying Latitude and Longitude Values

Create a geoshape vector specifying latitude and longitude values as input arguments.

```
s = geoshape([42 43 45],[10 11 15])
s =
1x1 geoshape vector with properties:
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  Latitude: [42 43 45]
  Longitude: [10 11 15]
```

Construct a Geoshape Vector with Dynamic Properties

Create a geoshape vector using a Name-Value pair to define a new Feature property. This example defines a property called 'Temperature' and assigns it the value 89.

```
point = geoshape(42, -72, 'Temperature', 89)
```

```
point =
  1x1 geoshape vector with properties:
```

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  Latitude: 42
  Longitude: -72
Feature properties:
  Temperature: 89
```

To add dynamic properties to a geoshape vector after it has been constructed, use standard dot notation. Add a dynamic property called 'TemperatureUnits' with the value 'Fahrenheit'.

```
point.TemperatureUnits = 'Fahrenheit'
```

```
point =
  1x1 geoshape vector with properties:
```

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  Latitude: 42
  Longitude: -72
Feature properties:
  Temperature: 89
  TemperatureUnits: 'Fahrenheit'
```

To modify properties, use standard dot notation. Update the temperature, and change 'Geometry' to 'point'.

```
point.Temperature = 86;
point.Geometry = 'point'
```

```
point =
  1x1 geoshape vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Vertex properties:
  Latitude: 42
  Longitude: -72
Feature properties:
  Temperature: 86
  TemperatureUnits: 'Fahrenheit'
```

Construct a Geoshape Vector from a Structure Array

This example highlights the two ways by which a geoshape vector with the same features can be created. The first way uses a structure array in the constructor for a geoshape vector. The second way adds fields of the structure array to a geoshape vector after construction.

First, read data into a structure array. The array in this example contains 128 elements. Each element defines a river as a line using multiple location vertices.

```
structArray = shaperead('worldrivers.shp', 'UseGeoCoords', true);
```

Display the first element in `structArray`. Note that the `Lat` and `Lon` vectors are terminated with a `NaN` delimiter, which separates the Vertex feature data in the geoshape class.

```
structArray(1)

ans = struct with fields:
    Geometry: 'Line'
    BoundingBox: [2x2 double]
                Lon: [126.7796 126.5321 126.3121 126.2383 126.0362 NaN]
                Lat: [73.4571 73.0669 72.8343 72.6010 72.2894 NaN]
                Name: 'Lena'
```

Method 1: Provide the structure as an argument to the constructor that builds the geoshape vector.

Create a geoshape vector, providing the structure array as an argument to the constructor.

```
shape1 = geoshape(structArray)
```

```
shape1 =
    128x1 geoshape vector with properties:
```

```
Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
Vertex properties:
    (128 features concatenated with 127 delimiters)
    Latitude: [73.4571 73.0669 72.8343 72.6010 72.2894 NaN NaN 72.2894 72.3784 72.4620 72.5086 ...]
    Longitude: [126.7796 126.5321 126.3121 126.2383 126.0362 NaN NaN 126.0362 125.1356 124.7906 ...]
Feature properties:
    Name: {1x128 cell}
```

Note that the `BoundingBox` field in `structArray` does not get assigned to a property in `shape1` because the field value is not a supported type.

Method 2: Add features to a geoshape vector after construction.

Create an empty geoshape vector.

```
shape2 = geoshape;
```

Add the Vertex properties `Latitude` and `Longitude` from each entry in the structure array using dot notation. Add a dynamic Feature property, `RiverName`, the name of the river from each entry in `structArray`. Since the default value of the `Geometry` Collection property is `'line'` there is no need to set it explicitly in this example.

```

shape2.Latitude = {structArray.Lat};
shape2.Longitude = {structArray.Lon};
shape2.RiverName = {structArray.Name}

shape2 =
  128x1 geoshape vector with properties:

  Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
  Vertex properties:
    (128 features concatenated with 127 delimiters)
    Latitude: [73.4571 73.0669 72.8343 72.6010 72.2894 NaN NaN 72.2894 72.3784 72.4620 72.5086 ...]
    Longitude: [126.7796 126.5321 126.3121 126.2383 126.0362 NaN NaN 126.0362 125.1356 124.7906 ...]
  Feature properties:
    RiverName: {1x128 cell}

```

Construct a Geoshape Vector Using Cell Arrays

First, read data into a structure array. The array in this example contains 128 elements. Each element defines a river as a line using multiple location vertices.

```
structArray = shaperead('worldrivers.shp', 'UseGeoCoords', true)
```

```

structArray=128x1 struct array with fields:
  Geometry
  BoundingBox
  Lon
  Lat
  Name

```

Create latitude and longitude vectors. For illustrative purposes, the vectors do not correspond to the elements of `structArray`.

```

lat = {[0:10:40], [1:5]};
lon = {[ -60:30:60], [0:2:8]};

```

Construct a geoshape vector using the latitude and longitude vectors and the structure array.

```
s = geoshape(lat,lon,structArray);
```

Display the first three elements of `s`. Features are separated with a NaN delimiter.

```

s(1:3)

ans =
  3x1 geoshape vector with properties:

  Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
  Vertex properties:
    (3 features concatenated with 2 delimiters)
    Latitude: [0 10 20 30 40 NaN 1 2 3 4 5 NaN 0]
    Longitude: [-60 -30 0 30 60 NaN 0 2 4 6 8 NaN 0]

```

```
Feature properties:
  Name: {'Lena' 'Lena' 'Mackenzie'}
```

Observe that `geoshape` uses the arguments `lat` and `lon` to populate the `Latitude` and `Longitude` properties, even though `structArray` provides `Lat` and `Lon` field values. Also, since `lat` and `lon` have fewer elements than features in `structArray`, the `Latitude` and `Longitude` properties expand in size using a value of 0.

Use Indexing to Append a Single Point and a Shape to a Geoshape Vector

Create a geoshape vector containing a single feature of the locations of world cities.

```
S = shaperead('worldcities.shp', 'UseGeoCoords', true);
cities = geoshape([S.Lat], [S.Lon], 'Name', {{S.Name}});
cities.Geometry = 'point';
```

Append Paderborn Germany to the geoshape vector.

```
lat = 51.715254;
lon = 8.75213;
cities(1).Latitude(end+1) = lat;
cities(1).Longitude(end) = lon;
cities(1).Name{end} = 'Paderborn'
```

```
cities =
```

```
1x1 geoshape vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Vertex properties:
  Latitude: [1x319 double]
  Longitude: [1x319 double]
  Name: {1x319 cell}
```

The length of each vertex property grows by one when `Latitude(end+1)` is set. The remaining properties are indexed with `end`.

You can display the last point by constructing a `geopoint` vector.

```
paderborn = geopoint(cities.Latitude(end), cities.Longitude(end), ...
  'Name', cities.Name{end})
```

```
paderborn =
```

```
1x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: 51.7153
  Longitude: 8.7521
  Name: 'Paderborn'
```


Create a geoshape vector with two new features containing the cities in the northern and southern hemispheres. Add a Location dynamic Feature property to distinguish the different classifications.

```
northern = cities(1).Latitude >= 0;
southern = cities(1).Latitude < 0;
index = {northern; southern};
location = {'Northern Hemisphere', 'Southern Hemisphere'};
hemispheres = geoshape();
for k = 1:length(index)
    hemispheres = append(hemispheres, ...
        cities.Latitude(index{k}), cities.Longitude(index{k}), ...
        'Name', {cities.Name(index{k})}, 'Location', location{k});
end
hemispheres.Geometry = 'point'
```

```
hemispheres =
```

```
2x1 geoshape vector with properties:
```

```
Collection properties:
```

```
    Geometry: 'point'
    Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(2 features concatenated with 1 delimiter)
```

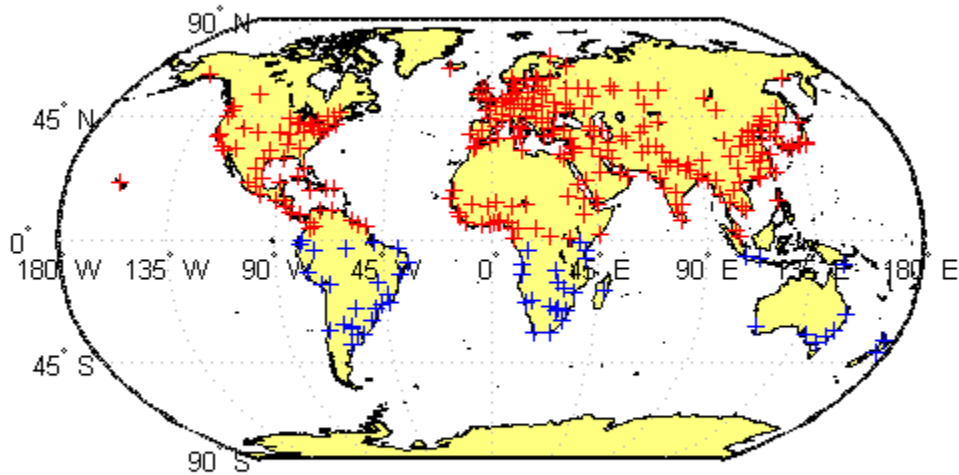
```
    Latitude: [1x320 double]
    Longitude: [1x320 double]
    Name: {1x320 cell}
```

```
Feature properties:
```

```
    Location: {'Northern Hemisphere' 'Southern Hemisphere'}
```

Plot the northern cities in red and the southern cities in blue.

```
hemispheres.Color = {'red', 'blue'};
figure;worldmap('world')
geoshow('landareas.shp')
for k=1:2
    geoshow(hemispheres(k).Latitude, hemispheres(k).Longitude, ...
        'DisplayType', hemispheres.Geometry, ...
        'MarkerEdgeColor', hemispheres(k).Color)
end
```



Use Indexing to Sort and Modify Dynamic Features

Construct a geoshape vector and sort its dynamic properties.

```
shape = geoshape(shaperead('tsunamis.shp', 'UseGeoCoords', true));  
shape.Geometry = 'point';  
shape = shape(:, sort(fieldnames(shape)))
```

```
shape =
```

```
162x1 geoshape vector with properties:
```

```
Collection properties:
```

```
Geometry: 'point'
```

```
Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(162 features concatenated with 161 delimiters)
```

```
Latitude: [1x323 double]
```

```
Longitude: [1x323 double]
```

```
Feature properties:
```

```
Cause: {1x162 cell}
```

```
Cause_Code: [1x162 double]
```

```
Country: {1x162 cell}
```

```
Day: [1x162 double]
```

```
Desc_Deaths: [1x162 double]
```

```

    Eq_Mag: [1x162 double]
    Hour: [1x162 double]
    Iida_Mag: [1x162 double]
    Intensity: [1x162 double]
    Location: {1x162 cell}
    Max_Height: [1x162 double]
    Minute: [1x162 double]
    Month: [1x162 double]
    Num_Deaths: [1x162 double]
    Second: [1x162 double]
    Val_Code: [1x162 double]
    Validity: {1x162 cell}
    Year: [1x162 double]

```

Modify the geoshape vector to contain only the dynamic properties, Year, Month, Day, Hour, Minute.

```
shape = shape(:, {'Year', 'Month', 'Day', 'Hour', 'Minute'})
```

```
shape =
```

```
162x1 geoshape vector with properties:
```

```

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Vertex properties:
(162 features concatenated with 161 delimiters)
  Latitude: [1x323 double]
  Longitude: [1x323 double]
Feature properties:
  Year: [1x162 double]
  Month: [1x162 double]
  Day: [1x162 double]
  Hour: [1x162 double]
  Minute: [1x162 double]

```

Display the first five elements.

```
shape(1:5)
```

```
ans =
```

```
5x1 geoshape vector with properties:
```

```

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Vertex properties:
(5 features concatenated with 4 delimiters)
  Latitude: [-3.8000 NaN 19.5000 NaN -9.0200 NaN 42.1500 NaN 19.1000]
  Longitude: [128.3000 NaN -156 NaN 157.9500 NaN 143.8500 NaN -155]
Feature properties:
  Year: [1950 1951 1951 1952 1952]
  Month: [10 8 12 3 3]
  Day: [8 21 22 4 17]

```

```
Hour: [3 10 NaN 1 3]
Minute: [23 57 NaN 22 58]
```

Construct a Geoshape Vector from Multiple Objects

Read multiple GPS track log data from a file. `trk1` and `trk2` are geopoint objects.

```
trk1 = gpxread('sample_tracks.gpx')
```

```
trk1 =
1851x1 geopoint vector with properties:
```

```
Collection properties:
```

```
Geometry: 'point'
Metadata: [1x1 struct]
```

```
Feature properties:
```

```
Latitude: [42.2995 42.2995 42.2994 42.2994 42.2994 42.2994 42.2994 42.2994 42.2994 42.2993 4
Longitude: [-71.3502 -71.3504 -71.3504 -71.3504 -71.3504 -71.3504 -71.3504 -71.3504 -71.3504
Elevation: [90.0206 90.0206 90.0206 90.5013 90.0206 90.0206 90.0206 90.0206 90.5013 90.0206 9
Time: {1x1851 cell}
```

```
trk2 = gpxread('sample_tracks.gpx', 'Index', 2);
```

To construct a geoshape vector with multiple features, place the coordinates into cell arrays.

```
lat = {trk1.Latitude, trk2.Latitude};
lon = {trk1.Longitude, trk2.Longitude};
```

Place the elevation and time values into cell arrays.

```
elevation = {trk1.Elevation, trk2.Elevation};
time = {trk1.Time, trk2.Time};
```

Construct a geoshape vector containing two track log features that include `Elevation` and `Time` as dynamic Vertex properties.

```
tracks = geoshape(lat, lon, 'Elevation', elevation, 'Time', time)
```

```
tracks =
2x1 geoshape vector with properties:
```

```
Collection properties:
```

```
Geometry: 'line'
Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(2 features concatenated with 1 delimiter)
```

```
Latitude: [42.2995 42.2995 42.2994 42.2994 42.2994 42.2994 42.2994 42.2994 42.2994 42.2993 4
Longitude: [-71.3502 -71.3504 -71.3504 -71.3504 -71.3504 -71.3504 -71.3504 -71.3504 -71.3504
Elevation: [90.0206 90.0206 90.0206 90.5013 90.0206 90.0206 90.0206 90.0206 90.5013 90.0206 9
Time: {1x2591 cell}
```

Each `Latitude` and `Longitude` coordinate pair has associated `Elevation` and `Time` values.


```
pts2 = [coastlat; coastlon];
```

Create a geoshape object and store the latitude and longitude data. If you store latitude and longitude coordinate values in a 2-by-*m* array, `geoshape` assigns the `Latitude` property values to the first **row** and the `Longitude` property values to the second **row**.

```
shape2 = geoshape();  
shape2(1) = pts2
```

```
shape2 =  
  1x1 geoshape vector with properties:
```

```
  Collection properties:
```

```
    Geometry: 'line'
```

```
    Metadata: [1x1 struct]
```

```
  Vertex properties:
```

```
    Latitude: [-83.8300 -84.3300 -84.5000 -84.6700 -84.9200 -85.4200 -85.4200 -85.5800 -85.3300
```

```
    Longitude: [-83.8300 -84.3300 -84.5000 -84.6700 -84.9200 -85.4200 -85.4200 -85.5800 -85.3300
```

More About

Collection Properties

Collection properties contain only one value per class instance. In contrast, the `Feature` and `Vertex` property types have attribute values associated with each feature or with each vertex in a set that defines a feature. `Geometry` and `Metadata` are the only two Collection properties.

Vertex Properties

Vertex properties provide a scalar number or a character vector for each vertex in a geoshape object. Vertex properties are suitable for attributes that vary spatially from point to point (vertex to vertex) along a line. Examples of such spatially varying attributes could be elevation, speed, temperature, or time. `Latitude` and `Longitude` are vertex properties since they contain a scalar number for each vertex in a geoshape vector.

Attribute values are associated with each vertex during construction or by using dot notation after construction. This process is similar to adding dynamic fields to a structure. Dynamic Vertex property values of an individual feature match its `Latitude` and `Longitude` values in length.

Feature Properties

Feature properties provide one value (a scalar number, scalar string, or character vector) for each feature in a geoshape vector. They are suitable for properties, such as name, owner, serial number, or age, that describe a given feature (an element of a geoshape vector) as a whole. Like Vertex properties, Feature properties can be added during construction or by using dot notation after construction.

Tips

- The `geoshape` function separates features using NaN values. If you display a feature by using a scalar to index into the geoshape vector, such as `s(1)`, then NaN values that separate the features do not display.

- If `Latitude`, `Longitude`, or a dynamic property is set with more values than features in the geoshape vector, then all other properties expand in size using 0 for numeric values and an empty character vector (' ') for cell values.
- If a dynamic property is set with fewer values than the number of features, then this dynamic property expands to match the size of the other properties, by inserting a 0 if the value is numeric or an empty character vector (' '), if the value is a cell array.
- If the `Latitude` or `Longitude` property of the geoshape vector is set with fewer values than contained in the object, then all other properties shrink in size.
- If either `Latitude` or `Longitude` are set to [], then both coordinate properties are set to [] and all dynamic properties are removed.
- If a dynamic property is set to [], then it is removed from the object.
- The geoshape vector can be indexed like any MATLAB vector. You can access any element of the vector to obtain a specific feature. The following examples demonstrate this behavior:

“Use Indexing to Append a Single Point and a Shape to a Geoshape Vector” on page 1-682

“Use Indexing to Sort and Modify Dynamic Features” on page 1-684

“Construct a Geoshape Vector from Multiple Objects” on page 1-686

Version History

Introduced in R2012a

See Also

Functions

`gpxread` | `shaperead`

Objects

`geopoint` | `mappoint` | `mapshape`

Topics

“Create and Display Polygons”

geoshow

Display map latitude and longitude data

Syntax

```
geoshow(lat, lon)
geoshow(S)
```

```
geoshow(lat, lon, Z)
geoshow(Z, R)
```

```
geoshow(lat, lon, I)
geoshow(lat, lon, X, cmap)
geoshow(I, R)
geoshow(X, cmap, R)
```

```
geoshow(filename)
```

```
geoshow( ____, Name, Value)
geoshow(ax, ____)
h = geoshow( ____)
```

Description

`geoshow(lat, lon)` projects and displays the latitude and longitude vectors `lat` and `lon` using the projection stored in the current `axesm`-based map (previously referred to as map axes). If there is no current `axesm`-based map, then `lat` and `lon` are projected using a default Plate Carrée projection on a set of regular axes.

Note To display data on an `axesm`-based map, create a map using the `axesm`, `worldmap`, or `usamap` function before calling `geoshow`.

By default, `geoshow` displays `lat` and `lon` as lines. You can optionally display the vector data as points, multipoints, or polygons by using the `DisplayType` name-value pair argument.

`geoshow(S)` displays the vector geographic features stored in `S` as points, multipoints, lines, multilines, polygons, or multipolygons according to the geometry of `S`.

You can optionally specify symbolization rules using the `SymbolSpec` name-value pair argument.

`geoshow(lat, lon, Z)` projects and displays the geolocated data grid, `Z`. In this syntax, `lat` and `lon` are `M`-by-`N` latitude-longitude arrays. `Z` is an `M`-by-`N` array of class `double`. You can optionally display the data as a surface, mesh, texture map, or contour by using the `DisplayType` name-value pair argument.

`geoshow(Z, R)` projects and displays a regular data grid, `Z`, with referencing object `R`. You can optionally display the data as a surface, mesh, texture map, or contour by using the `DisplayType` name-value pair argument. If `DisplayType` is `'texturemap'`, then `geoshow` constructs a surface with `ZData` values set to 0.

`geoshow(lat,lon,I)` and

`geoshow(lat,lon,X,cmap)` projects and displays a geolocated image as a texture map on a zero-elevation surface. The geolocated image `I` can be a truecolor, grayscale, or binary image. `X` is an indexed image with colormap `cmap`. Examples of geolocated images include a color composite from a satellite swath or an image originally referenced to a different coordinate system.

`geoshow(I,R)` and

`geoshow(X,cmap,R)` project and display an image georeferenced to latitude-longitude through the referencing object `R`. The image is shown as a texture map on a zero-elevation surface.

`geoshow(filename)` projects and displays data from the file specified according to the type of file format.

`geoshow(____,Name,Value)` specifies parameters and corresponding values that modify the type of display or set MATLAB graphics properties. You can use name,value pairs to set:

- `Name,Value` arguments
- Any MATLAB Graphics line, patch, and surface properties
- Any Mapping Toolbox contour properties

Parameter names can be abbreviated, and case does not matter.

`geoshow(ax, ____)` sets the parent axes to `ax`.

`h = geoshow(____)` returns a handle to a MATLAB graphics object.

Examples

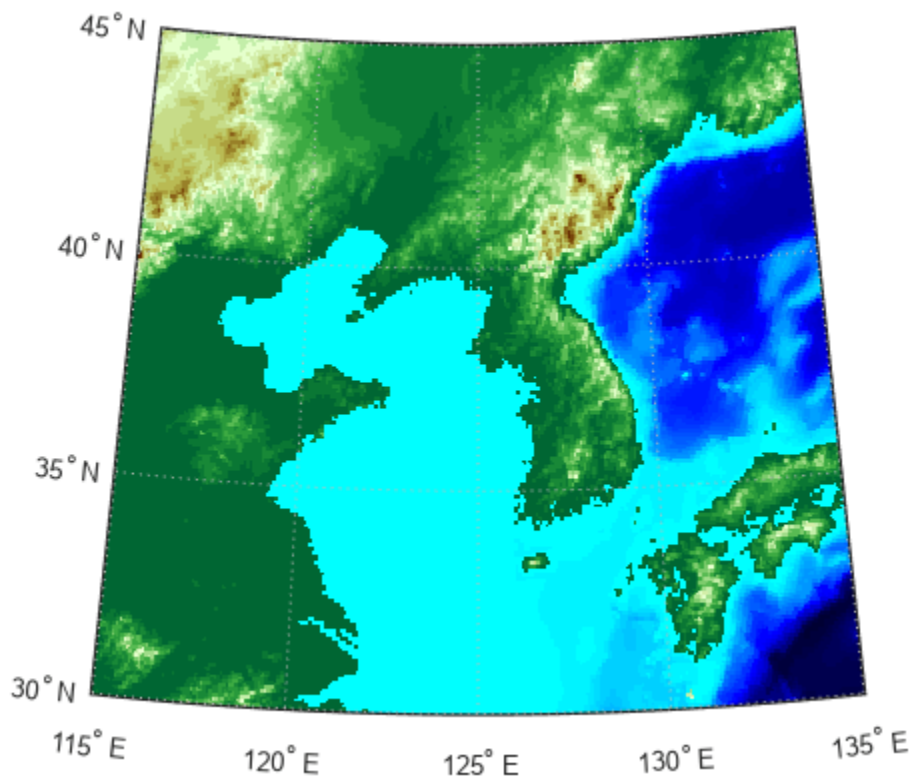
Display Regular Data Grid as Texture Map

Load elevation data and a geographic cells reference object for the Korean peninsula. Create a map for the Korean peninsula using `worldmap`.

```
load korea5c
worldmap(korea5c,korea5cR)
```

Display the elevation data as a texture map. Apply a colormap appropriate for elevation data using `demcmap`.

```
geoshow(korea5c,korea5cR,'DisplayType','texturemap')
demcmap(korea5c)
```



Display Polygons on Map Projection

Import a shapefile containing worldwide land areas as a geospatial table. The shapefile represents the land areas using polygons.

```
landAreas = readgeotable("landareas.shp");
```

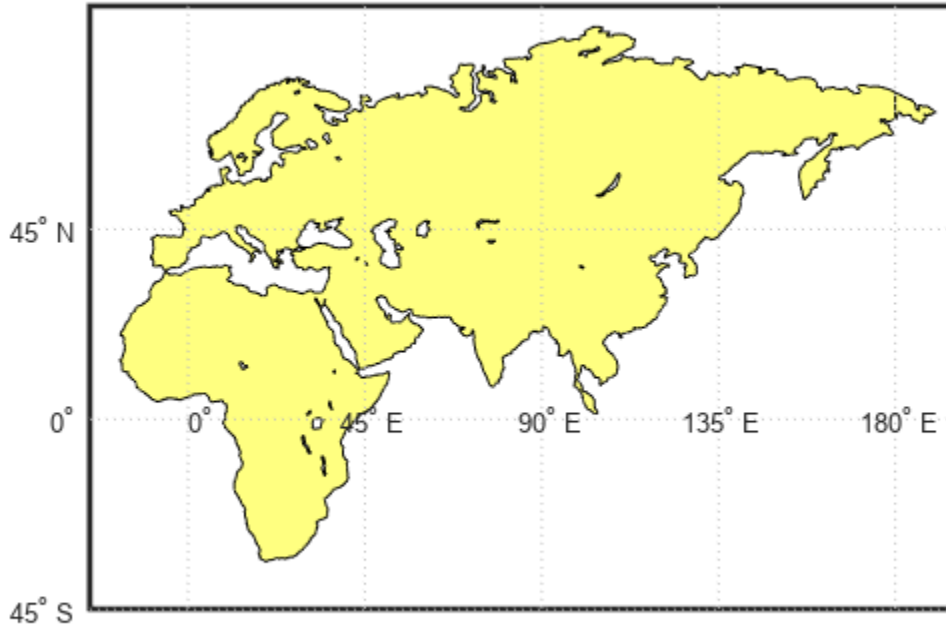
Create a subtable that contains the polygon representing Africa, Europe, and Asia. Get information about the polygon by querying the Shape variable of the table.

```
row = landAreas.Name == "Africa and Eurasia";  
landAreasSubset = landAreas(row,:);  
landAreasSubset.Shape
```

```
ans =  
  geopolyshape with properties:  
    NumRegions: 2  
    NumHoles: 22  
    Geometry: "polygon"  
    CoordinateSystemType: "geographic"  
    GeographicCRS: [1x1 geocrs]
```

Display the polygon on a world map.

```
worldmap([-45 80],[-25 195]);
geoshow(landAreasSubset)
```



Define Face Colors and Set Default Face Colors

Import a shapefile containing USA state polygons as a geospatial table. Create a map using a projection and limits suitable for displaying all 50 states.

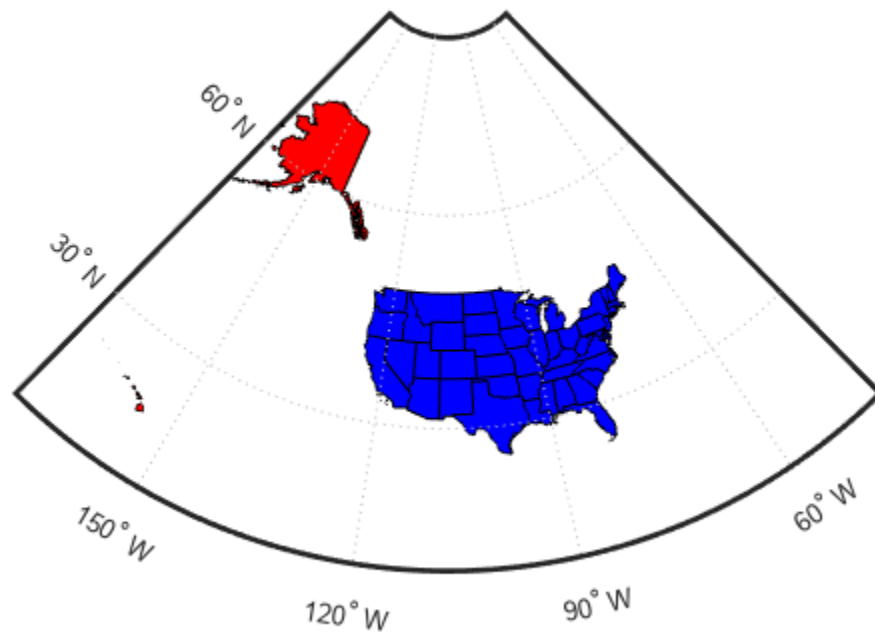
```
states = readgeotable("usastatehi.shp");
figure
worldmap("na")
```

Create a symbol specification that sets the color of the Alaska and Hawaii polygons to red.

```
symspec = makesymbolspec("Polygon", ...
    {'Name', 'Alaska', 'FaceColor', 'red'}, ...
    {'Name', 'Hawaii', 'FaceColor', 'red'});
```

Display all the state polygons. Set the default face color to blue and the default edge color to black.

```
geoshow(states, "SymbolSpec", symspec, ...
    "DefaultFaceColor", "blue", ...
    "DefaultEdgeColor", "black");
```



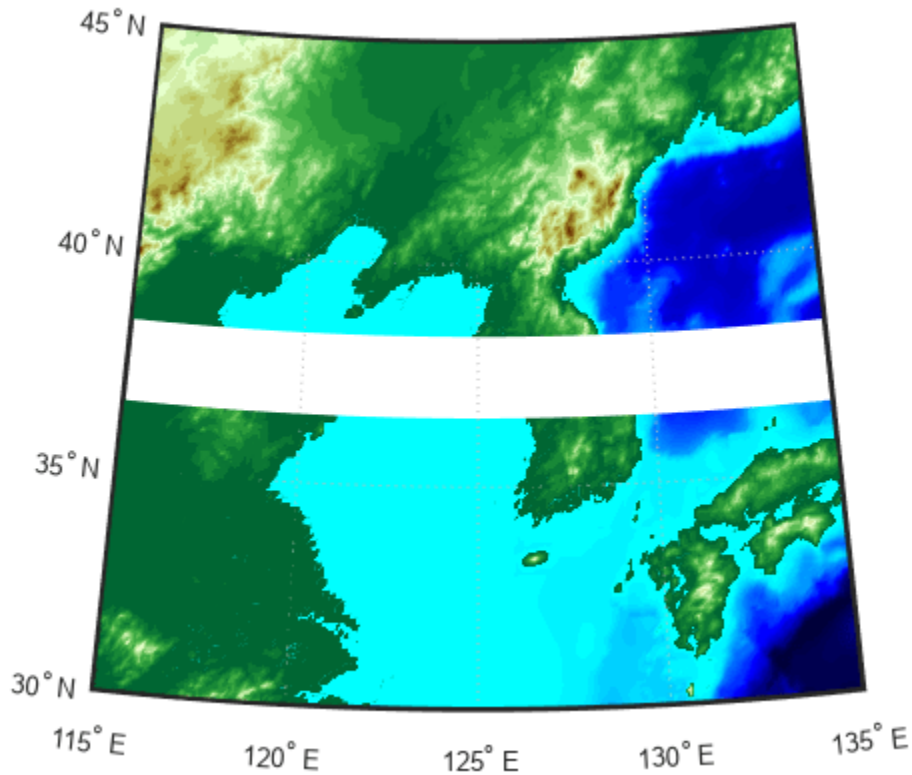
Create Map and Display NaNs as Transparent

Load elevation data and a geographic cells reference object for the Korean peninsula. Insert a band of null values into the elevation data.

```
load korea5c
korea5c(80:100,:) = NaN;
```

Create a map for the Korean peninsula using `worldmap`. Then, display the elevation data as a surface with transparent null values.

```
worldmap(korea5c,korea5cR)
geoshow(korea5c,korea5cR,'DisplayType','surface')
demcmap(korea5c)
```



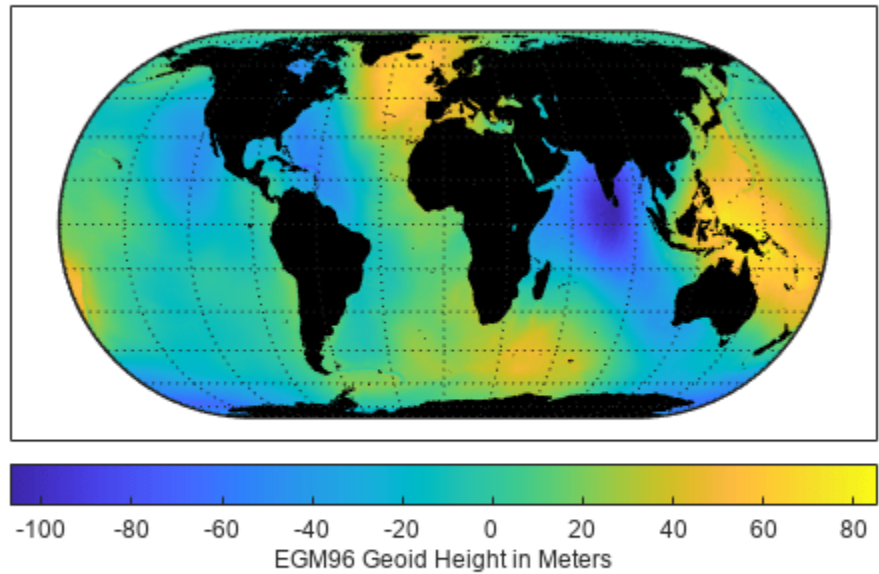
Display EGM96 Geoid Heights Masking Out Land Areas

Get geoid heights and a geographic postings reference object from the EGM96 geoid model. Then, display the geoid heights as a surface using an Eckert projection. Ensure the surface appears under the land mask by setting the 'CData' name-value pair to the geoid height data and the 'ZData' name-value pair to a matrix of zeros. Display the frame and grid of the map using `framem` and `gridm`.

```
[N,R] = egm96geoid;
axesm eckert4
Z = zeros(R.RasterSize);
geoshow(N,R,'DisplayType','surface','CData',N,'ZData',Z)
framem
gridm
```

Create a colorbar and add a text description. Then, mask out all the land.

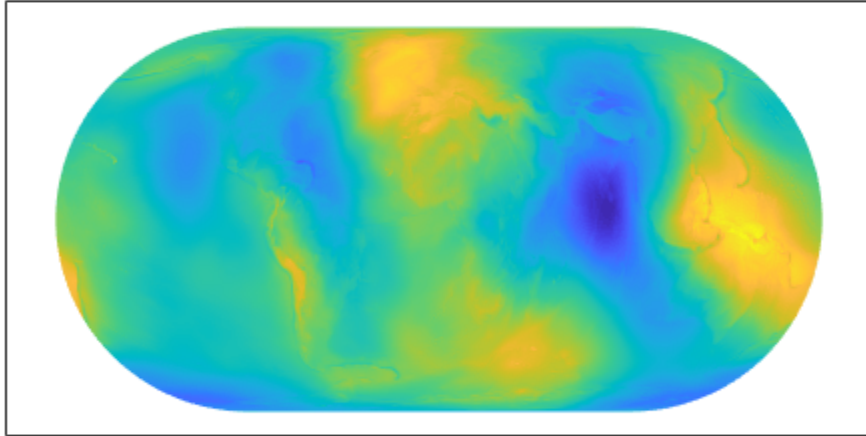
```
cb = colorbar('southoutside');
cb.Label.String = 'EGM96 Geoid Height in Meters';
geoshow('landareas.shp','FaceColor','black')
```



Display EGM96 Geoid Heights as 3-D Surface

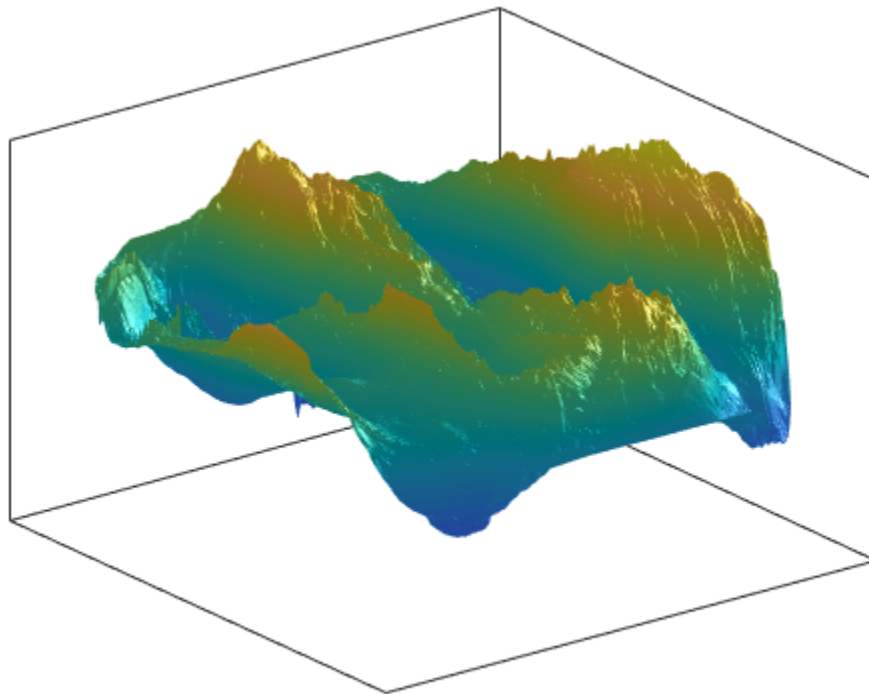
Get geoid heights and a geographic postings reference object from the EGM96 geoid model. Then, display the geoid heights as a surface using an Eckert projection.

```
[N,R] = egm96geoid;  
axesm eckert4  
geoshow(N,R, 'DisplayType', 'surface')
```



Add light and material. Then, view the map as a 3-D surface.

```
light  
material(0.6*[1 1 1])  
axis normal  
view(3)
```



Display Moon Albedo Using Orthographic Projection

Load moon albedo data and a geographic cells reference object.

```
load moonalb20c
```

Then, display the data. To do this, create a map and specify its projection as orthographic. Display the data as a texture map using the `geoshow` function. Then, change the colormap to grayscale and remove the axis lines.

```
axesm ortho  
geoshow(moonalb20c,moonalb20cR,'DisplayType','texturemap')  
colormap gray  
axis off
```




Input Arguments

lat, lon — Latitude or longitude data

numeric vector | *M*-by-*N* numeric array

Latitude or longitude data, specified as a numeric vector or an *M*-by-*N* numeric matrix.

- `lat` and `lon` are vectors when used with the syntax `geoshow(lat, lon)`.
- `lat` and `lon` are 2-D arrays when used with the `geoshow(lat, lon, Z)` syntax, the `geoshow(lat, lon, I)` syntax, or the `geoshow(lat, lon, X, cmap)` syntax. If `lat` and `lon` are matrices, they represent coordinate arrays or a geolocation array in geographic coordinates, and must be the same size as `Z`, `I`, or `X`. If `I` is an RGB image, `lat` and `lon` must be matrices that match the first two dimensions of the image.

`lat` and `lon` may contain embedded NaNs to delimit individual lines or polygon parts.

S — Geographic features

geospatial table | `geopoint` vector | `geoshape` vector | geographic structure array

Geographic features, specified as one of the following:

- A geospatial table. The `Shape` variable of the table must contain `geopointshape`, `geolineshape`, or `geopolyshape` objects. The `geoshow` function does not support geospatial tables containing more than one type of shape object. For more information about geospatial tables, see “Create Geospatial Tables”.

- A `geopoint` vector.
- A `geoshape` vector.
- A geographic structure array (`geostruct`) with `Lat` and `Lon` coordinate fields.

The `geoshow` function assumes the coordinates are geographic coordinates and projects them to map coordinates.

If you specify a `mappoint` vector, a `mapshape` vector, or a map structure array (`mapstruct`) with `X` and `Y` coordinate fields, then the `geoshow` function display the vertices as pre-projected map coordinates and issues a warning. If you specify a geospatial table containing `mappointshape`, `maplineshape`, or `mappolyshape` objects, then the `geoshow` function throws an error. In these cases, use the `mapshow` function instead.

Z – Data grid

M-by-*N* numeric array

Data grid, specified as an *M*-by-*N* numeric array that may contain `NaN` values. `Z` is either a georeferenced data grid, or a regular data grid associated with a geographic reference `R`.

R – Geographic reference

geographic raster reference object | vector | matrix

Geographic reference, specified as one of the following. For more information about referencing vectors and matrices, see “Georeferenced Raster Data”.

Type	Description
Geographic raster reference object	<p><code>GeographicCellsReference</code> or <code>GeographicPostingsReference</code> geographic raster reference object that relates the subscripts of <code>Z</code> to geographic coordinates. The <code>RasterSize</code> property must be consistent with the size of the data grid, <code>size(Z)</code>.</p> <p>If <code>R</code> is a <code>GeographicPostingsReference</code> object, then the <code>'image'</code> and <code>'texturemap'</code> values of <code>DisplayType</code> are not accepted.</p>
Vector	<p>1-by-3 numeric vector with elements:</p> <p><code>[cells/degree northern_latitude_limit western_longitude_limit]</code></p>
Matrix	<p>3-by-2 numeric matrix that transforms raster row and column indices to or from geographic coordinates according to:</p> $[\text{lon } \text{lat}] = [\text{row } \text{col } 1] * R$ <p><code>R</code> defines a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. <code>NaN</code> is returned for points outside the grid limits or for which <code>lat</code> or <code>lon</code> contain <code>NaN</code>. All angles are in units of degrees.</p>

I – Truecolor, grayscale, or binary image

M-by-*N*-by-3 array | *M*-by-*N* array

Truecolor, grayscale, or binary image, specified as an M -by- N -by-3 array for truecolor images, or an M -by- N array for grayscale or binary images. `lat` and `lon` must be M -by- N arrays. If specified, `'DisplayType'` must be set to `'image'`.

X — Indexed image

M -by- N array

Indexed image with color map defined by `cmap`, specified as an M -by- N array. `lat` and `lon` must be M -by- N arrays. If specified, `'DisplayType'` must be set to `'image'`.

cmap — Color map

c -by-3 matrix

Color map of indexed image X , specified as an c -by-3 numeric matrix. There are c colors in the color map, each represented by a red, green, and blue pixel value.

filename — File name

character vector | string scalar

File name, specified as a string scalar or character vector. `geoshow` automatically sets the `DisplayType` parameter according to the format of the data.

Format	DisplayType
Shape file	'point', 'multipoint', 'line', or 'polygon'
GeoTIFF	'image'
TIFF/JPEG/PNG with a world file	'image'
ARC ASCII GRID	'surface' (can be overridden)
SDTS raster	'surface' (can be overridden)

Data Types: char | string

ax — Parent axes

axes object

Parent axes, specified as an axes object.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `'DisplayType','point'`

SymbolSpec — Symbolization rules

structure

Symbolization rules to be used for displaying vector data, specified as the comma-separated pair consisting of `'SymbolSpec'` and a structure returned by `makesymbolspec`. It is used only for vector data stored in geographic data structures. In cases where both `SymbolSpec` and one or more graphics properties are specified, the graphics properties override any settings in the `symbolspec` structure.

To change the default symbolization rule for a `Name, Value` pair in the `SymbolSpec` structure, prefix the word 'Default' to the graphics property name.

DisplayType — Display type

'point' | 'multipoint' | 'line' | 'polygon' | 'image' | 'surface' | 'mesh' | 'texturemap' | 'contour'

Type of graphic display for the data, specified as the comma-separated pair consisting of 'DisplayType' and one of the following values.

Data Type	Display Type	Type of Property
Vector	'point'	<i>line marker</i>
	'multipoint'	<i>line marker</i>
	'line'	<i>line</i>
	'polygon'	<i>patch</i>
Image	'image'	<i>surface</i>
Grid	'surface'	<i>surface</i>
	'mesh'	<i>surface</i>
	'texturemap'	<i>surface</i>
	'contour'	<i>contour</i>

Valid values of `DisplayType` depend on the format of the map data. For example, if the map data is a geolocated image or georeferenced image, then the only valid value of `DisplayType` is 'image'. Different display types support different geographic data class types:

Display Type	Supported Class Types
Image	logical, uint8, uint16, and double
Surface	single and double
Texture map	All numeric types and logical

Output Arguments

h — Parent axes

handle object | modified patch object

Parent axes, returned as a handle to a MATLAB graphics object or, in the case of polygons, a modified patch object. If a geostruct or shapefile name is input, `geoshow` returns the handle to an `hgroup` object with one child per feature in the geostruct or shapefile, excluding any features that are completely trimmed away. In the case of a polygon geostruct or shapefile, each child is a modified patch object; otherwise it is a line object.

Tips

- When calling `shaperead` to read files that contain coordinates in latitude and longitude, be sure to specify the `shaperead` argument pair 'UseGeoCoords', `true`. If you do not include this argument, `shaperead` will create a mapstruct, with coordinate fields labelled X and Y instead of Lon and Lat. In such cases, `geoshow` assumes that the geostruct is in fact a mapstruct containing

projected coordinates, warns, and calls `mapshow` to display the `geostruct` data without projecting it.

- If you do not want `geoshow` to draw on top of an existing map, create a new figure or subplot before calling it.
- When you display vector data in an `axesm`-based map using `geoshow`, you should not subsequently change the map projection using `setm`. You can, however, change the projection with `setm` for raster data. For more information, see “Change Map Projections Using `geoshow`”.
- If you display a polygon, do not set `'EdgeColor'` to either `'flat'` or `'interp'`. This combination may result in a warning.
- When projecting data onto an `axesm`-based map, `geoshow` uses the projection stored within the `axesm`-based map. When displaying on a regular axes, it constructs a default Plate Carrée projection with a scale factor of $180/\pi$, enabling direct readout of coordinates in degrees.
- When you pass two points to the `geoshow` function, the function projects the locations of each point on the map and displays a straight line that connects them, regardless of the map projection or the distance between the points. To display a projected geodesic or rhumbline curve between two points, first insert intermediate points using the `track2` function.
- `geoshow` can generally be substituted for `displaym`. However, there are limitations where display of specific objects is concerned. See the remarks under `updategeostruct` for further information.
- When you display raster data in a map using `geoshow`, columns near the eastern or western edge may fail to display. This is seldom noticeable, except when the raster is very coarse relative to the displayed area. To include additional columns in the display, it might help to:
 - Resize the grid to a finer mesh.
 - Make sure the cell boundaries and map limits align.
 - Expand the map limits.

Version History

Introduced before R2006a

R2021b: Display data from geospatial tables

The `geoshow` function accepts geospatial tables as input.

See Also

Functions

`axesm` | `makesymbolspec` | `mapshow` | `updategeostruct`

Objects

`GeographicCellsReference` | `GeographicPostingsReference`

Topics

“Create and Display Polygons”

geotable2table

Convert geospatial table to table

Syntax

```
T = geotable2table(GT)
T = geotable2table(GT,varnames)
```

Description

`T = geotable2table(GT)` converts the geospatial table `GT` to a table. The function replaces the objects in the `Shape` variable of `GT` with well-known text (WKT) string representations of geometry. The geospatial table and the table have the same dimensions.

`T = geotable2table(GT,varnames)` replaces the `Shape` variable with variables that have names specified by `varnames`.

Examples

Convert Geospatial Table to Table

Convert a geospatial table to a table, then write the data to an Excel® spreadsheet file.

Import a shapefile containing the coordinates of world cities as a geospatial table.

```
GT = readgeotable("worldcities.shp");
```

Find the coordinate reference system type. The coordinate reference system type helps you determine appropriate variable names for the table.

```
GT.Shape.CoordinateSystemType
```

```
ans =
"geographic"
```

Convert the geospatial table to a table. Replace the `Shape` variable with two variables containing coordinates by specifying the second argument as a two-element vector. The coordinate system is geographic, so use the variable names "Latitude" and "Longitude".

```
T = geotable2table(GT,["Latitude" "Longitude"]);
```

Write the table to an Excel spreadsheet file.

```
writetable(T,"worldcities.xlsx")
```

View WKT String Representations of Geometry

Import a shapefile containing a road network in Boston, MA, as a geospatial table. The `Shape` variable of the geospatial table contains `maplineshape` objects.

```
GT = readgeotable("boston_roads.shp");
class(GT.Shape)
```

```
ans =
'maplineshape'
```

Convert the geospatial table to a table. The `geotable2table` function replaces the objects in the `Shape` variable with WKT string representations of geometry.

```
T = geotable2table(GT);
```

View the WKT string for the road called `C STREET`.

```
wkt = T.Shape(T.STREETNAME == "C STREET")
```

```
wkt =
"LINestring (237527.171875 899661.1875,237343.875 899443.0625)"
```

Input Arguments

GT — Geospatial table

geospatial table

Geospatial table. A geospatial table is a `table` or `timetable` object with a `Shape` variable that contains `geopointshape`, `geolineshape`, `geopolyshape`, `mappointshape`, `maplineshape`, or `mappolyshape` objects. The `Shape` variable must be the first variable.

For more information about geospatial tables, see “Create Geospatial Tables”.

Data Types: `table`

varnames — Table variable names

string scalar | two-element string vector

Table variable names used to replace the `Shape` variable of the geospatial table, specified as a string scalar or two-element string vector.

- To replace the shape objects in the `Shape` variable with WKT string representations of geometry, specify `varnames` as a string scalar, such as `"WKTStrings"`. Unlike shape objects, WKT string representations of geometry do not contain information about the coordinate reference system.
- To replace the `Shape` variable with two table variables containing latitude and longitude coordinates or x- and y-coordinates, specify `varnames` as a two-element string vector, such as `["Latitude" "Longitude"]`.

The `geotable2table` function does not project or unproject coordinates. For more information about projecting or unprojecting coordinates, see `proj fwd` or `proj inv`.

Data Types: `string`

Output Arguments

T — Output table

table object | timetable object

Output table, returned as a `table` or `timetable` object.

- When you specify `varnames` as a string scalar, the output table contains WKT string representations of geometry.
- When you specify `varnames` as a two-element string vector, the output table contains latitude-longitude or *x*-*y* coordinates. If a table row represents an individual point, then the coordinates are returned as numeric scalars. Otherwise, the coordinates are returned as cell arrays of numeric vectors.

Data Types: `table`

Version History

Introduced in R2021b

See Also

Functions

`isgeotable` | `readgeotable` | `table2geotable` | `table2timetable` | `polyjoin`

map.geotiff.RPCCoefficientTag

Create a Rational Polynomial Coefficients Tag object

Syntax

```
rpctag = map.geotiff.RPCCoefficientTag
rpctag = map.geotiff.RPCCoefficientTag(tiffTagValue)
```

Description

`rpctag = map.geotiff.RPCCoefficientTag` creates a default `RPCCoefficientTag` object.

`rpctag = map.geotiff.RPCCoefficientTag(tiffTagValue)` creates an `RPCCoefficientTag` object and sets the property values to the corresponding values in the 92-element vector specified in `tiffTagValue`.

Examples

Create RPCCoefficientTag Object with Default Properties

Call the `RPCCoefficientTag` class constructor with no arguments.

```
rpctag = map.geotiff.RPCCoefficientTag
rpctag =
  RPCCoefficientTag with properties:
      BiasErrorInMeters: -1
      RandomErrorInMeters: -1
          LineOffset: 0
          SampleOffset: 0
      GeodeticLatitudeOffset: 0
      GeodeticLongitudeOffset: 0
      GeodeticHeightOffset: 0
          LineScale: 1
          SampleScale: 1
      GeodeticLatitudeScale: 1
      GeodeticLongitudeScale: 1
      GeodeticHeightScale: 1
      LineNumeratorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
      LineDenominatorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
      SampleNumeratorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
      SampleDenominatorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
```

Write Raw RPC Coefficient Metadata to GeoTIFF File

This example shows how to write RPC coefficient metadata to a TIFF file. In a real workflow, you would create the RPC coefficient metadata according to the TIFF extension specification. This


```

        BiasErrorInMeters: -1
        RandomErrorInMeters: -1
            LineOffset: 1
            SampleOffset: 1
        GeodeticLatitudeOffset: 0
        GeodeticLongitudeOffset: 0
        GeodeticHeightOffset: 0
            LineScale: 2
            SampleScale: 2
        GeodeticLatitudeScale: 1
        GeodeticLongitudeScale: 1
        GeodeticHeightScale: 500
    LineNumeratorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
    LineDenominatorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
    SampleNumeratorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
    SampleDenominatorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]

```

Pass the `RPCCoefficientTag` object to the `geotiffwrite` function and write the RPC metadata to a file.

```
geotiffwrite('myfile2',myimage,R,'RPCCoefficientTag',rpcdata)
```

To verify that the data was written to the file, read the RPC metadata from the TIFF file using `geotiffinfo`. Compare the returned RPC metadata with the metadata written to the test file.

```
ginfo = geotiffinfo('myfile2');
ginfo.GeoTIFFTags.RPCCoefficientTag
```

```
ans =
    RPCCoefficientTag with properties:
```

```

        BiasErrorInMeters: -1
        RandomErrorInMeters: -1
            LineOffset: 1
            SampleOffset: 1
        GeodeticLatitudeOffset: 0
        GeodeticLongitudeOffset: 0
        GeodeticHeightOffset: 0
            LineScale: 2
            SampleScale: 2
        GeodeticLatitudeScale: 1
        GeodeticLongitudeScale: 1
        GeodeticHeightScale: 500
    LineNumeratorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
    LineDenominatorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
    SampleNumeratorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
    SampleDenominatorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]

```

Input Arguments

tiffTagValue — Value of `RPCCoefficientTag` properties

92-element vector

Value of `RPCCoefficientTag` properties, specified as a 92-element vector.

Data Types: double

Version History

Introduced in R2015b

See Also

[RPCCoefficientTag](#) | [geotiffinfo](#) | [geotiffwrite](#) | [Tiff](#)

geotiff2mstruct

Convert GeoTIFF information to map projection structure

Syntax

```
mstruct = geotiff2mstruct(proj)
```

Description

`mstruct = geotiff2mstruct(proj)` converts the GeoTIFF projection structure, `proj`, to the map projection structure, `mstruct`. The unit of length of the `mstruct` projection is meter.

The GeoTIFF projection structure, `proj`, must reference a projected coordinate system, as indicated by a value of 'ModelTypeProjected' in the ModelType field. If ModelType has the value 'ModelTypeGeographic' then it doesn't make sense to convert to a map projection structure and an error is issued.

Examples

Verify that unprojecting coordinates using a GeoTIFF projection structure gives the same result as unprojecting them using a map projection structure.

To do this, first get the GeoTIFF projection structure of an image. Convert the corner map coordinates to latitude and longitude by calling `projinv` and specifying the GeoTIFF projection structure.

```
proj = geotiffinfo('boston.tif');
x = proj.CornerCoords.X;
y = proj.CornerCoords.Y;
[latProj,lonProj] = projinv(proj,x,y);
```

Get a map projection structure from the GeoTIFF projection structure using the `geotiff2mstruct` function. The length unit for map projection structures is meter, but the map coordinates are in survey feet. Therefore, convert the corner map coordinates from survey feet to meters. Then, unproject the corner coordinates by calling `projinv` and specifying the map projection structure.

```
mstruct = geotiff2mstruct(proj);
xsf = unitsratio('meter','sf') * x;
ysf = unitsratio('meter','sf') * y;
[latMstruct,lonMstruct] = projinv(mstruct,xsf,ysf);
```

Verify the values are within a tolerance of each other.

```
abs(latProj - latMstruct) <= 1e-7
abs(lonProj - lonMstruct) <= 1e-7
```

```
ans =
     1     1     1     1
```

```
ans =  
    1    1    1    1
```

Version History

Introduced before R2006a

See Also

[axesm](#) | [defaultm](#) | [geotiffinfo](#) | [projfwd](#) | [projinv](#) | [projlist](#)

geotiffinfo

Information about GeoTIFF file

Syntax

```
info = geotiffinfo(filename)
info = geotiffinfo(url)
```

Description

`info = geotiffinfo(filename)` returns a structure whose fields contain image properties and cartographic information about a GeoTIFF file.

`info = geotiffinfo(url)` reads the GeoTIFF image from a URL.

Examples

Return Information about GeoTIFF File

Return information about a GeoTIFF file as a structure by using the `geotiffinfo` function.

```
info = geotiffinfo('boston.tif')
```

`info = struct with fields:`

```

    Filename: 'C:\TEMP\Bdoc23a_2213998_3568\ib570499\16\tpe5117a7d\map-ex98657947\boston.tif'
    FileModDate: '13-May-2011 22:28:45'
    FileSize: 38729900
    Format: 'tif'
    FormatVersion: []
    Height: 2881
    Width: 4481
    BitDepth: 8
    ColorType: 'truecolor'
    ModelType: 'ModelTypeProjected'
    PCS: 'NAD83 / Massachusetts Mainland'
    Projection: 'SPCS83 Massachusetts Mainland zone (meters)'
    MapSys: 'STATE_PLANE_83'
    Zone: 2001
    CTProjection: 'CT_LambertConfConic_2SP'
    ProjParm: [7x1 double]
    ProjParmId: {7x1 cell}
    GCS: 'NAD83'
    Datum: 'North American Datum 1983'
    Ellipsoid: 'GRS 1980'
    SemiMajor: 6378137
    SemiMinor: 6.3568e+06
    PM: 'Greenwich'
    PMLongToGreenwich: 0
    UOMLength: 'US survey foot'
    UOMLengthInMeters: 0.3048
    UOMAngle: 'degree'
```

```
UOMAngleInDegrees: 1
  TiePoints: [1x1 struct]
  PixelScale: [3x1 double]
  SpatialRef: [1x1 map.rasterref.MapCellsReference]
  RefMatrix: [3x2 double]
  BoundingBox: [2x2 double]
  CornerCoords: [1x1 struct]
  GeoTIFFCodes: [1x1 struct]
  GeoTIFFTags: [1x1 struct]
  ImageDescription: '"GeoEye"'
```

Find Coordinate Reference System for GeoTIFF File

Find the projected coordinate reference system (CRS) for the `boston.tif` file.

Read information about the file as a structure array. Then, query the `ProjectedCRS` property of the raster reference object within the `SpatialRef` field of the structure array.

```
info = geotiffinfo("boston.tif");
crs = info.SpatialRef.ProjectedCRS

crs =
  projcrs with properties:
      Name: "NAD83 / Massachusetts Mainland"
      GeographicCRS: [1x1 geocrs]
      ProjectionMethod: "Lambert Conic Conformal (2SP)"
      LengthUnit: "U.S. survey foot"
      ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

If your file is referenced to a geographic CRS, then query the `GeographicCRS` property instead of the `ProjectedCRS` property.

Input Arguments

filename — Name of GeoTIFF file

character vector

Name of the GeoTIFF file, specified as a character vector. Include the folder name in `filename` or place the file in the current folder or in a folder on the MATLAB path. If the named file includes the extension `.TIF` or `.TIFF` (either upper- or lowercase), you can omit the extension from `filename`.

If the named file contains multiple GeoTIFF images, `info` is a structure array with one element for each image in the file. For example, `info(3)` would contain information about the third image in the file. If multiple images exist in the file, it is assumed that each image has the same cartographic information and image width and height.

url — Internet URL

character vector

Internet URL, specified as a character vector. The URL must include the protocol type (e.g., "http://").

Output Arguments

info — Image properties and cartographic information about a GeoTIFF file

structure

Image properties and cartographic information about a GeoTIFF file, returned as a structure containing the following fields.

Field	Description
Filename	Name of the file or URL
FileModDate	Modification date of the file
FileSize	Integer indicating the size of the file in bytes.
Format	File format (always 'tiff')
FormatVersion	File format version
Height	Integer indicating the height of the image in pixels
Width	Integer indicating the width of the image in pixels
BitDepth	Integer indicating the number of bits per pixel
ColorType	Type of image: 'truecolor' for a true-color (RGB) image, 'grayscale' for a grayscale image, or 'indexed' for an indexed image.
ModelType	Type of coordinate system used to georeference the image: 'ModelTypeProjected', 'ModelTypeGeographic', 'ModelTypeGeocentric', or ''.
PCS	Projected coordinate system
Projection	EPSG identifier for the underlying projection method
MapSys	Map system, if applicable: 'STATE_PLANE_27', 'STATE_PLANE_83', 'UTM_NORTH', 'UTM_SOUTH', or ''
Zone	double indicating the UTM or State Plane Zone number, empty ([]) if not applicable or unknown
CTProjection	GeoTIFF identifier for the underlying projection method
ProjParm	N-by-1 double vector containing projection parameter values. The identity of each element is specified by the corresponding element of ProjParmId. Lengths are in meters, angles in decimal degrees.

Field	Description
ProjParmId	<p>N-by-1 cell array listing the projection parameter identifier for each corresponding numerical element of ProjParm:</p> <ul style="list-style-type: none"> • 'ProjNatOriginLatGeoKey' • 'ProjNatOriginLongGeoKey' • 'ProjFalseEastingGeoKey' • 'ProjFalseNorthingGeoKey' • 'ProjFalseOriginLatGeoKey' • 'ProjFalseOriginLongGeoKey' • 'ProjCenterLatGeoKey' • 'ProjCenterLongGeoKey' • 'ProjAzimuthAngleGeoKey' • 'ProjRectifiedGridAngleGeoKey' • 'ProjScaleAtNatOriginGeoKey' • 'ProjStdParallel1GeoKey' • 'ProjStdParallel2GeoKey'
GCS	Geographic coordinate system
Datum	Projection datum type, such as 'North American Datum 1927' or 'North American Datum 1983'
Ellipsoid	Name of the ellipsoid, returned as a character vector.
SemiMajor	double indicating the length of the semimajor axis of the ellipsoid, in meters
SemiMinor	double indicating the length of the semiminor axis of the ellipsoid, in meters
PM	Prime meridian location, for example, 'Greenwich' or 'Paris'
PmLongToGreenwich	double indicating the decimal degrees of longitude between this prime meridian and Greenwich. Prime meridians to the west of Greenwich are negative.
UOMLength	Units of length used in the projected coordinate system
UOMLengthInMeters	double defining the UOMLength unit in meters.
UOMAngle	Angular units used for geographic coordinates
UOMAngleInDegrees	double defining the UOMAngle unit in degrees.

Field	Description						
TiePoints	Structure containing the image tiepoints. The structure contains these fields: <table border="1" data-bbox="553 386 1474 961"> <thead> <tr> <th>Field Name</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>ImagePoints</td> <td>Structure containing row and column coordinates of each image tiepoint. The ImagePoints structure contains these fields: <ul style="list-style-type: none"> Row — double array of size 1-by-N Col — double array of size 1-by-N </td> </tr> <tr> <td>WorldPoints</td> <td>Structure containing the x and y world coordinates of the tiepoints. The WorldPoints structure contains these fields: <ul style="list-style-type: none"> X — double array of size 1-by-N Y — double array of size 1-by-N </td> </tr> </tbody> </table>	Field Name	Description	ImagePoints	Structure containing row and column coordinates of each image tiepoint. The ImagePoints structure contains these fields: <ul style="list-style-type: none"> Row — double array of size 1-by-N Col — double array of size 1-by-N 	WorldPoints	Structure containing the x and y world coordinates of the tiepoints. The WorldPoints structure contains these fields: <ul style="list-style-type: none"> X — double array of size 1-by-N Y — double array of size 1-by-N
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PixelScale	3-by-1 double array that specifies the X, Y, Z pixel scale values.						
SpatialRef	Value depends on the value of the ModelType field: <ul style="list-style-type: none"> 'ModelTypeProjected' — SpatialRef is a MapCellsReference or MapPostingsReference object. 'ModelTypeGeographic' — SpatialRef is a GeographicCellsReference or GeographicPostingsReference object, unless the geometric transformation is affine, in which case it is empty ([]). 'ModelTypeGeocentric' — SpatialRef is empty ([]). Empty ([]) — geotiffinfo issues a warning and SpatialRef is a map raster reference object. <p>If the spatial referencing is ambiguously defined by the GeoTIFF file, then SpatialRef is empty ([]).</p>						
RefMatrix	3-by-2 double referencing matrix that must be unambiguously defined by the GeoTIFF file. Otherwise it is empty ([]).						
BoundingBox	2-by-2 double array that specifies the minimum (row 1) and maximum (row 2) values for each dimension of the image data in the GeoTIFF file.						

Field	Description														
CornerCoords	Structure with six fields that contains coordinates of the outer corners of the GeoTIFF image. Each field is a 1-by-4 double array, or empty ([]) if unknown. The arrays contain the coordinates of the outer corners of the corner pixels, starting from the (1,1) corner and proceeding clockwise:														
	<table border="1"> <thead> <tr> <th>Field</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>Easting coordinates in the projected coordinate system. X equals Lon (below) if <i>ModelType</i> is 'ModelTypeGeographic'</td> </tr> <tr> <td>Y</td> <td>Northing coordinates in the projected coordinate system. Y equals Lat (below) if <i>ModelType</i> is 'ModelTypeGeographic'</td> </tr> <tr> <td>Row</td> <td>Row coordinates of the corner.</td> </tr> <tr> <td>Col</td> <td>Column coordinates of the corner.</td> </tr> <tr> <td>Lat</td> <td>Latitudes of the corner.</td> </tr> <tr> <td>Lon</td> <td>Longitudes of the corner.</td> </tr> </tbody> </table>	Field	Description	X	Easting coordinates in the projected coordinate system. X equals Lon (below) if <i>ModelType</i> is 'ModelTypeGeographic'	Y	Northing coordinates in the projected coordinate system. Y equals Lat (below) if <i>ModelType</i> is 'ModelTypeGeographic'	Row	Row coordinates of the corner.	Col	Column coordinates of the corner.	Lat	Latitudes of the corner.	Lon	Longitudes of the corner.
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Row	Row coordinates of the corner.														
Col	Column coordinates of the corner.														
Lat	Latitudes of the corner.														
Lon	Longitudes of the corner.														
GeoTIFFCodes	<p>Structure containing raw numeric values for those GeoTIFF fields that are encoded numerically in the file. These raw values, converted to a character vectors elsewhere in the <i>info</i> structure, are provided here for reference.</p> <ul style="list-style-type: none"> • Model • PCS • GCS • UOMLength • UOMAngle • Datum • PM • Ellipsoid • ProjCode • Projection • CTProjection • ProjParmId • MapSys <p>Each is scalar, except for ProjParmId, which is a column vector.</p>														

Field	Description																
GeoTIFFTags	Structure containing field names that match the GeoTIFF tags in the file. At least one GeoTIFF tag must be present in the file or an error is issued. The following fields may be included: <table border="1" data-bbox="553 415 1474 751"> <thead> <tr> <th>Field</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>ModelPixelScaleTag</td> <td>1-by-3 double</td> </tr> <tr> <td>ModelTiepointTag</td> <td>1-by-6 double</td> </tr> <tr> <td>ModelTransformationTag</td> <td>1-by-16 double</td> </tr> <tr> <td>GeoKeyDirectoryTag</td> <td>scalar structure</td> </tr> <tr> <td>GeoAsciiParamsTag</td> <td>character vector</td> </tr> <tr> <td>GeoDoubleParamsTag</td> <td>1-by-N double</td> </tr> <tr> <td>RPCCoefficientTag</td> <td>scalar RPCCoefficientTag</td> </tr> </tbody> </table> <p>The <code>GeoKeyDirectoryTag</code> contains field names that match the names of the "GeoKeys". For more information about the "GeoKeys" refer to the GeoTIFF specification.</p> <p>The <code>RPCCoefficientTag</code> contains properties with names corresponding to the tag elements listed in the RPCs in GeoTIFF technical note at: http://geotiff.maptools.org/rpc_prop.html</p>	Field	Value	ModelPixelScaleTag	1-by-3 double	ModelTiepointTag	1-by-6 double	ModelTransformationTag	1-by-16 double	GeoKeyDirectoryTag	scalar structure	GeoAsciiParamsTag	character vector	GeoDoubleParamsTag	1-by-N double	RPCCoefficientTag	scalar RPCCoefficientTag
Field	Value																
ModelPixelScaleTag	1-by-3 double																
ModelTiepointTag	1-by-6 double																
ModelTransformationTag	1-by-16 double																
GeoKeyDirectoryTag	scalar structure																
GeoAsciiParamsTag	character vector																
GeoDoubleParamsTag	1-by-N double																
RPCCoefficientTag	scalar RPCCoefficientTag																
ImageDescription	Description of the image. If no description is included in the file, the field is omitted.																

Version History

Introduced before R2006a

R2022a: Read coordinate reference system for GeoTIFF files

The `geotiffinfo` function reads the projected or geographic coordinate reference system (CRS) for GeoTIFF files as a `projcrs` or `geocrs` object, respectively.

To find the CRS, get information about the GeoTIFF file using the `geotiffinfo` function, returned as a structure array. Then, query the CRS property of the raster reference object within the `SpatialRef` field of the structure array. If the file is referenced to a projected CRS, query the `ProjectedCRS` property. If the file is referenced to a geographic CRS, query the `GeographicCRS` property. This code snippet shows how to get the CRS of the `boston.tif` file, which is referenced to a projected CRS.

```
info = geotiffinfo("boston.tif");
crs = info.SpatialRef.ProjectedCRS
```

```
crs =
```

```
projcrs with properties:
```

```
    Name: "NAD83 / Massachusetts Mainland"
    GeographicCRS: [1x1 geocrs]
```

```
ProjectionMethod: "Lambert Conic Conformal (2SP)"  
LengthUnit: "U.S. survey foot"  
ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

See Also

Functions

georasterinfo | readgeoraster | geotiffwrite | projinv | projfwd

Objects

RPCCoefficientTag

geotiffread

(Not recommended) Read GeoTIFF file

Note `geotiffread` is not recommended, except when reading a GeoTIFF file from a URL or when reading multiple images from the same file. In other situations, use `readgeoraster` instead. For more information, see “Compatibility Considerations”.

Syntax

```
[A,R] = geotiffread(filename)
[X,cmap,R] = geotiffread(filename)
[A,refmat,bbox] = geotiffread(filename)
[X,cmap,refmat,bbox] = geotiffread(filename)
[___] = geotiffread(url)
[___] = geotiffread( ___,idx)
```

Description

`[A,R] = geotiffread(filename)` reads a georeferenced grayscale, RGB, or multispectral image or data grid from the GeoTIFF file specified by `filename` into `A` and creates a spatial referencing object, `R`.

`[X,cmap,R] = geotiffread(filename)` reads an indexed image into `X` and the associated colormap into `cmap`, and creates a spatial referencing object, `R`.

`[A,refmat,bbox] = geotiffread(filename)` reads a georeferenced grayscale, RGB, or multispectral image or data grid into `A`, the corresponding referencing matrix into `refmat`, and the bounding box into `bbox`.

`[X,cmap,refmat,bbox] = geotiffread(filename)` reads an indexed image into `X`, the associated colormap into `cmap`, the referencing matrix into `refmat`, and the bounding box into `bbox`. The referencing matrix must be unambiguously defined by the GeoTIFF file, otherwise it and the bounding box are returned empty.

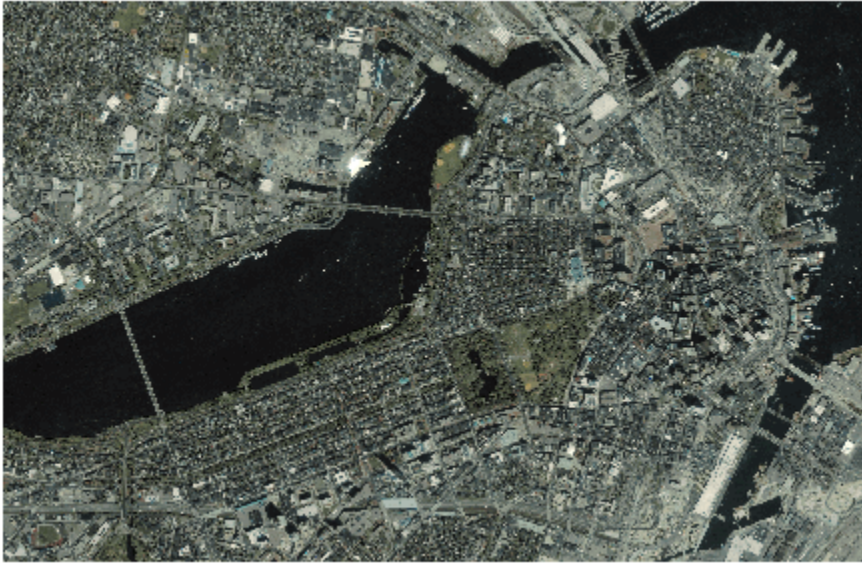
`[___] = geotiffread(url)` reads the GeoTIFF image from a URL.

`[___] = geotiffread(___,idx)` reads one image from a multi-image GeoTIFF file or URL.

Examples

Read and Display the Boston GeoTIFF Image

```
[boston,R] = geotiffread('boston.tif');
figure
mapshow(boston,R);
axis image off
```



boston.tif copyright © GeoEye™, all rights reserved.

Input Arguments

filename — Name of GeoTIFF file

character vector | string scalar

Name of the GeoTIFF file, specified as a string scalar or character vector. Include the folder name in `filename` or place the file in the current folder or in a folder on the MATLAB path. If the named file includes the extension `.TIF` or `.TIFF` (either upper- or lowercase), you can omit the extension from `filename`.

idx — Index of image in GeoTIFF file

1 (default) | positive integer

Index of image in GeoTIFF file, specified as a positive integer. For example, if `idx` is 3, `geotiffread` reads the third image in the file. By default, `idx` indexes to the first image in the file.

url — Internet URL

character vector | scalar string

Internet URL, specified as a string scalar or character vector. The URL must include the protocol type (e.g., "https://").

Output Arguments

A — Georeferenced image or data grid

M -by- N numeric matrix | M -by- N -by- P numeric array

Georeferenced image or data grid, returned as one of the following:

- An M -by- N numeric matrix when the file contains a grayscale image or data grid

- An M -by- N -by- P numeric array when the file contains a color image, multispectral image, hyperspectral image, or data grid

The class of A depends on the storage class of the pixel data in the file, which is related to the `BitsPerSample` property as returned by the `imfinfo` function.

R — Spatial referencing object

geographic raster reference object | map raster reference object

Spatial referencing object, returned as one of the following.

- A geographic raster reference object of type `GeographicCellsReference` or `GeographicPostingsReference`. This object is returned when the image or data grid is referenced to a geographic coordinate system.
- A map raster reference object of type `MapCellsReference` or `MapPostingsReference`. This object is returned when the image or data grid is referenced to a projected coordinate system.

X — Indexed image

M -by- N numeric matrix

Indexed image, returned as an M -by- N numeric matrix.

cmap — Color map

c -by-3 numeric matrix

Color map associated with indexed image X , specified as an c -by-3 numeric matrix. There are c colors in the color map, each represented by a red, green, and blue pixel value. Colormap values are rescaled into the range $[0,1]$.

refmat — Referencing matrix

3-by-2 numeric matrix | []

Referencing matrix, returned as 3-by-2 numeric matrix that transforms raster row and column indices to or from geographic coordinates according to:

$$[\text{lon } \text{lat}] = [\text{row } \text{col } 1] * \text{refmat}$$

`refmat` defines a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. `refmat` must be unambiguously defined by the GeoTIFF file, otherwise it and the bounding box, `bbox`, are returned empty.

Data Types: `double`

bbox — Bounding box

2-by-2 numeric matrix | []

Bounding box, returned as a 2-by-2 numeric matrix that specifies the minimum (row 1) and maximum (row 2) values for each dimension of the image data in the GeoTIFF file. `bbox` is returned empty if `refmat` is ambiguously defined by the GeoTIFF file.

Data Types: `double`

Tips

- `geotiffread` imports pixel data using the TIFF-reading capabilities of the MATLAB function `imread` and likewise shares any limitations of `imread`. Consult the `imread` documentation for information on TIFF image support.

Version History

Introduced before R2006a

R2020a: `geotiffread` is not recommended

Not recommended starting in R2020a

`geotiffread` is not recommended, except when reading a GeoTIFF file from a URL or when reading multiple images from the same file. In other situations, use `readgeoraster` instead. There are no plans to remove `geotiffread`.

Unlike `geotiffread`, which returns a referencing matrix in some cases, the `readgeoraster` function returns a raster reference object. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns. For examples of reference object properties, see `GeographicCellsReference` and `MapPostingsReference`.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` or `mapcrop` functions.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` or `mapresize` functions.

This table shows some typical usages of `geotiffread` and how to update your code to use `readgeoraster` instead. Unlike `geotiffread`, the `readgeoraster` function requires you to specify a file extension. For example, use `[Z,R] = readgeoraster('boston.tif')`.

Not Recommended	Recommended
<code>[A,R] = geotiffread(filename);</code>	<code>[A,R] = readgeoraster(filename);</code>
<code>[X,cmap,R] = geotiffread(filename);</code>	<code>[X,R,cmap] = readgeoraster(filename);</code>
<code>[A,refmat,bbox] = geotiffread(filename);</code>	<code>[A,R] = readgeoraster(filename);</code> <code>xlimits = R.XWorldLimits;</code> <code>ylimits = R.YWorldLimits;</code> <code>bbox = [xlimits' ylimits'];</code>

See Also

`geoshow` | `geotiffinfo` | `geotiffwrite` | `imread` | `mapshow` | `readgeoraster`

geotiffwrite

Write GeoTIFF file

Syntax

```
geotiffwrite(filename,A,R)
geotiffwrite(filename,X,cmap,R)
geotiffwrite( ____,Name,Value)
```

Description

`geotiffwrite(filename,A,R)` writes a georeferenced image or data grid, `A`, spatially referenced by `R`, into an output file, `filename`.

`geotiffwrite(filename,X,cmap,R)` writes the indexed image in `X` and its associated colormap, `cmap`, to `filename`. `X` is spatially referenced by `R`.

`geotiffwrite(____,Name,Value)` writes an image or data grid with one or more `Name,Value` pair arguments that control various characteristics of the output file.

Examples

Write Image from JPEG File to GeoTIFF File

Read a JPEG image from a file.

```
basename = "boston_ovr";
imagefile = basename + ".jpg";
RGB = imread(imagefile);
```

Derive the world file name from image file name, read the world file, and create a reference object.

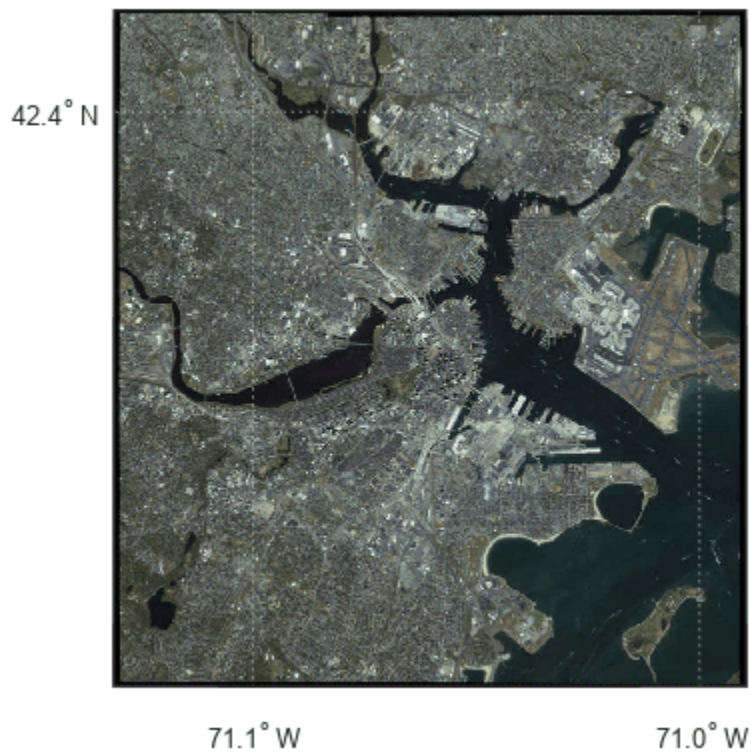
```
worldfile = getworldfilename(imagefile);
R = worldfileread(worldfile,"geographic",size(RGB));
```

Write the image data and reference object to a GeoTIFF file.

```
filename = basename + ".tif";
geotiffwrite(filename, RGB, R)
```

Create a map and display the data from the file.

```
figure
usamap(RGB,R)
geoshow(filename)
```



Convert Classic TIFF to Tiled BigTIFF

Convert a georeferenced classic TIFF file to a tiled BigTIFF file by extracting information from the classic TIFF file. First, import a classic TIFF image of Boston and a map cells reference object. Get metadata from the file using `geotiffinfo`.

```
infilename = 'boston.tif';  
[A,R] = readgeoraster(infilename);  
info = geotiffinfo(infilename);
```

Specify tags to include in the tiled BigTIFF file. To do this, extract the GeoKey directory tag from the metadata. Then, create tags specifying the length and width of the tiles.

```
geoTags = info.GeoTIFFTags.GeoKeyDirectoryTag;  
tiffTags = struct('TileLength',1024,'TileWidth',1024);
```

Write the data to a new GeoTIFF file. Specify the file format as BigTIFF using the 'TiffType' name-value pair. Include tags by specifying the 'GeoKeyDirectoryTag' and 'TiffTags' name-value pairs.

```
outfilename = 'boston_bigtiff.tif';  
geotiffwrite(outfilename,A,R,'TiffType','bigtiff', ...  
             'GeoKeyDirectoryTag',geoTags, ...  
             'TiffTags',tiffTags)
```

Verify you have written the BigTIFF file by reading the file and querying the tags.

```
biginfo = geotiffinfo(outfilename);
biginfo.GeoTIFFTags.GeoKeyDirectoryTag

ans = struct with fields:
    GTModelTypeGeoKey: 1
    GTRasterTypeGeoKey: 1
    ProjectedCSTypeGeoKey: 26986
    PCSCitationGeoKey: 'State Plane Zone 2001 NAD = 83'
    ProjLinearUnitsGeoKey: 9003

t = Tiff(outfilename);
getTag(t, 'TileLength')

ans = 1024

getTag(t, 'TileWidth')

ans = 1024

close(t)
```

Write WMS Image to GeoTIFF File

Read data from WMS server.

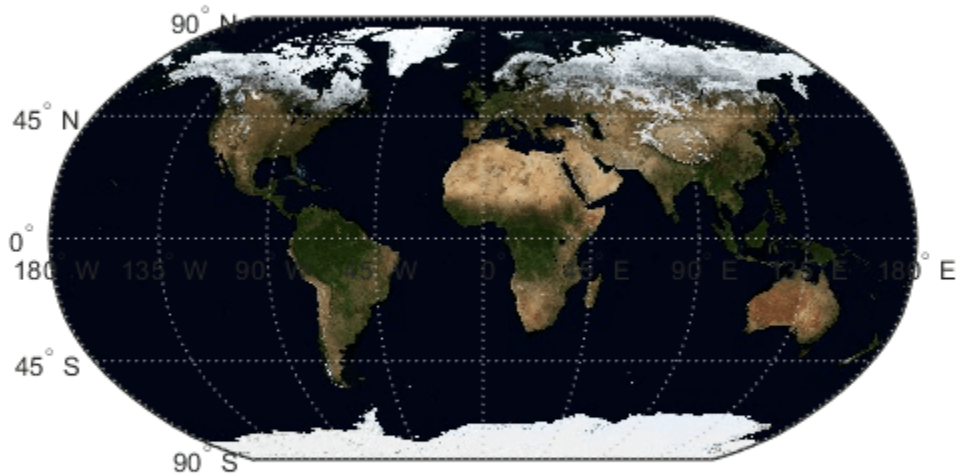
```
nasaLayers = wmsfind('nasa', 'SearchField', 'serverurl');
layerName = 'bluemarbleng';
layer = refine(nasaLayers, layerName, 'SearchField', 'layername', ...
    'MatchType', 'exact');
[A, R] = wmsread(layer(1));
```

Write data to GeoTIFF file.

```
filename = [layerName '.tif'];
geotiffwrite(filename, A, R)
```

View data in file.

```
figure
worldmap world
geoshow(filename)
```



Write Concord Orthophotos to Single GeoTIFF File

Read the two adjacent orthophotos and combine them.

```
X_west = imread('concord_ortho_w.tif');
X_east = imread('concord_ortho_e.tif');
X = [X_west X_east];
```

Construct referencing objects for the orthophotos and for their combination.

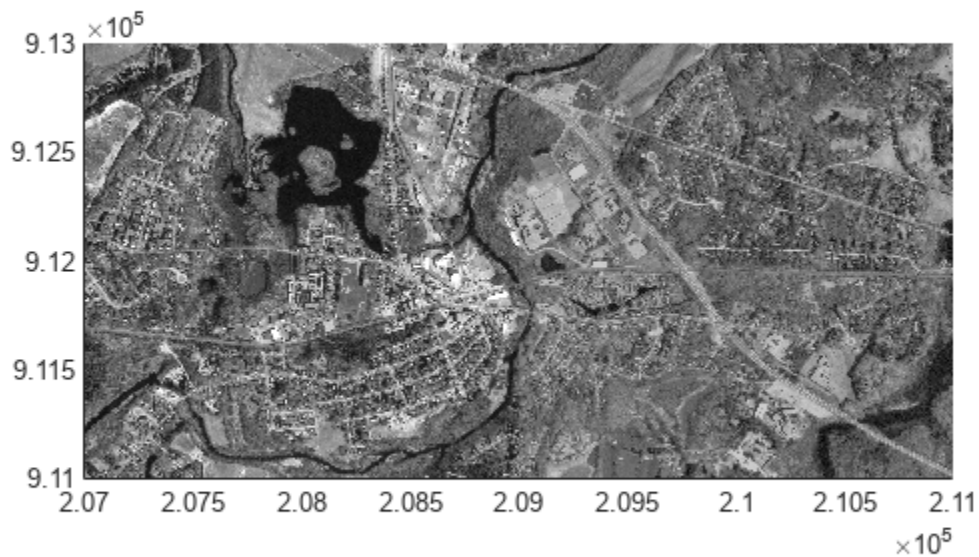
```
R_west = worldfileread('concord_ortho_w.tfw', 'planar', size(X_west));
R_east = worldfileread('concord_ortho_e.tfw', 'planar', size(X_east));
R = R_west;
R.XLimWorld = [R_west.XLimWorld(1) R_east.XLimWorld(2)];
R.RasterSize = size(X);
```

Write the combined image to a GeoTIFF file. Use the code number, 26986, indicating the PCS_NAD83_Massachusetts Projected Coordinate System.

```
coordRefSysCode = 26986;
filename = 'concord_ortho.tif';
geotiffwrite(filename, X, R, 'CoordRefSysCode', coordRefSysCode);
```

Display the map.

```
figure
mapshow(filename)
```



Write Subset of GeoTIFF File to New GeoTIFF File

Import a GeoTIFF image and map cells reference object for an area around Boston using `readgeoraster`.

```
[A,RA] = readgeoraster('boston.tif');
```

Crop the data to the limits specified by `xlimits` and `ylimits` using `mapcrop`.

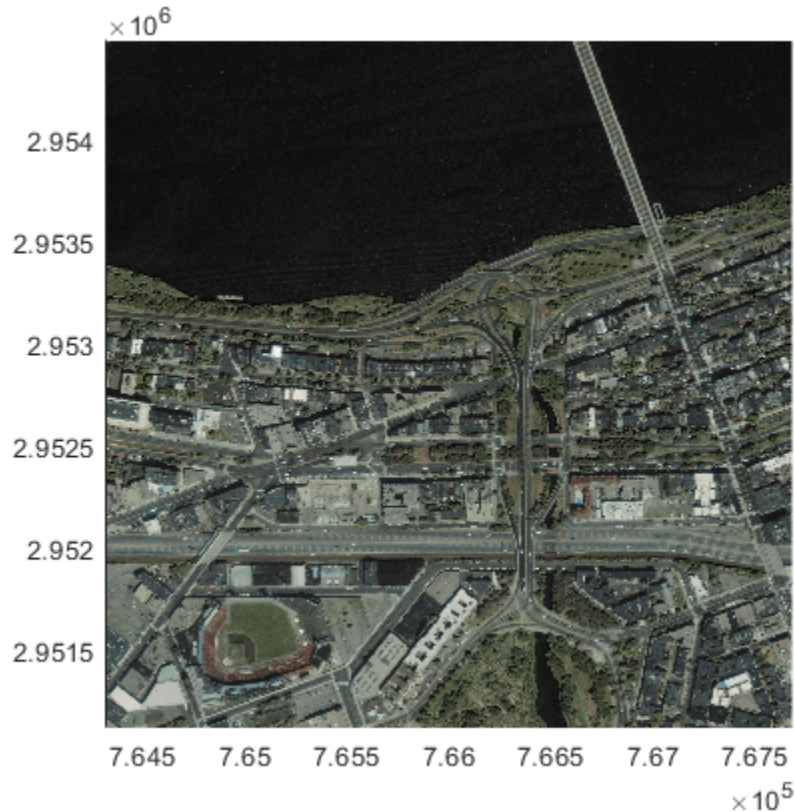
```
xlimits = [764318 767678];
ylimits = [2951122 2954482];
[B,RB] = mapcrop(A,RA,xlimits,ylimits);
```

Get information about the GeoTIFF image using `geotiffinfo`. Extract the GeoKey directory tag from the information.

```
info = geotiffinfo('boston.tif');
key = info.GeoTIFFTags.GeoKeyDirectoryTag;
```

Write the cropped data and GeoKey directory tag to a file. Verify the cropped data has been written to a file by displaying it.

```
filename = 'boston_subimage.tif';
geotiffwrite(filename,B,RB,'GeoKeyDirectoryTag',key)
figure
mapshow(filename)
```



Write Elevation Data to GeoTIFF File

Write elevation data for an area around South Boulder Peak in Colorado to a GeoTIFF file. First, import the elevation data and a geographic postings reference object.

```
[Z,R] = readgeoraster('n39_w106_3arc_v2.dt1','OutputType','double');
```

Specify GeoKey directory tag information for the GeoTIFF file as a structure. Indicate the data is in a geographic coordinate system by specifying the `GTModelTypeGeoKey` field as 2. Indicate that the reference object uses postings (rather than cells) by specifying the `GTRasterTypeGeoKey` field as 2. Indicate the data is referenced to a geographic coordinate reference system by specifying the `GeographicTypeGeoKey` field as 4326.

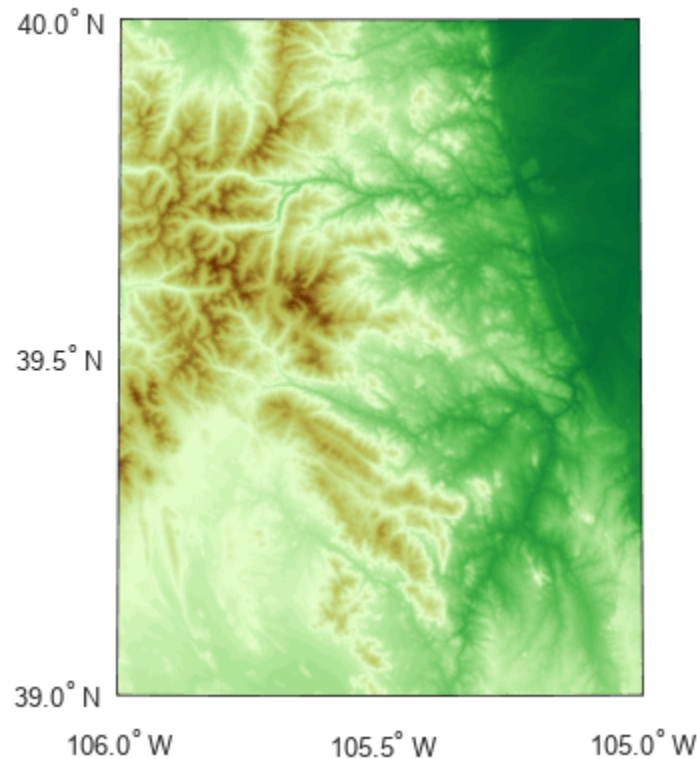
```
key.GTModelTypeGeoKey = 2;
key.GTRasterTypeGeoKey = 2;
key.GeographicTypeGeoKey = 4326;
```

Write the data and GeoKey directory tag to a file.


```
filename = 'southboulder.tif';
geotiffwrite(filename,Z,R,'GeoKeyDirectoryTag',key)
```

Verify the data has been written to a file by displaying it on a map.

```
usamap([39 40],[-106 -105])
g = geoshow(filename,'DisplayType','mesh');
demcmap(g.CData)
```



The elevation data used in this example is courtesy of the US Geological Survey.

Write TIFF File Containing RPC Metadata

Create a sample TIFF file with RPC metadata. To do this, create an array of zeros and an associated reference object.

```
A = zeros(180,360);
latlim = [-90 90];
lonlim = [-180 180];
RA = georefcells(latlim,lonlim,size(A));
```

Then, create an `RPCCoefficientTag` metadata object and set some fields with typical values. The `RPCCoefficientTag` object represents RPC metadata in a readable form.

```
rpctag = map.geotiff.RPCCoefficientTag;
rpctag.LineOffset = 1;
```

```
rpctag.SampleOffset = 1;
rpctag.LineScale = 2;
rpctag.SampleScale = 2;
rpctag.GeodeticHeightScale = 500;
```

Write the image, the associated referencing object, and the RPCCoefficientTag object to a file.

```
geotiffwrite('myfile',A,RA,'RPCCoefficientTag',rpctag)
```

Write Raw RPC Coefficient Metadata to GeoTIFF File

This example shows how to write RPC coefficient metadata to a TIFF file. In a real workflow, you would create the RPC coefficient metadata according to the TIFF extension specification. This example does not show the specifics of how to create valid RPC metadata. To simulate raw RPC metadata, the example creates a sample TIFF file with RPC metadata and then uses `imfinfo` to read this RPC metadata in raw, unprocessed form from the file. The example then writes this raw RPC metadata to a file using the `geotiffwrite` function.

Create Raw RPC Coefficient Metadata

To simulate raw RPC metadata, create a simple test file and write some RPC metadata to the file. For this test file, create a toy image and a referencing object associated with the image.

```
myimage = zeros(180,360);
latlim = [-90 90];
lonlim = [-180 180];
R = georefcells(latlim,lonlim,size(myimage));
```

Create an RPCCoefficientTag metadata object and set some of the fields. The toolbox uses the RPCCoefficientTag object to represent RPC metadata in human readable form.

```
rpctag = map.geotiff.RPCCoefficientTag;
rpctag.LineOffset = 1;
rpctag.SampleOffset = 1;
rpctag.LineScale = 2;
rpctag.SampleScale = 2;
rpctag.GeodeticHeightScale = 500;
```

Write the image, the associated referencing object, and the RPCCoefficientTag object to a file.

```
geotiffwrite('myfile',myimage,R,'RPCCoefficientTag',rpctag)
```

Read Raw RPC Coefficient Metadata

Read the RPC coefficient metadata from the test file using the `imfinfo` function. When it encounters unfamiliar metadata, `imfinfo` returns the data, unprocessed, in the `UnknownTags` field. Note that the `UnknownTags` field contains an array of 92 doubles. This is the raw RPC coefficient metadata, read from the file in unprocessed form.

```
info = imfinfo('myfile.tif');
info.UnknownTags

ans = struct with fields:
    ID: 50844
    Offset: 10676
```



```

        SampleScale: 2
    GeodeticLatitudeScale: 1
    GeodeticLongitudeScale: 1
        GeodeticHeightScale: 500
    LineNumeratorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
    LineDenominatorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
    SampleNumeratorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
    SampleDenominatorCoefficients: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]

```

Input Arguments

filename — Name and location of output file

character vector | string scalar

Name and location of output file, specified as a string scalar or character vector. If your `filename` includes an extension, it must be `'.tif'` or `'.TIF'`. If the input, `A`, is at least 160-by-160 in size, the output file is a tiled GeoTIFF file. Otherwise, `geotiffwrite` organizes the output file as rows-per-strip.

Data Types: `char` | `string`

A — Georeferenced image or data grid

M-by-*N* numeric matrix | *M*-by-*N*-by-*P* numeric array

Georeferenced image or data grid, specified as one of the following:

- An *M*-by-*N* numeric matrix representing a grayscale image or data grid
- An *M*-by-*N*-by-*P* numeric array representing a color image, multispectral image, hyperspectral image, or data grid

The coordinates of `A` are geographic and in the 'WGS 84' coordinate system, unless you specify 'GeoKeyDirectoryTag' or 'CoordRefSysCode' and indicate a different coordinate system.

Data Types: `double` | `single` | `uint8` | `uint16` | `uint32` | `uint64` | `int8` | `int16` | `int32` | `int64` | `logical`

R — Spatial referencing information

geographic raster reference object | map raster reference object

Spatial referencing information, specified as a geographic raster reference object of type `GeographicCellsReference` or `GeographicPostingsReference` or a map raster reference object of type `MapCellsReference` or `MapPostingsReference`.

If you are working with image coordinates in a projected coordinate system and `R` is a map raster reference object, specify 'GeoKeyDirectoryTag' or 'CoordRefSysCode' accordingly.

The `geotiffwrite` function does not use information contained in the `GeographicCRS` property of geographic raster reference objects or the `ProjectedCRS` property of map raster reference objects.

X — Indexed image

M-by-*N* numeric matrix

Indexed image data, specified as an *M*-by-*N* numeric matrix.

Data Types: `uint8` | `uint16`

cmap — Color map*c*-by-3 numeric matrix

Color map associated with indexed image *X*, specified as an *c*-by-3 numeric matrix. There are *c* colors in the color map, each represented by a red, green, and blue pixel value.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `'CoordRefSysCode', 26986`

CoordRefSysCode — Coordinate reference system code

4326 (default) | positive integer | string scalar | character vector

Coordinate reference system code for the coordinates of the data, specified as the comma-separated pair consisting of `'CoordRefSysCode'` and a positive integer, string scalar, or character vector. You can specify coordinates in either a geographic or a projected coordinate system. If you specify the coordinate system with a string scalar or character vector, include the `'EPSG: '` prefix. To find code numbers, see the EPSG registry or the GeoTIFF specification in the “Tips” on page 1-738 section.

If you specify both the `GeoKeyDirectoryTag` and the `CoordRefSysCode`, the coordinate system code in `CoordRefSysCode` takes precedence over the coordinate system key found in the `GeoKeyDirectoryTag`. If one value specifies a geographic coordinate system and the other value specifies a projected coordinate system, you receive an error.

If you do not specify a value for this argument, the default value is 4326, indicating that the coordinates are geographic and in the `'WGS 84'` geographic coordinate system.

Example: 26986

Example: `'EPSG:26986'`

GeoKeyDirectoryTag — GeoKey directory tag

structure

GeoKey directory tag, specified as the comma-separated pair consisting of `'GeoKeyDirectoryTag'` and a structure that specifies the GeoTIFF coordinate reference system and meta-information. The structure contains field names that match the GeoKey names in the GeoTIFF specification. The field names are case insensitive. The structure can be obtained from the GeoTIFF information structure, returned by `geotiffinfo`, in the field, `GeoTIFFTags.GeoKeyDirectoryTag`.

if you specify the `GTRasterTypeGeoKey` field, `geotiffwrite` ignores it. The value for this GeoKey is derived from `R`. If you set certain fields of the `GeoKeyDirectoryTag` to inconsistent settings, you receive an error message. For instance, if `R` is a geographic raster reference object and you specify a `ProjectedCSTypeGeoKey` field or set the `GTModelTypeGeoKey` field to 1 (projected coordinate system), you receive an error. Likewise, if `R` is a map raster reference object and you do not specify a `ProjectedCSTypeGeoKey` field or a `CoordRefSysCode`, or the `GTModelTypeGeoKey` field is set to 2 (geographic coordinate system), you receive an error message.

RPCCoefficientTag — Rational Polynomial Coefficients (RPC) tag

RPCCoefficientTag object

Values for the optional RPC TIFF tag, specified as the comma-separated pair consisting of 'RPCCoefficientTag' and an RPCCoefficientTag object.

TiffTags – TIFF tags

structure

Values for the TIFF tags in the output file, specified as the comma-separated pair consisting of 'TiffTags' and a structure. The field names of the structure match the TIFF tag names supported by the Tiff class. The field names are case insensitive.

You cannot set most TIFF tags using the structure input.

TiffTags Exceptions

BitsPerSample	SubFileType	GeoAsciiParamsTag
SampleFormat	SubIFD	GeoDoubleParamsTag
SamplesPerPixel	TileByteCounts	GeoKeyDirectoryTag
StripByteCounts	TileOffsets	ModelPixelScaleTag
StripOffsets	ImageLength	ModelTiepointTag
ColorMap	ImageWidth	ModelTransformationTag

The function sets several TIFF tags. The field names corresponding to the TIFF tag, their corresponding field values set by the function, their permissible values (if different from the Tiff class), and their data type are noted in the following table.

Automatic TIFF Tags

Field Name	Description
Compression	Type of image compression. The default is 'PackBits'. Other permissible values are 'LZW', 'Deflate', and 'none'. Numeric values, <code>Tiff.Compression.LZW</code> , <code>Tiff.Compression.PackBits</code> , <code>Tiff.Compression.Deflate</code> , or <code>Tiff.Compression.None</code> can also be used.
PhotometricInterpretation	Type of photometric interpretation. The field name can be shortened to <code>Photometric</code> . The value is set based on the input image characteristic, using the following algorithm: If A is [M-by-N-by-3] and is class type <code>uint8</code> or <code>uint16</code> , then the value is 'RGB'. For all other sizes and data types, the value is 'MinIsBlack'. If the X, CMAP syntax is supplied, the value is 'Palette'. If the value is set to 'RGB' and A is not [M-by-N-by-3], an error is issued. Permissible values are 'MinIsBlack', 'RGB', 'Palette', 'Separated'. The numeric values, <code>Tiff.Photometric.MinIsBlack</code> , <code>Tiff.Photometric.RGB</code> , <code>Tiff.Photometric.Palette</code> , <code>Tiff.Photometric.Separated</code> can also be used.
Software	Software maker of the file. The value is set to the value 'MATLAB, Mapping Toolbox, The MathWorks, Inc.'. To remove the value, set the tag to the empty string or character vector ('').
RowsPerStrip	A scalar positive integer-valued number specifying the desired rows per strip in the output file. If the size of A is less than [160-by-160], <code>geotiffwrite</code> sets <code>RowsPerStrip</code> to 1. If you specify <code>RowsPerStrip</code> and <code>TileWidth</code> , with or without <code>TileLength</code> , <code>geotiffwrite</code> issues an error.
TileWidth	A scalar positive integer-valued number and a multiple of 16 specifying the width of the tiles. <code>TileWidth</code> is set if the size of A is greater than [160-by-160]. If so, the value is such that a maximum of [10-by-10] tiles are created. If you specify both <code>RowsPerStrip</code> and <code>TileWidth</code> , <code>geotiffwrite</code> issues an error.
TileLength	A scalar positive integer-valued number and a multiple of 16 specifying the length of the tiles. <code>TileLength</code> is set if the size of A is greater than [160-by-160]. If so, the value is such that a maximum of [10-by-10] tiles are created. If you specify both <code>RowsPerStrip</code> and <code>TileLength</code> , <code>geotiffwrite</code> issues an error.

TiffType — Type of TIFF file

'classictiff' (default) | 'bigtiff'

Type of TIFF file, specified as the comma-separated pair consisting of 'TiffType' and either 'classictiff' or 'bigtiff'. The 'classictiff' value creates a Classic TIFF file. The 'bigtiff' value creates a BigTIFF file. In BigTIFF format, files can be larger than 4 GB.

While using the 'bigtiff' format enables you to create files larger than 4 GB, the data you want to write must fit in memory.

Tips

- If you are working with image coordinates in a projected coordinate system and R is a map raster reference object, set the `GeoKeyDirectoryTag` or `CoordRefSysCode` argument, accordingly.
- Check the GeoTIFF specification for values of the following parameters:
 - 'CoordRefSysCode' value for geographic coordinate systems
 - 'CoordRefSysCode' value for projected coordinate systems
 - GeoKey field names for the 'GeoKeyDirectoryTag'

Version History

Introduced before R2006a

R2022b: `geotiffwrite` will not accept referencing vectors or referencing matrices as input
Not recommended starting in R2022b

The `geotiffwrite` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object (specified as a `GeographicCellsReference` or `GeographicPostingsReference` object) or a map raster reference object (specified as a `MapCellsReference` or `MapPostingsReference` object) as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` or `mapcrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` or `mapresize` function.

Depending on whether the referencing vector or referencing matrix is in geographic or planar coordinates, there are different ways to update your code.

Geographic Coordinates

If the referencing vector or referencing matrix is in geographic coordinates, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

Planar Map Coordinates

If the referencing vector or referencing matrix is in planar map coordinates, create a map reference object.

- Create a map reference object for a raster of cells by using the `maprefcells` function.
- Create a map reference object or for a raster of regularly posted samples by using the `maprefpostings` function.
- Convert from a referencing matrix to a map reference object by using the `refmatToMapRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

R2018a: Export data containing more than 4 GB in BigTIFF format

Specify the format of the GeoTIFF file to write as either classic TIFF or BigTIFF by using the `TiffType` name-value argument. The BigTIFF format enables you to create files that exceed 4 GB in size.

See Also

`geotiffinfo` | `readgeoraster` | `imread` | `imwrite` | `RPCCoefficientTag` | `Tiff`

getCapabilities

Get capabilities document from server

Syntax

```
capabilities = getCapabilities(server)
```

Description

`capabilities = getCapabilities(server)` retrieves the capabilities document from the Web map service server, `server`, and updates the `RequestURL` property of the server.

Examples

Get Capabilities Document From Server

Search the WMS Database for layers from the NASA SVS Image Server. Create a `WebMapServer` object from one of the layers. Get the capabilities document from the server.

```
nasa = wmsfind('NASA SVS Image', 'SearchField', 'servertitle');  
serverURL = nasa(1).ServerURL;  
server = WebMapServer(serverURL);  
capabilities = getCapabilities(server);
```

Input Arguments

server — Web map server

`WebMapServer` object

Web map server, specified as a `WebMapServer` object.

Output Arguments

capabilities — Capabilities document

`WMSCapabilities` object

Capabilities document, returned as a `WMSCapabilities` object.

Tips

The `getCapabilities` method accesses the Internet to retrieve the document. Periodically, the WMS server is unavailable. Retrieving the document can take several minutes.

Version History

Introduced before R2006a

See Also

disp | WebMapServer | WMSCapabilities

getm

Query properties of axesm-based map

Syntax

```
mstruct = getm(abm)
propval = getm(obj,propname)
getm("MapProjection")
getm("axes")
getm("units")
```

Description

`mstruct = getm(abm)` returns the map projection structure of the axesm-based map `abm`.

`propval = getm(obj,propname)` returns the value of the property `propname` that is stored in the map graphics object `obj`.

`getm("MapProjection")` displays a list of available map projections. For each projection, the list includes the class, the English name, and the standard projection identifier.

`getm("axes")` displays a list of axesm-based map properties by property name. For a full list of axesm-based map property names and valid values, see [axesm-Based Map Properties](#).

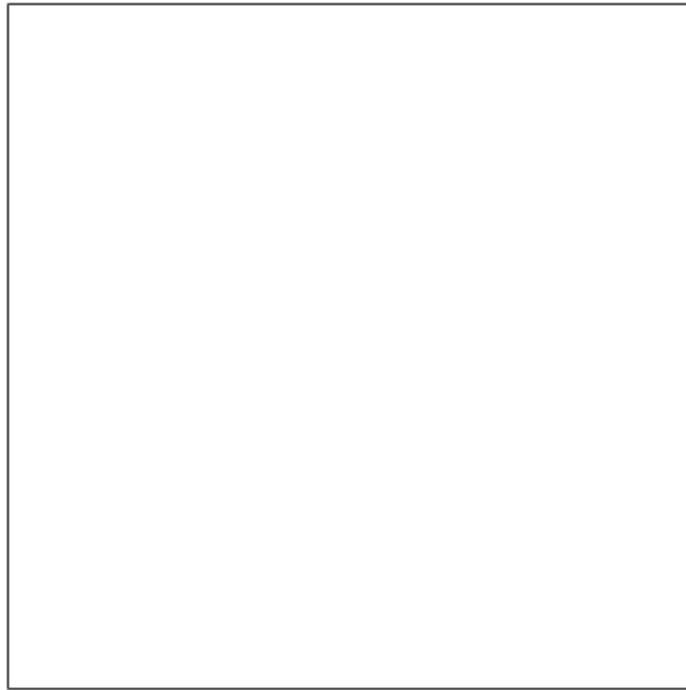
`getm("units")` displays a list of valid length units. For a full list of valid length units, see the ["unit"](#) on page 1-0 argument for the `validateLengthUnit` reference page.

Examples

Query Properties of axesm-Based Map

Create a default axesm-based map, and query a property value.

```
axesm("mercator")
```



```
abm = gca;  
getm(abm, "MapParallels")  
  
ans = 0
```

Input Arguments

abm — axesm-based map

map created using `axesm`, `worldmap`, or `usamap`

axesm-based map, specified as a map created using the `axesm`, `worldmap`, or `usamap` function.

obj — Map graphics objects

array of graphic objects

Map graphics objects, specified as an array of graphics objects. Each object must be an axesm-based map or a child of an axesm-based map.

propname — Property name

character vector | string scalar

Property name, specified as a character vector or a string scalar. For a full list of axesm-based map property names and valid values, see `axesm-Based Map Properties`. For a full list of graphic scale property names and valid values, see `scaleruler`.

Data Types: `char` | `string`

Output Arguments

mstruct — Map projection structure

structure

Map projection structure, returned as a structure with fields identical to the properties of an axesm-based map. Examples of map projection structure fields include the projection name, angle unit, origin, aspect, false easting, and false northing. For more information about the properties of axesm-based maps, see axesm-Based Map Properties.

propval — Property value

array

Property value, returned as an array. For a full list of axesm-based map property names and valid values, see axesm-Based Map Properties. For a full list of graphic scale property names and valid values, see scaleruler.

Version History

Introduced before R2006a

See Also

Functions

axesm | setm

Properties

axesm-Based Map Properties

getMap

Get raster map from server

Syntax

```
A = getMap(server,mapRequestURL)
```

Description

`A = getMap(server,mapRequestURL)` dynamically renders and retrieves a color or grayscale, geographically referenced, raster map from the Web map services server, `server`, and stores it in `A`. Parameters in the URL, `mapRequestURL`, define the map. The `getMap` function also updates the `RequestURL` property of the server with `mapRequestURL`.

Most of the time, you can read a WMS map using `wmsread` function instead of the `getMap` function. Use the `getMap` function when:

- Working with non-EPSG:4326 reference systems
- Creating an animation of a specific geographic area over time
- Retrieving multiple layers from a WMS server

Examples

Read Map From WMS Server

Search the WMS Database for a layer containing terrain elevation data from the WMS server hosted by MathWorks®.

```
layers = wmsfind("mathworks","SearchField","serverurl");
layer = refine(layers,"elevation");
```

Create a web map server object and a map request object. Change the background color of the map request to cyan.

```
server = WebMapServer(layer.ServerURL);
mapRequest = WMSMapRequest(layer,server);
mapRequest.BackgroundColor = [0 255 255];
```

Read the map from the server.

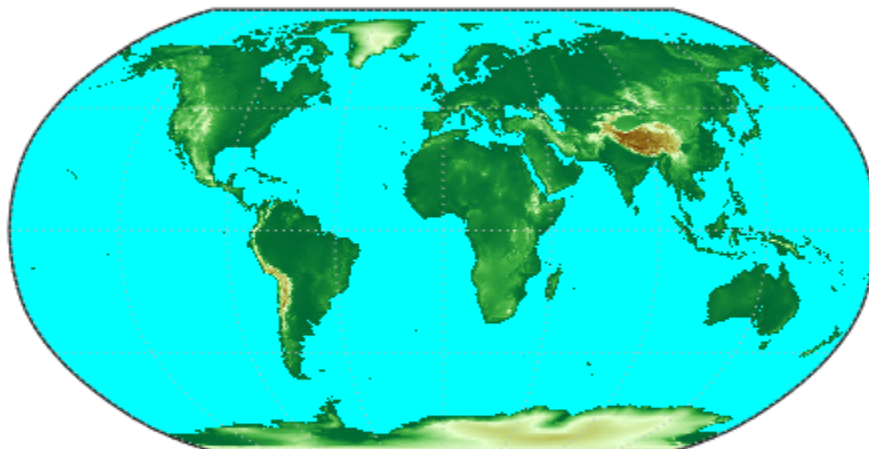
```
A = getMap(server,mapRequest.RequestURL);
R = mapRequest.RasterReference;
```

Display the map.

```
figure
worldmap world
geoshow(A,R)
plabel off
```

```
mlabel off  
title(layer.LayerTitle)
```

Terrain elevation data derived from GMTED2010



Input Arguments

server — Web map server

WebMapServer object

Web map server, specified as a WebMapServer object.

mapRequestURL — URL

character vector

URL, specified as a character vector. Parameters in the URL define the map.

You can get a URL from:

- The output of `wms read`
- The `RequestURL` property of a `WMSMapRequest` object
- An Internet search

Output Arguments

A — Rendered map

color or grayscale image

Rendered map, returned as a color or grayscale image.

Tips

getMap accesses the Internet to retrieve the map. Periodically, the WMS server is unavailable. Retrieving the map can take several minutes.

Version History

Introduced before R2006a

See Also

WMSMapRequest | WebMapServer

getseeds

(Removed) Interactively assign seeds for data grid encoding using axesm-based map

Note The `getseeds` function has been removed.

Syntax

```
[row,col,val] = getseeds(map,R,nseeds)
[row,col,val] = getseeds(map,R,nseeds,seedval)
mat = getseeds(...)
```

Description

`[row,col,val] = getseeds(map,R,nseeds)` allows user to identify geographical objects while customizing a raster map. It prompts the user for mouse click positions of objects and assigns them a code value. The user is prompted for the value to seed at each location. The outputs are the row and column of the seed location and the value assigned at that location. `R` is either a 1-by-3 vector containing elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

or a 3-by-2 referencing matrix that transforms raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel.

`[row,col,val] = getseeds(map,R,nseeds,seedval)` assigns the value `seedval` to each location supplied. If `seedval` is a scalar then the same value is assigned at each location. Otherwise, if `seedval` is a vector it must be `length(nseeds)` and each entry is assigned to the corresponding location. `getseeds` operates on the current axes (`gca`).

`mat = getseeds(...)` returns a single output matrix where `mat = [row col val]`.

Examples

Load elevation raster data and a geographic cells reference object. Create a map. Then, call `getseeds` and interactively select three points.

```
load topo60c
axesm('gortho','grid','on')
seedmat = getseeds(topo60c,topo60cR,3);
```

When you have selected three points, you are prompted for their values. The regular data grid need not be displayed to execute `getseeds` on it.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `getseeds` function has been removed.

R2022a: Warns

Warns starting in R2022a

The `getseeds` function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The `getseeds` function runs without warning but will be removed in a future release.

See Also

`encodem`

getworldfilename

Derive world file name from image file name

Syntax

```
worldfilename = getworldfilename(imagefilename)
```

Description

`worldfilename = getworldfilename(imagefilename)` returns the name of the corresponding world file derived from the name of an image file.

The world file and the image file have the same base name. If `imagefilename` follows the “.3” convention, then you create the world file extension by removing the middle letter and appending the letter 'w'.

If `imagefilename` has an extension that does not follow the “.3” convention, then a 'w' is appended to the full image name to construct the world file name.

If `imagefilename` has no extension, then '.wld' is appended to construct a world file name.

Examples

Given the following image file names, `worldfilename` would return these world file names:

Image File Name	World File Name
myimage.tif	myimage.tfw
myimage.jpeg	myimage.jpegw
myimage	myimage.wld

Version History

Introduced before R2006a

See Also

`mapshow` | `worldfileread` | `worldfilewrite`

globedem

(To be removed) Read Global Land One-km Base Elevation (GLOBE) data

Note `globedem` will be removed in a future release. Use `readgeoraster` instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z,refvec] = globedem(filename,scalefactor)
[Z,refvec] = globedem(filename,scalefactor,latlim,lonlim)
[Z,refvec] = globedem(foldername,scalefactor,latlim,lonlim)
```

Description

`[Z,refvec] = globedem(filename,scalefactor)` reads the GLOBE DEM files and returns the result as a regular data grid. The `filename` is given as a string scalar or character vector that does not include an extension. `globedem` first reads the Esri header file found in the subfolder `'/esri/hdr/'` and then the binary data file name. If the files are not found on the MATLAB path, they can be selected interactively. `scalefactor` is an integer that when equal to 1 gives the data at its full resolution. When `scalefactor` is an integer `n` larger than 1, every `n`th point is returned. The map data is returned as an array of elevations and associated three-element referencing vector. Elevations are given in meters above mean sea level, using WGS 84 as a horizontal datum.

`[Z,refvec] = globedem(filename,scalefactor,latlim,lonlim)` allows a subset of the map data to be read. The limits of the desired data are specified as vectors of latitude and longitude in degrees. The elements of `latlim` and `lonlim` must be in ascending order.

`[Z,refvec] = globedem(foldername,scalefactor,latlim,lonlim)` reads and concatenates data from multiple files within a GLOBE folder tree. The `foldername` input is a string scalar or character vector with the name of the folder that contains both the uncompressed data files and the Esri header files.

Background

GLOBE, the Global Land One-km Base Elevation data, was compiled by the National Geophysical Data Center from more than 10 different sources of gridded elevation data. GLOBE can be considered a higher resolution successor to TerrainBase. The data set consists of 16 tiles, each covering 50 by 90 degrees. Tiles require as much as 60 MB of storage. Uncompressed tiles take between 100 and 130 MB.

Examples

Determine the file that contains the area around Cape Cod. (This example assumes you have already downloaded some GLOBE data tiles.)

```
latlim = [41 42.5]; lonlim = [-73 -69.9];
globedems(latlim,lonlim)
```

```
ans =
    'f10g'
```

Extract every 20th point from the tile covering the northeastern United States and eastern Canada. If you specify an empty file name (' '), `globedem` presents a file browser that you use to first select the header file and then select the data file interactively.

```
[Z,refvec] = globedem(' ',20);
size(Z)
```

```
ans =
    300    540
```

Extract a subset of the data for Massachusetts at the full resolution.

```
latlim = [41 42.5]; lonlim = [-73 -69.9];
[Z,refvec] = globedem('f10g',1,latlim,lonlim);
size(Z)
```

```
ans =
    181    373
```

Replace the NaNs in the ocean with -1 to color them blue.

```
Z(isnan(Z)) = -1;
```

Extract some data for southern Louisiana in an area that straddles two tiles. Provide the name of the folder containing the data files, and let `globedem` determine which files are required, read from the files, and concatenate the data into a single regular data grid.

```
latlim =[28.61 31.31]; lonlim = [-91.24 -88.62];
globedems(latlim,lonlim)
```

```
ans =
    'e10g'
    'f10g'
```

```
[Z,refvec] =
globedem('d:\externalData\globe\elev',1,latlim,lonlim);
size(Z)
```

```
ans =
    325.00    315.00
```

Tips

The `globedem` function reads data from GLOBE Version 1.0. The data is for elevations only. Elevations are given in meters above mean sea level using WGS 84 as a horizontal datum. Areas with no data, such as the oceans, are coded with NaNs.

The data set and documentation are available over the Internet.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: “Find Geospatial Data Online”.

Version History

Introduced before R2006a

R2021b: Warns

Warns starting in R2021b

Raster reading functions that return referencing vectors issue a warning that they will be removed in a future release, including `globedem`. Instead, use `readgeoraster`, which returns a geographic raster reference object. Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see `GeographicCellsReference` and `GeographicPostingsReference`.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` function.
- Most functions that accept referencing vectors as input also accept reference objects.

This table shows some typical usages of `globedem` and how to update your code to use `readgeoraster` instead. Unlike `globedem`, which requires the `.hdr` header file to be in the `/esri/hdr/` subfolder, the `readgeoraster` function requires the data file and header file to be in the same folder. The `readgeoraster` function also requires you to specify a file extension.

Will Be Removed	Recommended
<code>[Z,refvec] = globedem(filename,samplefactor)</code>	<code>[Z,R] = readgeoraster(filename, ... 'CoordinateSystemType','geographic');</code> <code>[Z,R] = georesize(Z,R,1/samplefactor);</code>
<code>[Z,refvec] = globedem(filename,samplefactor)</code>	<code>[Z,R] = readgeoraster(filename, ... 'CoordinateSystemType','geographic');</code> <code>[Z,R] = geocrop(Z,R,latlim,lonlim);</code> <code>[Z,R] = georesize(Z,R,1/scalefactor);</code>

The `readgeoraster` function returns data using the native data type embedded in the file. Return a different data type by specifying the 'OutputType' name-value pair. For example, use `[Z,R] = readgeoraster(filename,'OutputType','double')`.

The `readgeoraster` function does not automatically replace missing data with NaN values. If your data set uses large negative numbers to indicate missing data, replace them with NaN values using the `standardizeMissing` function.

```
[Z,R] = readgeoraster('MtWashington-ft.grd');
info = georasterinfo('MtWashington-ft.grd');
m = info.MissingDataIndicator;
Z = standardizeMissing(Z,m);
```

R2020a: To be removed

Not recommended starting in R2020a

The `globedem` function runs without warning but will be removed in a future release.

References

See Web site for the National Oceanic and Atmospheric Administration, National Geophysical Data Center

See Also

`readgeoraster` | `georasterinfo`

globedems

GLOBE data file names for latitude-longitude quadrangle

Syntax

```
tileNames = globedems(latlim,lonlim)
tileNames = globedems(lat,lon)
```

Description

`tileNames = globedems(latlim,lonlim)` returns a cell array of the tile names covering the geographic region for GLOBEDEM digital elevation maps. The region is specified by two-element vectors of latitude and longitude limits in units of degrees.

`tileNames = globedems(lat,lon)` returns a cell array of the tile names covering the geographic region for GLOBEDEM digital elevation maps. The region is specified by scalar latitude and longitude points, in units of degrees.

Background

GLOBE, the Global Land One-km Base Elevation data, was compiled by the National Geophysical Data Center from more than 10 different sources of gridded elevation data. The data set consists of 16 tiles, each covering 50 by 90 degrees. Determining which tiles are needed to cover a particular region generally requires consulting an index map. This function takes the place of such a reference by returning the file names for a given geographic region.

Examples

Which tiles are needed for southern Louisiana?

```
latlim =[28.61 31.31];
lonlim = [-91.24 -88.62];
globedems(latlim,lonlim)
```

```
ans =
    'e10g'
    'f10g'
```

Tips

The `globedems` function reads data from the format GLOBE Version 1.0.

Version History

Introduced before R2006a

See Also
readgeoraster

gpxread

Read GPX file

Syntax

```
P = gpxread(filename)
```

```
P = gpxread(URL)
```

```
S = gpxread( ____, 'Index', V)
```

```
____ = gpxread( ____, Name, Value)
```

Description

`P = gpxread(filename)` reads point data from the GPS Exchange Format (GPX) file, `filename`, and returns an n -by-1 geopoint vector, `P`, where n is the number of waypoints, or points that define a route or track.

`gpxread` searches the file first for waypoints, then routes, and then tracks, and it returns the first type of data it finds. The `Metadata` field of `P` identifies the feature type ('waypoint', 'track', or 'route') and any additional metadata associated with waypoint, route, or track. If the file contains multiple tracks or routes, `P` contains the points that define the first track or route in the file. If `gpxread` cannot find any features in the file, it returns an empty geopoint vector.

`P = gpxread(URL)` reads the GPX data from a URL. The URL must include the protocol type (for example, `http://`).

`S = gpxread(____, 'Index', V)` returns data from the GPX file in a geoshape vector, rather than a geopoint vector, only if the file contains track or route data and you specify the value of 'Index' as a vector, `V`. Use this syntax when you want to work with the data as a line, rather than as a collection of points.

`____ = gpxread(____, Name, Value)` reads data from a GPX file with additional options, specified by one or more `Name, Value` pair arguments, that control various characteristics of the import. `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`'`) and is case insensitive. You can specify several name-value pair arguments in any order.

Examples

Read Waypoints and Display Them Over Image

Read and display waypoints from the `boston_placenames.gpx` file and overlay the points onto the `boston.tif` image.

First, import the waypoints and GeoTIFF file.

```
p = gpxread('boston_placenames.gpx');
[A,R] = readgeoraster('boston.tif');
```

Get the projection structure of the GeoTIFF image. Convert the length unit of the X and Y limits to meters for use with the projection structure.

```
proj = geotiffinfo('boston.tif');  
mstruct = geotiff2mstruct(proj);  
R.XWorldLimits = R.XWorldLimits * proj.UOMLengthInMeters;  
R.YWorldLimits = R.YWorldLimits * proj.UOMLengthInMeters;
```

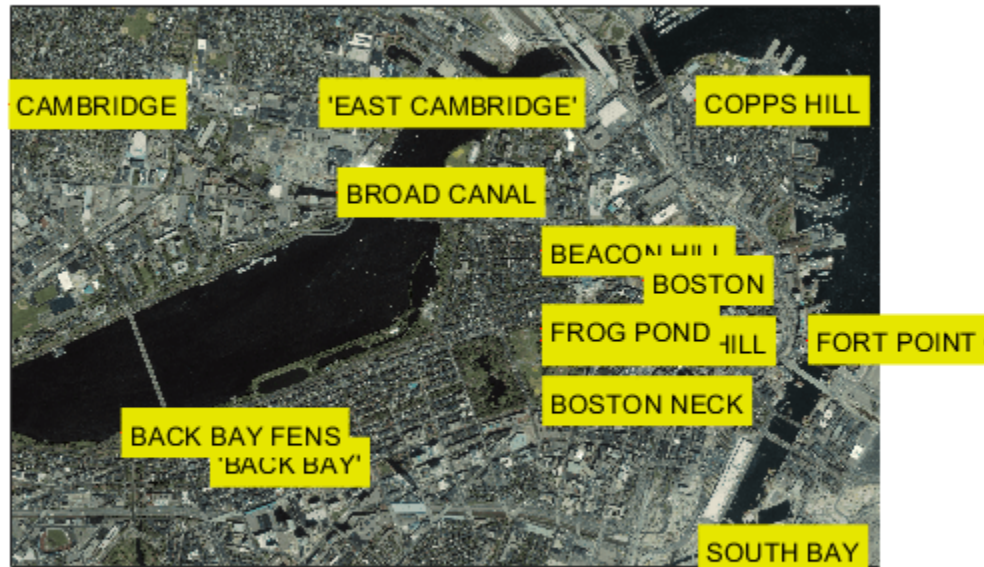
Display the map.

```
axesm(mstruct)  
mapshow(A,R)
```



Display the names and positions of each point.

```
for k=1:length(p)  
    textm(p(k).Latitude, p(k).Longitude, p(k).Name, ...  
        'Color', 'k', 'BackgroundColor', [0.9 0.9 0], ...  
        'Interpreter', 'none');  
end  
geoshow(p)  
xlim(R.XWorldLimits)  
ylim(R.YWorldLimits)
```



Read and Display a Route

Read and display a route from Boston Logan International Airport to MathWorks in Natick, MA.

Read the route information from the GPX file.

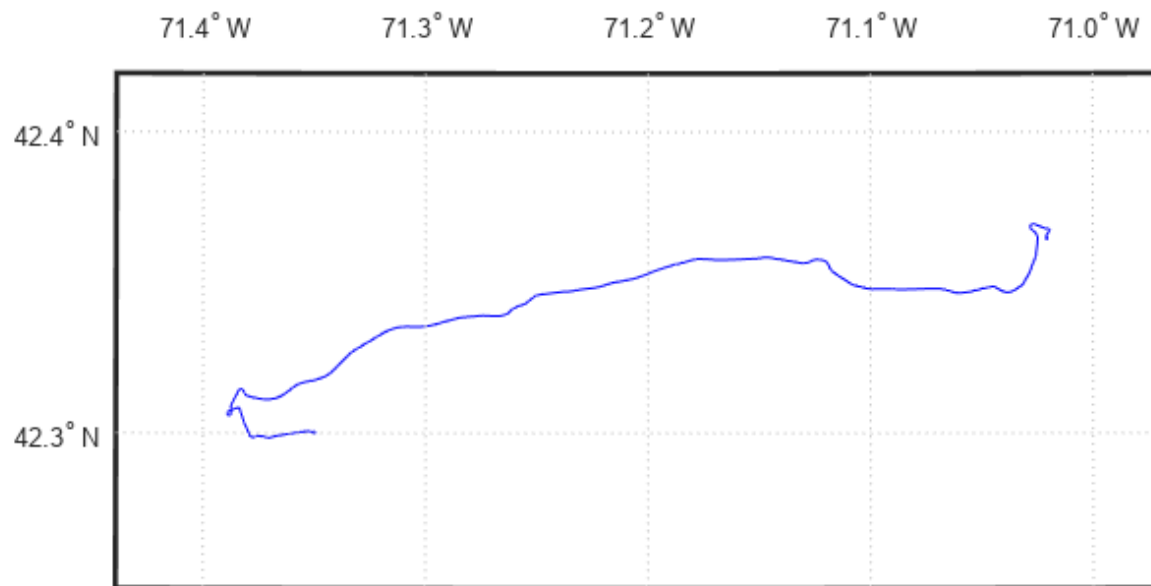
```
route = gpxread('sample_route.gpx');
```

Compute latlim and lonlim with a 0.05 buffer.

```
[latlim, lonlim] = geoquadline(route.Latitude, route.Longitude);
[latlim, lonlim] = bufgeoquad(latlim, lonlim, .05, .05);
```

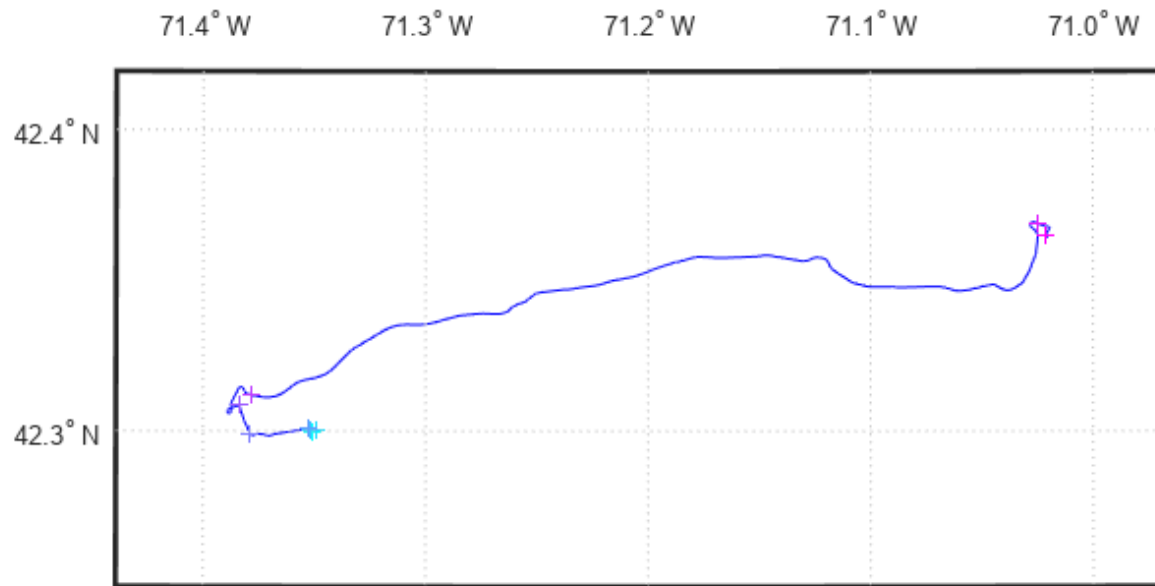
Display the route.

```
fig = figure;
pos = fig.Position;
fig.Position = [300 300 1.25*pos(3) 1.25*pos(4)];
ax = usamap(latlim, lonlim);
setm(ax, 'MLabelParallel', 43.5)
geoshow(route.Latitude, route.Longitude)
```



Extract the elements of route that include descriptions of turns, mark and color code each turn on the map, and construct a legend that displays the descriptions. Reverse the order, so that the legend displays the first turn at the top and the last at the bottom.

```
turns = route(~cellfun(@isempty, route.Description));
turns = turns(end:-1:1);
n = length(turns);
colors = cool(n);
for k=1:n
    geoshow(turns(k).Latitude, turns(k).Longitude, ...
            'DisplayType','point','MarkerEdgeColor',colors(k,:),...
            'Tag','turn','DisplayName',turns(k).Description)
end
legend(findobj(ax,'Tag','turn'),'Location','SouthOutside')
```



- + Head southeast
- + Keep left at the fork, follow signs for I-90 W/I-93 S/Williams Tunnel/Mass Pike and merge onto I-90 W
Partial toll road
- + Take exit 13 to merge onto MA-30 E/Cochituate Rd toward Natick
Partial toll road
- + Turn right onto Speen St
- + Merge onto MA-9 E/Worcester St via the ramp on the left to Boston
- + Slight right onto Apple Hill Dr
- + Turn left toward Apple Hill Dr
- + Take the 1st right onto Apple Hill Dr
- + Destination will be on the right
- + The MathWorks, Inc., Natick, MA.

Read and Display Multiple Track Logs on Web Map

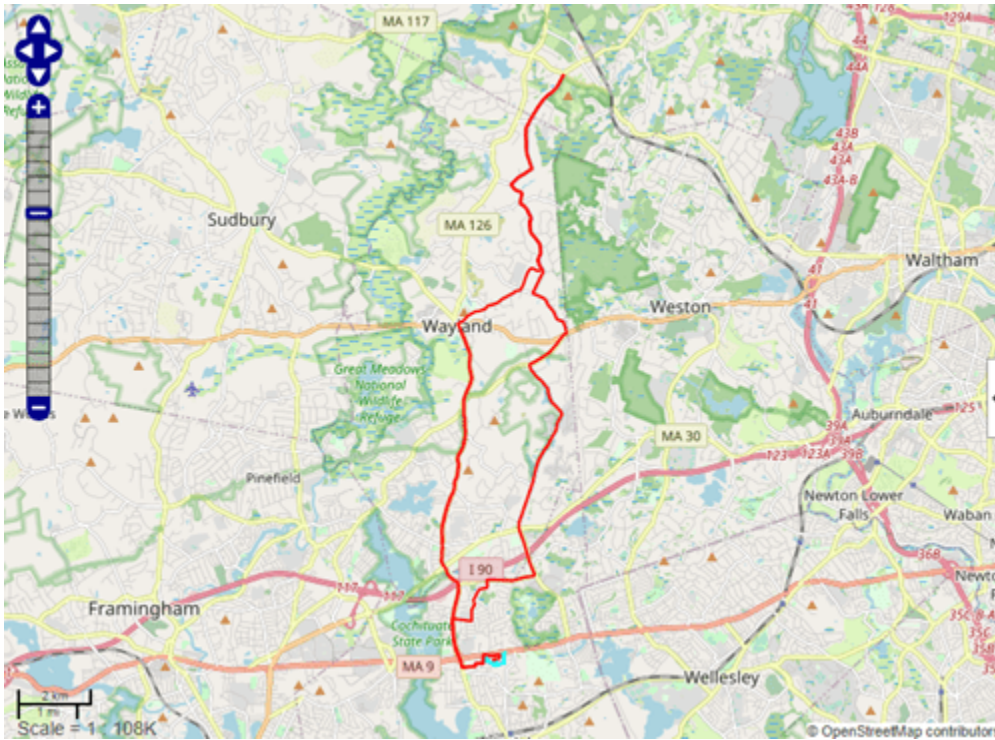
Read track log from a GPX file and display overlaid on a web map.

Read the track logs from a GPX file. `gpxread` returns the data in a geoshape object.

```
tracks = gpxread('sample_tracks', 'Index', 1:2);
```

Display the track logs on a web map with a different color for each track log.

```
webmap('openstreetmap')
colors = {'cyan', 'red'};
wmline(tracks, 'Color', colors)
```

Zoom the web map to view the first track near the MathWorks campus in Natick.

```
[latlim, lonlim] = geoquadline(tracks(1).Latitude, tracks(1).Longitude);  
wmlimits(latlim, lonlim)
```



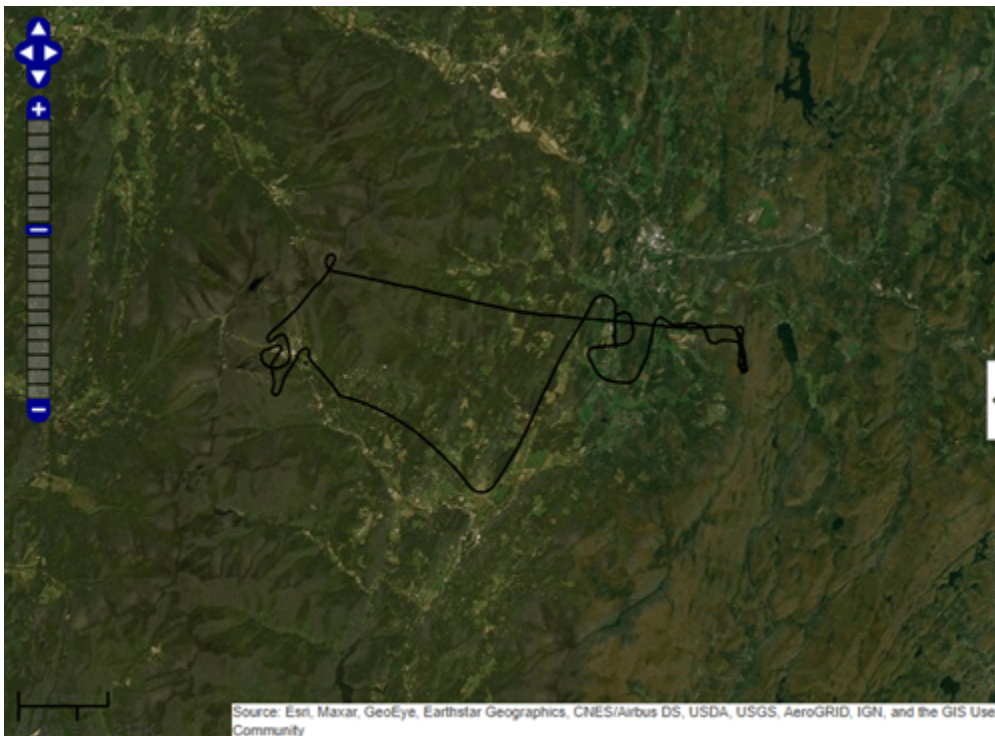
Read and Display Waypoints and Track Log on Web Map

Read waypoints and track log from the `sample_mixed.gpx` file.

```
wpt = gpxread('sample_mixed');  
trk = gpxread('sample_mixed', 'FeatureType', 'track');
```

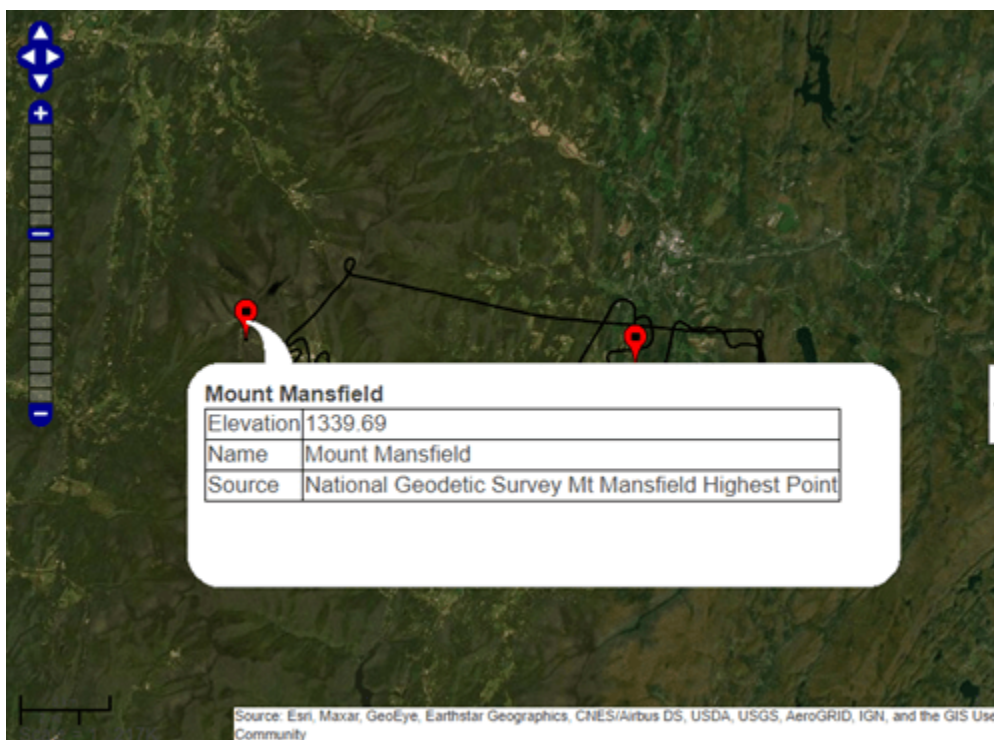
Display the waypoints and the track log on a web map.

```
webmap('worldimagery')  
wmline(trk, 'OverlayName', 'Track Logs');
```



Add web markers to mark the positions of each way point.

```
wmmarker(wpt, 'FeatureName', wpt.Name, 'OverlayName', 'Waypoints')
```



Display Elevation and Time-Area Maps

This example shows how to display elevation and time area maps and calculate distance using track logs.

Read the track log from the `sample_mixed.gpx` file.

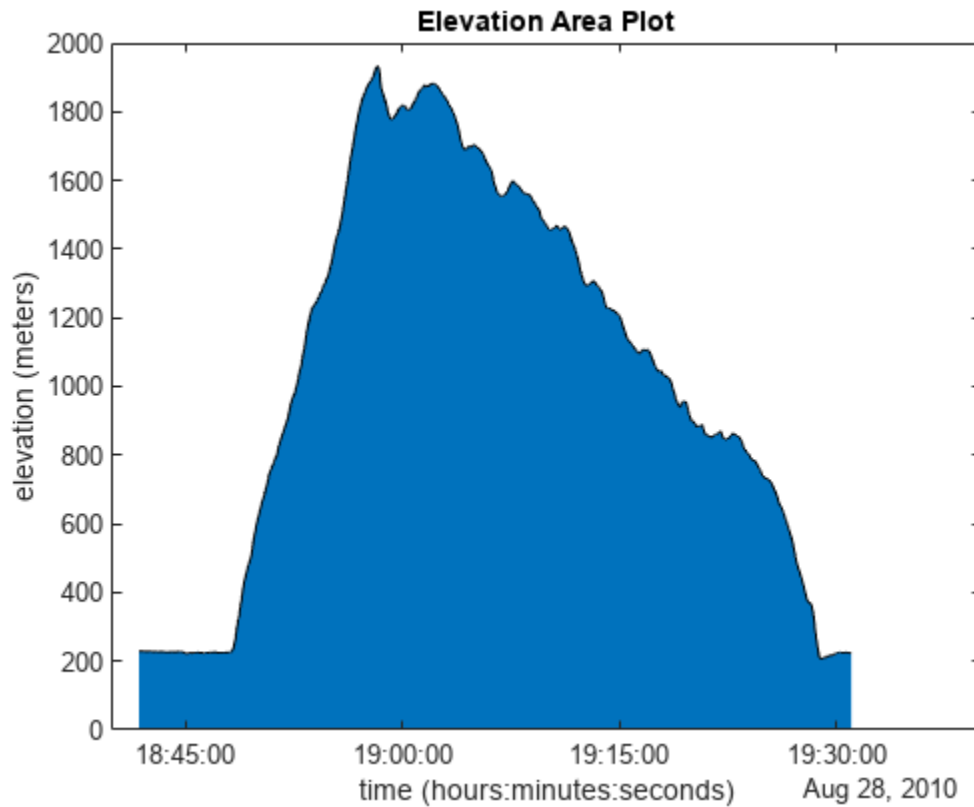
```
trk = gpxread('sample_mixed.gpx', 'FeatureType', 'track');
```

Simplify the format of the time value strings by removing the fractional seconds and time zone offset. Convert the strings to a `datetime` array.

```
timeStr = strrep(trk.Time, '.000Z', '');
t = datetime(timeStr);
```

Display an area plot of the time and elevation values.

```
figure
area(t, trk.Elevation)
xtickformat('HH:mm:ss')
xlabel('time (hours:minutes:seconds)')
ylabel('elevation (meters)')
title('Elevation Area Plot');
```

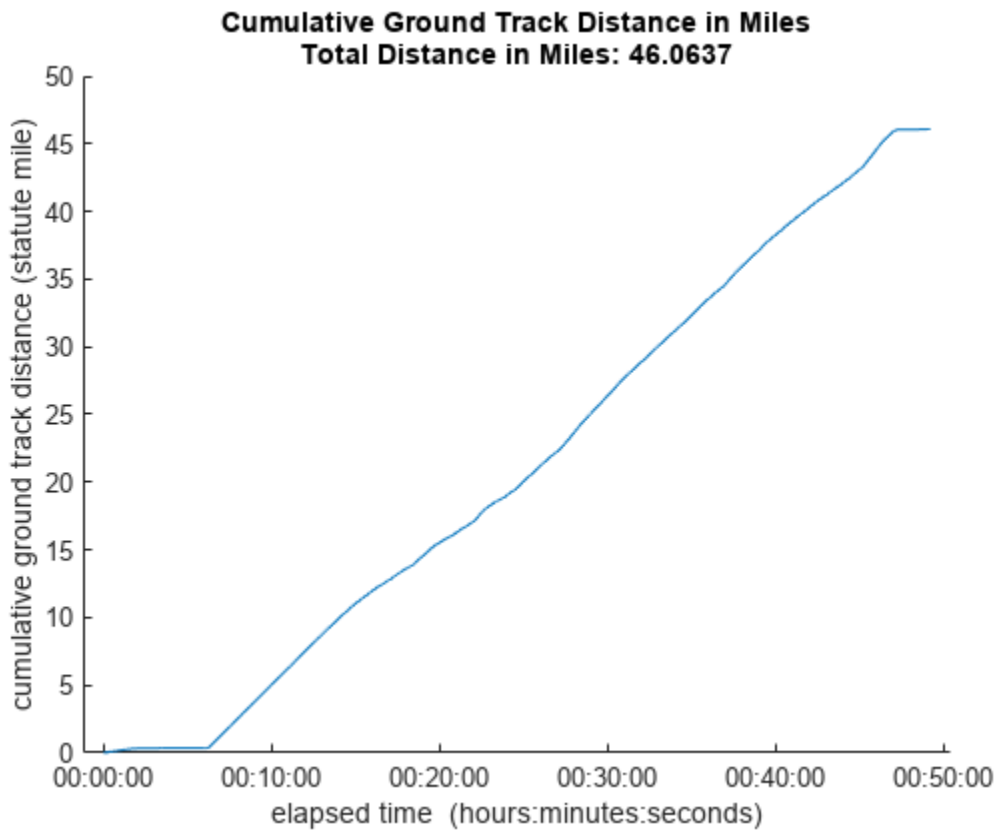


Calculate and display ground track distance. Convert distance in meters to distance in U.S. survey miles.

```
e = wgs84Ellipsoid;
lat = trk.Latitude;
lon = trk.Longitude;
d = distance(lat(1:end-1), lon(1:end-1), lat(2:end), lon(2:end), e);
d = d * unitsratio('sm', 'meter');
```

Display the cumulative ground track distance and elapsed time.

```
elapsedTime = t - t(1);
figure
line(elapsedTime(2:end), cumsum(d))
ylabel('cumulative ground track distance (statute mile)')
xlabel('elapsed time (hours:minutes:seconds)')
title({'Cumulative Ground Track Distance in Miles', ...
      ['Total Distance in Miles: ' num2str(sum(d))]})
```



Input Arguments

filename — Name of GPX file to open

character vector | string scalar

Name of GPX file to open, specified as a string scalar or character vector. If the file is not in the current folder or in a folder on the MATLAB path, you must specify the folder path. If the file name includes the extension `'.gpx'` (either uppercase or lowercase), you can omit the extension from filename.

Example: `'boston_placenames'`

Data Types: `char` | `string`

URL — Internet location containing GPX data

URL

Internet location containing GPX data, specified as a URL. The URL must include protocol type (for example, `https://`).

Data Types: `char` | `string`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose `Name` in quotes.

Example: `'FeatureType', 'track'`

FeatureType — Type of feature to read from file

`'auto'` (default) | `'track'` | `'route'` | `'waypoint'`

Type of feature to read from file, specified as one of the following: `'track'`, `'route'`, `'waypoint'`, or `'auto'`. If `gpxread` cannot find the specified feature in the file, it returns an empty geoint vector.

Example: `'FeatureType', 'waypoint'`

Data Types: `char` | `string`

Index — Index of waypoint, track, or route data in file

scalar or vector of positive integers

Index of waypoint, track, or route data in file, specified as a scalar or vector of positive integers.

- If the value is a scalar, `gpxread` returns the specified waypoint, route, or track as a geoint vector. If the scalar value is greater than the total number of elements found in the file, `gpxread` returns an empty geoint vector.
- If the value is a vector, and the file contains waypoints, `gpxread` returns those waypoints specified by the vector. If the file contains routes or tracks (and does not contain waypoints), `gpxread` returns the specified routes or track logs in a geoshape vector. `gpxread` sets the `Geometry` field of the geoshape vector to `'line'`.

Example: `'Index', [1:2]` would read up to two routes or tracks, if the file contained routes or tracks, in a geoshape vector.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

Output Arguments

P — Waypoint, track, or route data

n -by-1 geoint vector

Waypoint, track, or route data, returned as an n -by-1 geoint vector, where n is the number of points.

For a track log or route with multiple segments, `gpxread` concatenates the coordinates of the segments with NaN separators. NaN denotes numeric elements not found in the file. The empty character vector (`''`) is used to denote text elements not found in the file.

S — Track or route data

n -by-1 geoshape vector

Track or route data, returned as an n -by-1 geoint vector

More About

waypoint

A point of interest, or named feature on a map.

track

An ordered list of waypoints that describe a path.

route

An ordered list of waypoints representing a series of turn points leading to a destination.

Tips

- Excluding extensions, GPX version 1.1 is fully supported. If any other version is detected, a warning is issued. However, in most cases, version 1.0 GPX files can be read successfully unless they contain certain metadata tags. For more information, see the [GPX 1.1 Schema Documentation](#).

Version History

Introduced in R2012a

See Also

[geopoint](#) | [geoshape](#) | [readgeotable](#) | [shaperead](#)

gradientm

Gradient, slope, and aspect of data grid

Syntax

```
[aspect,slope,gradN,gradE] = gradientm(F,R)
[aspect,slope,gradN,gradE] = gradientm(F,R,spheroid)

[aspect,slope,gradN,gradE] = gradientm(lat,lon,F)
[aspect,slope,gradN,gradE] = gradientm(lat,lon,F,spheroid)
[aspect,slope,gradN,gradE] = gradientm(lat,lon,F,spheroid,angleUnit)
```

Description

Regular Data Grids

`[aspect,slope,gradN,gradE] = gradientm(F,R)` returns the aspect angle, slope angle, and north and east components of the gradient for a regular data grid `F` with respect to a geographic reference `R`. By default, `gradientm` locates the latitude and longitude coordinates referenced by `R` using the spheroid contained in the `Spheroid` property of the `geocrs` object in the `GeographicCRS` property of `R`. If the `GeographicCRS` property of `R` is empty, then `geopeaks` uses `GRS80`.

`[aspect,slope,gradN,gradE] = gradientm(F,R,spheroid)` uses the specified reference spheroid instead of the spheroid contained in the `Spheroid` property of the `geocrs` object in the `GeographicCRS` property of `R` or the spheroid `GRS80`.

Geolocated Data Grids

`[aspect,slope,gradN,gradE] = gradientm(lat,lon,F)` returns the same values for a geolocated data grid `F` with respect to the latitude-longitude mesh defined by `lat` and `lon`. By default, latitude and longitude are in degrees. The default reference spheroid is `GRS80`.

`[aspect,slope,gradN,gradE] = gradientm(lat,lon,F,spheroid)` uses the specified reference spheroid instead of `GRS80`.

`[aspect,slope,gradN,gradE] = gradientm(lat,lon,F,spheroid,angleUnit)` specifies the units for latitude and longitude as 'degrees' (the default) or 'radians'.

Examples

Calculate and Display Gradient, Slope, and Aspect of Elevation Data

Generate sample elevation data for the region around a mountain summit using a geographic postings reference object and the `geopeaks` function. To do this, first create a reference object for the region by specifying the latitude and longitude limits and the size of the elevation data grid. Next, generate elevation data for the region using `geopeaks`.

```
latlim = [10 45];
lonlim = [60 100];
size = [100 100];
```

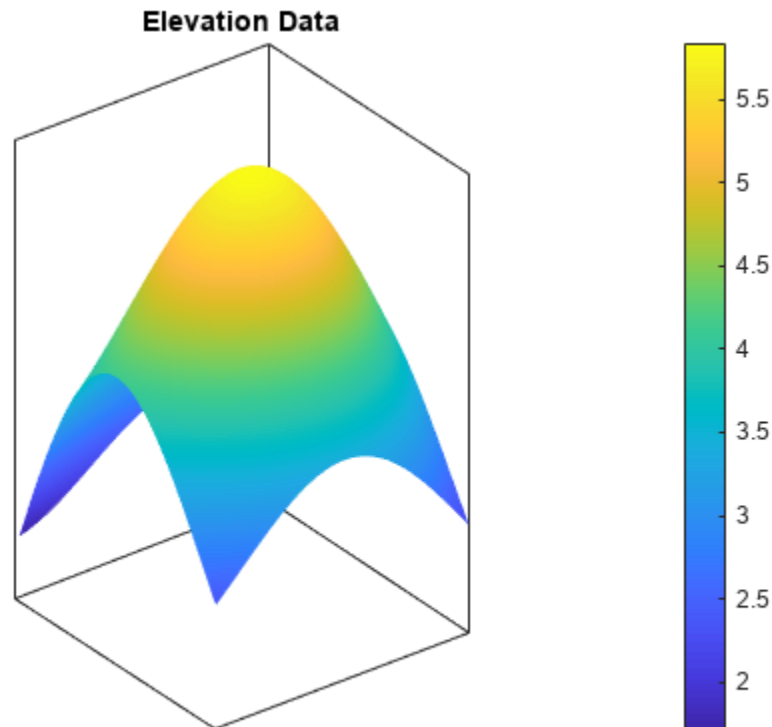
```
R = georefpostings(latlim,lonlim,size);  
F = geopeaks(R);
```

Compute the aspect angles, slope angles, and gradient components of the data.

```
[aspect,slope,gradN,gradE] = gradientm(F,R);
```

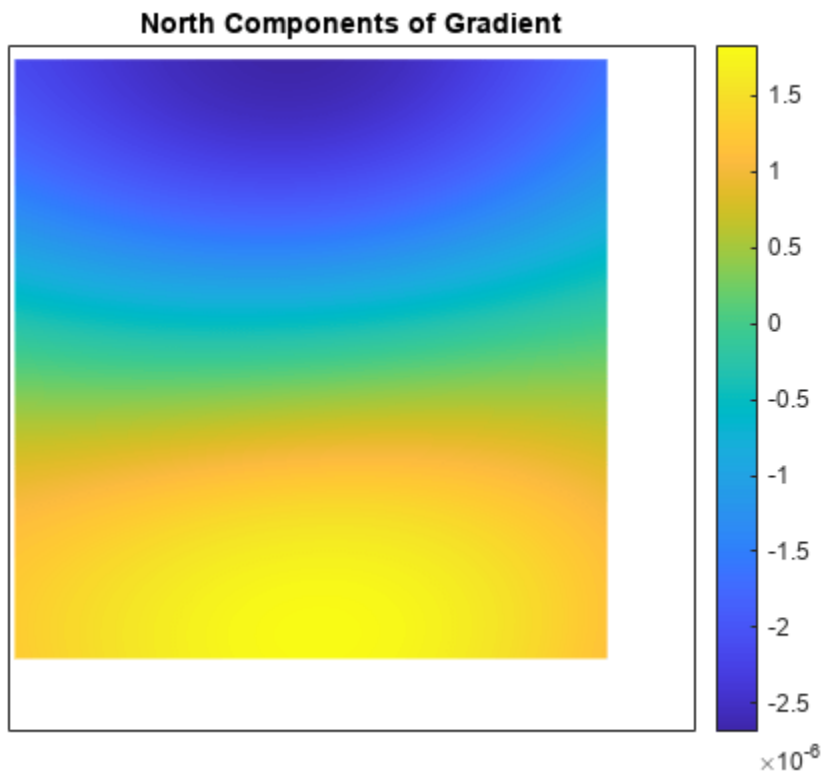
Visualize the results by plotting the data. Create a map using an equidistant cylindrical projection and plot the data as a surface. Adjust the aspect ratio of the map by using the `daspect` function. View the map in 3-D by using the `view` function.

```
figure  
axesm('eqdcylin');  
geoshow(F,R,'DisplayType','surface')  
daspect([1 1 5])  
title('Elevation Data')  
colorbar  
view(3)
```

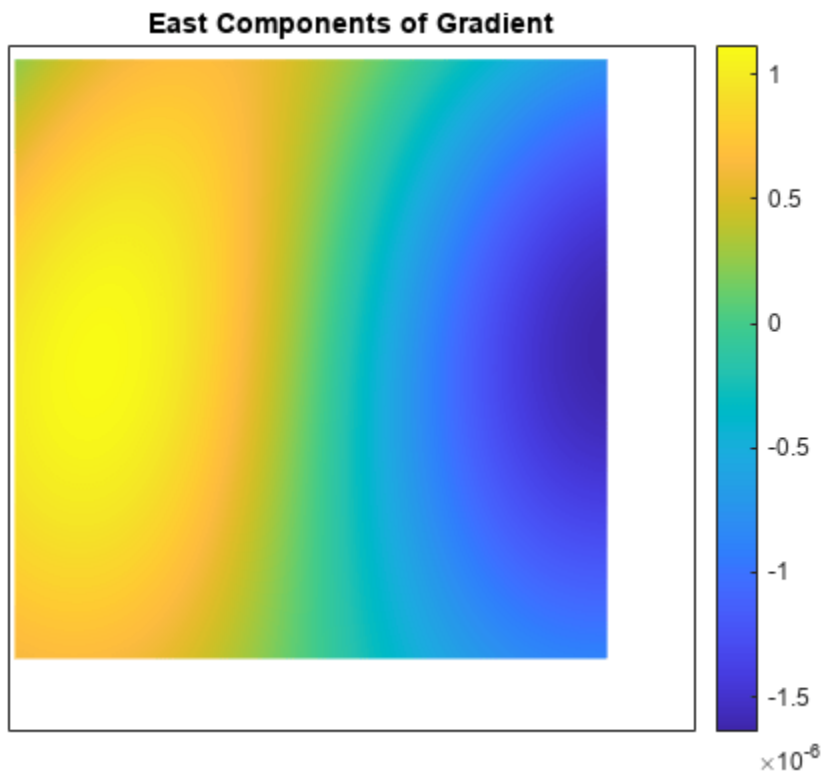


Then, plot the gradient components using the same projection. Note that both the north and east component values are zero at the summit.

```
figure  
axesm('eqdcylin')  
geoshow(gradN,R,'DisplayType','surface')  
title('North Components of Gradient')  
colorbar
```

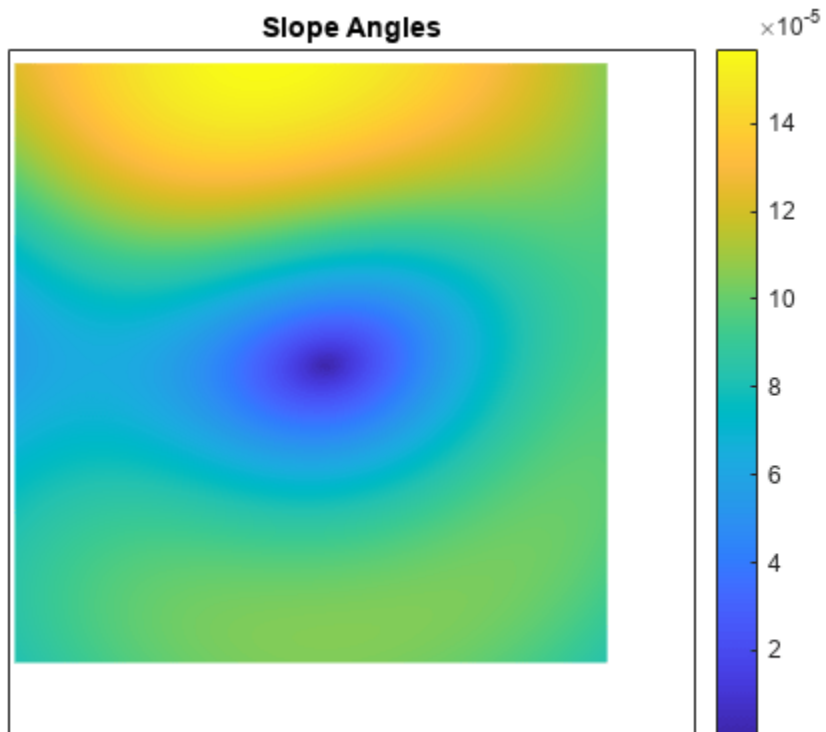



```
figure
axesm('eqdcylin')
geoshow(gradE,R,'DisplayType','surface')
title('East Components of Gradient')
colorbar
```



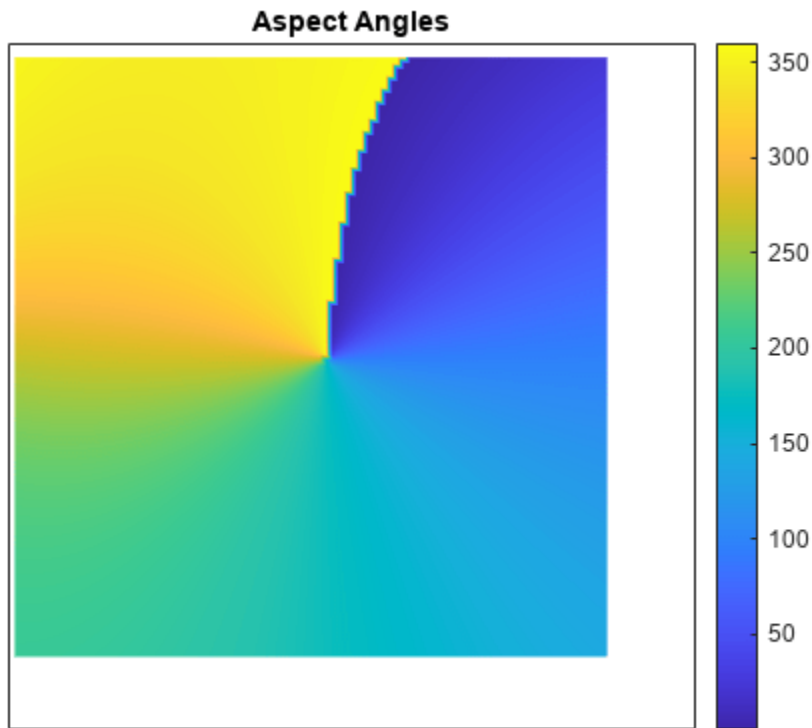
Plot the slope angles. Note that the value of the slope angle is zero at the summit.

```
figure
axesm('eqdcylin')
geoshow(slope,R,'DisplayType','surface')
title('Slope Angles')
colorbar
```



Plot the aspect angles. An aspect angle describes the direction the mountain slope faces as an azimuth measured clockwise from north.

```
figure
axesm('eqdcylin')
geoshow(aspect,R,'DisplayType','surface')
title('Aspect Angles')
colorbar
```



Input Arguments

F — Data grid

numeric matrix

Data grid, specified as a numeric matrix with at least two rows and two columns. The data grid may contain NaN values. F is either a regular data grid associated with a geographic raster reference object, or a georeferenced data grid with respect to a latitude-longitude mesh.

If F is a regular data grid and R is a reference object, then `size(F)` must be the same as `R.RasterSize`. If F is a geolocated data grid, then `size(F)` must be the same as `size(lat)` and `size(lon)`.

Data Types: `single` | `double`

R — Geographic reference

`GeographicCellsReference` object | `GeographicPostingsReference` object

Geographic reference that contains geospatial referencing information for F, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object. The `RasterSize` property of R must be the same as `size(F)`.

spheroid — Reference spheroid

'GRS80' (default) | `referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object | vector

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, `referenceSphere` object, or vector of the form `[semimajorAxis eccentricity]`.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid(wgs84Ellipsoid);`

lat — Latitudes

numeric matrix

Latitudes, specified as a numeric matrix with at least two rows and two columns. By default, specify latitudes in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

`lat` must be the same size as `lon` and `F`.

Data Types: `single` | `double`

lon — Longitudes

numeric matrix

Longitudes, specified as a numeric matrix with at least two rows and two columns. By default, specify longitudes in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

`lon` must be the same size as `lat` and `F`.

Data Types: `single` | `double`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

aspect — Aspect angles

matrix

Aspect angles, returned as a matrix of the same size as `F`. An aspect angle is the direction in which `F` decreases most rapidly, expressed as an azimuth measured clockwise from north.

By default, aspect angles are in degrees. To return values in radians, specify `lat` and `lon` in radians and `angleUnit` as `'radians'`.

If both components of the gradient are zero, then the aspect angle is returned as `NaN`.

Data Types: `double`

slope — Slope angles

matrix

Slope angles, returned as a matrix of the same size as `F`. For the slope angles to have physical meaning, the data grid must specify elevation, and its distance unit must match the length unit of the reference spheroid. Otherwise, a slope angle is the arctangent of the magnitude of the gradient.

By default, slope angles are in degrees. To return values in radians, specify `lat` and `lon` in radians and `angleUnit` as `'radians'`.

Data Types: double

gradN — North components of gradient

matrix

North components of the gradient, returned as a matrix of the same size as F. The north component of a gradient is the change in R per unit of distance in the north direction, where the distance unit matches the length unit of the reference spheroid.

Data Types: double

gradE — East components of gradient

matrix

East components of the gradient, returned as a matrix of the same size as F. The east component of a gradient is the change in R per unit of distance in the east direction, where the distance unit matches the length unit of the reference spheroid.

Data Types: double

Version History

Introduced before R2006a

R2022b: `gradientm` will not accept referencing vectors or referencing matrices as input

Not recommended starting in R2022b

The `gradientm` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

R2020b: gradientm uses reference ellipsoid information in raster reference objects

When you specify `R` as a geographic raster reference object, the `gradientm` function uses the reference ellipsoid within the object. To find the reference ellipsoid for a geographic raster reference object, `R`, first get its geographic coordinate reference system as a `geocrs` object. Then, query the `Spheroid` property of the `geocrs` object.

```
g = R.GeographicCRS;  
g.Spheroid
```

To use `gradientm` with a different spheroid, specify the `spheroid` argument.

See Also**Functions**

`gradient` | `geoshow` | `axesm`

Objects

`GeographicPostingsReference` | `GeographicCellsReference`

Topics

“Geolocated Data Grids”

gridm

Control graticule lines on axesm-based map

Syntax

```
gridm
gridm('on')
gridm('off')
gridm('reset')
gridm(linespec)
gridm(MapAxesPropertyName, PropertyValue,...)
h = gridm(...)
```

Description

`gridm` toggles the display of a latitude-longitude graticule. The choice of meridians and parallels, as well as their graphics properties, depends on the property settings of the axesm-based map.

`gridm('on')` creates the graticule, if it does not yet exist, and makes it visible.

`gridm('off')` makes the graticule invisible.

`gridm('reset')` redraws the graticule using the current axesm-based map properties.

`gridm(linespec)` uses any valid `linespec` to control the graphics properties of the lines in the graticule.

`gridm(MapAxesPropertyName, PropertyValue,...)` sets the appropriate graticule properties to the desired values. For a description of these property names and values, see “Properties That Control the Grid” on page 1-0 section of the axesm property reference page.

`h = gridm(...)` returns the handles of the graticule lines. If both parallels and meridians exist, then `h` is a two-element vector: `h(1)` is the handle to the line comprising the parallels, and `h(2)` is the handle to the line comprising the meridians.

Tips

- You can also create or alter map grid properties using the `axesm` or `setm` functions.
- By default the Clipping property is set to 'off'. Override this setting with the following code:

```
hgrat = gridm('on');
set(hgrat,'Clipping','on')
```

Version History

Introduced before R2006a

See Also

axesm | setm

grid2image

Display regular data grid as image

Syntax

```
grid2image(Z,R)
grid2image(Z,R,PropertyName,PropertyValue,...)
h = grid2image(...)
```

Description

`grid2image(Z,R)` displays a regular data grid `Z` as an image. The image is displayed in unprojected form, with longitude as x and latitude as y , producing considerable distortion away from the Equator. `Z` can be M -by- N or M -by- N -by-3, and can contain `double`, `uint8`, or `uint16` data. The grid is georeferenced to latitude-longitude by `R`, which can be a geographic raster reference object, a referencing vector, or a referencing matrix.

If `R` is a geographic raster reference object, its `RasterSize` property must be consistent with `size(Z)` and its `RasterInterpretation` must be `'cells'`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel.

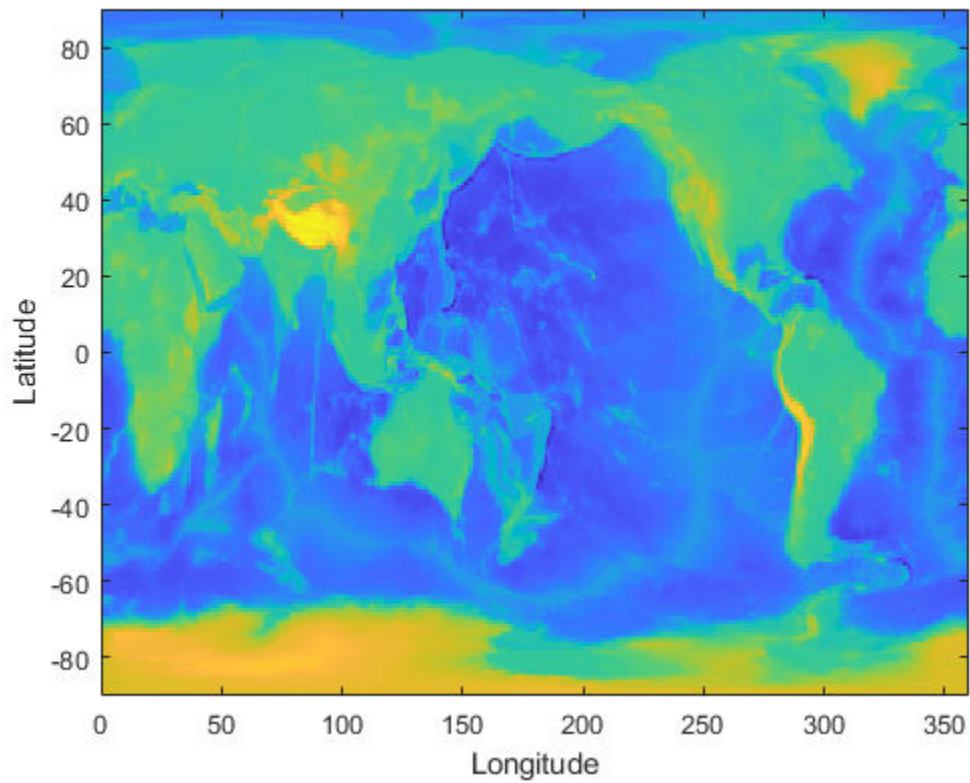
`grid2image(Z,R,PropertyName,PropertyValue,...)` uses the specified image properties to display the map. See the `image` function reference page for a list of properties that can be changed.

`h = grid2image(...)` returns the handle of the image object displayed.

Examples

Load elevation raster data and a geographic cells reference object. Then, display the data as an image.

```
load topo60c
figure
grid2image(topo60c,topo60cR)
```



Version History

Introduced before R2006a

See Also

[image](#) | [mapshow](#) | [meshm](#) | [surfacem](#) | [surfm](#)

grn2eqa

Convert from Greenwich to equal area coordinates

Syntax

```
[x,y] = grn2eqa(lat,lon)
[x,y] = grn2eqa(lat,lon,origin)
[x,y] = grn2eqa(lat,lon,origin,ellipsoid)
[x,y] = grn2eqa(lat,lon,origin,units)
mat = grn2eqa(lat,lon,origin...)
```

Description

`[x,y] = grn2eqa(lat,lon)` converts the Greenwich coordinates `lat` and `lon` to the equal-area coordinate points `x` and `y`.

`[x,y] = grn2eqa(lat,lon,origin)` specifies the location in the Greenwich system of the `x-y` origin (0,0). The two-element vector `origin` must be of the form [`latitude`, `longitude`]. The default places the origin at the Greenwich coordinates (0^o,0^o).

`[x,y] = grn2eqa(lat,lon,origin,ellipsoid)` specifies the ellipsoidal model of the figure of the Earth using `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form [`semimajor_axis` `eccentricity`]. The `ellipsoid` is spherical by default.

`[x,y] = grn2eqa(lat,lon,origin,units)` specifies the units for the inputs, where `units` is any valid angle units value. The default value is 'degrees'.

`mat = grn2eqa(lat,lon,origin...)` packs the outputs into a single variable.

The `grn2eqa` function converts data from Greenwich-based latitude-longitude coordinates to equal-area `x-y` coordinates. The opposite conversion can be performed with `eqa2grn`.

Examples

```
lats = [56 34]; longs = [-140 23];
[x,y] = grn2eqa(lats,longs)
```

```
x =
   -2.4435    0.4014
y =
    0.8290    0.5592
```

Version History

Introduced before R2006a

See Also

eqa2grn | hista

gshhs

Read Global Self-Consistent Hierarchical High-Resolution Geography (GSHHG) data

Syntax

```
S = gshhs(filename)
S = gshhs(filename,latlim,lonlim)
indexFilename = gshhs(filename,"createindex")
```

Description

`S = gshhs(filename)` reads “Global Self-Consistent Hierarchical High-Resolution Geography” on page 1-790 (GSHHG) vector data from a file.

`S = gshhs(filename,latlim,lonlim)` reads data within the latitude and longitude limits specified by `latlim` and `lonlim`.

`indexFilename = gshhs(filename,"createindex")` creates an index file called `indexFilename` that enables the `gshhs` function to more quickly read subsets of large data sets. Once you create the index file, the `gshhs` function uses it to access data by location.

This syntax does not read the GSHHG data. To read the data after creating the index file, use the `gshhs` function again.

Examples

Read and Display GSHHG Data

Extract a file containing coarse GSHHG data from a GNU zipped file. Read the file into the workspace as a geographic data structure array.

```
filename = gunzip("gshhs_c.b.gz");
S = gshhs(filename{1});
```

Verify that all elements of the structure array represent polygons.

```
isequal(S.Geometry,"Polygon")
```

```
ans = logical
     1
```

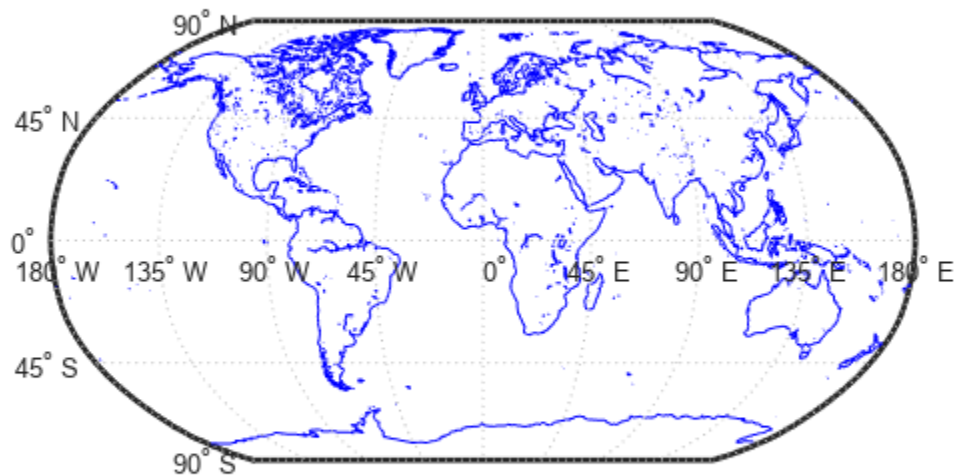
Query the number of polygons in the structure array.

```
length(S)
```

```
ans = 1866
```

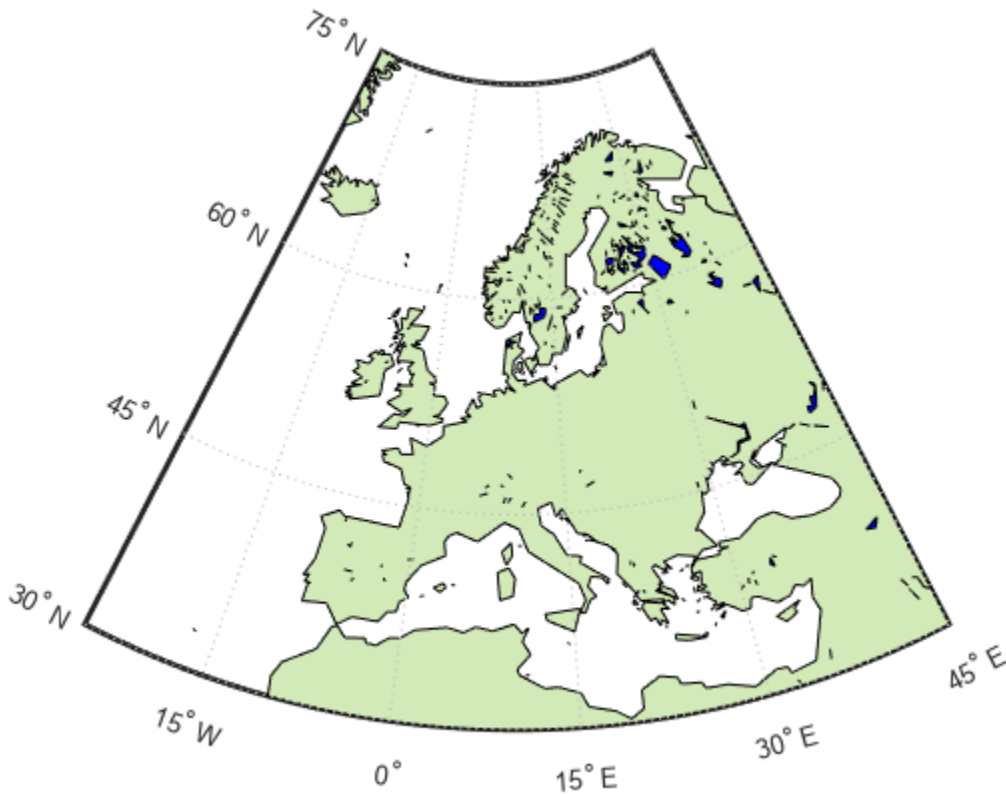
Extract the latitude and longitude coordinates of the polygons from the structure array. Then, display the data using lines on a world map.

```
lat = [S.Lat];  
lon = [S.Lon];  
  
figure  
worldmap world  
geoshow(lat,lon,"DisplayType","line")
```



Find the polygons corresponding to land areas (`levels == 1`) and lakes (`levels == 2`). Create a map of Europe with the land areas in green and the lakes in blue.

```
levels = [S.Level];  
land = (levels == 1);  
lake = (levels == 2);  
  
figure  
worldmap europe  
geoshow(S(land),"FaceColor","#d2e9b8")  
geoshow(S(lake),"FaceColor","b")
```



Read GSHHG Data Using Index

Extract a file containing coarse GSHHG data from a GNU zipped file. Create an index for the data.

```
filename = gunzip("gshhs_c.b.gz");
indexFilename = gshhs(filename{1}, "createindex");
```

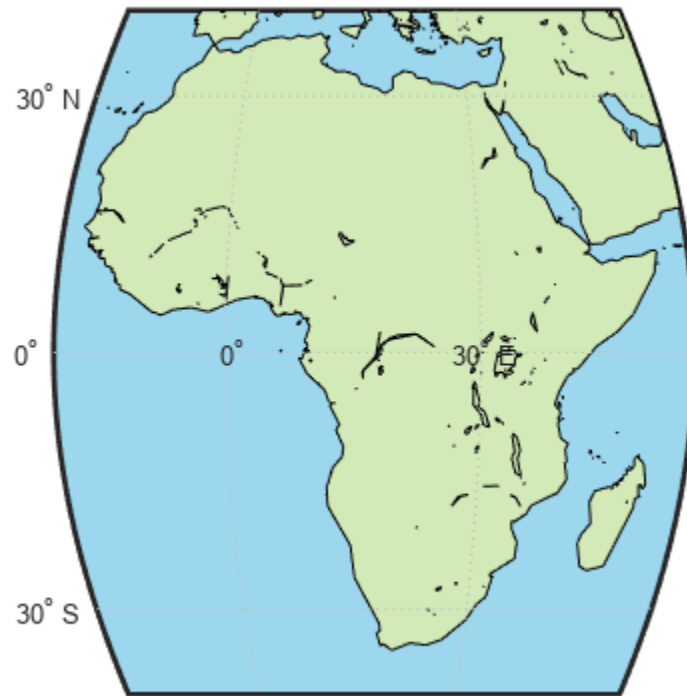
Read data for a region surrounding Africa into the workspace as a geographic data structure array. The `gshhs` function uses the index to more quickly read the data.

```
latlim = [-40 40];
lonlim = [-20 55];
S = gshhs(filename{1}, latlim, lonlim);
```

Display the data on a world map. To display the lakes and islands within the land areas, sort the structure array in descending order according to the `Level` field.

```
[~,ix] = sort([S.Level], "descend");
S = S(ix);
```

```
figure
worldmap(latlim, lonlim)
geoshow(S, "FaceColor", "#d2e9b8")
setm(gca, "FFaceColor", "#9dd7ee")
```

Input Arguments

filename — Name of GSHHG file

character vector | string scalar

Name of the GSHHG file, specified as a character vector or a string scalar.

The filename must have one of these forms:

- "gshhs_x.b"
- "wdb_borders_x.b"
- "wdb_rivers_x.b"

x must be c, l, i, h, or f. These letters correspond to the resolution of the file.

Data Types: char | string

latlim — Latitude limits

[] | two-element vector

Latitude limits, specified as an empty vector ([]) or a two-element vector in units of degrees.

When you specify `latlim` as an empty vector, the `gshhs` function reads data within the latitude limits [-90 90].

When you specify `latlim` as a two-element vector, the value of `latlim(1)` must be less than the value of `latlim(2)`.

Data Types: `double`

lonlim – Longitude limits

`[]` | two-element vector

Longitude limits, specified as an empty vector (`[]`) or a two-element vector in units of degrees.

When you specify `lonlim` as an empty vector, the `gshhs` function reads data within the longitude limits `[-180 195]`.

When you specify `lonlim` as a two-element vector, the value of `lonlim(1)` must be less than the value of `lonlim(2)`.

Data Types: `double`

Output Arguments

S – Geographic data structure

structure array

Geographic data structure, returned as a structure array with these fields:

Field	Description
Geometry	Geometric type, returned as 'Line' or 'Polygon'.
BoundingBox	Bounding box, returned as a 2-by-2 matrix of the form <code>[minLon minLat; maxLon maxLat]</code> . The values <code>minLon</code> and <code>minLat</code> indicate the minimum longitude and latitude, respectively. The values <code>maxLon</code> and <code>maxLat</code> indicate the maximum longitude and latitude, respectively.
Lon	Longitude coordinates, returned as a numeric vector.
Lat	Latitude coordinates, returned as a numeric vector.
South	Southern latitude boundary, returned as a numeric scalar.
North	Northern latitude boundary, returned as a numeric scalar.
West	Western longitude boundary, returned as a numeric scalar.
East	Eastern longitude boundary, returned as a numeric scalar.
Area	Area of the polygon in square kilometers, returned as a numeric scalar.

Field	Description
Level	Level in topological hierarchy, returned as an integer in the range [1, 4].
LevelString	Level in topological hierarchy, returned as 'land', 'lake', 'island_in_lake', 'pond_in_island_in_lake', or ''. When you read the WDB rivers and borders data sets, the LevelString field is empty.
NumPoints	Number of points in the polygon, returned as a nonnegative integer.
FormatVersion	Format version of the data file, returned as one of these values: <ul style="list-style-type: none"> • A positive integer — Indicates version 3 or later. • Empty — Indicates version 1 or 2.
Source	Data source, returned as one of these values: <ul style="list-style-type: none"> • 'WDBII' — CIA World Data Bank II • 'WVS' — World Vector Shorelines
CrossesGreenwich	Indicator for the polygon crossing the prime meridian, returned as 1 when the polygon crosses the prime meridian and 0 otherwise
GSHHS_ID	Unique polygon ID, returned as a nonnegative integer.

When the value of FormatVersion is at least 7 (release 2.0 and later), the structure array contains these additional fields.

Field	Description
RiverLake	Indicator for a river-lake, returned as 1 when a polygon is the fat part of a major river and the value of Level is 2, and 0 otherwise.
AreaFull	Area of the original full-resolution polygon, returned as a numeric scalar in units of $\frac{1}{10}km^2$.
Container	ID of the container polygon, returned as a nonnegative integer or -1. A value of -1 indicates that the polygon does not have a container (as in, the value of Level is 1).
Ancestor	ID of the ancestor full-resolution polygon, returned as a nonnegative integer or -1. A value of -1 indicates that the polygon does not have an ancestor.

When the value of FormatVersion is at least 9 (release 2.2 and later), the structure array contains this additional field.

Field Name	Field Contents
CrossesDateline	Indicator for the polygon crossing the dateline, returned as 1 when the polygon crosses the prime meridian and 0 otherwise

indexFilename — Name of index file

character vector

Name of the index file, returned as a character vector.

The index file has the same name as the GSHHG data file, but with the extension `i` instead of `b`. The function writes the file in the same folder as `filename`.

More About**Global Self-Consistent Hierarchical High-Resolution Geography**

Global Self-Consistent Hierarchical High-Resolution Geography (GSHHG) is a database created by Paul Wessel of the University of Hawaii and Walter H.F. Smith of the National Oceanic and Atmospheric Administration (NOAA) Geosciences Lab. This database includes coastlines, major rivers, and lakes. You can find GSHHG data in various resolutions from the Shoreline / Coastline Resources page on the NOAA website.

GSHHG is formerly known as Global Self-Consistent Hierarchical High-Resolution Shorelines (GSHHS).

Tips

- Mapping Toolbox contains the file `gshhs_c.b` within the GNU zipped file `gshhs_c.b.gz`. The file contains the coarse data set for version 3 (release 1.3).
- When you read data within specified limits, the `gshhs` function does not clip data that is partially within the limits. To clip the data and maintain polygon topology, use the `maptrim` function and specify the limits as the `Lat` and `Lon` fields contained in `S`.
- The `gshhs` function supports files up to version 15 (releases 1.1 through 2.3.6). The function can also read newer versions, provided they use the same header format as releases 2.0 and 2.1.

Version History

Introduced before R2006a

See Also**Functions**

readgeotable | vmap@data

Topics

"Find Geospatial Vector Data"

"Converting Coastline Data (GSHHG) to Shapefile Format"

gtextm

Add text to axesm-based map using mouse

Syntax

```
h = gtextm(text)
h = gtextm(text,PropertyName,PropertyValue,...)
```

Description

`h = gtextm(text)` places `text`, a string scalar or character vector, at the position selected by mouse input. When you call this function, `gtextm` brings up the current axesm-based map and activates the cursor for mouse-click position entry. `gtextm` returns a text object.

`h = gtextm(text,PropertyName,PropertyValue,...)` allows the specification of any properties supported by the MATLAB text function.

Examples

Create an axesm-based map:

```
axesm('sinusoid','FEdgeColor','red')
gtextm('hello world','FontWeight','bold')
```

Click inside the frame and the text appears.

Version History

Introduced before R2006a

See Also

`axesm` | `textm`

gtopo30

(To be removed) Read 30-arc-second global digital elevation data (GTOPO30)

Note `gtopo30` will be removed in a future release. Use `readgeoraster` instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z,refvec] = gtopo30(tilename)
[Z,refvec] = gtopo30(tilename,samplefactor)
[Z,refvec] = gtopo30(tilename,samplefactor,latlim,lonlim)
[Z,refvec] = gtopo30(foldername, ...)
```

Description

`[Z,refvec] = gtopo30(tilename)` reads the GTOPO30 tile specified by `tilename` and returns the result as a regular data grid. `tilename` is a string scalar or character vector which does not include an extension and indicates a GTOPO30 tile in the current folder or on the MATLAB path. If `tilename` is empty or omitted, a file browser will open for interactive selection of the GTOPO30 header file. The data is returned at full resolution with the latitude and longitude limits determined from the GTOPO30 tile. The data grid, `Z`, is returned as an array of elevations. Elevations are given in meters above mean sea level using WGS84 as a horizontal datum. `refvec` is the associated referencing vector.

`[Z,refvec] = gtopo30(tilename,samplefactor)` reads a subset of the elevation data from `tilename`. `samplefactor` is a scalar integer, which when equal to 1 reads the data at its full resolution. When `samplefactor` is an integer `n` greater than one, every `n`th point is read. If `samplefactor` is omitted or empty, it defaults to 1.

`[Z,refvec] = gtopo30(tilename,samplefactor,latlim,lonlim)` reads a subset of the elevation data from `tilename` using the latitude and longitude limits `latlim` and `lonlim` specified in degrees. `latlim` is a two-element vector of the form:

```
[southern_limit northern_limit]
```

Likewise, `lonlim` has the form:

```
[western_limit eastern_limit]
```

If `latlim` and `lonlim` are omitted, the coordinate limits are determined from the file. The latitude and longitude limits are snapped outward to define the smallest possible rectangular grid of GTOPO30 cells that fully encloses the area defined by the input limits. Any cells in this grid that fall outside the extent of the tile are filled with NaN.

`[Z,refvec] = gtopo30(foldername, ...)` is similar to the syntaxes above except that GTOPO30 data are read and concatenated from multiple tiles within a GTOPO30 CD-ROM or folder structure. The `foldername` input is a string scalar or character vector with the name of the folder

which contains the GTOPO30 tile folders or GTOPO30 tiles. Within the tile folders are the uncompressed data files. The foldername for CD-ROMs distributed by the USGS is the device name of the CD-ROM drive. As with the case with a single tile, any cells in the grid specified by `latlim` and `lonlim` are NaN filled if they are not covered by a tile within foldername. `samplefactor` if omitted or empty defaults to 1. `latlim` if omitted or empty defaults to [-90 90]. `lonlim` if omitted or empty defaults to [-180 180].

For details on locating GTOPO30 data for download over the Internet, see “Find Geospatial Data Online”.

Examples

Display Data Grid and Overlay State Line Boundary

To run this example, you must download the GTOPO30 data set. For details on locating this data set for download over the Internet, see “Find Geospatial Data Online”.

Extract and display full resolution data for the state of Massachusetts. Read the state line polygon boundary and calculate boundary limits.

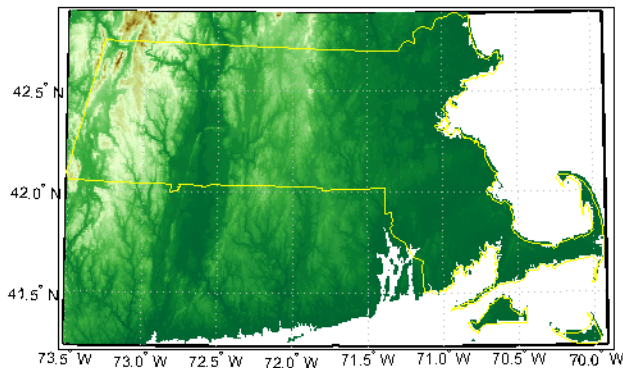
```
Massachusetts = shaperead('usastatehi','UseGeoCoords',true, ...
    'Selector',{@(name) strcmpi(name,'Massachusetts'),'Name'});
latlim = [min(Massachusetts.Lat(:)) max(Massachusetts.Lat(:))];
lonlim = [min(Massachusetts.Lon(:)) max(Massachusetts.Lon(:))];
```

Read the GTOPO30 data at full resolution.

```
[Z,refvec] = gtopo30('W100N90',1,latlim,lonlim);
```

Display the data grid and overlay the state line boundary.

```
figure
ax = usamap(Z,refvec);
ax.SortMethod = 'ChildOrder';
geoshow(Z,refvec,'DisplayType','surface')
demcmap(Z)
geoshow(Massachusetts,'DisplayType','polygon',...
    'facecolor','none','edgecolor','y')
```



Version History

Introduced before R2006a

R2021b: Warns

Warns starting in R2021b

Raster reading functions that return referencing vectors issue a warning that they will be removed in a future release, including `gtopo30`. Instead, use `readgeoraster`, which returns a raster reference object. Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see `GeographicCellsReference` and `GeographicPostingsReference`.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` function.
- Most functions that accept referencing vectors as input also accept reference objects.

This table shows some typical usages of `gtopo30` and how to update your code to use `readgeoraster` instead. Unlike `gtopo30`, the `readgeoraster` function requires you to specify a file extension. For example, use `[Z,R] = readgeoraster('W100N90.dem')`.

Will Be Removed	Recommended
<code>[Z,refvec] = gtopo30(filename);</code>	<code>[Z,R] = readgeoraster(filename);</code>
<code>[Z,refvec] = gtopo30(filename,samplefactor);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>[Z,R] = georesize(Z,R,1/samplefactor);</code>
<code>[Z,refvec] = gtopo30(filename,samplefactor,LatLim=lonlim);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>[Z,R] = geocrop(Z,R,latlim,lonlim);</code> <code>[Z,R] = georesize(Z,R,1/scalefactor);</code>

The `readgeoraster` function returns data using the native data type embedded in the file. Return a data using a different data type by specifying the 'OutputType' name-value pair. For example, use `[Z,R] = readgeoraster(filename,'OutputType','double')`.

The `readgeoraster` function does not automatically replace missing data with NaN values. If your data set uses large negative numbers to indicate missing data, you can replace them with NaN values using the `standardizeMissing` function.

```
[Z,R] = readgeoraster('MtWashington-ft.grd');  
info = georasterinfo('MtWashington-ft.grd');  
m = info.MissingDataIndicator;  
Z = standardizeMissing(Z,m);
```

R2020a: To be removed

Not recommended starting in R2020a

The `gtopo30` function runs without warning but will be removed in a future release.

See Also

`gtopo30s` | `readgeoraster` | `georasterinfo`

gtopo30s

GTOPO30 data file names for latitude-longitude quadrangle

Syntax

```
tileNames = gtopo30s(latlim,lonlim)
tileNames = gtopo30s(lat,lon)
```

Description

`tileNames = gtopo30s(latlim,lonlim)` returns a cell array of the tile names covering the geographic region for GTOPO30 digital elevation maps (also referred to as “30-arc second” DEMs). `latlim` and `lonlim` specify the region as two-element vectors of latitude and longitude limits in units of degrees.

`tileNames = gtopo30s(lat,lon)` returns a cell array of the tile names covering the geographic region for GTOPO30 digital elevation maps. `lat` and `lon` specify the region as scalar latitude and longitude points.

Version History

Introduced before R2006a

See Also

`readgeoraster`

handlem

Handles of objects on axesm-based map

Syntax

```
handlem
handlem('taglist')
handlem('prompt')
h = handlem(object)
h = handlem(tagstr)
h = handlem(____,axesh)
h = handlem(____,axesh,'searchmethod')
h = handlem(handles)
```

Description

handlem displays a dialog box for selecting objects that have their Tag property set.

handlem('taglist') displays a dialog box for selecting objects that have their Tag property set.

handlem('prompt') displays a dialog box for selecting objects based on the objects listed below.

`h = handlem(object)` returns the graphics objects in the current axes specified by the input, object. The options for the object are defined by the following list:

'all'	All children
'clabel'	Contour labels
'contour'	hggroup containing contours
'fillcontour'	hggroup containing filled contours
'frame'	Map frame
'grid'	Map grid lines
'hggroup'	All hggroup objects
'hidden'	Hidden objects
'image'	Untagged image objects
'light'	Untagged light objects
'line'	Untagged line objects
'map'	All objects on the map, excluding the frame and grid
'meridian'	Longitude grid lines
'mlabel'	Longitude labels
'parallel'	Latitude grid lines
'plabel'	Latitude labels
'patch'	Untagged patch objects
'scaleruler'	scaleruler objects

'surface'	Untagged surface objects
'text'	Untagged text objects
'tissot'	Tissot indicatrices
'visible'	Visible objects

`h = handlem(tagstr)` returns any graphics objects whose tags match the value of `tagstr`.

`h = handlem(____, axes)` searches within the specified axes.

`h = handlem(____, axes, 'searchmethod')` controls the method used to match the `object` input. If omitted, 'exact' is assumed. Search method 'strmatch' searches for matches that start at the beginning of the tag. Search method 'findstr' searches anywhere within the tag for the object.

`h = handlem(handles)` returns those graphics objects in the input vector of graphics objects that are still valid.

You can apply the prefix 'all' when defining an object type (text, line, patch, light, surface, or image) to find all objects that meet the type criteria (for example, 'allimage'). Without the 'all' prefix, `handlem` returns only objects with an empty tag.

Version History

Introduced before R2006a

See Also

`findobj`

hidem

Hide objects on axesm-based map

Syntax

```
hidem  
hidem(obj)  
hidem(objType)
```

Description

hidem opens a dialog box that enables you to interactively select objects to hide. The hidem function hides objects by setting their `Visible` property to "off".

hidem(obj) hides the specified objects.

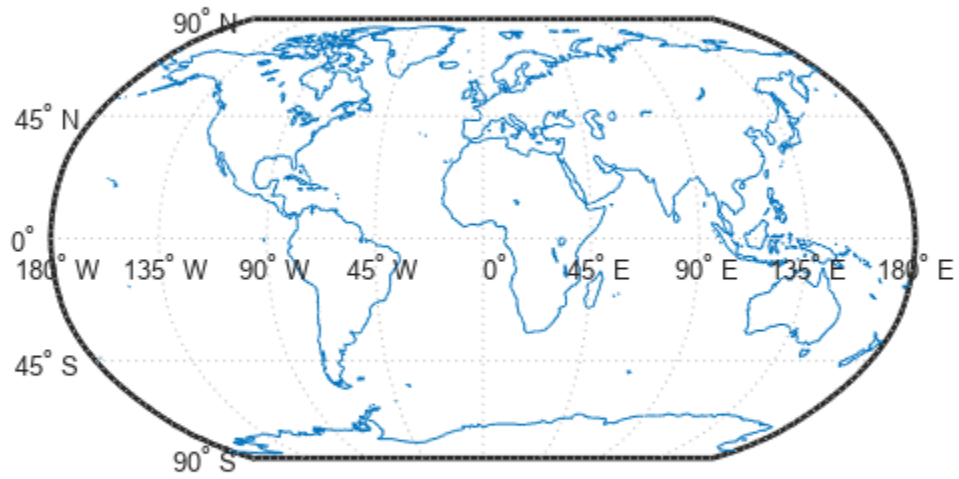
hidem(objType) hides objects of the specified type.

Examples

Hide and Show Objects on Map

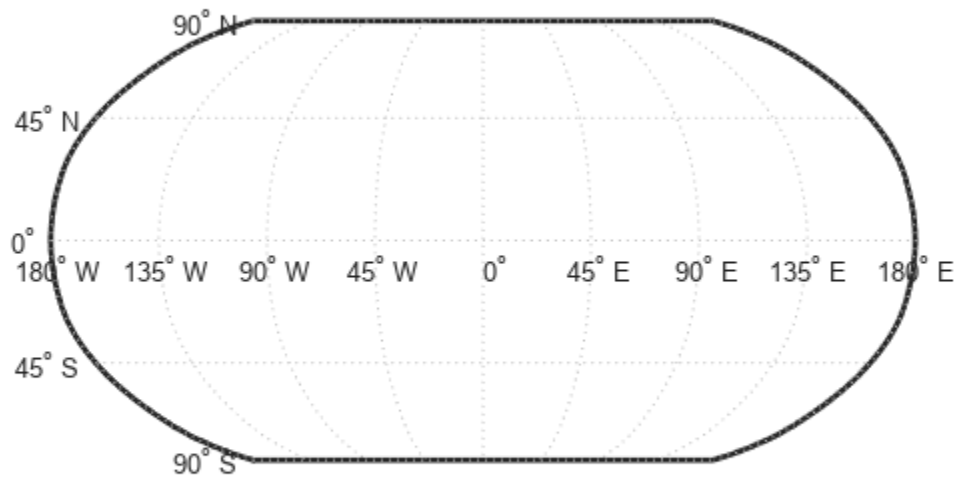
Load a MAT file containing the coordinates of global coastlines into the workspace. Create a world map, and then plot the coastline data.

```
load coastlines  
figure  
worldmap world  
p = plotm(coastlat,coastlon);
```



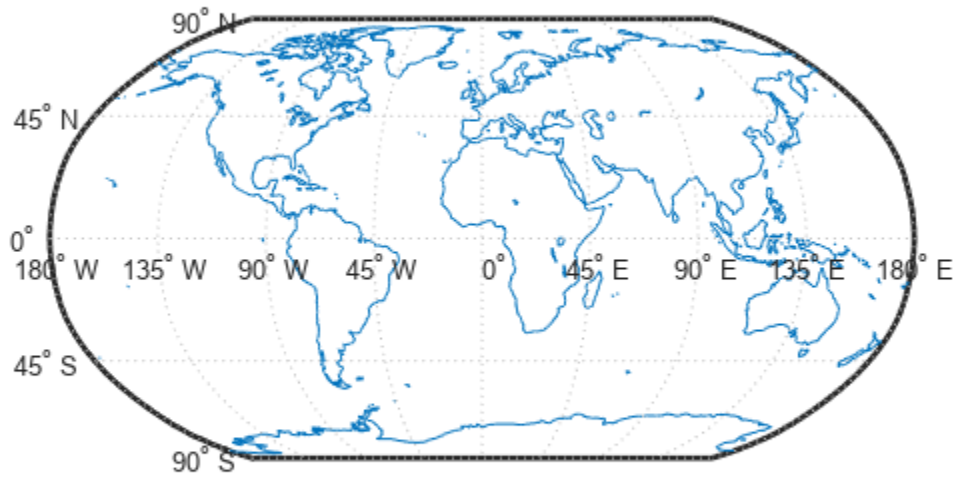
Hide the plotted data.

```
hidem(p)
```



Show the plotted data again.

```
showm(p)
```



Input Arguments

obj — **Objects to hide**
array of graphics objects

Objects to hide, specified as an array of graphics objects.

objType — **Type of graphics object to hide**
"all" | "clabel" | "contour" | "fillcontour" | "frame" | ...

Type of graphics object to hide, specified as one of these options.

Option	Description
"all"	All children
"clabel"	Contour labels
"contour"	hggroup containing contours
"fillcontour"	hggroup containing filled contours
"frame"	Map frame
"grid"	Map grid lines
"hggroup"	All hggroup objects

Option	Description
"hidden"	Hidden objects
"image"	Untagged image objects
"light"	Untagged light objects
"line"	Untagged line objects
"map"	All objects on the map, excluding the frame and grid
"meridian"	Longitude grid lines
"mlabel"	Longitude labels
"parallel"	Latitude grid lines
"plabel"	Latitude labels
"patch"	Untagged patch objects
"scaleruler"	Scale rulers
"surface"	Untagged surface objects
"text"	Untagged text objects
"tissot"	Tissot indicatrices
"visible"	Visible objects

Data Types: char | string

Version History

Introduced before R2006a

See Also

Functions

clma | clmo | showm

hista

Bin counts for geographic points using equal-area bins

Syntax

```
[latbin,lonbin,count] = hista(lat,lon)
[latbin,lonbin,count] = hista(lat,lon,binarea)
[latbin,lonbin,count] = hista(lat,lon,binarea,spheroid)
[latbin,lonbin,count] = hista( ____,angleunits)
```

Description

`[latbin,lonbin,count] = hista(lat,lon)` bins the geographic locations indicated by vectors `lat` and `lon`, using equal area binning on a sphere. The default bin area is 100 square kilometers. The `latbin` and `lonbin` outputs are column vectors indicating the centers of non-empty bins. `count` matches `latbin` and `lonbin` in size, with each element containing a positive integer equal to the number of occurrences in the corresponding bin.

Binning is performed on a mesh within a quadrangle whose latitude and longitude limits match the extrema of the input locations. The input and output latitudes and longitudes are in units of degrees.

`[latbin,lonbin,count] = hista(lat,lon,binarea)` uses the bin size specified by the input `binarea`, which must be in square kilometers

`[latbin,lonbin,count] = hista(lat,lon,binarea,spheroid)` bins the data on the reference spheroid defined by `spheroid`. `spheroid` is a `referenceEllipsoid` (`oblateSpheroid`) object, a `referenceSphere` object, or a vector of the form `[semimajor_axis eccentricity]`. The eccentricity/flattening of the spheroid is used in determining the latitude extent of the bins. The semimajor axis of the spheroid is used to determine the longitude extent of the bins, but if the length unit of the spheroid is unspecified, the mean radius of the earth in kilometers is used as the equatorial radius.

`[latbin,lonbin,count] = hista(____,angleunits)` where `angleunits` defines the angle units of the inputs and outputs, specified as `'degrees'` or `'radians'`.

Examples

Bin Latitudes and Longitudes

Create some random latitudes.

```
rng(0,'twister')
lats = rand(4)
```

```
lats = 4×4
```

```
    0.8147    0.6324    0.9575    0.9572
    0.9058    0.0975    0.9649    0.4854
    0.1270    0.2785    0.1576    0.8003
```

```
0.9134 0.5469 0.9706 0.1419
```

Create some random longitudes.

```
lons = rand(4)
```

```
lons = 4x4
```

```
0.4218 0.6557 0.6787 0.6555
0.9157 0.0357 0.7577 0.1712
0.7922 0.8491 0.7431 0.7060
0.9595 0.9340 0.3922 0.0318
```

Bin the data in 50-by-50 km cells (2500 sq km).

```
[lat,lon,num] = hista(lats,lons,2500);
```

```
[lat,lon,num]
```

```
ans = 9x3
```

```
0.0932 -0.0208 2.0000
0.5341 0.3235 1.0000
0.9750 0.3235 2.0000
0.0932 0.6678 2.0000
0.5341 0.6678 1.0000
0.9750 0.6678 4.0000
0.0932 1.0122 1.0000
0.5341 1.0122 1.0000
0.9750 1.0122 2.0000
```

Version History

Introduced before R2006a

See Also

eqa2grn | grn2eqa | histr

histr

Histogram for geographic points with equirectangular bins

Syntax

```
[lat,lon,num,wnum] = histr(lats,lons)
[lat,lon,num,wnum] = histr(lats,lons,units)
[lat,lon,num,wnum] = histr(lats,lons,bindensty)
```

Description

`[lat,lon,num,wnum] = histr(lats,lons)` returns the center coordinates of equal-rectangular bins and the number of observations, `num`, falling in each based on the geographically distributed input data. Additionally, an area-weighted observation value, `wnum`, is returned. `wnum` is the bin's `num` divided by its normalized area. The largest bin has the same `num` and `wnum`; a smaller bin has a larger `wnum` than `num`.

`[lat,lon,num,wnum] = histr(lats,lons,units)` where `units` specifies the angle unit. The default value is 'degrees'.

`[lat,lon,num,wnum] = histr(lats,lons,bindensty)` sets the number of bins per angular unit. For example, if `units` is 'degrees', a `bindensty` of 10 would be 10 bins per degree of latitude or longitude, resulting in 100 bins per *square* degree. The default is one cell per angular unit.

The `histr` function sorts geographic data into equirectangular bins for histogram purposes. Equirectangular in this context means that each bin has the same angular measurement on each side (e.g., 1°-by-1°). Consequently, the result is not an equal-area histogram. The `hista` function provides that capability. However, the results of `histr` can be weighted by their area bias to correct for this, in some sense.

Examples

Bin Latitudes and Longitudes with Equirectangular Bins

Create some random latitudes.

```
rng(0, 'twister')
lats = rand(4)
```

```
lats = 4×4
```

```
    0.8147    0.6324    0.9575    0.9572
    0.9058    0.0975    0.9649    0.4854
    0.1270    0.2785    0.1576    0.8003
    0.9134    0.5469    0.9706    0.1419
```

Create some random longitudes.

```
lons = rand(4)
```

```
lons = 4x4
```

```
0.4218 0.6557 0.6787 0.6555
0.9157 0.0357 0.7577 0.1712
0.7922 0.8491 0.7431 0.7060
0.9595 0.9340 0.3922 0.0318
```

Bin the data in 0.5-by-0.5 degree cells (two bins per degree). The bins centered at 0.75°N are slightly smaller in area than the others. `wnum` reflects the relative count per normalized unit area.

```
[lat,lon,num,wnum] = histr(lats,lons,2);
```

```
[lat,lon,num,wnum]
```

```
ans = 4x4
```

```
0.2500 0.2500 3.0000 3.0000
0.7500 0.2500 2.0000 2.0002
0.2500 0.7500 3.0000 3.0000
0.7500 0.7500 8.0000 8.0006
```

Version History

Introduced before R2006a

See Also

`filterm` | `hista`

imbedm

Encode data points into regular data grid

Syntax

```
Z = imbedm(lat, lon, value, Z, R)
Z = imbedm(lat, lon, value, Z, R, units)
[Z, indxPointOutsideGrid] = imbedm(...)
```

Description

`Z = imbedm(lat, lon, value, Z, R)` resets certain entries of a regular data grid, `Z`. Specify `R` as a `GeographicCellsReference` or `GeographicPostingsReference` object. The `RasterSize` property of `R` must be consistent with `size(Z)`.

`Z = imbedm(lat, lon, value, Z, R, units)` specifies the units of the vectors `lat` and `lon`, where `units` is any valid angle units character vector ('degrees' by default).

`[Z, indxPointOutsideGrid] = imbedm(...)` returns the indices of `lat` and `lon` corresponding to points outside the grid in the variable `indxPointOutsideGrid`.

Examples

Create a simple grid map and embed new values in it:

```
Z = ones(3,6)
```

```
Z =
     1     1     1     1     1     1
     1     1     1     1     1     1
     1     1     1     1     1     1
```

```
refvec = [1/60 90 -180]
```

```
refvec =
     0.0167     90.0000    -180.0000
```

```
newgrid = imbedm([23 -23], [45 -45],[5 5],Z,refvec)
```

```
newgrid =
     1     1     1     1     1     1
     1     1     5     5     1     1
     1     1     1     1     1     1
```

Version History

Introduced before R2006a

R2022b: `imbedm` will not accept referencing vectors or referencing matrices as input
Not recommended starting in R2022b

The `imbedm` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

See Also

`geointerp` | `geographicToDiscrete`

ind2rgb8

Convert indexed image to uint8 RGB image

Syntax

```
RGB = ind2rgb8(X,cmap)
```

Description

`RGB = ind2rgb8(X,cmap)` creates an RGB image of class `uint8`. `X` must be `uint8`, `uint16`, or `double`, and `cmap` must be a valid MATLAB colormap.

Examples

```
% Convert the 'concord_ortho_e.tif' image to RGB.  
[X, cmap] = imread('concord_ortho_e.tif');  
RGB = ind2rgb8(X, cmap);  
R = worldfileread('concord_ortho_e.tfw','planar',size(X));  
mapshow(RGB, R);
```

Version History

Introduced before R2006a

See Also

`ind2rgb`

ingeoquad

True for points inside or on lat-lon quadrangle

Syntax

```
tf = ingeoquad(lat, lon, latlim, lonlim)
```

Description

`tf = ingeoquad(lat, lon, latlim, lonlim)` returns an array `tf` that has the same size as `lat` and `lon`. `tf(k)` is true if and only if the point `lat(k)`, `lon(k)` falls within or on the edge of the geographic quadrangle defined by `latlim` and `lonlim`. `latlim` is a vector of the form [southern-limit northern-limit], and `lonlim` is a vector of the form [western-limit eastern-limit]. All angles are in units of degrees.

Examples

- 1 Load elevation data and a geographic cells reference object for the Korean peninsula. Display the data on a world map. Apply a colormap appropriate for elevation data using `demcmap`.

```
load korea5c
figure('Color','white')
worldmap([20 50],[90 150])
geoshow(korea5c,korea5cR,'DisplayType','texturemap');
demcmap(korea5c)
```

- 2 Outline the quadrangle containing the elevation data:

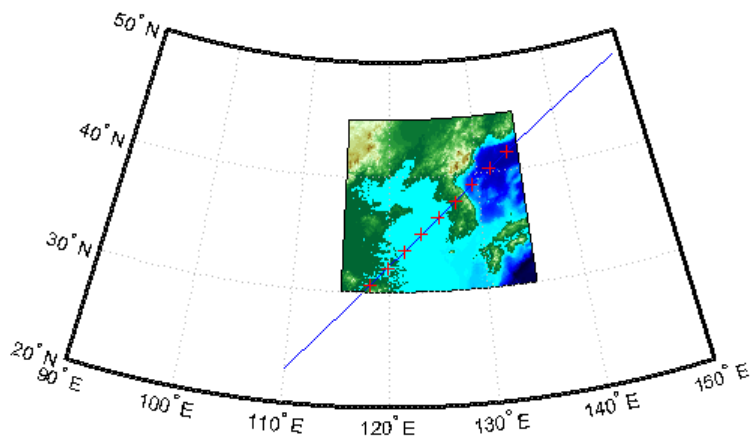
```
[outlineLat, outlineLon] = outlinegeoquad(korea5cR.LatitudeLimits, ...
    korea5cR.LongitudeLimits,90,5);
geoshow(outlineLat,outlineLon,'DisplayType','line', ...
    'Color','k')
```

- 3 Generate a track that crosses the elevation data:

```
[lat,lon] = track2(23,110,48,149,[1 0],'degrees',20);
geoshow(lat,lon,'DisplayType','line')
```

- 4 Identify and mark points on the track that fall within the quadrangle outlining the elevation data:

```
tf = ingeoquad(lat,lon,korea5cR.LatitudeLimits, ...
    korea5cR.LongitudeLimits);
geoshow(lat(tf),lon(tf),'DisplayType','point')
```



Version History

Introduced in R2008a

See Also

`inpolygon` | `intersectgeoquad`

intersectgeoquad

Intersection of two latitude-longitude quadrangles

Syntax

```
[latlim, lonlim] = intersectgeoquad(latlim1, lonlim1, latlim2, lonlim2)
```

Description

`[latlim, lonlim] = intersectgeoquad(latlim1, lonlim1, latlim2, lonlim2)` computes the intersection of the quadrangle defined by the latitude and longitude limits `latlim1` and `lonlim1`, with the quadrangle defined by the latitude and longitude limits `latlim2` and `lonlim2`. `latlim1` and `latlim2` are two-element vectors of the form `[southern-limit northern-limit]`. Likewise, `lonlim1` and `lonlim2` are two-element vectors of the form `[western-limit eastern-limit]`. All input and output angles are in units of degrees. The intersection results are given in the output arrays `latlim` and `lonlim`. Given an arbitrary pair of input quadrangles, there are three possible results:

- 1 *The quadrangles fail to intersect.* In this case, both `latlim` and `lonlim` are empty arrays.
- 2 *The intersection consists of a single quadrangle.* In this case, `latlim` (like `latlim1` and `latlim2`) is a two-element vector that has the form `[southern-limit northern-limit]`, where `southern-limit` and `northern-limit` represent scalar values. `lonlim` (like `lonlim1` and `lonlim2`), is a two-element vector that has the form `[western-limit eastern-limit]`, with a pair of scalar limits.
- 3 *The intersection consists of a pair of quadrangles.* This can happen when longitudes wrap around such that the eastern end of one quadrangle overlaps the western end of the other and vice versa. For example, if `lonlim1 = [-90 90]` and `lonlim2 = [45 -45]`, there are two intervals of overlap: `[-90 -45]` and `[45 90]`. These limits are returned in `lonlim` in separate rows, forming a 2-by-2 array. In our example (assuming that the latitude limits overlap), `lonlim` would equal `[-90 -45; 45 90]`. It still has the form `[western-limit eastern-limit]`, but `western-limit` and `eastern-limit` are 2-by-1 rather than scalar. The two output quadrangles have the same latitude limits, but these are replicated so that `latlim` is also 2-by-2.

To continue the example, if `latlim1 = [0 30]` and `latlim2 = [20 50]`, `latlim` equals `[20 30; 20 30]`. The form is still `[southern-limit northern-limit]`, but in this case `southern-limit` and `northern-limit` are 2-by-1.

Examples

Example 1

Nonintersecting quadrangles:

```
[latlim, lonlim] = intersectgeoquad( ...
    [-40 -60], [-180 180], [40 60], [-180 180])
```

```
latlim =
```

```
    []
```

```
lonlim =
```

```
    []
```

Example 2

Intersection is a single quadrangle:

```
[latlim, lonlim] = intersectgeoquad( ...  
                                [-40 60], [-120 45], [-60 40], [160 -75])
```

```
latlim =
```

```
    -40    40
```

```
lonlim =
```

```
   -120   -75
```

Example 3

Intersection is a pair of quadrangles:

```
[latlim, lonlim] = intersectgeoquad( ...  
                                [-30 90], [-10 -170], [-90 30], [170 10])
```

```
latlim =
```

```
   -30    30  
   -30    30
```

```
lonlim =
```

```
   -10    10  
   170  -170
```

Example 4

Inputs and output fully encircle the planet:

```
[latlim, lonlim] = intersectgeoquad( ...  
                                [-30 90], [-180 180], [-90 30], [0 360])
```

```
latlim =
```

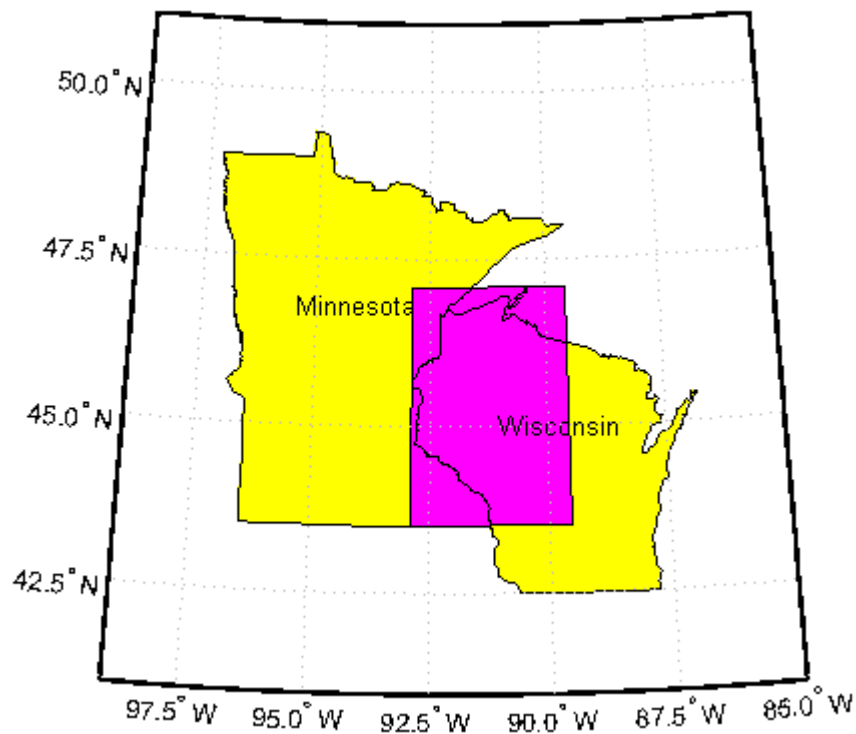
```
   -30    30
```

```
lonlim =
    -180    180
```

Example 5

Find and map the intersection of the bounding boxes of adjoining U.S. states:

```
usamap({'Minnesota','Wisconsin'})
S = shaperead('usastatehi','UseGeoCoords',true,'Selector',...
    {@(name) any(strcmp(name,{'Minnesota','Wisconsin'})), 'Name'});
geoshow(S, 'FaceColor', 'y')
textm([S.LabelLat], [S.LabelLon], {S.Name},...
    'HorizontalAlignment', 'center')
latlimMN = S(1).BoundingBox(:,2)';
lonlimMN = S(1).BoundingBox(:,1)';
latlimWI = S(2).BoundingBox(:,2)';
lonlimWI = S(2).BoundingBox(:,1)';
[latlim lonlim] = ...
    intersectgeoquad(latlimMN, lonlimMN, latlimWI, lonlimWI);
geoshow(latlim([1 2 2 1]), lonlim([1 1 2 2]), ...
    'DisplayType','polygon','FaceColor','m')
```



Tips

latlim1 and latlim2 should normally be given in order of increasing numerical value. No error will result if, for example, latlim1(2) < latlim1(1), but the outputs will both be empty arrays.

No such restriction applies to `lonlim1` and `lonlim2`. The first element is always interpreted as the western limit, even if it exceeds the second element (the eastern limit). Furthermore, `intersectgeoquad` correctly handles whatever longitude-wrapping convention may have been applied to `lonlim1` and `lonlim2`.

In terms of output, `intersectgeoquad` wraps `lonlim` such that all elements fall in the closed interval `[-180 180]`. This means that if (one of) the output quadrangle(s) crosses the 180° meridian, its western limit exceeds its eastern limit. The result would be such that

```
lonlim(2) < lonlim(1)
```

if the intersection comprises a single quadrangle or

```
lonlim(k,2) < lonlim(k,1)
```

where `k` equals 1 or 2 if the intersection comprises a pair of quadrangles.

If `abs(diff(lonlim1))` or `abs(diff(lonlim2))` equals 360, its quadrangle is interpreted as a latitudinal zone that fully encircles the planet, bounded only by one parallel on the south and another parallel on the north. If two such quadrangles intersect, `lonlim` is set to `[-180 180]`.

If you want to display geographic quadrangles generated by this function or any other which are more than one or two degrees in extent, they may not follow curved meridians and parallels very well. The degree of departure depends on the extent of the quadrangle, the map projection, and the map scale. In such cases, you can interpolate intermediate vertices along quadrangle edges with the `outlinegeoquad` function.

Version History

Introduced in R2008a

See Also

`ingeoquad` | `outlinegeoquad`

inputm

Identify latitudes and longitudes on axesm-based map using mouse

Syntax

```
[lat, lon] = inputm
[lat, lon] = inputm(n)
[lat, lon] = inputm(n,h)
[lat, lon, button] = inputm(n)
MAT = inputm(...)
```

Description

`[lat, lon] = inputm` returns the latitudes and longitudes in geographic coordinates of points selected by mouse clicks on a displayed grid. The point selection continues until the return key is pressed.

To identify latitudes and longitudes on geographic axes or map axes, use the `ginput` function instead.

`[lat, lon] = inputm(n)` returns n points specified by mouse clicks.

`[lat, lon] = inputm(n,h)` prompts for points from the axesm-based map specified by the handle `h`. If omitted, the current axes (`gca`) is assumed.

`[lat, lon, button] = inputm(n)` returns a third result, `button`, that contains a vector of integers specifying which mouse button was used (1,2,3 from left) or ASCII numbers if a key on the keyboard was used.

`MAT = inputm(...)` returns a single matrix, where `MAT = [lat lon]`.

Tips

`inputm` works much like the standard MATLAB `ginput`, except that the returned values are latitudes and longitudes extracted from the projection, rather than axes x - y coordinates. If you click outside of the projection bounds (beyond the map frame in the corners of a Robinson projection, for example), no coordinates are returned for that location.

`inputm` cannot be used with a 3-D display, including those created using `globe`.

Version History

Introduced before R2006a

See Also

`gcpmap` | `ginput`

interpm

Densify latitude-longitude sampling in lines or polygons

Syntax

```
[latout,lonout] = interpm(lat,lon,maxdiff)
[latout,lonout] = interpm(lat,lon,maxdiff,method)
[latout,lonout] = interpm(lat,lon,maxdiff,method,units)
```

Description

`[latout,lonout] = interpm(lat,lon,maxdiff)` fills in any gaps in latitude (`lat`) or longitude (`lon`) data vectors that are greater than a defined tolerance `maxdiff` apart in either dimension. The angle units of the three inputs need not be specified, but they must be identical. `latout` and `lonout` are the new latitude and longitude data vectors, in which any gaps larger than `maxdiff` in the original vectors have been filled with additional points. The default method of interpolation used by `interpm` is linear.

`[latout,lonout] = interpm(lat,lon,maxdiff,method)` interpolates between vector data coordinate points using a specified interpolation method. Valid interpolation methods are 'gc' for great circle, 'rh' for rhumb line, and 'lin' for linear interpolation.

`[latout,lonout] = interpm(lat,lon,maxdiff,method,units)` specifies the units used, where `units` is any valid angle unit. The default is 'degrees'.

Examples

Interpolate Vertices Between Known Data Points

Define two vectors containing the latitude and longitude values for a set of vertices. In `lat`, note that a gap of 2 degrees exists between the values 2 and 4. Similarly, in `lon`, a gap of 2 degrees exists between the values 1 and 3.

```
lat = [1 2 4 5];
lon = [1 3 4 5];
```

Call `interpm` to fill in any gaps greater than 1 degree in either vector. For example, `interpm` interpolates and inserts the value 2 into the `lon` vector to fill the gap between the values 1 and 3, and inserts the value 1.5 in the `lat` vector for this new vertex. Similarly, `interpm` inserts the value 3 into the `lat` vector to fill the gap between the values 2 and 4, and inserts the value 3.5 in the `lon` vector for this new vertex. Now, the separation of adjacent vertices is no greater than `maxdiff` in either `newlat` or `newlon`.

```
maxdiff = 1;
[newlat,newlon] = interpm(lat,lon,maxdiff)
```

```
newlat = 6×1
```

```
1.0000
```



```
1.5000  
2.0000  
3.0000  
4.0000  
5.0000
```

```
newlon = 6×1
```

```
1.0000  
2.0000  
3.0000  
3.5000  
4.0000  
5.0000
```

Version History

Introduced before R2006a

See Also

[intrplat](#) | [intrplon](#)

intrinsicToGeographic

Package: map.rasterref

Transform intrinsic to geographic coordinates

Syntax

```
[lat,lon] = intrinsicToGeographic(R,xIntrinsic,yIntrinsic)
```

Description

`[lat,lon] = intrinsicToGeographic(R,xIntrinsic,yIntrinsic)` returns the geographic coordinates corresponding to intrinsic coordinates (`xIntrinsic`, `yIntrinsic`) in geographic raster `R`.

Examples

Find Geographic Coordinates from Intrinsic Coordinates

Find the geographic coordinates of cells within a raster by specifying a raster reference object and intrinsic coordinates.

First, load a geographic cells reference object for the Korean peninsula. To do this, load the `korea5cR` variable from the `korea5c` MAT-file. Then, specify the intrinsic coordinates of the cell in the lower-left corner. For this example, the lower-left corner is also the southwest corner because the `ColumnsStartFrom` property of the reference object has a value of 'south' and the `RowsStartFrom` property has a value of 'west'. Integer coordinates such as (1,1) indicate the center of a cell.

```
load korea5c korea5cR
xIntrinsic = 1;
yIntrinsic = 1;
```

Find the geographic coordinates.

```
[lat,lon] = intrinsicToGeographic(korea5cR,xIntrinsic,yIntrinsic)

lat = 30.0417
lon = 115.0417
```

You can reverse the operation by using the `geographicToIntrinsic` function.

```
[xIntrinsic,yIntrinsic] = geographicToIntrinsic(korea5cR,lat,lon)

xIntrinsic = 1.0000
yIntrinsic = 1.0000
```

Input Arguments

R — Geographic raster

GeographicCellsReference or GeographicPostingsReference object

Geographic raster, specified as a GeographicCellsReference or GeographicPostingsReference object.

xIntrinsic — x-coordinates in intrinsic coordinate system

numeric array

x-coordinates in intrinsic coordinate system, specified as a numeric array. xIntrinsic coordinates can be outside the bounds of the raster R.

Data Types: single | double

yIntrinsic — y-coordinates in intrinsic coordinate system

numeric array

y-coordinates in intrinsic coordinate system, specified as a numeric array. yIntrinsic is the same size as xIntrinsic. yIntrinsic coordinates can be outside the bounds of the raster R.

Data Types: single | double

Output Arguments

lat — Latitude coordinates

numeric array

Latitude coordinates, returned as a numeric array. lat is the same size as xIntrinsic.

When a point (xIntrinsic(k), yIntrinsic(k)) is outside the bounds of raster R, lat(k) and lon(k) are extrapolated in the geographic coordinate system. However, for any point that extrapolates to a latitude beyond the poles (latitude outside the range [-90, 90] degrees), lat(k) and lon(k) are set to NaN.

Data Types: double

lon — Longitude coordinates

numeric array

Longitude coordinates, returned as a numeric array. lon is the same size as xIntrinsic.

When a point (xIntrinsic(k), yIntrinsic(k)) is outside the bounds of raster R, lat(k) and lon(k) are extrapolated in the geographic coordinate system. However, for any point that extrapolates to a latitude beyond the poles (latitude outside the range [-90, 90] degrees), lat(k) and lon(k) are set to NaN.

Data Types: double

Version History

Introduced in R2013b

See Also

`geographicToIntrinsic` | `intrinsicXToLongitude` | `intrinsicYToLatitude` | `intrinsicToWorld`

intrinsicToWorld

Package: map.rasterref

Transform intrinsic to planar world coordinates

Syntax

```
[xWorld,yWorld] = intrinsicToWorld(R,xIntrinsic,yIntrinsic)
```

Description

`[xWorld,yWorld] = intrinsicToWorld(R,xIntrinsic,yIntrinsic)` returns the planar world coordinates corresponding to intrinsic coordinates (`xIntrinsic`, `yIntrinsic`) in map raster `R`. If a point is outside the bounds of `R`, then `intrinsicToWorld` extrapolates the `xWorld` and `yWorld` coordinates.

Examples

Find World Coordinates from Intrinsic Coordinates

Import a GeoTIFF image [1] on page 1-823 of Boston as an array and a `MapCellsReference` object. Find the world coordinates of the center of the cell in column 3500 and row 1200 of the array.

```
[Z,R] = readgeoraster('boston.tif');  
[xWorld,yWorld] = intrinsicToWorld(R,3500,1200)
```

```
xWorld = 7.7580e+05
```

```
yWorld = 2.9566e+06
```

You can reverse the operation by using the `worldToIntrinsic` function.

```
[xIntrinsic,yIntrinsic] = worldToIntrinsic(R,xWorld,yWorld)
```

```
xIntrinsic = 3.5000e+03
```

```
yIntrinsic = 1.2000e+03
```

[1] The data used in this example includes material copyrighted by GeoEye, all rights reserved.

Input Arguments

R — Map raster

`MapCellsReference` object | `MapPostingsReference` object

Map raster, specified as a `MapCellsReference` or `MapPostingsReference` object.

xIntrinsic — x-coordinates in intrinsic coordinate system

numeric array

x-coordinates in intrinsic coordinate system, specified as a numeric array. `xIntrinsic` coordinates can be outside the bounds of the raster `R`.

Data Types: `single` | `double`**yIntrinsic — y-coordinates in intrinsic coordinate system**

numeric array

y-coordinates in intrinsic coordinate system, specified as a numeric array. `yIntrinsic` is the same size as `xIntrinsic`. `yIntrinsic` coordinates can be outside the bounds of the raster `R`.

Data Types: `single` | `double`**Output Arguments****xWorld — x-coordinates in the world coordinate system**

numeric array

x-coordinates in the world coordinate system, specified as a numeric array. `xWorld` is the same size as `xIntrinsic`. When `xIntrinsic(k)` is outside the bounds of `R`, `intrinsicToWorld` extrapolates the `xWorld` coordinate.

Data Types: `double`**yWorld — y-coordinates in the world coordinate system**

numeric array

y-coordinates in the world coordinate system, specified as a numeric array. `yWorld` is the same size as `xIntrinsic`. When `yIntrinsic(k)` is outside the bounds of `R`, `intrinsicToWorld` extrapolates the `yWorld` coordinate.

Data Types: `double`**Version History****Introduced in R2013b****See Also**`worldToIntrinsic` | `intrinsicToGeographic` | `intrinsicXToLongitude` | `intrinsicYToLatitude`

intrinsicXToLongitude

Package: map.rasterref

Convert from intrinsic x to longitude coordinates

Syntax

```
lon = intrinsicXToLongitude(R,xIntrinsic)
```

Description

`lon = intrinsicXToLongitude(R,xIntrinsic)` returns the longitude of the meridian corresponding to the x-coordinate `xIntrinsic` in the intrinsic coordinate system, based on the relationship defined by geographic raster `R`.

Examples

Find Longitude from Intrinsic x-Coordinate

Import a GeoTIFF image [1] on page 1-825 of the Gulf of Mexico as an array and a `GeographicCellsReference` object. Find the longitude corresponding to the centers of cells in column 144 of the array.

```
[Z,R] = readgeoraster('katrina.tif');  
lon = intrinsicXToLongitude(R,144)
```

```
lon = -95.7959
```

[1] The image used in this example is derived from imagery obtained from the NASA Goddard Scientific Visualization Studio (SVS) Image Server.

Input Arguments

R — Geographic raster

`GeographicCellsReference` or `GeographicPostingsReference` object

Geographic raster, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object.

xIntrinsic — x-coordinates in intrinsic coordinate system

numeric array

x-coordinates in intrinsic coordinate system, specified as a numeric array. `xIntrinsic` coordinates can be outside the bounds of the raster `R`.

Data Types: `single` | `double`

Output Arguments

lon — Longitude coordinates

numeric array

Longitude coordinates, returned as a numeric array. `lon` is the same size as `xIntrinsic`.

When a point has intrinsic x -coordinate outside the bounds of raster R , `lon(k)` is extrapolated outside the longitude limits. Elements of `xIntrinsic` with value `NaN` map to `NaN` in `lon`. Longitude values are not wrapped.

Data Types: `double`

Version History

Introduced in R2013b

See Also

`intrinsicToGeographic` | `intrinsicYToLatitude` | `longitudeToIntrinsicX`

intrinsicYToLatitude

Package: `map.rasterref`

Convert from intrinsic *y* to latitude coordinates

Syntax

```
lat = intrinsicYToLatitude(R,yIntrinsic)
```

Description

`lat = intrinsicYToLatitude(R,yIntrinsic)` returns the latitude of the small circle corresponding to the *y*-coordinate `yIntrinsic` in the intrinsic coordinate system, based on the relationship defined by geographic raster `R`.

Examples

Find Latitude from Intrinsic *y*-Coordinate

Import elevation data [1] on page 1-827 for a region in Colorado as an array and a `GeographicPostingsReference` object. Find the latitude corresponding to the posting points in row 91 of the array.

```
[Z,R] = readgeoraster('n39_w106_3arc_v2.dt1');  
lat = intrinsicYToLatitude(R,91)
```

```
lat = 39.9250
```

[1] The elevation data used in this example is from the U.S. Geological Survey.

Input Arguments

R — Geographic raster

`GeographicCellsReference` or `GeographicPostingsReference` object

Geographic raster, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object.

yIntrinsic — *y*-coordinates in intrinsic coordinate system

numeric array

y-coordinates in intrinsic coordinate system, specified as a numeric array. `yIntrinsic` coordinates can be outside the bounds of the raster `R`.

Data Types: `single` | `double`

Output Arguments

lat — Latitude coordinates

numeric array

Latitude coordinates, returned as a numeric array. `lat` is the same size as `yIntrinsic`.

When a point has intrinsic *y*-coordinate outside the bounds of raster *R*, `lat(k)` is extrapolated outside the latitude limits. However, when a point extrapolates to a latitude beyond the poles (latitude outside the range [-90, 90] degrees), `lat(k)` is set to `NaN`. Elements of `yIntrinsic` with value `NaN` map to `NaN` in `lat`.

Data Types: double

Version History

Introduced in R2013b

See Also

`intrinsicXToLongitude` | `intrinsicToGeographic` | `latitudeToIntrinsicY`

intrplat

Interpolate latitude at given longitude

Syntax

```
newlat = intrplat(long,lat,newlong)
newlat = intrplat(long,lat,newlong,method)
newlat = intrplat(long,lat,newlong,method,units)
```

Description

`newlat = intrplat(long,lat,newlong)` returns an interpolated latitude, `newlat`, corresponding to a longitude `newlong`. `long` must be a monotonic vector of longitude values. The actual entries must be monotonic; that is, the longitude vector `[350 357 3 10]` is not allowed even though the geographic *direction* is unchanged (use `[350 357 363 370]` instead). `lat` is a vector of the latitude values paired with each entry in `long`.

`newlat = intrplat(long,lat,newlong,method)` specifies the method of interpolation employed, listed in the table below.

Method	Description
'linear'	Linear, or Cartesian, interpolation (default)
'pchip'	Piecewise cubic Hermite interpolation
'rh'	Returns interpolated points that lie on rhumb lines between input data
'gc'	Returns interpolated points that lie on great circles between input data

`newlat = intrplat(long,lat,newlong,method,units)` specifies the units used, where `units` is any valid angle units string scalar or character vector. The default is 'degrees'.

The function `intrplat` is a geographic data analogy of the standard MATLAB function `interp1`.

Examples

Interpolate Coordinates at Specific Locations

Define the latitudes and longitudes.

```
lat = [57 68 60 65 56];
lon = [1 3 4 9 13];
```

Specify the longitude for which you want to compute a latitude.

```
newlon = 7.3;
```

Linear Interpolation

Generate a new latitude using the default method of linear interpolation.

```
newlatLinear = intrplat(lon,lat,newlon)
```

```
newlatLinear = 63.3000
```

Great Circle Interpolation

Generate a new latitude using great circle interpolation.

```
newlatGC = intrplat(lon,lat,newlon,'gc')
```

```
newlatGC = 63.5029
```

Rhumb Line Interpolation

Generate a new latitude using interpolation along a rhumb line.

```
newlatRhumb = intrplat(lon,lat,newlon,'rh')
```

```
newlatRhumb = 63.3937
```

Tips

There are separate functions for interpolating latitudes and longitudes, for although the cases are identical when using those methods supported by `interp1`, when latitudes and longitudes are treated like the spherical angles they are (using 'rh' or 'gc'), the results are different. Compare the example above to the example under `intrplon`, which reverses the values of latitude and longitude.

Version History

Introduced before R2006a

See Also

Functions

`interp` | `intrplon`

Topics

“Geographic Interpolation of Vectors”

intrplon

Interpolate longitude at given latitude

Syntax

```
newlon = intrplon(lat,lon,newlat)
newlon = intrplon(lat,lon,newlat,method)
newlon = intrplon(lat,lon,newlat,method,units)
```

Description

`newlon = intrplon(lat,lon,newlat)` returns an interpolated longitude, `newlon`, corresponding to a latitude `newlat`. `lat` must be a monotonic vector of longitude values. `lon` is a vector of the longitude values paired with each entry in `lat`.

`newlon = intrplon(lat,lon,newlat,method)` specifies the method of interpolation employed, listed in the table below.

Method	Description
'linear'	Linear, or Cartesian, interpolation (default)
'pchip'	Piecewise cubic Hermite interpolation
'rh'	Returns interpolated points that lie on rhumb lines between input data
'gc'	Returns interpolated points that lie on great circles between input data

`newlon = intrplon(lat,lon,newlat,method,units)` specifies the units used, where `units` is any valid angle units string scalar or character vector. The default is 'degrees'.

The function `intrplon` is a geographic data analogy of the MATLAB function `interp1`.

Examples

Compare the results of the various methods:

```
long = [25 45]; lat = [30 60];
newlon = intrplon(lat,long,45,'linear')
```

```
newlon =
    35
```

```
newlon = intrplon(lat,long,45,'rh')
```

```
newlon =
    33.6515
```

```
newlon = intrplon(lat,long,45,'gc')
```

```
newlon =
    32.0526
```

Tips

There are separate functions for interpolating latitudes and longitudes, for although the cases are identical when using those methods supported by `interp1`, when latitudes and longitudes are treated like the spherical angles they are (using `'rh'` or `'gc'`), the results are different. Compare the previous example to the example under `intrplat`, which reverses the values of latitude and longitude.

Version History

Introduced before R2006a

See Also

Functions

`interp` | `intrplat`

Topics

“Geographic Interpolation of Vectors”

inverse

Package: map.geodesy

Convert authalic, conformal, isometric, or rectifying latitude to geodetic latitude

Syntax

```
phi = inverse(converter,lat)
phi = inverse(converter,lat,angleUnit)
```

Description

`phi = inverse(converter,lat)` returns the geodetic latitude coordinates corresponding to authalic, conformal, isometric, or rectifying latitude coordinates `lat`.

`phi = inverse(converter,lat,angleUnit)` specifies the units of output `phi`.

Examples

Convert Conformal Latitude to Geodetic Latitude

Specify conformal latitude coordinates and create a conformal latitude converter. Then, convert the coordinates.

```
chi = [-90 -67.3637 -44.8077 -22.3643 0 22.3643 44.8077 67.3637 90];
conv = map.geodesy.ConformalLatitudeConverter(wgs84Ellipsoid);
phi = inverse(conv,chi)
```

```
phi = 1×9
```

```
-90.0000 -67.5000 -45.0000 -22.5000          0  22.5000  45.0000  67.5000  90.0000
```

Convert Isometric Latitude to Geodetic Latitude Using Radians

Specify isometric latitude coordinates and convert them to radians. Create an isometric latitude converter. Then, convert the coordinates by specifying the angle unit as 'radians'.

```
psi = [-Inf -1.6087 -0.87663 -0.40064 0 0.40064 0.87663 1.6087 Inf];
conv = map.geodesy.IsometricLatitudeConverter(wgs84Ellipsoid);
phi = inverse(conv,psi,'radians')
```

```
phi = 1×9
```

```
-1.5708 -1.1781 -0.7854 -0.3927          0  0.3927  0.7854  1.1781  1.5708
```

Input Arguments

converter — Latitude converter

`AuthalicLatitudeConverter`, `ConformalLatitudeConverter`, `IsometricLatitudeConverter`, or `RectifyingLatitudeConverter` object

Latitude converter, specified as an `AuthalicLatitudeConverter`, `ConformalLatitudeConverter`, `IsometricLatitudeConverter`, or `RectifyingLatitudeConverter` object.

lat — Latitude coordinates to convert

numeric scalar, vector, matrix, or N-D array

Latitude coordinates to convert, specified as a numeric scalar, vector, matrix, or N-D array.

The interpretation of `lat` depends on the latitude converter. If the conversion is:

- `authalic`, `lat` represents the variable β (beta).
- `conformal`, `lat` represents χ (chi).
- `isometric`, `lat` represents ψ (psi). `lat` is a dimensionless number and does not have an angle unit.
- `rectifying`, `lat` represents μ (mu).

For `authalic`, `conformal`, and `rectifying` conversions, the values of `lat` must be consistent with `angleUnit`.

angleUnit — Unit of latitude coordinates

'degrees' (default) | 'radians'

Units of latitude coordinates, specified as 'degrees' or 'radians'.

Output Arguments

phi — Geodetic latitude coordinates

numeric scalar, vector, matrix, or N-D array

Geodetic latitude coordinates, specified as a numeric scalar value, vector, matrix, or N-D array. `phi` is the same size as `lat`. If `angleUnit` is not supplied, `phi` is in degrees. Otherwise, values of `phi` are consistent with the units of `angleUnit`.

Data Types: `single` | `double`

Version History

Introduced in R2013a

See Also

`forward`

map.geodesy.isDegree

True if input matches 'degree' and false if 'radian'

Syntax

```
tf = map.geodesy.isDegree(angleUnit)
```

Description

`tf = map.geodesy.isDegree(angleUnit)` returns true if `angleUnit` is a partial match for 'degree' (or 'degrees') and false if `angleUnit` is a partial match for 'radian' (or 'radians'). If `angleUnit` matches neither 'degrees' or 'radians', `map.geodesy.isDegree` returns an error.

Examples

Test Inputs to a Function for Validity Before Processing

Create a function to calculate a cosine. In the function, use `map.geodesy.isDegree` to check the validity of the inputs.

```
function y = cosine(x, angleUnit)
% X can be in either degrees or radians

if map.geodesy.isDegree(angleUnit)
    y = cosd(x);
else
    y = cos(x);
end
```

Input Arguments

angleUnit — Angle unit value

'degree' | 'radian'

Angle unit value, specified as 'degree' or 'radian'.

Data Types: char | string

Output Arguments

tf — True/false flag indicating if a match was found

logical scalar

True/false flag indicating if a match was found, returned as a logical scalar.

Version History

Introduced in R2013a

isempty

Determine if geographic or planar vector is empty

Syntax

```
tf = isempty(v)
```

Description

`tf = isempty(v)` determines whether the geographic or planar vector `v` is empty.

Examples

Check If a Geopoint Vector Is Empty

Create a default geopoint vector.

```
gp = geopoint()
```

```
gp =
```

```
0x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: []
  Longitude: []
```

Check if the geopoint vector is empty. A returned value of 1 (true) indicates the vector is empty.

```
isempty(gp)
```

```
ans = logical
      1
```

Create a second geopoint vector, specifying a geographic point. Confirm that this vector is not empty. A returned value of 0 (false) indicates the vector is not empty.

```
gp2 = geopoint(42.356, -71.101)
```

```
gp2 =
```

```
1x1 geopoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  Latitude: 42.3560
```

```
Longitude: -71.1010
```

```
isempty(gp2)
ans = logical
     0
```

Input Arguments

v — Geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Geographic or planar vector, specified as a geopoint, geoshape, mappoint, or mapshape object.

Output Arguments

tf — Flag indicating geographic or planar vector is empty

logical scalar

Flag indicating geographic or planar vector is empty, returned as a logical scalar. **tf** is True when **v** is empty.

Data Types: logical

Version History

Introduced in R2012a

isequal

Compare two `projcrs` or `geocrs` objects for equivalence

Syntax

```
tf = isequal(crs1,crs2)
```

Description

`tf = isequal(crs1,crs2)` returns logical 1 (`true`) if the coordinate reference systems (CRSs) `crs1` and `crs2` are equivalent. Otherwise, it returns logical 0 (`false`).

- Two `projcrs` objects are equivalent if they have the same geographic CRS, projection method, projection parameters, and length unit.
- Two `geocrs` objects are equivalent if they have the same datum name, reference spheroid, prime meridian, and angle unit.

The `isequal` function does not consider CRS names.

Examples

Compare Two Coordinate Reference Systems

Get information about two raster data sets using the `georasterinfo` function. Assign their coordinate reference systems to variables. In this case, the coordinate reference systems are `projcrs` objects.

```
info1 = georasterinfo('MtWashington-ft.grd');
info2 = georasterinfo('MountDartmouth-ft.grd');
```

```
crs1 = info1.CoordinateReferenceSystem;
crs2 = info2.CoordinateReferenceSystem;
```

Compare the coordinate reference systems.

```
tf = isequal(crs1,crs2)
```

```
tf = logical
    1
```

Compare Coordinate Reference Systems with Different WKT Strings

Two coordinate reference systems can be equivalent, even if the strings returned by the `wktstring` function are not identical.

Return information about a shapefile as a structure. Find the coordinate reference system by querying the `CoordinateReferenceSystem` field.

```
info = shapeinfo('landareas.shp');
g1 = info.CoordinateReferenceSystem

g1 =
  geocrs with properties:
      Name: "WGS 84"
      Datum: "World Geodetic System 1984"
      Spheroid: [1x1 referenceEllipsoid]
      PrimeMeridian: 0
      AngleUnit: "degree"
```

Create a second coordinate reference system by using the `geocrs` function.

```
g2 = geocrs(4326)

g2 =
  geocrs with properties:
      Name: "WGS 84"
      Datum: "World Geodetic System 1984 ensemble"
      Spheroid: [1x1 referenceEllipsoid]
      PrimeMeridian: 0
      AngleUnit: "degree"
```

The coordinate reference systems have the same datum name, reference spheroid, prime meridian, and angle unit. Therefore, the coordinate reference systems are equivalent.

```
isequal(g1,g2)

ans = logical
     1
```

Note that the WKT strings are not identical. The string for `g2` contains additional information about the area of use ("USAGE") and authority code ("ID").

```
wktstring(g1, 'Format', 'Formatted')

ans =
  "GEOGCRS["WGS 84",
    DATUM["World Geodetic System 1984",
      ELLIPSOID["WGS 84",6378137,298.257223563,
        LENGTHUNIT["metre",1]],
      ID["EPSG",6326]],
    PRIMEM["Greenwich",0,
      ANGLEUNIT["Degree",0.0174532925199433]],
    CS[ellipsoidal,2],
      AXIS["longitude",east,
        ORDER[1],
        ANGLEUNIT["Degree",0.0174532925199433]],
      AXIS["latitude",north,
        ORDER[2],
        ANGLEUNIT["Degree",0.0174532925199433],
        ID["EPSG",7030]]]"
```

```
wktstring(g2, 'Format', 'Formatted')

ans =
  "GEOGCRS["WGS 84",
    ENSEMBLE["World Geodetic System 1984 ensemble",
      MEMBER["World Geodetic System 1984 (Transit)"],
      MEMBER["World Geodetic System 1984 (G730)"],
      MEMBER["World Geodetic System 1984 (G873)"],
      MEMBER["World Geodetic System 1984 (G1150)"],
      MEMBER["World Geodetic System 1984 (G1674)"],
      MEMBER["World Geodetic System 1984 (G1762)"],
      MEMBER["World Geodetic System 1984 (G2139)"],
      ELLIPSOID["WGS 84",6378137,298.257223563,
        LENGTHUNIT["metre",1]],
      ENSEMBLEACCURACY[2.0]],
    PRIMEM["Greenwich",0,
      ANGLEUNIT["degree",0.0174532925199433]],
    CS[ellipsoidal,2],
      AXIS["geodetic latitude (Lat)",north,
        ORDER[1],
        ANGLEUNIT["degree",0.0174532925199433]],
      AXIS["geodetic longitude (Lon)",east,
        ORDER[2],
        ANGLEUNIT["degree",0.0174532925199433]],
    USAGE[
      SCOPE["Horizontal component of 3D system."],
      AREA["World."],
      BBOX[-90,-180,90,180]],
    ID["EPSG",4326]]"
```

Input Arguments

crs1 — First coordinate reference system

`projcrs` object | `geocrs` object

First coordinate reference system, specified as a `projcrs` or `geocrs` object.

crs2 — Second coordinate reference system

`projcrs` object | `geocrs` object

Second coordinate reference system, specified as a `projcrs` or `geocrs` object.

Tips

- If you expect two coordinate reference systems to be equivalent, but the `isequal` function returns `0` (false), you can inspect the WKT strings for differences using the `wktstring` function.

Version History

Introduced in R2021a

See Also

Objects

projcrs | geocrs

isfield

Determine if dynamic property exists in geographic or planar vector

Syntax

```
tf = isfield(v,name)
tf = isfield(v,names)
```

Description

`tf = isfield(v,name)` determines whether the value specified by `name` is a dynamic property in geographic or planar vector `v`.

`tf = isfield(v,names)` determines whether each value specified by `names` is a dynamic property in `v`.

Examples

Check If a Dynamic Property Exists in a Mappoint Vector

Create a mappoint vector.

```
mp = mappoint(-33.961, 18.484, 'Name', 'Cape Town')
```

```
mp =
  1x1 mappoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: -33.9610
  Y: 18.4840
  Name: 'Cape Town'
```

Check if individual properties are dynamic properties in the mappoint vector.

```
isfield(mp, 'X')
```

```
ans = logical
      0
```

This result is 0 (false) because property X in the mappoint vector is not a dynamic property.

```
isfield(mp, 'Name')
```

```
ans = logical
      1
```

This result is 1 (true) because the property `Name` is a dynamic property that exists in the mappoint vector.

```
isfield(mp, 'Latitude')
```

```
ans = logical  
     0
```

This result is 0 (false) because the dynamic property `Latitude` does not exist in the mappoint vector.

Check If Multiple Dynamic Properties Exist in a Geoshape Vector

Create a geoshape vector.

```
gs = geoshape(-33.961, 18.484, 'Name', 'Cape Town')
```

```
gs =  
1x1 geoshape vector with properties:
```

```
Collection properties:  
  Geometry: 'line'  
  Metadata: [1x1 struct]  
Vertex properties:  
  Latitude: -33.9610  
  Longitude: 18.4840  
Feature properties:  
  Name: 'Cape Town'
```

Check if a group of properties are dynamic properties in the geoshape vector.

```
tf = isfield(gs, {'Latitude', 'longitude', 'Name'})
```

```
tf = 1x3 logical array
```

```
     0     0     1
```

The first element of `tf` is 0 (false) because the property `Latitude` exists in the geoshape vector but is not a dynamic property. The second element of `tf` is 0 (false) because the property `longitude` does not exist in the geoshape vector (property names are case-sensitive.) The last element of `tf` is 1 (true), indicating that `Name` is a dynamic property in the geoshape vector.

Input Arguments

v — Geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Geographic or planar vector, specified as a geopoint, geoshape, mappoint, or mapshape object.

name — Name of single property

character vector

Name of a single property, specified as a character vector.

names — Name of multiple properties

cell array of character vectors

Name of multiple properties, specified as a cell array of character vectors.

Output Arguments

tf — Flag indicating the dynamic property exists in the geographic or planar vector

logical scalar or vector

Flag indicating the dynamic property exists in the geographic or planar vector, returned as a logical scalar or vector. Each element of `tf` is `True` when the corresponding value in `name` or `names` is a dynamic property that exists in `v`.

Data Types: `logical`

Version History

Introduced in R2012a

See Also

`fieldnames` | `isprop`

isgeotable

Determine if input is geospatial table

Syntax

```
tf = isgeotable(A)
```

Description

`tf = isgeotable(A)` determines if the input `A` is a geospatial table. The function returns a logical `1` (true) if `A` is a geospatial table and a logical `0` (false) otherwise.

A geospatial table is a `table` or `timetable` object in which:

- The first variable of the table is called `Shape`.
- The `Shape` variable contains `geopointshape`, `geolineshape`, `geopolyshape`, `mappointshape`, `maplineshape`, or `mappolyshape` objects.

For more information about geospatial tables, see “Create Geospatial Tables”.

Examples

Determine if Input is Geospatial Table

Import a shapefile as a geospatial table. Verify that it is a geospatial table.

```
GT = readgeotable("concord_roads.shp");  
tf = isgeotable(GT)
```

```
tf = logical  
    1
```

Convert the geospatial table `GT` to a table `T`. The `isgeotable` function returns `false` because `T` is not a geospatial table.

```
T = geotable2table(GT);  
tf = isgeotable(T)
```

```
tf = logical  
    0
```

Input Arguments

A — Input array

array

Input array. The array can have any data type.

Version History

Introduced in R2021b

See Also

Functions

readgeotable | istable

isinterior

Query geographic or planar points in polygon

Syntax

```
inpoly = isinterior(shape,querypoint)
[inpoly,onboundary] = isinterior(shape,querypoint)
```

Description

`inpoly = isinterior(shape,querypoint)` returns a logical array whose elements are 1 (true) when the corresponding geographic or planar points in `querypoint` are in the polygon shape. A point is in the polygon shape if it is either inside a solid region or on one of the boundaries.

`[inpoly,onboundary] = isinterior(shape,querypoint)` returns an additional logical array whose elements are 1 (true) when the corresponding points are on a boundary of the polygon shape.

Examples

Query Points in Polygon Using Geographic Coordinates

Read worldwide land areas into the workspace as a geospatial table. Extract the polygon shape for Australia.

```
GT = readgeotable("landareas.shp");
australia = GT(GT.Name == "Australia",:);
shape = australia.Shape;
```

Read the coordinates of world cities as a geospatial table. Extract the point shapes.

```
cities = readgeotable("worldcities.shp");
querypoint = cities.Shape;
```

Create an array of cities in Australia.

```
inpoly = isinterior(shape,querypoint);
citiesAU = cities(inpoly,:);
```

Compare the number of world cities to the number of cities in Australia.

```
height(querypoint)
```

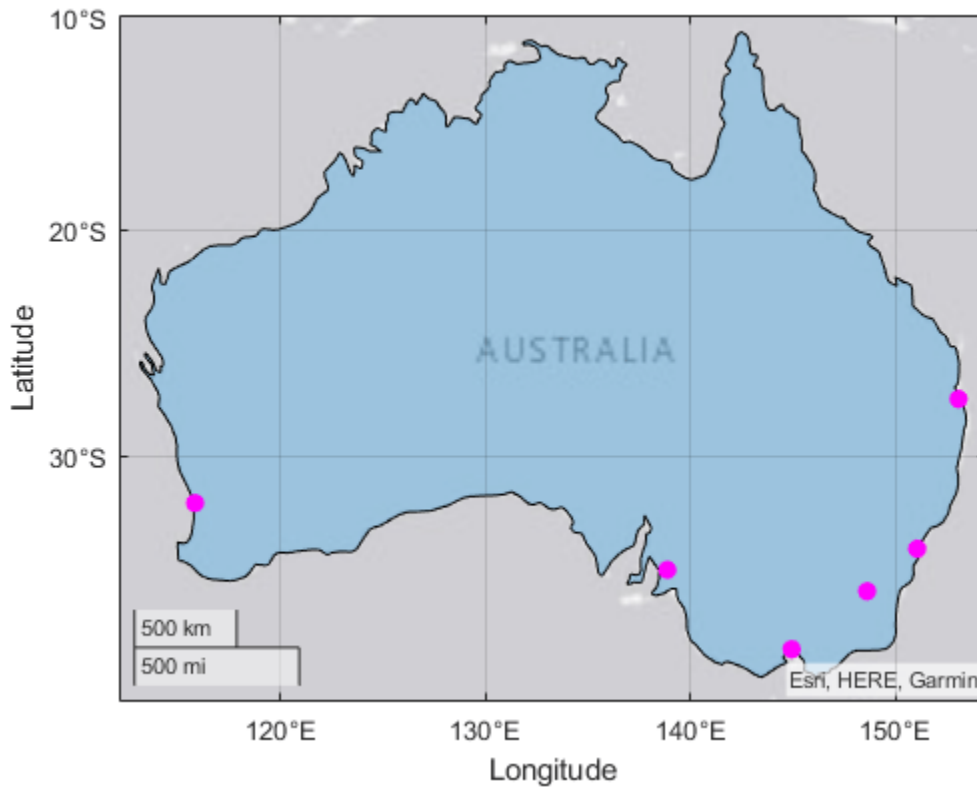
```
ans = 318
```

```
height(citiesAU)
```

```
ans = 6
```

Display Australia and the cities in Australia on a map.

```
figure
geoplot(shape)
hold on
geoplot(citiesAU,"mo",MarkerFaceColor="m")
```



Query Points in Polygon Using Planar Coordinates

Read hydrography data into the workspace as a geospatial table. Extract the polygon shape for a pond.

```
GT = readgeotable("concord_hydro_area.shp");
pond = GT(14,:);
shape = pond.Shape;
```

Specify the coordinates of the query points using the same projected CRS as the hydrography data.

```
xq = [207768 208399 208218 208044 207879 208210 208076];
yq = [912697 912324 912290 912453 912476 912542 912127];
querypoint = mappointshape(xq,yq);
querypoint.ProjectedCRS = shape.ProjectedCRS;
```

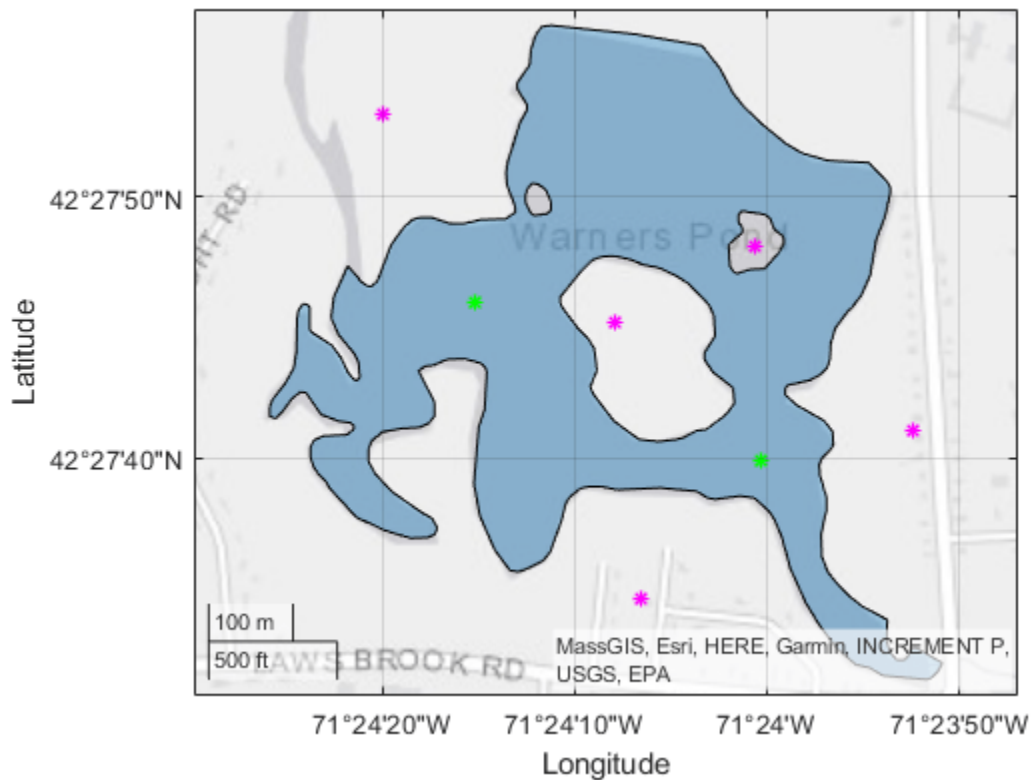
Determine which points are in the pond.

```
inpoly = isinterior(shape,querypoint)
```

```
inpoly = 1x7 logical array
    0    0    1    0    1    0    0
```

Display the pond and all points on a map. Use green for points inside the pond and magenta for points outside the pond.

```
figure
geoplot(pond)
hold on
geoplot(querypoint(inpoly), "*g")
geoplot(querypoint(~inpoly), "*m")
```



Input Arguments

shape — Polygon shape

geopolyshape object | mappolyshape object

Polygon shape, specified as a geopolyshape object or a mappolyshape object.

- When you specify shape as a geopolyshape object, then you must specify querypoint as an array of geopointshape objects. The GeographicCRS properties of the geopolyshape and geopointshape objects must match.

- When you specify `shape` as a `mappolyshape` object, then you must specify `querypoint` as an array of `mappointshape` objects. The `ProjectedCRS` properties of the `mappolyshape` and `mappointshape` objects must match.

querypoint — Point shapes to query

array of `geopointshape` objects | array of `mappointshape` objects

Point shapes to query, specified as an array of `geopointshape` or `mappointshape` objects.

- When you specify `querypoint` as an array of `geopointshape` objects, then you must specify `shape` as a `geopolyshape` object. The `GeographicCRS` properties of the `geopointshape` and `geopolyshape` objects must match.
- When you specify `querypoint` as an array of `mappointshape` objects, then you must specify `shape` as a `mappolyshape` object. The `ProjectedCRS` properties of the `mappointshape` and `mappolyshape` objects must match.

Output Arguments

inpoly — Indicator for points inside or on boundary of polygon

logical array

Indicator for points inside or on the boundary of the polygon, returned as a logical array. The size of `inpoly` matches the size of `querypoint`.

- A logical 1 (`true`) indicates that the corresponding query point is inside the polygon or on the boundary.
- A logical 0 (`false`) indicates that the corresponding query point is outside the polygon.

You can identify query points of interest by using `inpoly` to index into `querypoint`.

Points of Interest	Example Code
Query points inside or on the boundary of the polygon	<code>querypoint(inpoly)</code>
Query points outside the polygon	<code>querypoint(~inpoly)</code>

If a query point is a multipoint, then the `isinterior` function returns 1 (`true`) only when all points of the multipoint are inside the polygon or on the boundary.

If a query point does not contain coordinate data, then the `isinterior` function returns 0 (`false`).

onboundary — Indicator for points on boundary of polygon

logical array

Indicator for points on the boundary of the polygon, returned as a logical array. The size of `onboundary` matches the size of `querypoint`.

- A logical 1 (`true`) indicates that the corresponding query point is on the polygon boundary.
- A logical 0 (`false`) indicates that the corresponding query point is inside or outside the polygon boundary.

You can identify query points of interest by using `onboundary` to index into `querypoint`.

Points of Interest	Example Code
Query points on the polygon boundary	<code>querypoint(onboundary)</code>
Query points inside or outside the polygon boundary	<code>querypoint(~onboundary)</code>
Query points strictly inside the polygonal region	<code>querypoint(inpoly&~onboundary)</code>

If a query point is a multipoint, then the `isinterior` function returns 1 (`true`) only when all points of the multipoint are on the polygon boundary.

If a query point does not contain coordinate data, then the `isinterior` function returns 0 (`false`).

Tips

- If your polygon shape is in planar coordinates (a `mappointshape` object) and your query points are in geographic coordinates, first project the points by using the `projfwd` function. Then, create a point shape from the projected coordinates by using the `mappointshape` function.

Version History

Introduced in R2022a

See Also

Functions

`isinterior` | `inpolygon`

ismap

Determine if axes is axesm-based map

Syntax

```
tf = ismap
tf = ismap(A)
[tf,msg] = ismap(A)
```

Description

`tf = ismap` determines if the current axes is an axesm-based map. An axesm-based map is a map created using the `axesm`, `worldmap`, or `usamap` function. The function returns 1 if the current axes is an axesm-based map and 0 otherwise.

`tf = ismap(A)` determines if the input `A` is an axesm-based map.

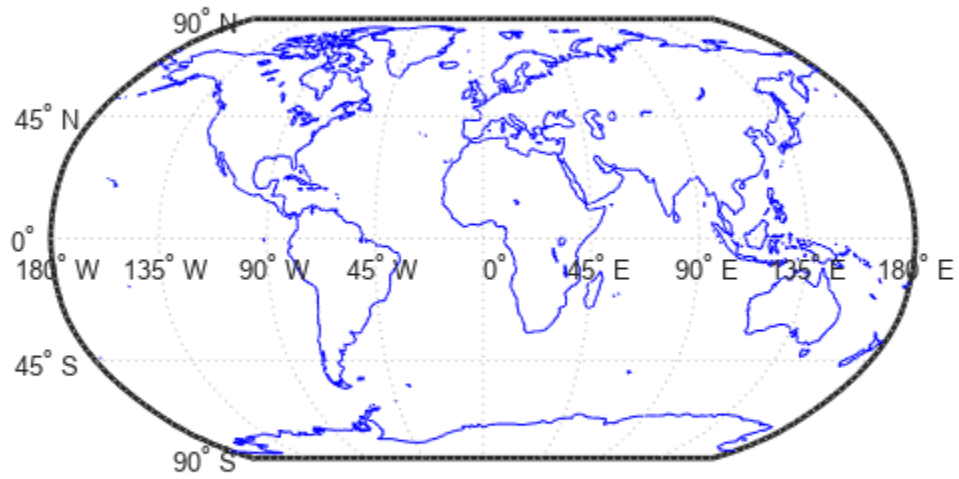
`[tf,msg] = ismap(A)` additionally returns the reason why the input is not an axesm-based map.

Examples

Query axesm-Based Map

Load a MAT file containing the coordinates of global coastlines into the workspace. Create a world map and then plot the coastline data.

```
load coastlines
figure
worldmap("world")
geoshow(coastlat,coastlon)
```



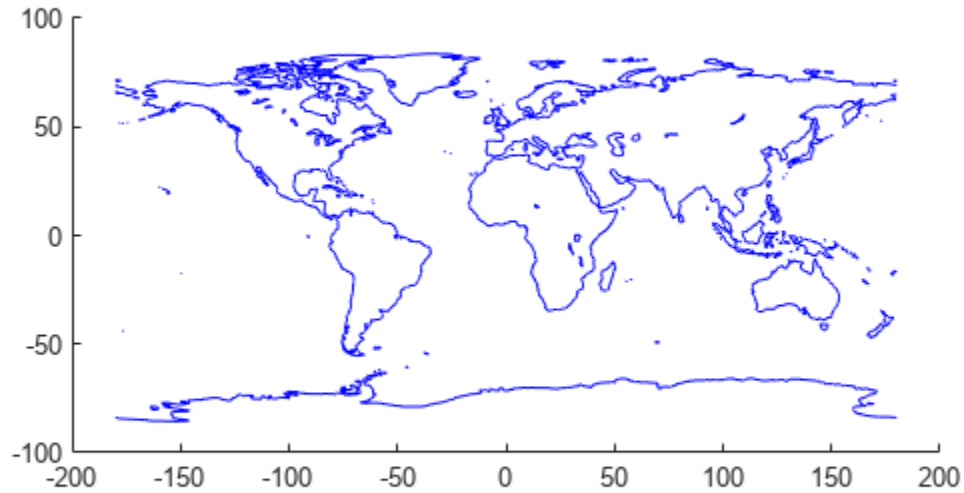
Determine whether the current axes is an axesm-based map.

```
tf1 = ismap
```

```
tf1 = 1
```

Plot the same data without first creating an axesm-based map.

```
figure  
geoshow(coastlat,coastlon)
```



Determine whether the current axes is an axesm-based map.

```
tf2 = ismap
```

```
tf2 = 0
```

Input Arguments

A — Input array

array

Input array. The array can have any type.

Output Arguments

tf — Indicator for axesm-based map

1 | 0

Indicator for an axesm-based map, returned as one of these values:

- 1 indicates that the current axes or A is an axesm-based map.
- 0 indicates that the current axes or A is not an axesm-based map.

Data Types: double

msg — Reason why input is not axesm-based map

character vector

Reason why the input is not an axesm-based map, returned as a character vector. For example, if you specify A as a Line object, msg is 'Input is not an axes handle.'

Version History

Introduced before R2006a

See Also**Functions**

gcm | ismapped

ismapped

Determine if object is projected on axesm-based map

Syntax

```
tf = ismapped
tf = ismapped(A)
[tf,msg] = ismapped(A)
```

Description

`tf = ismapped` determines if the current object is projected on an axesm-based map. An axesm-based map is a map created using the `axesm`, `worldmap`, or `usamap` function. The function returns 1 if the current object is projected on an axesm-based map and 0 otherwise.

`tf = ismapped(A)` determines if the input `A` is projected on an axesm-based map.

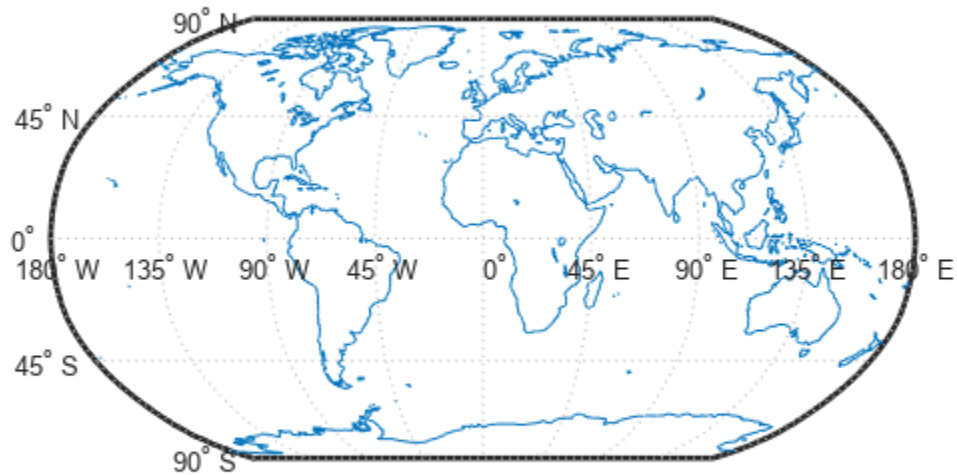
`[tf,msg] = ismapped(A)` additionally returns the reason why the input is not projected on an axesm-based map.

Examples

Query Objects Projected on axesm-Based Map

Load a MAT file containing the coordinates of global coastlines into the workspace. Create a world map and then plot the coastline data.

```
load coastlines
figure
worldmap("world")
p = plotm(coastlat,coastlon);
```



Determine if the object is projected on an axesm-based map.

```
tf = ismapped(p)
```

```
tf = 1
```

Input Arguments

A — Input array

array

Input array. The array can have any type.

Output Arguments

tf — Indicator for current object projected on axesm-based map

1 | 0

Indicator for an object projected on an axesm-based map, returned as one of these values:

- 1 indicates that the current object is projected on an axesm-based map.
- 0 indicates that the current object is not projected on an axesm-based map.

Data Types: double

msg — Reason why current object is not projected on axesm-based map

character vector

Reason why current object is not projected on axesm-based map, returned as a character vector.

Limitations

- The `ismapped` function does not support mapped objects created using the `geoshow` function.

Version History

Introduced before R2006a

See Also**Functions**

gcm | ismap

ismultipoint

Determine which array elements are multipoint shapes

Syntax

```
tf = ismultipoint(shape)
```

Description

`tf = ismultipoint(shape)` returns a logical array whose elements are 1 (true) when the corresponding shape object in `shape` is a multipoint shape. A shape object is a multipoint shape when it is a `geopointshape` or `mappointshape` object and the value of its `NumPoints` property is greater than 1.

Examples

Determine Which Array Elements Are Multipoint Shapes

Create an array of point shapes.

```
shape = geopointshape({39,[38 -30 29]},{-113,[-66 -31 42]});
```

Determine which elements of the array are multipoint shapes. The result indicates that the second element is a multipoint shape.

```
tf = ismultipoint(shape)
```

```
tf = 1×2 logical array
```

```
    0    1
```

Determine If Array Contains Multipoint Shapes

Accessing the coordinate properties of a point shape array is not supported when the array contains multipoint shapes. You can determine whether an array contains multipoints by using the `ismultipoint` and `any` functions.

Create an array of `geopointshape` objects that represent locations in Boston, and determine which are multipoint shapes.

```
GT = readgeotable("boston_placenames.gpx");  
shape = GT.Shape;  
tf1 = ismultipoint(shape);
```

Use the `any` function to check whether the `ismultipoint` function detected any multipoint shapes in the array. A value of 0 indicates that the array does not contain multipoint shapes.

```
any(tf1, "all")
ans = logical
     0
```

Create a multipoint shape that represents three locations. Add the multipoint shape to the end of the array.

```
mp = geointshape([42.3625 42.3693 42.3477]},{[-71.0904 -71.0733 -71.0787]});
shape(end+1) = mp;
```

Verify that the array contains a multipoint shape.

```
tf2 = ismultipoint(shape);
any(tf2, "all")
ans = logical
     1
```

Input Arguments

shape — Shape objects

array of `geointshape`, `geolineshape`, and `geopolysshape` objects | array of `mappointshape`, `maplineshape`, and `mappolysshape` objects

Shape objects, specified as one of these options:

- An array in which each element is a `geointshape`, `geolineshape`, or `geopolysshape` object.
- An array in which each element is a `mappointshape`, `maplineshape`, or `mappolysshape` object.

Output Arguments

tf — Indicator for multipoint shape

logical array

Indicator for multipoint shape, returned as a logical array. The size of `tf` matches the size of `shape`.

- A logical 1 (`true`) indicates that the corresponding shape object is a multipoint shape.
- A logical 0 (`false`) indicates that the corresponding shape object is not a multipoint shape.

You can identify points of interest by using `tf` to index into `shape`.

Points of Interest	Example Code
Query multipoint shapes	<code>shape(tf)</code>
Query shapes that are not multipoint shapes	<code>shape(~tf)</code>

Version History

Introduced in R2022b

See Also

Functions

any

Objects

geopointshape | mappointshape

map.geodesy.IsometricLatitudeConverter

Convert between geodetic and isometric latitudes

Description

An `IsometricLatitudeConverter` object provides conversion methods between geodetic and isometric latitudes for an ellipsoid with a given eccentricity.

The isometric latitude is a nonlinear function of the geodetic latitude that is directly proportional to the spacing of parallels, relative to the Equator, in an ellipsoidal Mercator projection. It is a dimensionless quantity and, unlike other types of auxiliary latitude, the isometric latitude is not angle-valued. It equals Inf at the north pole and $-\text{Inf}$ at the south pole.

Creation

Syntax

```
converter = map.geodesy.IsometricLatitudeConverter
converter = map.geodesy.IsometricLatitudeConverter(spheroid)
```

Description

`converter = map.geodesy.IsometricLatitudeConverter` returns an `IsometricLatitudeConverter` object for a sphere and sets the `Eccentricity` property to 0.

`converter = map.geodesy.IsometricLatitudeConverter(spheroid)` returns an isometric latitude converter object and sets the `Eccentricity` property to match the specified spheroid object.

Input Arguments

spheroid — Reference spheroid

referenceEllipsoid object | oblateSpheroid object | referenceSphere object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

Properties

Eccentricity — Ellipsoid eccentricity

0 | numeric scalar

Ellipsoid eccentricity, specified as a numeric scalar. Eccentricity is in the interval [0, 0.5]. Eccentricities larger than 0.5 are possible in theory, but do not occur in practice and are not supported.

Data Types: double

Object Functions

`forward` Convert geodetic latitude to authalic, conformal, isometric, or rectifying latitude
`inverse` Convert authalic, conformal, isometric, or rectifying latitude to geodetic latitude

Examples

Create an Isometric Latitude Converter Object and Set Property

```
grs80 = referenceEllipsoid('GRS 80');  
  
conv1 = map.geodesy.IsometricLatitudeConverter;  
conv1.Eccentricity = grs80.Eccentricity  
  
conv1 =  
  
    IsometricLatitudeConverter with properties:  
  
    Eccentricity: 0.0818
```

Create an Isometric Latitude Converter Object Specifying Spheroid

```
grs80 = referenceEllipsoid('GRS 80');  
  
conv2 = map.geodesy.IsometricLatitudeConverter(grs80)  
  
conv2 =  
  
    IsometricLatitudeConverter with properties:  
  
    Eccentricity: 0.0818
```

Version History

Introduced in R2013a

See Also

Functions

`geocentricLatitude` | `parametricLatitude`

Objects

`AuthalicLatitudeConverter` | `ConformalLatitudeConverter` | `RectifyingLatitudeConverter`

ispolycw

Determine if polygon vertices are in clockwise order

Syntax

```
tf = ispolycw(x,y)
```

Description

`tf = ispolycw(x,y)` determines if the Cartesian vertices of the polygon defined by `x` and `y` are in clockwise order. The function returns logical `1` (`true`) when the vertices are in clockwise order and logical `0` (`false`) otherwise.

Examples

Determine If Vertices Are in Clockwise Order

Specify the vertices of a polygon. Close the polygon by repeating the first vertex at the end of the list. Then, determine whether the vertices are in clockwise order.

```
x1 = [0 1 4 3 0];
y1 = [0 1 3 2 0];
ispolycw(x1,y1)
```

```
ans = logical
     1
```

The vertices are in clockwise order. Flip the order of the vertices and then verify that the flipped vertices are not in clockwise order.

```
x2 = fliplr(x1);
y2 = fliplr(y1);
ispolycw(x2,y2)
```

```
ans = logical
     0
```

Input Arguments

x — x-coordinates of polygon

numeric vector | cell array of numeric vectors

x-coordinates of the polygon, specified as a numeric vector or a cell array of numeric vectors.

- Define one polygon by specifying a vector, such as `[39 45 19 39]`.
- Define multiple polygons by using one of these options:

- Specify a vector and separate the polygons using NaN values, such as [37 46 31 20 37 NaN 45 49 35 32 45 NaN 35 40 42 35]. The NaN values in *x* must correspond to the NaN values in *y*.
- Specify a cell array of vectors, such as {[37 46 31 20 37],[45 49 35 32 45],[35 40 42 35]}. The size of the vector in each cell of *x* must match the size of the vector in the corresponding cell of *y*.

The size and type of *x* must match the size and type of *y*.

y — **y-coordinates of polygon**

numeric vector | cell array of numeric vectors

y-coordinates of the polygon, specified as a numeric vector or a cell array of numeric vectors.

- Define one polygon by specifying a vector, such as [-113 -49 -100 -113].
- Define multiple polygons by using one of these options:
 - Specify a vector and separate the polygons using NaN values, such as [69 90 105 79 69 NaN 6 52 43 14 6 NaN 18 32 22 18]. The NaN values in *y* must correspond to the NaN values in *x*.
 - Specify a cell array of vectors, such as {[69 90 105 79 69],[6 52 43 14 6],[18 32 22 18]}. The size of the vector in each cell of *y* must match the size of the vector in the corresponding cell of *x*.

The size and type of *y* must match the size and type of *x*.

Output Arguments

tf — **Indicator for vertices in clockwise order**

logical vector

Indicator for vertices in a clockwise order, returned as a logical vector.

- A logical 1 (`true`) indicates that the corresponding vertices of the polygon are in clockwise order.
- A logical 0 (`false`) indicates that the corresponding vertices of the polygon are not in clockwise order.

When *x* and *y* define multiple polygons, the `ispolycw` function determines whether the coordinates of each individual polygon are in clockwise order.

The size of *tf* is the number of polygons specified by *x* and *y*.

Tips

- The `ispolycw` function returns 1 (`true`) when a polygon contains two or fewer vertices.
- You can specify geographic coordinates as input to the `ispolycw` function when the polygon does not cross the Antimeridian or contain a pole. A polygon contains a pole when the longitude data spans 360 degrees. To use geographic coordinates as input, specify *x* using the longitude vector and *y* using the latitude vector.

Algorithms

When a polygon intersects itself, the order of the vertices is not well defined. In this case, the `ispolycw` function determines the vertex order using the vertices immediately before and after the leftmost vertex with the lowest y value. If the function does not determine the order from the leftmost vertex with the lowest y value, it determines the order by using a signed area test.

Version History

Introduced before R2006a

See Also

Functions

`poly2cw` | `poly2ccw`

Objects

`mappolyshape` | `geopolyshape`

Topics

“Create and Display Polygons”

isprop

Determine if property exists in geographic or planar vector

Syntax

```
tf = isprop(v,name)
tf = isprop(v,names)
```

Description

`tf = isprop(v,name)` determines whether the value specified by `name` is a property in geographic or planar vector `v`.

`tf = isprop(v,names)` determines whether each value specified by `names` is a property in `v`.

Examples

Check If a Single Property Exists in Geoshape Vector

Create a geoshape vector.

```
s = geoshape(-33.961, 18.484, 'Name', 'Cape Town');
```

Check if Latitude and Name are properties in the geoshape vector.

```
isprop(s, 'Latitude')
```

```
ans = logical
      1
```

```
isprop(s, 'Name')
```

```
ans = logical
      1
```

Both Latitude and Name are properties in the geoshape vector.

Check If Multiple Properties Exist in a Mappoint Vector

Create a mappoint vector.

```
mp = mappoint(-33.961, 18.484, 'Name', 'Cape Town')
```

```
mp =
  1x1 mappoint vector with properties:
```

```
  Collection properties:
```

```

    Geometry: 'point'
    Metadata: [1x1 struct]
    Feature properties:
        X: -33.9610
        Y: 18.4840
        Name: 'Cape Town'

```

Check if a group of properties exist in the mappoint vector.

```
tf = isprop(mp, {'X','x','Latitude','Name'})
```

```
tf = 1x4 logical array
```

```
    1    0    0    1
```

The first and last elements of `tf` are 1 (true) because the properties `X` and `Name` exist in the mappoint vector. The second and third elements of `tf` are 0 (false) because the properties `x` and `Latitude` do not exist in the mappoint vector. Property names are case-sensitive.

Input Arguments

v — Geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Geographic or planar vector, specified as a geopoint, geoshape, mappoint, or mapshape object.

name — Name of single property

character vector

Name of a single property, specified as a character vector.

names — Name of multiple properties

cell array of character vectors

Name of multiple properties, specified as a cell array of character vectors.

Output Arguments

tf — Flag indicating the property exists in the geographic or planar vector

logical scalar or vector

Flag indicating the property exists in the geographic or planar vector, returned as a logical scalar or vector. Each element of `tf` is `True` when the corresponding value in `name` or `names` is a property that exists in `v`.

Data Types: `logical`

Version History

Introduced in R2012a

See Also

isfield | properties

isShapeMultipart

True if polygon or line has multiple parts

Syntax

```
tf = isShapeMultipart(xdata, ydata)
```

Description

`tf = isShapeMultipart(xdata, ydata)` returns 1 (true) if the polygon or line shape specified by `xdata` and `ydata` consists of multiple NaN-separated parts (i.e. has inner or multiple polygon rings or multiple line segments). The coordinate arrays `xdata` and `ydata` must match in size and have identical NaN locations.

Examples

Check If Datasets Are Multipart

Create a simple data set and check if it's multipart. If a data set contains NaN separators, `isShapeMultipart` returns 1, otherwise 0.

```
sample_xdata = [0 0 1];
sample_ydata = [0 1 0];
isShapeMultipart(sample_xdata, sample_ydata)

ans = logical
     0
```

Create simple multipart data sets.

```
multi_xdata = [0 0 1 NaN 2 2 3 3];
multi_ydata = [0 1 0 NaN 2 3 3 2];
isShapeMultipart(multi_xdata, multi_ydata)

ans = logical
     1
```

Check a real data set.

```
load coastlines
isShapeMultipart(coastlat, coastlon)

ans = logical
     1
```

Check the data in a shapefile.

```
S = shaperead('concord_hydro_area.shp');
isShapeMultipart(S(1).X, S(1).Y)
```

```
ans = logical  
0
```

Check another dataset in the shapefile.

```
isShapeMultipart(S(14).X, S(14).Y)
```

```
ans = logical  
1
```

Version History

Introduced in R2006a

See Also

polysplit

Topics

“Create and Display Polygons”

km2deg

Convert spherical distance from kilometers to degrees

Syntax

```
deg = km2deg(km)
deg = km2deg(km, radius)
deg = km2deg(km, sphere)
```

Description

`deg = km2deg(km)` converts distances from kilometers to degrees, as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`deg = km2deg(km, radius)` converts distances from kilometers to degrees, as measured along a great circle on a sphere having the specified radius.

`deg = km2deg(km, sphere)` converts distances from kilometers to degrees, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Kilometers to Degrees

Two cities are 340 km apart. How many degrees of arc is that?

```
deg = km2deg(340)
```

```
deg =
```

```
3.0577
```

How many degrees would it be if the cities were on Mars?

```
deg = km2deg(340, 'mars')
```

```
deg =
```

```
5.7465
```

Input Arguments

km — Distance in kilometers

numeric array

Distance in kilometers, specified as a numeric array.

Data Types: `single` | `double`

radius — Radius

6371 (default) | numeric scalar

Radius of sphere in units of kilometers, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments**deg — Distance in degrees**

numeric array

Distance in degrees, returned as a numeric array.

Data Types: `single` | `double`

Version History

Introduced in R2007a

See Also

`deg2rad` | `rad2deg` | `deg2km` | `km2rad` | `nm2deg` | `sm2deg`

km2nm

Convert kilometers to nautical miles

Syntax

```
nm = km2nm(km)
```

Description

`nm = km2nm(km)` converts distances from kilometers to nautical miles.

Examples

Convert Kilometers to Nautical Miles

Convert 500 kilometers to nautical miles.

```
nm = km2nm(500)
```

```
nm = 269.9784
```

Input Arguments

km — Distance in kilometers

numeric array

Distance in kilometers, specified as a numeric array.

Output Arguments

nm — Distance in nautical miles

numeric array

Distance in nautical miles, returned as a numeric array of the same size as `km`.

Version History

Introduced in R2007a

See Also

Functions

`nm2km` | `deg2km` | `km2deg` | `deg2nm` | `nm2deg`

km2rad

Convert spherical distance from kilometers to radians

Syntax

```
rad = km2rad(km)
rad = km2rad(km, radius)
rad = km2rad(km, sphere)
```

Description

`rad = km2rad(km)` converts distances from kilometers to radians, as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`rad = km2rad(km, radius)` converts distances from kilometers to radians, as measured along a great circle on a sphere having the specified radius.

`rad = km2rad(km, sphere)` converts distances from kilometers to radians, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Kilometers to Radians

How many radians does 1,000 km span on the Earth and on the Moon?

```
rad = km2rad(1000)
```

```
rad =
```

```
    0.1570
```

```
rad = km2rad(1000, 'moon')
```

```
rad =
```

```
    0.5754
```

Input Arguments

km — Distance in kilometers

numeric array

Distance in kilometers, specified as a numeric array.

Data Types: `single` | `double`

radius — Radius

6371 (default) | numeric scalar

Radius of sphere in units of kilometers, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments**rad — Distance in radians**

numeric array

Distance in radians, returned as a numeric array.

Data Types: single | double

Version History

Introduced in R2007a

See Also

deg2rad | rad2deg | km2deg | nm2rad | sm2rad | rad2km

km2sm

Convert kilometers to statute miles

Syntax

```
sm = km2sm(km)
```

Description

`sm = km2sm(km)` converts distances from kilometers to statute miles.

Examples

Convert Kilometers to Statute Miles

Convert 500 kilometers to statute miles.

```
sm = km2sm(500)
```

```
sm = 310.6850
```

Input Arguments

km — Distance in kilometers

numeric array

Distance in kilometers, specified as a numeric array.

Output Arguments

sm — Distance in statute miles

numeric array

Distance in statute miles, returned as a numeric array of the same size as `km`.

Version History

Introduced in R2007a

See Also

Functions

`sm2km` | `deg2km` | `km2deg` | `deg2sm` | `sm2deg`

kmlwrite

Write geographic data to KML file

Syntax

```
kmlwrite(filename,S)
kmlwrite(filename,address)
kmlwrite( ____,Name,Value)
```

Description

`kmlwrite(filename,S)` writes the geographic point, line, or polygon data stored in `S` to the file specified by `filename` in Keyhole Markup Language (KML) format. The `kmlwrite` function creates a KML Placemark in the file and populates the tags in the placemark with the data in `S`.

`kmlwrite(filename,address)` writes `address` to the file specified by `filename` in KML format. `address` is a string scalar or character vector containing freeform address data, that can include street, city, state, country, and/or postal code. To specify multiple addresses, use a cell array of character vectors or string scalars. `kmlwrite` creates a KML Placemark in the file, setting the value of the address tag. An address is an alternative way to specify a point, instead of using latitude and longitude.

`kmlwrite(____,Name,Value)` specifies name-value pairs that set additional KML feature properties. Parameter names can be abbreviated and are case-insensitive.

Examples

Write Polygon Data to KML File

Import a shapefile containing polygon data into a geospatial table. The polygons represent state boundaries.

```
GT = readgeotable("usastatelo.shp");
```

Create a colormap for the data using random, muted colors.

```
colors = polcmap(height(GT));
```

Write the polygon data to a KML file called `usastatelo.kml`. Specify the labels and the colors of the polygon faces and edges using name-value arguments.

```
kmlwrite("usastatelo.kml",GT,"Name",GT.Name, ...
        "FaceColor",colors,"EdgeColor","k")
```

Write Point Data to KML File Using Geographic Point Vector

Import point data as a geographic point (`geopoint`) vector.

```
placenames = gpxread("boston_placenames.gpx");
```

Specify the colors to use with the point data.

```
colors = jet(length(placenames));
```

Write the point data to a file called `boston_placenames.kml`. Specify the point names and icon colors using name-value arguments.

```
kmlwrite("boston_placenames.kml",placenames,"Name",placenames.Name,"Color",colors)
```

Write Line Data to KML File Using Geographic Shape Vector

Read line features into a geographic shape (geoshape) vector.

```
tracks = gpxread("sample_tracks.gpx","Index",1:2);
```

Write the line data to a KML file. Specify the colors, widths, names, and descriptions of the lines using name-value arguments.

```
colors = ["red" "green"];
```

```
description = tracks.Metadata.Name;
```

```
name = ["track1" "track2"];
```

```
kmlwrite("sample_tracks.kml",tracks,"Color",colors,"LineWidth",2, ...  
        "Description",description,"Name",name)
```

Write Geographic Data to KML File Using Geographic Structure Array

Read the names and locations of major European cities from a shapefile. The `shaperead` function returns a geographic structure array (`geostruct`).

```
latlim = [30;75];
```

```
lonlim = [-25;45];
```

```
cities = shaperead("worldcities.shp","UseGeoCoords",true, ...  
                 "BoundingBox",[lonlim, latlim]);
```

Convert the structure to a geographic point (`geopoint`) vector.

```
cities = geopoint(cities);
```

Write the data to a KML file. Include city names in the placemarks by using the `Name` name-value argument. Remove the default `Description` table.

```
kmlwrite("european_cities.kml",cities,"Name",cities.Name,"Description",{});
```

Write Unstructured Address to KML File

Create a cell array of unstructured addresses. For this example, use the names of several Australian cities.

```
address = {'Perth, Australia', ...
          'Melbourne, Australia', ...
          'Sydney, Australia'};
```

Write the unstructured address data to a KML file called `australian_cities.kml`. Include the names of the cities in the placemarks using the `Name` name-value argument.

```
kmlwrite("australian_cities.kml",address,"Name",address);
```

Input Arguments

filename — Name of output file

character vector | string scalar

Name of output file, specified as a string scalar or character vector. `kmlwrite` writes the file in the current folder, unless you specify a full or relative path name. If the file name includes an extension, it must be `.kml`.

Data Types: `char` | `string`

S — Geographic features to write to file

geospatial table | geopoint vector | geoshape vector | geographic structure array

Geographic features to write to file, specified as one of the following:

- A geospatial table containing `geopointshape`, `geolineshape`, or `geopolysshape` objects. The `kmlwrite` function does not support geospatial tables containing more than one type of shape object. For more information about geospatial tables, see “Create Geospatial Tables”.
- A `geopoint` vector.
- A `geoshape` vector. The `Geometry` field identifies the type of the data as `'point'`, `'line'`, or `'polygon'`.
- A geographic structure array (`geosstruct`) with `Lat` and `Lon` fields. If you specify a geographic structure array with `X` and `Y` fields, `kmlwrite` throws an error.

The attribute fields of `S` appear as a table in the `Description` tag of the `Placemark` for each element of `S`. The attribute fields appear in the table in the same order as they occur in `S`.

If `S` contains valid altitude data, `kmlwrite` writes the field values to the file as KML altitudes and sets the altitude interpretation to `'relativeToSeaLevel'`. If `S` does not contain altitude data, `kmlwrite` sets the altitude field in the file to `0` and sets the altitude interpretation to `'clampToGround'`. The altitude data can be in a field named either `Elevation`, `Altitude`, or `Height`. If `S` contains fields with more than one of these names, `kmlwrite` issues a warning and ignores the altitude fields.

address — Location of KML placemark

character vector | string scalar | cell array of character vectors

Location of KML placemark, specified as a string scalar, character vector or cell array of character vectors containing freeform address data, such as street, city, state, and postal code. If `address` is a cell array, each cell represents a unique location.

Data Types: `char` | `string` | `cell`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose `Name` in quotes.

Example: `'Name', 'Point Reyes'`

Name — Label of object displayed in viewer

`'Address N', 'Point N', 'Line N', or 'Polygon N'`, where `N` is the index of the feature.
(default) | string scalar | character vector | cell array of character vectors

Label for an object displayed in viewer, specified as a string scalar, character vector, or cell array of character vectors. If you specify a string scalar or character vector, `kmlwrite` applies the name to all objects. If a string vector or cell array of character vectors, you must specify a name for each feature. That is, the cell array must be the same length as `S` or `address`. The following describes the default behavior for various features.

Feature	Default Name
Address	'Address N' where <i>N</i> is the index of the feature.
Point	'Point N' where <i>N</i> is the index of the feature.
Multipoint	'Multipoint N' where <i>N</i> is the index of the feature. <code>kmlwrite</code> places the points in the named folder and each point is named 'Point M' where <i>M</i> is the index of the point.
Line	'Line N' where <i>N</i> is the index of the feature. If the line data contains NaN values, <code>kmlwrite</code> places the line segments in a folder named 'Segment M', where <i>M</i> is the line segment number.
Polygon	'Polygon N' where <i>N</i> is the index of the feature. If the polygon vertex list contains multiple outer rings, <code>kmlwrite</code> places each ring in a folder labeled 'Part M', where <i>M</i> is the number for that feature.

Data Types: `char` | `string` | `cell`

Description — Content to be displayed in the placemark description balloon

string scalar | character vector | cell array of character vectors | attribute specification

Content to be displayed in the placemark description balloon, specified as a string scalar or character vector, cell array of character vectors, or an attribute specification. `kmlwrite` uses this data to set the values of the feature description tags. The description appears in the description balloon associated with the feature in Google Earth™.

- If you specify a string scalar or character vector, `kmlwrite` applies the description to all objects.
- If you specify a string vector or cell array of character vectors, there must be one label for each feature; that is, it must be the same length as `S` or `address`.

Description elements can be either plain text or tagged with HTML mark up. When in plain text, Google Earth applies basic HTML formatting automatically. For example, Google Earth replaces newlines with line break tags and encloses valid URLs in anchor tags to make them hyperlinks. To see examples of HTML tags that are recognized by Google Earth, view <https://earth.google.com>.

If you provide an attribute specification, the attribute fields of `S` display as a table in the description tag of the placemark for each element of `S`, in the order in which the fields appear in the specification. To construct an attribute spec, call `makeattribspec` and then modify the output to remove attributes or change the `Format` field for one or more attributes. The `latitude` and `longitude` coordinates of `S` are not considered to be attributes. If included in an attribute spec, `kmlwrite` ignores them.

Data Types: `char` | `string` | `cell`

Icon — File name of custom icon

defined by viewer (default) | string scalar | character vector | cell array of character vectors

File name of custom icon, specified as a string scalar, character vector or cell array of character vectors.

- If a string scalar or character vector, `kmlwrite` applies the value to all icons.
- If a string vector or cell array of character vectors, specify an icon for each feature; that is, the cell array must be the same length as `S` or `address`.
- If the string scalar or character vector is an Internet URL, the URL must include the protocol type.
- If the icon file name is not in the current folder, or in a folder on the MATLAB path, specify a full or relative path name.

Data Types: `char` | `string` | `cell`

IconScale — Scaling factor for icon

positive numeric scalar or vector

Scaling factor for the icon, specified as a positive numeric scalar or vector.

- If a scalar, `kmlwrite` applies the value to all objects
- If a vector, specify a scale factor for each feature. That is, the cell array must be the same length as `S` or `address`.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32`

Color — Color of icons, lines, or the faces and edges of polygons

defined by viewer (default) | color name | RGB triplet | cell array of color names | string vector of color names | matrix of RGB triplets | 'none'

Color of icons, lines, or the faces and edges of polygons, specified as one of these values.

- A color name such as `'red'` or a short name such as `'r'`.
- An RGB triplet, which is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range `[0, 1]`; for example, `[0.4 0.6 0.7]`.
- A cell array of color names such as `{'red', 'green', 'blue'}` or `{'r', 'g', 'b'}`.
- A string vector of color names such as `["red" "green" "blue"]` or `["r" "g" "b"]`.
- A matrix of RGB triplets, which is a three-column matrix in which each row is an RGB triplet.







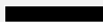

The way you specify the color depends on the desired color scheme.

- To apply the same color to all features, specify a single color name or RGB triplet.

- To apply a different color to each feature, specify a cell array of color names, a string vector of color names, or a matrix of RGB triplets. The number of colors and RGB triplets must match the length of `S` or `address`.
- To create a polygon `geoshape` with no fill or edge color, specify `'none'`.
- To exclude a color specification for icons or lines, specify `'none'`. In this case, the viewer defines the icon or line color.

Note that `Color` specifies the color of polygon faces and edges if you do not specify `FaceColor` and `EdgeColor`.

This table contains the color names and equivalent RGB triplets for some common colors.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Data Types: `char` | `string` | `cell` | `double`

Alpha — Transparency of the icons, lines, or the faces and edges of polygons

1 (fully opaque) (default) | numeric scalar or vector in the range [0 1]

Transparency of the icons, lines, or the faces and edges of polygons, specified as a numeric scalar or vector in the range [0 1]. If a scalar, `kmlwrite` applies the value to all features. If a vector, specify a value for each feature; that is, the vector must be the same length as `S` or `address`. If `S` is a polygon `geoshape`, `kmlwrite` applies the value to all the polygon faces if `FaceAlpha` is not specified and the polygon edges if `EdgeAlpha` is not specified.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32`

LineWidth — Width of lines and polygon edges in pixels

defined by viewer (default) | positive numeric scalar or vector

Width of lines and polygon edges in pixels, specified as a positive numeric scalar or vector.

- If a scalar, `kmlwrite` applies the value to all polygon edges.
- If a vector, specify a value for each feature. That is, the vector must have the same length as `S`.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32`

FaceColor — Color of polygon faces

defined by viewer (default) | color name | RGB triplet | cell array of color names | string vector of color names | matrix of RGB triplets | `'none'`





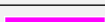
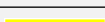


Color of polygon faces, specified as one of these values.

- A color name such as 'red' or a short name such as 'r'.
- An RGB triplet, which is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1]; for example, [0.4 0.6 0.7].
- A cell array of color names such as {'red', 'green', 'blue'} or {'r', 'g', 'b'}.
- A string vector of color names such as ["red" "green" "blue"] or ["r" "g" "b"].
- A matrix of RGB triplets, which is a three-column matrix in which each row is an RGB triplet.

The way you specify the color depends on the desired color scheme.

- To apply the same color to all polygon faces, specify a single color name or RGB triplet.
- To apply a different color to each face, specify a cell array of color names, a string vector of color names, or a matrix of RGB triplets. The number of colors and RGB triplets must match the length of *S* or *address*.
- To create a polygon geoshape with no face color, specify 'none'.

This table contains the color names and equivalent RGB triplets for some common colors.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Data Types: char | string | cell | double

FaceAlpha — Transparency of polygon faces

1 (fully opaque) (default) | numeric scalar or vector in the range [0 1]

Transparency of polygon faces, specified as a numeric scalar or vector in the range [0 1].

- If a scalar, kmlwrite applies the value to all polygon faces.
- If a vector, specify a value for each polygon face; that is, the vector must be the same length as *S* or *address*.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32

EdgeColor — Color of polygon edges

defined by viewer (default) | color name | RGB triplet | cell array of color names | string vector of color names | matrix of RGB triplets | 'none'

Color of polygon edges, specified as one of these values.


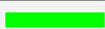






- A color name such as 'red' or a short name such as 'r'.

- An RGB triplet, which is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1]; for example, [0.4 0.6 0.7].
- A cell array of color names such as {'red', 'green', 'blue'} or {'r', 'g', 'b'}.
- A string vector of color names such as ["red" "green" "blue"] or ["r" "g" "b"].
- A matrix of RGB triplets, which is a three-column matrix in which each row is an RGB triplet.

The way you specify the color depends on the desired color scheme.

- To apply the same color to the edges of all polygons, specify a single color name or RGB triplet.
- To apply a different edge color for each polygon, specify a cell array of color names, a string vector of color names, or a matrix of RGB triplets. The number of colors and RGB triplets must match the length of *S* or *address*.
- To create a polygon geoshape with no edge color, specify 'none'.

This table contains the color names and equivalent RGB triplets for some common colors.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Data Types: char | string | cell | double

EdgeAlpha — Transparency of the polygon edges

1 (fully opaque) (default) | numeric scalar or vector in the range [0 1]

Transparency of the polygon edges, specified as a numeric scalar or vector.

- If a scalar, `kmlwrite` applies the value to all polygon edges.
- If a vector, *y* specify a value for each polygon edge; that is, the vector must be the same length as *S*. If you do not specify `EdgeAlpha`, `kmlwrite` uses the value of `Alpha`, if specified. If you do not specify either value, `kmlwrite` uses the default value 1 (fully opaque).

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32

Extrude — Connect polygons to the ground

false (default) | true | logical or numeric scalar | logical or numeric vector

Connect polygon to the ground, specified as a logical or numeric scalar, `true` (1) or `false` (0), or vector. If a scalar, the values applies to all polygons. If a vector, specify a value for each polygon; that is, the vector must be the same length as *S* or *address*.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64 | logical

CutPolygons – Cut polygon parts

true (default) | false

Cut polygon parts, specified as a logical or numeric scalar true (1) or false (0). If true, kmlwrite cuts polygon parts at the PolygonCutMeridian value. If true, and the polygon parts require cutting, kmlwrite returns an error if the altitude values are nonuniform.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | logical

PolygonCutMeridian – Meridian where polygon parts are cut

180 (default) | scalar numeric

Meridian where polygon parts are cut, specified as a scalar numeric.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32

AltitudeMode – Interpretation of altitude values

'clampToGround' | 'relativeToGround' | 'relativeToSeaLevel'

Interpretation of altitude values, specified as one of the following values:

Value	Description
'clampToGround'	Ignore altitude values and set the feature on the ground. This is the default interpretation when you do not specify altitude values.
'relativeToGround'	Set altitude values relative to the actual ground elevation of a particular feature
'relativeToSeaLevel'	Set altitude values relative to sea level, regardless of the actual elevation values of the terrain beneath the feature. (Named 'absolute' in the KML specification.) This is the default interpretation when you specify altitude values.

Data Types: char | string

LookAt – Position of virtual camera (eye) relative to object being viewed

geopoint vector

Position of the virtual camera (eye) relative to the object being viewed, specified as a geopoint vector. The fields of the geopoint vector, listed below, define the view. LookAt is limited to looking down at a feature. To tilt the virtual camera to look above the horizon into the sky, use the Camera parameter.

Property Name	Description	Data Type
Latitude	Latitude of the object the camera is looking at, in degrees	Scalar double, from -90 to 90
Longitude	Longitude of the object the camera is looking at, in degrees	Scalar double, from -180 to 180
Altitude	Altitude of the object the camera is looking at from the Earth's surface, in meters	Scalar numeric

Property Name	Description	Data Type
Heading	Camera direction (azimuth), in degrees (optional)	Scalar numeric [0 360], default 0 (true North)
Tilt	Angle between the direction of the LookAt position and the normal to the surface of the Earth, in degrees (optional)	Scalar numeric [0 90], default 0 (directly above)
Range	Distance in meters from the object specified by <code>latitude</code> , <code>longitude</code> , and <code>altitude</code> to the location of the camera.	Scalar numeric, default 0
AltitudeMode	Interpretation of the camera altitude value (optional)	'relativeToSeaLevel', 'clampToGround', (default) 'relativeToGround'

Camera — Position of virtual camera relative to surface of Earth

geopoint vector

Position of virtual camera (eye) relative to Earth's surface, specified as a geopoint vector. The fields of the geopoint vector, listed below, define the view. Camera provides full six degrees of freedom control over the view, so you can position the camera in space and then rotate it around the x-, y-, and z-axes. You can tilt the camera view so that you're looking above the horizon into the sky.

Property Name	Description	Data Type
Latitude	Latitude of the virtual camera (eye), in degrees	Scalar double, in the range [-90 90]
Longitude	Longitude of the virtual camera, in degrees	Scalar double, in the range [-180 180].
Altitude	Distance of the virtual camera from the Earth's surface, in meters	Scalar numeric
Heading	Direction (azimuth) in degrees (optional)	Scalar numeric [0 360], default 0 (true North)
Tilt	Camera rotation around the X-axis, in degrees (optional)	Scalar numeric [0 180], default 0 (directly above)
Roll	Camera rotation in degrees around the Z-axis (optional)	Scalar numeric, in the range [-180 180], default 0
AltitudeMode	Specifies how camera altitude is interpreted (optional)	'relativeToSeaLevel', 'clampToGround', 'relativeToGround' (default)

Tips

- You can view KML files with the Google Earth browser, which must be installed on your computer.

For Windows, use the `winopen` function:

```
winopen(filename)
```

For Linux, if the file name is a partial path, use the following commands:

```
cmd = 'googleearth ';
fullfilename = fullfile(pwd, filename);
system([cmd fullfilename])
```

For Mac, if the file name is a partial path, use the following commands:

```
cmd = 'open -a Google\ Earth '
fullfilename = fullfile(pwd, filename);
system([cmd fullfilename])
```

- You can also view KML files with a Google Maps™ browser. The file must be located on a web server that is accessible from the Internet. A private intranet server will not suffice because Google's server must be able to access the URL that you provide. The following is a template for using Google Maps. Replace `your-web-server-path` with a real value.

```
GMAPS_URL = 'http://maps.google.com/maps?q=';
KML_URL = 'http://your-web-server-path';
web([GMAPS_URL KML_URL])
```

Version History

Introduced in R2007b

R2021b: Write geospatial tables to KML format

The `kmlwrite` function accepts geospatial tables as input.

R2016a: Syntaxes that accept numeric vectors are not recommended

Not recommended starting in R2016a

Syntaxes of the `kmlwrite` function that accept numeric vectors are not recommended. Use the `kmlwritepoint` function instead. To update your code, replace instances of the `kmlwrite` function with the `kmlwritepoint` function.

Not Recommended	Recommended
<code>kmlwrite(filename,lat,lon)</code>	<code>kmlwritepoint(filename,lat,lon)</code>
<code>kmlwrite(filename,lat,lon,alt)</code>	<code>kmlwritepoint(filename,lat,lon,alt)</code>

See Also

`kmlwriteline` | `kmlwritepoint` | `kmlwritepolygon` | `makeattribspec` | `shapewrite`

kmlwriteline

Write geographic line data to KML file

Syntax

```
kmlwriteline(filename,latitude,longitude)
kmlwriteline(filename,latitude,longitude,altitude)
kmlwriteline( ____,Name,Value)
```

Description

`kmlwriteline(filename,latitude,longitude)` writes the geographic line data specified by `latitude` and `longitude` to the file specified by `filename` in Keyhole Markup Language (KML) format. `kmlwriteline` creates a KML Placemark element for each line, using the latitude and longitude values as the coordinates of the points that define the line. `kmlwriteline` sets the altitude values associated with the line to 0 and sets the altitude interpretation to `'clampToGround'`.

`kmlwriteline(filename,latitude,longitude,altitude)` uses the values of `latitude`, `longitude`, and `altitude` to set the coordinates of the points that define the line. When you specify an altitude value, `kmlwriteline` sets the `AltitudeMode` attribute to `'relativeToSeaLevel'`.

`kmlwriteline(____,Name,Value)` specifies name-value pairs that set additional KML feature properties. Parameter names can be abbreviated and are case-insensitive.

Examples

Write Line Data to KML File

Load geographic data describing coast lines.

```
load coastlines
```

Define the name of the KML file you want to create.

```
filename = 'coastlines.kml';
```

Write the line data to the file, specifying the color and width of the line.

```
kmlwriteline(filename, coastlat, coastlon, 'Color','black', ...
             'LineWidth', 3);
```

Retrieve GPS Track Log from GPX File and Write Data to KML File

Read the track log from a GPX file. `gpxread` returns the data as a geopoint vector.

```
points = gpxread('sample_tracks');
```

Get the latitude, longitude, and altitude values from the data.


```
lat = points.Latitude;
lon = points.Longitude;
alt = points.Elevation;
```

Define the name of the KML file you want to create.

```
filename = 'track.kml';
```

Write the geographic line data to the file, specifying a description and a name.

```
kmlwriteline(filename,lat, lon, alt, ...
    'Description', points.Metadata.Name, 'Name', 'Track Log');
```

Display Equally Spaced Waypoints Along Two Great Circle Tracks

Read the track data into a geopoint vector.

```
cities = geopoint(shaperead('worldcities','UseGeoCoords',true));
```

Get the latitude, longitude, and altitude values from the data. The example uses London and New York.

```
city1 = 'London';
city2 = 'New York';
pt1 = cities(strcmp(city1,cities.Name));
pt2 = cities(strcmp(city2,cities.Name));
lat1 = pt1.Latitude;
lon1 = pt1.Longitude;
lat2 = pt2.Latitude;
lon2 = pt2.Longitude;
nlegs = 20;
[lat,lon] = gcwaypts(lat1,lon1,lat2,lon2,nlegs);
midpoint = nlegs/2;
altscale = 5000;
alt = [0:midpoint midpoint-1:-1:0] * altscale;
```

Specify the view using LookAt parameter values.

```
lookLat = 49.155804;
lookLon = -56.698494;
lookAt = geopoint(lookLat, lookLon);
lookAt.Range = 2060400;
lookAt.Heading = 10;
lookAt.Tilt = 70;
```

Write the geographic line data to two KML files, specifying color, width, and view. One track displays altitude values and the other has the track clamped to the ground.

```
width = 4;
filename1 = 'altitudetrack.kml';
kmlwriteline(filename1,lat,lon,alt,'Color','k','LineWidth',width)

filename2 = 'groundtrack.kml';
```

```
kmlwriteline(filename2,lat,lon,alt,'Color','w','LineWidth',width, ...  
            'LookAt',lookAt,'AltitudeMode','clampToGround')
```

Input Arguments

filename — Name of output file

character vector | string scalar

Name of output file, specified as a string scalar or character vector. `kmlwriteline` creates the file in the current folder, unless you specify a full or relative path name. If the file name includes an extension, it must be `.kml`.

Data Types: `char` | `string`

latitude — Latitudes of points that define the line

vector in the range [-90 90]

Latitudes of points that define the line, specified as a vector in the range [-90 90].

Data Types: `single` | `double`

longitude — Longitudes of points that define the line

vector

Longitudes of points that define the line, specified as a vector. Longitude values automatically wrap to the range [-180, 180].

Data Types: `single` | `double`

altitude — Altitude of points that define the line

0 (default) | scalar or vector

Altitude of points that define the line, specified as a scalar or vector. Unit of measure is meters.

- If a scalar, `kmlwriteline` applies the value to each point.
- If a vector, you must specify an altitude value for each point. That is, the vector must have the same length as `latitude` and `longitude`.

Data Types: `single` | `double`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `'Name', 'Point Reyes'`

Name — Label of line displayed in viewer

'Line N' where N is the index of the line (default) | string scalar | character vector

Label of line displayed in viewer, specified as a string scalar or character vector.

If the line contains NaN values, `kmlwriteline` places the line segments in a folder labeled 'Line 1'. `kmlwriteline` labels the line segments 'Segment N', where N is the index value of the line segment.

Data Types: `char` | `string`

Description – Content to be displayed in the line description balloon

`string scalar` | `character vector`

Content to be displayed in the line description balloon, specified as a string scalar or character vector. The description appears in the description balloon when the user clicks either the feature name in the Google Earth Places panel or the line in the viewer window.

You can include basic HTML mark up, however, Google Earth applies some HTML formatting automatically. For example, Google Earth replaces newlines with line break tags and encloses valid URLs in anchor tags to make them hyperlinks. To see examples of HTML tags recognized by Google Earth, view <https://earth.google.com>.

Data Types: `char` | `string`

Color – Line color





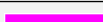
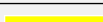

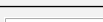
defined by viewer (default) | color name | RGB triplet | 'none'

Line color, specified as one of these options.

- A color name such as 'red' or a short name such as 'r'.
- An RGB triplet, which is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1]; for example, [0.4 0.6 0.7].

If you do not specify a line color, or specify 'none', then the `kmlwriteline` function does not include a color specification in the file and the viewer defines the color.

This table contains the color names and equivalent RGB triplets for some common colors.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Data Types: `char` | `string` | `double`

Alpha – Transparency of line

1 (default) | numeric scalar in the range [0 1]

Transparency of line, specified as a numeric scalar in the range [0 1]. The default value, 1, indicates that the line is fully opaque.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

LineWidth — Width of line in pixels

defined by viewer (default) | positive numeric scalar

Width of line in pixels, specified as a positive numeric scalar. If you do not specify a width, `kmlwriteline` does not include width information in the file and the viewer defines the line width.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32`

AltitudeMode — Interpretation of altitude values

'`clampToGround`' (default) | '`relativeToGround`' | '`relativeToSeaLevel`'

Interpretation of altitude values, specified as one of the following:

Value	Description
' <code>clampToGround</code> '	Ignore altitude values and set the feature on the ground. The default interpretation when you do not specify altitude values.
' <code>relativeToGround</code> '	Set altitude values relative to the actual ground elevation of a particular feature.
' <code>relativeToSeaLevel</code> '	Set altitude values relative to sea level, regardless of the actual elevation values of the terrain beneath the feature. The default interpretation when you specify altitude values. Called ' <code>absolute</code> ' in KML terminology.

Data Types: `char` | `string`

LookAt — Position of virtual camera (eye) relative to object being viewed

geopoint vector

Position of the virtual camera (eye) relative to the object being viewed, specified as a geopoint vector. The fields of the geopoint vector define the view. `LookAt` is limited to looking down at a feature. To tilt the virtual camera to look above the horizon into the sky, use the `Camera` parameter.

Property Name	Description	Data Type
Latitude	Latitude of the line the camera is looking at, in degrees	Scalar double, from -90 to 90
Longitude	Longitude of the line the camera is looking at, in degrees	Scalar double, from -180 to 180
Altitude	Altitude of the line the camera is looking at from the Earth's surface, in meters	Scalar numeric
Heading	Camera direction (azimuth), in degrees (optional)	Scalar numeric [0 360], default 0 (true North)
Tilt	Angle between the direction of the <code>LookAt</code> position and the normal to the surface of the Earth, in degrees (optional)	Scalar numeric [0 90], default 0 (directly above)

Property Name	Description	Data Type
Range	Distance in meters from the point specified by <code>latitude</code> , <code>longitude</code> , and <code>altitude</code> to the position of the camera.	Scalar numeric, default 0
AltitudeMode	Interpretation of the camera altitude value (optional)	'relativeToSeaLevel', 'clampToGround', (default) 'relativeToGround'

Camera – Position of virtual camera relative to surface of Earth

geopoint vector

Position of virtual camera (eye) relative to Earth's surface, specified as a geopoint vector. The fields of the geopoint vector, listed below, define the view. Camera provides full 6 degrees of freedom control over the view, so you can position the camera in space and then rotate it around the x-, y-, and z-axes. You can tilt the camera view so that you're looking above the horizon into the sky.

Property Name	Description	Data Type
Latitude	Latitude of the virtual camera (eye), in degrees	Scalar double, in the range [-90 90]
Longitude	Longitude of the virtual camera, in degrees,	Scalar double, in the range [-180 180].
Altitude	Distance of the virtual camera from the Earth's surface, in meters	Scalar numeric
Heading	Direction (azimuth) in degrees (optional)	Scalar numeric [0 360], default 0 (true North)
Tilt	Camera rotation around the X-axis, in degrees (optional)	Scalar numeric [0 180], default 0 (directly above)
Roll	Camera rotation in degrees around the Z-axis (optional)	Scalar numeric, in the range [-180 180], default 0
AltitudeMode	Specifies how camera altitude is interpreted (optional)	'relativeToSeaLevel', 'clampToGround', 'relativeToGround' (default)

Tips

- If you do not see your line, set `AltitudeMode` to 'clampToGround'. If the line appears, then you may have a problem with your altitude value.
- You can view KML files with the Google Earth browser, which must be installed on your computer.

For Windows, use the `winopen` function:

```
winopen(filename)
```

For Linux, if the file name is a partial path, use the following commands:

```
cmd = 'googleearth ';
fullfilename = fullfile(pwd, filename);
system([cmd fullfilename])
```

For Mac, if the file name is a partial path, use the following commands:

```
cmd = 'open -a Google\ Earth '  
fullfilename = fullfile(pwd, filename);  
system([cmd fullfilename])
```

- You can also view KML files with a Google Maps browser. The file must be located on a web server that is accessible from the Internet. A private intranet server will not suffice because Google's server must be able to access the URL that you provide. The following is a template for using Google Maps. Replace `your-web-server-path` with a real value.

```
GMAPS_URL = 'http://maps.google.com/maps?q=';  
KML_URL = 'http://your-web-server-path';  
web([GMAPS_URL KML_URL])
```

Version History

Introduced in R2013a

See Also

`kmlwrite` | `kmlwritepoint` | `kmlwritepolygon` | `shapewrite`

kmlwritepoint

Write geographic point data to KML file

Syntax

```
kmlwritepoint(filename,latitude,longitude)
kmlwritepoint(filename,latitude,longitude,altitude)
kmlwritepoint( ____,Name,Value)
```

Description

`kmlwritepoint(filename,latitude,longitude)` writes the geographic point data specified by `latitude` and `longitude` to the file specified by `filename` in Keyhole Markup Language (KML) format. `kmlwritepoint` creates a KML Placemark element for each point, using the latitude and longitude values as coordinates of the points. `kmlwritepoint` sets the altitude values associated with the points to 0 and sets the altitude interpretation to 'clampToGround'.

`kmlwritepoint(filename,latitude,longitude,altitude)` writes `latitude`, `longitude`, and `altitude` data as point coordinates. When you specify an altitude value, `kmlwritepoint` sets the `AltitudeMode` attribute to 'relativeToSeaLevel'.

`kmlwritepoint(____,Name,Value)` specifies name-value pairs that set additional KML feature properties. Parameter names can be abbreviated and are case-insensitive.

Examples

Write Data to KML File that Includes HTML Format Tags

Define a point by latitude and longitude.

```
lat = 42.299827;
lon = -71.350273;
```

Specify the description text used with the placemark, including HTML tags for formatting.

```
description = sprintf('%s<br>%s</br><br>%s</br>', ...
    '3 Apple Hill Drive', 'Natick, MA. 01760', ...
    'https://www.mathworks.com');
name = 'The MathWorks, Inc.';
iconDir = fullfile(matlabroot,'toolbox','matlab','icons');
iconFilename = fullfile(iconDir, 'matlabicon.gif');
```

Define the name of the KML file you want to create.

```
filename = 'MathWorks.kml';
```

Write the data to a KML file, using the `Description` parameter to include the names of the cities in the placemarks.

```
kmlwritepoint(filename, lat, lon, ...
    'Description', description, 'Name', name, 'Icon', iconFilename);
```

Retrieve Point Data from Shape File and Write Data to KML File

Read the locations of major cities from a shape file into a geostruct.

```
latlim = [ 30; 75];  
lonlim = [-25; 45];  
cities = shaperead('worldcities.shp','UseGeoCoords', true, ...  
    'BoundingBox', [lonlim, latlim]);
```

Get the latitudes, longitudes, and names of the cities from the geostruct.

```
lat = [cities.Lat];  
lon = [cities.Lon];  
name = {cities.Name};
```

Define the name of the KML file you want to create.

```
filename = 'European_Cities.kml';
```

Write the geographic data to the file, specifying the names of the cities and the size of the icon.

```
kmlwritepoint(filename, lat, lon, 'Name', name, 'IconScale', 2);
```

Write Point Data to KML File Using Camera to Specify View

Create a geopoint object to specify the viewing options available through the Camera parameter. The example sets up a view of the Washington Monument in Washington D.C.

```
camlat = 38.889301;  
camlon = -77.039731;  
camera = geopoint(camlat, camlon);  
camera.Altitude = 500;  
camera.Heading = 90;  
camera.Tilt = 45;  
camera.Roll = 0;  
name = 'Camera ground location';
```

Define the name of the KML file you want to create.

```
filename = 'WashingtonMonument.kml';
```

Write the point data to the file with the view specification. Place a marker at the ground location of the camera.

```
lat = camera.Latitude;  
lon = camera.Longitude;  
kmlwritepoint(filename, lat, lon, 'Camera', camera, 'Name', name);
```


Write Point Data to KML File Using LookAt to Specify View

Specify the latitude, longitude, and altitude values that define a point. In this example, the location is the Machu Picchu ruins in Peru.

```
lat = -13.163111;
lon = -72.544945;
alt = 2430;
```

Create a geoint object to specify the viewing options available through the LookAt parameter.

```
lookAt = geoint(lat,lon);
lookAt.Range = 1500;
lookAt.Heading = 260;
lookAt.Tilt = 67;
name = 'LookAt location parameters';
```

Define the name of the KML file you want to create.

```
filename = 'Machu_Picchu.kml';
```

Write the point data to the file, using the LookAt parameter to specify the view.

```
kmlwritepoint(filename,lat,lon,alt,'Name',name,'LookAt',lookAt)
```

Use Camera Parameter to Specify View

Specify the latitude and longitude values that define the point that you want to view. In this example, the location is Mount Rainier.

```
lat_rainier = 46.8533;
lon_rainier = -121.7599;
```

Create a geoint vector to specify the position of the virtual camera (eye) you will use to view the location using the Camera parameter.

```
myview = geoint(46.7, -121.7, 'Altitude',2500, 'Tilt',85, 'Heading',345);
```

Define the name of the KML file you want to create.

```
filename = 'Mt_Rainier.kml';
```

Write the point data to the file, specifying a name and a custom color for the icon.

```
kmlwritepoint(filename,lat_rainier,lon_rainier,'Name','Mt Rainier',...
    'Color','red','IconScale',2,'Camera',myview)
```

Input Arguments

filename — Name of output file

string scalar | character vector

Name of output file, specified as a string scalar or character vector. `kmlwritepoint` creates the file in the current folder, unless you specify a full or relative path name. If the file name includes an extension, it must be `.kml`.

Data Types: `char` | `string`

latitude — Latitudes of points

vector in the range `[-90 90]`

Latitudes of points, specified as a vector in the range `[-90 90]`.

Data Types: `single` | `double`

longitude — Longitudes of points

vector

Longitudes of points, specified as a vector. Longitude values automatically wrap to the range `[-180 180]`, in compliance with the KML specification.

Data Types: `single` | `double`

altitude — Altitude of points in meters

0 (default) | scalar or vector

Altitude of points in meters, specified as a scalar or vector.

- If a scalar, `kmlwritepoint` applies the value to each point.
- If a vector, you must specify an altitude value for each point. That is, the vector must have the same length as `latitude` and `longitude`.

Data Types: `single` | `double`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `kmlwritepoint(filename,lat,lon,'Name','Point Reyes','IconScale',2);`

Name — Label of point displayed in viewer

'Point N' where N is the index of the point (default) | string scalar | string array | character vector | cell array of character vectors

Label of point displayed in viewer, specified as a string scalar or character vector or cell array of character vectors.

- If a string scalar or character vector, `kmlwritepoint` applies the name to all points.
- If a string array or cell array of character vectors, you must include a label for each point; that is, the cell array must have the same length as `latitude` and `longitude`.

Data Types: `char` | `string` | `cell`

Description — Content to be displayed in the point description balloon

string scalar | character vector | cell array of character vectors

Content to be displayed in the point description balloon, specified as a string scalar or character vector or a cell array of character vectors. The content appears in the description balloon when you click either the feature name in the Google Earth Places panel or the point in the viewer window.

- If a string scalar or character vector, `kmlwritepoint` applies the description to all points.
- If a string array or cell array of character vectors, you must include description information for each point; that is, the cell array must be the same length as `latitude` and `longitude`.

Description elements can be either plain text or marked up with HTML. When it is plain text, Google Earth applies basic formatting, replacing newlines with line break tags and enclosing valid URLs with anchor tags to make them hyperlinks. To see examples of HTML tags that Google Earth recognizes, view <https://earth.google.com>.

Data Types: `char` | `string` | `cell`

Icon — File name of a custom icon

defined by viewer, for example, Google Earth uses an image of a push pin. (default) | string scalar | string array | character vector | cell array of character vectors

File name of a custom icon, specified as a string scalar or character vector or cell array of character vectors.

- If a string scalar or character vector, `kmlwritepoint` uses the icon for all points.
- If a string array or cell array of character vectors, you must specify an icon for each point. That is, the cell array must be the same length as `latitude` and `longitude`.

If the icon file name is not in the current folder, or in a folder on the MATLAB path, you must specify a full or relative path name. If the file name is an Internet URL, the URL must include the protocol type.

Data Types: `char` | `string` | `cell`

IconScale — Scaling factor for icon

positive numeric scalar or vector

Scaling factor for the icon, specified as a positive numeric scalar or vector.

- If a scalar, `kmlwritepoint` applies the scaling factor to the icon for all points.
- If a vector, you must specify a scaling factor for each icon. That is, the vector must be the same length as `latitude` and `longitude`.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32`

Color — Icon color

defined by viewer (default) | color name | RGB triplet | cell array of color names | string vector of color names | matrix of RGB triplets | 'none'

Icon color, specified as one of these options.





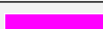
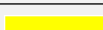


- A color name such as `'red'` or a short name such as `'r'`.
- An RGB triplet, which is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range `[0, 1]`; for example, `[0.4 0.6 0.7]`.
- A cell array of color names such as `{'red', 'green', 'blue'}` or `{'r', 'g', 'b'}`.

- A string vector of color names such as ["red" "green" "blue"] or ["r" "g" "b"].
- A matrix of RGB triplets, which is a three-column matrix in which each row is an RGB triplet.

The way you specify the color depends on the desired color scheme.

- To apply the same color to all icons, specify a single color name or RGB triplet.
- To apply a different color to each icon, specify a cell array of color names, a string vector of color names, or a matrix of RGB triplets. The number of colors and RGB triplets must match the length of `latitude` and `longitude`.
- To exclude a color specification for icons, specify 'none'. In this case, the viewer defines the icon color.

This table contains the color names and equivalent RGB triplets for some common colors.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Data Types: char | string | cell | double

Alpha — Transparency of the icons

1 (default) | numeric scalar or vector in the range [0 1]

Transparency of the icons, specified as a numeric scalar or vector in the range [0 1]. The default value, 1, indicates fully opaque.

- If a scalar, `kmlwritepoint` applies the value to all icons.
- If a vector, you must specify a value for each icon. That is, the vector must be the same length as `latitude` and `longitude`.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32

AltitudeMode — Interpretation of altitude values

'clampToGround' | 'relativeToGround' | 'relativeToSeaLevel'

Interpretation of altitude values, specified as one of the following values:

Value	Description
'clampToGround'	Ignore altitude values and set the feature on the ground. This is the default interpretation when you do not specify altitude values.

Value	Description
'relativeToGround'	Set altitude values relative to the actual ground elevation of a particular feature.
'relativeToSeaLevel'	Set altitude values relative to sea level, regardless of the actual elevation values of the terrain beneath the feature. This is the default interpretation when you specify altitude values. Called 'absolute' in KML terminology.

Data Types: char | string

LookAt — Position of the virtual camera (eye) relative to the object being viewed

geopoint vector

Position of the virtual camera (eye) relative to the object being viewed, specified as a geopoint vector. The view is defined by the fields of the geopoint vector, listed in the table below. LookAt is limited to looking down at a feature, you cannot tilt the virtual camera to look above the horizon into the sky. To tilt the virtual camera to look above the horizon into the sky, use the Camera parameter.

Property Name	Description	Data Type
Latitude	Latitude of the point the camera is looking at, in degrees north or south of the Equator (0 degrees)	Scalar double, from -90 to 90
Longitude	Longitude of the point the camera is looking at, in degrees, specifying angular distance relative to the Prime Meridian	Scalar double, in the range [-180 180]. Values west of the Meridian range from -180 to 0 degrees. Values east of the Meridian range from 0 to 180 degrees
Altitude	Altitude of the point the camera is looking at from the Earth's surface, in meters	Scalar numeric, default 0
Heading	Camera direction (azimuth), in degrees (optional)	Scalar numeric [0 360], default 0 (true North)
Tilt	Angle between the direction of the LookAt position and the normal to the surface of the earth, in degrees (optional)	Scalar numeric [0 90], default: 0, directly above.
Range	Distance in meters from the point specified by latitude, longitude, and altitude to the point where the camera is positioned—theLookAt position.	Scalar numeric, default: 0
AltitudeMode	Interpretation of camera altitude value (optional)	'relativeToSeaLevel', 'clampToGround', (default) 'relativeToGround'

Camera — Position of the virtual camera relative to the surface of the Earth

geopoint vector

Position of the camera relative to the Earth's surface, specified as a geopoint vector. The fields of the geopoint vector, listed below, define the view.Camera provides full six-degrees-of-freedom control

over the view, so you can position the camera in space and then rotate it around the X, Y, and Z axes. You can tilt the camera view so that you're looking above the horizon into the sky.

Property Name	Description	Data Type
Latitude	Latitude of the virtual camera (eye), in degrees north or south of the Equator (0 degrees)	Scalar double in the range [-90 90]
Longitude	Longitude of the virtual camera, in degrees, specifying angular distance relative to the Prime Meridian	Scalar double, in the range [-180 180]. Values west of the Meridian range from -180 to 0 degrees. Values east of the Meridian range from 0 to 180 degrees
Altitude	Distance of the virtual camera from the surface of the Earth, in meters	Scalar numeric
Heading	Direction (azimuth) in degrees (optional)	Scalar numeric [0 360], default 0 (true North)
Tilt	Camera rotation around the X-axis, in degrees (optional)	Scalar numeric [0 180], default: 0, directly above
Roll	Camera rotation in degrees around the Z-axis (optional)	Scalar numeric, in the range [-180 180] default: 0
AltitudeMode	Specifies the interpretation of camera altitude. (optional)	'relativeToSeaLevel', 'clampToGround', (default) 'relativeToGround'

- If a scalar, `kmlwritepoint` applies the value to all the points.
- If a vector, you must include an item for each point; that is, the length must be the same length as `latitude` and `longitude`.

Tips

- You can view KML files with the Google Earth browser, which must be installed on your computer.

For Windows, use the `winopen` function:

```
winopen(filename)
```

For Linux, if the file name is a partial path, use the following commands:

```
cmd = 'googleearth ';
fullfilename = fullfile(pwd, filename);
system([cmd fullfilename])
```

For Mac, if the file name is a partial path, use the following commands:

```
cmd = 'open -a Google\ Earth '
fullfilename = fullfile(pwd, filename);
system([cmd fullfilename])
```

- You can also view KML files with a Google Maps browser. The file must be located on a web server that is accessible from the Internet. A private intranet server will not suffice because Google's server must be able to access the URL that you provide. The following is a template for using Google Maps. Replace `your-web-server-path` with a real value.

```
GMAPS_URL = 'http://maps.google.com/maps?q=';  
KML_URL = 'http://your-web-server-path';  
web([GMAPS_URL KML_URL])
```

Version History

Introduced in R2013a

See Also

kmlwrite | kmlwriteline | kmlwritepolygon | shapewrite

kmlwritepolygon

Write geographic polygon to KML file

Syntax

```
kmlwritepolygon(filename,latitude,longitude)
kmlwritepolygon(filename,latitude,longitude,altitude)
kmlwritepolygon( ____,Name,Value)
```

Description

`kmlwritepolygon(filename,latitude,longitude)` writes the geographic latitude and longitude data that define polygon vertices to the file specified by `filename` in Keyhole Markup Language (KML) format. `kmlwritepolygon` creates a KML Placemark element for each polygon. By default, `kmlwritepolygon` sets the altitude value associated with the vertices to 0 and sets the altitude interpretation to 'clampToGround'.

`kmlwritepolygon(filename,latitude,longitude,altitude)` writes the polygon data to a KML file, including `altitude` values for each vertex. `altitude` can be a scalar value, in which case `kmlwritepolygon` uses it as the value for every vertex. If `altitude` is a vector, you must specify a value for every vertex; that is, `altitude` must be the same length as `latitude` and `longitude`. By default, when you specify altitude values, `kmlwritepolygon` sets the altitude interpretation to 'relativeToSeaLevel'.

`kmlwritepolygon(____,Name,Value)` specifies name-value pairs that set additional KML feature properties. Parameter names can be abbreviated and are not case sensitive.

Examples

Write Coastlines to KML File as Polygon

Load latitude and longitude data that defines the coastlines of the continents.

```
load coastlines
```

Specify the name of output KML file that you want to create.

```
filename = 'coastlines.kml';
```

Write the coastline data to the file as a polygon.

```
kmlwritepolygon(filename,coastlat,coastlon)
```

Create Polygon with Inner Ring

Define the latitude and longitude coordinates of the center of the rings. For this example, the coordinates specify the Eiffel Tower.


```
lat0 = 48.858288;
lon0 = 2.294548;
```

Define the inner radius and the outer radius of two small circles. The examples calls `poly2ccw` to change the direction of the vertex order of the second circle to counter-clockwise. This change of direction is needed to define the space between the two circles as a ring-shaped polygon.

```
outerRadius = .02;
innerRadius = .01;
[lat1,lon1] = scircle1(lat0,lon0,outerRadius);
[lat2,lon2] = scircle1(lat0,lon0,innerRadius);
[lon2,lat2] = poly2ccw(lon2,lat2);
lat = [lat1; NaN; lat2];
lon = [lon1; NaN; lon2];
alt = 500;
```

Specify name of output KML file and write the data to the file.

```
filename = 'EiffelTower.kml';
kmlwritepolygon(filename,lat,lon,alt, ...
    'EdgeColor','g','FaceColor','c','FaceAlpha',.5)
```

Create Polygon That Spans the 180 Degree Meridian

Specify latitude and longitude coordinates that define the vertices of the polygon. For this example, specify longitude values that span the 180 degree meridian.

```
lat = [0 1 1 0 0];
lon = [179.5 179.5 -179.5 -179.5 179.5];
h = 5000;
alt = ones(1,length(lat)) * h;
filename = 'cross180.kml';
kmlwritepolygon(filename,lat,lon,alt,'EdgeColor','r','FaceColor','w')
```

By default, the polygon contains a seam at the 180 degree mark. To remove this seam, set `PolygonCutMeridian` to 0.

```
filename = 'noseam.kml';
kmlwritepolygon(filename,lat,lon,alt,'EdgeColor','r', ...
    'FaceColor','w','PolygonCutMeridian',0);
```

To display a ramp without a seam, wrap the longitude values to the range [0 360], and set `CutPolygon` to `false`. Use the `Extrude` parameter to connect the polygon to the ground for better visibility.

```
filename = 'ramp.kml';
lon360 = wrapTo360(lon);
altramp = [0 0 h h 0];
kmlwritepolygon(filename,lat,lon360,altramp,'EdgeColor','r', ...
    'FaceColor','w','CutPolygons',false,'Extrude',true);
```

Input Arguments

filename — Name of output file

string scalar | character vector

Name of output file, specified as a string scalar or character vector. `kmlwritepolygon` creates the file in the current folder, unless you specify a full or relative path name. If the file name includes an extension, it must be `.kml`.

Data Types: `char` | `string`

latitude — Latitudes of polygon vertices

vector in the range [-90 90]

Latitudes of polygon vertices, specified as a vector in the range [-90 90].

Data Types: `single` | `double`

longitude — Longitude of polygon vertices

vector in the range [-180, 180]

Longitude of polygon vertices, specified as a vector in the range [-180, 180].

Data Types: `single` | `double`

altitude — Altitude of polygon vertices

0 (default) | scalar or vector

Altitude of polygon vertices, specified as a scalar or vector. Unit of measure is meters.

- If a scalar, `kmlwritepolygon` applies the value to each point.
- If a vector, you must specify an altitude value for each vertex. That is, the vector `altitude` must be the same length as `latitude` and `longitude`.

Data Types: `single` | `double`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example:

```
kmlwritepolygon(filename,lat,lon,alt,'EdgeColor','g','FaceColor','c','FaceAlpha',.5)
```

Name — Label displayed in the viewer for the polygon

'Polygon 1' (default) | string scalar | character vector

Label displayed in the viewer for the polygon, specified as the comma-separated pair consisting of 'Name' and a string scalar or character vector. If the vertex list contains multiple outer rings, `kmlwritepolygon` creates a folder with the value of `Name` and each outer ring labeled 'Part N' where `N` varies from 1 to the number of outer rings.

Data Types: `char` | `string`

Description — Content to be displayed in the polygon description balloon

character vector | string scalar

Content to be displayed in the polygon description balloon, specified as the comma-separated pair consisting of 'Description' and a string scalar or character vector. The content appears in the description balloon when you click either the feature name in the Google Earth Places panel or the polygon in the viewer window.

Description elements can be either plain text or HTML markup. When it is plain text, Google Earth applies basic formatting, replacing newlines with line break tags and enclosing valid URLs with anchor tags to make them hyperlinks. To see examples of HTML tags that Google Earth recognizes, see <https://earth.google.com>.

Data Types: char | string

FaceColor — Color of polygon face

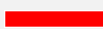



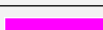



defined by viewer (default) | color name | RGB triplet | 'none'

Color of the polygon face, specified as the comma-separated pair of 'FaceColor' and one of these options.

- A color name — A color name such as 'red' or a short name such as 'r'.
- An RGB triplet — A three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1]; for example, [0.4 0.6 0.7].
- 'none' — No fill color.

If you do not specify a face color, then the `kmlwritepolygon` function does not include a color specification in the file and the viewer defines the color.

This table contains the color names and equivalent RGB triplets for some common colors.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Data Types: char | string | double

FaceAlpha — Transparency of the polygon face

1 (default) | numeric scalar in the range [0 1]

Transparency of the polygon face, specified as the comma-separated pair consisting of 'FaceAlpha' and a numeric scalar in the range [0 1]. The default value, 1, indicates that the face is fully opaque.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64

EdgeColor — Color of polygon edges

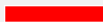







defined by viewer (default) | color name | RGB triplet | 'none'

Color of polygon edges, specified as the comma-separated pair of 'EdgeColor' and one of these values.

- A color name such as 'red' or a short name such as 'r'.
- An RGB triplet, which is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1]; for example, [0.4 0.6 0.7].
- 'none' — No edge color.

If you do not specify an edge color, then the `kmlwritepolygon` function does not include a color specification in the file and the viewer defines the color.

This table contains the color names and equivalent RGB triplets for some common colors.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Data Types: char | string | double

EdgeAlpha — Transparency of polygon edges

1 (default) | numeric scalar in the range [0 1]

Transparency of polygon edge, specified as the comma-separated pair consisting of 'EdgeAlpha' and a numeric scalar in the range [0 1]. The default value, 1, indicates that the edge is fully opaque.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64

LineWidth — Width of the polygon edge in pixels

determined by viewer (default)

Width of the polygon edge in pixels, specified as the comma-separated pair consisting of 'LineWidth' and a positive numeric scalar.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64

Extrude — Connect polygon to the ground

false (default) | true

Connect polygon to the ground, specified as the comma-separated pair consisting of 'Extrude' and a logical scalar or numeric value true (1) or false (0).

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

CutPolygons – Cut polygon parts

`true` (default) | `false`

Cut polygon parts, specified as the comma-separated pair consisting of 'CutPolygons' and a logical scalar or numeric value `true` (1) or `false` (0). If `true`, `kmlwritepolygon` cuts polygons at the meridian specified by `PolygonCutMeridian`. `kmlwritepolygon` returns an error if you set this to `true`, the polygon parts require cutting, and the altitude values are nonuniform.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

PolygonCutMeridian – Meridian where polygon parts are cut

180 (default) | scalar numeric

Meridian where polygon parts are cut, specified as the comma-separated pair consisting of 'PolygonCutMeridian' and a scalar numeric value.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

AltitudeMode – Interpretation of altitude values

'`clampToGround`' | '`relativeToGround`' | '`relativeToSeaLevel`'

Interpretation of altitude values, specified as the comma-separated pair consisting of 'AltitudeMode' and any of the following values:

Value	Meaning
' <code>clampToGround</code> '	Ignore the altitude values and set the feature on the ground. This value is the default interpretation when you do not specify altitude values.
' <code>relativeToGround</code> '	Set altitude values relative to the actual ground elevation of a particular feature.
' <code>relativeToSeaLevel</code> '	Set altitude values relative to sea level, regardless of the actual elevation values of the terrain beneath the feature. This value is the default interpretation when you specify altitude values. In KML terminology, this interpretation is called 'absolute'.

Data Types: `char`

LookAt – Position of virtual camera (eye) relative to object being viewed

geopoint vector

Position of virtual camera (eye) relative to object being viewed, specified as the comma-separated pair consisting of 'PLookAt' and a geopoint vector. The `LookAt` parameter defines the virtual camera that views the polygon. The fields of the geopoint vector define the view, outlined in the table below. `LookAt` can only look down at a feature. To tilt the virtual camera to look above the horizon into the sky, use the `Camera` parameter.

Field	Meaning	Value
' <code>Latitude</code> '	Latitude of the point the camera is looking at, in degrees	Scalar double
' <code>Longitude</code> '	Longitude of the point the camera is looking at, in degrees	Scalar double

Field	Meaning	Value
'Altitude'	Altitude of the point the camera is looking at, in meters (optional)	Scalar numeric default: 0
'Heading'	Camera direction (azimuth), in degrees (optional)	Scalar numeric [0 360] default 0
'Tilt'	Angle between the direction of the LookAt position and the normal to the surface of the Earth (optional)	Scalar numeric [0 90] default: 0
'Range'	Distance in meters from the point to the LookAt position	Scalar numeric
'AltitudeMode'	Specifies how the altitude is interpreted for the LookAt point (optional)	'relativeToSeaLevel', 'clampToGround', (default), 'relativeToGround'

Camera — Position and viewing direction of the virtual camera relative to the Earth's surface

geopoint vector

Position and viewing direction of the camera relative to the Earth's surface, specified as the comma-separated pair consisting of 'Camera' and a geopoint vector. The vector contains the following fields. The camera value provides full six-degrees-of-freedom control over the view, so you can position the camera in space and then rotate it around the X, Y, and Z axes. Most importantly, you can tilt the camera view to look above the horizon into the sky.

Field	Meaning	Value
'Latitude'	Latitude of the eye point (virtual camera), specified in degrees	Scalar double
'Longitude'	Longitude of the eye point (virtual camera), specified in degrees	Scalar double
'Altitude'	Distance of the camera from the Earth's surface, specified in meters	Scalar numeric default: 0
'Heading'	Camera direction (azimuth) in degrees (Optional)	Scalar numeric [0 360] default 0
'Tilt'	Camera rotation around the X axis, specified in degrees (Optional)	Scalar numeric [0 180] default: 0
'Roll'	Camera rotation around the Z axis, specified in degrees (Optional)	Scalar numeric, default: 0
'AltitudeMode'	Specifies how kmlwritepolygon interprets camera altitude values. (Optional)	'relativeToSeaLevel', 'clampToGround', (default), 'relativeToGround'

Version History

Introduced in R2016a

See Also

kmlwrite | kmlwritepoint | kmlwriteline | shapewrite

latitudeToIntrinsicY

Package: `map.rasterref`

Convert from latitude to intrinsic y coordinates

Syntax

```
yIntrinsic = latitudeToIntrinsicY(R,lat)
```

Description

`yIntrinsic = latitudeToIntrinsicY(R,lat)` returns the y-coordinate in the intrinsic coordinate system corresponding to latitude `lat` in the geographic coordinate system, based on the relationship defined by geographic raster `R`.

Examples

Find Intrinsic y-Coordinate from Latitude

Import elevation data [1] on page 1-914 for a region in Colorado as an array and a `GeographicPostingsReference` object. Find the intrinsic y-coordinate corresponding to a latitude of 39.9539 degrees.

```
[Z,R] = readgeoraster('n39_w106_3arc_v2.dt1');  
yIntrinsic = latitudeToIntrinsicY(R,39.9539)
```

```
yIntrinsic = 56.3200
```

The result means that coordinates with a latitude of 39.9539 degrees fall between rows 56 and 57 of the posting points.

[1] The elevation data used in this example is from the U.S. Geological Survey.

Input Arguments

R — Geographic raster

`GeographicCellsReference` or `GeographicPostingsReference` object

Geographic raster, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object.

lat — Latitude coordinates

numeric array

Latitude coordinates, specified as a numeric array. Valid values of `lat` are in the range [-90, 90] degrees. `lat` coordinates can be outside the bounds of the raster `R`.

Data Types: `single` | `double`

Output Arguments

yIntrinsic — y-coordinates in intrinsic coordinate system

numeric array

y-coordinates in intrinsic coordinate system, returned as a numeric array. `yIntrinsic` is the same size as `lat`.

When a point has valid latitude outside the bounds of raster `R`, `yIntrinsic(k)` is extrapolated in the intrinsic coordinate system. When `lat(k)` is outside the range `[-90, 90]` degrees, or has a value of `NaN`, the corresponding value `yIntrinsic(k)` is set to `NaN`.

Data Types: double

Version History

Introduced in R2013b

See Also

`geographicToIntrinsic` | `intrinsicYToLatitude` | `longitudeToIntrinsicX`

latlon2pix

(To be removed) Convert latitude-longitude coordinates to pixel coordinates

Note The `latlon2pix` function will be removed in a future release. Use the `geographicToIntrinsic` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[row, col ] = latlon2pix(R,lat,lon)
```

Description

`[row, col] = latlon2pix(R,lat,lon)` calculates pixel coordinates `row`, `col` from latitude-longitude coordinates `lat`, `lon`. `R` is either a 3-by-2 referencing matrix that transforms intrinsic pixel coordinates to geographic coordinates, or a geographic raster reference object. `lat` and `lon` are vectors or arrays of matching size. The outputs `row` and `col` have the same size as `lat` and `lon`. `lat` and `lon` must be in degrees.

Longitude wrapping is handled in the following way: Results are invariant under the substitution `lon = lon +/- n * 360` where `n` is an integer. Any point on the Earth that is included in the image or gridded data set corresponding to `r` will yield row/column values between 0.5 and 0.5 + the image height/width, regardless of what longitude convention is used.

Examples

Find the pixel coordinates of the upper left and lower right outer corners of a 2-by-2 degree gridded data set.

```
R = georefcalls([-90 90],[0 360],2,2,'ColumnsStartFrom','north')
[UL_row, UL_col] = latlon2pix(R, 90, 0)    % Upper left
[LR_row, LR_col] = latlon2pix(R, -90, 360) % Lower right
```

Version History

Introduced before R2006a

R2023a: Warns

Warns starting in R2023a

Some functions that accept referencing matrices as input issue a warning that they will be removed in a future release, including the `latlon2pix` function. Use a geographic raster reference object and the `geographicToIntrinsic` function instead. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `GeographicPostingsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` function.
- Most functions that accept referencing matrices as inputs also accept reference objects.

To update your code, first create a reference object for either a raster of cells using the `georefcells` function or a raster of regularly posted samples using the `georefpostings` function. Alternatively, convert from a referencing matrix to a reference object using the `refmatToGeoRasterReference` function.

Then, replace uses of the `latlon2pix` function with the `geographicToIntrinsic` function according to this pattern.

Will Be Removed	Recommended
<code>[row,col] = latlon2pix(R,lat,lon);</code>	<code>[col,row] = geographicToIntrinsic(R,lat,lon)</code>

R2021b: To be removed

Not recommended starting in R2021b

The `latlon2pix` function runs without warning but will be removed in a future release.

See Also

`geographicToIntrinsic` | `worldToIntrinsic` | `intrinsicToGeographic`

lcolorbar

Color bar with text labels

Syntax

```
lcolorbar(labels)
lcolorbar(labels,Name,Value)
h = lcolorbar( ___ )
```

Description

`lcolorbar(labels)` displays a vertical color bar, with labels specified by the text in `labels`, to the right of the current axes.

`lcolorbar(labels,Name,Value)` specifies options for the color bar using name-value arguments.

`h = lcolorbar(___)` returns the color bar, using any combination of input arguments from the previous syntaxes.

Examples

Create Labeled Color Bar

Import elevation data for a region surrounding South Boulder Peak in Colorado. Calculate the viewshed for a sample point 1000 meters above the terrain.

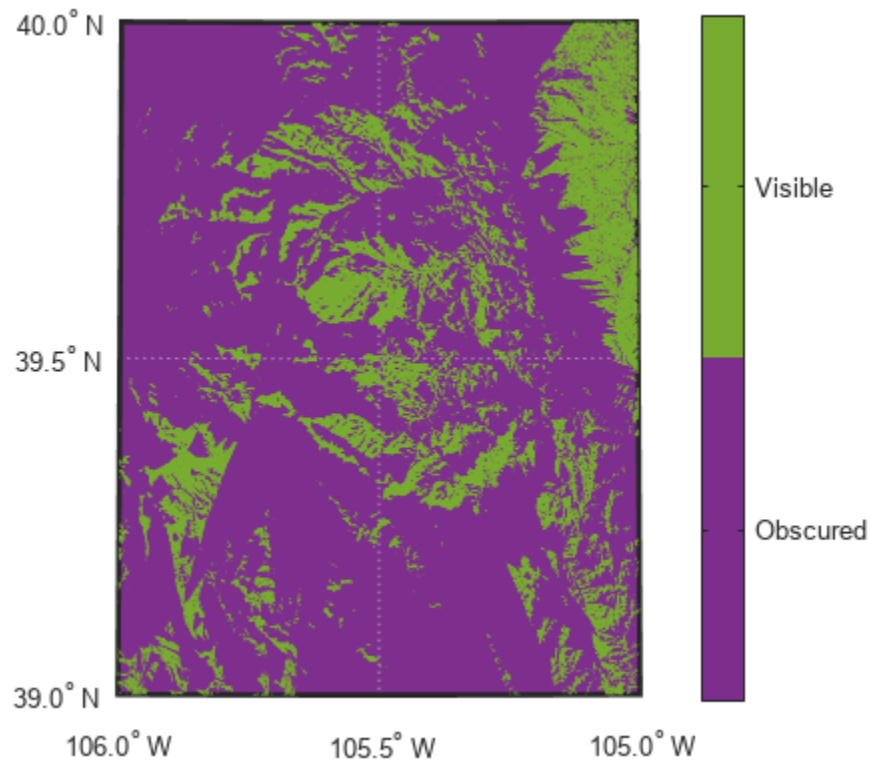
```
[Z,R] = readgeoraster("n39_w106_3arc_v2.dt1","OutputType","double");
[vis,visR] = viewshed(Z,R,39.6,-105.6,1000);
```

Display the viewshed on a map, using green for visible areas and purple for obscured areas.

```
figure
usamap(vis,visR)
geoshow(vis,visR,"DisplayType","surface")
cmap = [0.4940 0.1840 0.5560; 0.4660 0.6740 0.1880];
```

Add a labeled color bar. Avoid truncating the text by moving the color bar to the left.

```
colormap(cmap)
h = lcolorbar(["Obscured" "Visible"]);
h.Position(1) = h.Position(1)-0.1;
```



Input Arguments

Labels — Tick mark labels

cell array of character vectors | string array

Tick mark labels, specified as a cell array of character vectors or a string array. The number of elements in `labels` must match the length of the colormap.

Example: `["blue" "green" "yellow"]`

Data Types: `cell` | `char` | `string`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `lcolorbar(labels, Location="horizontal")` displays a horizontal color bar below the axes.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `lcolorbar(labels, "Location", "horizontal")` displays a horizontal color bar below the axes.

Note In addition to the name-value arguments in this section, you can use name-value arguments to specify values for the properties of the Axes object returned by this function. For more information about the properties of Axes objects, see Axes Properties.

Location — Location of color bar with respect to axes

"vertical" (default) | "horizontal"

Location of the color bar with respect to the axes, specified as one of these options:

- "vertical" — Display the color bar vertically and to the right of the axes.
- "horizontal" — Display the color bar horizontally and below the axes.

Data Types: char | string

TitleString — Title of color bar

character vector | string scalar

Title of the color bar, specified as a character vector or string scalar.

Data Types: char | string

XLabelString — x-label of color bar

character vector | string scalar

x-label of the color bar, specified as a character vector or string scalar.

Data Types: char | string

YLabelString — y-label of color bar

character vector | string scalar

y-label of the color bar, specified as a character vector or string scalar.

Data Types: char | string

ZLabelString — z-label of color bar

character vector | string scalar

z-label of the color bar, specified as a character vector or string scalar.

Data Types: char | string

ColorAlignment — Alignment of labels in color bar

"center" (default) | "ends"

Alignment of the labels in the color bar, specified as one of these options:

- "center" — Center the labels on the color bands.
- "ends" — Center the labels on the color breaks.

Data Types: char | string

Output Arguments**h — Output color bar**

Axes object

Output color bar, returned as an Axes object.

Version History

Introduced before R2006a

See Also

Functions

colorbar | colormap | polcmap

legs

Courses and distances between navigational waypoints

Syntax

```
[course,dist] = legs(lat,lon)
[course,dist] = legs(lat,lon,method)
[course,dist] = legs(pts, ___)
mat = legs( ___)
```

Description

`[course,dist] = legs(lat,lon)` returns the azimuths (`course`) and distances (`dist`) between navigational waypoints, which are specified by the column vectors `lat` and `lon`.

`[course,dist] = legs(lat,lon,method)` specifies the logic for the leg characteristics. If the `method` is 'rh' (the default), `course` and `dist` are calculated in a rhumb line sense. If `method` is 'gc', great circle calculations are used.

`[course,dist] = legs(pts, ___)` specifies waypoints in a single two-column matrix, `pts`.

`mat = legs(___)` packs up the outputs into a single two-column matrix, `mat`.

This is a navigation function. All angles are in degrees, and all distances are in nautical miles. Track legs are the courses and distances traveled between navigational waypoints.

Examples

Imagine an airplane taking off from Logan International Airport in Boston (42.3°N,71°W) and traveling to LAX in Los Angeles (34°N,118°W). The pilot wants to file a flight plan that takes the plane over O'Hare Airport in Chicago (42°N,88°W) for a navigational update, while maintaining a constant heading on each of the two legs of the trip.

What are those headings and how long are the legs?

```
lat = [42.3; 42; 34];
long = [-71; -88; -118];
[course,dist] = legs(lat,long,'rh')
```

```
course =
    268.6365
    251.2724
dist =
    1.0e+003 *
    0.7569
    1.4960
```

Upon takeoff, the plane should proceed on a heading of about 269° for 756 nautical miles, then alter course to 251° for another 1495 miles.

How much farther is it traveling by not following a great circle path between waypoints? Using rhumb lines, it is traveling

```
totalrh = sum(dist)
```

```
totalrh =  
    2.2530e+003
```

For a great circle route,

```
[coursegc,distgc] = legs(lat,long,'gc'); totalgc = sum(distgc)
```

```
totalgc =  
    2.2451e+003
```

The great circle path is less than one-half of one percent shorter.

See Also

[dreckon](#) | [gcwaypts](#) | [navfix](#) | [track](#)

length

Return number of elements in geographic or planar vector

Syntax

```
n = length(v)
```

Description

`n = length(v)` returns the number of elements contained in the geographic or planar vector `v`.

Examples

Find Length of Geopoint Vector

Create a geopoint vector and find its length.

```
load coastlines
p = geopoint(coastlat, coastlon);
length(p)
```

```
ans = 9865
```

```
length(coastlat)
```

```
ans = 9865
```

Input Arguments

v — Geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Geographic or planar vector, specified as a geopoint, geoshape, mappoint, or mapshape object.

Output Arguments

n — Number of elements

nonnegative integer scalar

Number of elements in vector `v`, returned as a nonnegative integer scalar. The result is equivalent to `size(v,1)`.

Version History

Introduced in R2012a

See Also

size

lightm

Project light objects on axesm-based map

Syntax

```
h = lightm(lat,lon)
h = lightm(lat,lon,PropertyName,PropertyValue,...)
h = lightm(lat,lon,alt)
```

Description

`h = lightm(lat,lon)` projects a light object at the coordinates `lat` and `lon`. The handle, `h`, of the object can be returned.

`h = lightm(lat,lon,PropertyName,PropertyValue,...)` allows the specification of any property name/property value pair supported by the standard MATLAB `light` function.

`h = lightm(lat,lon,alt)` allows the specification of an altitude, `alt`, for the light object. When omitted, the default is an infinite light source altitude.

Examples

Add Light to Map

Load elevation raster data and a geographic cells reference object. Create a globe frame by using an axesm-based map.

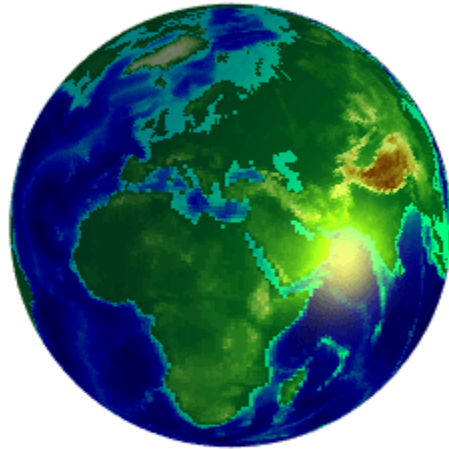
```
load topo60c
axesm globe
view(120,30)
axis off
```

Display the data and apply a colormap appropriate for elevation data.

```
meshm(topo60c,topo60cR)
demcmmap(topo60c)
```

Add light to the globe by specifying a latitude, longitude, and color. Set reflectance properties by using the `material` function. Change the lighting method using the `lighting` function.

```
lightm(0,90,'Color','y')
material([.5 .5 1])
lighting gouraud
```



Add a second light source that uses a different color.

```
lightm(90,0, 'Color', 'm')
```



Version History

Introduced before R2006a

See Also

light

limitm

(To be removed) Determine latitude and longitude limits of regular data grid

Note `limitm` will be removed in a future release. Instead, create a geographic raster reference object, and query its `LatitudeLimits` and `LongitudeLimits` properties. For more information, see “Compatibility Considerations”.

Syntax

```
[latlim,lonlim] = limitm(Z,R)
latlonlim = limitm(Z,R)
```

Description

`[latlim,lonlim] = limitm(Z,R)` computes the latitude and longitude limits of the geographic quadrangle bounding the regular data grid `Z` spatially referenced by `R`. `R` can be a geographic raster reference object, a referencing vector, or a referencing matrix.

If `R` is a geographic raster reference object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must also define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. The output `latlim` is a vector of the form `[southern_limit northern_limit]` and `lonlim` is a vector of the form `[western_limit eastern_limit]`. All angles are in units of degrees.

`latlonlim = limitm(Z,R)` concatenates `latlim` and `lonlim` into a 1-by-4 row vector of the form:

```
[southern_limit northern_limit western_limit eastern_limit]
```

Examples

Load elevation raster data and a geographic cells reference object. Then, find the latitude and longitude limits.

```
load topo60c
[latlimits,lonlimits] = limitm(topo60c,topo60cR)
```

```
latlimits =
```

```
-90  90  
  
lonlimits =  
  0  360
```

The data set covers the whole globe, so the result is expected.

Version History

Introduced before R2006a

R2022a: Warns

Warns starting in R2022a

Some functions that accept referencing vectors or referencing matrices as input issue a warning that they will be removed in a future release, including the `limitm` function. Instead, create a geographic raster reference object, and query its `LatitudeLimits` and `LongitudeLimits` properties. Reference objects have several advantages over referencing vectors and matrices.

- Unlike referencing vectors and matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `GeographicPostingsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` function.

To update your code, first create a reference object for either a raster of cells using the `georefcells` function or a raster of regularly posted samples using the `georefpostings` function. Alternatively, convert from a referencing vector or a referencing matrix to a reference object using the `refvecToGeoRasterReference` or `refmatToGeoRasterReference` function, respectively.

Then, find the limits of the raster by querying the `LatitudeLimits` and `LongitudeLimits` properties of the reference object, `R`.

```
latlim = R.LatitudeLimits;  
lonlim = R.LongitudeLimits;
```

R2020b: To be removed

Not recommended starting in R2020b

The `limitm` function runs without warning but will be removed in a future release.

See Also

`GeographicPostingsReference` | `GeographicCellsReference`

Line Properties

Geographic primitive line appearance and behavior

Description

Line properties control the appearance and behavior of a Line object. By changing property values, you can modify certain aspects of the line plot.

```
uif = uifigure;
g = geoglobe(uif);
p = geoplot3(g,51.5074,0.1900,200)
p.Marker = 'o';
p.LineWidth = 2;
```

Properties

Line

Color — Line color









[0 0 0] (default) | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...

Line color, specified as an RGB triplet, a hexadecimal color code, a color name, or a short name.








RGB triplets and hexadecimal color codes are useful for specifying custom colors.

- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1]; for example, [0.4 0.6 0.7].
- A hexadecimal color code is a character vector or a string scalar that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Thus, the color codes '#FF8800', '#ff8800', '#F80', and '#f80' are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

Example: 'blue'


Example: [0 0 1]

Example: '#0000FF'

LineStyle – Line style

'-' (default) | 'none'

Line style, specified as one of these options:

Line Style	Description	Resulting Line
'-'	Solid line (default)	
'none'	No line	No line

LineWidth – Line width

0.5 (default) | positive value

Line width, specified as a positive value in points, where 1 point = 1/72 of an inch. If the line has markers, then the line width also affects the marker edges.

The line width cannot be thinner than the width of a pixel. If you set the line width to a value that is less than the width of a pixel on your system, the line displays as one pixel wide.

SeriesIndex – Series index

positive integer

Series index, specified as a positive integer. This property is useful for reassigning the colors of several Line objects so that they match each other. By default, the SeriesIndex property of a line object is a number that corresponds to the object's order of creation, starting at 1.

MATLAB uses the number to calculate indices for assigning color when you call plotting functions. The indices refer to the rows of the arrays stored in the ColorOrder property of the parent object.

MATLAB automatically updates the color of the Line object when you change its SeriesIndex, or when you change the ColorOrder property on the parent object. However, the following conditions must be true for the changes to have any effect:

- The `SeriesIndex` property on the `Line` object is greater than 0.
- The `NextSeriesIndex` property on the parent object is greater than 0.

Markers

Marker — Marker symbol

'none' (default) | 'o'

Marker symbol, specified as 'none' or 'o'. By default, the line does not display markers. Specify 'o' to display circle markers at each data point or vertex.

Markers do not tilt or rotate as you navigate the globe.

MarkerIndices — Indices of data points at which to display markers

1:length(LatitudeData) (default) | vector of positive integers | scalar positive integer

Indices of data points at which to display markers, specified as a vector of positive integers. If you do not specify the indices, then MATLAB displays a marker at every data point.

Note To see the markers, you must also specify a marker symbol.

Example: `geoplot3(g,lat,lon,h,'-o','MarkerIndices',[1 5 10])` displays a circle marker at the first, fifth, and tenth data points.

Example: `geoplot3(g,lat,lon,h,'-o','MarkerIndices',1:3:length(lat))` displays a circle marker every three data points.

Example: `geoplot3(g,lat,lon,h,'Marker','o','MarkerIndices',5)` displays one circle marker at the fifth data point.

MarkerSize — Marker size

6 (default) | positive value

Marker size, specified as a positive value in points, where 1 point = 1/72 of an inch.

Coordinate Data

LatitudeData — Latitude values

vector

Latitude values, specified as a vector. `LatitudeData` and `LongitudeData` must have the same size.

LongitudeData — Longitude values

vector

Longitude values, specified as a vector. `LatitudeData` and `LongitudeData` must have the same size.

HeightData — Height values

scalar | vector

Height values, specified as a scalar or vector. If `HeightData` is a scalar, then its value is applied to every element in `LatitudeData` and `LongitudeData`. If `HeightData` is a vector, it must be the same size as `LatitudeData` and `LongitudeData`.

HeightReference — Height reference`'geoid' (default) | 'terrain' | 'ellipsoid'`

Height reference, specified as one of these values:

- `'geoid'` - Height values are relative to the geoid (mean sea level).
- `'terrain'` - Height values are relative to the ground.
- `'ellipsoid'` - Height values are relative to the WGS84 reference ellipsoid.

For more information about terrain, geoid, and ellipsoid height, see “Find Ellipsoidal Height from Orthometric and Geoid Height”.

Interactivity**Visible — State of visibility**`'on' (default) | on/off logical value`

State of visibility, specified as `'on'` or `'off'`, or as numeric or logical 1 (`true`) or 0 (`false`). A value of `'on'` is equivalent to `true`, and `'off'` is equivalent to `false`. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- `'on'` — Display the object.
- `'off'` — Hide the object without deleting it. You still can access the properties of an invisible object.

Parent/Child**Parent — Parent**`GeographicGlobe` object

Parent, specified as a `GeographicGlobe` object.

Children — Children`empty GraphicsPlaceholder` array

The object has no children. You cannot set this property.

HandleVisibility — Visibility of object handle`'on' (default) | 'off' | 'callback'`

Visibility of the object handle in the `Children` property of the parent, specified as one of these values:

- `'on'` — Object handle is always visible.
- `'off'` — Object handle is invisible at all times. This option is useful for preventing unintended changes by another function. Set the `HandleVisibility` to `'off'` to temporarily hide the handle during the execution of that function.
- `'callback'` — Object handle is visible from within callbacks or functions invoked by callbacks, but not from within functions invoked from the command line. This option blocks access to the object at the command line, but permits callback functions to access it.

If the object is not listed in the `Children` property of the parent, then functions that obtain object handles by searching the object hierarchy or querying handle properties cannot return it. Examples

of such functions include the `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close` functions.

Hidden object handles are still valid. Set the root `ShowHiddenHandles` property to `'on'` to list all object handles regardless of their `HandleVisibility` property setting.

Identifiers

Type — Type of graphics object

`'line'`

Type of graphics object, returned as `'line'`. Use this property to find all objects of a given type within a plotting hierarchy, for example, searching for the type using `findobj`.

Tag — Object identifier

`''` (default) | character vector | string scalar

Object identifier, specified as a character vector or string scalar. You can specify a unique `Tag` value to serve as an identifier for an object. When you need access to the object elsewhere in your code, you can use the `findobj` function to search for the object based on the `Tag` value.

UserData — User data

`[]` (default) | array

User data, specified as any MATLAB array. For example, you can specify a scalar, vector, matrix, cell array, character array, table, or structure. Use this property to store arbitrary data on an object.

If you are working in App Designer, create public or private properties in the app to share data instead of using the `UserData` property. For more information, see “Share Data Within App Designer Apps”.

Version History

Introduced in R2020a

See Also

`geoplot3` | `geoglobe`

Line Properties

Geographic chart line appearance and behavior

Description

Line properties control the appearance and behavior of a Line object. By changing property values, you can modify certain aspects of the line. Use dot notation to query and set properties.

```
shape = geolineshape(1:10,1:10);
p = geoplot(shape);
c = p.Color;
p.Color = "r";
```

Properties

Line

Color — Line color

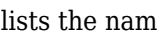
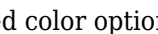


[0 0 0] (default) | 'flat' | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...

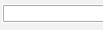
Line color, specified as 'flat', an RGB triplet, a hexadecimal color code, a color name, or a short name. The 'flat' option uses colors from the ColorData property. When the geoplot function sets the ColorData property, MATLAB updates this property to 'flat'.

For a custom color, specify an RGB triplet or a hexadecimal color code.

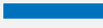
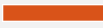



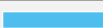

- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

Example: [0.5 0.5 0.5]





Example: 'blue'

Example: '#D2F9A7'

LineStyle – Line style

"-" (default) | "--" | ":" | "-." | "none"

Line style, specified as one of the options listed in this table.

Line Style	Description	Resulting Line
" - "	Solid line	
" - - "	Dashed line	
" : "	Dotted line	
" - . "	Dash-dotted line	
"none"	No line	No line

LineWidth – Line width

0.5 (default) | positive value

Line width, specified as a positive value in points, where 1 point = 1/72 of an inch.

The line width cannot be thinner than the width of a pixel. If you set the line width to a value that is less than the width of a pixel on your system, the line displays as one pixel wide.

Color Data

ColorData — Line colors

`[]` (default) | numeric vector

Line colors, specified as a numeric vector that linearly maps to the colors in the current colormap. The plot uses a different color for each element of `ShapeData`. Specify `ColorData` as a vector the same length as `ShapeData`.

The `ColorData` property controls the colors of the lines when the `Color` property has a value of `'flat'`.

ColorDataMode — Control how ColorData is set

`'auto'` (default) | `'manual'`

Control how the `ColorData` property is set, specified as one of these values:

- `'auto'` — MATLAB controls the value of the `ColorData` property.
- `'manual'` — You manually control the value of the `ColorData` property. When you set the `ColorData` property, MATLAB sets this property to `'manual'`.

To specify colors using the `ColorVariable` property, this property must have a value of `'auto'`.

SeriesIndex — Series index

non-negative integer

Series index, specified as a non-negative integer. This property is useful for reassigning the colors of several `Line` objects so that they match each other. By default, the `SeriesIndex` property of a `Line` object is a number that corresponds to the order of creation of the object, starting at 1.

MATLAB uses the number to calculate indices for assigning colors when you call plotting functions. The indices refer to the rows of the arrays stored in the `ColorOrder` property of the axes.

MATLAB automatically updates the color of the `Line` object when you change its `SeriesIndex`, or when you change the `ColorOrder` property on the axes. However, the following conditions must be true for the changes to have any effect:

- The `ColorDataMode` property on the `Line` object is has a value of `'auto'`.
- The `Color` property on the `Line` object has a value of `'flat'`.
- The `SeriesIndex` property on the `Line` object is greater than 0.
- The `NextSeriesIndex` property on the axes object is greater than 0.

Shape Data

ShapeData — Line shapes

empty `geolineshape` object (default) | `geolineshape` or `maplineshape` object | vector of `geolineshape` or `maplineshape` objects

Line shapes, specified as a `geolineshape` or `maplineshape` object or as a vector of `geolineshape` or `maplineshape` objects. For `maplineshape` objects, the value of the `ProjectedCRS` property must not be empty.

When you pass shape objects or a geospatial table to the `geoplot` function, the `geoplot` function sets the value of `ShapeData`.

ShapeDataMode — Control how ShapeData is set

'auto' (default) | 'manual'

Control how the ShapeData property is set, specified as one of these values:

- 'auto' — MATLAB automatically updates the ShapeData property based on the SourceTable and ShapeVariable properties. When you pass a geospatial table to the geoplot function, MATLAB sets this property to 'auto'.
- 'manual' — You manually control the value of the ShapeData property. When you set the ShapeData property or pass shape objects to the geoplot function, MATLAB sets this property to 'manual'.

Table Data**SourceTable — Source table**

geospatial table

Source table containing the data to plot, specified as a geospatial table. A geospatial table is a table or timetable object that contains a Shape variable and attribute variables. For more information about geospatial tables, see "Create Geospatial Tables".

ShapeVariable — Table variable containing shape objects

table variable index

Table variable containing the shape objects, specified as a table variable index. The table variable must contain geolineshape or maplineshape objects. For maplineshape objects, the value of the ProjectedCRS property must not be empty.

When you pass a geospatial table to the geoplot function, the value of this property is 'Shape'. When you set this property, MATLAB updates the ShapeData property.

This table lists the different indexing schemes you can use to specify the table variable.

Indexing Scheme	Examples
Variable name: <ul style="list-style-type: none"> • A string scalar or character vector. • A pattern object. The pattern object must refer to only one variable. 	<ul style="list-style-type: none"> • "A" or 'A' — A variable called A • "Var"+digitsPattern(1) — The variable with the name "Var" followed by a single digit
Variable index: <ul style="list-style-type: none"> • An index number that refers to the location of a variable in the table. • A logical vector. Typically, this vector is the same length as the number of variables, but you can omit trailing 0 or false values. 	<ul style="list-style-type: none"> • 3 — The third variable from the table • [false false true] — The third variable
Variable type: <p>A vartype subscript that selects a table variable of a specified type. The subscript must refer to only one variable.</p>	<ul style="list-style-type: none"> • vartype("double") — The variable containing values of type double

ColorVariable — Table variable containing color data

table variable index

Table variable containing the color data, specified as a variable index into the source table.

Specifying the Table Index

Use any of these indexing schemes to specify the desired variable.

Indexing Scheme	Examples
Variable name: <ul style="list-style-type: none"> A string scalar or character vector. A pattern object. The pattern object must refer to only one variable. 	<ul style="list-style-type: none"> "A" or 'A' — A variable called A "Var"+digitsPattern(1) — The variable with the name "Var" followed by a single digit
Variable index: <ul style="list-style-type: none"> An index number that refers to the location of a variable in the table. A logical vector. Typically, this vector is the same length as the number of variables, but you can omit trailing 0 or false values. 	<ul style="list-style-type: none"> 3 — The third variable from the table [false false true] — The third variable
Variable type: A vartype subscript that selects a table variable of a specified type. The subscript must refer to only one variable.	<ul style="list-style-type: none"> vartype("double") — The variable containing values of data type double

Specifying Color Data

The ColorVariable property controls the colors of the lines when the Color property has a value of 'flat'.

Specify the color data values as a numeric vector that linearly maps to the colors in the current colormap. The plot uses a different color for each element of ShapeData.

When you set the ColorVariable property, MATLAB updates the ColorData property.

Legend**DisplayName — Legend label**

'' (default) | character vector | string scalar

Legend label, specified as a character vector or string scalar. The legend does not display until you call the legend command. If you do not specify the text, then legend sets the label using the form 'dataN'.

Annotation — Control for including or excluding object from legend

Annotation object

This property is read-only.

Control for including or excluding the object from a legend, returned as an Annotation object. Set the underlying IconDisplayStyle property to one of these values:

- 'on' — Include the object in the legend (default).
- 'off' — Do not include the object in the legend.

For example, to exclude a graphics object, `go`, from the legend set the `IconDisplayStyle` property to 'off'.

```
go.Annotation.LegendInformation.IconDisplayStyle = 'off';
```

Alternatively, you can control the items in a legend using the `legend` function. Specify the first input argument as a vector of the graphics objects to include. If you do not specify an existing graphics object in the first input argument, then it does not appear in the legend. However, graphics objects added to the axes after the legend is created do appear in the legend. Consider creating the legend after creating all the plots to avoid extra items.

Interactivity

Visible — State of visibility

'on' (default) | on/off logical value

State of visibility, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to `true`, and 'off' is equivalent to `false`. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Display the object.
- 'off' — Hide the object without deleting it. You still can access the properties of an invisible object.

ContextMenu — Context menu

empty `GraphicsPlaceholder` array (default) | `ContextMenu` object

Context menu, specified as a `ContextMenu` object. Use this property to display a context menu when you right-click the object. Create the context menu using the `uicontextmenu` function.

Note If the `PickableParts` property is set to 'none' or if the `HitTest` property is set to 'off', then the context menu does not appear.

Selected — Selection state

'off' (default) | on/off logical value

Selection state, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to `true`, and 'off' is equivalent to `false`. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Selected. If you click the object when in plot edit mode, then MATLAB sets its `Selected` property to 'on'. If the `SelectionHighlight` property also is set to 'on', then MATLAB displays selection handles around the object.
- 'off' — Not selected.

SelectionHighlight — Display of selection handles

'on' (default) | on/off logical value

Display of selection handles when selected, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to true, and 'off' is equivalent to false. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Display selection handles when the `Selected` property is set to 'on'.
- 'off' — Never display selection handles, even when the `Selected` property is set to 'on'.

Callbacks

ButtonDownFcn — Mouse-click callback

' ' (default) | function handle | cell array | character vector

Mouse-click callback, specified as one of these values:

- Function handle
- Cell array containing a function handle and additional arguments
- Character vector that is a valid MATLAB command or function, which is evaluated in the base workspace (not recommended)

Use this property to execute code when you click the object. If you specify this property using a function handle, then MATLAB passes two arguments to the callback function when executing the callback:

- Clicked object — Access properties of the clicked object from within the callback function.
- Event data — Empty argument. Replace it with the tilde character (~) in the function definition to indicate that this argument is not used.

For more information on how to use function handles to define callback functions, see “Create Callbacks for Graphics Objects”.

Note If the `PickableParts` property is set to 'none' or if the `HitTest` property is set to 'off', then this callback does not execute.

CreateFcn — Creation function

' ' (default) | function handle | cell array | character vector

Object creation function, specified as one of these values:

- Function handle.
- Cell array in which the first element is a function handle. Subsequent elements in the cell array are the arguments to pass to the callback function.
- Character vector containing a valid MATLAB expression (not recommended). MATLAB evaluates this expression in the base workspace.

For more information about specifying a callback as a function handle, cell array, or character vector, see “Create Callbacks for Graphics Objects”.

This property specifies a callback function to execute when MATLAB creates the object. MATLAB initializes all property values before executing the `CreateFcn` callback. If you do not specify the `CreateFcn` property, then MATLAB executes a default creation function.

Setting the `CreateFcn` property on an existing component has no effect.

If you specify this property as a function handle or cell array, you can access the object that is being created using the first argument of the callback function. Otherwise, use the `gcbo` function to access the object.

DeleteFcn — Deletion function

' ' (default) | function handle | cell array | character vector

Object deletion function, specified as one of these values:

- Function handle.
- Cell array in which the first element is a function handle. Subsequent elements in the cell array are the arguments to pass to the callback function.
- Character vector containing a valid MATLAB expression (not recommended). MATLAB evaluates this expression in the base workspace.

For more information about specifying a callback as a function handle, cell array, or character vector, see “Create Callbacks for Graphics Objects”.

This property specifies a callback function to execute when MATLAB deletes the object. MATLAB executes the `DeleteFcn` callback before destroying the properties of the object. If you do not specify the `DeleteFcn` property, then MATLAB executes a default deletion function.

If you specify this property as a function handle or cell array, you can access the object that is being deleted using the first argument of the callback function. Otherwise, use the `gcbo` function to access the object.

Callback Execution Control

Interruptible — Callback interruption

' on ' (default) | on/off logical value

Callback interruption, specified as ' on ' or ' off ', or as numeric or logical 1 (true) or 0 (false). A value of ' on ' is equivalent to true, and ' off ' is equivalent to false. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

This property determines if a running callback can be interrupted. There are two callback states to consider:

- The running callback is the currently executing callback.
- The interrupting callback is a callback that tries to interrupt the running callback.

MATLAB determines callback interruption behavior whenever it executes a command that processes the callback queue. These commands include `drawnow`, `figure`, `uifigure`, `getframe`, `waitfor`, and `pause`.

If the running callback does not contain one of these commands, then no interruption occurs. MATLAB first finishes executing the running callback, and later executes the interrupting callback.

If the running callback does contain one of these commands, then the `Interruptible` property of the object that owns the running callback determines if the interruption occurs:

- If the value of `Interruptible` is `'off'`, then no interruption occurs. Instead, the `BusyAction` property of the object that owns the interrupting callback determines if the interrupting callback is discarded or added to the callback queue.
- If the value of `Interruptible` is `'on'`, then the interruption occurs. The next time MATLAB processes the callback queue, it stops the execution of the running callback and executes the interrupting callback. After the interrupting callback completes, MATLAB then resumes executing the running callback.

Note Callback interruption and execution behave differently in these situations:

- If the interrupting callback is a `DeleteFcn`, `CloseRequestFcn`, or `SizeChangedFcn` callback, then the interruption occurs regardless of the `Interruptible` property value.
 - If the running callback is currently executing the `waitfor` function, then the interruption occurs regardless of the `Interruptible` property value.
 - If the interrupting callback is owned by a `Timer` object, then the callback executes according to schedule regardless of the `Interruptible` property value.
-

Note When an interruption occurs, MATLAB does not save the state of properties or the display. For example, the object returned by the `gca` or `gcf` command might change when another callback executes.

BusyAction — Callback queuing

`'queue'` (default) | `'cancel'`

Callback queuing, specified as `'queue'` or `'cancel'`. The `BusyAction` property determines how MATLAB handles the execution of interrupting callbacks. There are two callback states to consider:

- The running callback is the currently executing callback.
- The interrupting callback is a callback that tries to interrupt the running callback.

The `BusyAction` property determines callback queuing behavior only when both of these conditions are met:

- The running callback contains a command that processes the callback queue, such as `drawnow`, `figure`, `uifigure`, `getframe`, `waitfor`, or `pause`.
- The value of the `Interruptible` property of the object that owns the running callback is `'off'`.

Under these conditions, the `BusyAction` property of the object that owns the interrupting callback determines how MATLAB handles the interrupting callback. These are possible values of the `BusyAction` property:

- `'queue'` — Puts the interrupting callback in a queue to be processed after the running callback finishes execution.
- `'cancel'` — Does not execute the interrupting callback.

PickableParts — Ability to capture mouse clicks

`'visible'` (default) | `'none'`

Ability to capture mouse clicks, specified as one of these values:

- `'visible'` — Capture mouse clicks only when visible. The `Visible` property must be set to `'on'`. The `HitTest` property determines if the `Line` object responds to the click or if an ancestor does.
- `'none'` — Cannot capture mouse clicks. Clicking the `Line` object passes the click to the object behind it in the current view of the figure window. The `HitTest` property of the `Line` object has no effect.

HitTest — Response to captured mouse clicks

`'on'` (default) | on/off logical value

Response to captured mouse clicks, specified as `'on'` or `'off'`, or as numeric or logical 1 (`true`) or 0 (`false`). A value of `'on'` is equivalent to `true`, and `'off'` is equivalent to `false`. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- `'on'` — Trigger the `ButtonDownFcn` callback of the `Line` object. If you have defined the `ContextMenu` property, then invoke the context menu.
- `'off'` — Trigger the callbacks for the nearest ancestor of the `Line` object that has one of these:
 - `HitTest` property set to `'on'`
 - `PickableParts` property set to a value that enables the ancestor to capture mouse clicks

Note The `PickableParts` property determines if the `Line` object can capture mouse clicks. If it cannot, then the `HitTest` property has no effect.

BeingDeleted — Deletion status

on/off logical value

This property is read-only.

Deletion status, returned as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

MATLAB sets the `BeingDeleted` property to `'on'` when the `DeleteFcn` callback begins execution. The `BeingDeleted` property remains set to `'on'` until the component object no longer exists.

Check the value of the `BeingDeleted` property to verify that the object is not about to be deleted before querying or modifying it.

Parent/Child

Parent — Parent

`GeographicAxes` object | `MapAxes` object

Parent, specified as a `GeographicAxes` object or `MapAxes` object.

Children — Children

empty `GraphicsPlaceholder` array

The object has no children. You cannot set this property.

HandleVisibility — Visibility of object handle

`'on'` (default) | `'off'` | `'callback'`

Visibility of the object handle in the `Children` property of the parent, specified as one of these values:

- `'on'` — Object handle is always visible.
- `'off'` — Object handle is invisible at all times. This option is useful for preventing unintended changes by another function. Set the `HandleVisibility` to `'off'` to temporarily hide the handle during the execution of that function.
- `'callback'` — Object handle is visible from within callbacks or functions invoked by callbacks, but not from within functions invoked from the command line. This option blocks access to the object at the command line, but permits callback functions to access it.

If the object is not listed in the `Children` property of the parent, then functions that obtain object handles by searching the object hierarchy or querying handle properties cannot return it. Examples of such functions include the `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close` functions.

Hidden object handles are still valid. Set the root `ShowHiddenHandles` property to `'on'` to list all object handles regardless of their `HandleVisibility` property setting.

Identifiers

Type — Type of graphics object

`'line'`

This property is read-only.

Type of graphics object, returned as `'line'`. Use this property to find all objects of a given type within a plotting hierarchy, for example, searching for the type using `findobj`.

Tag — Object identifier

`''` (default) | character vector | string scalar

Object identifier, specified as a character vector or string scalar. You can specify a unique `Tag` value to serve as an identifier for an object. When you need access to the object elsewhere in your code, you can use the `findobj` function to search for the object based on the `Tag` value.

UserData — User data

`[]` (default) | array

User data, specified as any MATLAB array. For example, you can specify a scalar, vector, matrix, cell array, character array, table, or structure. Use this property to store arbitrary data on an object.

If you are working in App Designer, create public or private properties in the app to share data instead of using the `UserData` property. For more information, see “Share Data Within App Designer Apps”.

Version History

Introduced in R2022a

See Also

Functions

geoplot

Objects

geolineshape | maplineshape

Properties

GeographicAxes Properties | MapAxes Properties

Topics

“Access Property Values”

“Graphics Object Properties”

linecirc

Find intersection of line and circle in Cartesian coordinates

Syntax

```
[xout,yout] = linecirc(slope,intercpt,centerx,centery,radius)
```

Description

`[xout,yout] = linecirc(slope,intercpt,centerx,centery,radius)` finds the intersection of a line with the specified slope and intercept and a circle with the specified center and radius, in Cartesian coordinates.

Examples

Find Intersection of Line and Circle

Find the intersection of the line $y = 2x - 1$ and a circle with its center at (3, 4) and a radius of 5.

```
[xout,yout] = linecirc(2,-1,3,4,5)
```

```
xout = 1×2
```

```
4.8271 0.3729
```

```
yout = 1×2
```

```
8.6542 -0.2542
```

Find Intersection of Vertical Line and Circle

Find the intersection of the line $x = -1$ and a circle with its center at (3, 4) and a radius of 5.

```
[xout,yout] = linecirc(Inf,-1,3,4,5)
```

```
xout = 1×2
```

```
-1 -1
```

```
yout = 1×2
```

```
7 1
```

Input Arguments

slope — Slope of line

numeric scalar | Inf

Slope of the line, specified as a numeric scalar or Inf. Specify Inf when the line is vertical.

intercpt — Intercept of line

numeric scalar

Intercept of the line, specified as a numeric scalar.

- When `slope` is a numeric scalar, this argument is the y-intercept of the line.
- When `slope` is Inf, this argument is the x-intercept of the line.

centerx — x-coordinate of center of circle

numeric scalar

x-coordinate of the center of the circle, specified as a numeric scalar.

centery — y-coordinate of center of circle

numeric scalar

y-coordinate of the center of the circle, specified as a numeric scalar.

radius — Radius of circle

positive scalar

Radius of the circle, specified as a positive scalar.

Output Arguments

xout — x-coordinates of intersections

two-element vector

x-coordinates of the intersections, returned as a two-element vector.

- When the line is tangent to the circle, the elements of the vector are equal.
- When the line does not intersect the circle, both elements are NaN.

yout — y-coordinates of intersections

two-element vector

y-coordinates of the intersections, returned as a two-element vector.

- When the line is tangent to the circle, the elements of the vector are equal.
- When the line does not intersect the circle, both elements are NaN.

Version History

Introduced before R2006a

See Also

Functions
circcirc

linem

Project line on axesm-based map

Syntax

```
h = linem(lat,lon)
h = linem(lat,lon,LineStyle)
h = linem(lat,lon,PropertyName,PropertyValue,...)
h = linem(lat,lon,z)
```

Description

`h = linem(lat,lon)` displays projected line objects on the current axesm-based map. `lat` and `lon` are the latitude and longitude coordinates, respectively, of the line object to be projected. Note that this ordering is conceptually reversed from the MATLAB `line` function, because the *vertical* (*y*) coordinate comes first. However, the ordering latitude, then longitude, is standard geographic usage. `lat` and `lon` must be the same size and in the `AngleUnits` of the axesm-based map. The object handle for the displayed line can be returned in `h`.

To display lines on geographic axes or map axes, use the `line` function instead.

`h = linem(lat,lon,LineStyle)` specifies the line style, marker, and color on page 1-952.

`h = linem(lat,lon,PropertyName,PropertyValue,...)` allows the specification of any number of property name/property value pairs for any properties recognized by the MATLAB `line` function except for `XData`, `YData`, and `ZData`.

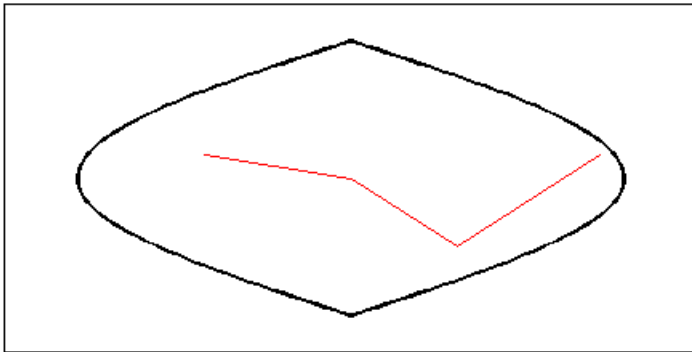
`h = linem(lat,lon,z)` displays a line object in three dimensions, where `z` is the same size as `lat` and `lon` and contains the desired altitude data. `z` is independent of `AngleUnits`. If omitted, all points are assigned a `z`-value of 0 by default.

The units of `z` are arbitrary, except when using the `globe` projection. In the case of `globe`, `z` should have the same units as the radius of the earth or semimajor axis specified in the `'geoid'` (reference ellipsoid) property of the axesm-based map. This implies that when the reference ellipsoid is a unit sphere, the units of `z` are earth radii.

`linem` is the mapping equivalent of the MATLAB `line` function. It is a low-level graphics function for displaying line objects in map projections. Ordinarily, it is not used directly. Use `plotm` or `plot3m` instead.

Examples

```
axesm sinusoid; framem
linem([15; 0; -45; 15],[-100; 0; 100; 170],'r-')
```









More About





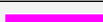
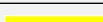

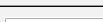
Line Style, Marker, and Color

Specify the line style, marker, and color as a character vector or string containing symbols. The symbols can appear in any order. You do not need to specify all three characteristics (line style, marker, and color). For example, specify a red dashed line using `'--r'`.

Line Style	Description	Resulting Line
"_"	Solid line	
"--"	Dashed line	
":"	Dotted line	
"-."	Dash-dotted line	

Marker	Description	Resulting Marker
"o"	Circle	
"+"	Plus sign	
"*"	Asterisk	
"."	Point	
"x"	Cross	
"-"	Horizontal line	
" "	Vertical line	
"square"	Square	
"diamond"	Diamond	

Marker	Description	Resulting Marker
"^"	Upward-pointing triangle	
"v"	Downward-pointing triangle	
">"	Right-pointing triangle	
"<"	Left-pointing triangle	
"pentagram"	Pentagram	
"hexagram"	Hexagram	

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

See Also

line | plot3m | plotm

longitudeToIntrinsicX

Package: `map.rasterref`

Convert from longitude to intrinsic x coordinates

Syntax

```
xIntrinsic = longitudeToIntrinsicX(R,lon)
```

Description

`xIntrinsic = longitudeToIntrinsicX(R,lon)` returns the x-coordinate in the intrinsic coordinate system corresponding to longitude `lon` in the geographic coordinate system, based on the relationship defined by geographic raster `R`.

Examples

Find Intrinsic x-Coordinate from Longitude

Import a GeoTIFF image [1] on page 1-954 of the Gulf of Mexico as an array and a `GeographicCellsReference` object. Find the intrinsic x-coordinate corresponding to a longitude of `-90.0226` degrees.

```
[Z,R] = readgeoraster('katrina.tif');  
xIntrinsic = longitudeToIntrinsicX(R,-90.0226)
```

```
xIntrinsic = 341.0619
```

The result means that coordinates with a longitude of `-90.0226` degrees fall between columns 341 and 342 of the posting points.

[1] The image used in this example is derived from imagery obtained from the NASA Goddard Scientific Visualization Studio (SVS) Image Server.

Input Arguments

R — Geographic raster

`GeographicCellsReference` or `GeographicPostingsReference` object

Geographic raster, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object.

lon — Longitude coordinates

numeric array

Longitude coordinates, specified as a numeric array. `lon` coordinates can be outside the bounds of the raster `R`.

Data Types: `single` | `double`

Output Arguments

xIntrinsic — x-coordinates in intrinsic coordinate system

numeric array

x-coordinates in intrinsic coordinate system, returned as a numeric array. `xIntrinsic` is the same size as `lat`.

When `lon(k)` is outside the bounds of raster `R`, `xIntrinsic(k)` is extrapolated in the intrinsic coordinate system. Elements of `lon` with value `NaN` map to `NaN` in `xIntrinsic`.

Data Types: `double`

Version History

Introduced in R2013b

See Also

`geographicToIntrinsic` | `latitudeToIntrinsicY` | `intrinsicXToLongitude`

lookAtSpheroid

Line of sight intersection with oblate spheroid

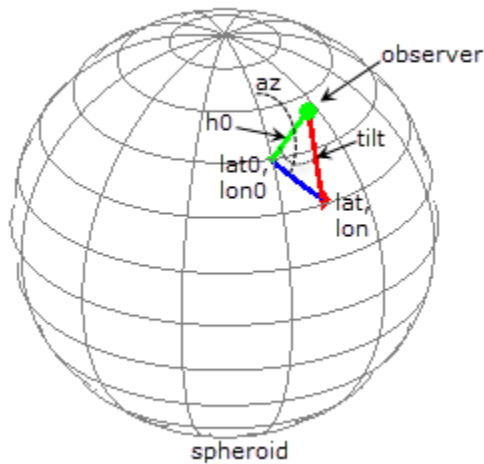
Syntax

```
[lat,lon,slanrange] = lookAtSpheroid(lat0,lon0,h0,az,tilt,spheroid)
```

Description

`[lat,lon,slanrange] = lookAtSpheroid(lat0,lon0,h0,az,tilt,spheroid)` computes the latitude and longitude (`lat` and `lon`) of the first point of intersection of the line-of-sight from a viewpoint in space with the surface of an oblate spheroid. If the line-of-sight does not intersect with the spheroid, `lat` and `lon` contain NaNs.

`lat0` and `lon0` are the geodetic coordinates of the viewpoint on the reference spheroid, `spheroid`. `h0` specifies the geodetic height of the viewpoint in space above the spheroid. The `az` and `tilt` arguments specify the direction of the view (line-of-sight) as the azimuth angle, measured clockwise from North, and a tilt angle. The following figure illustrates these measurements.



The optional `slanrange` output argument returns the (3-D Euclidean) distance from the viewpoint to the intersection. All angles are in degrees.

Examples

Calculate Intersection with Spheroid of View from Geostationary Orbit

Create a reference spheroid. Specify the length unit as kilometers.

```
spheroid = wgs84Ellipsoid('km');
```

Define location of view in space. The units for `h0` match the units of the spheroid (kilometers).

```
lat0 = 0;
lon0 = -100;
h0 = 35786;
```

Define the view from space in terms of the azimuth angle and tilt.

```
az = 45;
tilt = 6;
```

Calculate the point on the spheroid at which the view first intersects with the spheroid. The example also returns the distance in kilometers between the viewpoint in space and the first point of intersection with the spheroid.

```
[lat,lon,slanrange] = lookAtSpheroid(lat0,lon0,h0,az,tilt,spheroid)

lat = 25.7991
lon = -71.3039
slanrange = 3.7328e+04
```

Input Arguments

lat0 — Geodetic latitude of the viewpoint on the spheroid

scalar | vector | matrix | N-D array

Geodetic latitude of the viewpoint on the spheroid, specified as a scalar value, vector, matrix, or N-D array.

Data Types: `single` | `double`

lon0 — Geodetic longitude of the viewpoint on the spheroid

scalar | vector | matrix | N-D array

Geodetic longitude of the viewpoint on the spheroid, specified as a scalar value, vector, matrix, or N-D array.

Data Types: `single` | `double`

h0 — Height of the viewpoint in space above the spheroid

scalar | vector | matrix | N-D array

Height of the viewpoint in space above the spheroid, specified as a scalar value, vector, matrix, or N-D array. `h0` must be in units that match the spheroid input.

Data Types: `single` | `double`

az — Azimuth angle of view from space

scalar | vector | matrix | N-D array

Azimuth angle of view from space, specified as a scalar value, vector, matrix, or N-D array. Measured in degrees, clockwise from north.

Data Types: `single` | `double`

tilt — Tilt angle of view from space

scalar | vector | matrix | N-D array

Tilt angle of view from space, specified as scalar value, vector, matrix, or N-D array. Measured in degrees, relative to a vector pointing downward toward the nadir point. The nadir point is the point on the spheroid directly below the viewpoint, with geodetic coordinates (lat0, lon0, 0). When the tilt is zero (0), the line-of-sight is directed at the nadir point itself. `Tilt` can be in the range [0 180] but for large angles and all angles greater than or equal to 90 degrees, there is no intersection with the spheroid.

Data Types: `single` | `double`

spheroid – Reference spheroid

`referenceEllipsoid` | `oblateSpheroid` | `referenceSphere`

Reference spheroid, specified as a `referenceEllipsoid`, `oblateSpheroid`, or `referenceSphere` object. Use the constructor for one of these three classes, or the `wgs84Ellipsoid` function, to construct a spheroid object. You cannot directly pass in the name of the reference spheroid. Instead, pass the name to `referenceEllipsoid` or `referenceSphere` and use the resulting object.

Output Arguments

lat – Latitude of the first point of intersection with the spheroid

`scalar` | `vector` | `matrix` | N-D array

Latitude of the first point of intersection with the spheroid, returned as a scalar value, vector, matrix, or N-D array. If the line-of-sight does not intersect with the spheroid, `lat` contains NaNs.

lon – Longitude of the first point of intersection with the spheroid

`scalar` | `vector` | `matrix` | N-D array

Longitude of the first point of intersection with the spheroid, returned as a scalar value, vector, matrix, or N-D array. If the line-of-sight does not intersect with the spheroid, `lon` contains NaNs.

sLanrange – Distance from the viewpoint to the first intersection with the spheroid

`scalar` | `vector` | `matrix` | N-D array

Distance from the viewpoint to the intersection with the spheroid, returned as a scalar value, vector, matrix, or N-D array. Units match the `LengthUnit` property of the input spheroid object.

Version History

Introduced in R2016b

See Also

`geodetic2aer`

los2

Line-of-sight visibility between two points on or above terrain

Syntax

```
vis = los2(Z,R,lat1,lon1,lat2,lon2)
vis = los2(Z,R,lat1,lon1,lat2,lon2,h1)
vis = los2(Z,R,lat1,lon1,lat2,lon2,h1,h2)
vis = los2(Z,R,lat1,lon1,lat2,lon2,h1,h2,h1ref)
vis = los2(Z,R,lat1,lon1,lat2,lon2,h1,h2,h1ref,h2ref)

vis = los2(Z,R,lat1,lon1,lat2,lon2,h1,h2,h1ref,h2ref,rad)
vis = los2(Z,R,lat1,lon1,lat2,lon2,h1,h2,h1ref,h2ref,rad,effectiveRad)
```

```
[vis,visprofile,dist,h,lattrk,lontrk] = los2( ___ )
```

```
los2( ___ )
[ ___ ] = los2
```

Description

Specify Coordinates and Heights

`vis = los2(Z,R,lat1,lon1,lat2,lon2)` determines whether the point specified by `lat1` and `lon1` has line-of-sight visibility with the point specified by `lat2` and `lon2`. Specify spatially referenced terrain data, in meters, using `Z` and `R`. This function assumes that the Earth is a sphere.

`vis = los2(Z,R,lat1,lon1,lat2,lon2,h1)` specifies the height, in meters, of the first point.

`vis = los2(Z,R,lat1,lon1,lat2,lon2,h1,h2)` specifies the height, in meters, of the second point.

`vis = los2(Z,R,lat1,lon1,lat2,lon2,h1,h2,h1ref)` references the height of the first point to either the terrain (ground level) or the sphere (mean sea level).

`vis = los2(Z,R,lat1,lon1,lat2,lon2,h1,h2,h1ref,h2ref)` references the height of the second point to either the terrain (ground level) or the sphere (mean sea level).

Specify Reference Sphere

`vis = los2(Z,R,lat1,lon1,lat2,lon2,h1,h2,h1ref,h2ref,rad)` specifies the radius in meters of the reference sphere. This syntax is useful for finding line-of-sight visibility for planetary bodies other than Earth.

`vis = los2(Z,R,lat1,lon1,lat2,lon2,h1,h2,h1ref,h2ref,rad,effectiveRad)` specifies a larger radius for the propagation of line-of-sight paths. You can use this syntax to account for the curvature of signal paths due to refraction in the atmosphere.

Query Intermediate Points

`[vis,visprofile,dist,h,lattrk,lontrk] = los2(___)` determines line-of-sight visibility for intermediate points between the first and second points, using any combination of input arguments

from the previous syntaxes. For each intermediate point, the function returns the visibility in `visprofile`, the distance from the first point in `dist`, the height in `h`, the latitude in `latrk`, and the longitude in `lonrk`. The number of intermediate points depends on the resolution of the terrain data.

Display and Interactively Select Coordinates

`los2(___)` displays the visibility profile between the two points in a new figure on Cartesian axes. The figure illustrates the terrain, the observer, the line of sight, the visible points, and the obstructed points.

`[___] = los2` enables you to interactively select two points on the current `axesm`-based map and then determines whether the points have line-of-sight visibility, returning any combination of output arguments from previous syntaxes. If the current object on the map is a surface, then the function uses the `z`-coordinate data (the `ZData` property) as the terrain elevation data. Otherwise, the function uses `z`-coordinate data from the first surface it finds on the map. If the surface does not have `z`-coordinate data, then the function uses the color data (the `CData` property), instead.

Examples

Determine Line-of-Sight Visibility

Determine whether two points have line-of-sight visibility. Then, display the visibility profile.

Read terrain data for an area around South Boulder Peak into the workspace as an array and a reference object. Prepare the data for analysis by specifying the output type as "double".

```
[Z,R] = readgeoraster("n39_w106_3arc_v2.dt1", "OutputType", "double");
```

Specify the coordinates of South Boulder Peak and a nearby point.

```
lat1 = 39.95384;  
lon1 = -105.29916;  
lat2 = 39.96955;  
lon2 = -105.29867;
```

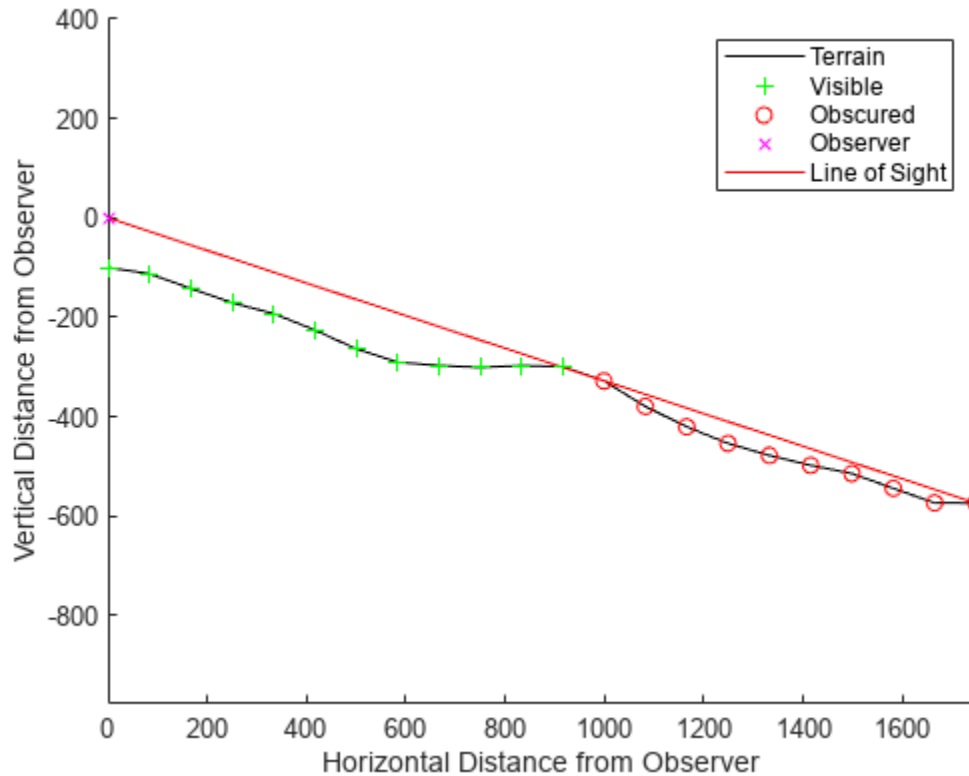
Determine whether the nearby point is visible from a location 100 meters above the peak. The result indicates that the points do not have line-of-sight visibility.

```
h1 = 100;  
vis = los2(Z,R, lat1, lon1, lat2, lon2, h1)
```

```
vis = logical  
     0
```

Display the visibility profile by omitting the output argument.

```
los2(Z,R, lat1, lon1, lat2, lon2, h1)
```



View Visibility Profile in 3-D

To view a visibility profile in 3-D, calculate the profile using the `los2` function and display the profile using the `geoglobe` and `geoplot3` functions.

Read terrain data for an area around South Boulder Peak into the workspace as an array and a reference object. Prepare the data for analysis by specifying the output type as "double".

```
[Z,R] = readgeoraster("n39_w106_3arc_v2.dt1", "OutputType", "double");
```

Specify the coordinates of South Boulder Peak and a nearby point.

```
lat1 = 39.95384;
lon1 = -105.29916;
lat2 = 39.96955;
lon2 = -105.29867;
```

Determine whether the nearby point is visible from a location 100 meters above the peak. The result indicates that the points do not have line-of-sight visibility.

```
h1 = 100;
vis = los2(Z,R,lat1,lon1,lat2,lon2,h1)
```

```
vis = logical  
    0
```

Calculate visibility information for the intermediate points. The outputs `lattrk` and `lontrk` contain the latitude and longitude coordinates of the intermediate points. The output `visprofile` indicates whether the intermediate points are visible from South Boulder Peak.

```
[~,visprofile,~,~,lattrk,lontrk] = los2(Z,R,lat1,lon1,lat2,lon2,100);
```

Create a geographic globe that uses custom terrain for the area around South Boulder Peak.

```
addCustomTerrain("southboulder","n39_w106_3arc_v2.dt1")  
uif = uifigure;  
g = geoglobe(uif,"Terrain","southboulder");
```

Plot the line of sight from South Boulder Peak to the nearby point. Use a magenta line to indicate the point is not visible from above the peak.

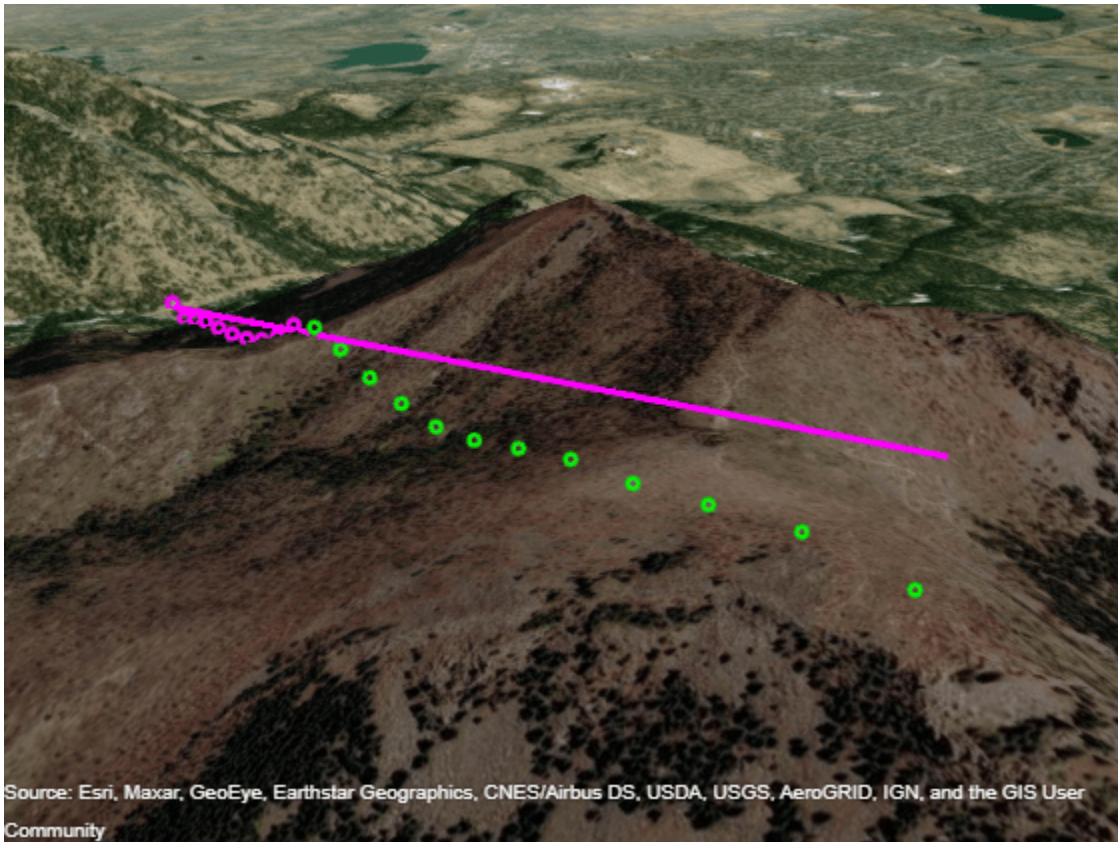
```
geoplot3(g,[lat1 lat2],[lon1 lon2],[h1 0],"m","LineWidth",2, ...  
          "HeightReference","terrain")
```

Plot the intermediate points. Use magenta markers for points that are not visible and green markers for points that are visible. Plot each value 10 meters above the terrain so the markers are not obscured by the terrain.

```
hold(g,"on")  
geoplot3(g,lattrk(~visprofile),lontrk(~visprofile),10, ...  
          "mo","MarkerSize",2,"LineWidth",2,"HeightReference","terrain")  
geoplot3(g,lattrk(visprofile),lontrk(visprofile),10,"go", ...  
          "MarkerSize",2,"LineWidth",2,"HeightReference","terrain")
```

Adjust the view by setting the camera position, pitch, roll, and heading.

```
campos(g,39.9519,-105.3039,2.9424e+03)  
campitch(g,-31.7850)  
camroll(g,0.3603)  
camheading(g,36.5618)
```

Close the figure containing the geographic globe and remove the custom terrain.

```
close(uif)
removeCustomTerrain("southboulder")
```

Input Arguments

Z — Elevation data grid

m-by-n array

Elevation data grid, in meters, specified as an *m-by-n* array.

Data Types: single | double

R — Spatial reference for Z

GeographicCellsReference object | GeographicPostingsReference object

Spatial reference for Z, specified as a GeographicCellsReference or GeographicPostingsReference object. The RasterSize property of R must be consistent with size(Z).

lat1 — Latitude of first point in degrees

scalar | vector

Latitude of the first point in degrees, specified as a scalar or vector.

The sizes of `lat1`, `lon1`, `lat2`, and `lon2` must match.

Data Types: `single` | `double`

lon1 — Longitude of first point

`scalar` | `vector`

Longitude of the first point, in degrees, specified as a scalar or vector.

The sizes of `lat1`, `lon1`, `lat2`, and `lon2` must match.

Data Types: `single` | `double`

lat2 — Latitude of second point

`scalar` | `vector`

Latitude of the second point, in degrees, specified as a scalar or vector.

The sizes of `lat1`, `lon1`, `lat2`, and `lon2` must match.

Data Types: `single` | `double`

lon2 — Longitude of second point

`scalar` | `vector`

Longitude of the second point, in degrees, specified as a scalar or vector.

The sizes of `lat1`, `lon1`, `lat2`, and `lon2` must match.

Data Types: `single` | `double`

h1 — Height of first point

0 (default) | `scalar` | `vector`

Height of the first point, in meters, specified as a scalar or vector.

The size of `h1` must match the size of `lat1` and `lon1`.

Data Types: `single` | `double`

h2 — Height of second point

0 (default) | `scalar` | `vector`

Height of the second point, in meters, specified as a scalar or vector.

The size of `h2` must match the size of `lat2` and `lon2`.

Data Types: `single` | `double`

h1ref — Height reference for first point

"AGL" (default) | "MSL"

Height reference for the first point, specified as one of these options:

- "AGL" — Reference `h1` to the terrain (ground level).
- "MSL" — Reference `h1` to the sphere (mean sea level).

Data Types: `char` | `string`

h2ref — Height reference for second point

"AGL" (default) | "MSL"

Height reference for the second point, specified as one of these options:

- "AGL" — Reference h2 to the terrain (ground level).
- "MSL" — Reference h2 to the sphere (mean sea level).

Data Types: char | string

rad — Radius of reference sphere

6371000 (default) | positive scalar

Radius of the reference sphere, in meters, specified as a positive scalar.

Data Types: single | double

effectiveRad — Effective radius of reference sphere

positive scalar

Effective radius of the reference sphere, in meters, specified as a positive scalar.

This argument enables you to account for the curvature of signal paths due to refraction in the atmosphere. For example, you can treat radio propagation in the atmosphere as straight-line propagation on a sphere with 4/3 the radius of the Earth by specifying `rad` as 6371000 and `effectiveRad` as $4/3 * 6371000$.

To calculate line-of-sight visibility for a flat Earth, specify this argument as `Inf`.

If you do not specify this argument, then the function uses the value of `rad`.

Data Types: single | double

Output Arguments**vis — Indicator for visibility between first and second points**

logical scalar | logical vector

Indicator for visibility between the first and second points, returned as a logical scalar or a logical array. The size of `vis` matches the size of `lat1`.

- A logical 1 (`true`) indicates that the first point has line-of-sight visibility with the corresponding second point.
- A logical 0 (`false`) indicates that the line of sight between the first point and corresponding second point is obscured by terrain.

visprofile — Indicator for visibility between first point and intermediate points

logical vector | cell array of logical vectors

Indicator for visibility between the first point and intermediate points, returned as a logical vector or a cell array of logical vectors.

- A logical 1 (`true`) indicates that the first point has line-of-sight visibility with that intermediate point.

- A logical `0` (`false`) indicates that the line of sight between the first point and that intermediate point is obscured by terrain.

The function returns a logical vector when `lat1`, `lon1`, `lat2`, and `lon2` are scalars. The function returns a cell array of logical vectors when `lat1`, `lon1`, `lat2`, and `lon2` are vectors. The number of cells within the cell array matches the size of `lat1`.

dist – Distance from first point to intermediate point

numeric vector | cell array of numeric vectors

Distance from the first point to the intermediate point, in meters, returned as a numeric vector or a cell array of numeric vectors.

The function returns a numeric vector when `lat1`, `lon1`, `lat2`, and `lon2` are scalars. The function returns a cell array of numeric vectors when `lat1`, `lon1`, `lat2`, and `lon2` are vectors. The number of cells within the cell array matches the size of `lat1`.

h – Height of intermediate points

numeric vector | cell array of numeric vectors

Height of intermediate points, in meters, returned as a numeric vector or a cell array of numeric vectors.

The function returns a numeric vector when `lat1`, `lon1`, `lat2`, and `lon2` are scalars. The function returns a cell array of numeric vectors when `lat1`, `lon1`, `lat2`, and `lon2` are vectors. The number of cells within the cell array matches the size of `lat1`.

latrk – Latitude of intermediate points

numeric vector | cell array of numeric vectors

Latitude of intermediate points, in degrees, returned as a numeric vector or a cell array of numeric vectors.

The function returns a numeric vector when `lat1`, `lon1`, `lat2`, and `lon2` are scalars. The function returns a cell array of numeric vectors when `lat1`, `lon1`, `lat2`, and `lon2` are vectors. The number of cells within the cell array matches the size of `lat1`.

lonrk – Longitude of intermediate points

numeric vector | cell array of numeric vectors

Longitude of intermediate points, in degrees, returned as a numeric vector or a cell array of numeric vectors.

The function returns a numeric vector when `lat1`, `lon1`, `lat2`, and `lon2` are scalars. The function returns a cell array of numeric vectors when `lat1`, `lon1`, `lat2`, and `lon2` are vectors. The number of cells within the cell array matches the size of `lat1`.

Version History

Introduced before R2006a

R2022b: `los2` will not accept referencing vectors or referencing matrices as input

Not recommended starting in R2022b

The `los2` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

See Also

Functions

`viewshed` | `mapprofile`

ltln2val

(To be removed) Extract data grid values for specified locations

Note `ltln2val` will be removed in a future release. Use the `geointerp` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
val = ltln2val(Z, R, lat, lon)
val = ltln2val(Z, R, lat, lon, method)
```

Description

`val = ltln2val(Z, R, lat, lon)` interpolates a regular data grid `Z` with referencing vector `R` at the points specified by vectors of latitude and longitude, `lat` and `lon`. `R` can be a geographic raster reference object, a referencing vector, or a referencing matrix.

If `R` is a geographic raster reference object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which `lat` or `lon` contain NaN. All angles are in units of degrees.

`val = ltln2val(Z, R, lat, lon, method)` where `method` specifies the type of interpolation: 'bilinear' for linear interpolation, 'bicubic' for cubic interpolation, or 'nearest' for nearest neighbor interpolation.

Examples

Load elevation raster data and a geographic cells reference object. Then, find the elevation in meters associated with Milan, Bern, and Prague.

```
load topo60c
lat = [45.45 46.95 50.1];
lon = [9.2 7.4 14.45];
elevations = ltln2val(topo60c,topo60cR,lat,lon)
```

```
elevations =
      313      1660      297
```

Version History

R2022a: Warns

Warns starting in R2022a

Some functions that accept referencing vectors or referencing matrices as input issue a warning that they will be removed in a future release, including the `ltln2val` function. Use a geographic reference object and the `geointerp` function instead. Reference objects have several advantages over referencing vectors and matrices.

- Unlike referencing vectors and matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `GeographicPostingsReference` objects.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, first create a reference object for either a raster of cells using the `georefcells` function or a raster of regularly posted samples using the `georefpostings` function. Alternatively, convert from a referencing vector or a referencing matrix to a reference object using the `refvecToGeoRasterReference` or `refmatToGeoRasterReference` function, respectively.

Then, replace uses of the `ltln2val` function with the `geointerp` function according to these patterns. Note that the default method of interpolation for the `geointerp` function is `'linear'` instead of `'nearest'`. In addition, replace the interpolation methods of `'bilinear'` and `'bicubic'` for the `ltln2val` function with `'linear'` and `'cubic'` for the `geointerp` function.

Will Be Removed	Recommended
<code>val = ltln2val(Z,R,lat,lon);</code>	<code>val = geointerp(Z,R,lat,lon,'nearest');</code>
<code>val = ltln2val(Z,R,lat,lon,method);</code>	<code>val = geointerp(Z,R,lat,lon,method);</code>

R2020b: To be removed

Not recommended starting in R2020b

The `ltln2val` function runs without warning but will be removed in a future release.

See Also

`findm` | `imbedm` | `geointerp`

lv2ecef

(Removed) Convert local vertical to geocentric (ECEF) coordinates

Note The `lv2ecef` function has been removed. Use the `enu2ecef` function instead. By default, the `enu2ecef` function assumes that the latitude and longitude of the local origin are in degrees. When you update your code, you can specify the `angleUnit` input argument as `'radians'`.

Syntax

```
[x,y,z] = lv2ecef(xl,yl,zl,phi0,lambda0,h0,ellipsoid)
```

Description

`[x,y,z] = lv2ecef(xl,yl,zl,phi0,lambda0,h0,ellipsoid)` converts arrays `xl`, `yl`, and `zl` in the local vertical coordinate system to arrays `x`, `y`, and `z` in the geocentric coordinate system. The origin of the local vertical system is at geodetic latitude `phi0`, geodetic longitude `lambda0`, and ellipsoidal height `h0`. The arrays `xl`, `yl`, and `zl` may have any shape, as long as they are all the same size. They are measured in the same length units as the semimajor axis. `phi0` and `lambda0` are scalars measured in radians; `h0` is a scalar with the same length units as the semimajor axis; and `ellipsoid` is a `referenceEllipsoid` (`oblateSpheroid`) object, a `referenceSphere` object, or a vector of the form `[semimajor axis, eccentricity]`. The coordinates `x`, `y`, and `z` also have the same units as the semimajor axis.

More About

Local Vertical System

In the local vertical Cartesian system defined by `phi0`, `lambda0`, `h0`, and `ellipsoid`, the `xl` axis is parallel to the plane tangent to the ellipsoid at `(phi0,lambda0)` and points due east. The `yl` axis is parallel to the same plane and points due north. The `zl` axis is normal to the ellipsoid at `(phi0,lambda0)` and points outward into space. The local vertical system is sometimes referred to as East-North-Up or ENU.

Geocentric System

The geocentric Cartesian coordinate system, also known as Earth-Centered, Earth-Fixed (ECEF), is fixed with respect to the Earth, with its origin at the center of the spheroid and its positive X-, Y-, and Z axes intersecting the surface at the following points:

	Latitude	Longitude	Notes
X-axis	0	0	Equator at the Prime Meridian
Y-axis	0	90	Equator at 90-degrees East
Z-axis	90	0	North Pole

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `lv2ecef` function has been removed. Use the `enu2ecef` function instead. By default, the `enu2ecef` function assumes that the latitude and longitude of the local origin are in degrees. When you update your code, you can specify the `angleUnit` input argument as `'radians'`.

R2022a: Warns

Warns starting in R2022a

The `lv2ecef` function issues a warning that it will be removed in a future release.

R2012b: To be removed

Not recommended starting in R2012b

The `lv2ecef` function runs without warning but will be removed in a future release.

See Also

`enu2ecef` | `ecef2enu`

majaxis

Semimajor axis of ellipse

Syntax

```
a = majaxis(semiminor,e)
```

Description

`a = majaxis(semiminor,e)` computes the semimajor axis length `a` of an ellipse or an ellipsoid of revolution given the semiminor axis length `semiminor` and eccentricity `e`.

Examples

Semimajor Axis of Ellipse from Semiminor Axis and Eccentricity

Find the semimajor axis length of an ellipse from the eccentricity and length of the semiminor axis.

```
a = majaxis(6356752,0.0818)
```

```
a = 6.3781e+06
```

Input Arguments

semiminor — Semiminor axis length

numeric scalar

Semiminor axis length, specified as a numeric scalar.

e — Eccentricity of ellipse

numeric scalar

Eccentricity of the ellipse, specified as a numeric scalar. The value of `e` must be in the range `[0, 1)`.

Data Types: `single` | `double`

Output Arguments

a — Semimajor axis length

numeric scalar

Semimajor axis length, returned as a numeric scalar. The units of `a` are the same as those of `semiminor`.

Version History

Introduced before R2006a

R2013b: Only numeric scalars will be accepted as input*Not recommended starting in R2013b*

The `majaxis` function will not accept vectors or matrices as input in a future release. To update your code, specify a numeric scalar instead.

See Also`axes2ecc` | `flat2ecc` | `minaxis` | `n2ecc`

makeattribspec

Create attribute specification

Syntax

```
attribspec = makeattribspec(S)
```

Description

`attribspec = makeattribspec(S)` creates an attribute specification for use with the `kmlwrite`, `wmmarker`, `wmline`, and `wmpolygon` functions based on the vector geographic features stored in `S`.

The `kmlwrite` function creates an HTML table from attribute fields. The first column of the table includes attribute labels and the second column includes attribute values as text. Use an attribute specification with the `kmlwrite` function and `Description` name-value argument to specify which attribute fields to include in the HTML table and the format of the attribute values.

When you plot features using `wmmarker`, `wmline`, or `wmpolygon`, you can view feature balloons with attribute information by clicking on features. Use an attribute specification with `wmmarker`, `wmline`, or `wmpolygon` and the `Description` name-value argument to specify which attribute fields to include in the feature balloons and the format of the attribute values.

Examples

Create Attribute Specification

Import a shapefile representing tsunami events reported over several decades, tagged geographically by source location, as a geospatial table. Create an attribute specification from the table.

```
GT = readgeotable("tsunamis.shp", "CoordinateSystemType", "geographic");  
attribspec = makeattribspec(GT)
```

```
attribspec = struct with fields:  
    Year: [1x1 struct]  
    Month: [1x1 struct]  
    Day: [1x1 struct]  
    Hour: [1x1 struct]  
    Minute: [1x1 struct]  
    Second: [1x1 struct]  
    Val_Code: [1x1 struct]  
    Validity: [1x1 struct]  
    Cause_Code: [1x1 struct]  
    Cause: [1x1 struct]  
    Eq_Mag: [1x1 struct]  
    Country: [1x1 struct]  
    Location: [1x1 struct]  
    Max_Height: [1x1 struct]  
    Iida_Mag: [1x1 struct]  
    Intensity: [1x1 struct]  
    Num_Deaths: [1x1 struct]
```

```
Desc_Deaths: [1x1 struct]
```

Remove all attributes from the specification, except for the attributes describing the maximum height, cause, year, location, and country.

```
desiredAttributes = {'Max_Height', 'Cause', 'Year', 'Location', 'Country'};
allAttributes = fieldnames(attribspec);
attributes = setdiff(allAttributes, desiredAttributes);
attribspec = rmfield(attribspec, attributes)
```

```
attribspec = struct with fields:
```

```
    Year: [1x1 struct]
    Cause: [1x1 struct]
    Country: [1x1 struct]
    Location: [1x1 struct]
    Max_Height: [1x1 struct]
```

Rename the Max_Height attribute to Maximum Height and highlight each attribute label in bold font.

```
attribspec.Max_Height.AttributeLabel = "<b>Maximum Height</b>";
attribspec.Cause.AttributeLabel = "<b>Cause</b>";
attribspec.Year.AttributeLabel = "<b>Year</b>";
attribspec.Location.AttributeLabel = "<b>Location</b>";
attribspec.Country.AttributeLabel = "<b>Country</b>";
```

Add Meters to the format of the maximum height attribute. Set the format of the year attribute to include no decimal places.

```
attribspec.Max_Height.Format = "%.1f Meters";
attribspec.Year.Format = "%.0f";
```

Export the selected attributes and tsunami source locations to a KML file.

```
kmlwrite("tsunamis.kml", GT, "Description", attribspec, "Name", GT.Location)
```

Display Marker Overlay Using Attribute Specification

Import a shapefile representing tsunami events reported over several decades, tagged geographically by source location.

```
GT = readgeotable("tsunamis.shp", "CoordinateSystemType", "geographic");
```

Create an attribute specification for use in the feature balloons. Modify the specification so that it defines a table of values, including year, cause, country, location, and maximum height. The attribute specification defines the format of the expected value for each field.

```
attribspec = makeattribspec(GT);

desiredAttributes = ...
    {'Max_Height', 'Cause', 'Year', 'Location', 'Country'};
allAttributes = fieldnames(attribspec);
attributes = setdiff(allAttributes, desiredAttributes);
```

```

attribspec = rmfield(attribspec,attributes);
attribspec.Max_Height.AttributeLabel = "<b>Maximum Height</b>";
attribspec.Max_Height.Format = "%.1f Meters";
attribspec.Cause.AttributeLabel = "<b>Cause</b>";
attribspec.Year.AttributeLabel = "<b>Year</b>";
attribspec.Year.Format = "%.0f";
attribspec.Location.AttributeLabel = "<b>Location</b>";
attribspec.Country.AttributeLabel = "<b>Country</b>";

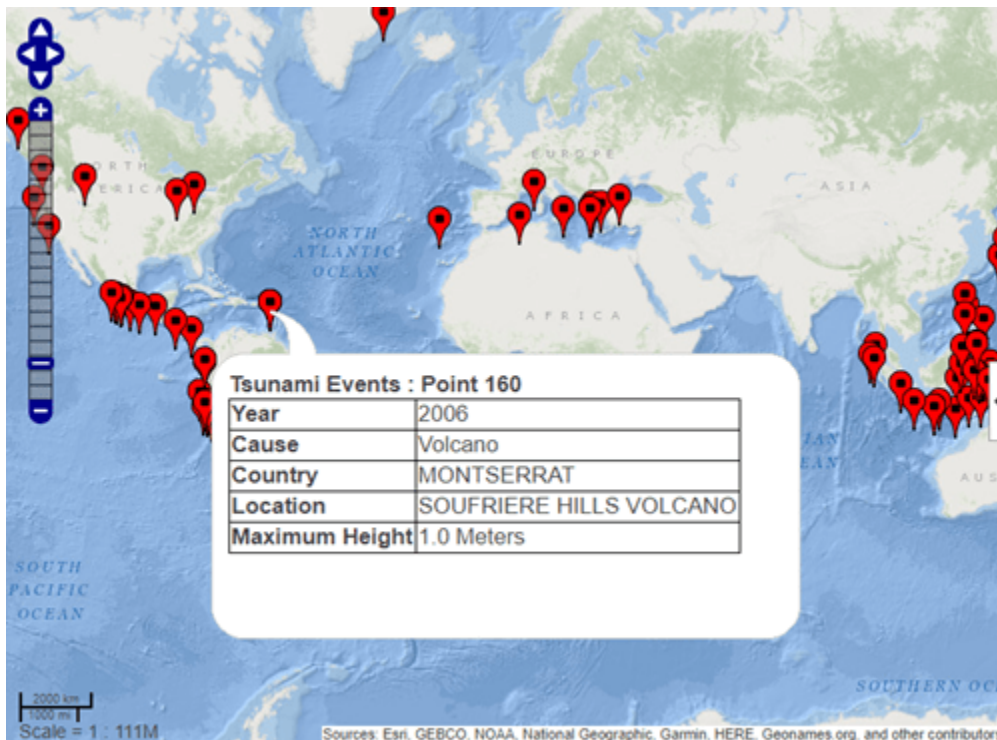
```

Create a web map with a base layer containing ocean details. Add the marker overlay. Display the table data you specified in the attribute specification by selecting a marker.

```

webmap("ocean basemap");
wmmarker(GT,"Description",attribspec,...
         "OverlayName","Tsunami Events")
wmzoom(2)

```



Input Arguments

S — Vector geographic features

geospatial table | geopoint vector | geoshape vector | geostruct vector

Vector geographic features, specified as one of these:

- A geospatial table containing `geopointshape`, `geolineshape`, or `geopolyshape` objects. The `makeattribspec` function does not support geospatial tables containing more than one type of shape object. For more information about geospatial tables, see “Create Geospatial Tables”.
- A `geopoint` vector.

- A geoshape vector with no dynamic vertex properties.
- A geographic structure array (geosruct) with Lat and Lon fields.

Output Arguments

attribspec — Attribute specification

structure array

Attribute specification, returned as a structure array with two levels. The top level contains a field for each attribute in `S`. Each field in the top level contains a scalar structure with two fields.

Field	Description
AttributeLabel	Attribute label for the <code>kmlwrite</code> function to use in the first column of the HTML table, returned as a character vector. By default, the label is identical to the name of the corresponding attribute field.
Format	Format for the <code>kmlwrite</code> function to use when converting the attribute value to text, returned as a character vector. For more information about formatting data, see the <code>sprintf</code> function.

You can change the structure array before using it with the `kmlwrite` function. For example, you can remove attributes from the structure or change the `AttributeLabel` field to include spaces.

Version History

Introduced before R2006a

R2021b: Create attribute specifications from geospatial tables

The `makeattribspec` function accepts geospatial tables as input.

See Also

Functions

`kmlwrite` | `wmmarker` | `wmline` | `wmpolygon` | `makedbfspec` | `shapewrite`

makedbfspec

Create DBF specification

Syntax

```
dbfspec = makedbfspec(S)
```

Description

`dbfspec = makedbfspec(S)` creates a DBF specification for use with the `shapewrite` function based on the vector geographic features stored in `S`.

The `shapewrite` function creates a main file (`.shp`), an index file (`.shx`), and an attribute file (`.dbf`). Use a DBF specification with the `shapewrite` function and `DbfSpec` name-value argument to specify which attribute fields to include in the DBF file, the length of each field, and the numerical precision of each field.

Examples

Create DBF Specification

Import a shapefile representing a network of road segments in Concord, MA, as a geospatial table. Create a DBF specification from the table.

```
GT = readgeotable("concord_roads.shp");  
dbfspec = makedbfspec(GT)
```

```
dbfspec = struct with fields:  
    STREETNAME: [1x1 struct]  
    RT_NUMBER: [1x1 struct]  
    CLASS: [1x1 struct]  
    ADMIN_TYPE: [1x1 struct]  
    LENGTH: [1x1 struct]
```

Remove the `ADMIN_TYPE` field from the specification, rename the `STREETNAME` field to `Street Name`, and reduce the number of decimal places used to store road lengths.

```
dbfspec = rmfield(dbfspec,"ADMIN_TYPE");  
dbfspec.STREETNAME.FieldName = "Street Name";  
dbfspec.LENGTH.FieldDecimalCount = 1;
```

Export the road network to a new shapefile.

```
shapewrite(GT,"concord_roads_new.shp","DbfSpec",dbfspec)
```


Input Arguments

S — Vector geographic features

geospatial table | mappoint vector | mapshape vector | mapstruct vector | geopoint vector | geoshape vector | geostruct vector

Vector geographic features, specified as one of these:

- A geospatial table. The `makedbfspec` function does not support geospatial tables containing more than one type of shape object. For more information about geospatial tables, see “Create Geospatial Tables”.
- A `mappoint` vector.
- A `mapshape` vector.
- A map structure array (`mapstruct`) with X and Y coordinate fields.
- A `geopoint` vector.
- A `geoshape` vector.
- A geographic structure array (`geostruct`) with Lat and Lon fields.

Output Arguments

dbfspec — DBF specification

structure array

DBF specification, returned as a structure array with two levels. The top level contains a field for each attribute in S. Each field in the top level contains a scalar structure with four fields.

Field	Description
FieldName	Field name for the <code>shapewrite</code> function to use in the DBF file. By default, the field name is identical to the name of the corresponding attribute.
FieldType	Field type for the <code>shapewrite</code> function to use in the DBF file, specified as 'N' (numeric) or 'C' (character).
FieldLength	Number of bytes each instance of the field occupies in the file.
FieldDecimalCount	Number of digits to the right of the decimal place. Specify the number of digits as 0 for integer-valued fields and character fields. The default value for noninteger numeric fields is 6.

You can change the structure array before using it with the `shapewrite` function. For example, you can remove attributes from the structure or change the `FieldName` field to include spaces.

Version History

Introduced before R2006a

R2021b: Create DBF specifications from geospatial tables

The `makedbfspec` function accepts geospatial tables as input.

See Also

Functions

shapeinfo | shapewrite | readgeotable

makemapped

(Removed) Convert ordinary graphics object to mapped object

Note The makemapped function has been removed.

Syntax

makemapped(h)

Description

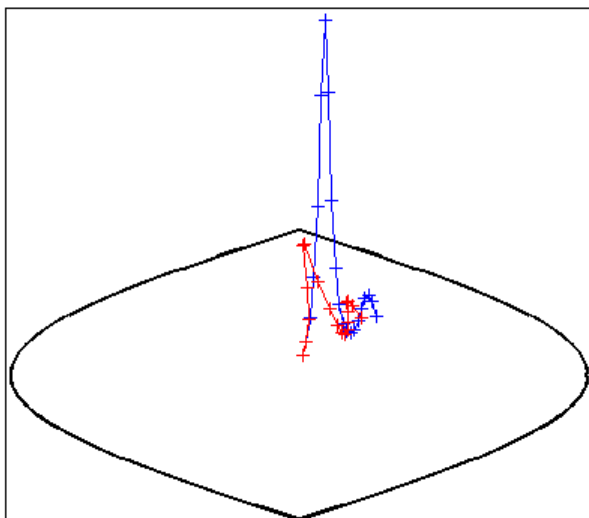
makemapped(h) modifies the graphic object(s) associated with h such that upon subsequent modification of axesm-based map properties, they are automatically reprojected appropriately. The object's coordinates are not changed by makemapped, but will change should you modify the map projection. h can be a handle, vector of handles, or any name recognized by handlem. The objects are then considered to be geographic data. You should first trim objects extending outside the map frame to the map frame using trimcart.

Examples

```
axesm('miller','geoid',[25 0])
framem
plot(humps,'b+-')

h = plot(humps,'r+-');
trimcart(h)
makemapped(h)

setm(gca,'MapProjection','sinusoid')
```



Tips

Objects should first be trimmed to the map frame using `trimcart`. This avoids problems in taking inverse map projections with out-of-range data.

Version History

R2023a: Removed

Errors starting in R2023a

The `makemapped` function has been removed.

R2022a: Warns

Warns starting in R2022a

The `makemapped` function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The `makemapped` function runs without warning but will be removed in a future release.

makerefmat

(To be removed) Construct affine spatial-referencing matrix

Note makerefmat will be removed in a future release. Create a raster reference object using the `georefcells`, `georefpostings`, `georasterref`, `maprefcells`, `maprefpostings`, or `maprasterref` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
R = makerefmat(x11, y11, dx, dy)
R = makerefmat(lon11, lat11, dlon, dlat)
R = makerefmat(param1, val1, param2, val2, ...)
```

Description

`R = makerefmat(x11, y11, dx, dy)`, with scalars `dx` and `dy`, constructs a referencing matrix that aligns image or data grid rows to map `x` and columns to map `y`. Scalars `x11` and `y11` specify the map location of the center of the first (1,1) pixel in the image or the first element of the data grid.

`dx` is the difference in `x` (or longitude) between pixels in successive columns, and `dy` is the difference in `y` (or latitude) between pixels in successive rows.

Pixels cover squares on the map when `abs(dx) = abs(dy)`. To achieve the most typical kind of alignment, where `x` increases from column to column and `y` decreases from row to row, make `dx` positive and `dy` negative. In order to specify such an alignment along with square pixels, make `dx` positive and make `dy` equal to `-dx`:

```
R = makerefmat(x11, y11, dx, -dx)
```

`R = makerefmat(x11, y11, dx, dy)`, with two-element vectors `dx` and `dy`, constructs the most general possible kind of referencing matrix.

In this general case, each pixel can become a parallelogram on the map, with neither edge necessarily aligned to map `x` or `y`. The vector `[dx(1) dy(1)]` is the difference in map location between a pixel in one row and its neighbor in the preceding row. Likewise, `[dx(2) dy(2)]` is the difference in map location between a pixel in one column and its neighbor in the preceding column.

To specify pixels that are rectangular or square (but possibly rotated), choose `dx` and `dy` such that `prod(dx) + prod(dy) = 0`. To specify square (but possibly rotated) pixels, choose `dx` and `dy` such that the 2-by-2 matrix `[dx(:) dy(:)]` is a scalar multiple of an orthogonal matrix (that is, its two eigenvalues are real, nonzero, and equal in absolute value). This amounts to either rotation, a mirror image, or a combination of both. Note that for scalars `dx` and `dy`,

```
R = makerefmat(x11, y11, [0 dx], [dy 0])
```

is equivalent to

```
R = makerefmat(x11, y11, dx, dy)
```

`R = makerefmat(lon11, lat11, dlon, dlat)`, with longitude preceding latitude, constructs a referencing matrix for use with geographic coordinates.

`R = makerefmat(param1, val1, param2, val2, ...)` uses parameter name-value pairs to construct a referencing matrix for an image or raster grid that is referenced to and aligned with a geographic coordinate system. There can be no rotation or skew: each column must fall along a meridian, and each row must fall along a parallel. Each parameter name must be specified exactly as shown, including case.

Parameter Name	Data Type	Value
RasterSize	Two-element size vector [M N]	<p>The number of rows (M) and columns (N) of the raster or image to be used with the referencing matrix.</p> <p>With 'RasterSize', you may also provide a size vector having more than two elements. This enables usage such as:</p> <pre>R = makerefmat('RasterSize', ... size(RGB), ...)</pre> <p>where RGB is M-by-N-by-3. However, in cases like this, only the first two elements of the size vector will actually be used. The higher (non-spatial) dimensions will be ignored. The default value is [1 1].</p>
LatitudeLimits	Two-element row vector of the form: [southern_limit, northern_limit], in units of degrees.	The limits in latitude of the geographic quadrangle bounding the georeferenced raster. The default value is [0 1].
LongitudeLimits	Two-element row vector of the form: [western_limit, eastern_limit], in units of degrees.	The limits in longitude of the geographic quadrangle bounding the georeferenced raster. The elements of the 'LongitudeLimits' vector must be ascending in value. In other words, the limits must be unwrapped. The default value is [0 1].
ColumnsStartFrom	String scalar or character vector	Indicates the column direction of the raster (south-to-north vs. north-to-south) in terms of the edge from which row indexing starts. Values are 'south' or 'north' and they can be shortened, and are case-insensitive. In a typical terrain grid, row indexing starts at southern edge. In images, row indexing starts at northern edge. The default value is 'south'.
RowsStartFrom	String scalar or character vector	Indicates the row direction of the raster (west-to-east vs. east-to-west) in terms of the edge from which column indexing starts. Values are: 'west' or 'east' and they can be shortened, and are case-insensitive. Rows almost always run from west to east. The default value is 'west'.

Examples

Create a referencing matrix for an image with square, four-meter pixels and with its upper left corner (in a map coordinate system) at $x = 207000$ meters, $y = 913000$ meters. The image follows the typical orientation: x increasing from column to column and y decreasing from row to row.

```
x11 = 207002; % Two meters east of the upper left corner
y11 = 912998; % Two meters south of the upper left corner
dx = 4;
dy = -4;
R = makerefmat(x11, y11, dx, dy)
```

More About

Spatial Referencing Matrix

A spatial referencing matrix R ties the row and column subscripts of an image or regular data grid to 2-D map coordinates or to geographic coordinates (longitude and geodetic latitude). R is a 3-by-2 affine transformation matrix. R either transforms pixel subscripts (row, column) to/from map coordinates (x,y) according to

$$[x \ y] = [\text{row} \ \text{col} \ 1] * R$$

or transforms pixel subscripts to/from geographic coordinates according to

$$[\text{lon} \ \text{lat}] = [\text{row} \ \text{col} \ 1] * R$$

To construct a referencing matrix for use with geographic coordinates, use longitude in place of X and latitude in place of Y , as shown in the $R = \text{makerefmat}(X11, Y11, dx, dy)$ syntax. This is one of the few places where longitude precedes latitude in a function call.

Version History

R2022a: Warns

Warns starting in R2022a

Some functions that return referencing matrices issue a warning that they will be removed in a future release, including the `makerefmat` function. Instead, create a geographic raster reference object by using the `georefcells`, `georefpostings`, or `georasterref` function, or a map raster reference object by using the `maprefcells`, `maprefpostings`, or `maprasterref` function. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `MapPostingsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` or `mapcrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` or `mapresize` function.
- Most functions that accept referencing matrices as inputs also accept reference objects.

Depending on the `makerefmat` function syntax, there are different ways to update your code.

- To specify the first data point of `A` and scalar values of `dx` and `dy` or `dlon` and `dlat`, use these replacement patterns. Use the `georasterref` function for geographic coordinates and the `maprasterref` function for planar map coordinates.

Will Be Removed	Recommended
<code>R = makerefmat(x11,y11,dx,dy);</code>	<code>W = [dx 0 x11; 0 dy y11];</code> <code>R = maprasterref(W,size(A));</code>
<code>R = makerefmat(lon11,lat11,dlon,dlat);</code>	<code>W = [dlon 0 lon11; 0 dlat lat11];</code> <code>R = georasterref(W,size(A));</code>

- To specify the first data point of `A` and vector values of `dx` and `dy` or `dlon` and `dlat`, use these replacement patterns. Use the `georasterref` function for geographic coordinates and the `maprasterref` function for planar map coordinates.

Will Be Removed	Recommended
<code>R = makerefmat(x11,y11,dx,dy);</code>	<code>W = [dx x11; dy y11];</code> <code>R = maprasterref(W,size(A));</code>
<code>R = makerefmat(lon11,lat11,dlon,dlat);</code>	<code>W = [dlon lon11; dlat lat11];</code> <code>R = georasterref(W,size(A));</code>

- To specify arguments such as the raster size or latitude and longitude limits, use this replacement pattern. Use the `georefcells` function for a raster of cells and the `georefpostings` function for a raster of regularly posted samples.

Will Be Removed	Recommended
<code>R = makerefmat('RasterSize',size, ...</code> <code> 'LatitudeLimits',latlim, ...</code> <code> 'LongitudeLimits',lonlim);</code>	<code>R = georefcells(latlim,lonlim,size);</code>

You can also create a map raster reference object using the `maprefcells` or `maprefpostings` function. These functions are useful if you have information such as world limits or cell extents. Use the `maprefcells` function for a raster of cells and the `maprefpostings` function for a raster of regularly posted samples.

R2020b: To be removed

Not recommended starting in R2020b

The `makerefmat` function runs without warning but will be removed in a future release.

See Also

`maprasterref` | `georasterref` | `georefpostings` | `georefcells` | `maprefcells` | `maprefpostings`

makesymbolspec

Create vector layer symbol specification

Syntax

```
symbolspec = makesymbolspec(geometry,rule1,rule2,...,ruleN)
```

Description

`symbolspec = makesymbolspec(geometry,rule1,rule2,...,ruleN)` creates a symbol specification `symbolspec` for the shape geometry according to the rules specified in one or more rule arguments.

Use symbol specifications to customize the appearance of vector shapes for maps you create using the `mapshow` and `geoshow` functions.

Examples

Specify Default Line Color

Import a shapefile containing road data for Concord, MA, as a geospatial table.

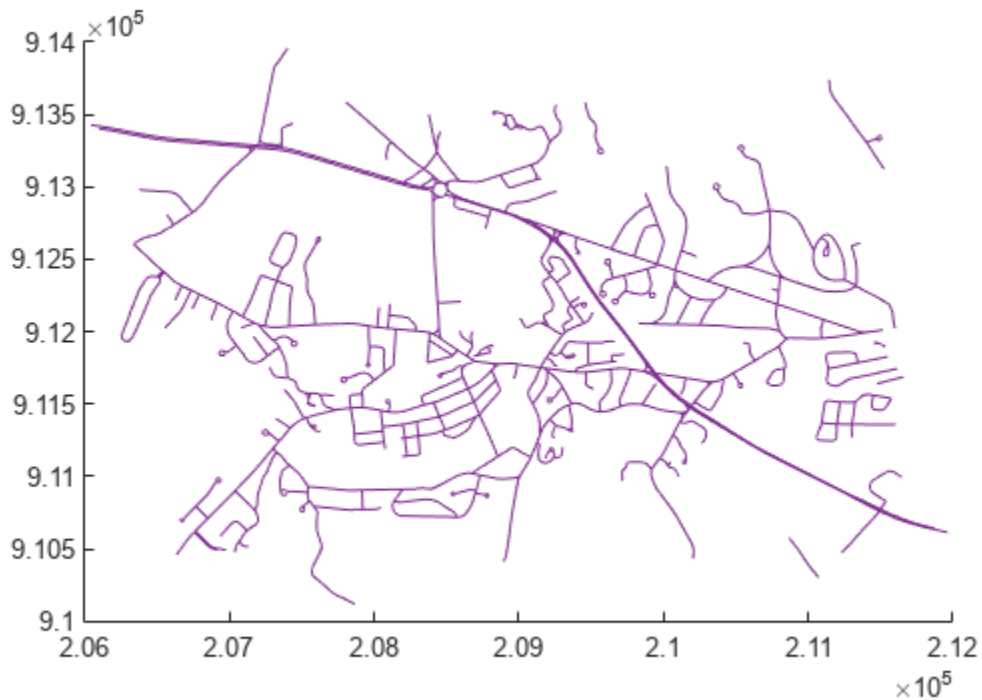
```
roads = readgeotable("concord_roads.shp");
```

Create a symbol specification that specifies the default line color as purple.

```
blueRoads = makesymbolspec("Line",{ 'Default', 'Color', '#7E2F8E' });
```

Display the roads using the symbol specification.

```
mapshow(roads, "SymbolSpec", blueRoads)
```



Specify Line Color Based on Attribute Values

Import a shapefile containing road data for Concord, MA, as a geospatial table.

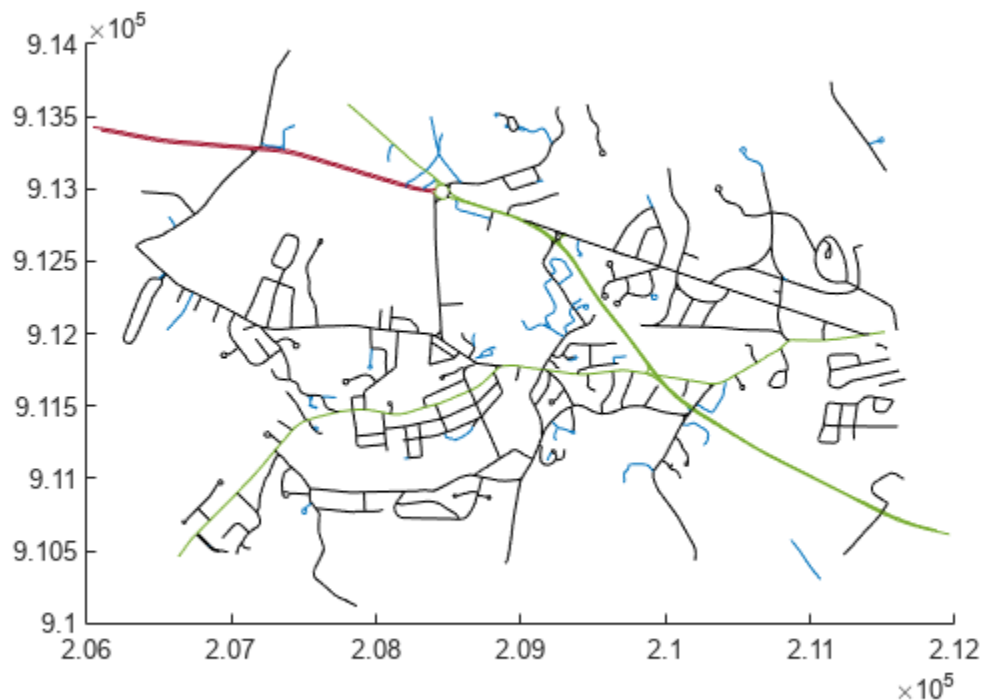
```
roads = readgeotable("concord_roads.shp");
```

The CLASS attribute includes information about road types. For example, a value of 2 indicates a multilane highway and a value of 6 indicates a minor road. Create a symbol specification that specifies road colors based on the value of CLASS.

```
roadColors = makesymbolspec("Line", ...
    {'CLASS', 2, 'Color', '#A2142F'}, ...
    {'CLASS', 3, 'Color', '#77AC30'}, ...
    {'CLASS', 6, 'Color', '#0072BD'}, ...
    {'Default', 'Color', 'k'});
```

Display the roads using the symbol specification.

```
mapshow(roads, "SymbolSpec", roadColors)
```



Specify Line Style Using Range of Attribute Values

Import a shapefile containing road data for Concord, MA, as a geospatial table.

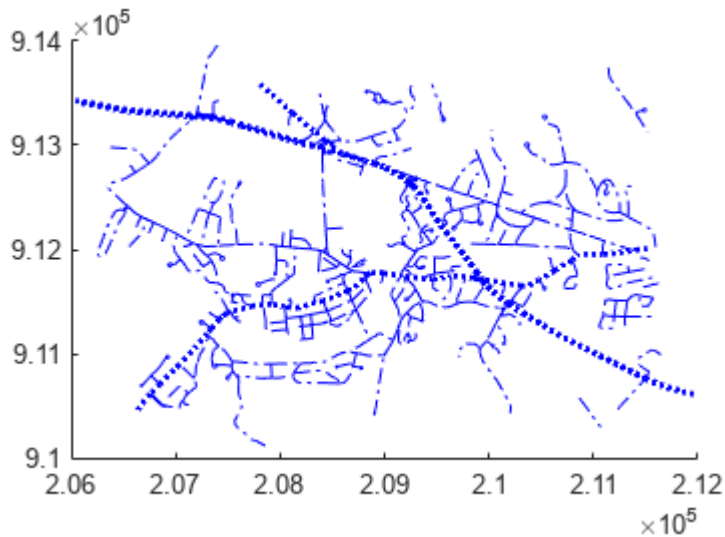
```
roads = readgeotable("concord_roads.shp");
```

The CLASS attribute includes information about road types. For example, a value of 2 indicates a multilane highway and a value of 6 indicates a minor road. Create a symbol specification that specifies line styles and widths based on the value of CLASS such that major roads have a thick dashed lines and minor roads have thin dash-dotted lines.

```
lineStyles = makesymbolspec("Line", ...
    {'CLASS',[1 3],'LineStyle',':','LineWidth',2}, ...
    {'CLASS',[4 6],'LineStyle','-.','LineWidth',0.25});
```

Display the roads using the symbol specification.

```
mapshow(roads,"SymbolSpec",lineStyles)
```



Specify Line Style Using Range of Attribute and Property Values

Import a shapefile containing road data for Concord, MA, as a geospatial table.

```
roads = readgeotable("concord_roads.shp");
```

The CLASS attribute includes information about road types. For example, a value of 2 indicates a multilane highway, a value of 3 indicates a major road, and a value of 6 indicates a minor road. Create a symbol specification that specifies line colors in the `turbo` colormap based on the value of CLASS so that highways are blue, major roads are green, and minor roads are red.

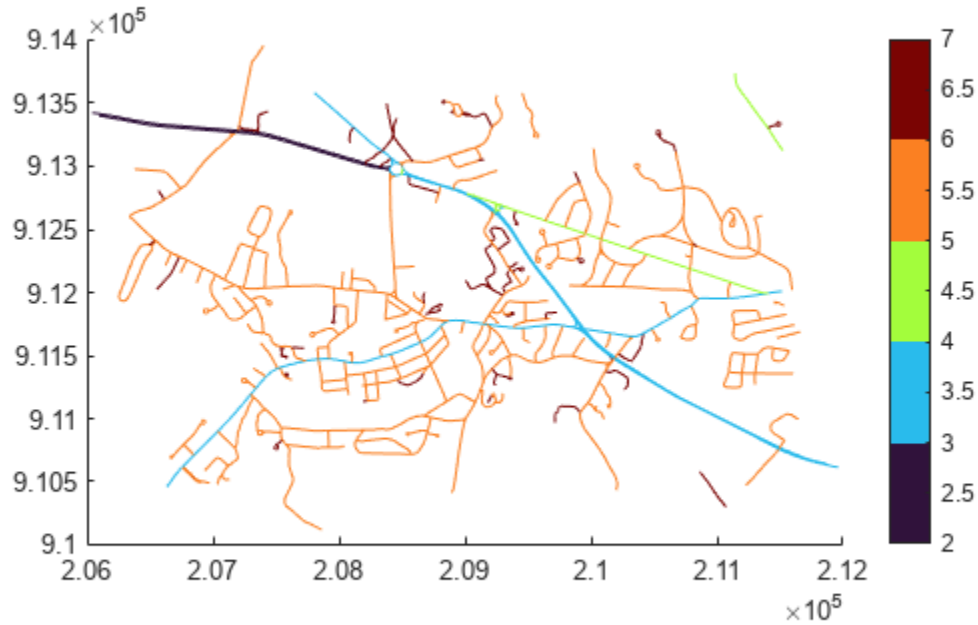
```
cmap = turbo(5);
colorRange = makesymbolspec("Line", ...
    {'CLASS',[2 6],'Color',cmap});
```

Display the roads using the symbol specification.

```
mapshow(roads,"SymbolSpec",colorRange)
```

Add a colorbar to the map by setting the colormap and colormap limits of the axes.

```
colormap(cmap)
caxis([2 7])
colorbar
```



Input Arguments

geometry — Shape type

"Point" | "Line" | "PolyLine" | "Polygon" | "Patch"

Shape type, specified as one of these options:

- "Point" — Point shape
- "Line" — Line shape
- "PolyLine" — Series of connected line shapes
- "Polygon" — Polygon shape
- "Patch" — Patch shape

Data Types: char | string

rule — Shape customization rule

cell array

Shape customization rule, specified as a cell array.

To create a default rule for all features with the specified geometry, specify rule using this pattern:

```
{'Default',Property1,Value1,Property2,Value2,...,PropertyN,ValueN},
```

where `Property1`, `Property2`, and `PropertyN` are graphics properties and `Value1`, `Value2`, and `ValueN` are values. Specify properties using character vectors. Valid properties depend on the value of geometry:

- "Point" — Valid properties are `Marker`, `Color`, `MarkerEdgeColor`, `MarkerFaceColor`, `MarkerSize`, and `Visible`. For a description of each property, see [Line Properties](#).
- "Line" and "PolyLine" — Valid properties are `Color`, `LineStyle`, `LineWidth`, and `Visible`. For a description of each property, see [Line Properties](#).
- "Polygon" and "Patch" — Valid properties are `FaceColor`, `FaceAlpha`, `LineStyle`, `LineWidth`, `EdgeColor`, and `EdgeAlpha`, and `Visible`. For a description of each property, see [Patch Properties](#).

To create a rule based on the values of an attribute, specify rule using this pattern:

```
{AttributeName,AttributeValue,Property1,Value1,Property2,Value2,...,PropertyN,ValueN},
```

where `AttributeName` is the attribute and `AttributeValue` is the value or range of values. The size of `AttributeValue` and `Value1`, `Value2`, and `ValueN` do not need to match.

When a feature does not match a rule, the `mapshow` and `geoshow` functions display the feature using default graphics properties.

Data Types: `cell`

Version History

Introduced before R2006a

See Also

Functions

`mapshow` | `geoshow` | `readgeotable`

map2pix

(To be removed) Convert map coordinates to pixel coordinates

Note The `map2pix` function will be removed in a future release. Use the `worldToIntrinsic` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[row,col] = map2pix(R,x,y)
p = map2pix(R,x,y)
[...] = map2pix(R,s)
```

Description

`[row,col] = map2pix(R,x,y)` calculates pixel coordinates `row`, `col` from map coordinates `x`, `y`. `R` is either a 3-by-2 referencing matrix defining a 2-dimensional affine transformation from intrinsic pixel coordinates to map coordinates, or a map raster reference object. `x` and `y` are vectors or arrays of matching size. The outputs `row` and `col` have the same size as `x` and `y`.

`p = map2pix(R,x,y)` combines `row` and `col` into a single array `p`. If `x` and `y` are column vectors of length `n`, then `p` is an `n`-by-2 matrix and each `p(k,:)` specifies the pixel coordinates of a single point. Otherwise, `p` has size `[size(row) 2]`, and `p(k1,k2,...,kn,:)` contains the pixel coordinates of a single point.

`[...] = map2pix(R,s)` combines `x` and `y` into a single array `s`. If `x` and `y` are column vectors of length `n`, the `s` should be an `n`-by-2 matrix such that each row (`s(k,:)`) specifies the map coordinates of a single point. Otherwise, `s` should have size `[size(X) 2]`, and `s(k1,k2,...,kn,:)` should contain the map coordinates of a single point.

Examples

```
% Find the pixel coordinates for the spatial coordinates
% (207050, 912900)
[X,cmap] = imread('concord_ortho_w.tif');
R = worldfileread('concord_ortho_w.tfw','planar',size(X));
[r,c] = map2pix(R,207050,912900);
```

Version History

Introduced before R2006a

R2023a: Warns

Warns starting in R2023a

Some functions that accept referencing matrices as input issue a warning that they will be removed in a future release, including the `map2pix` function. Use a map raster reference object and the

`worldToIntrinsic` function instead. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns. For more information about reference object properties, see the `MapPostingsReference` and `MapCellsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `mapcrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `mapresize` function.
- Most functions that accept referencing matrices as inputs also accept reference objects.

To update your code, first create a reference object for either a raster of cells using the `maprefcells` function or a raster of regularly posted samples using the `maprefpostings` function. Alternatively, convert from a referencing matrix to a reference object using the `refmatToMapRasterReference` function.

Then, replace uses of the `map2pix` function with the `worldToIntrinsic` function according to these patterns.

Will Be Removed	Recommended
<code>[row,col] = map2pix(R,x,y);</code>	<code>[col,row] = worldToIntrinsic(R,x,y);</code>
<code>p = map2pix(R,x,y);</code>	If <code>x</code> and <code>y</code> are column vectors: <code>[col,row] = worldToIntrinsic(R,x,y);</code> <code>p = [row col];</code> If <code>row</code> and <code>col</code> have size <i>M-by-N</i> or <i>1-by-N</i> : <code>[col,row] = worldToIntrinsic(R,x,y);</code> <code>p = cat(3,row,col);</code>
<code>[row,col] = map2pix(R,s);</code>	If <code>s</code> has size <i>N-by-2</i> : <code>[col,row] = worldToIntrinsic(R,s(:,1),s(:,2));</code>

R2021b: To be removed

Not recommended starting in R2021b

The `map2pix` function runs without warning but will be removed in a future release.

See Also

`intrinsicToWorld` | `worldfileread` | `worldToIntrinsic`

mapaxes

Create map axes

Syntax

```
mapaxes
mapaxes(Name=Value)
mapaxes(parent, ___)
mx = mapaxes( ___)
```

```
mapaxes(cmx)
```

Description

Create Map Axes

`mapaxes` creates the default map axes in the current figure. By default, the function creates a world map that uses an Equal Earth projection.

`mapaxes(Name=Value)` specifies options for the map axes using one or more name-value arguments. For example, `FontSize=14` sets the font size for the map axes text to 14 points. For a list of properties, see [MapAxes Properties](#).

`mapaxes(parent, ___)` creates the map axes in the object specified by `parent`, instead of in the current figure, in addition to any combination of inputs from the previous syntaxes.

`mx = mapaxes(___)` returns the `MapAxes` object. Use `mx` to query and modify properties of the `MapAxes` object after creation. For a list of properties, see [MapAxes Properties](#).

Specify Current Axes

`mapaxes(cmx)` specifies the map axes `cmx` as the current axes.

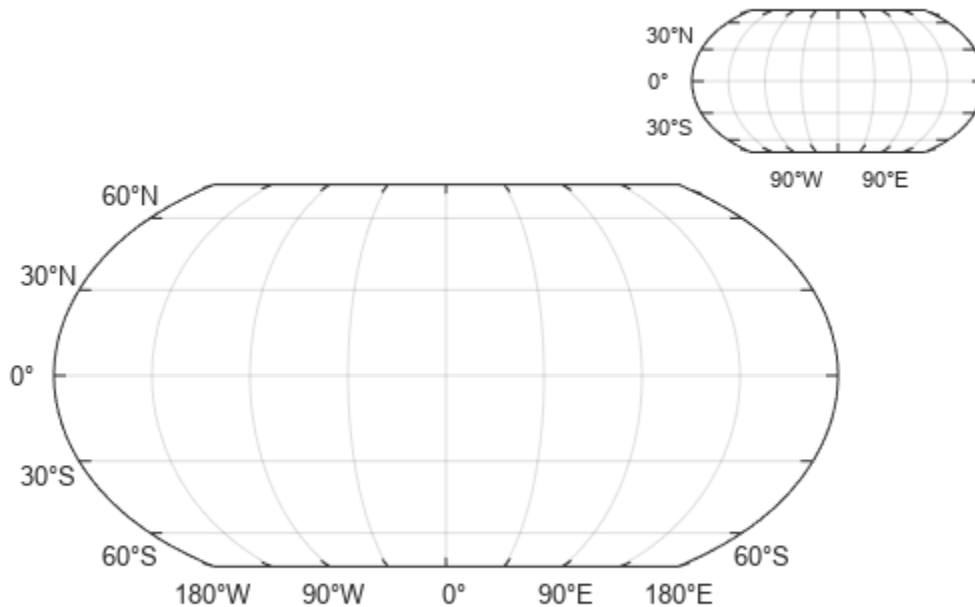
Examples

Position Multiple Map Axes in Figure

Create a map with an inset map by positioning two `MapAxes` objects in a figure.

Specify the position of the first `MapAxes` object so that it has a lower-left corner at the point (0.1, 0.1) with a width and height of 0.7. Specify the position of the second `MapAxes` object so that it has a lower-left corner at the point (0.67, 0.67) with a width and height of 0.26. By default, `mapaxes` normalizes the values to the figure. Return the `MapAxes` objects as `mx1` and `mx2`.

```
figure
mx1 = mapaxes(Position=[0.1 0.1 0.7 0.7]);
mx2 = mapaxes(Position=[0.67 0.67 0.26 0.26]);
```



Read a shapefile containing world land areas into the workspace as a geospatial table. The table represents the land areas using polygon shapes in geographic coordinates. Extract the table row for Australia.

```
world = readgeotable("landareas.shp");
idx = world.Name == "Australia";
australia = world(idx,:);
```

Change the projected coordinate reference system (CRS) of the first map axes to a CRS appropriate for Australia. Then, display the Australia polygon in the first axes.

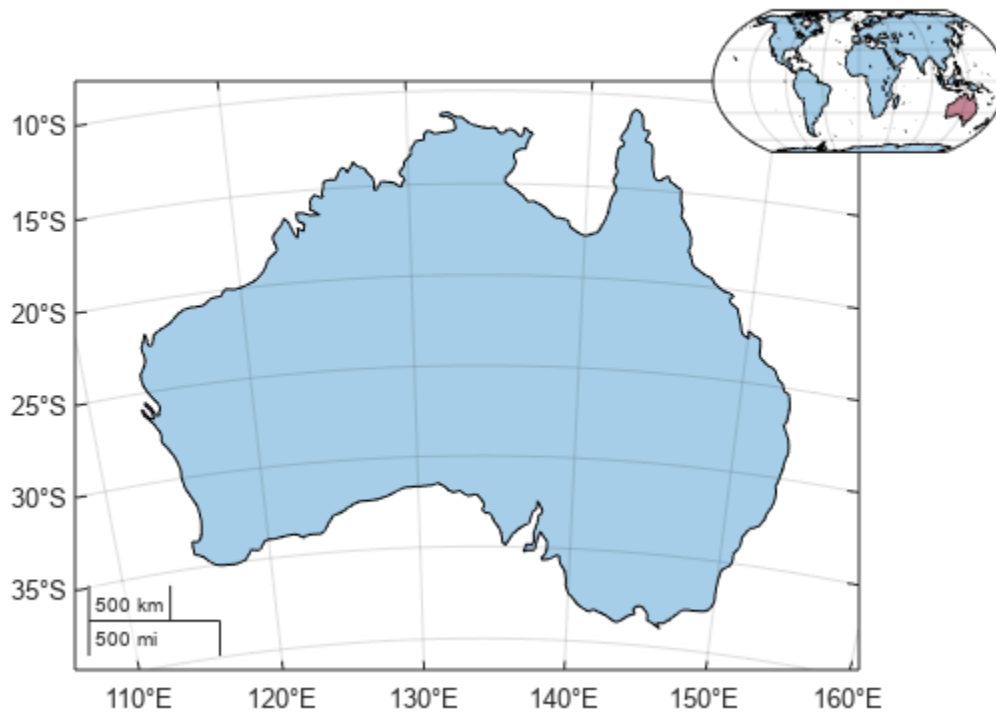
```
mx1.ProjectedCRS = projcrs(3112);
geoplot(mx1,australia)
```

Display the global land area polygons and the Australia polygon in the second map axes. Use red for the Australia polygon.

```
geoplot(mx2,world)
hold on
geoplot(mx2,australia,"red")
```

Hide the ticks and tick labels on the second map axes by setting the `TickDir` and `FontColor` properties.

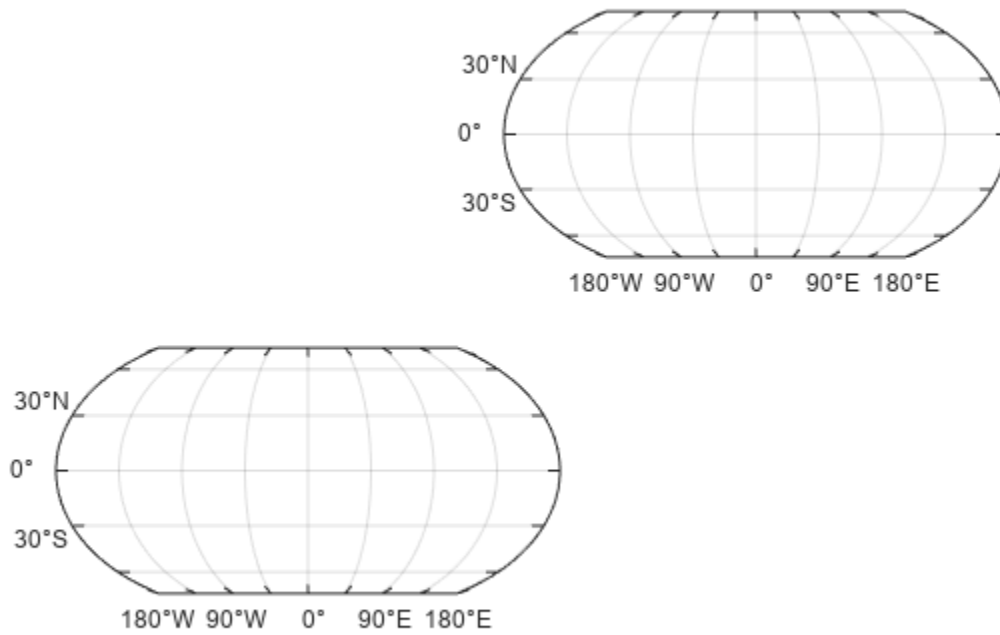
```
mx2.TickDir = "none";
mx2.FontColor = "none";
```



Make Map Axes the Current Axes

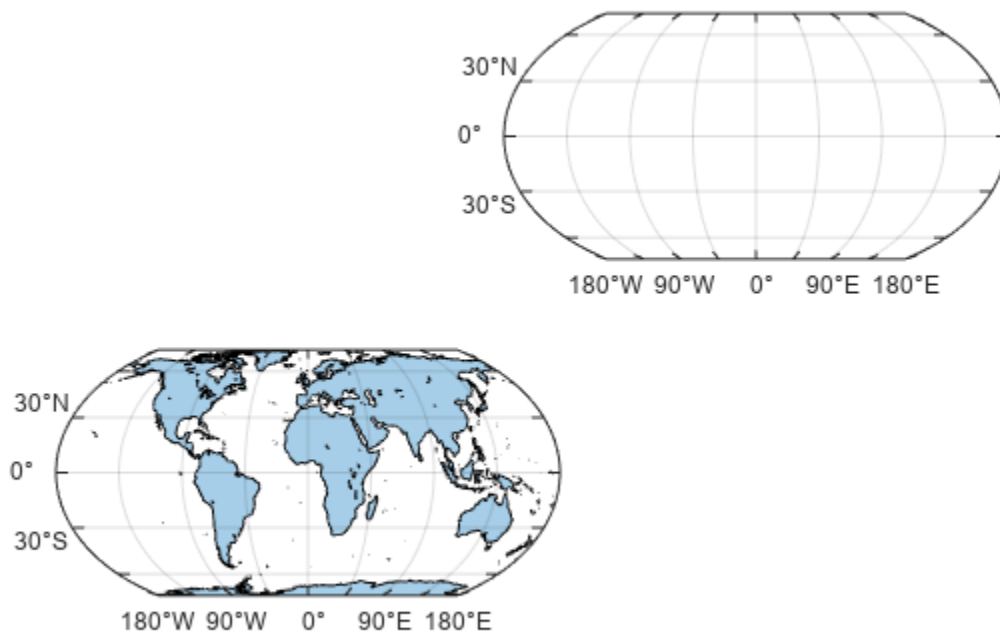
Create two MapAxes objects and specify their positions. Return the MapAxes objects as mx1 and mx2.

```
figure
mx1 = mapaxes(Position=[0.1 0.1 0.45 0.45]);
mx2 = mapaxes(Position=[0.5 0.5 0.45 0.45]);
```



Make `mx1` the current axes. This action makes the axes the target for subsequent graphics functions. Display polygons representing global land areas on the axes.

```
mapaxes(mx1)  
land = readgeotable("landareas.shp");  
geoplot(land)
```



Create Map Axes in Tabs

Create a figure with two tabs. Add a map axes to each tab by specifying the parent container for each axes.

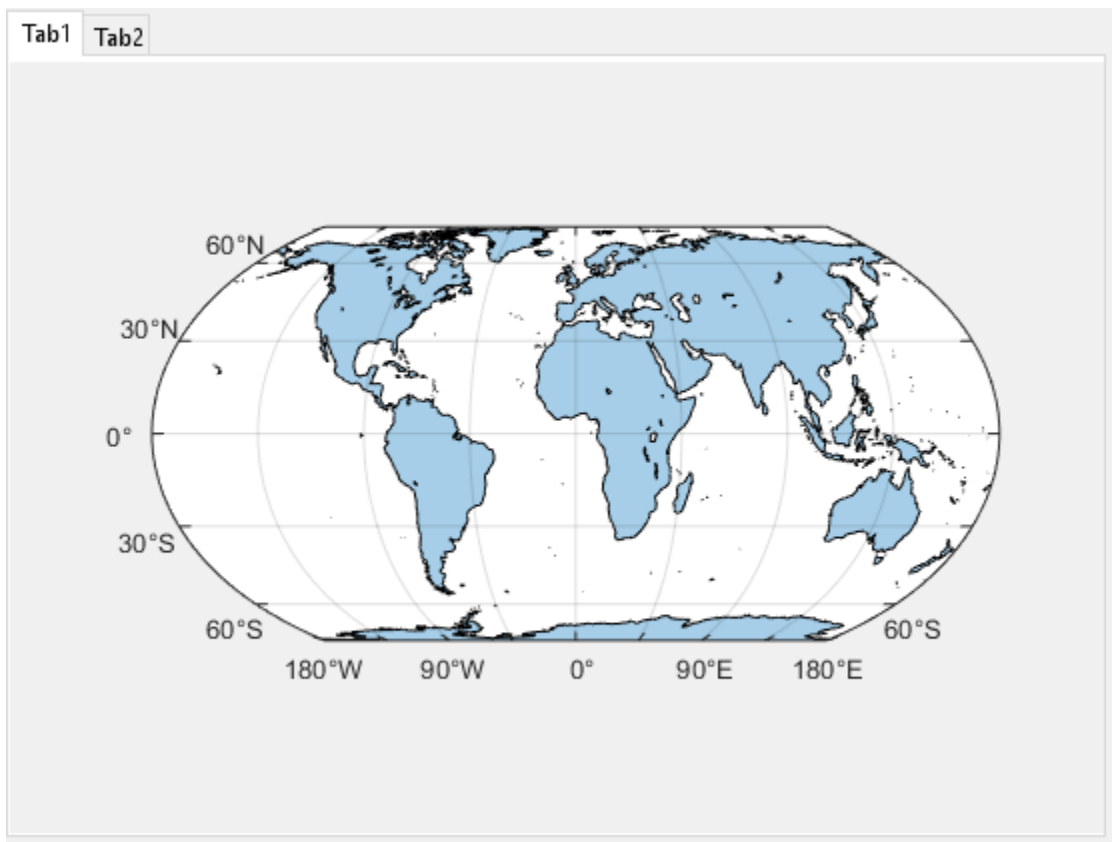
```
figure
tab1 = uitab(Title="Tab1");
mx1 = mapaxes(tab1);
```

```
tab2 = uitab(Title="Tab2");
mx2 = mapaxes(tab2);
```

Plot polygons representing global land areas in the first tab and points representing global cities in the second tab.

```
land = readgeotable("landareas.shp");
geoplot(mx1,land)

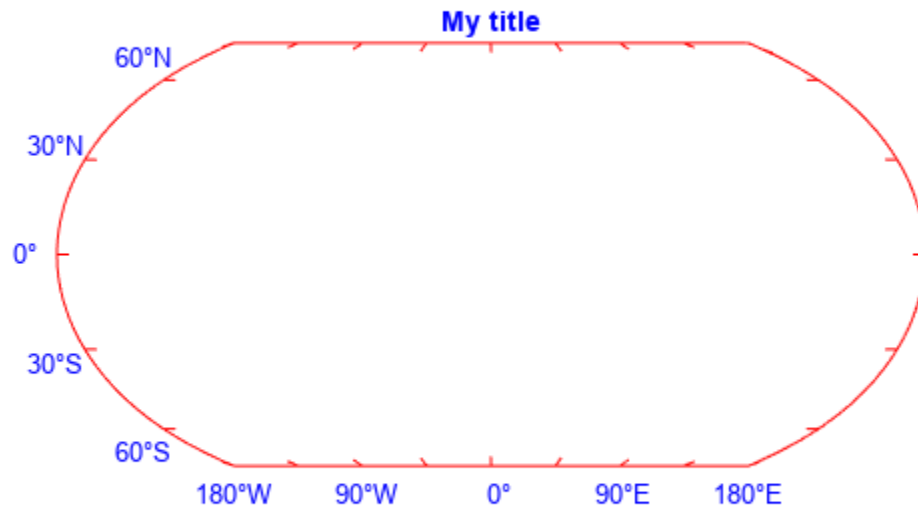
cities = readgeotable("worldcities.shp");
geoplot(mx2,cities)
```



Customize Appearance of Map Axes

Create a map axes with a title. Remove the graticule lines, specify the map outline color, and specify the font color using name-value arguments.

```
mapaxes(GraticuleLineStyle="none",OutlineColor="r",FontColor="b")  
title("My title")
```



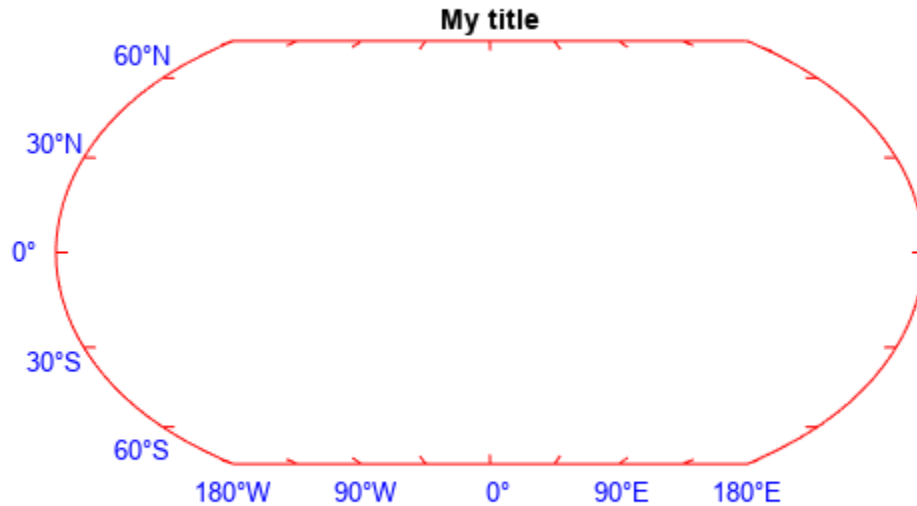
Alternatively, you can set properties of the MapAxes object after creation by returning the MapAxes object as a variable.

```
figure
mx = mapaxes;
title("My title")

mx.GraticuleLineStyle = "none";
mx.OutlineColor = "r";
mx.FontColor = "b";
```

To use a different color for the title than for the tick labels, set the Color property of the title.

```
mx.Title.Color = "k";
```



Input Arguments

parent — Parent container

Figure object | Panel object | Tab object | TiledChartLayout object | GridLayout object

Parent container, specified as a Figure, Panel, Tab, TiledChartLayout, or GridLayout object.

cmx — Axes to make current

MapAxes object

Axes to make current, specified as a MapAxes object.

Name-Value Pair Arguments

Specify optional pairs of arguments as Name1=Value1, . . . , NameN=ValueN, where Name is the argument name and Value is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `mapaxes(Position=[0.3 0.3 0.5 0.5])` specifies the position of the map axes so that it has a lower-left corner at the point (0.3, 0.3) with a width and height of 0.5. By default, `mapaxes` normalizes the values to the figure.

Note Use name-value arguments to specify values for the properties of the MapAxes objects created by this function. The properties listed here are only a subset. For a full list, see MapAxes Properties.

ProjectedCRS — Projected coordinate reference system`projcrs(8857)` (default) | `projcrs` object

Projected coordinate reference system (CRS), specified as a `projcrs` object. `MapAxes` objects use the projection method and projection parameters stored in the projected CRS to transform geographic (latitude-longitude) coordinates to projected (*xy*) coordinates.

When you change the projected CRS, MATLAB automatically updates the map axes to use the new projected CRS.

To change the projection parameters of the CRS, access the underlying `ProjectionParameters` property of the `projcrs` object.

```
p = projcrs(26919);
newmap(p)
mx = gca;
mx.ProjectionParameters.LongitudeOfNaturalOrigin = -75;
```

For examples of how to customize the projection used by map axes, see “Change Projection and Projection Parameters”.

By default, map axes objects use the World Geodetic System of 1984 (WGS 84) / Equal Earth Greenwich projected CRS, which has the EPSG code 8857.

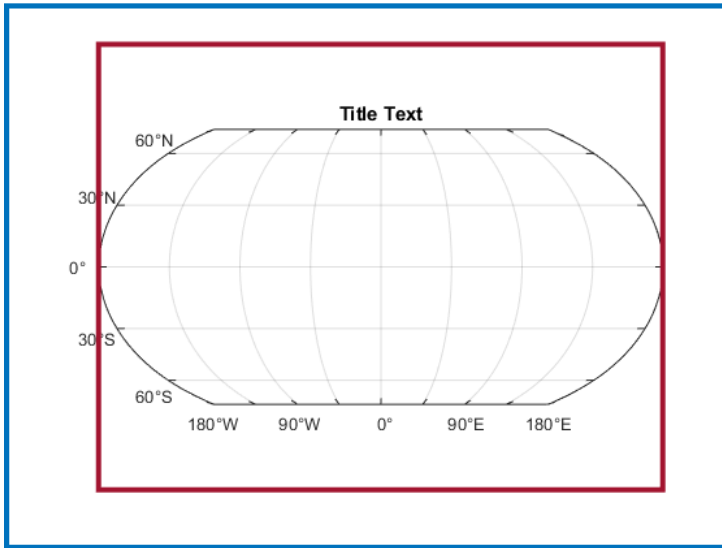
The projected CRS must have a forward and inverse projection implementation. Most projected CRSs have a forward and inverse projection implementation.

Position — Size and location, excluding margin for labels`[0.1300 0.1100 0.7750 0.8150]` (default) | four-element vector

Size and location, excluding a margin for the labels, specified as a four-element vector of the form `[left bottom width height]`. By default, MATLAB measures the values in units normalized to the container. To change the units, set the `Units` property.

- The `left` and `bottom` elements define the distance from the lower-left corner of the container (typically a figure, panel, or tab) to the lower-left corner of the position boundary.
- The `width` and `height` elements are the position boundary dimensions.

If you want to specify the position and account for the text around the axes, then set the `OuterPosition` property instead. This figure shows the areas defined by the `OuterPosition` values (blue) and the `Position` values (red).



Note Setting this property has no effect when the parent container is a `TiledChartLayout` object.

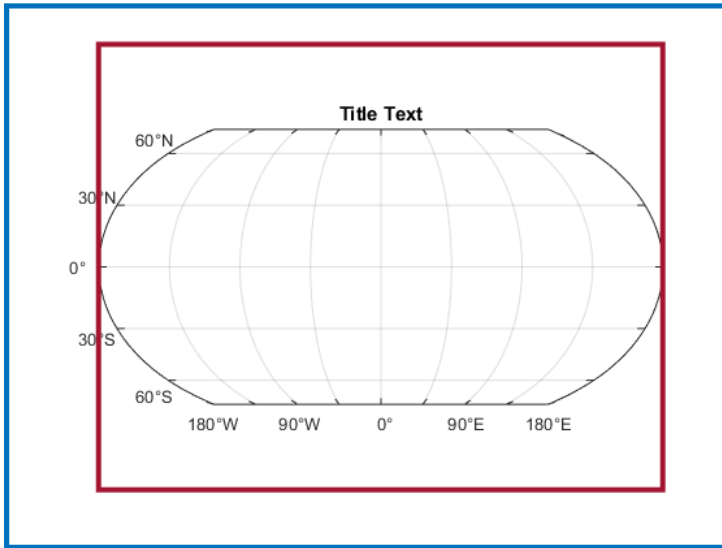
OuterPosition — Size and location, including labels and margin

`[0 0 1 1]` (default) | four-element vector

Size and location, including the labels and a margin, specified as a four-element vector of the form `[left bottom width height]`. By default, MATLAB measures the values in units normalized to the container. To change the units, set the `Units` property. The default value of `[0 0 1 1]` includes the whole interior of the container.

- The `left` and `bottom` elements define the distance from the lower-left corner of the container (typically a figure, panel, or tab) to the lower-left corner of the outer position boundary.
- The `width` and `height` elements are the outer position boundary dimensions.

This figure shows the areas defined by the `OuterPosition` values (blue) and the `Position` values (red).



Note Setting this property has no effect when the parent container is a `TiledChartLayout`.

Units – Position units

"normalized" (default) | "inches" | "centimeters" | "points" | "pixels" | "characters"

Position units, specified as one of these values.

Units	Description
"normalized" (default)	Normalized with respect to the container, which is typically the figure or a panel. The lower-left corner of the container maps to $(0, 0)$ and the upper-right corner maps to $(1, 1)$.
"inches"	Inches.
"centimeters"	Centimeters.
"characters"	Based on the default <code>UIFont</code> font of the graphics root object: <ul style="list-style-type: none"> Character width = width of letter x. Character height = distance between the baselines of two lines of text.
"points"	Typography points. One point equals 1/72 of an inch.

Units	Description
"pixels"	Pixels. Starting in R2015b, distances in pixels are independent of your system resolution on Windows and Macintosh systems. <ul style="list-style-type: none">• On Windows systems, a pixel is 1/96 of an inch.• On Macintosh systems, a pixel is 1/72 of an inch.• On Linux systems, the size of a pixel is determined by your system resolution.

When specifying the units using a name-value argument during object creation, you must set the `Units` property before specifying the properties that you want to use these units, such as `Position`.

Version History

Introduced in R2023a

See Also

Properties

MapAxes Properties

Functions

`newmap` | `geoaxes` | `cla` | `gca` | `figure` | `clf`

Topics

“Create Map Axes in an App”

MapAxes Properties

Map axes appearance and behavior

Description

MapAxes properties control the appearance and behavior of a MapAxes object. By changing property values, you can modify certain aspects of the map axes. Use dot notation to query and set properties.

```
p = projcrs(26919);
newmap(p)
mx = gca;
c = mx.OutlineColor;
mx.OutlineColor = "blue";
```

Properties

Map

ProjectedCRS — Projected coordinate reference system

`projcrs(8857)` (default) | `projcrs` object

Projected coordinate reference system (CRS), specified as a `projcrs` object. MapAxes objects use the projection method and projection parameters stored in the projected CRS to transform geographic (latitude-longitude) coordinates to projected (xy) coordinates.

When you change the projected CRS, MATLAB automatically updates the map axes to use the new projected CRS.

To change the projection parameters of the CRS, access the underlying `ProjectionParameters` property of the `projcrs` object.

```
p = projcrs(26919);
newmap(p)
mx = gca;
mx.ProjectionParameters.LongitudeOfNaturalOrigin = -75;
```

For examples of how to customize the projection used by map axes, see “Change Projection and Projection Parameters”.

By default, map axes objects use the World Geodetic System of 1984 (WGS 84) / Equal Earth Greenwich projected CRS, which has the EPSG code 8857.

The projected CRS must have a forward and inverse projection implementation. Most projected CRSs have a forward and inverse projection implementation.

Scalebar — Scale bar

`GeographicScalebar` object

This property is read-only.

Scale bar, stored as a `GeographicScalebar` object. The scale bar shows proportional distances on the map.

Change the appearance and behavior of the scale bar by setting properties of the `GeographicScalebar` object. For example, this code shows how to hide the scale bar.

```
newmap
mx = gca;
mx.Scalebar.Visible = "off";
```

For more information about the properties of `GeographicScalebar` objects, see `GeographicScalebar Properties`.

Font

FontColor — Text color for title, tick labels, and scale bar

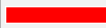



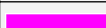
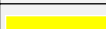


[1 1 1] (default) | RGB triplet | hexadecimal color code | "r" | "g" | "b" | ...

Text color for the title, the tick labels, and the scale bar, specified as an RGB triplet, a hexadecimal color code, a color name, or a short name.

For a custom color, specify an RGB triplet or a hexadecimal color code.







- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	

RGB Triplet	Hexadecimal Color Code	Appearance
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

To use a different text color for the title than for the tick labels and scale bar, set the `Color` property of the title, such as `mx.Title.Color = "blue"`.

To use a different text color for the scale bar than for the title and tick labels, set the `FontColor` property of the scale bar, such as `mx.Scalebar.FontColor = "blue"`.

Example: `mx.FontColor = [0 0 1];`

Example: `mx.FontColor = "b";`

Example: `mx.FontColor = "blue";`

Example: `mx.FontColor = "#0000FF";`

FontName — Font name

supported font name | "FixedWidth"

Font name, specified as a supported font name or "FixedWidth". To display and print text properly, you must choose a font that your system supports. The default font depends on your operating system and locale.

To use a fixed-width font that looks good in any locale, specify "FixedWidth". The fixed-width font relies on the root `FixedWidthFontName` property. Setting the root `FixedWidthFontName` property causes the display to immediately update to use the new font.

FontSize — Font size

numeric scalar

Font size, specified as a numeric scalar. The font size affects the title, tick labels, and scale bar, as well as any legends or color bars associated with the axes. The default font size depends on the specific operating system and locale. By default, the axes object measures the font size in points. To change the units, set the `FontUnits` property.

MATLAB automatically scales some of the text to a percentage of the axes font size.

- Titles — 110% of the axes font size by default. To control title scaling, use the `TitleFontSizeMultiplier` and `LabelFontSizeMultiplier` properties.
- Legends and color bars — 90% of the axes font size by default. To specify a different font size, set the `FontSize` property for the `Legend` or `ColorBar` object instead.
- Scale bar — 80% of the axes font size by default. To specify a different font size, set the `FontSize` property for the `GeographicScalebar` object instead.

FontSizeMode — Selection mode for font size

'auto' (default) | 'manual'

Selection mode for the font size, specified as one of these values:

- 'auto' — Font size specified by MATLAB. If you resize the axes to be smaller than the default size, the font size might scale down to improve readability and layout.
- 'manual' — Font size specified manually. Do not scale the font size as the axes size changes. To specify the font size, set the `FontSize` property.

FontWeight — Character thickness

"normal" (default) | "bold"

Character thickness, specified as "normal" or "bold".

MATLAB uses the `FontWeight` property to select a font from those available on your system. Not all fonts have a bold weight. Therefore, specifying a bold font weight can still result in the normal font weight.

FontAngle — Character slant

"normal" (default) | "italic"

Character slant, specified as "normal" or "italic".

Not all fonts have both font styles. Therefore, the italic font might look the same as the normal font.

TitleFontSizeMultiplier — Scale factor for title font size

1.1 (default) | numeric value greater than 0

Scale factor for the title font size, specified as a numeric value greater than 0. The scale factor is applied to the value of the `FontSize` property to determine the font size for the title.

TitleFontWeight — Title character thickness

'bold' (default) | 'normal'

Title character thickness, specified as one of these values:

- 'normal' — Default weight as defined by the particular font
- 'bold' — Thicker characters than normal

SubtitleFontWeight — Subtitle character thickness

'normal' (default) | 'bold'

Subtitle character thickness, specified as one of these values:

- 'normal' — Default weight as defined by the particular font
- 'bold' — Thicker characters than normal

FontUnits — Font size units

'points' (default) | 'inches' | 'centimeters' | 'normalized' | 'pixels'

Font size units, specified as one of these values.

Units	Description
'points'	Points. One point equals 1/72 inch.
'inches'	Inches.

Units	Description
'centimeters'	Centimeters.
'normalized'	Interpret font size as a fraction of the axes height. If you resize the axes, the font size modifies accordingly. For example, if the <code>FontSize</code> is 0.1 in normalized units, then the text is 1/10 of the height value stored in the axes <code>Position</code> property.
'pixels'	<p>Pixels.</p> <p>Starting in R2015b, distances in pixels are independent of your system resolution on Windows and Macintosh systems.</p> <ul style="list-style-type: none"> • On Windows systems, a pixel is 1/96th of an inch. • On Macintosh systems, a pixel is 1/72nd of an inch. • On Linux systems, the size of a pixel is determined by your system resolution.

To set both the font size and the font units in a single function call, you first must set the `FontUnits` property so that the `Axes` object correctly interprets the specified font size.

Ticks

TickDir — Tick mark direction

"in" (default) | "out" | "both" | "none"

Tick mark direction, specified as one of these values:

- "in" — Direct the tick marks inward from the axis lines.
- "out" — Direct the tick marks outward from the axis lines.
- "both" — Center the tick marks over the axis lines.
- "none" — Do not display any tick marks.

TickLabelFormat — Tick label format

"dms" (default) | "dd" | "dm" | "-dd" | "-dm" | "-dms"

Tick label format, specified as one of these options:

Format	Description	Example
"dd"	Decimal degrees plus compass direction	23°N
"dm"	Degrees and decimal minutes plus compass direction	18°30'W
"dms" (default)	Degrees, minutes, and decimal seconds plus compass direction	110°06'18.5"E

Format	Description	Example
"-dd"	Decimal degrees with a minus sign (-) to indicate south and west	-115.25°
"-dm"	Degrees and decimal minutes with a minus sign (-) to indicate south and west	-5°45.5'
"-dms"	Degrees, minutes, and decimal seconds with a minus sign (-) to indicate south and west	-3°21'05"

Graticule

GraticuleColor — Color of graticule lines









[0.15 0.15 0.15] (default) | RGB triplet | hexadecimal color code | "r" | "g" | "b" | ...

Color of the graticule lines, specified as an RGB triplet, a hexadecimal color code, a color name, or a short name.








For a custom color, specify an RGB triplet or a hexadecimal color code.

- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

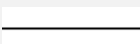
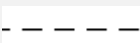


RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

To set the outline color of the axes, use the `OutlineColor` property.

GraticuleLineStyle — Line style for graticule lines

"-" (default) | "--" | ":" | "-." | "none"

Line style for graticule lines, specified as one of the line styles in this table.

Line Style	Description	Resulting Line
"-"	Solid line	
--"	Dashed line	
:"	Dotted line	
-."	Dash-dotted line	
"none"	No line	No line

GraticuleLineWidth — Width of graticule lines

0.5 (default) | positive scalar

Width of the graticule lines, specified as a positive scalar in point units. One point equals 1/72 of an inch.

When the `GraticuleLineWidthMode` property has a value of "auto", the value of `GraticuleLineWidth` matches the value of `LineWidth`.

GraticuleLineWidthMode — Selection mode for GraticuleLineWidth

"auto" (default) | "manual"

Selection mode for the `GraticuleLineWidth` property, specified as one of these values:

- "auto" — Automatically select the width of graticule lines based on the value of the `LineWidth` property.
- "manual" — Manually specify the width of graticule lines. To specify the value, set the `GraticuleLineWidth` property.

GraticuleAlpha — Transparency of graticule lines

0.15 (default) | value in the range [0, 1]

Transparency of the graticule lines, specified as a value in the range [0, 1]. A value of 1 means opaque and a value of 0 means completely transparent.

Labels

Title — Text object for title

text object

Text object for the axes title. To add a title, set the `String` property of the text object. To change the title appearance, such as the font style or color, set other properties. For a complete list, see `Text`.

```
ax = gca;  
ax.Title.String = 'My Title';  
ax.Title.FontWeight = 'normal';
```

Alternatively, use the `title` function to add a title and control the appearance.

```
title('My Title', 'FontWeight', 'normal')
```

Note This text object is not contained in the axes `Children` property, cannot be returned by `findobj`, and does not use default values defined for text objects.

Subtitle — Text object for subtitle

text object

Text object for the axes subtitle. To add a subtitle, set the `String` property of the text object. To change its appearance, such as the font angle, set other properties. For a complete list, see `Text`.

```
ax = gca;  
ax.Subtitle.String = 'An Insightful Subtitle';  
ax.Subtitle.FontAngle = 'italic';
```

Alternatively, use the `subtitle` function to add a subtitle and control the appearance.

```
subtitle('An Insightful Subtitle', 'FontAngle', 'italic')
```

Or use the `title` function, and specify two character vector input arguments and two output arguments. Then set properties on the second text object returned by the function.

```
[t,s] = title('Clever Title', 'An Insightful Subtitle');  
s.FontAngle = 'italic';
```

Note This text object is not contained in the axes `Children` property, cannot be returned by `findobj`, and does not use default values defined for text objects.

TitleHorizontalAlignment — Title and subtitle horizontal alignment

"center" (default) | "left" | "right"

Title and subtitle horizontal alignment, specified as one of these values:

- "center" — Center the title and subtitle over the map axes.
- "left" — Align the title and subtitle with the left edge of an invisible box that circumscribes the map axes.
- "right" — Align the title and subtitle with the right edge of an invisible box that circumscribes the map axes.

Legend — Legend associated with axes

empty GraphicsPlaceholder (default) | Legend object

This property is read-only.

Legend associated with the axes, stored as a Legend object. To add a legend to the axes, use the legend function. Then, you can use this property to modify the legend. For a complete list of properties, see Legend.

```
newmap
geoplot(1:10,1:10)
hold on
geoplot(5:14,1:10)

legend(["Line 1" "Line 2"],FontSize=12)
mx = gca;
mx.Legend.TextColor = "red";
```

You also can use this property to determine if the axes has a legend.


```
newmap
mx = gca;

lgd = mx.Legend
if ~isempty(lgd)
    disp("Legend Exists")
end
```

Multiple Plots**ColorOrder — Color order**

seven predefined colors (default) | three-column matrix of RGB triplets

Color order, specified as a three-column matrix of RGB triplets. This property defines the palette of colors MATLAB uses to create plot objects such as Line and Scatter objects. Each row of the matrix is an RGB triplet. An RGB triplet is a three-element vector whose elements specify the intensities of the red, green, and blue components of a color. The intensities must be in the range [0, 1]. This table lists the default colors.

Colors	ColorOrder Matrix
	<pre>[0 0.4470 0.7410 0.8500 0.3250 0.0980 0.9290 0.6940 0.1250 0.4940 0.1840 0.5560 0.4660 0.6740 0.1880 0.3010 0.7450 0.9330 0.6350 0.0780 0.1840]</pre>

MATLAB assigns colors to objects according to their order of creation. For example, when plotting lines, the first line uses the first color, the second line uses the second color, and so on. If there are more lines than colors, then the cycle repeats.

Changing the Color Order Before or After Plotting

You can change the color order in either of these ways:

- Call the `colororder` function to change the color order for all the axes in a figure. The colors of existing plots in the figure update immediately. If you place additional axes into the figure, those axes also use the new color order. If you continue to call plotting commands, those commands also use the new colors.
- Set the `ColorOrder` property on the axes, call the `hold` function to set the axes hold state to "on", and then call the desired plotting functions. Unlike the `colororder` function, this process sets the color order for the specific axes rather than the entire figure. You must set the hold state to "on" to ensure that subsequent plotting commands do not reset the axes to use the default color order.

LineStyleOrder — Line style order

" - " solid line (default) | character vector | cell array of character vectors | string array

Line style order, specified as a character vector, a cell array of character vectors, or a string array. This property lists the line styles that MATLAB uses to display multiple plot lines in the axes. MATLAB assigns styles to lines according to their order of creation. By default, it changes to the next line style only after cycling through all the colors in the `ColorOrder` property with the current line style. Set the `LineStyleCyclingMethod` property to "withcolor" to cycle through both together, or "beforecolor" to cycle through the line styles first. The default `LineStyleOrder` has only one line style, " - ".

To customize the line style order, create a cell array of character vectors or a string array. Specify each element of the array as a line specifier or marker specifier from these tables. You can combine a line and a marker specifier into a single element, such as ' - * '.

Line Specifier	Description
" - " (default)	Solid line
" - - "	Dashed line
" : "	Dotted line
" - . "	Dash-dotted line

Marker Specifier	Description
" + "	Plus sign markers
" o "	Circle markers
" * "	Star markers
" . "	Point markers
" x "	Cross markers
" s "	Square markers
" d "	Diamond markers
" ^ "	Upward-pointing triangle markers
" v "	Downward-pointing triangle markers
" > "	Right-pointing triangle markers

Marker Specifier	Description
"<"	Left-pointing triangle markers
"p"	Five-pointed star (pentagram) markers
"h"	Six-pointed star (hexagram) markers

Changing Line Style Order Before or After Plotting


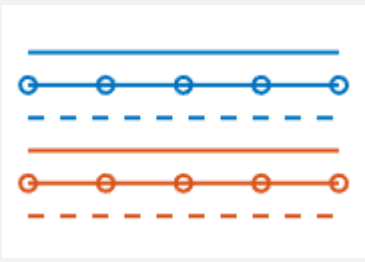
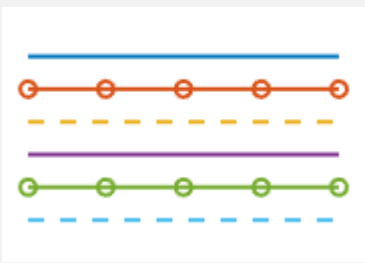
You can change the line style order before or after plotting into the axes. When you set the `LineStyleOrder` property to a new value, MATLAB updates the styles of any lines that are in the axes. If you continue plotting into the axes, your plotting commands continue using the line styles from the updated list.

LineStyleCyclingMethod — How to cycle through line styles

"aftercolor" (default) | "beforecolor" | "withcolor"

How to cycle through the line styles when there are multiple lines in the axes, specified as one of the values from this table.

The examples in this table were created using the default colors in the `ColorOrder` property and three line styles (["-", "-o", "--"]) in the `LineStyleOrder` property.

Value	Description	Example
"aftercolor"	Cycle through the line styles of the <code>LineStyleOrder</code> after the colors of the <code>ColorOrder</code> .	
"beforecolor"	Cycle through the line styles of the <code>LineStyleOrder</code> before the colors of the <code>ColorOrder</code> .	
"withcolor"	Cycle through the line styles of the <code>LineStyleOrder</code> with the colors of the <code>ColorOrder</code> .	

NextSeriesIndex — SeriesIndex value for next object

whole number

This property is read-only.

`SeriesIndex` value for the next plot object added to the axes, returned as a whole number greater than or equal to 0. This property is useful when you want to track how the objects cycle through the colors and line styles. This property maintains a count of the objects in the axes that have a `SeriesIndex` property. MATLAB uses it to assign a `SeriesIndex` value to each new object. The count starts at 1 when you create the axes, and it increases by 1 for each additional object. Thus, the count is typically $n+1$, where n is the number of objects in the axes.

If you manually change the `ColorOrderIndex` or `LineStyleOrderIndex` property on the axes, the value of the `NextSeriesIndex` property changes to 0. As a consequence, objects that have a `SeriesIndex` property no longer update automatically when you change the `ColorOrder` or `LineStyleOrder` properties on the axes.

NextPlot — Properties to reset

"replace" (default) | "add" | "replacechildren" | "replaceall"

Properties to reset when adding a new plot to the axes, specified as one of these values:

- "add" — Add new plots to the existing axes. Do not delete existing plots or reset axes properties before displaying the new plot.
- "replacechildren" — Delete existing plots before displaying the new plot. Reset the `ColorOrderIndex` and `LineStyleOrderIndex` properties to 1, but do not reset other axes properties. The next plot added to the axes uses the first color and line style based on the `ColorOrder` and `LineStyleOrder` properties. This value is similar to using `cla` before every new plot.
- "replace" — Delete existing plots and reset axes properties, except `ProjectedCRS`, `Position`, and `Units`, to their default values before displaying the new plot.
- "replaceall" — Delete existing plots and reset axes properties, except `Position` and `Units`, to their default values before displaying the new plot. This value is similar to using `cla reset` before every new plot.

Figures also have a `NextPlot` property. Alternatively, you can use the `newmap` function to prepare figures and axes for subsequent graphics commands.

SortMethod — Order for rendering objects

'depth' | 'childorder'

Order for rendering objects, specified as one of these values:

- 'depth' — Draw objects in back-to-front order based on the current view. Use this value to ensure that objects in front of other objects are drawn correctly.
- 'childorder' — Draw objects in the order in which they are created by graphics functions, without considering the relationship of the objects in three dimensions. This value can result in faster rendering, particularly if the figure is very large, but also can result in improper depth sorting of the objects displayed.

ColorOrderIndex — Color order index

1 (default) | positive integer

Color order index, specified as a positive integer. This property specifies the next color MATLAB selects from the axes `ColorOrder` property when it creates the next plot object, such as a `Line` or `Scatter` object. For example, if the color order index value is 1, then the next object added to the

axes uses the first color in the `ColorOrder` matrix. If the index value exceeds the number of colors in the `ColorOrder` matrix, then the index value modulo of the number of colors in the `ColorOrder` matrix determines the color of the next object.

When the `NextPlot` property of the axes is set to 'add', then the color order index value increases every time you add a new plot to the axes. To start again with first color, set the `ColorOrderIndex` property to 1.

LineStyleOrderIndex — Line style order index

1 (default) | positive integer

Line style order index, specified as a positive integer. This property specifies the next line style MATLAB selects from the axes `LineStyleOrder` property to create the next plot line. For example, if this property is set to 1, then the next plot line you add to the axes uses the first item in the `LineStyleOrder` property. If the index value exceeds the number of line styles in the `LineStyleOrder` array, then the index value modulo of the number of elements in the `LineStyleOrder` array determines the style of the next line.

When the `NextPlot` property of the axes is set to "add", MATLAB increments the index value after cycling through all the colors in the `ColorOrder` property with the current line style. To start again with first line style, set the `LineStyleOrderIndex` property to 1.

Color and Transparency Maps

Colormap — Color map

parula (default) | m-by-3 array of RGB triplets

Color map, specified as an m-by-3 array of RGB (red, green, blue) triplets that define m individual colors.

Example: `ax.Colormap = [1 0 1; 0 0 1; 1 1 0]` sets the color map to three colors: magenta, blue, and yellow.

MATLAB accesses these colors by their row number.

Alternatively, use the `colormap` function to change the color map.

ColorScale — Scale for color mapping

'linear' (default) | 'log'

Scale for color mapping, specified as one of these values:

- 'linear' — Linear scale. The tick values along the colorbar also use a linear scale.
- 'log' — Log scale. The tick values along the colorbar also use a log scale.

CLim — Color limits

[0 1] (default) | two-element vector of the form [cmin cmax]

Color limits for objects in axes that use the colormap, specified as a two-element vector of the form [cmin cmax]. This property determines how data values map to the colors in the colormap where:

- cmin specifies the data value that maps to the first color in the colormap.
- cmax specifies the data value that maps to the last color in the colormap.

The axes object interpolates data values between cmin and cmax across the colormap. Values outside this range use either the first or last color, whichever is closest.

CLimMode — Selection mode for CLim`'auto'` (default) | `'manual'`

Selection mode for the `CLim` property, specified as one of these values:

- `'auto'` — Automatically select the limits based on the color data of the graphics objects contained in the axes.
- `'manual'` — Manually specify the values. To specify the values, set the `CLim` property. The values do not change when the limits of the axes children change.

Alphamap — Transparency map`array of 64 values from 0 to 1` (default) | array of finite alpha values from 0 to 1

Transparency map, specified as an array of finite alpha values that progress linearly from 0 to 1. The size of the array can be *m*-by-1 or 1-by-*m*. MATLAB accesses alpha values by their index in the array. An alphamap can be any length.

AlphaScale — Scale for transparency mapping`'linear'` (default) | `'log'`

Scale for transparency mapping, specified as one of these values:

- `'linear'` — Linear scale
- `'log'` — Log scale

ALim — Alpha limits`[0 1]` (default) | two-element vector of form `[amin amax]`

Alpha limits, specified as a two-element vector of the form `[amin amax]`. This property affects the `AlphaData` values of graphics objects, such as scatter and bubble chart objects. This property determines how the `AlphaData` values map to the figure alphamap, where:

- `amin` specifies the data value that maps to the first alpha value in the figure alphamap.
- `amax` specifies the data value that maps to the last alpha value in the figure alphamap.

The `MapAxes` object interpolates data values between `amin` and `amax` across the figure alphamap. Values outside this range use either the first or last alphamap value, whichever is closest.

The `Alphamap` property of the figure contains the alphamap. For more information, see the `alpha` function.

ALimMode — Selection mode for ALim`'auto'` (default) | `'manual'`

Selection mode for the `ALim` property, specified as one of these values:

- `'auto'` — Automatically select the limits based on the `AlphaData` values of the graphics objects contained in the axes.
- `'manual'` — Manually specify the alpha limits. To specify the alpha limits, set the `ALim` property.



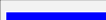
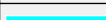

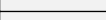


Map Styling**Color — Background color**`[1 1 1]` (default) | RGB triplet | hexadecimal color code | `"r"` | `"g"` | `"b"` | ...

Background color, specified as an RGB triplet, a hexadecimal color code, a color name, or a short name.





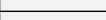


For a custom color, specify an RGB triplet or a hexadecimal color code.

- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range $[0, 1]$, for example, $[0.4 \ 0.6 \ 0.7]$.
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

Example: `mx.Color = [0 0 1];`

Example: `mx.Color = "b";`

Example: `mx.Color = "blue";`

Example: `mx.Color = "#0000FF";`

OutlineColor — Color of map outline, ticks, and edge of scale bar





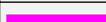
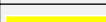


[1 1 1] (default) | RGB triplet | hexadecimal color code | "r" | "g" | "b" | ...

Color of the map outline, the ticks, and the edge of the scale bar, specified as an RGB triplet, a hexadecimal color code, a color name, or a short name.








For a custom color, specify an RGB triplet or a hexadecimal color code.

- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

To use a different color for the edge of the scale bar than for the map outline and ticks, set the EdgeColor property of the scale bar, such as `mx.Scalebar.EdgeColor = "blue"`.

Example: `mx.OutlineColor = [0 0 1];`

Example: `mx.OutlineColor = "b";`

Example: `mx.OutlineColor = "blue";`

Example: `mx.OutlineColor = "#0000FF";`

LineWidth — Line width

0.5 (default) | positive scalar

Line width of the axes outline, the tick marks, the graticule lines, and the edge of the scale bar, specified as a positive scalar in point units. One point equals 1/72 inch.

You can use a different line width for the graticule lines than for the axes outline and tick marks by setting the `GraticuleLineWidth` property. The `LineWidth` property controls the width of the graticule lines only when the value of the `GraticuleLineWidthMode` property is "auto".

To use a different line width for the edge of the scale bar than for the axes outline, the tick marks, and the graticule lines, set the `LineWidth` property of the scale bar, such as `mx.Scalebar.LineWidth = 2`.

MapLayout — Map layout



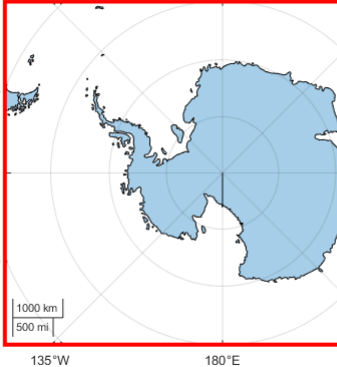
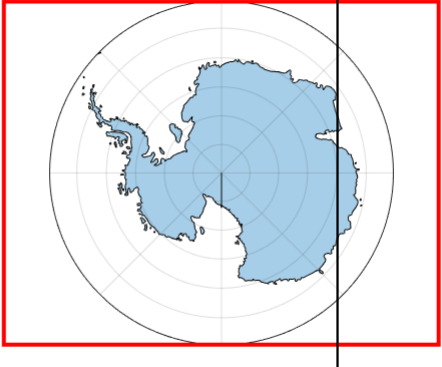
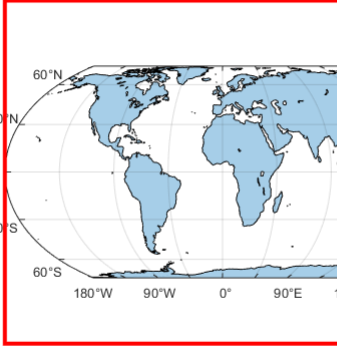
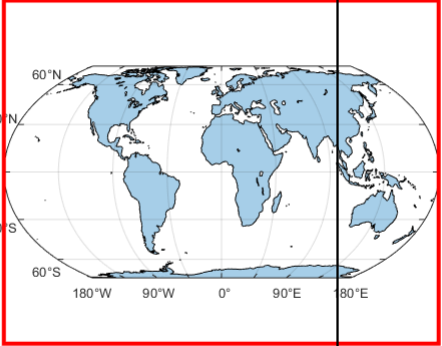
"normal" (default) | "cartographic"

Map layout, specified as one of these options:

- "normal" — Display data within the box specified by `Position`. For many projected CRSs, this box includes the quadrangle defined by `CartographicLatitudeLimits` and `CartographicLongitudeLimits` and some areas surrounding the quadrangle. The axes does not display data where the projection has undefined numeric results or extreme map distortion.
- "cartographic" — Display only the data within the quadrangle defined by the `CartographicLatitudeLimits` and `CartographicLongitudeLimits` properties.

The "normal" option is appropriate for most data visualization and exploration workflows. The "cartographic" option is useful when creating static maps or when preparing maps for publication. For more information about creating maps using the "cartographic" option, see "Create Map of Quadrangle Using Cartographic Map Layout".

This table compares the "normal" and "cartographic" options for several projected CRSs. The figures within the table show the box specified by `Position` in red.

Projected CRS	"normal"	"cartographic"
<p>A projected CRS for a temperate region.</p> <p>This row shows maps created from a <code>projcrs</code> object that uses a Lambert Conic Conformal projection method. The <code>projcrs</code> object corresponds to the EPSG code 3112.</p>		
<p>A projected CRS for a polar region.</p> <p>This row shows maps created from a <code>projcrs</code> object that uses a Polar Stereographic projection method. The <code>projcrs</code> object corresponds to the EPSG code 5042.</p>		
<p>A projected CRS for a global region.</p> <p>This row shows maps created from a <code>projcrs</code> object that uses an Equal Earth projection method. The <code>projcrs</code> object corresponds to the EPSG code 8857.</p> <p>In this case, the map layouts for the "normal" and "cartographic" options are the same.</p>		

CartographicLatitudeLimits — Latitude limits for quadrangle used by MapLayout
 two-element vector of form [latmin latmax]

Latitude limits for the quadrangle used by MapLayout, specified as a two-element vector of the form [latmin latmax], where latmax is greater than latmin.

By default, MATLAB sets this property using the area of use on page 1-1036 for the projected CRS. When a projected CRS does not indicate the area of use, MATLAB sets this property to [-90 90].

Changing the value of this property does not change the value of `ProjectedCRS`.

Panning or zooming within the map does not change the value of this property.

To change the geographic limits of a map that is in the default layout (`MapLayout` is "normal"), use the `geolimits` function instead of the `CartographicLatitudeLimits` and `CartographicLongitudeLimits` properties.

CartographicLongitudeLimits — Longitude limits for quadrangle used by MapLayout

two-element vector of form `[lonmin lonmax]`

Longitude limits for the quadrangle used by `MapLayout`, specified as a two-element vector of the form `[lonmin lonmax]`. In most cases, `lonmax` is greater than `lonmin`.

By default, MATLAB sets this property using the area of use on page 1-1036 for the projected CRS. When a projected CRS does not indicate the area of use, MATLAB sets this property to `[-180 180]`.

Changing the value of this property does not change the value of `ProjectedCRS`.

Panning or zooming within the map does not change the value of this property.

To change the geographic limits of a map that is in the default layout (`MapLayout` is "normal"), use the `geolimits` function instead of the `CartographicLatitudeLimits` and `CartographicLongitudeLimits` properties.

Position

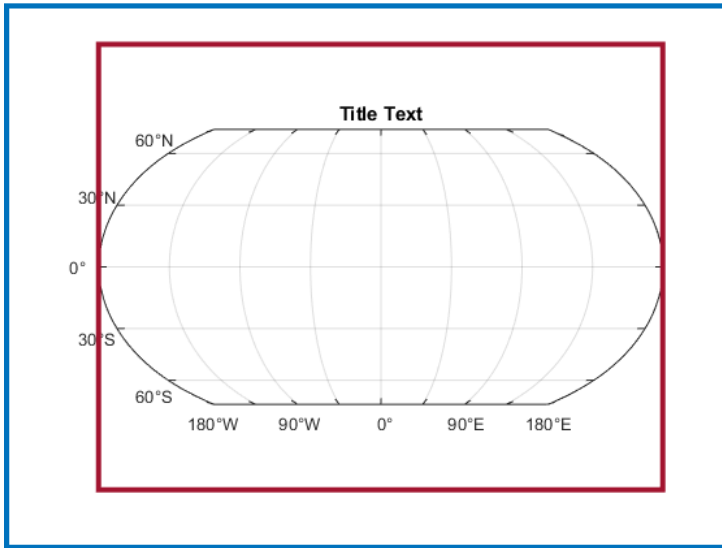
OuterPosition — Size and location, including labels and margin

`[0 0 1 1]` (default) | four-element vector

Size and location, including the labels and a margin, specified as a four-element vector of the form `[left bottom width height]`. By default, MATLAB measures the values in units normalized to the container. To change the units, set the `Units` property. The default value of `[0 0 1 1]` includes the whole interior of the container.

- The `left` and `bottom` elements define the distance from the lower-left corner of the container (typically a figure, panel, or tab) to the lower-left corner of the outer position boundary.
- The `width` and `height` elements are the outer position boundary dimensions.

This figure shows the areas defined by the `OuterPosition` values (blue) and the `Position` values (red).



Note Setting this property has no effect when the parent container is a `TiledChartLayout`.

InnerPosition — Inner size and location

`[0.1300 0.1100 0.7750 0.8150]` (default) | four-element vector

Inner size and location, specified as a four-element vector of the form `[left bottom width height]`. This property is equivalent to the `Position` property.

Note Setting this property has no effect when the parent container is a `TiledChartLayout` object.

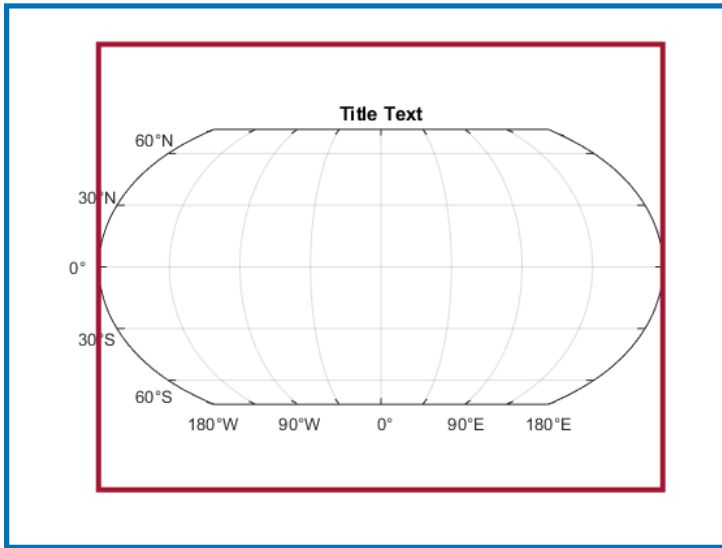
Position — Size and location, excluding margin for labels

`[0.1300 0.1100 0.7750 0.8150]` (default) | four-element vector

Size and location, excluding a margin for the labels, specified as a four-element vector of the form `[left bottom width height]`. By default, MATLAB measures the values in units normalized to the container. To change the units, set the `Units` property.

- The `left` and `bottom` elements define the distance from the lower-left corner of the container (typically a figure, panel, or tab) to the lower-left corner of the position boundary.
- The `width` and `height` elements are the position boundary dimensions.

If you want to specify the position and account for the text around the axes, then set the `OuterPosition` property instead. This figure shows the areas defined by the `OuterPosition` values (blue) and the `Position` values (red).



Note Setting this property has no effect when the parent container is a `TiledChartLayout` object.

PositionConstraint — Position to hold constant

"outerposition" | "innerposition"

Position property to hold constant when adding, removing, or changing decorations, specified as one of the following values:

- "outerposition" — The `OuterPosition` property remains constant when you add, remove, or change decorations such as a title or an axis label. If any positional adjustments are needed, MATLAB adjusts the `InnerPosition` property.
- "innerposition" — The `InnerPosition` property remains constant when you add, remove, or change decorations such as a title or an axis label. If any positional adjustments are needed, MATLAB adjusts the `OuterPosition` property.

Note Setting this property has no effect when the parent container is a `TiledChartLayout`.

Units — Position units

"normalized" (default) | "inches" | "centimeters" | "points" | "pixels" | "characters"

Position units, specified as one of these values.

Units	Description
"normalized" (default)	Normalized with respect to the container, which is typically the figure or a panel. The lower-left corner of the container maps to (0,0) and the upper-right corner maps to (1,1).
"inches"	Inches.
"centimeters"	Centimeters.

Units	Description
"characters"	Based on the default <code>UIFont</code> font of the graphics root object: <ul style="list-style-type: none"> • Character width = width of letter x. • Character height = distance between the baselines of two lines of text.
"points"	Typography points. One point equals 1/72 of an inch.
"pixels"	Pixels. Starting in R2015b, distances in pixels are independent of your system resolution on Windows and Macintosh systems. <ul style="list-style-type: none"> • On Windows systems, a pixel is 1/96 of an inch. • On Macintosh systems, a pixel is 1/72 of an inch. • On Linux systems, the size of a pixel is determined by your system resolution.

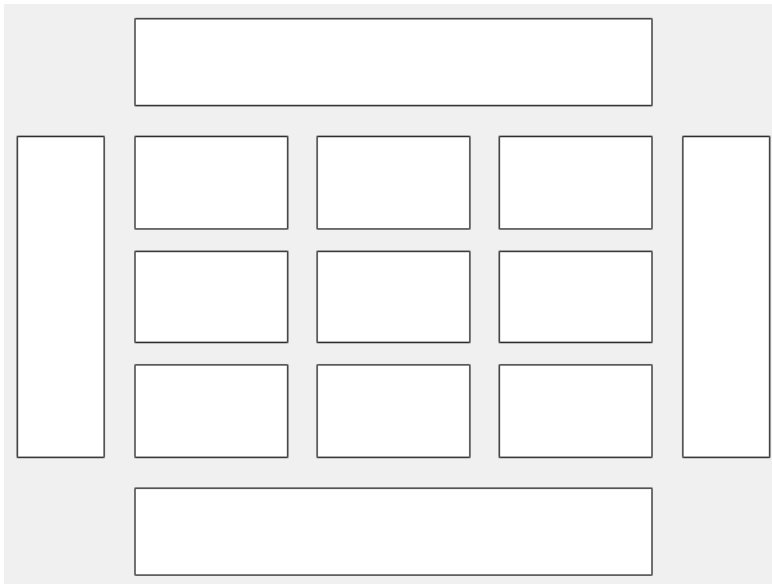
When specifying the units using a name-value argument during object creation, you must set the `Units` property before specifying the properties that you want to use these units, such as `Position`.

Layout – Layout options

empty `LayoutOptions` array (default) | `TiledChartLayoutOptions` object | `GridLayoutOptions` object

Layout options, specified as a `TiledChartLayoutOptions` or a `GridLayoutOptions` object. This property is useful when the axes object is either in a tiled chart layout or a grid layout.

To position the axes within the grid of a tiled chart layout, set the `Tile` and `TileSpan` properties on the `TiledChartLayoutOptions` object. For example, consider a 3-by-3 tiled chart layout. The layout has a grid of tiles in the center, and four tiles along the outer edges. In practice, the grid is invisible and the outer tiles do not take up space until you populate them with axes or charts.



This code places the axes `ax` in the third tile of the grid.

```
ax.Layout.Tile = 3;
```

To make the axes span multiple tiles, specify the `TileSpan` property as a two-element vector. For example, this axes spans 2 rows and 3 columns of tiles.

```
ax.Layout.TileSpan = [2 3];
```

To place the axes in one of the surrounding tiles, specify the `Tile` property as `'north'`, `'south'`, `'east'`, or `'west'`. For example, setting the value to `'east'` places the axes in the tile to the right of the grid.

```
ax.Layout.Tile = 'east';
```

To place the axes into a layout within an app, specify this property as a `GridLayoutOptions` object. For more information about working with grid layouts in apps, see `uigridlayout`.

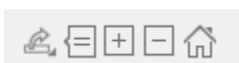
If the axes is not a child of either a tiled chart layout or a grid layout (for example, if it is a child of a figure or panel) then this property is empty and has no effect.

Interactivity

Toolbar — Data exploration toolbar

`AxesToolbar` object (default)

Data exploration toolbar, specified as an `AxesToolbar` object. The toolbar appears at the top-right corner of the axes when you hover over it.



By default, the toolbar includes buttons for exporting content, zooming into the map center, zooming out of the map center, and restoring the original view. You can customize the toolbar buttons using the `axtoolbar` and `axtoolbarbtn` functions.

If you do not want the toolbar to appear when you hover over the axes, set the `Visible` property of the `AxesToolbar` object to "off".

```
newmap
mx = gca;
mx.Toolbar.Visible = "off";
```

For more information, see `AxesToolbar`.

Interactions – Interactions

array of interaction objects | []

Interactions, specified as an array of `PanInteraction`, `ZoomInteraction`, or `DataTipInteraction` objects or as an empty array. The interactions you specify are available within your chart through gestures. You do not have to select any axes toolbar buttons to use them. For example, a `PanInteraction` object enables you to pan within a chart by dragging. For a list of interaction objects, see “Control Chart Interactivity”.

By default, charts within map axes have pan, zoom, and data tip interactions. You can replace the default set with a new set of interactions, but you cannot access or modify any of the interactions in the default set. For example, this code replaces the default set of interactions with the `PanInteraction` and `ZoomInteraction` objects.

```
newmap
mx = gca;
mx.Interactions = [panInteraction zoomInteraction];
```

To remove all interactions from the axes, set this property to an empty array. To temporarily disable the current set of interactions, call the `disableDefaultInteractivity` function. You can reenable them by calling the `enableDefaultInteractivity` function.

Note Interaction objects are not returned by `findobj` or `findall`, and they are not copied by `copyobj`.

Visible – State of visibility

'on' (default) | on/off logical value

State of visibility, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to `true`, and 'off' is equivalent to `false`. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Display the axes and its children.
- 'off' — Hide the axes without deleting it. You still can access the properties of an invisible axes object.

Note When the `Visible` property is 'off', the axes object is invisible, but child objects such as lines remain visible.

CurrentPoint – Location of mouse pointer

two-element vector

This property is read-only.

Location of the mouse pointer, stored as a two-element vector of the form `[lat lon]`. The elements of the vector indicate the location of the last click within the axes. `lat` is the latitude in degrees, and `lon` is the longitude in degrees.

If the figure has a defined `WindowButtonMotionFcn` callback, then the value indicates the last location of the pointer. The figure also has a “`CurrentPoint`” property.

ContextMenu — Context menu

empty `GraphicsPlaceholder` array (default) | `ContextMenu` object

Context menu, specified as a `ContextMenu` object. Use this property to display a context menu when you right-click the object. Create the context menu using the `uicontextmenu` function.

Note If the `PickableParts` property is set to 'none' or if the `HitTest` property is set to 'off', then the context menu does not appear.

Selected — Selection state

'off' (default) | on/off logical value

Selection state, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to true, and 'off' is equivalent to false. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Selected. If you click the object when in plot edit mode, then MATLAB sets its `Selected` property to 'on'. If the `SelectionHighlight` property also is set to 'on', then MATLAB displays selection handles around the object.
- 'off' — Not selected.

SelectionHighlight — Display of selection handles

'on' (default) | on/off logical value

Display of selection handles when selected, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to true, and 'off' is equivalent to false. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Display selection handles when the `Selected` property is set to 'on'.
- 'off' — Never display selection handles, even when the `Selected` property is set to 'on'.

Callbacks

ButtonDownFcn — Mouse-click callback

' ' (default) | function handle | cell array | character vector

Mouse-click callback, specified as one of these values:

- Function handle
- Cell array containing a function handle and additional arguments
- Character vector that is a valid MATLAB command or function, which is evaluated in the base workspace (not recommended)

Use this property to execute code when you click the object. If you specify this property using a function handle, then MATLAB passes two arguments to the callback function when executing the callback:

- Clicked object — Access properties of the clicked object from within the callback function.
- Event data — Empty argument. Replace it with the tilde character (~) in the function definition to indicate that this argument is not used.

For more information on how to use function handles to define callback functions, see “Create Callbacks for Graphics Objects”.

Note If the `PickableParts` property is set to 'none' or if the `HitTest` property is set to 'off', then this callback does not execute.

CreateFcn — Creation function

' ' (default) | function handle | cell array | character vector

Object creation function, specified as one of these values:

- Function handle.
- Cell array in which the first element is a function handle. Subsequent elements in the cell array are the arguments to pass to the callback function.
- Character vector containing a valid MATLAB expression (not recommended). MATLAB evaluates this expression in the base workspace.

For more information about specifying a callback as a function handle, cell array, or character vector, see “Create Callbacks for Graphics Objects”.

This property specifies a callback function to execute when MATLAB creates the object. MATLAB initializes all property values before executing the `CreateFcn` callback. If you do not specify the `CreateFcn` property, then MATLAB executes a default creation function.

Setting the `CreateFcn` property on an existing component has no effect.

If you specify this property as a function handle or cell array, you can access the object that is being created using the first argument of the callback function. Otherwise, use the `gcbo` function to access the object.

DeleteFcn — Deletion function

' ' (default) | function handle | cell array | character vector

Object deletion function, specified as one of these values:

- Function handle.
- Cell array in which the first element is a function handle. Subsequent elements in the cell array are the arguments to pass to the callback function.
- Character vector containing a valid MATLAB expression (not recommended). MATLAB evaluates this expression in the base workspace.

For more information about specifying a callback as a function handle, cell array, or character vector, see “Create Callbacks for Graphics Objects”.

This property specifies a callback function to execute when MATLAB deletes the object. MATLAB executes the `DeleteFcn` callback before destroying the properties of the object. If you do not specify the `DeleteFcn` property, then MATLAB executes a default deletion function.

If you specify this property as a function handle or cell array, you can access the object that is being deleted using the first argument of the callback function. Otherwise, use the `gcbo` function to access the object.

Callback Execution Control

Interruptible — Callback interruption

'on' (default) | on/off logical value

Callback interruption, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to true, and 'off' is equivalent to false. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

This property determines if a running callback can be interrupted. There are two callback states to consider:

- The running callback is the currently executing callback.
- The interrupting callback is a callback that tries to interrupt the running callback.

MATLAB determines callback interruption behavior whenever it executes a command that processes the callback queue. These commands include `drawnow`, `figure`, `uifigure`, `getframe`, `waitfor`, and `pause`.

If the running callback does not contain one of these commands, then no interruption occurs. MATLAB first finishes executing the running callback, and later executes the interrupting callback.

If the running callback does contain one of these commands, then the `Interruptible` property of the object that owns the running callback determines if the interruption occurs:

- If the value of `Interruptible` is 'off', then no interruption occurs. Instead, the `BusyAction` property of the object that owns the interrupting callback determines if the interrupting callback is discarded or added to the callback queue.
- If the value of `Interruptible` is 'on', then the interruption occurs. The next time MATLAB processes the callback queue, it stops the execution of the running callback and executes the interrupting callback. After the interrupting callback completes, MATLAB then resumes executing the running callback.

Note Callback interruption and execution behave differently in these situations:

- If the interrupting callback is a `DeleteFcn`, `CloseRequestFcn`, or `SizeChangedFcn` callback, then the interruption occurs regardless of the `Interruptible` property value.
 - If the running callback is currently executing the `waitfor` function, then the interruption occurs regardless of the `Interruptible` property value.
 - If the interrupting callback is owned by a `Timer` object, then the callback executes according to schedule regardless of the `Interruptible` property value.
-

Note When an interruption occurs, MATLAB does not save the state of properties or the display. For example, the object returned by the `gca` or `gcf` command might change when another callback executes.

BusyAction — Callback queuing

'queue' (default) | 'cancel'

Callback queuing, specified as 'queue' or 'cancel'. The `BusyAction` property determines how MATLAB handles the execution of interrupting callbacks. There are two callback states to consider:

- The running callback is the currently executing callback.
- The interrupting callback is a callback that tries to interrupt the running callback.

The `BusyAction` property determines callback queuing behavior only when both of these conditions are met:

- The running callback contains a command that processes the callback queue, such as `drawnow`, `figure`, `uifigure`, `getframe`, `waitfor`, or `pause`.
- The value of the `Interruptible` property of the object that owns the running callback is 'off'.

Under these conditions, the `BusyAction` property of the object that owns the interrupting callback determines how MATLAB handles the interrupting callback. These are possible values of the `BusyAction` property:

- 'queue' — Puts the interrupting callback in a queue to be processed after the running callback finishes execution.
- 'cancel' — Does not execute the interrupting callback.

PickableParts — Ability to capture mouse clicks

"visible" (default) | "all" | "none"

Ability to capture mouse clicks, specified as one of these values:

- "visible" — Capture mouse clicks only when visible. The `Visible` property must be set to "on". The `HitTest` property determines if the `MapAxes` object responds to the click or if an ancestor does.
- "all" — Capture mouse clicks regardless of visibility. The `Visible` property can be set to "on" or "off". The `HitTest` property determines if the `MapAxes` object responds to the click or if an ancestor does.
- "none" — Cannot capture mouse clicks. Clicking the `MapAxes` object passes the click to the object below it in the current view of the figure window, which is typically the axes or the figure. The `HitTest` property has no effect.

If you want an object to be clickable when it is underneath other objects that you do not want to be clickable, then set the `PickableParts` property of the other objects to "none" so that the click passes through them.

HitTest — Response to captured mouse clicks

'on' (default) | on/off logical value

Response to captured mouse clicks, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to true, and 'off' is equivalent to false. Thus, you can use

the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Trigger the `ButtonDownFcn` callback of the `MapAxes` object. If you have defined the `ContextMenu` property, then invoke the context menu.
- 'off' — Trigger the callbacks for the nearest ancestor of the `MapAxes` object that has one of these:
 - `HitTest` property set to 'on'
 - `PickableParts` property set to a value that enables the ancestor to capture mouse clicks

Note The `PickableParts` property determines if the `MapAxes` object can capture mouse clicks. If it cannot, then the `HitTest` property has no effect.

BeingDeleted — Deletion status

on/off logical value

This property is read-only.

Deletion status, returned as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

MATLAB sets the `BeingDeleted` property to 'on' when the `DeleteFcn` callback begins execution. The `BeingDeleted` property remains set to 'on' until the component object no longer exists.

Check the value of the `BeingDeleted` property to verify that the object is not about to be deleted before querying or modifying it.

Parent/Child

Parent — Parent container

Figure object | Panel object | Tab object | TiledChartLayout object | GridLayout object

Parent container, specified as a `Figure`, `Panel`, `Tab`, `TiledChartLayout`, or `GridLayout` object.

Children — Children

empty `GraphicsPlaceholder` array | array of graphics objects

Children, returned as an array of graphics objects. Use this property to view a list of the children or to reorder the children by setting the property to a permutation of itself.

You cannot add or remove children using the `Children` property. To add a child to this list, set the `Parent` property of the child graphics object to the `MapAxes` object.

HandleVisibility — Visibility of object handle

'on' (default) | 'off' | 'callback'

Visibility of the object handle in the `Children` property of the parent, specified as one of these values:

- 'on' — Object handle is always visible.
- 'off' — Object handle is invisible at all times. This option is useful for preventing unintended changes by another function. Set the `HandleVisibility` to 'off' to temporarily hide the handle during the execution of that function.

- 'callback' — Object handle is visible from within callbacks or functions invoked by callbacks, but not from within functions invoked from the command line. This option blocks access to the object at the command line, but permits callback functions to access it.

If the object is not listed in the `Children` property of the parent, then functions that obtain object handles by searching the object hierarchy or querying handle properties cannot return it. Examples of such functions include the `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close` functions.

Hidden object handles are still valid. Set the root `ShowHiddenHandles` property to 'on' to list all object handles regardless of their `HandleVisibility` property setting.

Identifiers

Type — Type of graphics object

'mapaxes'

This property is read-only.

Type of graphics object, stored as 'mapaxes'.

Tag — Object identifier

'' (default) | character vector | string scalar

Object identifier, specified as a character vector or string scalar. You can specify a unique `Tag` value to serve as an identifier for an object. When you need access to the object elsewhere in your code, you can use the `findobj` function to search for the object based on the `Tag` value.

UserData — User data

[] (default) | array

User data, specified as any MATLAB array. For example, you can specify a scalar, vector, matrix, cell array, character array, table, or structure. Use this property to store arbitrary data on an object.

If you are working in App Designer, create public or private properties in the app to share data instead of using the `UserData` property. For more information, see “Share Data Within App Designer Apps”.

More About

Area of Use

The area of use is the region for which a projected CRS is valid.

Many `projcrs` objects specify the area of use. To find the area of use for a projected CRS, display the well-known text (WKT) string of the CRS and search for the `BBOX` attribute.

This code shows how to display the WKT string for a `projcrs` object stored in a `mapaxes` object by using the `wktstring` function.

```
newmap
mx = gca;
p = mx.ProjectedCRS;
wktstring(p, Format="Formatted")
```

Version History

Introduced in R2023a

See Also

newmap | mapaxes | gca | cla

Topics

"Access Property Values"

"Graphics Object Properties"

"Customize Appearance of Map Axes"

mapbbox

(To be removed) Compute bounding box of georeferenced image or data grid

Note `mapbbox` will be removed in a future release. Instead, create a map raster reference object, and query its `XWorldLimits` and `YWorldLimits` properties. For more information, see “Compatibility Considerations”.

Syntax

```

bbox = mapbbox(R,height,width)
bbox = mapbbox(R, sizea)
BBOX = mapbbox(info)

```

Description

`bbox = mapbbox(R,height,width)` computes the 2-by-2 bounding box of a georeferenced image or regular gridded data set. `R` is either a 3-by-2 referencing matrix defining a 2-dimensional affine transformation from intrinsic pixel coordinates to map coordinates, or a `MapCellsReference` object. (If you are using a raster reference object, you can calculate the bounding box from the object limit properties of the object rather than using this function.) `height` and `width` are the image dimensions. `bbox` bounds the outer edges of the image in map coordinates:

```

[minX minY
maxX maxY]

```

`bbox = mapbbox(R, sizea)` accepts `sizea = [height, width, ...]` instead of `height` and `width`.

`BBOX = mapbbox(info)` accepts a scalar structure array with the fields

'RefMatrix'	3-by-2 referencing matrix
'Height'	Scalar number
'Width'	Scalar number

Version History

Introduced before R2006a

R2022a: Warns

Warns starting in R2022a

Some functions that accept referencing matrices as input issue a warning that they will be removed in a future release, including the `mapbbox` function. Instead, create a map raster reference object, and query its `XWorldLimits` and `YWorldLimits` properties. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its world limits, and the direction of its rows and columns. For more information about reference object properties, see the `MapCellsReference` and `MapPostingsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `mapcrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `mapresize` function.

To update your code, first create a reference object for either a raster of cells using the `maprefcells` function or a raster of regularly posted samples using the `maprefpostings` function. Alternatively, convert from a referencing matrix to a reference object using the `refmatToMapRasterReference` function.

Then, find the limits of the raster by querying the `XWorldLimits` and `YWorldLimits` properties of the reference object, `R`. Create a bounding box matrix using the property values.

```
xlimits = R.XWorldLimits;  
ylimits = R.YWorldLimits;  
bbox = [xlimits' ylimits'];
```

R2020b: To be removed

Not recommended starting in R2020b

The `mapbbox` function runs without warning but will be removed in a future release.

See Also

Functions

`geotiffinfo` | `mapoutline` | `worldGrid` | `intrinsicToWorld`

Objects

`MapCellsReference` | `MapPostingsReference`

MapCellsReference

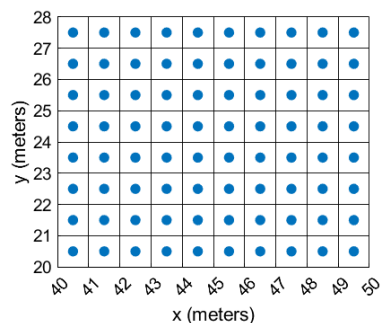
Reference raster cells to map coordinates

Description

A map cells reference object contains information that describes the relationship between a planar map coordinate system and an intrinsic coordinate system on page 1-1045 that is anchored to the columns and rows of a 2-D spatially referenced raster grid or image of cells.

Typically, the raster is sampled regularly in the planar world x and world y coordinates of the map system, such that the intrinsic x and world x axes align and the intrinsic y and world y axes align. When this is true, the relationship between the two systems is rectilinear. More generally, and much more rarely, their relationship is affine. The affine relationship allows for a possible rotation (and skew). In either case, rectilinear or affine, the sample spacing from row to row need not equal the sample spacing from column to column. The cells or pixels need not be square. In the most general case, they could conceivably be parallelograms, but in practice they are always rectangular.

This image illustrates a 8-by-10 planar raster of cells. The raster cells have an extent of 1 meter in x and y , cover x values in the range [40,50] in meters, and cover y values in the range [20,28] in meters. The boundary of the raster of cells is made up of the outermost boundaries of the outermost cells.



To reference a raster of postings to planar map coordinates, use a `MapPostingsReference` object instead.

Creation

You can use these functions to create `MapCellsReference` objects:

- `readgeoraster` — Import a raster data file as an array and a reference object.
- `maprefcells` — Create a map raster reference object by specifying the x and y world limits of the raster and either the size of the raster or the extent of the cells.
- `maprasterref` — Convert a world file to a map raster reference object.
- `refmatToMapRasterReference` — Convert a referencing matrix to a map raster reference object.

Properties

XWorldLimits — Limits of raster in world x-coordinates

[0.5 2.5] (default) | two-element row vector

Limits of raster in world x-coordinates, specified as a two-element row vector of the form [xMin xMax].

The value of the `ProjectedCRS` property determines the length units for the raster. This code shows how to find the length units for a raster associated with the map cells reference object `R`.

`R.ProjectedCRS.LengthUnit`

Example: [207000 209000]

Data Types: double

YWorldLimits — Limits of raster in world y-coordinates

[0.5 2.5] (default) | two-element row vector

Limits of raster in world y-coordinates, specified as a two-element row vector of the form [yMin yMax].

The value of the `ProjectedCRS` property determines the length units for the raster. This code shows how to find the length units for a raster associated with the map cells reference object `R`.

`R.ProjectedCRS.LengthUnit`

Example: [911000 913000]

Data Types: double

RasterSize — Number of rows and columns of the raster or image associated with the referencing object

[2 2] (default) | two-element vector of positive integers

Number of rows and columns of the raster or image associated with the referencing object, specified as a two-element vector, $[m\ n]$, where m represents the number of rows and n the number of columns.

For convenience, you can assign a size vector having more than two elements. This enables assignments like `R.RasterSize = size(RGB)`, where `RGB` is m -by- n -by-3. In cases like this, the object stores only the first two elements of the size vector and ignores the higher (nonspatial) dimensions.

Example: [200 300]

Data Types: double

RasterInterpretation — Geometric nature of the raster

'cells' (default)

This property is read-only.

Geometric nature of the raster, specified as 'cells'. The value 'cells' indicates that the raster comprises a grid of quadrangular cells, and is bounded on all sides by cell edges. For an m -by- n raster, points with an intrinsic x-coordinate of 1 or n or an intrinsic x-coordinate of 1 or m fall within the raster, not on its edges.

Data Types: char

ColumnsStartFrom — Edge from which column indexing starts

'south' (default) | 'north'

Edge from which column indexing starts, specified as 'south' or 'north'.

Example: 'south'

Data Types: char

RowsStartFrom — Edge from which row indexing starts

'west' (default) | 'east'

Edge from which row indexing starts, specified as 'west' or 'east'.

Example: 'east'

Data Types: char

CellExtentInWorldX — Extent in world x-coordinates of individual cells

1 (default) | positive numeric scalar

Extent in world x-coordinates of individual cells, specified as a positive numeric scalar. Distance between the eastern and western limits of a single raster cell. The value is the same for all cells in the raster.

Example: 2.5

Data Types: double

CellExtentInWorldY — Extent in world y-coordinates of individual cells

1 (default) | positive numeric scalar

Extent in world y-coordinates of individual cells, specified as a positive numeric scalar. Distance between the northern and southern limits of a single raster cell. The value is the same for all cells in the raster.

Example: 2.5

Data Types: double

RasterExtentInWorldX — Extent of the full raster or image as measured in the world system in a direction parallel to its rows

2 (default) | positive numeric scalar

This property is read-only.

Extent of the full raster or image as measured in the world system in a direction parallel to its rows, specified as a positive numeric scalar. In the case of a rectilinear geometry, which is most typical, this is the horizontal direction (east-west).

Data Types: double

RasterExtentInWorldY — Extent of the full raster or image as measured in the world system in a direction parallel to its columns

2 (default) | positive numeric scalar

This property is read-only.

Extent of the full raster or image as measured in the world system in a direction parallel to its columns, specified as a positive numeric scalar. In the case of a rectilinear geometry, which is most typical, this is the vertical direction (north-south).

Data Types: double

XIntrinsicLimits — Raster limits in intrinsic x-coordinates

[0.5 2.5] (default) | two-element row vector of positive integers

This property is read-only.

Raster limits in intrinsic x-coordinates, specified as a two-element row vector of positive integers, [xMin xMax]. For an m -by- n raster, XIntrinsicLimits equals [0.5, $m+0.5$], because the RasterInterpretation is 'cells'.

Data Types: double

YIntrinsicLimits — Raster limits in intrinsic y-coordinates

[0.5 2.5] (default) | two-element row vector of positive integers

This property is read-only.

Raster limits in intrinsic y-coordinates, specified as a two-element row vector of positive integers, [yMin yMax]. For an m -by- n raster, YIntrinsicLimits equals [0.5, $m+0.5$], because the RasterInterpretation is 'cells'.

Data Types: double

TransformationType — Type of geometric relationship between intrinsic and world systems

'rectilinear' (default) | 'affine'

This property is read-only.

Type of geometric relationship between the intrinsic coordinate system and the world coordinate system, specified as either 'rectilinear' or 'affine'. Its value is 'rectilinear' when world x depends only on intrinsic x and vice versa, and world y depends only on intrinsic y and vice versa. When the value is 'rectilinear', the image displays without rotation in the world system, although it might be flipped. Otherwise, the value is 'affine'.

Data Types: char

CoordinateSystemType — Type of coordinate system to which the image or raster is referenced

'planar' (default)

This property is read-only.

Type of coordinate system to which the image or raster is referenced, specified as 'planar'.

Data Types: char

ProjectedCRS — Projected coordinate reference system

[] (default) | projcrs object

Projected coordinate reference system (CRS), specified as a projcrs object. A projected CRS consists of a geographic CRS and several parameters that are used to transform coordinates to and from the geographic CRS.

The value of `ProjectedCRS` determines the length units for the raster. To find the length units, query the `LengthUnit` property of the `projcrs` object.

Object Functions

<code>contains</code>	Determine if geographic or map raster contains points
<code>firstCornerX</code>	Return world x-coordinate of map raster index (1,1)
<code>firstCornerY</code>	Return world y-coordinate of map raster index (1,1)
<code>intrinsicToWorld</code>	Transform intrinsic to planar world coordinates
<code>sizesMatch</code>	Determine if geographic or map raster object and image or raster are size-compatible
<code>worldFileMatrix</code>	Return world file parameters for transformation
<code>worldGrid</code>	World coordinates of raster elements
<code>worldToDiscrete</code>	Transform planar world to discrete coordinates
<code>worldToIntrinsic</code>	Transform planar world to intrinsic coordinates

Examples

Display Planar Raster with Regularly Spaced Cell Centers

Import a land cover classification of Oahu, Hawaii as an array, a `MapCellsReference` object, and a colormap by using the `readgeoraster` function.

```
[Z,R,cmap] = readgeoraster('oahu_landcover.img');
```

View the properties of the `MapCellsReference` object.

```
R
```

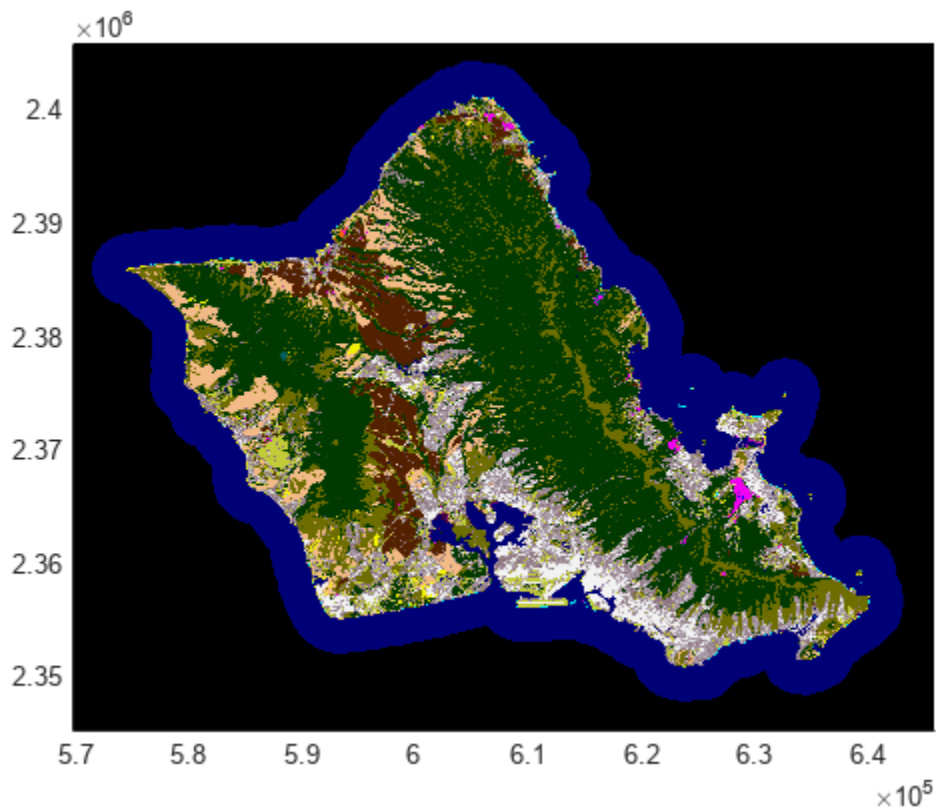
```
R =
```

```
MapCellsReference with properties:
```

```
    XWorldLimits: [569857 645907]
    YWorldLimits: [2345284 2405884]
    RasterSize: [2020 2535]
    RasterInterpretation: 'cells'
    ColumnsStartFrom: 'north'
    RowsStartFrom: 'west'
    CellExtentInWorldX: 30
    CellExtentInWorldY: 30
    RasterExtentInWorldX: 76050
    RasterExtentInWorldY: 60600
    XIntrinsicLimits: [0.5 2535.5]
    YIntrinsicLimits: [0.5 2020.5]
    TransformationType: 'rectilinear'
    CoordinateSystemType: 'planar'
    ProjectedCRS: [1x1 projcrs]
```

Display the land cover classification on a map.

```
mapshow(Z, cmap, R)
```



More About

Intrinsic Coordinate System

A 2-D Cartesian system with its x-axis running parallel to the rows of a raster or image and its y-axis running parallel to the columns. x increases by 1 from column to column, and y increases by 1 from row to row.

The Mapping Toolbox and Image Processing Toolbox use the convention for the location of the origin relative to the raster cells or sampling points such that, at a sample location or at the center of a cell, x has an integer value equal to the column index. Likewise, at a sample location or at the center of a cell, y has an integer value equal to the row index. For details, see Image Coordinate Systems (Image Processing Toolbox).

Version History

Introduced in R2013b

See Also

Functions

[maprefpostings](#) | [maprasterref](#) | [readgeoraster](#)

Objects

MapPostingsReference | GeographicPostingsReference | GeographicCellsReference

Topics

“Spatially Reference Imported Rasters”

mapclip

Clip shape to xy-limits in planar coordinates

Syntax

```
clipped = mapclip(shape,xlimits,ylimits)
```

Description

`clipped = mapclip(shape,xlimits,ylimits)` clips the planar point, line, or polygon shapes in shape to the xy-limits in `xlimits` and `ylimits`.

To crop raster data that is represented by an array and a map raster reference object, use the `mapcrop` function instead.

Examples

Clip Shapes in Planar Coordinates

Read hydrography data as a geospatial table. Extract the polygon shape for a pond.

```
hydro = readgeotable("concord_hydro_area.shp");
shape = hydro.Shape(14)
```

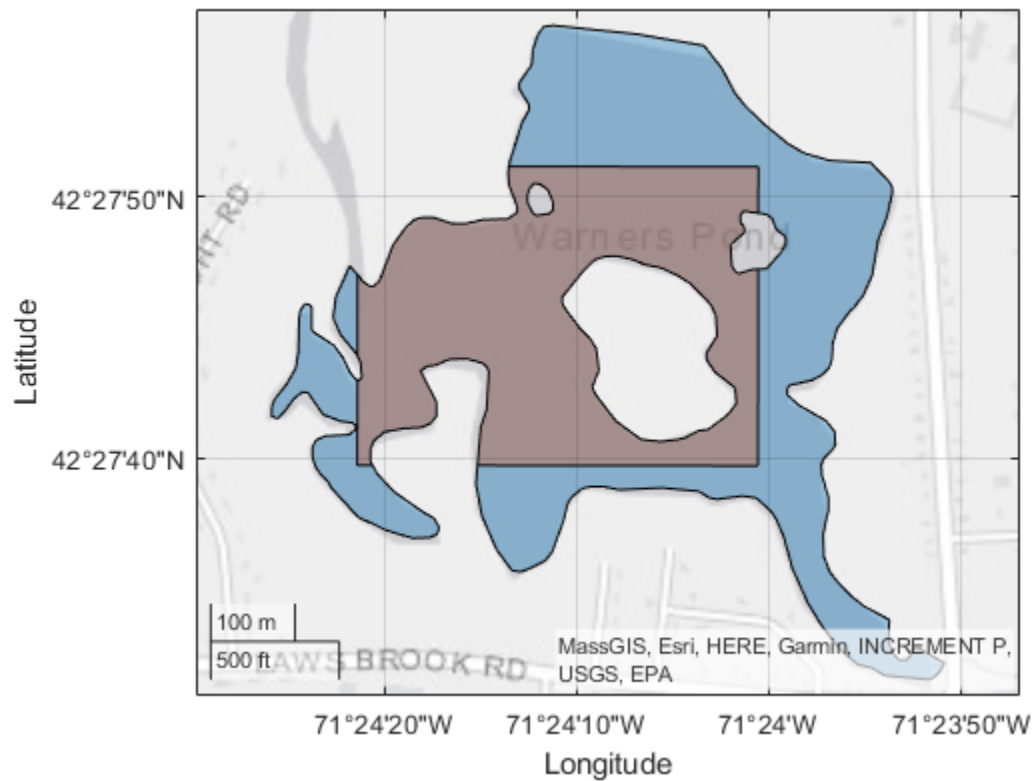
```
shape =
  mappolyshape with properties:
      NumRegions: 1
      NumHoles: 3
      Geometry: "polygon"
      CoordinateSystemType: "planar"
      ProjectedCRS: [1x1 projcrs]
```

Specify the xy-limits and clip the shape.

```
xlimits = [207736 208212];
ylimits = [912283 912636];
clipped = mapclip(shape,xlimits,ylimits);
```

Display the shape and the clipped shape on a map.

```
figure
geoplot(shape)
hold on
geoplot(clipped)
```



Remove Shapes with No Coordinate Data from Output

Read the names and locations of places in Boston as a geospatial table. Extract the point shapes.

```
places = readgeotable("boston_placenames.shp");
shape = places.Shape
```

```
shape =
  13x1 mappointshape array with properties:
```

```
    NumPoints: [13x1 double]
           X: [13x1 double]
           Y: [13x1 double]
    Geometry: "point"
CoordinateSystemType: "planar"
    ProjectedCRS: [1x1 projcrs]
```

Specify the xy-limits and clip the shapes.

```
xlimits = [235226 237174];
ylimits = [900179 901059];
clipped = mapclip(shape,xlimits,ylimits);
```

When a point shape lies outside the specified limits, the clipped shape has no coordinate data and the `NumPoints` property is 0. Remove shapes with no coordinate data from the clipped shapes.

```

idx = clipped.NumPoints ~= 0;
clipped = clipped(idx)

clipped =
  5x1 mappointshape array with properties:

        NumPoints: [5x1 double]
           X: [5x1 double]
           Y: [5x1 double]
        Geometry: "point"
  CoordinateSystemType: "planar"
        ProjectedCRS: [1x1 projcrs]

```

When a line or polygon shape has no coordinate data, its respective the `NumParts` or `NumRegions` property is 0.

Clip Projected Shape Using Geographic Limits

If your shape is in projected coordinates and your limits are in geographic coordinates, then you must project the geographic coordinates before clipping the shape. To use this approach:

- You must know the projected coordinate reference system (CRS) for the shape. You can determine whether a shape object is associated with a projected CRS by querying the `ProjectedCRS` property.
- The projection method for the CRS must result in x-coordinates and y-coordinates that run approximately west-to-east and south-to-north, respectively, such as transverse Mercator or Lambert Conic Conformal. This approach is not valid for projection methods such as polar stereographic. You can find the projection method for a projected CRS object by querying the `ProjectionMethod` property.

Read road data for an area in Boston as a geospatial table. Extract the line shapes.

```

roads = readgeotable("boston_roads.shp");
shape = roads.Shape

shape=2795x1 object
  16x1 maplineshape array with properties:

        NumParts: [16x1 double]
        Geometry: "line"
  CoordinateSystemType: "planar"
        ProjectedCRS: [1x1 projcrs]
        :

```

Verify that the shape has a projected CRS with an appropriate projection method.

```

crs = shape.ProjectedCRS

crs =
  projcrs with properties:

        Name: "NAD83 / Massachusetts Mainland"
  GeographicCRS: [1x1 geocrs]

```

```
ProjectionMethod: "Lambert Conic Conformal (2SP)"  
LengthUnit: "meter"  
ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

Specify the latitude and longitude limits using geographic coordinates. Project the latitude and longitude limits to xy-limits by using the projected CRS and the `proj fwd` function.

```
latlim = [42.3494 42.3614];  
lonlim = [-71.0766 -71.0571];  
[xlims,ylims] = projfwd(crs,latlim,lonlim);
```

Clip the shapes.

```
clipped = mapclip(shape,xlims,ylims);
```

Display the clipped shapes on a map. Compare the limits you specified with the limits of the plot by setting the tick format to decimal degrees.

```
figure  
geoplot(clipped)  
geotickformat("dd")
```



Input Arguments

shape — Shape

mappointshape, maplineshape, or mappolyshape object | array of mappointshape, maplineshape, or mappolyshape objects

Shape, specified as a mappointshape, maplineshape, or mappolyshape object or as an array of mappointshape, maplineshape, or mappolyshape objects. When you specify an array, you can include a combination of point, line, and polygon shape objects.

xlimits — x-limits

two-element vector

x-limits, specified as a two-element vector of the form `[xmin xmax]`, where `xmax` is greater than `xmin`.

The units of `xlimits` must match the units of `shape`. If the `ProjectedCRS` property of `shape` contains a `projcrs` object, you can find the units by querying the `LengthUnit` property of the `projcrs` object, for example `shape.ProjectedCRS.LengthUnit`.

ylimits — y-limits

two-element vector

y-limits, specified as a two-element vector of the form `[ymin ymax]`, where `ymax` is greater than `ymin`.

The units of `ylimits` must match the units of `shape`. If the `ProjectedCRS` property of `shape` contains a `projcrs` object, you can find the units by querying the `LengthUnit` property of the `projcrs` object, for example `shape.ProjectedCRS.LengthUnit`.

Output Arguments

clipped — Clipped shape

mappointshape, maplineshape, or mappolyshape object | array of mappointshape, maplineshape, or mappolyshape objects

Clipped shape, returned as a mappointshape, maplineshape, or mappolyshape object or as an array of mappointshape, maplineshape, or mappolyshape objects.

`clipped` has the same type and size as `shape`.

If an element of `shape` lies completely outside the specified limits, then the corresponding element of `clipped` does not contain coordinate data. When a point, line, or polygon shape does not contain coordinate data, its respective `NumPoints`, `NumParts`, or `NumRegions` property is `0`.

Tips

- If you clip a shape within a geospatial table, the function does not modify any attributes of the table.

Version History

Introduced in R2022a

See Also

Functions

geoclip | mapcrop

Objects

projcrs

Topics

“Create Geospatial Tables”

mapcrop

Crop projected map raster

Syntax

```
[B,RB] = mapcrop(A,RA,xlimits,ylimits)
```

Description

`[B,RB] = mapcrop(A,RA,xlimits,ylimits)` crops the projected map raster specified by `A` and raster reference `RA` and returns the cropped raster `B` and raster reference `RB`. The returned raster is cropped to limits in world coordinates close to those specified by `xlimits` and `ylimits`.

To clip vector data represented by a point, line, or polygon shape in planar coordinates, use the `mapclip` function instead.

Examples

Crop Projected Raster Image

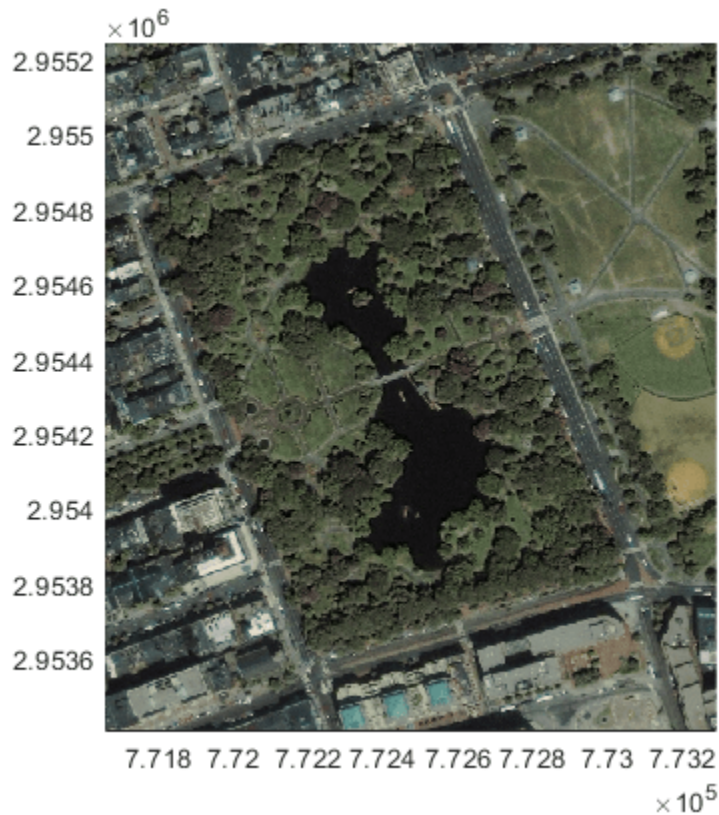
Crop a projected raster image and display the cropped image.

First, import a projected raster image of Boston and a map cells reference object. Then, crop the image to the limits specified by `xlimits` and `ylimits`.

```
[A,RA] = readgeoraster('boston.tif');  
xlimits = [771660 773290];  
ylimits = [2953410 2955240];  
[B,RB] = mapcrop(A,RA,xlimits,ylimits);
```

Display the cropped image.

```
mapshow(B,RB)
```



Input Arguments

A — Projected map raster

array

Projected map raster, specified as an M -by- N or M -by- N -by- P numeric or logical array.

RA — Raster reference

MapCellsReference object | MapPostingsReference object

Raster reference for A, specified as a MapCellsReference object or MapPostingsReference object. The TransformationType property of RA must be 'rectilinear'.

xlimits — Minimum and maximum x limits

two-element vector

Minimum and maximum x limits, specified as a two-element numeric vector of the form [xmin xmax], where xmax is greater than xmin.

ylimits — Minimum and maximum y limits

two-element vector

Minimum and maximum y limits, specified as a two-element numeric vector of the form [ymin ymax], where ymax is greater than ymin.

Output Arguments

B — Cropped projected map raster

array

Cropped projected map raster, returned as a numeric or logical array. The data type and size of B matches the data type and size of A.

If the limits specified by `xlimits` and `ylimits` do not intersect the raster specified by A and RA, then B is empty.

RB — Raster reference

MapCellsReference object | MapPostingsReference object

Raster reference for B, returned as MapCellsReference object or MapPostingsReference object. The object type of RB matches the object type of RA.

The exact *x* and *y* limits of RB do not match the limits specified by `xlimits` and `ylimits`, unless they coincide with a cell boundary or posting location. Otherwise, the limits of RB are slightly larger than `xlimits` and `ylimits`.

If the limits specified by `xlimits` and `ylimits` do not intersect the raster specified by A and RA, then RB is empty.

Version History

Introduced in R2020a

See Also

geocrop | mapclip | mapresize

mapinterp

Map raster interpolation

Syntax

```
Vq = mapinterp(V,R,xq,yq)
Vq = mapinterp( ____,method)
```

Description

`Vq = mapinterp(V,R,xq,yq)` interpolates the spatially referenced raster `V`, using bilinear interpolation. The function returns a value in `Vq` for each of the query points in arrays `xq` and `yq`. `R` is a map raster reference object that specifies the location and extent of data in `V`.

`Vq = mapinterp(____,method)` specifies alternate interpolation methods.

Examples

Interpolate Spatially Referenced Raster Grid at Defined Coordinates

Load projected elevation data and a map cells reference object for an area around Mount Washington. Specify the points you want to interpolate. Then, interpolate the values.

```
[Z,R] = readgeoraster('MtWashington-ft.grd');
x = [ 312829  317447  316083  311150];
y = [4913618 4912253 4904329 4904172];
Vinterpolated = mapinterp(Z,R,x,y)
```

```
Vinterpolated = 1x4 int32 row vector
```

```
    1524    3678    6236    2365
```

Input Arguments

V — Spatially referenced raster grid

numeric or logical array

Spatially referenced raster grid, specified as numeric or logical array.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

R — Map raster

`MapCellsReference` or `MapPostingsReference` object

Map raster, specified as a `MapCellsReference` or `MapPostingsReference` object.

To convert a referencing matrix to a map raster reference object, use `refmatToMapRasterReference`.

xq — Query point coordinates in x dimension

numeric array

Query point coordinates in x dimension, specified as a numeric array.

Data Types: `single` | `double`

yq — Query point coordinates in y dimension

numeric array

Query point coordinates in y dimension, specified as a numeric array.

Data Types: `single` | `double`

method — Interpolation methods

'linear' (default) | 'nearest' | 'cubic' | 'spline'

Interpolation methods, specified as one of these values:

Method	Description
'nearest'	Nearest neighbor interpolation
'linear'	Bilinear interpolation
'cubic'	Bicubic interpolation
'spline'	Spline interpolation

Data Types: `char` | `string`

Output Arguments

Vq — Interpolated values

numeric array

Interpolated values, returned as a numeric array.

Version History

Introduced in R2017a

See Also

`geointerp` | `interp2` | `griddedInterpolant`

maplist

Map projection support for axesm-based maps and map projection structures

Syntax

```
list = maplist  
[list,defproj] = maplist
```

Description

`list = maplist` returns a structure that lists the IDs and classifications of map projections for use with axesm-based maps and map projection structures. The structure `list` contains the fields `Name`, `IdString`, `Classification`, and `ClassCode`. The `maps` and `axesmui` functions use the structure when processing map projection identifiers during operation of the toolbox functions.

`[list,defproj] = maplist` also returns the default projection's `IdString`.

`list.Name` defines the full name of the projection. This entry is used in the command-line table display and in the Projection Control Box.

`list.IdString` provides the name of the MATLAB function that computes the projection.

`list.Classification` defines the projection classification that is used in the command-line table display.

`list.ClassCode` defines the character vector that is used to label the classes of projections in the Projection Control Box. The eight class codes are

- `Azim` — Azimuthal
- `Coni` — Conic
- `Cyln` — Cylindrical
- `Mazi` — Modified azimuthal
- `Pazi` — Pseudoazimuthal
- `Pcon` — Pseudoconic
- `Pcy` — Pseudocylindrical
- `Poly` — Polyconic

See Also

`maps` | `axesmui`

mapoutline

Compute outline of georeferenced image or data grid

Syntax

```
[x,y] = mapoutline(R,height,width)
[x,y] = mapoutline(R, sizea)
[x,y] = mapoutline(...,'close')
[lon,lat] = mapoutline(R,...)
outline = mapoutline(...)
```

Description

`[x,y] = mapoutline(R,height,width)` computes the outline of a georeferenced image or regular gridded data set in map coordinates. `R` is a `MapCellsReference` or `MapPostingsReference` object. `height` and `width` are the image dimensions. `x` and `y` are 4-by-1 column vectors containing the map coordinates of the outer corners of the corner pixels, in the following order:

```
(1,1), (height,1), (height, width), (1, width).
```

`[x,y] = mapoutline(R, sizea)` accepts `sizea = [height, width, ...]` instead of `height` and `width`.

`[x,y] = mapoutline(...,'close')` returns `x` and `y` as 5-by-1 vectors, appending the coordinates of the first of the four corners to the end.

`[lon,lat] = mapoutline(R,...)`, where `R` georeferences pixels to longitude and latitude rather than map coordinates, returns the outline in geographic coordinates. Longitude must precede latitude in the output argument list.

`outline = mapoutline(...)` returns the corner coordinates in a 4-by-2 or 5-by-2 array.

Examples

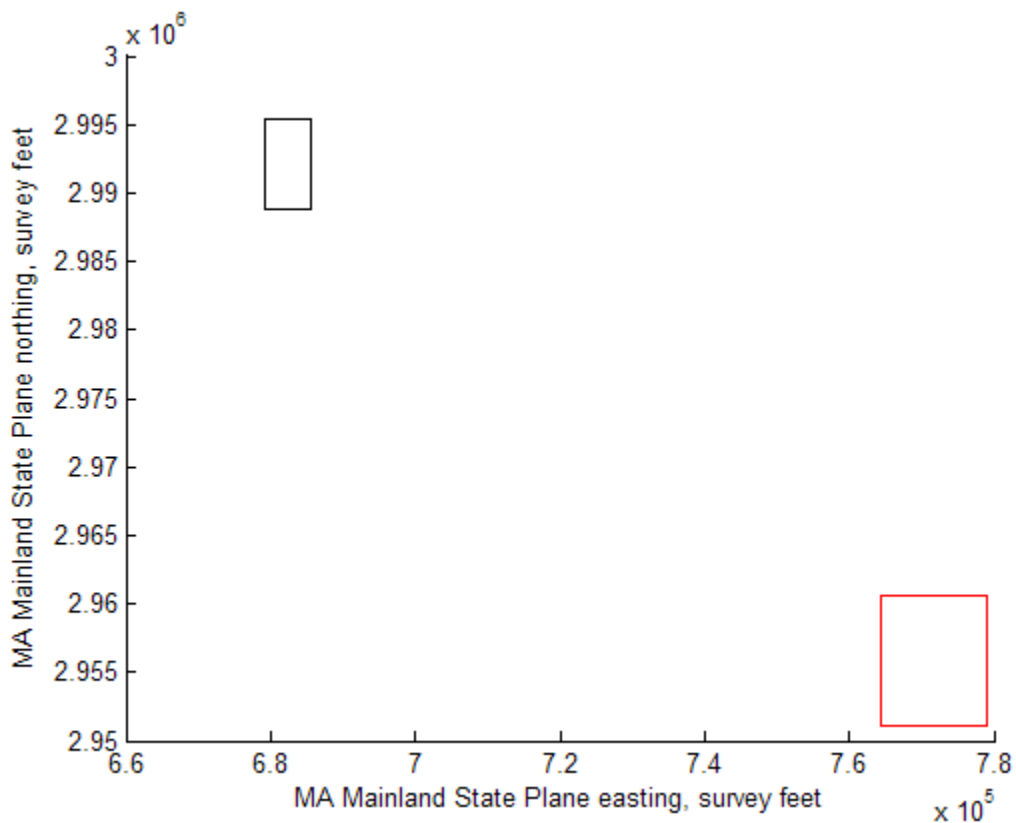
Draw a red outline delineating the Boston GeoTIFF image, which is referenced to the Massachusetts Mainland State Plane coordinate system with units of survey feet.

```
figure
info = georasterinfo('boston.tif');
R = info.RasterReference;
[x,y] = mapoutline(R,R.RasterSize,'close');

hold on
plot(x,y,'r')
xlabel('MA Mainland State Plane easting, survey feet')
ylabel('MA Mainland State Plane northing, survey feet')
```

Draw a black outline delineating a TIFF image of Concord, Massachusetts, while lies roughly 25 km north west of Boston. Convert world file units to survey feet from meters to be consistent with the Boston image.

```
info = imfinfo('concord_ortho_w.tif');
R = worldfileread('concord_ortho_w.tfw','planar', ...
  [info.Height info.Width]);
[x,y] = mapoutline(R, info.Height, info.Width, 'close');
x = x * unitsratio('sf','meter');
y = y * unitsratio('sf','meter');
plot(x,y,'k')
```



Version History

Introduced before R2006a

R2022b: mapoutline will not accept referencing matrices as input

Not recommended starting in R2022b

The `mapoutline` function will not accept referencing matrices as input in a future release. Use a map raster reference object (specified as a `MapCellsReference` or `MapPostingsReference` object) or a geographic raster reference object (specified as a `GeographicCellsReference` or `GeographicPostingsReference` object) as input instead. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its world limits, and the direction of its rows and columns.
- You can manipulate the limits of rasters associated with reference objects using the `mapcrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `mapresize` function.

The strategy you use to update your code depends on whether your data is in planar or geographic coordinates.

Planar Map Coordinates

If the referencing matrix is in planar map coordinates, create a map reference object and use a different syntax of the `mapoutline` function.

- Create a map reference object for a raster of cells by using the `maprefcells` function.
- Create a map reference object for a raster of regularly posted samples by using the `maprefpostings` function.
- Alternatively, you can convert from a referencing matrix to a map reference object by using the `refmatToMapRasterReference` function.

Once you have created a reference object, replace uses of the `mapoutline` function in your code with the syntax `[X,Y] = mapoutline(R,R.RasterSize)`, where R is the reference object.

Geographic Coordinates

If the referencing matrix is in geographic coordinates, create a geographic reference object and replace uses of the `mapoutline` function with the `outlinegeoquad` function.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the `mapoutline` function in your code with the `outlinegeoquad` syntax `[LAT,LON] = outlinegeoquad(R.LatitudeLimits,R.LongitudeLimits)`, where R is the reference object.

R2022b: mapoutline will not accept structure arrays as input

Not recommended starting in R2022b

The `mapoutline` function will not accept structure arrays containing `RefMatrix`, `Height`, and `Width` fields as input in a future release. Use a map raster reference object as input instead.

To update your code, convert the structure array to a reference object by using the `refmatToMapRasterReference` function. Then, replace uses of the `mapoutline` function with the syntax `[X,Y] = mapoutline(R,R.RasterSize)`, where R is the reference object.

To Be Removed	Recommended
<code>[X,Y] = mapoutline(INFO);</code>	<code>R = refmatToMapRasterReference(INFO.RefMatrix, ... [INFO.Height INFO.Width]); [X,Y] = mapoutline(R,R.RasterSize);</code>

See Also

Functions

[worldGrid](#) | [intrinsicToWorld](#) | [outlinegeoquad](#)

Objects

[MapCellsReference](#) | [MapPostingsReference](#)

mappoint

Planar point vector

Description

A mappoint vector is a container object that holds planar point coordinates and attributes. The points are coupled, such that the size of the x- and y-coordinate arrays are always equal and match the size of any dynamically added attribute arrays. Each entry of a coordinate pair and associated attributes, if any, represents a discrete element in the mappoint vector.

To create a planar point shape for use with a geospatial table, create a `mappointshape` object instead.

Creation

Syntax

```
p = mappoint()
p = mappoint(x,y)
p = mappoint(x,y,Name,Value)
p = mappoint(structArray)
p = mappoint(x,y,structArray)
```

Description

`p = mappoint()` constructs an empty mappoint vector, `p`, with these default property settings:

`p =`

```
0x1 mappoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: []
  Y: []
```

`p = mappoint(x,y)` constructs a new mappoint vector and assigns the X and Y properties to the numeric array inputs, `x` and `y`.

`p = mappoint(x,y,Name,Value)` constructs a mappoint vector, then adds dynamic properties to the mappoint vector using `Name`, `Value` argument pairs. You can specify several name-value pair arguments in any order as `Name1, Value1, . . . , NameN, ValueN`.

`p = mappoint(structArray)` constructs a new mappoint vector, assigning the fields of the structure array, `structArray`, as dynamic properties. Field values in `structArray` that are not numeric values, string scalar, string array, character vectors, or cell arrays of numeric values or character vectors are ignored.

`p = mappoint(x,y,structArray)` constructs a new `mappoint` vector, sets the `X` and `Y` properties equal to the numeric arrays `x` and `y`, and sets dynamic properties from the field values of `structArray`.

Properties

Each element in a `mappoint` vector is considered a feature. For more about the property types in `mappoint`, see “Collection Properties” on page 1-1078 and “Feature Properties” on page 1-1078.

Dynamic properties are new features that are added to a `mappoint` vector and that apply to each individual feature in the `mappoint` vector. You can attach dynamic Feature properties to a `mappoint` object during construction with a `Name,Value` pair or after construction using dot (`.`) notation. This is similar to adding dynamic fields to a structure. For an example of adding Feature properties dynamically, see “Construct a Mappoint Vector for Multiple Features and Examine Autosizing” on page 1-1068.

Geometry — Type of geometry

`'point'`

Type of geometry, specified as `'point'`. For `mappoint`, `Geometry` is always `'point'`.

Data Types: `char` | `string`

Metadata — Information for the entire set of mappoint vector elements

scalar structure

Information for the entire set of `mappoint` vector elements, specified as a scalar structure. You can add any data type to the structure.

- If `Metadata` is provided as a dynamic property `Name` in the constructor, and the corresponding `Value` is a scalar structure, then `Value` is copied to the `Metadata` property. Otherwise, an error is issued.
- If a `Metadata` field is provided by `structArray`, and both `Metadata` and `structArray` are scalar structures, then the `Metadata` field value is copied to the `Metadata` property value. If `structArray` is a scalar but the `Metadata` field is not a structure, then an error is issued. If `structArray` is not scalar, then the `Metadata` field is ignored.

Data Types: `struct`

X — Planar x-coordinates

numeric row or column vector

Planar x-coordinate, specified as a numeric row or column vector.

Data Types: `double` | `single`

Y — Planar y-coordinates

numeric row or column vector

Planar y-coordinates, specified as a numeric row or column vector.

Data Types: `double` | `single`

Object Functions

append	Append features to geographic or planar vector
cat	Concatenate geographic or planar vector
disp	Display geographic or planar vector
fieldnames	Return dynamic property names of geographic or planar vector
isempty	Determine if geographic or planar vector is empty
isfield	Determine if dynamic property exists in geographic or planar vector
isprop	Determine if property exists in geographic or planar vector
length	Return number of elements in geographic or planar vector
properties	Return property names of geographic or planar vector
rmfield	Remove dynamic property from geographic or planar vector
rmprop	Remove property from geographic or planar vector
size	Return size of geographic or planar vector
struct	Convert geographic or planar vector to scalar structure
vertcat	Vertically concatenate geographic or planar vectors

Examples

Construct a Default Mappoint Vector

Dynamically set the X and Y property values, and dynamically add Vertex property Z.

```
p = mappoint();
p.X = 1:3;
p.Y = 1:3;
p.Z = [10 10 10]
```

p =

3x1 mappoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1 2 3]
  Y: [1 2 3]
  Z: [10 10 10]
```

Construct a Mappoint Vector from X and Y Values

Define x and y coordinates. Use them to create a mappoint.

```
x = [40 50 60];
y = [10, 11, 12];
p = mappoint(x, y)
```

p =

3x1 mappoint vector with properties:

```
Collection properties:
  Geometry: 'point'
```

```
Metadata: [1x1 struct]
Feature properties:
  X: [40 50 60]
  Y: [10 11 12]
```

Construct a Mappoint Vector from X, Y, and Temperature Values

```
x = 41:43;
y = 1:3;
temperature = 61:63;
p = mappoint(x, y, 'Temperature', temperature)
```

```
p =
```

```
3x1 mappoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [41 42 43]
  Y: [1 2 3]
  Temperature: [61 62 63]
```

Construct a Mappoint Vector from a Structure Array

Create a structure array and then create a mappoint vector, specifying the array as input.

```
structArray = shaperead('boston_placenames')
p = mappoint(structArray)
```

```
structArray =
```

```
13x1 struct array with fields:
  Geometry
  X
  Y
  NAME
  FEATURE
  COORD
```

```
p =
```

```
13x1 mappoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1x13 double]
  Y: [1x13 double]
  NAME: {1x13 cell}
```



```
FEATURE: {1x13 cell}
COORD: {1x13 cell}
```

Construct a Mappoint Vector from X and Y Numeric Arrays and a Structure Array

```
[structArray, A] = shaperead('boston_placenames');
x = [structArray.X];
y = [structArray.Y];
p = mappoint(x, y, A)
```

p =

13x1 mappoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1x13 double]
  Y: [1x13 double]
  NAME: {1x13 cell}
  FEATURE: {1x13 cell}
  COORD: {1x13 cell}
```

Construct a Mappoint Vector for One Feature

This example shows how to add a single feature to an empty mappoint vector after construction.

```
x = 1;
y = 1;
p = mappoint(x, y)
```

p =

1x1 mappoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: 1
  Y: 1
```

Add a dynamic Feature property with a character vector value.

```
p.FeatureName = 'My Feature'
```

p =

1x1 mappoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
```

```
        X: 1
        Y: 1
FeatureName: 'My Feature'
```

Construct a Mappoint Vector for Multiple Features and Examine Autosizing

This example show how mappoint vectors autoresize all properties lengths to ensure they are equal in size when a new dynamic property is added or an existing property is appended or shortened.

Create a mappoint vector.

```
x = [1 2];
y = [10 10];
p = mappoint(x,y)
```

p =

2x1 mappoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1 2]
  Y: [10 10]
```

Add a dynamic Feature property.

```
p.FeatureName = {'Feature 1','Feature 2'}
```

p =

2x1 mappoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1 2]
  Y: [10 10]
  FeatureName: {'Feature 1' 'Feature 2'}
```

Add a numeric dynamic Feature property.

```
p.ID = [1 2]
```

p =

2x1 mappoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1 2]
  Y: [10 10]
```

```
FeatureName: {'Feature 1' 'Feature 2'}
ID: [1 2]
```

Add a third feature. All properties are autosized so that all vector lengths match.

```
p(3).X = 3
p(3).Y = 10
```

```
p =
```

```
3x1 mappoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1 2 3]
  Y: [10 10 10]
  FeatureName: {'Feature 1' 'Feature 2' ''}
  ID: [1 2 0]
```

Set the values for the ID feature dynamic property with more values than contained in X or Y. All properties are expanded to match in size.

```
p.ID = 1:4
```

```
p =
```

```
4x1 mappoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1 2 3 0]
  Y: [10 10 10 0]
  FeatureName: {'Feature 1' 'Feature 2' '' ''}
  ID: [1 2 3 4]
```

Set the values for the ID dynamic Feature property with fewer values than contained in X or Y. The ID property values expand to match the length of X and Y.

```
p.ID = 1:2
```

```
p =
```

```
4x1 mappoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1 2 3 0]
  Y: [10 10 10 0]
  FeatureName: {'Feature 1' 'Feature 2' '' ''}
  ID: [1 2 0 0]
```

Set the values of either coordinate property (X or Y) with fewer values. All properties shrink in size to match the new length.

```
p.X = 1:2
p =
2x1 mappoint vector with properties:
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1 2]
  Y: [10 10]
  FeatureName: {'Feature 1' 'Feature 2'}
  ID: [1 2]
```

Remove the `FeatureName` property by setting its value to `[]`.

```
p.FeatureName = []
p =
2x1 mappoint vector with properties:
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1 2]
  Y: [10 10]
  ID: [1 2]
```

Remove all dynamic properties and set the object to empty by setting a coordinate property value to `[]`.

```
p.X = []
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: []
  Y: []
```

Construct a Mappoint Specifying Two Features

This example shows how to include multiple dynamic features during object construction.

```
point = mappoint([42 44],[10, 11],'Temperature',[63 65], ...
  'TemperatureUnits','Fahrenheit')
point =
2x1 mappoint vector with properties:
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
```

```

Feature properties:
    X: [42 44]
    Y: [10 11]
    Temperature: [63 65]
TemperatureUnits: 'Fahrenheit'

```

Create a Mappoint Vector from a MAT-File

This example shows how to construct a mappoint vector using data from a MAT-file containing oceanic depths.

Load data from the `seamount` MAT-file and construct a mappoint vector to hold the coordinates.

```

seamount = load('seamount');
p = mappoint(seamount.x, seamount.y, 'Z', seamount.z);

```

Create a level list to use to bin the z values and create a list of color values for each level.

```

levels = [unique(floor(seamount.z/1000)) * 1000; 0];
colors = {'red', 'green', 'blue', 'cyan', 'black'};

```

Add a `MinLevel` and `MaxLevel` feature property to indicate the lowest and highest binned level. Add a dynamic feature property to indicate the z-coordinate. Add a dynamic Feature property to indicate a binned level value and a color value for a given level. Include metadata information from the MAT-file.

```

for k = 1:length(levels) - 1
    index = levels(k) <= p.Z & p.Z < levels(k+1);
    p(index).MinLevel = levels(k);
    p(index).MaxLevel = levels(k+1) - 1;
    p(index).Color = colors{k};
end

```

Add metadata information. `Metadata` is a scalar structure containing information for the entire set of properties. You can add any type of data to the structure.

```

p.Metadata.Caption = seamount.caption;
p.Metadata

```

```

ans =

```

```

    Caption: [1x229 char]

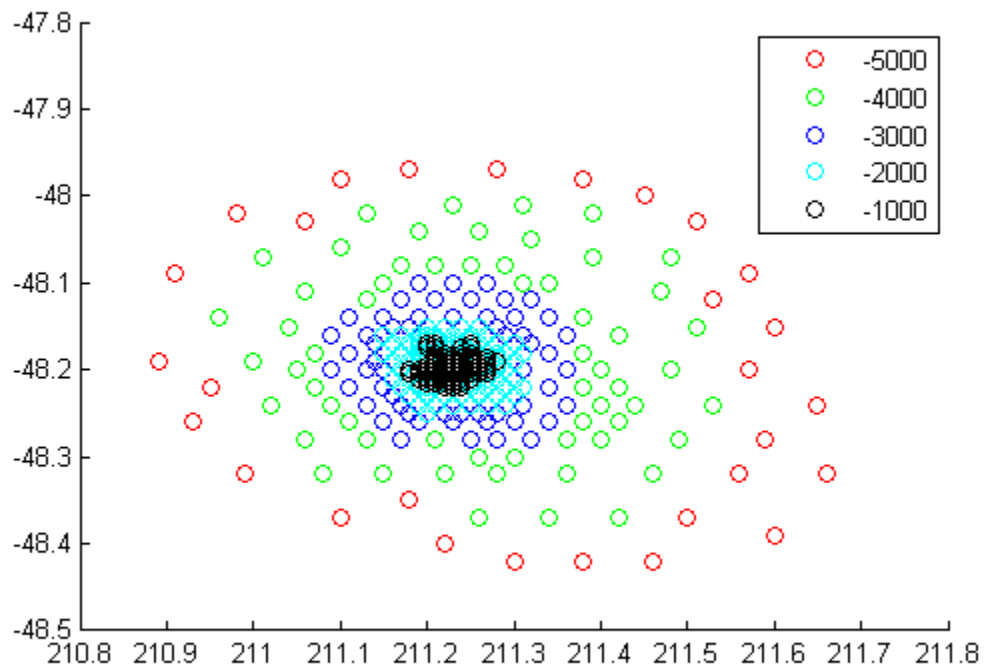
```

Display the point data as a 2-D plot.

```

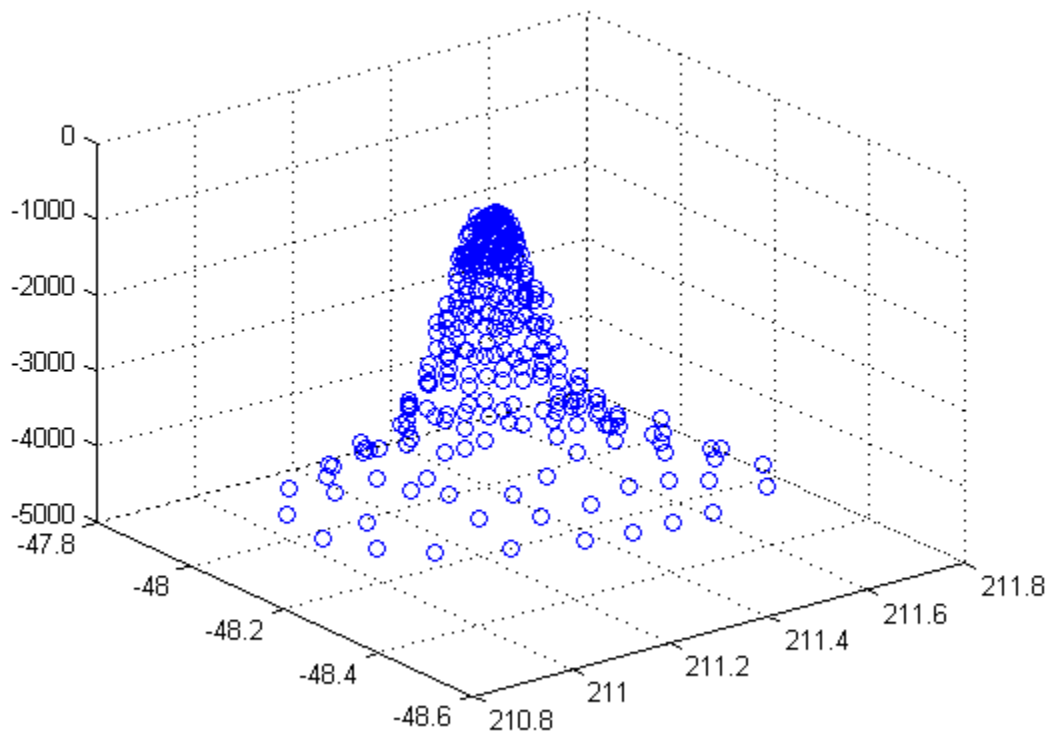
figure
minLevels = unique(p.MinLevel);
for k=1:length(minLevels)
    index = p.MinLevel == minLevels(k);
    mapshow(p(index).X, p(index).Y, ...
        'MarkerEdgeColor', p(find(index,1)).Color, ...
        'Marker', 'o', ...
        'DisplayType', 'point')
end
legend(num2str(minLevels'))

```



Display the point data as a 3-D scatter plot.

```
figure  
scatter3(p.X, p.Y, p.Z)
```



Assign Dynamic Features to Mappoint Vector from a Structure Array

This example shows how to create a mappoint vector from a structure array, and how to add features and metadata to the mappoint vector.

```
structArray = shaperead('boston_placenames');
p = mappoint();
p.X = [structArray.X];
p.Y = [structArray.Y];
p.Name = {structArray.NAME}
```

p =

13x1 mappoint vector with properties:

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1x13 double]
  Y: [1x13 double]
  Name: {1x13 cell}
```

Construct a mappoint vector from a structure array using the constructor syntax.

```
filename = 'boston_placenames.shp';
structArray = shaperead(filename);
p = mappoint(structArray)

p =

13x1 mappoint vector with properties:

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1x13 double]
  Y: [1x13 double]
  NAME: {1x13 cell}
  FEATURE: {1x13 cell}
  COORD: {1x13 cell}
```

Add a Filename field to the Metadata structure. Display the first five points and the Metadata structure.

```
p.Metadata.FileName = filename;
p(1:5)
p.Metadata

ans =

5x1 mappoint vector with properties:

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [2.3403e+05 2.3357e+05 2.3574e+05 2.3627e+05 2.3574e+05]
  Y: [900038 9.0019e+05 9.0113e+05 9.0097e+05 9.0036e+05]
  NAME: {1x5 cell}
  FEATURE: {'PPL-SUBDVSN' ' MARSH' ' HILL' ' PPL' ' PENINSULA'}
  COORD: {1x5 cell}

ans =

Filename: 'boston_placenames.shp'
```

Append a Point by Indexing

This example show how to add a feature to the mappoint vector using linear indexing.

Append Paderborn, Germany to the vector of world cities.

```
p = mappoint(shaperead('worldcities.shp'));
x = 51.715254;
y = 8.75213;
p = append(p, x, y, 'Name', 'Paderborn');
p(end)

ans =
```



```
1x1 mappoint vector with properties:
```

```
Collection properties:  
  Geometry: 'point'  
  Metadata: [1x1 struct]  
Feature properties:  
  X: 51.7153  
  Y: 8.7521  
  Name: 'Paderborn'
```

You can also add a point to the end of the mappoint vector using linear indexing. Add Arlington, Virginia to the end of the vector.

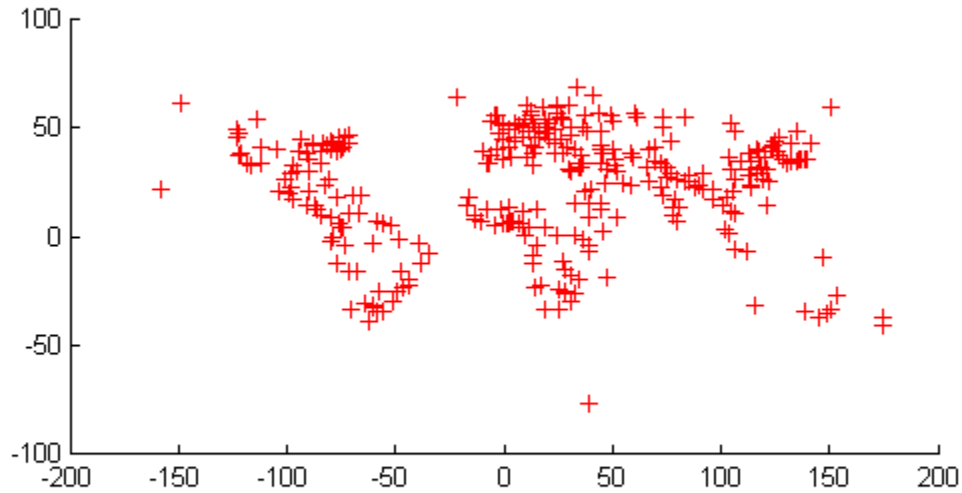
```
p(end+1).X = 38.880043;  
p(end).Y = -77.196676;  
p(end).Name = 'Arlington';  
p(end-1:end)
```

```
ans =
```

```
2x1 mappoint vector with properties:
```

```
Collection properties:  
  Geometry: 'point'  
  Metadata: [1x1 struct]  
Feature properties:  
  X: [51.7153 38.8800]  
  Y: [8.7521 -77.1967]  
  Name: {'Paderborn' 'Arlington'}
```

```
% Plot the points  
figure  
mapshow(p.X, p.Y, 'DisplayType', 'point')
```



Sort Dynamic Properties

This example shows how features can be sorted by using the indexing behavior of the mappoint class.

Construct a mappoint vector and sort the dynamic properties.

```
p = mappoint(shaperead('tsunamis'));  
p = p(:, sort(fieldnames(p)))
```

```
p =
```

```
162x1 mappoint vector with properties:
```

```
Collection properties:
```

```
    Geometry: 'point'
```

```
    Metadata: [1x1 struct]
```

```
Feature properties:
```

```
    X: [1x162 double]
```

```
    Y: [1x162 double]
```

```
    Cause: {1x162 cell}
```

```
    Cause_Code: [1x162 double]
```

```
    Country: {1x162 cell}
```

```
    Day: [1x162 double]
```

```
    Desc_Deaths: [1x162 double]
```

```
    Eq_Mag: [1x162 double]
```

```
    Hour: [1x162 double]
```

```

Iida_Mag: [1x162 double]
Intensity: [1x162 double]
Location: {1x162 cell}
Max_Height: [1x162 double]
    Minute: [1x162 double]
    Month: [1x162 double]
Num_Deaths: [1x162 double]
    Second: [1x162 double]
Val_Code: [1x162 double]
Validity: {1x162 cell}
Year: [1x162 double]

```

Modify the mappoint vector to contain only the dynamic properties, 'Year', 'Month', 'Day', 'Hour', 'Minute'.

```
p = p(:, {'Year', 'Month', 'Day', 'Hour', 'Minute'})
```

```
p =
```

```
162x1 mappoint vector with properties:
```

```

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1x162 double]
  Y: [1x162 double]
  Year: [1x162 double]
  Month: [1x162 double]
  Day: [1x162 double]
  Hour: [1x162 double]
  Minute: [1x162 double]

```

Display the first five elements.

```
p(1:5)
```

```
ans =
```

```
5x1 mappoint vector with properties:
```

```

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [128.3000 -156 157.9500 143.8500 -155]
  Y: [-3.8000 19.5000 -9.0200 42.1500 19.1000]
  Year: [1950 1951 1951 1952 1952]
  Month: [10 8 12 3 3]
  Day: [8 21 22 4 17]
  Hour: [3 10 NaN 1 3]
  Minute: [23 57 NaN 22 58]

```

Row and Column Input Arguments

This example demonstrates that input arguments `x` and `y` can be either row or column vectors.

If you typically store x - and y -coordinate values in an n -by-2 or 2-by- m array, you can assign a mappoint object to these numeric values. If the values are stored in an n -by-2 array, then the X property values are assigned to the first column and the Y property values are assigned to the second column.

```
x = 1:10;
y = 21:30;
pts = [x' y'];
p = mappoint;
p(1:length(pts)) = pts

p =

10x1 mappoint vector with properties:

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1 2 3 4 5 6 7 8 9 10]
  Y: [21 22 23 24 25 26 27 28 29 30]
```

If the values are stored in a 2-by- m array, then the X property values are assigned to the first row and the Y property values are assigned to the second row.

```
pts = [x; y];
p(1:length(pts)) = pts

p =

10x1 mappoint vector with properties:

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: [1 2 3 4 5 6 7 8 9 10]
  Y: [21 22 23 24 25 26 27 28 29 30]
```

Observe that in both cases, X and Y are stored as row vectors.

More About

Collection Properties

Collection properties contain only one value per class instance. In contrast, the Feature property type has attribute values associated with each feature. `Geometry` and `Metadata` are the only two Collection properties.

Feature Properties

Feature properties contain one value (a scalar number, string scalar, or a character vector) for each feature in a mappoint vector. They are suitable for properties such as name, owner, serial number, or age, that describe a given feature (an element of a mappoint vector) as a whole. The X and Y coordinate properties are feature properties as there is one value for each element in the mappoint vector.

Feature properties can be added dynamically using dot notation. This is similar to adding dynamic fields to a structure.

Tips

- If X, Y, or a dynamic property is set with more values than features in the mappoint vector, then all other properties expand in size using 0 for numeric values and an empty character vector (' ') for cell values.
- If a dynamic property is set with fewer values than the number of features, then this dynamic property expands to match the size of the other properties, by inserting a 0 if the value is numeric or an empty character vector (' '), if the value is a cell array.
- If the X or Y property of the mappoint vector is set with fewer values than contained in the object, then all other properties shrink in size.
- If either X or Y is set to [], then both coordinate properties are set to [] and all dynamic properties are removed.
- If a dynamic property is set to [], then it is removed from the object.
- The mappoint vector can be indexed like any MATLAB vector. You can access any element of the vector to obtain a specific feature. The following examples demonstrate this behavior:

“Append a Point by Indexing” on page 1-1074

“Sort Dynamic Properties” on page 1-1076

Version History

Introduced in R2012a

See Also

Functions

gpxread | shaperead

Objects

geopoint | geoshape | mapshape

mappointshape

Point shape in planar coordinates

Description

A `mappointshape` object represents a point or multipoint in planar coordinates. A multipoint is an individual point shape that contains a set of point locations.

To represent a point or multipoint in geographic coordinates, use a `geopointshape` object instead.

Creation

To create `mappointshape` objects, either:

- Import point data in planar coordinates as a geospatial table using the `readgeotable` function, and then query the `Shape` variable of the table.
- Use the `mappointshape` function (described here).

Syntax

```
shape = mappointshape(x,y)
```

Description

`shape = mappointshape(x,y)` creates a `mappointshape` object or array of `mappointshape` objects with the specified `x`- and `y`-coordinates. The sizes of `x`, `y`, and the `mappointshape` object array `shape` match.

Input Arguments

x — **x-coordinates**

numeric array | cell array of numeric arrays

`x`-coordinates, specified as a numeric array or a cell array of numeric arrays.

- Create a point by specifying a scalar, such as `39`.
- Create a multipoint by specifying an array within a cell, such as `{[38 -30 29]}`.
- Create an array of points by specifying an array, such as `[38 -30 29]`.
- Create an array of points and multipoints by specifying a cell array of numeric arrays, such as `{39,[38 -30 29]}`.

Create placeholders for points with missing data by including `NaN` values. The `NaN` values in `x` must correspond to the `NaN` values in `y`.

The size of `x` must match the size of `y`. For cell arrays, the size of the array in each cell of `x` must match the size of the array in the corresponding cell of `y`.

Data Types: `double` | `cell`

y — y-coordinates

numeric array | cell array of numeric arrays

y-coordinates, specified as a numeric array or a cell array of numeric arrays.

- Create a point by specifying a scalar, such as `-113`.
- Create a multipoint by specifying an array within a cell, such as `{[-66 -31 42]}`.
- Create an array of points by specifying an array, such as `[-66 -31 42]`.
- Create an array of points and multipoints by specifying a cell array of numeric arrays, such as `{-113, [-66 -31 42]}`.

Create placeholders for points with missing data by including NaN values. The NaN values in `x` must correspond to the NaN values in `y`.

The size of `x` must match the size of `y`. For cell arrays, the size of the array in each cell of `x` must match the size of the array in the corresponding cell of `y`.

Data Types: `double` | `cell`

Properties**NumPoints — Number of points**

array of nonnegative integers

This property is read-only.

Number of points, returned as an array of nonnegative integers.

For a `mappointshape` scalar, the value of `NumPoints` is 1 when the `mappointshape` object represents a single point and more than 1 when the object represents a multipoint.

For a `mappointshape` array, the size of `NumPoints` matches the size of the array.

Data Types: `double`

X — x-coordinates

array

x-coordinates, specified as an array.

For a `mappointshape` scalar, the size of `X` matches the value of `NumPoints`.

For a `mappointshape` array, the size of `X` matches the size of `NumPoints`. If the array contains `mappointshape` objects with multipoints, then accessing the `X` property of the array is not supported. Instead, access the `X` property of individual objects within the array. You can determine whether a `mappointshape` array contains multipoints by using the `ismultipoint` function.

This property is read-only for arrays when any element of `NumPoints` is greater than 1.

`X` and `Y` must be the same size.

Data Types: `double`

Y — y-coordinates

array

y-coordinates, specified as an array.

For a `mappointshape` scalar, the size of `Y` matches the value of `NumPoints`.

For a `mappointshape` array, the size of `Y` matches the size of `NumPoints`. If the array contains `mappointshape` objects with multipoints, then accessing the `Y` property of the array is not supported. Instead, access the `Y` property of individual objects within the array. You can determine whether a `mappointshape` array contains multipoints by using the `ismultipoint` function.

This property is read-only for arrays when any element of `NumPoints` is greater than 1.

`X` and `Y` must be the same size.

Data Types: `double`

Geometry — Geometric type

"point" (default)

This property is read-only.

Geometric type, returned as "point".

Data Types: `string`

CoordinateSystemType — Coordinate system type

"planar" (default)

This property is read-only.

Coordinate system type, returned as "planar".

Data Types: `string`

ProjectedCRS — Projected coordinate reference system

[] (default) | `projcrs` object

Projected coordinate reference system (CRS), specified as a `projcrs` object. A projected CRS consists of a geographic CRS and several parameters that are used to transform coordinates to and from the geographic CRS.

Object Functions

<code>geoplot</code>	Plot points, lines, and polygons on map
<code>mapclip</code>	Clip shape to xy-limits in planar coordinates
<code>ismultipoint</code>	Determine which array elements are multipoint shapes

Examples

Get Information about Imported Planar Points

Import a shapefile containing the coordinates of locations in Boston as a geospatial table. The shapefile represents the locations using points. Get information about the points by querying the `Shape` variable of the table.

```
GT = readgeotable("boston_placenames.shp");  
GT.Shape
```

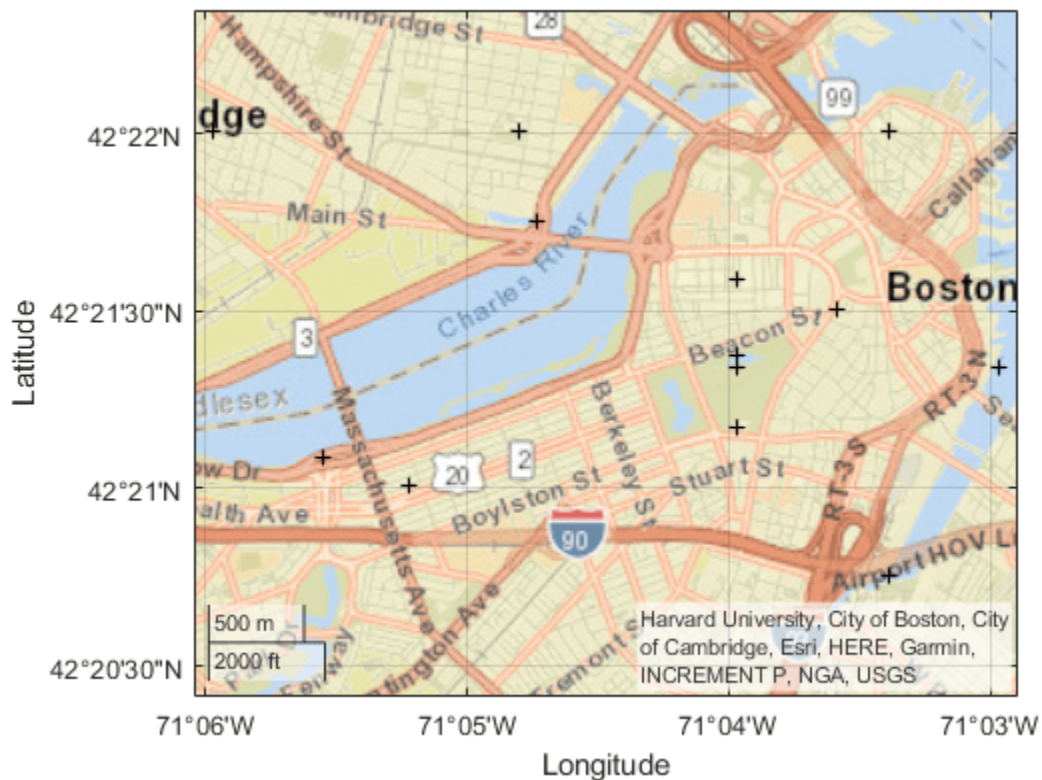


```
ans =
  13x1 mappointshape array with properties:

      NumPoints: [13x1 double]
           X: [13x1 double]
           Y: [13x1 double]
      Geometry: "point"
CoordinateSystemType: "planar"
      ProjectedCRS: [1x1 projcrs]
```

Display the locations using black plus signs on a road map.

```
geoplot(GT, "+k")
geobasemap streets
```



Create Planar Points and Multipoints

Create an individual point as a mappointshape scalar. Specify the projected CRS as World Equidistant Cylindrical, which has the EPSG authority code 4087.

```
point = mappointshape(-113,39);
p = projcrs(4087);
point.ProjectedCRS = p
```

```
point =
  mappointshape with properties:
      NumPoints: 1
          X: -113
          Y: 39
      Geometry: "point"
  CoordinateSystemType: "planar"
  ProjectedCRS: [1x1 projcrs]
```

Create a multipoint as a mappointshape scalar.

```
multipoint = mappointshape([-66 -31 42],[38 -30 29]);
multipoint.ProjectedCRS = p
```

```
multipoint =
  mappointshape with properties:
      NumPoints: 3
          X: [-66 -31 42]
          Y: [38 -30 29]
      Geometry: "point"
  CoordinateSystemType: "planar"
  ProjectedCRS: [1x1 projcrs]
```

Create three individual points as a 1-by-3 mappointshape array.

```
pointVector = mappointshape([-66 -31 42],[38 -30 29]);
pointVector.ProjectedCRS = p
```

```
pointVector =
  1x3 mappointshape array with properties:
      NumPoints: [1 1 1]
          X: [-66 -31 42]
          Y: [38 -30 29]
      Geometry: "point"
  CoordinateSystemType: "planar"
  ProjectedCRS: [1x1 projcrs]
```

Create one individual point and one multipoint as a 1-by-2 mappointshape array.

```
pointMultipoint = mappointshape([-113,-66 -31 42],[39, [38 -30 29]]);
pointMultipoint.ProjectedCRS = p
```

```
pointMultipoint =
  1x2 mappointshape array with properties:
      NumPoints: [1 3]
      Geometry: "point"
  CoordinateSystemType: "planar"
  ProjectedCRS: [1x1 projcrs]
```

Version History

Introduced in R2021b

R2022a: Points with missing coordinate data have some changed property values

Behavior changed in R2022a

When a point shape has missing coordinate data, its `NumPoints` property has a value of 0 and its `X` and `Y` properties each have a value of `NaN`.

- When you create a point by specifying both coordinates as `NaN` values, its `NumPoints` property has a value of 0. In the previous release, the property had a value of 1.
- When a point has no coordinate data, its `X` and `Y` properties each have a value of `NaN`. In the previous release, the properties were each empty `double` values.

These changes make it easier to create and access the properties of `mappointshape` arrays when the input coordinates contain missing data. For example, you can now access the coordinates of a `mappointshape` array when the array contains a combination of points with coordinate data (`NumPoints` is 1) and without coordinate data (`NumPoints` is 0). In the previous release, MATLAB issued an error.

See Also

Functions

`readgeotable`

Objects

`maplineshape` | `mappolyshape` | `geopointshape`

Topics

“Create Geospatial Tables”

maplineshape

Line shape in planar coordinates

Description

A `maplineshape` object represents a line or multiline in planar coordinates. A multiline is an individual line shape that contains a set of separate lines.

To represent a line or multiline in geographic coordinates, use a `geolineshape` object instead.

Creation

To create `maplineshape` objects, either:

- Import line data in planar coordinates as a geospatial table using the `readgeotable` function, and then query the `Shape` variable of the table.
- Use the `maplineshape` function (described here).

Syntax

```
shape = maplineshape(x,y)
```

Description

`shape = maplineshape(x,y)` creates a `maplineshape` object or array of `maplineshape` objects with vertices at the specified `x`- and `y`-coordinates. The sizes of `x`, `y`, and the `maplineshape` object array `shape` match.

Input Arguments

x — x-coordinates

numeric vector | cell array of numeric vectors

`x`-coordinates, specified as a numeric vector or a cell array of numeric vectors.

- Create a line by specifying a vector, such as `[65 62 53 66]`.
- Create a multiline by specifying a vector and including line breaks as `NaN` values, such as `[55 34 18 NaN 14 19 42 26]`.
- Create an array of lines and multilines by specifying a cell array of vectors, such as `{[55 34 18],[14 19 NaN 42 26 31]}`.

The `NaN` values in `x` must correspond to the `NaN` values in `y`.

The size of `x` must match the size of `y`. For cell arrays, the size of the vector in each cell of `x` must match the size of the vector in the corresponding cell of `y`.

Data Types: `double` | `cell`

y — y-coordinates

numeric vector | cell array of numeric vectors

y-coordinates, specified as a numeric vector or a cell array of numeric vectors.

- Create a line by specifying a vector, such as [4 59 121 98].
- Create a multiline by specifying a vector and including line breaks as NaN values, such as [78 56 63 NaN 83 106 104 126].
- Create an array of lines and multilines by specifying a cell array of vectors, such as {[78 56 63],[83 106 NaN 104 126 131]}.

The NaN values in x must correspond to the NaN values in y.

The size of x must match the size of y. For cell arrays, the size of the vector in each cell of x must match the size of the vector in the corresponding cell of y.

Data Types: double | cell

Properties**NumParts — Number of line parts**

array of nonnegative integers

This property is read-only.

Number of line parts, returned as an array of nonnegative integers.

For a maplineshape scalar, the value of NumParts is 1 when the maplineshape object represents a single line and more than 1 when the object represents a multiline.

For a maplineshape array, the size of NumParts matches the size of the array.

Data Types: double

Geometry — Geometric type

"line" (default)

This property is read-only.

Geometric type, returned as "line".

Data Types: string

CoordinateSystemType — Coordinate system type

"planar" (default)

This property is read-only.

Coordinate system type, returned as "planar".

Data Types: string

ProjectedCRS — Projected coordinate reference system

[] (default) | projcrs object

Projected coordinate reference system (CRS), specified as a `projcrs` object. A projected CRS consists of a geographic CRS and several parameters that are used to transform coordinates to and from the geographic CRS.

Object Functions

`geoplot` Plot points, lines, and polygons on map
`mapclip` Clip shape to xy-limits in planar coordinates
`ismultipoint` Determine which array elements are multipoint shapes

Examples

Get Information About Imported Planar Lines

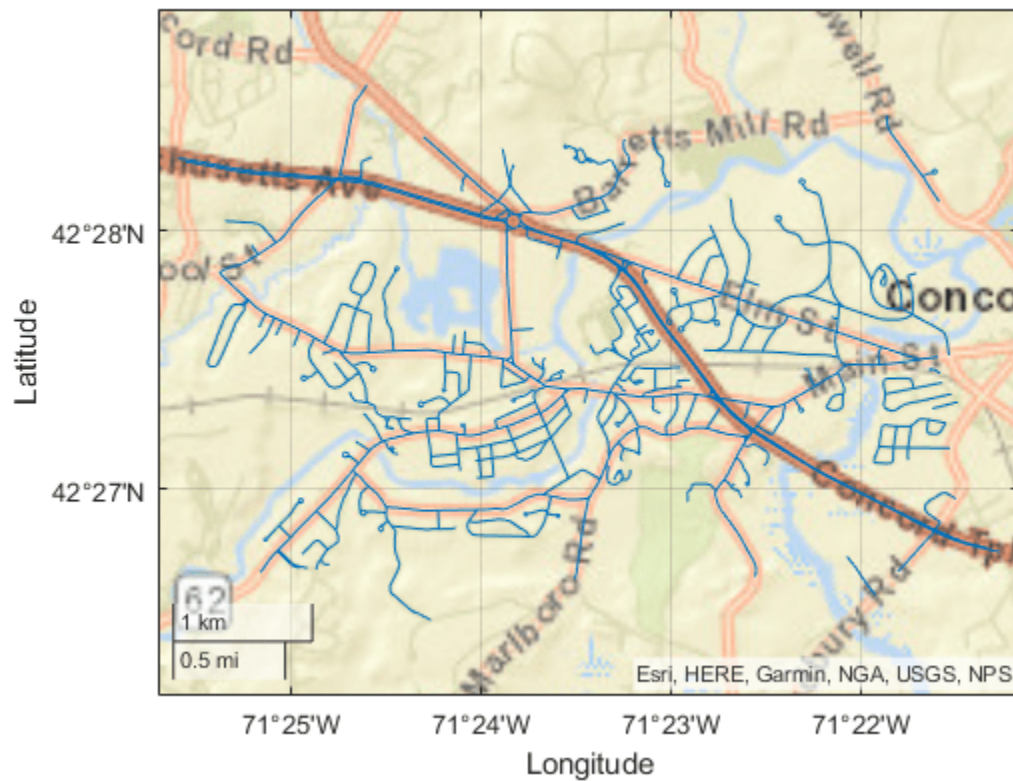
Import a shapefile containing a network of road segments in Concord, MA as a geospatial table. The shapefile represents the road segments using lines. Get information about the fourth line by querying the `Shape` variable of the table.

```
GT = readgeotable("concord_roads.shp");  
GT.Shape(4)
```

```
ans =  
  maplineshape with properties:  
  
      NumParts: 1  
      Geometry: "line"  
  CoordinateSystemType: "planar"  
      ProjectedCRS: [1x1 projcrs]
```

Display the road segments on a street map.

```
geoplot(GT)  
geobasemap streets
```



Create Planar Lines and Multilines

Create an individual line as a `maplineshape` scalar. Specify the projected CRS as World Equidistant Cylindrical, which has the EPSG authority code 4087.

```
x = [4 59 121 98];
y = [65 62 53 66];
lineshp = maplineshape(x,y);

p = projcrs(4087);
lineshp.ProjectedCRS = p

lineshp =
  maplineshape with properties:
    NumParts: 1
    Geometry: "line"
    CoordinateSystemType: "planar"
    ProjectedCRS: [1x1 projcrs]
```

Create a multiline as a `maplineshape` scalar.

```
x = [78 56 63 NaN 83 106 104 126];
y = [55 34 18 NaN 14 19 42 26];
```

```
multiline = maplineshape(x,y);
multiline.Project CRS = p

multiline =
  maplineshape with properties:

      NumParts: 2
      Geometry: "line"
  CoordinateSystemType: "planar"
      ProjectedCRS: [1x1 projcrs]
```

Create one individual line and one multiline as a 1-by-2 maplineshape array.

```
x = {[78 56 63],[83 106 NaN 104 126 113]};
y = {[55 34 18],[14 19 NaN 42 26 37]};
lineMultiline = maplineshape(x,y);
lineMultiline.Project CRS = p

lineMultiline=1x2 object
  1x2 maplineshape array with properties:

      NumParts: [1 2]
      Geometry: "line"
  CoordinateSystemType: "planar"
      ProjectedCRS: [1x1 projcrs]
```

Version History

Introduced in R2021b

See Also

Functions

readgeotable

Objects

mappointshape | mappolyshape | geolineshape

Topics

“Create Geospatial Tables”

mappolyshape

Polygon in planar coordinates

Description

A `mappolyshape` object represents a polygon or multipolygon in planar coordinates. A polygon is a region bounded by a closed curve and can include interior holes. A multipolygon is an individual polygon shape that includes multiple nonintersecting regions.

To represent a polygon or multipolygon in geographic coordinates, use a `geopolyshape` object instead.

Creation

To create `mappolyshape` objects, either:

- Import polygon data in planar coordinates as a geospatial table using the `readgeotable` function, and then query the `Shape` variable of the table.
- Use the `mappolyshape` function (described here).

Syntax

```
shape = mappolyshape(x,y)
```

Description

`shape = mappolyshape(x,y)` creates a `mappolyshape` object or array of `mappolyshape` objects with vertices at the specified `x`- and `y`-coordinates. The sizes of `x`, `y`, and the `mappolyshape` object array `shape` match.

The `mappolyshape` function assumes that `x` and `y` define polygons with valid topology. A polygon has valid topology when:

- Region interiors are to the right as you trace boundaries from vertex to vertex.
- The boundaries have no self-intersections.

In general, the outer boundaries of polygons with valid topology have vertices in clockwise order and the interior holes have vertices in counterclockwise order.

Input Arguments

x — x-coordinates

numeric vector | cell array of numeric vectors

`x`-coordinates, specified as a numeric vector or a cell array of numeric vectors.

- Create a polygon by specifying a vector, such as `[-113 -49 -100 -113]`.

- Create a polygon with holes or a multipolygon by specifying a vector and including breaks between the hole and region boundaries as NaN values, such as [69 90 105 79 69 NaN 6 52 43 14 6 NaN 18 32 22 18].
- Create an array of polygons and multipolygons by specifying a cell array of vectors, such as {[69 90 105 79 69],[6 52 43 14 6 NaN 18 32 22 18]}.

The NaN values in `x` must correspond to the NaN values in `y`.

The size of `x` must match the size of `y`. For cell arrays, the size of the vector in each cell of `x` must match the size of the vector in the corresponding cell of `y`.

Data Types: `double` | `cell`

y – y-coordinates

numeric vector | cell array of numeric vectors

`y`-coordinates, specified as a numeric vector or a cell array of numeric vectors.

- Create a polygon by specifying a vector, such as [39 45 19 39].
- Create a polygon with holes or a multipolygon by specifying a vector and including breaks between the hole and region boundaries as NaN values, such as [37 46 31 20 37 NaN 45 49 35 32 45 NaN 35 40 42 35].
- Create an array of polygons and multipolygons by specifying a cell array of vectors, such as {[37 46 31 20 37],[45 49 35 32 45 NaN 35 40 42 35]}.

The NaN values in `x` must correspond to the NaN values in `y`.

The size of `x` must match the size of `y`. For cell arrays, the size of the vector in each cell of `x` must match the size of the vector in the corresponding cell of `y`.

Data Types: `double` | `cell`

Properties

NumRegions – Number of regions

array of nonnegative integers

This property is read-only.

Number of regions, returned as an array of nonnegative integers. A region is a connected area such that any two points within the area can be connected by a path entirely within the area. Regions may contain holes.

For a `mappolyshape` scalar, the value of `NumRegions` is 1 when the `mappolyshape` object represents a single polygon and more than 1 when the object represents a multipolygon.

For a `mappolyshape` array, the size of `NumRegions` matches the size of the array.

Data Types: `double`

NumHoles – Number of holes

array of nonnegative integers

This property is read-only.

Number of holes in the polygon or multipolygon, returned as an array of nonnegative integers.

For a `mappolyshape` array, the size of `NumHoles` matches the size of the array.

Data Types: `double`

Geometry — Geometric type

"polygon" (default)

This property is read-only.

Geometric type, returned as "polygon".

Data Types: `string`

CoordinateSystemType — Coordinate system type

"planar" (default)

This property is read-only.

Coordinate system type, returned as "planar".

Data Types: `string`

ProjectedCRS — Projected coordinate reference system

[] (default) | `projcrs` object

Projected coordinate reference system (CRS), specified as a `projcrs` object. A projected CRS consists of a geographic CRS and several parameters that are used to transform coordinates to and from the geographic CRS.

Object Functions

<code>geoplot</code>	Plot points, lines, and polygons on map
<code>mapclip</code>	Clip shape to xy-limits in planar coordinates
<code>isinterior</code>	Query geographic or planar points in polygon
<code>ismultipoint</code>	Determine which array elements are multipoint shapes

Examples

Get Information About Imported Planar Polygons

Import a shapefile containing hydrographic data for Concord, MA as a geospatial table. The shapefile represents the data using polygons.

```
hydro = readgeotable("concord_hydro_area.shp");
```

Create a subtable that contains a polygon representing a pond. Get information about the polygon by querying the `Shape` variable of the table.

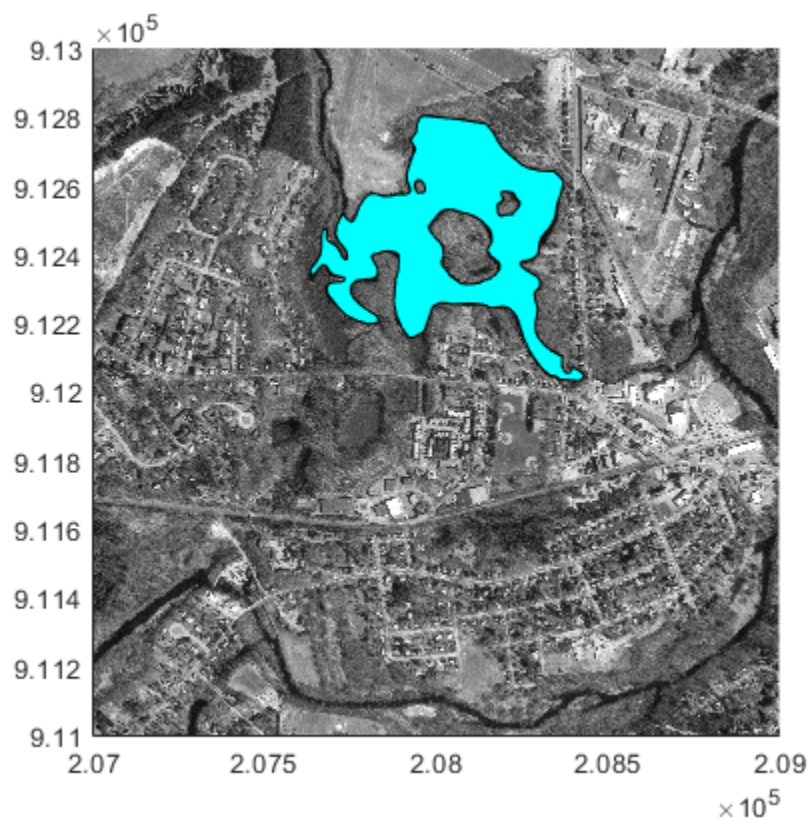
```
pond = hydro(14, :);
pond.Shape
```

```
ans =
    mappolyshape with properties:
```

```
    NumRegions: 1
    NumHoles: 3
    Geometry: "polygon"
    CoordinateSystemType: "planar"
    ProjectedCRS: [1x1 projcrs]
```

Import an orthophoto of Concord, MA, along with a map cells reference object and a colormap. Display the orthophoto and polygon on a map.

```
[ortho,R,cmap] = readgeoraster("concord_ortho_w.tif");
mapshow(ortho,cmap,R)
mapshow(pond,FaceColor="c")
```



Create Planar Polygons and Multipolygons

Create an individual polygon with no holes as a `mappolyshape` scalar. Specify the projected CRS as World Equidistant Cylindrical, which has the EPSG authority code 4087.

```
x = [-113 -49 -100 -113];
y = [39 45 19 39];
polyshp = mappolyshape(x,y);
```

```
p = projcrs(4087);
polyshp.ProjectedCRS = p
```

```

polyshp =
  mappolyshape with properties:

      NumRegions: 1
      NumHoles: 0
      Geometry: "polygon"
  CoordinateSystemType: "planar"
  ProjectedCRS: [1x1 projcrs]

```

Create a multipolygon with two regions and one hole as a mappolyshape scalar.

```

x = [69 90 105 79 69 NaN 6 52 43 14 6 NaN 18 32 22 18];
y = [37 46 31 20 37 NaN 45 49 35 32 45 NaN 35 40 42 35];
multipolygon = mappolyshape(x,y);
multipolygon.ProjectedCRS = p

```

```

multipolygon =
  mappolyshape with properties:

      NumRegions: 2
      NumHoles: 1
      Geometry: "polygon"
  CoordinateSystemType: "planar"
  ProjectedCRS: [1x1 projcrs]

```

Create two individual polygons as a 1-by-2 mappolyshape array. The second polygon contains a hole.

```

x = {[69 90 105 79 69],[6 52 43 14 6 NaN 18 32 22 18]};
y = {[37 46 31 20 37],[45 49 35 32 45 NaN 35 40 42 35]};
polyArray = mappolyshape(x,y);
polyArray.ProjectedCRS = p

```

```

polyArray=1x2 object
  1x2 mappolyshape array with properties:

      NumRegions: [1 1]
      NumHoles: [0 1]
      Geometry: "polygon"
  CoordinateSystemType: "planar"
  ProjectedCRS: [1x1 projcrs]

```

Version History

Introduced in R2021b

See Also

Functions

readgeotable

Objects

mappointshape | maplineshape | geopolyshape

Topics

“Create Geospatial Tables”

MapPostingsReference

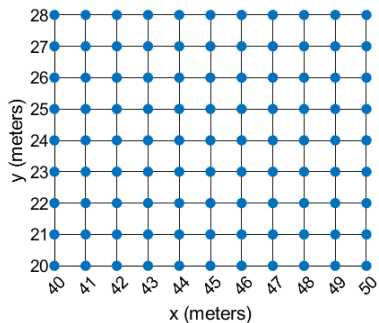
Reference raster postings to map coordinates

Description

A map postings raster reference object contains information that describes the relationship between a planar map coordinate system and an intrinsic coordinate system on page 1-1102 that is anchored to the columns and rows of a 2-D spatially referenced grid of point samples (or postings).

Typically, the raster is sampled regularly in the planar world x - and world y -coordinates of the map system, such that the intrinsic x and world x axes align and the intrinsic y and world y axes align. When this is true, the relationship between the two systems is rectilinear. More generally, and much more rarely, their relationship is affine. The affine relationship allows for a possible rotation (and skew). In either case, rectilinear or affine, the sample spacing from row to row need not equal the sample spacing from column to column.

This image illustrates a 9-by-11 planar raster of postings. The postings are spaced 1 meter apart in x and y , cover x values in the range [40,50] in meters, and cover y values in the range [20,28] in meters. The boundary of the raster of postings is a rectangle with edges that pass through the outermost postings.



To reference a raster of cells to planar map coordinates, use a `MapCellsReference` object instead.

Creation

You can use these functions to create `MapPostingsReference` objects:

- `readgeoraster` — Import a raster data file as an array and a reference object.
- `maprefpostings` — Create a map raster reference object by specifying the x and y world limits of the raster and either the size of the raster or the spacing of the postings.
- `maprasterref` — Convert a world file to a map raster reference object.
- `refmatToMapRasterReference` — Convert a referencing matrix to a map raster reference object.

Properties

XWorldLimits — Limits of raster in world x-coordinates

[0.5 2.5] (default) | two-element row vector

Limits of raster in world x-coordinates, specified as a two-element row vector of the form [xMin xMax].

The value of the ProjectedCRS property determines the length units for the raster. This code shows how to find the length units for a raster associated with the map postings reference object R.

```
R.ProjectedCRS.LengthUnit
```

```
Example: [207000 209000]
```

Data Types: double

YWorldLimits — Limits of raster in world y-coordinates

[0.5 2.5] (default) | two-element row vector

Limits of raster in world y-coordinates, specified as a two-element row vector of the form [yMin yMax].

The value of the ProjectedCRS property determines the length units for the raster. This code shows how to find the length units for a raster associated with the map postings reference object R.

```
R.ProjectedCRS.LengthUnit
```

```
Example: [911000 913000]
```

Data Types: double

RasterSize — Number of rows and columns of the raster or image associated with the referencing object

[2 2] (default) | two-element vector of positive integers

Number of rows and columns of the raster or image associated with the referencing object, specified as a two-element vector, [m n], where *m* represents the number of rows and *n* the number of columns. For convenience, you can assign a size vector having more than two elements. This enables assignments like `R.RasterSize = size(RGB)`, where RGB is *m*-by-*n*-by-3. In cases like this, the object stores only the first two elements of the size vector and ignores the higher (nonspatial) dimensions. *m* and *n* must be positive in all cases and must be 2 or greater.

```
Example: [200 300]
```

Data Types: double

RasterInterpretation — Geometric nature of the raster

'postings' (default)

Geometric nature of the raster, specified as 'postings'. The value 'postings' indicates that the raster comprises a grid of sample points, where rows or columns of samples run along the edge of the grid. For an *m*-by-*n* raster, points with an intrinsic x-coordinate of 1 or *n* or an intrinsic y-coordinate of 1 or *m* fall right on an edge (or corner) of the raster.

Cannot be set.

Data Types: char

ColumnsStartFrom — Edge from which column indexing starts

'south' (default) | 'north'

Edge from which column indexing starts, specified as 'south' or 'north'.

Example: ColumnsStartFrom: 'south'

Data Types: char

RowsStartFrom — Edge from which row indexing starts

'west' (default) | 'east'

Edge from which row indexing starts, specified as 'west' or 'east'.

Example: RowsStartFrom: 'east'

Data Types: char

SampleSpacingInWorldX — East-west distance between adjacent postings

2 (default) | positive numeric scalar

East-west distance between adjacent postings, specified as a positive numeric scalar. The value is constant throughout the raster.

Example: 2.5

Data Types: double

SampleSpacingInWorldY — North-south distance between adjacent postings

2 (default) | positive numeric scalar

North-south distance between adjacent postings, specified as a positive numeric scalar. The value is constant throughout the raster.

Example: 2.5

Data Types: double

RasterExtentInWorldX — Extent of the full raster or image as measured in the world system in a direction parallel to its rows

2 (default) | positive numeric scalar

This property is read-only.

Extent of the full raster or image as measured in the world system in a direction parallel to its rows, specified as a positive numeric scalar. In the case of a rectilinear geometry, which is most typical, this is the horizontal direction (east-west).

Data Types: double

RasterExtentInWorldY — Extent of the full raster or image as measured in the world system in a direction parallel to its columns

2 (default) | positive numeric scalar

This property is read-only.

Extent of the full raster or image as measured in the world system in a direction parallel to its columns. In the case of a rectilinear geometry, which is most typical, this is the vertical direction (north-south).

Data Types: double

XIntrinsicLimits — Raster limits in intrinsic x-coordinates

[1 2] (default) | two-element row vector of positive integers

This property is read-only.

Raster limits in intrinsic x-coordinates, specified as a two-element row vector of positive integers, [xMin xMax]. For an m -by- n raster, XIntrinsicLimits equals [1 m], because the RasterInterpretation is 'postings'.

Example: [2 4]

Data Types: double

YIntrinsicLimits — Raster limits in intrinsic y-coordinates

[1 2] (default) | two-element row vector of positive integers

This property is read-only.

Raster limits in intrinsic y-coordinates, specified as a two-element row vector of positive integers, [yMin yMax]. For an m -by- n raster with RasterInterpretation equal to 'postings', YIntrinsicLimits equals [1 m].

Data Types: double

TransformationType — Type of geometric relationship between intrinsic and world systems

'rectilinear' (default) | 'affine'

This property is read-only.

Type of geometric relationship between the intrinsic coordinate system and the world coordinate system, specified as either 'rectilinear' or 'affine'. Its value is 'rectilinear' when world x depends only on intrinsic x and vice versa, and world y depends only on intrinsic y and vice versa. When the value is 'rectilinear', the image displays without rotation in the world system, although it might be flipped. Otherwise, the value is 'affine'.

Data Types: char

CoordinateSystemType — Type of coordinate system to which the image or raster is referenced

'planar' (default)

This property is read-only.

Type of coordinate system to which the image or raster is referenced, specified as 'planar'.

Data Types: char

ProjectedCRS — Projected coordinate reference system

[] (default) | projcrs object

Projected coordinate reference system (CRS), specified as a projcrs object. A projected CRS consists of a geographic CRS and several parameters that are used to transform coordinates to and from the geographic CRS.

The value of `ProjectedCRS` determines the length units for the raster. To find the length units, query the `LengthUnit` property of the `projcrs` object.

Object Functions

<code>contains</code>	Determine if geographic or map raster contains points
<code>firstCornerX</code>	Return world x-coordinate of map raster index (1,1)
<code>firstCornerY</code>	Return world y-coordinate of map raster index (1,1)
<code>intrinsicToWorld</code>	Transform intrinsic to planar world coordinates
<code>sizesMatch</code>	Determine if geographic or map raster object and image or raster are size-compatible
<code>worldFileMatrix</code>	Return world file parameters for transformation
<code>worldGrid</code>	World coordinates of raster elements
<code>worldToDiscrete</code>	Transform planar world to discrete coordinates
<code>worldToIntrinsic</code>	Transform planar world to intrinsic coordinates

Examples

Display Planar Raster of Regularly Spaced Posting Points

Import elevation data as an array and a `MapPostingsReference` object. Then, display the data on a map.

For this example, specify the file to import by extracting a GZ file into a temporary directory. Then, set the name of the first extracted file to a variable.

```
filenames = gunzip('sanfranciscos.dem.gz', tempdir);
filename1 = filenames{1};
```

Import the data by using the `readgeoraster` function. Prepare the data for plotting by specifying the output type as `'double'` and by replacing missing data with NaN values.

```
[Z,R] = readgeoraster(filename1, 'OutputType', 'double');
info = georasterinfo(filename1);
Z = standardizeMissing(Z, info.MissingDataIndicator);
```

View the properties of the `MapPostingsReference` object.

R

R =

MapPostingsReference with properties:

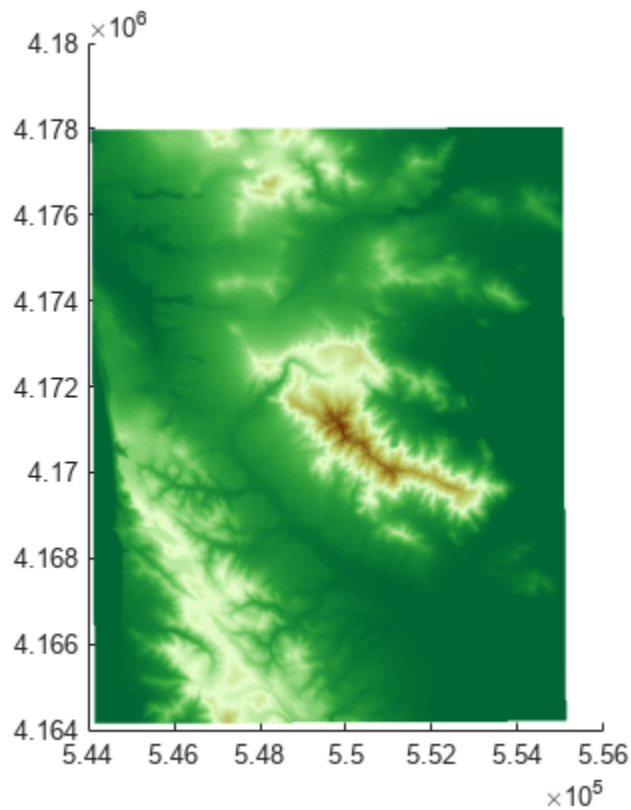
```

    XWorldLimits: [544050 555150]
    YWorldLimits: [4164120 4178070]
    RasterSize: [466 371]
    RasterInterpretation: 'postings'
    ColumnsStartFrom: 'north'
    RowsStartFrom: 'west'
    SampleSpacingInWorldX: 30
    SampleSpacingInWorldY: 30
    RasterExtentInWorldX: 11100
    RasterExtentInWorldY: 13950
    XIntrinsicLimits: [1 371]
    YIntrinsicLimits: [1 466]
```

```
TransformationType: 'rectilinear'  
CoordinateSystemType: 'planar'  
ProjectedCRS: [1x1 projcrs]
```

Display the elevation data as a surface on a map. Apply a colormap that is appropriate for elevation data.

```
mapshow(Z,R, 'DisplayType', 'surface')  
demcmmap(Z)
```



More About

Intrinsic Coordinate System

A 2-D Cartesian system with its x-axis running parallel to the rows of a raster or image and its y-axis running parallel to the columns. x increases by 1 from column to column, and y increases by 1 from row to row.

The Mapping Toolbox and Image Processing Toolbox use the convention for the location of the origin relative to the raster cells or sampling points such that, at a sample location or at the center of a cell, x has an integer value equal to the column index. Likewise, at a sample location or at the center of a cell, y has an integer value equal to the row index. For details, see Image Coordinate Systems (Image Processing Toolbox).

Version History

Introduced in R2013b

See Also

Functions

[maprefpostings](#) | [maprasterref](#) | [readgeoraster](#)

Objects

[GeographicCellsReference](#) | [GeographicPostingsReference](#) | [MapCellsReference](#)

Topics

“Spatially Reference Imported Rasters”

mapprofile

Interpolate between waypoints on terrain

Syntax

```
[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon)
[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,units)
[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,units,trackmethod)
[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,units,trackmethod,interpmethod)

[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,ellipsoid)
[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,ellipsoid,trackmethod)
[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,ellipsoid,trackmethod,
interpmethod)
```

```
mapprofile(____)
[____] = mapprofile
```

Description

Use Unit Sphere and Get Range in Degrees

[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon) interpolates intermediate points between the waypoints specified by lat and lon. You must specify the elevation data Z and spatial reference R for the terrain. For each intermediate point, the function returns the interpolated terrain height in zq, the distance from the first waypoint (the range) in distq, the latitude in latq, and the longitude in lonq.

Specify Range Units

[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,units) specifies the units units for distq. The function calculates surface distances using the default radius of the Earth (equivalent to 6371 kilometers).

[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,units,trackmethod) additionally specifies whether intermediate points are along great circles or rhumb lines.

[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,units,trackmethod,interpmethod) additionally specifies the interpolation method.

Specify Reference Ellipsoid

[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,ellipsoid) specifies the reference ellipsoid for the coordinates. This syntax returns distq using the units of the semimajor axis of the reference ellipsoid.

[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,ellipsoid,trackmethod) additionally specifies whether intermediate points are along great circle tracks or rhumb line tracks.

[zq,distq,latq,lonq] = mapprofile(Z,R,lat,lon,ellipsoid,trackmethod,interpmethod) additionally specifies the interpolation method.

Display and Interactively Select Coordinates

`mapprofile(___)` displays an elevation profile of the intermediate points in a new figure on an `axesm`-based map.

`[___] = mapprofile` enables you to interactively select waypoints on the current `axesm`-based map. If the current object on the map is a regular data grid, then the function uses the `z`-coordinate data (the `ZData` property) as the terrain elevation data. Otherwise, the function uses `z`-coordinate data from the first regular data grid it finds on the map. If the grid does not have `z`-coordinate data, then the function uses the color data (the `CData` property), instead. To finish selecting points, press **Enter**.

Examples

Compute Elevation Profile Along Track

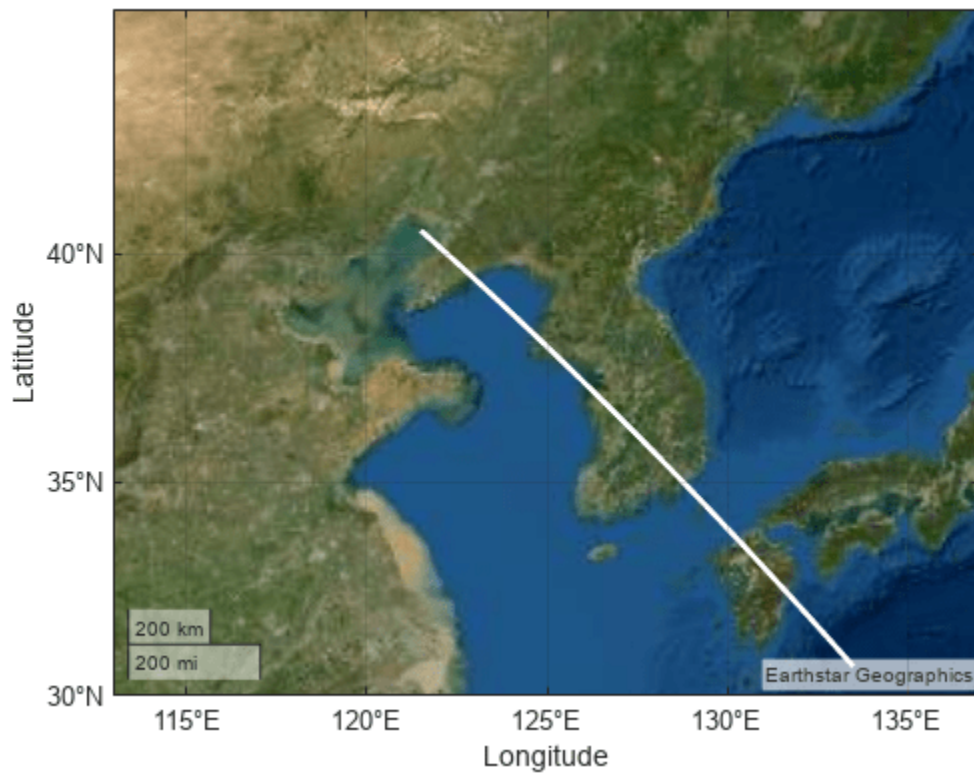
Load elevation data and a geographic cells reference object for the Korean peninsula. Compute the elevation profile between two points in the region, specifying the units for the range (`distq`) as kilometers. By default, the `mapprofile` function uses bilinear interpolation along a great circle track.

```
load korea5c

lat = [40.5 30.7];
lon = [121.5 133.5];
[zq,distq,latq,lonq] = mapprofile(korea5c,korea5cR,lat,lon,"km");
```

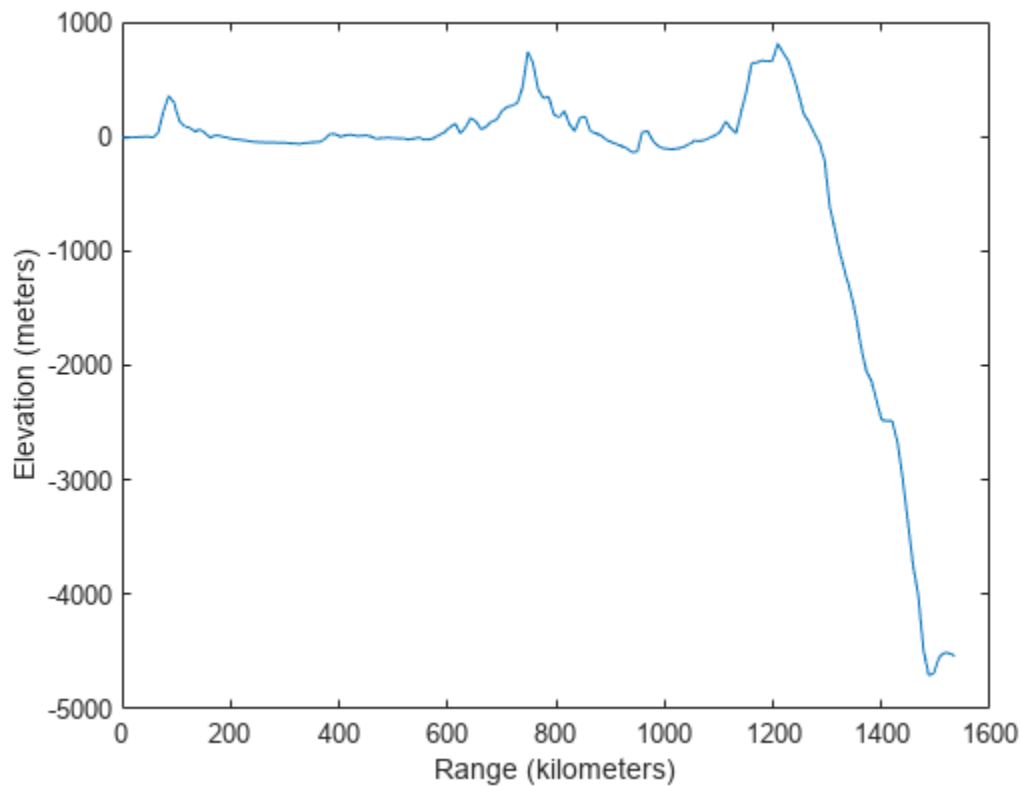
Plot the track over a satellite basemap.

```
figure
geolimits(korea5cR.LatitudeLimits,korea5cR.LongitudeLimits)
hold on
geoplot(latq,lonq,"w","LineWidth",2)
geobasemap satellite
```



Display the elevation profile on a Cartesian plot.

```
figure
plot(distq,zq)
xlabel("Range (kilometers)")
ylabel("Elevation (meters)")
```

Specify Track Method and Interpolation Method

Load world topography data into the workspace as an array and a geographic raster reference object. Calculate an elevation profile for the great circle track between San Francisco and New York City, using nearest neighbor interpolation.

```
load topo60c

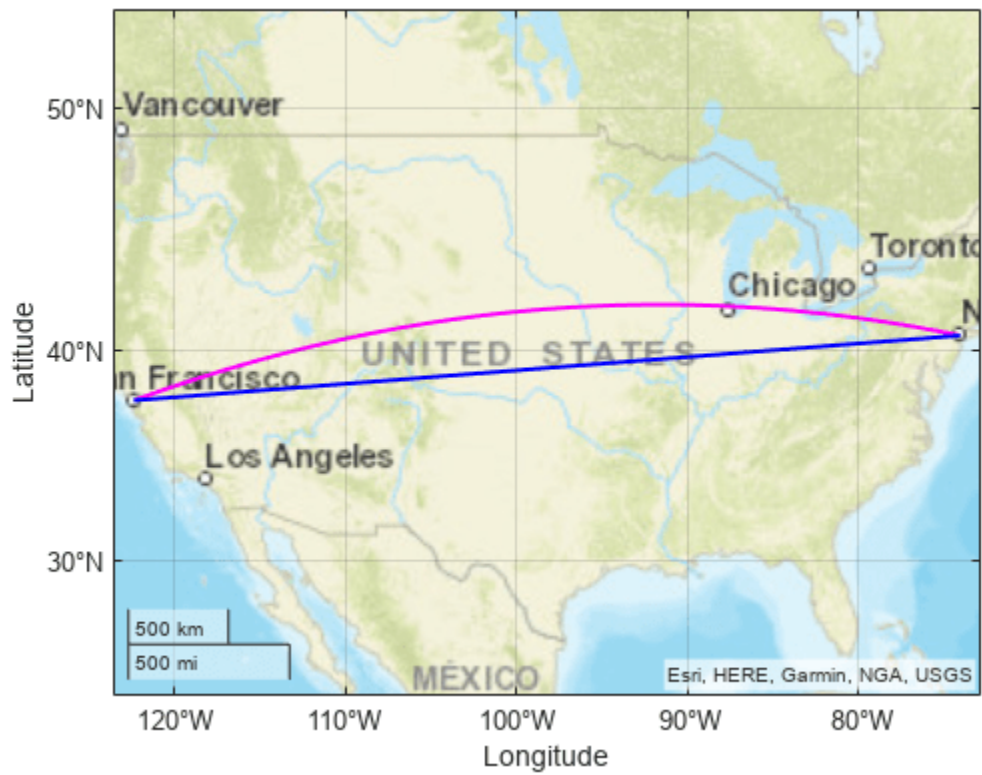
lat = [37.77 40.71];
lon = [-122.41 -74.01];
[zqgc,distqgc,latqgc,lonqgc] = mapprofile(topo60c,topo60cR,lat,lon,"km","gc","nearest");
```

Calculate an elevation profile for the rhumb line track between the same cities, using bicubic interpolation.

```
[zqrh,distqrh,latqrh,lonqrh] = mapprofile(topo60c,topo60cR,lat,lon,"km","rh","bicubic");
```

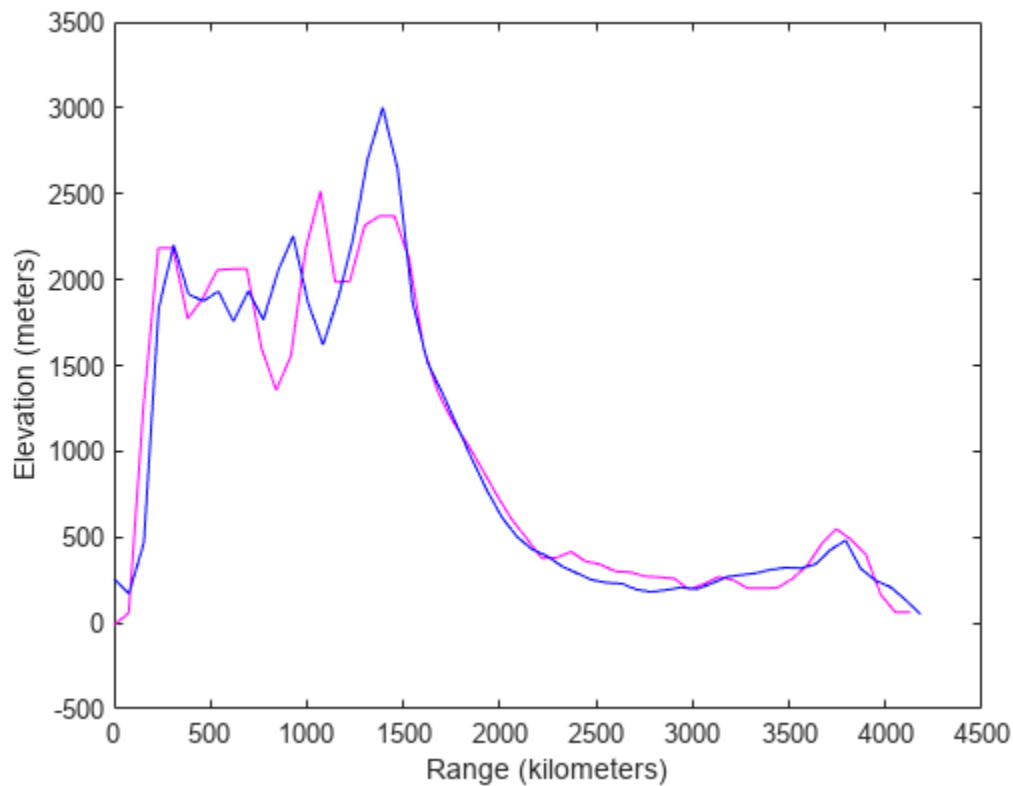
Display both tracks on a map. Use magenta for the great circle track and blue for the rhumb line track.

```
figure
geoplot(latqgc,lonqgc,"m","LineWidth",1.5)
hold on
geoplot(latqrh,lonqrh,"b","LineWidth",1.5)
geobasemap streets
```



Display both elevation profiles on a Cartesian plot.

```
figure
plot(distqgc,zqgc,"m")
hold on
plot(distqrh,zqrh,"b")
xlabel("Range (kilometers)")
ylabel("Elevation (meters)")
```



Display 3-D Elevation Profile on Map

Load terrain elevation data for the Korean peninsula into the workspace as an array and a geographic cells reference object. Specify the coordinates of four waypoints.

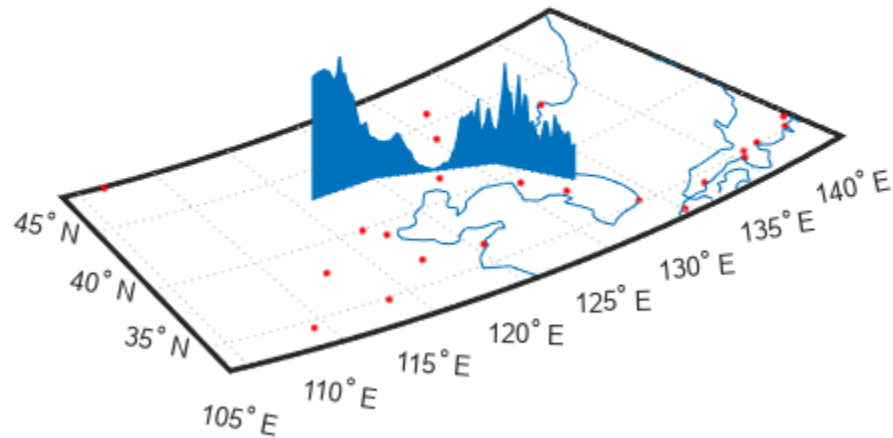
```
load korea5c
lat = [43 43 41 38];
lon = [116 120 126 128];
```

Display the elevation profile on a map by omitting the output arguments. When you specify more than two waypoints, the function displays the result in 3-D.

```
mapprofile(korea5c,korea5cR,lat,lon)
```

Add coastlines and city locations to the map.

```
load coastlines
plotm(coastlat,coastlon)
geoshow("worldcities.shp","Marker",".", "Color","r")
```



Input Arguments

Z — Elevation data grid

m-by-n array

Elevation data grid, specified as an *m-by-n* array.

Data Types: `single` | `double`

R — Spatial reference for Z

`GeographicCellsReference` object | `GeographicPostingsReference` object

Spatial reference for Z, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object. The `RasterSize` property of R must be consistent with `size(Z)`.

lat — Latitude coordinates of waypoints

vector

Latitude coordinates of the waypoints, in degrees, specified as a vector. You can separate sets of waypoints into line sequences using NaN values. The NaN values in `lat` must correspond to the NaN values in `lon`.

The size of `lat` must match the size of `lon`.

Data Types: `single` | `double`

lon — Longitude coordinates of waypoints

vector

Longitude coordinates of the waypoints, in degrees, specified as a vector. You can separate sets of waypoints into line sequences using NaN values. The NaN values in `lon` must correspond to the NaN values in `lat`.

The size of `lat` must match the size of `lon`.

Data Types: `single` | `double`

units — Units for distq

"degrees" (default) | "degree" | "deg" | "kilometer" | "kilometers" | "km" | ...

Units for `distq`, specified as one of these options:

- These angular units.

Value	Unit Name
"degree", "degrees", "deg"	Degrees
"radian", "radians", "rad"	Radians

- Any length unit supported by the `validateLengthUnit` function.

Value	Unit Name
"m", "meter", "meters", "metre", "metres"	Meters
"cm", "centimeter", "centimeters", "centimetre", "centimetres"	Centimeters
"mm", "millimeter", "millimeters", "millimetre", "millimetres"	Millimeters
"micron", "microns"	Microns
"km", "kilometer", "kilometers", "kilometre", "kilometers"	Kilometers
"nm", "naut mi", "nautical mile", "nautical miles"	Nautical miles
"ft", "international ft", "foot", "international foot", "feet", "international feet"	Feet
"in", "inch", "inches"	Inches
"yd", "yds", "yard", "yards"	Yards
"mi", "mile", "miles", "international mile", "international miles"	Miles
"sf", "survey ft", "US survey ft", "U.S. survey ft", "survey foot", "US survey foot", "U.S. survey foot", "survey feet", "US survey feet", "U.S. survey feet"	U.S. survey feet

Value	Unit Name
"sm", "survey mile", "survey miles", "statute mile", "statute miles", "US survey mile", "US survey miles", "U.S. survey mile(s)", "U.S. survey miles"	U.S. survey miles (statute miles)
"Clarke's foot", "Clarkes foot"	Clarke's feet
"German legal metre", "German legal meter"	German legal metres
"Indian foot"	Indian feet

This argument is case insensitive.

Data Types: `char` | `string`

ellipsoid — Reference ellipsoid

[1 0] (default) | `referenceSphere` object | `referenceEllipsoid` object | `oblateSpheroid` object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element vector of the form `[semimajor_axis eccentricity]`, where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of `[1 0]` represents the unit sphere.

When you specify the `ellipsoid` argument, the `mapprofile` function returns `distq` in the units of the semimajor axis of the reference ellipsoid.

If you do not specify the `ellipsoid` argument and R contains a `geocrs` object in its `GeographicCRS` property, then the `mapprofile` function uses the ellipsoid contained in the `geocrs` object. For example, given a reference object `R`, the function uses `R.GeographicCRS.Spheroid`.

trackmethod — Track method

"gc" (default) | "rh"

Track method, specified as one of these options:

- "rh" — Find track points along rhumb line paths.
- "gc" — For spheres, find track points along great circle paths. For ellipsoids, find track points along geodesic paths.

Data Types: `char` | `string`

interpmethod — Interpolation method

"bilinear" (default) | "bicubic" | "nearest"

Interpolation method, specified as one of these options:

- "bilinear" — Use linear interpolation.
- "bicubic" — Use cubic interpolation.
- "nearest" — Use nearest neighbor interpolation.

Data Types: char | string

Output Arguments

zq — Terrain heights of intermediate points

numeric vector

Terrain heights of the intermediate points, returned as a numeric vector. The function calculates the terrain heights using the same units as Z.

The number of intermediate points depends on the density of the terrain elevation data. When you increase the density of the data, the `mapprofile` function returns more intermediate points.

The sizes of `zq`, `distq`, `latq`, and `lonq` match.

distq — Range

numeric vector

Range, returned as a numeric vector. For each intermediate point, the range is the distance from the first point to the intermediate point. If you separate the input waypoints into sequences using NaN values, then the function calculates the distance of each intermediate waypoint from the first waypoint in the corresponding sequence.

By default, the units for `distq` are degrees. You can specify the units for `distq` using the `units` or `ellipsoid` argument.

The number of intermediate points depends on the density of the terrain elevation data. When you increase the density of the data, the `mapprofile` function returns more intermediate points.

The sizes of `zq`, `distq`, `latq`, and `lonq` match.

latq — Latitudes of intermediate points

numeric vector

Latitudes of the intermediate points, in degrees, returned as a numeric vector.

The number of intermediate points depends on the density of the terrain elevation data. When you increase the density of the data, the `mapprofile` function returns more intermediate points.

The sizes of `zq`, `distq`, `latq`, and `lonq` match.

lonq — Longitudes of intermediate point

numeric vector

Longitudes of the intermediate points, in degrees, returned as a numeric vector.

The number of intermediate points depends on the density of the terrain elevation data. When you increase the density of the data, the `mapprofile` function returns more intermediate points.

The sizes of `zq`, `distq`, `latq`, and `lonq` match.

Version History

Introduced before R2006a

R2022b: `mapprofile` will not accept referencing vectors or referencing matrices as input
Not recommended starting in R2022b

The `mapprofile` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

R2020b: `mapprofile` uses reference ellipsoid information in raster reference objects

When you specify `R` as a geographic raster reference object, the `mapprofile` function uses the reference ellipsoid within the object. To find the reference ellipsoid for a geographic raster reference object, `R`, first get its geographic coordinate reference system as a `geocrs` object. Then, query the `Spheroid` property of the `geocrs` object.

```
g = R.GeographicCRS;  
g.Spheroid
```

To use `mapprofile` with a different ellipsoid, specify the `ellipsoid` argument.

See Also

Functions

`geointerp` | `los2`

maprasterref

(Not recommended) Create map raster reference object

Note The `maprasterref` function is not recommended, except when creating a raster reference object from a world file matrix. To specify options using name-value arguments, use the `maprefcells` or `maprefpostings` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
R = maprasterref(W,rasterSize)
R = maprasterref(W,rasterSize,rasterInterpretation)
R = maprasterref(Name,Value)
```

Description

`R = maprasterref(W,rasterSize)` creates a reference object for a raster of cells referenced to planar coordinates using the world file matrix `W` and raster size `rasterSize`.

`R = maprasterref(W,rasterSize,rasterInterpretation)` specifies the geometric nature of the raster. When the raster contains posting point samples referenced to planar coordinates, specify `rasterInterpretation` as "postings". The default for `rasterInterpretation` is "cells", which specifies a raster of cells.

`R = maprasterref(Name,Value)` specifies options using name-value arguments.

Examples

Create Map Reference Object from World File Matrix

Create a reference object for a raster of cells with size 1000-by-2000, cell `xy`-extents of 0.5 linear units, world `x`-limits of [207000, 208000] linear units, and world `y`-limits of [912500, 913000] linear units. Orient the raster using a convention typical for imagery, where image rows run from west to east and image columns run from north to south.

Specify the world file matrix using these values:

Value	Explanation
0.5	The rows of the raster start from the west and each cell is 0.5 linear units wide.
207000.25	World <code>x</code> -coordinate of the first cell center.
-0.5	The rows of the raster start from the north and each cell is 0.5 linear units tall.
912999.75	World <code>y</code> -coordinate of the first cell center.

```
W = [0.5 0 207000.25; 0 -0.5 912999.75];
```

Create the reference object.

```
R = maprasterref(W, [1000 2000], "cells")
```

```
R =
```

```
MapCellsReference with properties:
```

```
    XWorldLimits: [207000 208000]
    YWorldLimits: [912500 913000]
    RasterSize: [1000 2000]
    RasterInterpretation: 'cells'
    ColumnsStartFrom: 'north'
    RowsStartFrom: 'west'
    CellExtentInWorldX: 1/2
    CellExtentInWorldY: 1/2
    RasterExtentInWorldX: 1000
    RasterExtentInWorldY: 500
    XIntrinsicLimits: [0.5 2000.5]
    YIntrinsicLimits: [0.5 1000.5]
    TransformationType: 'rectilinear'
    CoordinateSystemType: 'planar'
    ProjectedCRS: []
```

Input Arguments

W — World file matrix

2-by-3 numeric array

World file matrix, specified as a 2-by-3 numeric array. A world file matrix defines a transformation that maps intrinsic coordinates to world coordinates.

The form of *W* depends on whether the intrinsic and world axes have a rectilinear relationship, where the intrinsic and world axes align, or an affine relationship, where the intrinsic axes are rotated with respect to the world axes.

When the relationship is rectilinear, specify *W* using the form `[xspacing 0 x; 0 yspacing y]`, where

- `xspacing` determines the `RowsStartFrom` and the `CellExtentInWorldX` or `SampleSpacingInWorldX` properties of *R*.
 - When `xspacing` is positive, `RowsStartFrom` is 'west'. When `xspacing` is negative, `RowsStartFrom` is 'east'.
 - `CellExtentInWorldX` or `SampleSpacingInWorldX` is `abs(xspacing)`.
- `yspacing` determines the `ColumnsStartFrom` and the `CellExtentInWorldY` or `SampleSpacingInWorldY` properties of *R*.
 - When `yspacing` is positive, `ColumnsStartFrom` is 'south'. When `yspacing` is negative, `ColumnsStartFrom` is 'north'.
 - `CellExtentInWorldY` or `SampleSpacingInWorldY` is `abs(yspacing)`.
- `x` and `y` are the world *xy*-coordinates of the first cell center or posting point. For a spatially referenced raster *A*, the first cell center or posting point is the spatial location associated with `A(1,1,:)`.

When the relationship is affine, specify W so that $\begin{bmatrix} x_w \\ y_w \end{bmatrix} = W \cdot \begin{bmatrix} x_i - 1 \\ y_i - 1 \\ 1 \end{bmatrix}$, where (x_i, y_i) is a location in intrinsic coordinates and (x_w, y_w) is the same location in world coordinates.

rasterSize — Number of rows and columns

two-element vector

Number of rows and columns of the raster, specified as a two-element vector of the form $[m \ n]$, where m is the number of rows and n is the number of columns.

For convenience, you can specify this argument as a vector with more than two elements, such as the size of an RGB image (m -by- n -by-3). The `maprasterref` function uses only the first two elements of the size vector.

rasterInterpretation — Geometric nature of raster

"cells" (default) | "postings"

Geometric nature of the raster, specified as one of these options:

- "cells" — The raster is a grid of quadrangular cells. The boundary of the raster is made up of the outermost boundaries of the outermost cells.
- "postings" — The raster is a grid of posting point samples. The boundary of the raster is made up of sampling points along the edge of the raster.

For more information about cells and posting points, see "Spatially Reference Imported Rasters".

The corresponding property of the reference object, `RasterInterpretation`, is read-only after you create the object.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `maprasterref("XWorldLimits",[207000 208000],"YWorldLimits",[912500 913000])` creates a map cells reference object with x-values in the range [207000, 208000] linear units and y-values in the range [912500, 913000] linear units.

XWorldLimits — x-limits in world coordinates

[0.5 2.5] (default) | two-element vector

x-limits in world coordinates of the rectangle that bounds the georeferenced raster, specified as a two-element vector of the form $[xMin \ xMax]$.

YWorldLimits — y-limits in world coordinates

[0.5 2.5] (default) | two-element vector

y-limits in world coordinates of the rectangle that bounds the georeferenced raster, specified as a two-element vector of the form $[yMin \ yMax]$.

RasterSize — Number of rows and columns

[2 2] (default) | two-element vector of positive integers

Number of rows and columns of the raster, specified as a two-element vector [m n], where m is the number of rows and n is the number of columns.

For convenience, you can specify `RasterSize` as a vector with more than two elements, such as the size of an RGB image (*m-by-n-by-3*). The `maprasterref` function uses only the first two elements of the size vector.

RasterInterpretation — Geometric nature of raster

"cells" (default) | "postings"

Geometric nature of the raster, specified as one of these options:

- "cells" — The raster is a grid of quadrangular cells. The boundary of the raster is made up of the outermost boundaries of the outermost cells.
- "postings" — The raster is a grid of posting point samples. The boundary of the raster is made up of sampling points along the edge of the raster.

For more information about cells and posting points, see “Spatially Reference Imported Rasters”.

The corresponding property of the raster reference object is read-only after you create the object.

Data Types: char | string

ColumnsStartFrom — Edge from which column indexing starts

"south" (default) | "north"

Edge from which column indexing starts, specified as "south" or "north".

Data Types: char | string

RowsStartFrom — Edge from which row indexing starts

"west" (default) | "east"

Edge from which row indexing starts, specified as "west" or "east".

Data Types: char | string

Output Arguments**R — Map raster reference object**

MapCellsReference object | MapPostingsReference object

Map raster reference object, returned as a `MapCellsReference` or `MapPostingsReference` object. The value of R depends on the value of the `rasterInterpretation` argument or `RasterInterpretation` name-value argument.

rasterInterpretation or RasterInterpretation	R
"cells"	MapCellsReference object
"postings"	MapPostingsReference object

Tips

- When you create a reference object by using the `R = maprasterref(Name, Value)` syntax, the function assumes the raster has a rectilinear relationship between the intrinsic and world systems and sets the read-only property `TransformationType` to `'rectilinear'`. If your raster is rotated with respect to the world system, set the `TransformationType` property to `'affine'` by specifying a world matrix or by using the `maprefcells` or `maprefpostings` function instead.

Version History

Introduced in R2011a

R2015b: maprasterref is not recommended

Not recommended starting in R2015b

The `maprasterref` function is not recommended, except when creating a reference object from a world file matrix. To specify options using name-value arguments, use the `maprefcells` or `maprefpostings` function instead.

- Create a reference object for a grid of rectangular cells referenced to world xy-coordinates by using the `maprefcells` function.
- Create a reference object for a grid of posting point samples referenced to world coordinates by using the `maprefpostings` function.

See Also

Functions

`worldfileread` | `maprefcells` | `maprefpostings` | `georasterref` | `worldFileMatrix`

Topics

“Spatially Reference Imported Rasters”

maprefcells

Reference raster cells to map coordinates

Syntax

```
R = maprefcells()  
R = maprefcells(xlimits,ylimits,rasterSize)  
R = maprefcells(xlimits,ylimits,xcellextent,ycellextent)  
R = maprefcells(xlimits,ylimits, __ ,Name,Value)
```

Description

`R = maprefcells()` returns a default referencing object for a regular raster of cells in planar (map) coordinates.

`R = maprefcells(xlimits,ylimits,rasterSize)` constructs a referencing object for a raster of cells spanning the specified limits in planar coordinates, with the numbers of rows and columns specified by `rasterSize`.

`R = maprefcells(xlimits,ylimits,xcellextent,ycellextent)` allows the cell extents to be set precisely. If necessary, `maprefcells` adjusts the limits of the raster slightly to ensure an integer number of cells in each dimension.

`R = maprefcells(xlimits,ylimits, __ ,Name,Value)` allows the directions of the columns and rows to be specified via name-value pairs.

Examples

Construct Referencing Object with Raster Interpretation of Cells

Define latitude and longitude limits and dimensions of the image. The image follows the popular convention in which world *x* coordinates increase from column to column and world *y* coordinates decrease from row to row.

```
xlimits = [207000 208000];  
ylimits = [912500 913000];  
rasterSize = [1000 2000]
```

```
rasterSize = 1x2  
           1000    2000
```

Create the referencing object specifying the raster size.

```
R = maprefcells(xlimits,ylimits,rasterSize, ...  
              'ColumnsStartFrom','north')
```

```
R =  
  MapCellsReference with properties:
```

```

XWorldLimits: [207000 208000]
YWorldLimits: [912500 913000]
  RasterSize: [1000 2000]
RasterInterpretation: 'cells'
  ColumnsStartFrom: 'north'
  RowsStartFrom: 'west'
  CellExtentInWorldX: 1/2
  CellExtentInWorldY: 1/2
RasterExtentInWorldX: 1000
RasterExtentInWorldY: 500
  XIntrinsicLimits: [0.5 2000.5]
  YIntrinsicLimits: [0.5 1000.5]
TransformationType: 'rectilinear'
CoordinateSystemType: 'planar'
ProjectedCRS: []

```

Obtain the same result by specifying the cell extents. For this example, the pixels are 1/2 meter square, referenced to a planar map coordinate system (the "world" system).

```
extent = 1/2;
```

```
R = maprefcells(xlimits,ylimits,extent,extent, ...
  'ColumnsStartFrom','north')
```

```
R =
```

```
MapCellsReference with properties:
```

```

XWorldLimits: [207000 208000]
YWorldLimits: [912500 913000]
  RasterSize: [1000 2000]
RasterInterpretation: 'cells'
  ColumnsStartFrom: 'north'
  RowsStartFrom: 'west'
  CellExtentInWorldX: 1/2
  CellExtentInWorldY: 1/2
RasterExtentInWorldX: 1000
RasterExtentInWorldY: 500
  XIntrinsicLimits: [0.5 2000.5]
  YIntrinsicLimits: [0.5 1000.5]
TransformationType: 'rectilinear'
CoordinateSystemType: 'planar'
ProjectedCRS: []

```

Input Arguments

xlimits — Limits in the x direction

[0.5 2.5] (default) | 1-by-2 numeric vector

Limits in the x direction, specified as a 1-by-2 numeric vector. The value of `xlimits` determines the `XWorldLimits` property of `R`.

Example: `xlimits = [207000 208000];`

ylimits – Limits in the y direction

[0.5 2.5] (default) | 1-by-2 numeric vector

Limits in the y direction, specified as a 1-by-2 numeric vector. The value of `ylimits` determines the `YWorldLimits` property of `R`.

Example: `ylimits = [912500 913000];`

rasterSize – Size of the raster

[2 2] (default) | 1-by-2 numeric vector

Size of the raster, specified as a 1-by-2 numeric vector.

Example: `rasterSize = [180 360];`

xcellextent – Width of cells

1 (default) | numeric scalar

Width of cells, specified as a numeric scalar. The value of `xcellextent` determines the `CellExtentInWorldX` property of `R`.

Example: `xcellextent = 1.5`

ycllextent – Height of cells

1 (default) | numeric scalar

Height of cells, specified as a numeric scalar. The value of `ycllextent` determines the `CellExtentInWorldY` property of `R`.

Example: `ycllextent = 1.5`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `R = maprefcells(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')`

ColumnsStartFrom – Edge from which column indexing starts

'south' (default) | 'north'

Edge from which column indexing starts, specified as 'north' or 'south'.

Example: `R = maprefcells(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')`

Data Types: char | string

RowsStartFrom – Edge from which row indexing starts

'west' (default) | 'east'

Edge from which column indexing starts, specified as 'west' or 'east'.

Example: `R = maprefcells(latlim,lonlim,rasterSize,'RowsStartFrom','east')`

Data Types: char | string

Output Arguments

R — Object that references raster cells to map coordinates

MapCellsReference raster reference object

Object that references raster cells to map coordinates, returned as a MapCellsReference raster reference object.

Tips

- To construct a map raster reference object from a world file matrix, use the `maprasterref` function.

Version History

Introduced in R2015b

See Also

`maprefpostings` | `MapCellsReference` | `georefcells`

maprefpostings

Reference raster postings to map coordinates

Syntax

```
R = maprefpostings()  
R = maprefpostings(xlimits,ylimits,rasterSize)  
R = maprefpostings(xlimits,ylimits,xspacing,yspacing)  
R = maprefpostings(xlimits,ylimits,___, Name,Value)
```

Description

`R = maprefpostings()` returns a default referencing object for a raster of regularly posted samples in planar (map) coordinates.

`R = maprefpostings(xlimits,ylimits,rasterSize)` constructs a referencing object for a raster spanning the specified limits in planar coordinates, with the numbers of rows and columns specified by `rasterSize`.

`R = maprefpostings(xlimits,ylimits,xspacing,yspacing)` allows the sample spacings to be set precisely. If necessary, `maprefpostings` adjusts the limits of the raster slightly to ensure an integer number of samples in each dimension.

`R = maprefpostings(xlimits,ylimits,___, Name,Value)` allows the directions of the columns and rows to be specified via name-value pairs.

Examples

Construct Referencing Object for Grid

Define latitude and longitude limits and dimension of a grid. The example uses postings separated by 1/2 meter, referenced to a planar map coordinate system (the "world" system).

```
xlimits = [207000 208000];  
ylimits = [912500 913000];  
rasterSize = [1001 2001]
```

```
rasterSize = 1x2
```

```
    1001    2001
```

Create the referencing object specifying the raster size.

```
R = maprefpostings(xlimits,ylimits,rasterSize)
```

```
R =  
  MapPostingsReference with properties:
```

```
    XWorldLimits: [207000 208000]
```

```

        YWorldLimits: [912500 913000]
        RasterSize: [1001 2001]
RasterInterpretation: 'postings'
  ColumnsStartFrom: 'south'
  RowsStartFrom: 'west'
SampleSpacingInWorldX: 1/2
SampleSpacingInWorldY: 1/2
  RasterExtentInWorldX: 1000
  RasterExtentInWorldY: 500
  XIntrinsicLimits: [1 2001]
  YIntrinsicLimits: [1 1001]
  TransformationType: 'rectilinear'
CoordinateSystemType: 'planar'
  ProjectedCRS: []

```

Obtain the same result by specifying the sample spacing.

```
spacing = 1/2;
```

```
R = maprefpostings(xlimits,ylimits,spacing,spacing)
```

```
R =
```

```
MapPostingsReference with properties:
```

```

        XWorldLimits: [207000 208000]
        YWorldLimits: [912500 913000]
        RasterSize: [1001 2001]
RasterInterpretation: 'postings'
  ColumnsStartFrom: 'south'
  RowsStartFrom: 'west'
SampleSpacingInWorldX: 1/2
SampleSpacingInWorldY: 1/2
  RasterExtentInWorldX: 1000
  RasterExtentInWorldY: 500
  XIntrinsicLimits: [1 2001]
  YIntrinsicLimits: [1 1001]
  TransformationType: 'rectilinear'
CoordinateSystemType: 'planar'
  ProjectedCRS: []

```

Input Arguments

xlimits — Limits in the x direction

[0.5 2.5] (default) | 1-by-2 numeric vector

Limits in the x direction, specified as a 1-by-2 numeric vector. The value of `xlimits` determines the `XWorldLimits` property of `R`.

Example: `xlimits = [207000 208000];`

ylimits — Limits in the y direction

[0.5 2.5] (default) | 1-by-2 numeric vector

Limits in the y direction, specified as a 1-by-2 numeric vector. The value of `ylimits` determines the `YWorldLimits` property of R.

Example: `ylimits = [912500 913000];`

rasterSize — Size of the raster

[2 2] (default) | 1-by-2 numeric vector

Size of the raster, specified as a 1-by-2 numeric vector.

Example: `rasterSize = [180 360];`

xspacing — Horizontal spacing of posting

1 (default) | numeric scalar

Horizontal spacing of posting, specified as a numeric scalar. The value of `xspacing` determines the `SampleSpacingInWorldX` property of R.

Example: `xspacing = 1.5`

yspacing — Vertical spacing of postings

1 (default) | numeric scalar

Vertical spacing of postings, specified as a numeric scalar. The value of `yspacing` determines the `SampleSpacingInWorldY` property of R.

Example: `yspacing = 1.5`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose `Name` in quotes.

Example: `R = maprefpostings(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')`

ColumnsStartFrom — Edge from which column indexing starts

'south' (default) | 'north'

Edge from which column indexing starts, specified as 'north' or 'south'.

Example: `R = maprefpostings(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')`

Data Types: char | string

RowsStartFrom — Edge from which row indexing starts

'west' (default) | 'east'

Edge from which row indexing starts, specified as 'east' or 'west'.

Example: `R = maprefpostings(latlim,lonlim,rasterSize,'RowsStartFrom','east')`

Data Types: char | string

Output Arguments

R — Object that references raster postings to map coordinates

MapPostingsReference raster reference object

Object that references raster postings to map coordinates, returned as a MapPostingsReference raster reference object.

Tips

- To construct a map raster reference object from a world file matrix, use the `maprasterref` function.

Version History

Introduced in R2015b

See Also

`maprefcells` | `MapPostingsReference` | `georefpostings`

mapresize

Resize projected raster

Syntax

```
[B,RB] = mapresize(A,RA, scale)
[B,RB] = mapresize( ____, method)
[B,RB] = mapresize( ____, 'Antialiasing', TF)
```

Description

`[B,RB] = mapresize(A,RA, scale)` returns a raster B that is `scale` times the size of raster A. RA is a raster reference object that specifies the location and extent of data in A. `mapresize` returns the raster reference object RB that is associated with the returned raster B. By default, `mapresize` uses cubic interpolation.

`[B,RB] = mapresize(____, method)` returns a resized raster where `method` specifies the interpolation method.

`[B,RB] = mapresize(____, 'Antialiasing', TF)` specifies whether to perform antialiasing when shrinking a raster. When `true`, `mapresize` performs antialiasing. The default value depends on the type of interpolation specified. For nearest-neighbor interpolation, the default value is `false`. For all other interpolation methods, the default is `true`.

Examples

Resize Projected Raster

Import a sample projected raster and map cells reference object.

```
[Z,R] = readgeoraster('map_sample.tif');
```

Resize the raster using `mapresize`. Double the length and width of the raster by specifying the scale as 2. Use nearest neighbor interpolation by specifying the interpolation method as 'nearest'.

```
[Z2,R2] = mapresize(Z,R,2, 'nearest');
```

Verify the raster has been resized by comparing the size of the original raster with the size of the updated raster.

```
R.RasterSize
```

```
ans = 1×2
      2      2
```

```
R2.RasterSize
```

```
ans = 1×2
```

4 4

If the rasters are small, you can compare them directly.

Z

Z = 2×2

1 2
3 4

Z2

Z2 = 4×4

1 1 2 2
1 1 2 2
3 3 4 4
3 3 4 4

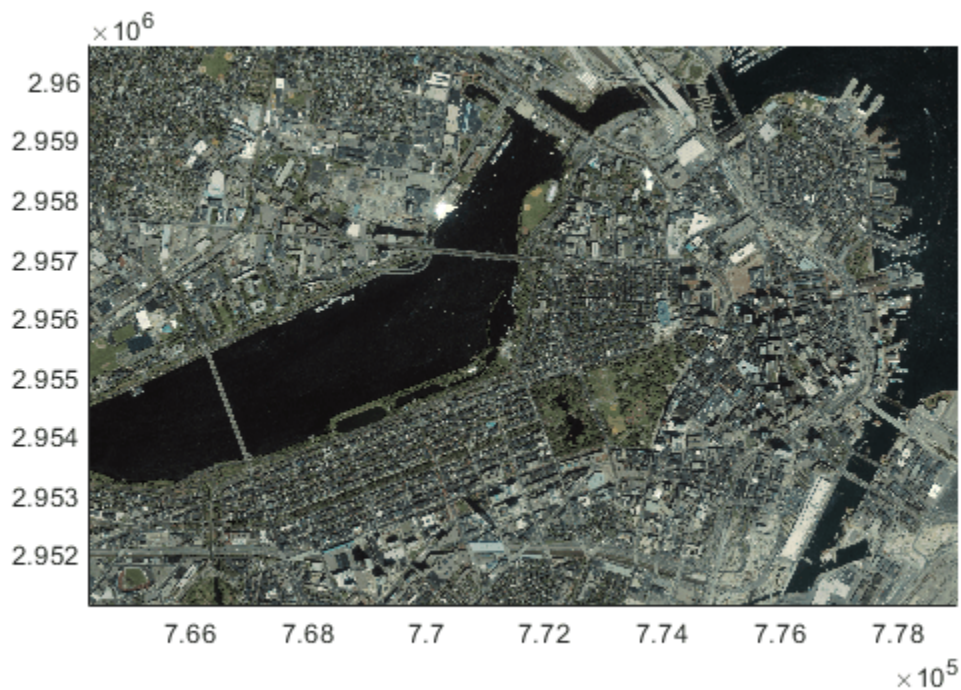
Resize Projected Raster Data Set

Read a projected raster data set and map cells reference object into the workspace.

```
[boston,R] = readgeoraster('boston.tif');
```

Display the raster with mapshow.

```
mapshow(boston,R)
```

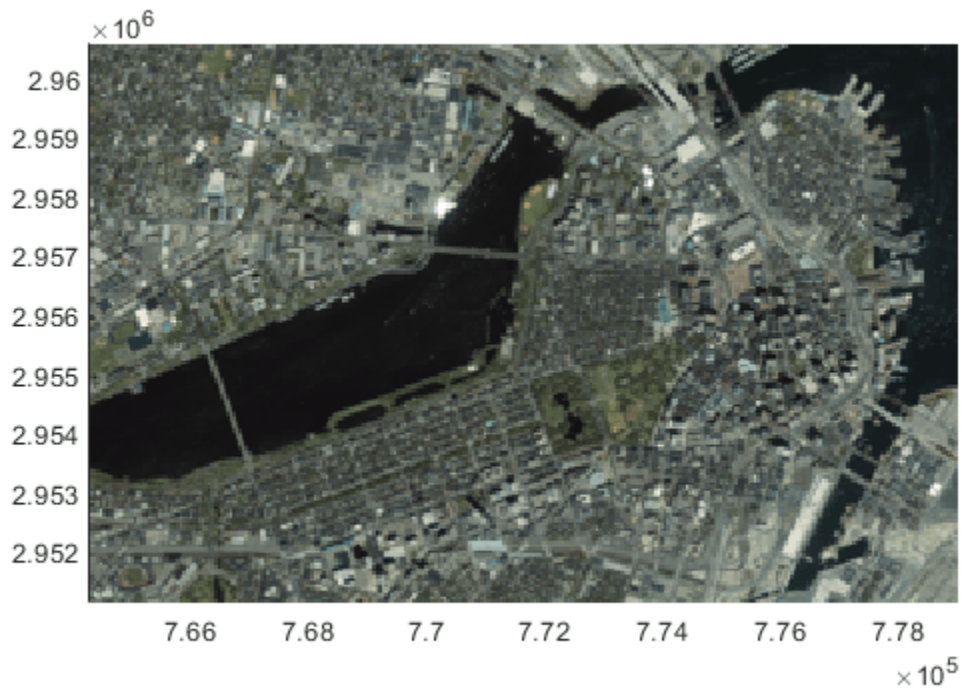


Resize the projected raster data set. For this example, reduce the raster to one sixteenth of the original size.

```
[resizedBoston, resizedR] = mapresize(boston, R, 1/16);
```

Display the resized raster. Note that `mapshow` preserves the original limits of the map in the display so that, at first glance, the resized raster appears to be the same size as the original. A closer look reveals that the size of pixels in the resized raster are larger than the pixels in the original.

```
figure  
mapshow(resizedBoston, resizedR)
```

Input Arguments

A — Projected map raster

numeric or logical array

Projected map raster, specified as a numeric or logical array. If A has more than two dimensions, `mapresize` only resizes the first two dimensions.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

RA — Raster reference for A

`MapCellsReference` object | `MapPostingsReference` object

Raster reference for A, specified as a `MapCellsReference` object or `MapPostingsReference` object.

scale — Amount of resizing

numeric scalar

Amount of resizing, specified as numeric scalar. If `scale` is in the range `[0 1]`, B is smaller than A. If `scale` is greater than 1, B is larger than A.

Example: 0.5

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

method — Interpolation method`cubic (default) | 'nearest' | 'bilinear'`

Interpolation method, specified as one of the following values.

Value	Description
'nearest'	Nearest-neighbor interpolation
'bilinear'	Bilinear interpolation
'cubic'	Cubic interpolation

Data Types: `char` | `string`

Output Arguments**B — Resized raster**`numeric` or `logical` array

Resized raster, returned as a numeric or logical array.

RB — Information about location and extent of raster`map` raster reference object

Information about location and extent of raster, returned as a map raster reference object.

Tips

- Use `mapresize` with raster data in *x*- and *y*-coordinates. To work with geographic raster data in latitude and longitude coordinates, use `georesize`.

Version History

Introduced in R2019a

See Also`georesize` | `maprefcells` | `mapinterp` | `maprefpostings`

maps

List map projections for axesm-based maps and map projection structures

Syntax

```
strmat = maps('namelist')
strmat = maps('idlist')
stdstr = maps('proj_id_abbrev')
```

Description

maps displays in the Command Window a table describing all projections available for use with axesm-based maps and map projection structures.

`strmat = maps('namelist')` returns the English names for the available projections as a matrix of character vectors.

`strmat = maps('idlist')` returns the standard projection identifiers for the available projections as a matrix of character vectors.

`stdstr = maps('proj_id_abbrev')` returns the specific standard projection identification associated with a unique abbreviation.

Examples

To show the first five entries of the projections name list,

```
str1 = maps('namelist');
str1(1:5,:)
ans =
Balthasart Cylindrical
Behrmann Cylindrical
Bolshoi Sovietskii Atlas Mira
Braun Perspective Cylindrical
Cassini Cylindrical
```

The corresponding shorthand names are

```
str2 = maps('idlist');
str2(1:5,:)
ans =
balthsrt
behrmann
bsam
braun
cassini
```

These shorthand names can be used, for example, when setting the axesm property MapProjection.

The functions `setm` and `axesm` recognize unique abbreviations (truncations) of these names. The `maps` function can be used to convert such an abbreviation to the standard ID:

```
stdstr = maps('merc')
stdstr =
mercator
```

When the function name alone is used,

```
maps
```

MapTools Projections

CLASS	NAME	ID STRING
Cylindrical	Balthasart Cylindrical	balthsrt
Cylindrical	Behrmann Cylindrical	behrmann
Cylindrical	Bolshoi Sovietskii Atlas Mira*	bsam
Cylindrical	Braun Perspective Cylindrical*	braun
Cylindrical	Cassini Cylindrical	cassini
Cylindrical	Central Cylindrical*	ccylin
Cylindrical	Equal Area Cylindrical	eqacylin
Cylindrical	Equidistant Cylindrical	eqdcylin
Cylindrical	Gall Isographic	giso...

The actual result contains all defined projections.

See Also

[axesm](#) | [setm](#)

mapshape

Planar shape vector

Description

A mapshape vector is an object that represents planar vector features with either point, line, or polygon topology. The features consist of x - and y -coordinates and associated attributes.

Attributes that vary spatially are termed Vertex properties. These elements of the mapshape vector are coupled such that the length of the x - and y -coordinate property values are always equal in length to any additional dynamic Vertex properties.

Attributes that only pertain to the overall feature (point, line, polygon) are termed Feature properties. Feature properties are not linked to the autosizing mechanism of the Vertex properties. Both property types can be added to a mapshape vector after construction using standard dot (.) notation.

To create a planar point, line, or polygon shape for use with a geospatial table, create a `mappointshape`, `maplineshape`, or `mappolyshape` object instead.

Creation

Syntax

```
s = mapshape()
s = mapshape(x,y)
s = mapshape(x,y,Name,Value)
s = mapshape(structArray)
s = mapshape(x,y,structArray)
```

Description

`s = mapshape()` constructs an empty mapshape vector, `s`, with these default property settings.

`s =`

0x1 mapshape vector with properties:

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  X: []
  Y: []
```

`s` is always a column vector.

`s = mapshape(x,y)` constructs a mapshape vector and sets the `X` and `Y` property values equal to vectors `x` and `y`.

`s = mapshape(x,y,Name,Value)` constructs a `mapshape` vector, then adds dynamic properties to the `mapshape` vector using `Name, Value` argument pairs. You can specify several name-value pair arguments in any order as `Name1, Value1, . . . , NameN, ValueN`.

`s = mapshape(structArray)` constructs a `mapshape` vector, assigning the fields of the structure array, `structArray`, as dynamic properties. Field values in `structArray` that are not numeric, logical, string scalars, string arrays, character vectors, cell arrays of character vectors, or cell arrays of numeric, logical, or cell array of character vectors values are ignored. You can specify vectors within cell arrays as either row or column vectors.

`s = mapshape(x,y,structArray)` constructs a new `mapshape` vector, sets the X and Y properties equal to vectors `x` and `y`, and sets dynamic properties from the field values of `structArray`.

Properties

`mapshape` class is a general class that represents a variety of planar features. The class permits features to have more than one vertex and can thus represent lines and polygons in addition to multipoints. For more about the property types in `mapshape`, see “Collection Properties” on page 1-1151, “Vertex Properties” on page 1-1151, and “Feature Properties” on page 1-1151.

Dynamic properties are new features and vertices that are added to a `mapshape` vector. You can attach dynamic Feature and Vertex properties to a `mapshape` vector during construction with a `Name, Value` pair or after construction using dot (`.`) notation after construction. This is similar to adding new fields to a structure. For an example of adding dynamic Feature properties, see “Construct a Mapshape Vector with Dynamic Properties” on page 1-1138.

Geometry — Shape of all the features in the mapshape vector

`'line' (default) | 'point' | 'polygon'`

Shape of all the features in the `mapshape` vector, specified as `'line'`, `'point'`, or `'polygon'`. As a Collection Property there can be only one value per object instance and its purpose is purely informational. The three allowable values for `Geometry` do not change class behavior. The class does not provide validation for line or polygon topologies.

Data Types: `char` | `string`

Metadata — Information for the entire set of features

`scalar structure`

Information for all the features, specified as a scalar structure. You can add any data type to the structure. As a Collection Property type, only one instance per object is allowed.

- If `Metadata` is provided as a dynamic property `Name` in the constructor, and the corresponding `Value` is a scalar structure, then `Value` is copied to the `Metadata` property. Otherwise, an error is issued.
- If a `Metadata` field is provided by `structArray`, and both `Metadata` and `structArray` are scalar structures, then the `Metadata` field value is copied to the `Metadata` property value. If `structArray` is a scalar but the `Metadata` field is not a structure, then an error is issued. If `structArray` is not scalar, then the `Metadata` field is ignored.

Data Types: `struct`

X — Planar x-coordinates

`numeric row or column vector`

Planar x-coordinates, specified as a numeric row or column vector, stored as a row vector.

Data Types: `double` | `single`

Y — Planar y-coordinates

numeric row or column vector

Planar y-coordinates, specified as a numeric row or column vector, stored as a row vector.

Data Types: `double` | `single`

Object Functions

<code>append</code>	Append features to geographic or planar vector
<code>cat</code>	Concatenate geographic or planar vector
<code>disp</code>	Display geographic or planar vector
<code>fieldnames</code>	Return dynamic property names of geographic or planar vector
<code>isempty</code>	Determine if geographic or planar vector is empty
<code>isfield</code>	Determine if dynamic property exists in geographic or planar vector
<code>isprop</code>	Determine if property exists in geographic or planar vector
<code>length</code>	Return number of elements in geographic or planar vector
<code>properties</code>	Return property names of geographic or planar vector
<code>rmfield</code>	Remove dynamic property from geographic or planar vector
<code>rmprop</code>	Remove property from geographic or planar vector
<code>size</code>	Return size of geographic or planar vector
<code>struct</code>	Convert geographic or planar vector to scalar structure
<code>vertcat</code>	Vertically concatenate geographic or planar vectors

Examples

Construct a Default Mapshape Vector and Set and Add Properties

Create default mapshape vector.

```
s = mapshape()
```

0x1 mapshape vector with properties:

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  X: []
  Y: []
```

Set the values of the existing X and Y properties and dynamically add the Vertex property Z.

```
s(1).X = 0:45:90;
s(1).Y = [10 10 10];
s(1).Z = [10 20 30]
```

```
s =
```

```
1x1 mapshape vector with properties:
```

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  X: [0 45 90]
  Y: [10 10 10]
  Z: [10 20 30]
```

Construct a Mapshape Vector Specifying X and Y Values

Create a mapshape vector specifying x and y.

```
x = [40, 50, 60];
y = [10, 20, 30];
shape = mapshape(x, y)
```

shape =

1x1 mapshape vector with properties:

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  X: [40 50 60]
  Y: [10 20 30]
```

Construct a Mapshape Vector with Dynamic Properties

Create mapshape vector specifying a Name-Value pair.

```
x = 1:10;
y = 21:30;
temperature = {61:70};
shape = mapshape(x, y, 'Temperature', temperature)
```

shape =

1x1 mapshape vector with properties:

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  X: [1 2 3 4 5 6 7 8 9 10]
  Y: [21 22 23 24 25 26 27 28 29 30]
  Temperature: [61 62 63 64 65 66 67 68 69 70]
```

When **Value** is a cell array containing numeric, logical, or cell array of character vectors, it is designated as a **Vertex property**. Otherwise the **Name-Value** pair is designated as being a **Feature property**.

Construct a Mapshape Vector from a Structure Array

Create structure array and then create mapshape vector with array.

```

structArray = shaperead('concord_roads');
shape = mapshape(structArray)

shape =

609x1 mapshape vector with properties:

Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
Vertex properties:
(609 features concatenated with 608 delimiters)
    X: [1x5422 double]
    Y: [1x5422 double]
Feature properties:
    STREETNAME: {1x609 cell}
    RT_NUMBER: {1x609 cell}
    CLASS: [1x609 double]
    ADMIN_TYPE: [1x609 double]
    LENGTH: [1x609 double]

```

Construct a Mapshape Vector Using Cell Arrays and Structures to Define Multiple Features and Properties

Read data from a shapefile into a structure.

```

[structArray, A] = shaperead('concord_hydro_area');

structArray =

98x1 struct array with fields:

    Geometry
    BoundingBox
    X
    Y

```

```
A =
```

```
98x1 struct array with fields:
```

```
    AREA
    PERIMETER
```

Create a mapshape vector specifying the structure.

```

shape = mapshape({structArray.X}, {structArray.Y}, A);
shape.Geometry = structArray(1).Geometry

shape =

98x1 mapshape vector with properties:

```

```
Collection properties:
  Geometry: 'polygon'
  Metadata: [1x1 struct]
Vertex properties:
(98 features concatenated with 97 delimiters)
  X: [1x4902 double]
  Y: [1x4902 double]
Feature properties:
  AREA: [1x98 double]
  PERIMETER: [1x98 double]
```

Construct a Mapshape Vector and Add a Feature Property

This example shows how to add a single feature after construction of the mapshape vector using dot (.) notation.

Create a mapshape vector.

```
x = 0:10:100;
y = 0:10:100;
shape = mapshape(x, y)
```

shape =

1x1 mapshape vector with properties:

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  X: [0 10 20 30 40 50 60 70 80 90 100]
  Y: [0 10 20 30 40 50 60 70 80 90 100]
```

Add a dynamic Feature property.

```
shape.FeatureName = 'My Feature'
```

shape =

1x1 mapshape vector with properties:

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  X: [0 10 20 30 40 50 60 70 80 90 100]
  Y: [0 10 20 30 40 50 60 70 80 90 100]
Feature properties:
  FeatureName: 'My Feature'
```

Add a dynamic Vertex property to the first feature.

```
shape(1).Temperature = [60 61 63 65 66 68 69 70 72 75 80];
```

shape =

1x1 mapshape vector with properties:

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  X: [0 10 20 30 40 50 60 70 80 90 100]
  Y: [0 10 20 30 40 50 60 70 80 90 100]
  Temperature: [60 61 63 65 66 68 69 70 72 75 80]
Feature properties:
  FeatureName: 'My Feature'
```

Construct a Mapshape Vector and Manipulate Features

This extended example adds multiple features that are both Vertex and Feature properties. It also demonstrates property behaviors when vector lengths are either changed or set to [].

Create a mapshape vector.

```
x = {1:3, 4:6};
y = {[0 0 0], [1 1 1]};
shape = mapshape(x, y)
```

shape =

2x1 mapshape vector with properties:

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  (2 features concatenated with 1 delimiter)
  X: [1 2 3 NaN 4 5 6]
  Y: [0 0 0 NaN 1 1 1]
```

Add a two element dynamic Feature property.

```
shape.FeatureName = {'Feature 1', 'Feature 2'}
```

shape =

2x1 mapshape vector with properties:

```
Collection properties:
  Geometry: 'line'
  Metadata: [1x1 struct]
Vertex properties:
  (2 features concatenated with 1 delimiter)
  X: [1 2 3 NaN 4 5 6]
  Y: [0 0 0 NaN 1 1 1]
Feature properties:
  FeatureName: {'Feature 1' 'Feature 2'}
```

Add a dynamic Vertex property.

```
z = {101:103, [115, 114, 110]}
shape.Z = z

z =

    [1x3 double]    [1x3 double]

shape =

2x1 mapshape vector with properties:

Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
Vertex properties:
    (2 features concatenated with 1 delimiter)
    X: [1 2 3 NaN 4 5 6]
    Y: [0 0 0 NaN 1 1 1]
    Z: [101 102 103 NaN 115 114 110]
Feature properties:
    FeatureName: {'Feature 1' 'Feature 2'}
```

Display the second feature.

```
shape(2)

ans =

1x1 mapshape vector with properties:

Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
Vertex properties:
    X: [4 5 6]
    Y: [1 1 1]
    Z: [115 114 110]
Feature properties:
    FeatureName: 'Feature 2'
```

Add a third feature. The lengths of all the properties are synchronized.

```
shape(3).X = 5:9

shape =

3x1 mapshape vector with properties:

Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
Vertex properties:
    (3 features concatenated with 2 delimiters)
    X: [1 2 3 NaN 4 5 6 NaN 5 6 7 8 9]
    Y: [0 0 0 NaN 1 1 1 NaN 0 0 0 0 0]
    Z: [101 102 103 NaN 115 114 110 NaN 0 0 0 0 0]
Feature properties:
    FeatureName: {'Feature 1' 'Feature 2' ''}
```

Set the values for the Z vertex property with fewer values than contained in X or Y. The Z values expand to match the length of X and Y.

```
shape(3).Z = 1:3
```

```
shape =
```

```
3x1 mapshape vector with properties:
```

```
Collection properties:
```

```
  Geometry: 'line'
```

```
  Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(3 features concatenated with 2 delimiters)
```

```
  X: [1 2 3 NaN 4 5 6 NaN 5 6 7 8 9]
```

```
  Y: [0 0 0 NaN 1 1 1 NaN 0 0 0 0 0]
```

```
  Z: [101 102 103 NaN 115 114 110 NaN 1 2 3 0 0]
```

```
Feature properties:
```

```
  FeatureName: {'Feature 1' 'Feature 2' ''}
```

Set the values for either coordinate property (X or Y) and all properties shrink in size to match the new vertex length of that feature.

```
shape(3).Y = 1
```

```
shape =
```

```
3x1 mapshape vector with properties:
```

```
Collection properties:
```

```
  Geometry: 'line'
```

```
  Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(3 features concatenated with 2 delimiters)
```

```
  X: [1 2 3 NaN 4 5 6 NaN 5]
```

```
  Y: [0 0 0 NaN 1 1 1 NaN 1]
```

```
  Z: [101 102 103 NaN 115 114 110 NaN 1]
```

```
Feature properties:
```

```
  FeatureName: {'Feature 1' 'Feature 2' ''}
```

Set the values for the Z vertex property with more values than contained in X or Y. All properties expand in length to match Z.

```
shape(3).Z = 1:6
```

```
shape =
```

```
3x1 mapshape vector with properties:
```

```
Collection properties:
```

```
  Geometry: 'line'
```

```
  Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(3 features concatenated with 2 delimiters)
```

```
  X: [1 2 3 NaN 4 5 6 NaN 5 0 0 0 0 0]
```

```
  Y: [0 0 0 NaN 1 1 1 NaN 1 0 0 0 0 0]
```

```
  Z: [101 102 103 NaN 115 114 110 NaN 1 2 3 4 5 6]
```

```
Feature properties:
```

```
  FeatureName: {'Feature 1' 'Feature 2' ''}
```

Remove the FeatureName property.

```
shape.FeatureName = []  
  
shape =  
  
3x1 mapshape vector with properties:  
  
Collection properties:  
  Geometry: 'line'  
  Metadata: [1x1 struct]  
Vertex properties:  
  (3 features concatenated with 2 delimiters)  
  X: [1 2 3 NaN 4 5 6 NaN 5 0 0 0 0 0]  
  Y: [0 0 0 NaN 1 1 1 NaN 1 0 0 0 0 0]  
  Z: [101 102 103 NaN 115 114 110 NaN 1 2 3 4 5 6]
```

Remove all dynamic properties and set the object to empty.

```
shape.X = []  
  
shape =  
  
0x1 mapshape vector with properties:  
  
Collection properties:  
  Geometry: 'line'  
  Metadata: [1x1 struct]  
Vertex properties:  
  X: []  
  Y: []
```

Construct a Mapshape Vector Specifying Several Name-Value Pairs

This example shows how to include multiple dynamic features during object construction.

Create a mapshape vector specifying several name-value pairs.

```
x = {1:3, 4:6};  
y = {[0 0 0], [1 1 1]};  
z = {41:43, [56 50 59]};  
name = {'Feature 1', 'Feature 2'};  
id = [1 2];  
shape = mapshape(x, y, 'Z', z, 'Name', name, 'ID', id)  
  
shape =  
  
2x1 mapshape vector with properties:  
  
Collection properties:  
  Geometry: 'line'  
  Metadata: [1x1 struct]  
Vertex properties:  
  (2 features concatenated with 1 delimiter)  
  X: [1 2 3 NaN 4 5 6]  
  Y: [0 0 0 NaN 1 1 1]  
  Z: [41 42 43 NaN 56 50 59]
```

```

Feature properties:
  Name: {'Feature 1' 'Feature 2'}
  ID: [1 2]

```

Construct a Mapshape Vector Containing Multiple Features and Indexing Behaviors

Load the data and create x, y, and z arrays. Create a level list to use to bin the z values.

```

seamount = load('seamount');
x = seamount.x; y = seamount.y; z = seamount.z;

levels = [unique(floor(seamount.z/1000)) * 1000; 0];

```

Construct a mapshape object and assign the X and Y Vertex properties to the binned x and y values. Create a new Z Vertex property to contain the binned z values. Add a Levels Feature property to contain the lowest level value per feature.

```

shape = mapshape;
for k = 1:length(levels) - 1
    index = z >= levels(k) & z < levels(k+1);
    shape(k).X = x(index);
    shape(k).Y = y(index);
    shape(k).Z = z(index);
    shape(k).Level = levels(k);
end

```

Add a Color Feature property to denote a color for that feature, and specify that the geometry is 'point'

```

shape.Color = {'red', 'green', 'blue', 'cyan', 'black'};
shape.Geometry = 'point'

```

```

shape =

```

```

5x1 mapshape vector with properties:

```

```

Collection properties:

```

```

  Geometry: 'point'

```

```

  Metadata: [1x1 struct]

```

```

Vertex properties:

```

```

  (5 features concatenated with 4 delimiters)

```

```

    X: [1x298 double]

```

```

    Y: [1x298 double]

```

```

    Z: [1x298 double]

```

```

Feature properties:

```

```

  Level: [-5000 -4000 -3000 -2000 -1000]

```

```

  Color: {'red' 'green' 'blue' 'cyan' 'black'}

```

Add metadata information. **Metadata** is a scalar structure containing information for the entire set of properties. Any type of data may be added to the structure.

```

shape.Metadata.Caption = seamount.caption;
shape.Metadata

```

```

ans =

```

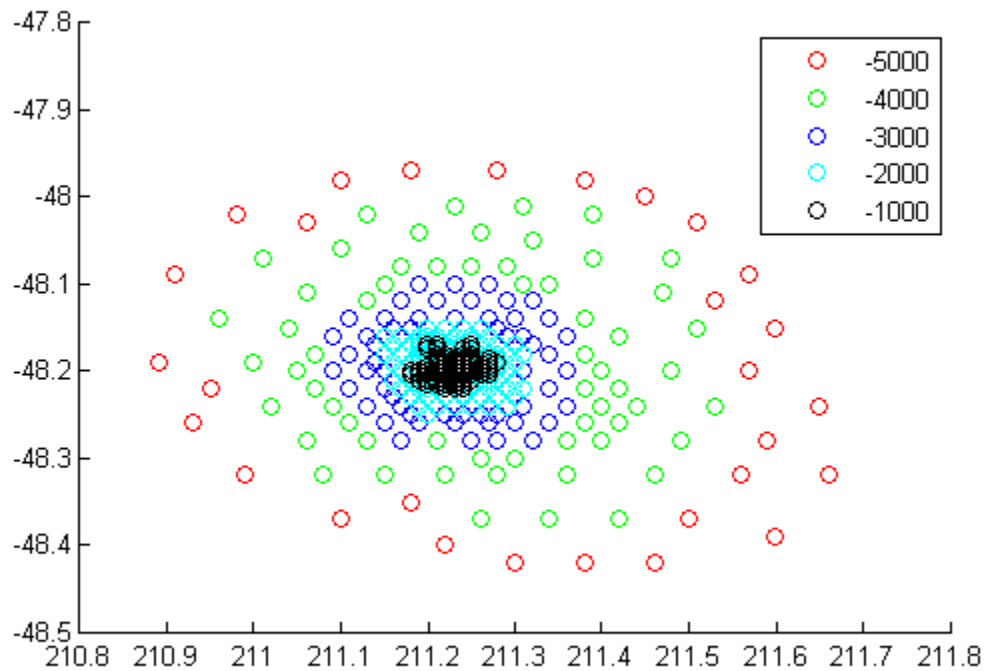
```

  Caption: [1x229 char]

```

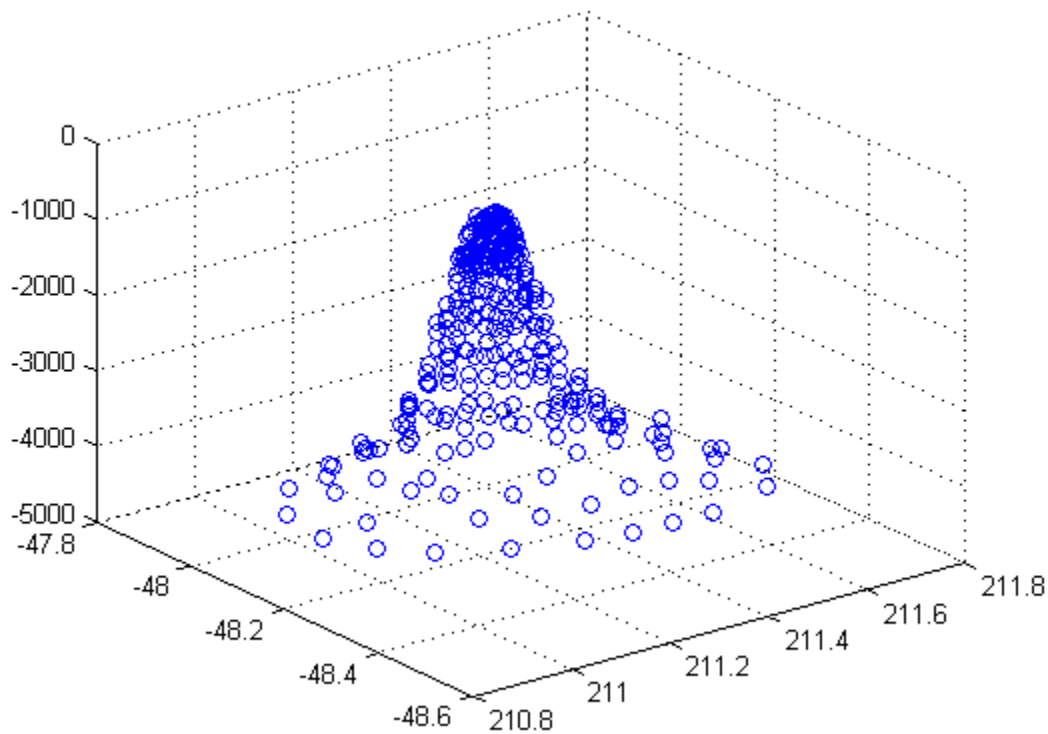
Display the point data in 2-D.

```
figure
for k=1:length(shape)
    mapshow(shape(k).X, shape(k).Y, ...
            'MarkerEdgeColor', shape(k).Color, ...
            'Marker', 'o', ...
            'DisplayType', shape.Geometry)
end
legend(num2str(shape.Level'))
```



Display data as a 3-D scatter plot.

```
figure
scatter3(shape.X, shape.Y, shape.Z)
```

Construct a Mapshape Vector and Add Metadata and Indexing

This example shows how to use selective indexing behavior of a mapshape vector, and how to add a Metadata property.

Construct a mapshape vector from a structure array

```
filename = 'concord_roads.shp';
S = shaperead(filename);
shape = mapshape(S)
```

shape =

609x1 mapshape vector with properties:

Collection properties:

Geometry: 'line'

Metadata: [1x1 struct]

Vertex properties:

(609 features concatenated with 608 delimiters)

X: [1x5422 double]

Y: [1x5422 double]

Feature properties:

STREETNAME: {1x609 cell}

RT_NUMBER: {1x609 cell}

CLASS: [1x609 double]

```
ADMIN_TYPE: [1x609 double]
LENGTH: [1x609 double]
```

Add a `Filename` field to the `Metadata` structure and then construct a new mapshape object with only CLASS 4 (major road) designation.

```
shape.Metadata.Filename = filename;
class4 = shape(shape.CLASS == 4)
```

```
class4 =
```

```
26x1 mapshape vector with properties:
```

```
Collection properties:
```

```
Geometry: 'line'
```

```
Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(26 features concatenated with 25 delimiters)
```

```
X: [1x171 double]
```

```
Y: [1x171 double]
```

```
Feature properties:
```

```
STREETNAME: {1x26 cell}
```

```
RT_NUMBER: {1x26 cell}
```

```
CLASS: [4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4]
```

```
ADMIN_TYPE: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
```

```
LENGTH: [1x26 double]
```

Construct a Mapshape Vector and Sort the Dynamic Properties

This example show how features can be sorted by using the indexing behavior of the mapshape class.

You can create a new mapshape vector that contains a subset of dynamic properties by adding the name of a property or a cell array of property names to the last index in the `()` operator.

Read data from file directly in mapshape constructor.

```
shape = mapshape(shaperead('tsunamis'))
```

```
shape =
```

```
162x1 mapshape vector with properties:
```

```
Collection properties:
```

```
Geometry: 'point'
```

```
Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(162 features concatenated with 161 delimiters)
```

```
X: [1x323 double]
```

```
Y: [1x323 double]
```

```
Feature properties:
```

```
Cause: {1x162 cell}
```

```
Cause_Code: [1x162 double]
```

```
Country: {1x162 cell}
```

```
Day: [1x162 double]
```

```
Desc_Deaths: [1x162 double]
```

```
Eq_Mag: [1x162 double]
```

```

    Hour: [1x162 double]
    Iida_Mag: [1x162 double]
    Intensity: [1x162 double]
    Location: {1x162 cell}
    Max_Height: [1x162 double]
    Minute: [1x162 double]
    Month: [1x162 double]
    Num_Deaths: [1x162 double]
    Second: [1x162 double]
    Val_Code: [1x162 double]
    Validity: {1x162 cell}
    Year: [1x162 double]

```

Alphabetize the Feature properties.

```
shape = shape(:, sort(fieldnames(shape)))
```

```
shape =
```

```
162x1 mapshape vector with properties:
```

```
Collection properties:
```

```
    Geometry: 'point'
    Metadata: [1x1 struct]
```

```
Vertex properties:
```

```
(162 features concatenated with 161 delimiters)
```

```
    X: [1x323 double]
    Y: [1x323 double]
```

```
Feature properties:
```

```
    Cause: {1x162 cell}
    Cause_Code: [1x162 double]
    Country: {1x162 cell}
    Day: [1x162 double]
    Desc_Deaths: [1x162 double]
    Eq_Mag: [1x162 double]
    Hour: [1x162 double]
    Iida_Mag: [1x162 double]
    Intensity: [1x162 double]
    Location: {1x162 cell}
    Max_Height: [1x162 double]
    Minute: [1x162 double]
    Month: [1x162 double]
    Num_Deaths: [1x162 double]
    Second: [1x162 double]
    Val_Code: [1x162 double]
    Validity: {1x162 cell}
    Year: [1x162 double]

```

Modify the mapshape vector to contain only the specified dynamic properties.

```
shape = shape(:, {'Year', 'Month', 'Day', 'Hour', 'Minute'})
```

```
shape =
```

```
162x1 mapshape vector with properties:
```

```
Collection properties:
```

```
    Geometry: 'point'
    Metadata: [1x1 struct]
```

```
Vertex properties:
(162 features concatenated with 161 delimiters)
  X: [1x323 double]
  Y: [1x323 double]
Feature properties:
  Year: [1x162 double]
  Month: [1x162 double]
  Day: [1x162 double]
  Hour: [1x162 double]
  Minute: [1x162 double]
```

Create a new mapshape vector in which each feature contains the points for the same year. Copy the data from a mappoint vector to ensure that NaN feature separators are not included. Create a subsection of data to include only Year and Country dynamic properties.

```
points = mappoint(shaperead('tsunamis'));
points = points(:, {'Year', 'Country'});
years = unique(points.Year);
multipoint = mapshape();
multipoint.Geometry = 'point';
for k = 1:length(years)
    index = points.Year == years(k);
    multipoint(k).X = points(index).X;
    multipoint(k).Y = points(index).Y;
    multipoint(k).Year = years(k);
    multipoint(k).Country = points(index).Country;
end
multipoint          % Display
```

```
multipoint =

53x1 mapshape vector with properties:

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Vertex properties:
(53 features concatenated with 52 delimiters)
  X: [1x214 double]
  Y: [1x214 double]
  Country: {1x214 cell}
Feature properties:
  Year: [1x53 double]
```

Display the third from the end feature.

```
multipoint(end-3)

ans =

1x1 mapshape vector with properties:

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Vertex properties:
  X: [3.6340 -62.1800 143.9100]
  Y: [36.9640 16.7220 41.8150]
```

```
Country: {'ALGERIA' 'MONTSEERRAT' 'JAPAN'}
Feature properties:
Year: 2003
```

More About

Collection Properties

Collection properties contain only one value per class instance. In contrast, the Feature and Vertex property types have attribute values associated with each feature or with each vertex in a set that defines a feature. Geometry and Metadata are the only two Collection properties.

Vertex Properties

Vertex properties provide a scalar number or a character vector for each vertex in a mapshape object. Vertex properties are suitable for attributes that vary spatially from point to point (vertex to vertex) along a line. Examples of such spatially varying attributes could be elevation, speed, temperature, or time. X and Y are Vertex properties since they contain a scalar number for each vertex in a mapshape vector.

Attribute values are associated with each vertex during construction or by using dot notation after construction. This process is similar to adding dynamic fields to a structure. Dynamic Vertex property values of an individual feature match its X and Y values in length.

Feature Properties

Feature properties provide one value (a scalar number, string scalar, or a character vector) for each feature in a mapshape vector. They are suitable for properties, such as name, owner, serial number, or age, that describe a given feature (an element of a mapshape vector) as a whole. Like Vertex properties, Feature properties can be added during construction or by using dot notation after construction.

Tips

- The `mapshape` function separates features using NaN values. If you display a feature by using a scalar to index into the mapshape vector, such as `s(1)`, then NaN values that separate the features do not display.
- If X, Y, or a dynamic property is set with more values than features in the mapshape vector, then all other properties expand in size using 0 for numeric values and an empty character vector (' ') for cell values.
- If a dynamic property is set with fewer values than the number of features, then this dynamic property expands to match the size of the other properties.
- If the X or Y property of the mapshape vector is set with fewer values than contained in the object, then all other properties shrink in size.
- If either X or Y is set to [], then both coordinate properties are set to [] and all dynamic properties are removed.
- If a dynamic property is set to [], then it is removed from the object.
- The mapshape vector can be indexed like any MATLAB vector. You can access any element of the vector to obtain a specific feature. The following example demonstrates this behavior:

“Construct a Mapshape Vector Containing Multiple Features and Indexing Behaviors” on page 1-1145

This example builds a mapshape vector from a structure array; adds a Metadata property and demonstrates selective indexing behavior. “Construct a Mapshape Vector and Add Metadata and Indexing” on page 1-1147

“Construct a Mapshape Vector and Sort the Dynamic Properties” on page 1-1148

Version History

Introduced in R2012a

See Also

Functions

gpxread | shaperead

Objects

geopoint | geoshape | mappoint

Topics

“Create and Display Polygons”

mapshow

Display map data without projection

Syntax

```
mapshow(x,y)
mapshow(S)
```

```
mapshow(x,y,Z)
mapshow(Z,R)
```

```
mapshow(x,y,I)
mapshow(x,y,X,cmap)
mapshow(I,R)
mapshow(X,cmap,R)
```

```
mapshow(filename)
```

```
mapshow( ____,Name,Value)
mapshow(ax, ____)
h = mapshow( ____)
```

Description

`mapshow(x,y)` displays the coordinate vectors `x` and `y` as lines. You can optionally display the coordinate vectors as points or polygons by using the `DisplayType` name-value pair argument.

`mapshow(S)` displays the vector geographic features stored in `S` as points, multipoints, lines, multilines, polygons, or multipolygons according to the geometry of `S`.

You can optionally specify symbolization rules using the `SymbolSpec` name-value pair argument.

`mapshow(x,y,Z)` displays a geolocated data grid, `Z`. You can optionally display the data as a surface, mesh, texture map, or contour by using the `DisplayType` name-value pair argument.

`mapshow(Z,R)` displays a regular data grid, `Z`, with referencing object `R`. You can optionally display the data as a surface, mesh, texture map, or contour by using the `DisplayType` name-value pair argument. If `DisplayType` is `'texturemap'`, then `mapshow` displays the image as a texture map on a zero-elevation surface (by setting `ZData` values to 0).

`mapshow(x,y,I)` and

`mapshow(x,y,X,cmap)` display a geolocated image as a texture map on a zero-elevation surface. The geolocated image can be a truecolor, grayscale, or binary image, `I`, or an indexed image `X` with colormap `cmap`. `x` and `y` are geolocation arrays in map coordinates. Examples of geolocated images include a color composite from a satellite swath or an image originally referenced to a different coordinate system.

`mapshow(I,R)` and

`mapshow(X,cmap,R)` display an image georeferenced to map coordinates through the referencing object `R`. The `mapshow` function constructs an image object if the display geometry permits.

Otherwise, `mapshow` displays the image as a texture map on a zero-elevation surface (by setting `ZData` values to 0).

`mapshow(filename)` displays data from the file specified according to the type of file format.

`mapshow(___, Name, Value)` modifies the displayed map by using name-value pair arguments to set the `DisplayType` and `SymbolSpec` parameters. You can also use name-value pairs to set any MATLAB graphics properties. Parameter names can be abbreviated, and case does not matter.

`mapshow(ax, ___)` sets the parent axes to `ax`.

`h = mapshow(___)` returns a handle to a MATLAB graphics object.

Examples

Overlay Vector on Orthophoto

Overlay Boston roads on an orthophoto. Note that `mapshow` draws a new layer in the axes rather than replacing its contents.

Display image.

```
figure
mapshow boston.tif
axis image off manual
```



Convert Boston roads to units of survey feet and overlay on orthophoto.

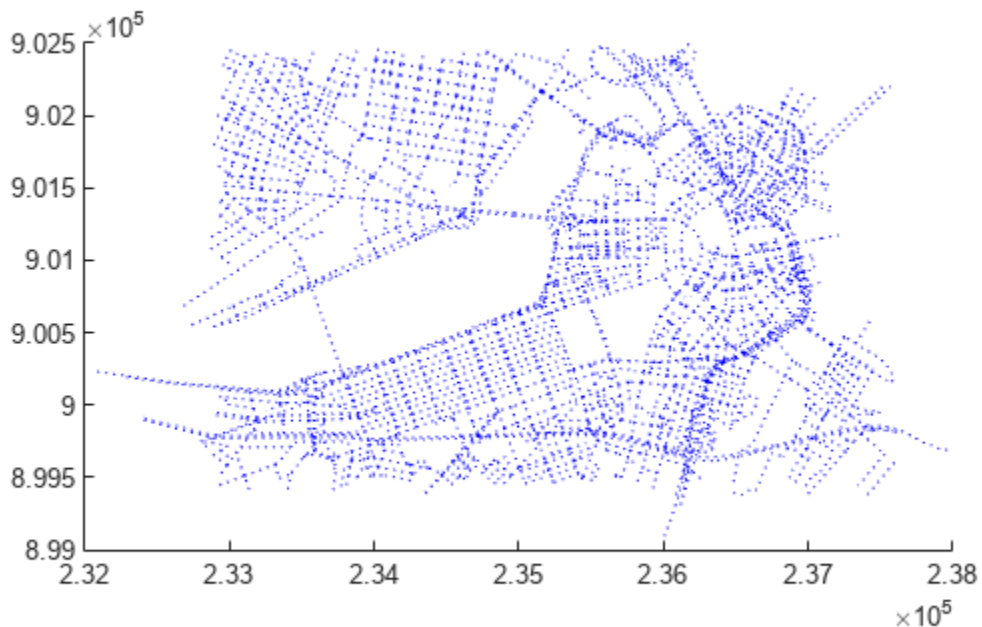
```
S = shaperead('boston_roads.shp');  
surveyFeetPerMeter = unitsratio('sf','meter');  
x = surveyFeetPerMeter * [S.X];  
y = surveyFeetPerMeter * [S.Y];  
mapshow(x,y)
```



Display Vector Data Customizing Line Style

Import a shapefile containing a network of road segments in Concord, MA as a geospatial table. Display the road segments using dotted lines.

```
roads = readgeotable("boston_roads.shp");  
figure  
mapshow(roads,"LineStyle",":");
```



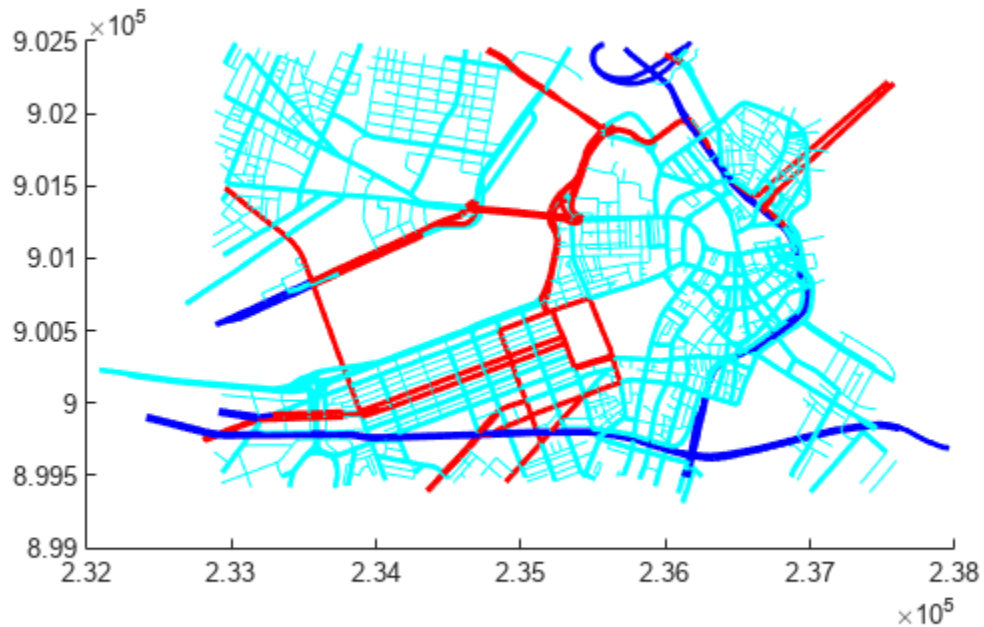
Display Vector Data Using Symbol Specification

Create a symbol specification to distinguish between different types of roads. For example, you can hide very minor roads (CLASS=6) by turning off their visibility and make major roads (CLASS=1-4) more visible by increasing their line widths. This symbol specification also uses color to distinguish between types of roads.

```
roadspec = makesymbolspec('Line',...
    {'ADMIN_TYPE',0,'Color','cyan'},...
    {'ADMIN_TYPE',3,'Color','red'},...
    {'CLASS',6,'Visible','off'},...
    {'CLASS',[1 4],'LineWidth',2});
```

Display the vector data using the symbol specification.

```
figure
mapshow('boston_roads.shp','SymbolSpec',roadspec);
```



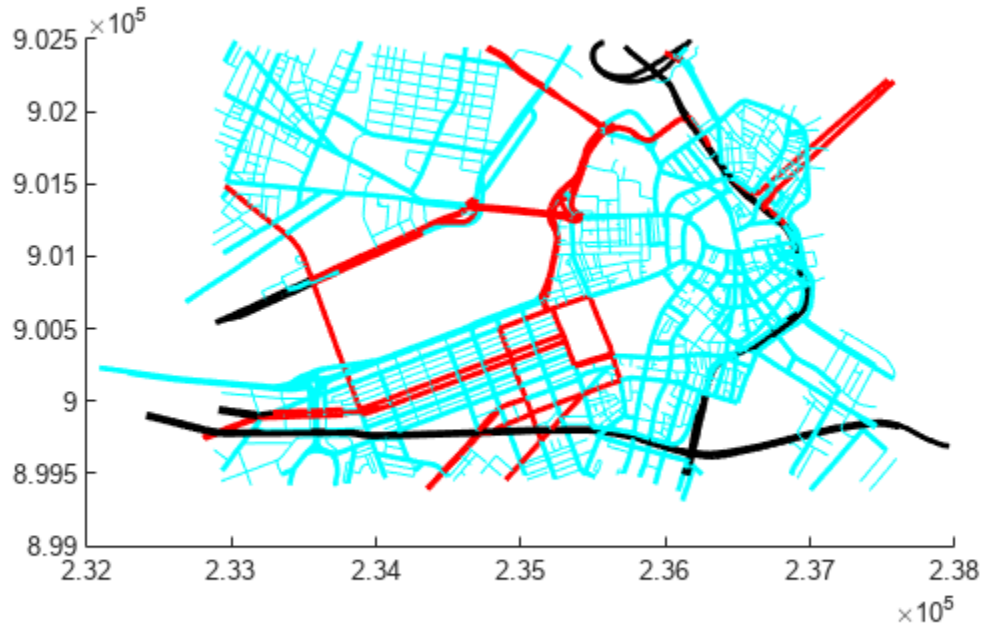
Override Default Properties of the Line

Create a symbol specification and specify the default color used for lines. As seen in the previous example, the default is blue. This example sets the default to black.

```
roadspec = makesymbolspec('Line',...
    {'Default', 'Color', 'black'}, ...
    {'ADMIN_TYPE',0,'Color','c'}, ...
    {'ADMIN_TYPE',3,'Color','r'},...
    {'CLASS',6,'Visible','off'},...
    {'CLASS',[1 4],'LineWidth',2});
```

Display the vector data, using the symbol specification. Note how the major roads displayed in blue in the previous example are now black.

```
figure
mapshow('boston_roads.shp','SymbolSpec',roadspec);
```



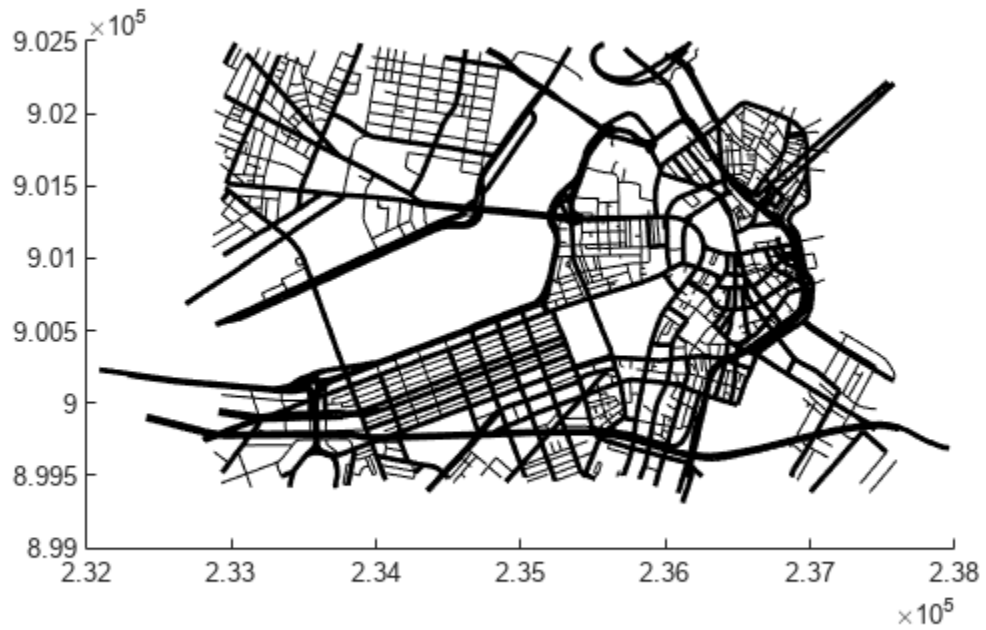
Override Symbol Specification on Command Line

Create a symbol specification, setting various properties.

```
roadspec = makesymbolspec('Line',...
    {'Default', 'Color', 'yellow'}, ...
    {'ADMIN_TYPE',0,'Color','c'}, ...
    {'ADMIN_TYPE',3,'Color','r'},...
    {'CLASS',6,'Visible','off'},...
    {'CLASS',[1 4],'LineWidth',2});
```

Display the vector data, specifying the color on the command line.

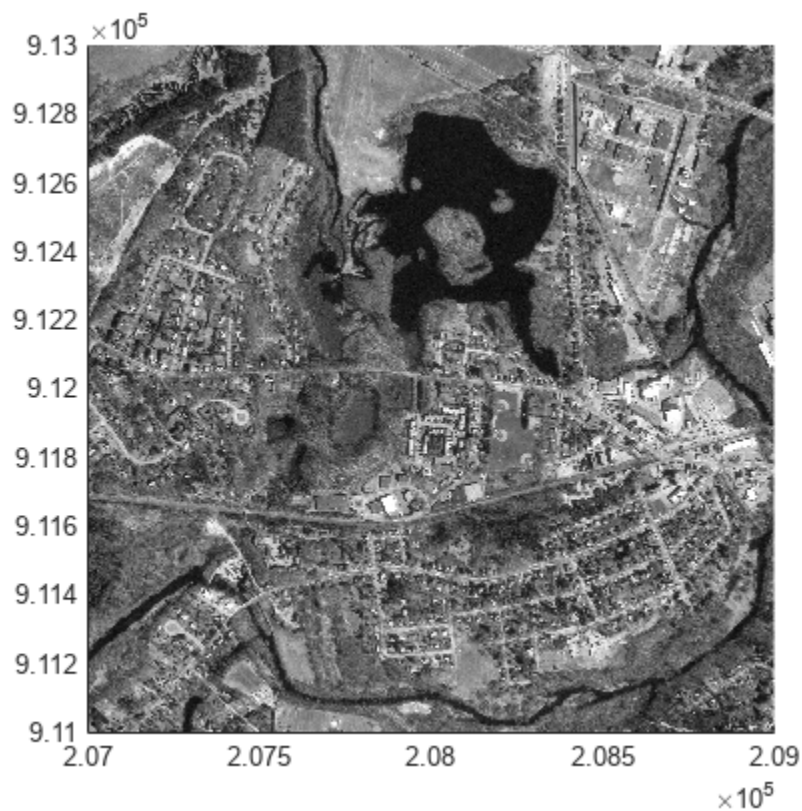
```
figure
mapshow('boston_roads.shp', 'Color', 'black', 'SymbolSpec', roadspec);
```



Display Polygon Over Orthophoto

Import an orthophoto of Concord, MA, along with a map cells reference object and a colormap. Display the orthophoto using the mapshow function.

```
[ortho,R,cmap] = readgeoraster("concord_ortho_w.tif");  
mapshow(ortho,cmap,R)
```



Import and display a polygon representing a pond in the middle of the orthophoto.

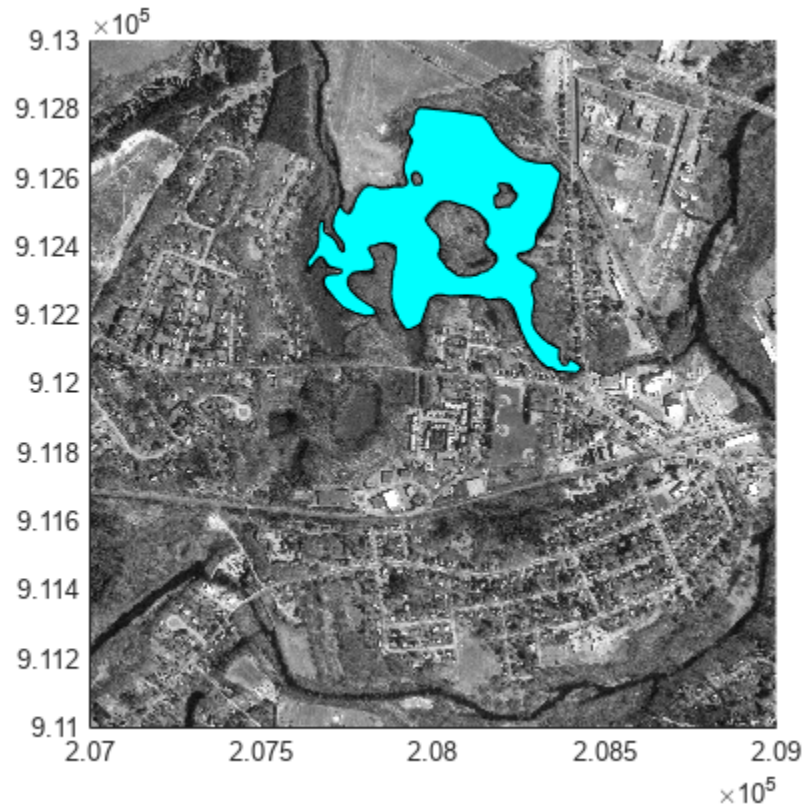
Import a shapefile containing hydrographic data for Concord as a geospatial table. Create a subtable that contains the 14th row of the table, which is the row containing the pond. Verify that the subtable contains polygon data by querying the Shape variable of the table.

```
hydro = readgeotable("concord_hydro_area.shp");
pond = hydro(14,:);
pond.Shape
```

```
ans =
  mappolyshape with properties:
    NumRegions: 1
    NumHoles: 3
    Geometry: "polygon"
    CoordinateSystemType: "planar"
    ProjectedCRS: [1x1 projcrs]
```

Display the polygon over the orthophoto.

```
mapshow(pond, "FaceColor", "c")
```

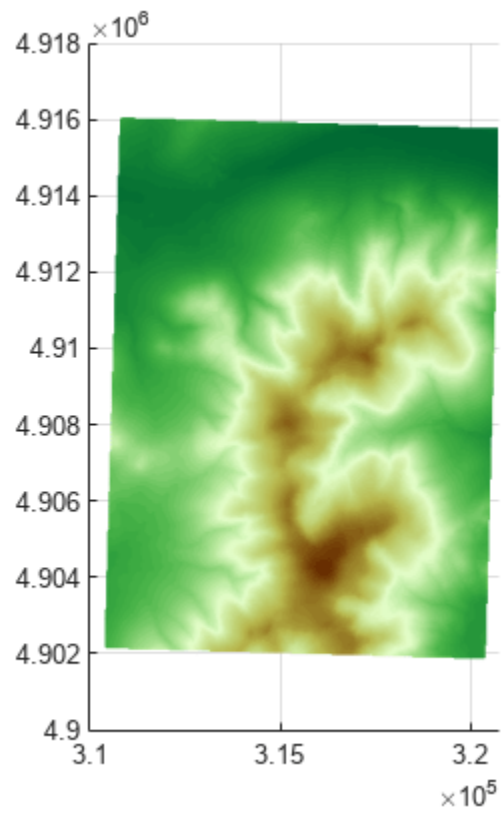
Display Terrain Data as Mesh, Surface, and 3-D Surface

Read SDTS terrain data for Mount Washington. Get information such as missing data indicators using `georasterinfo`. Replace the missing data with NaN values using `standardizeMissing`.

```
[Z,R] = readgeoraster('MtWashington-ft.grd', 'OutputType', 'double');
info = georasterinfo('MtWashington-ft.grd');
Z = standardizeMissing(Z,info.MissingDataIndicator);
```

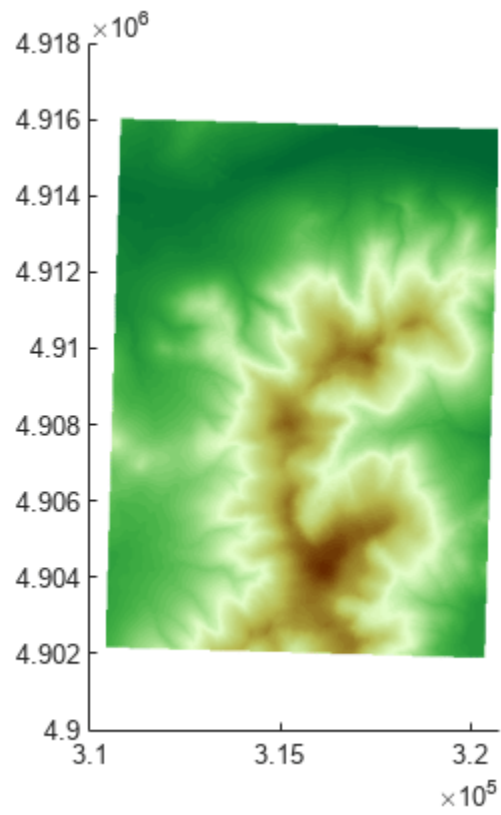
View the terrain data as a mesh. Apply a colormap appropriate for terrain data using `demcmap`.

```
figure
mapshow(Z,R, 'DisplayType', 'mesh');
demcmap(Z)
```



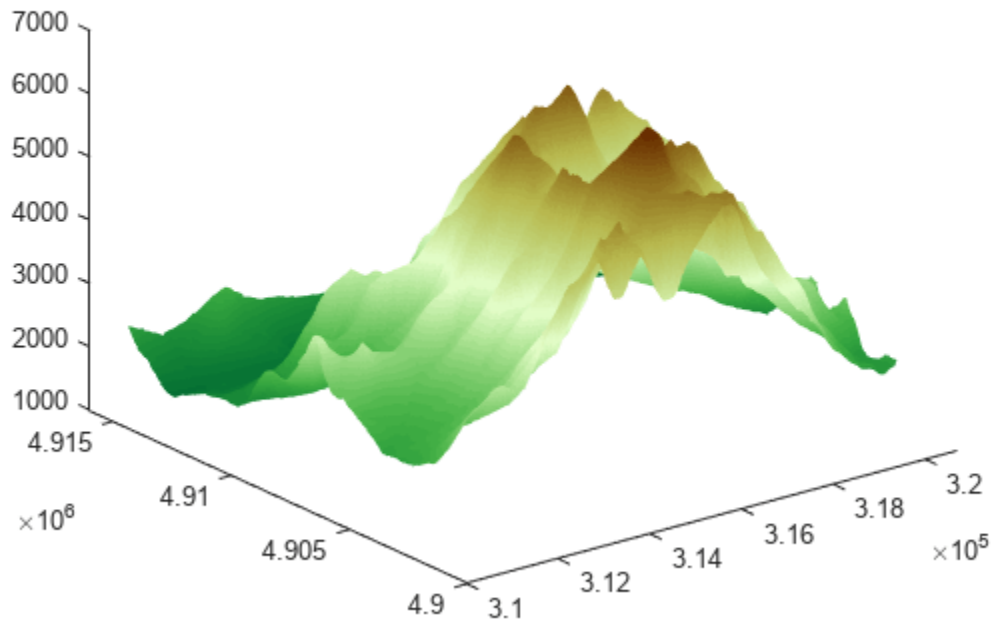
View the terrain data as a surface.

```
figure  
mapshow(Z,R, 'DisplayType', 'surface');  
demcmmap(Z)
```

View the terrain data as a 3-D surface.

```
view(3);  
axis normal
```



Display Grid and Contour Lines

Read the terrain data files for Mount Washington and Mount Dartmouth. To plot the data as a surface using `mapshow`, the raster must be of type `single` or `double`. Specify the data type for the raster using the `'OutputType'` name-value pair.

```
[ZWash,RWash] = readgeoraster('MtWashington-ft.grd','OutputType','double');
[ZDart,RDart] = readgeoraster('MountDartmouth-ft.grd','OutputType','double');
```

Find missing data using the `georasterinfo` function. The function returns an object with a `MissingDataIndicator` property that indicates which value represents missing data. Replace the missing data with `NaN` values using the `standardizeMissing` function.

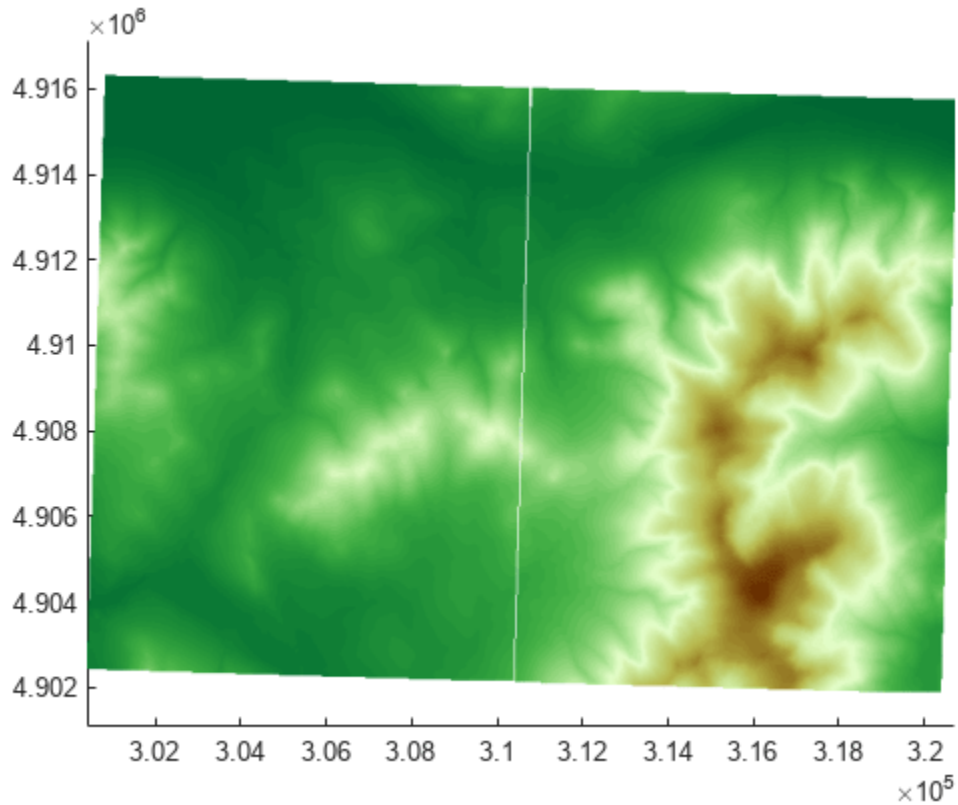
```
infoWash = georasterinfo('MtWashington-ft.grd');
ZWash = standardizeMissing(ZWash,infoWash.MissingDataIndicator);
```

```
infoDart = georasterinfo('MountDartmouth-ft.grd');
ZDart = standardizeMissing(ZDart,infoDart.MissingDataIndicator);
```

Display the terrain data under the contour lines and labels by specifying the `'ZData'` name-value pair as a matrix of zeros. Apply a colormap appropriate for terrain data using `demcmap`.

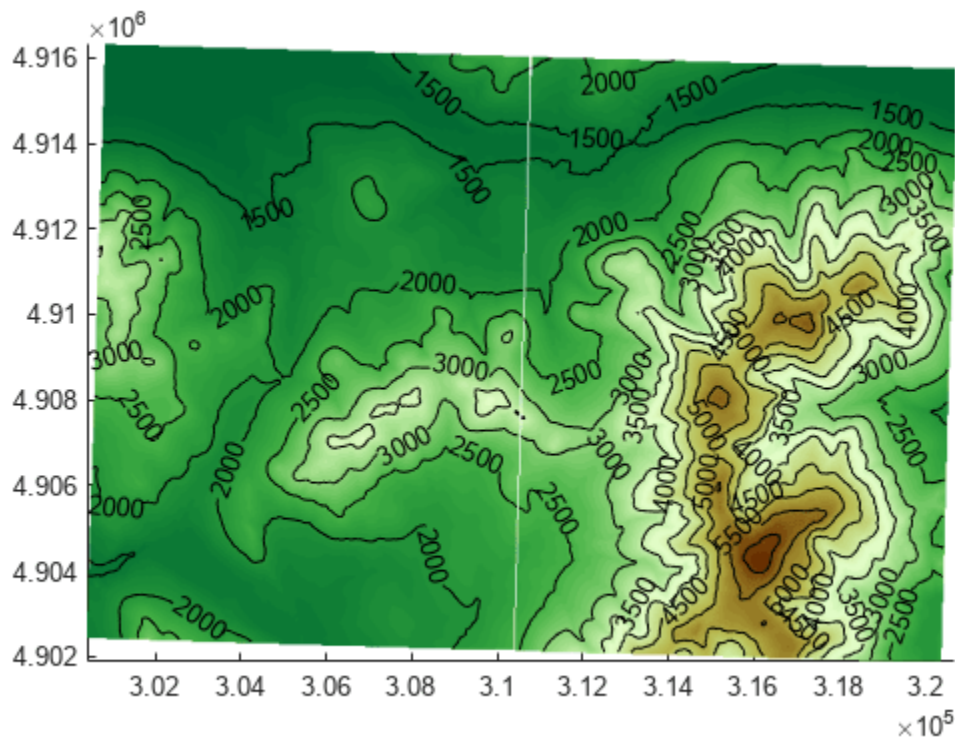
```
hold on
mapshow(ZWash,RWash,'DisplayType','surface','ZData',zeros(RWash.RasterSize))
```

```
mapshow(ZDart,RDart,'DisplayType','surface','ZData',zeros(RDart.RasterSize))  
axis equal  
demcmap(ZWash)
```



Overlay black contour lines and labels.

```
mapshow(ZWash,RWash,'DisplayType','contour',...  
        'LineColor','k','ShowText','on');  
mapshow(ZDart,RDart,'DisplayType','contour',...  
        'LineColor','k','ShowText','on');
```



Input Arguments

x, y — x- or y-coordinates

numeric vector | M -by- N numeric matrix

x- or y coordinates, specified as a numeric vector or an M -by- N numeric matrix. x and y must be the same size. If x and y are matrices, they represent coordinate arrays or a geolocation array in map coordinates. x and y may contain embedded NaNs to delimit individual lines or polygon parts.

S — Geographic features

geospatial table | mappoint vector | mapshape vector | map structure array

Geographic features, specified as one of the following:

- A geospatial table. The Shape variable of the table must contain mappointshape, maplineshape, or mappolyshape objects. The mapshow function does not support geospatial tables containing more than one type of shape object. For more information about geospatial tables, see “Create Geospatial Tables”.
- A mappoint vector.
- A mapshape vector.
- A map structure array (mapstruct) with X and Y coordinate fields.

The mapshow function assumes the coordinates are map coordinates.

If you specify a `geopoint` vector, a `geoshape` vector, or a geographic structure array (`geostruct`) with `Lat` and `Lon` coordinate fields, then the `mapshow` function projects the coordinates using a Plate Carrée projection and issues a warning. If you specify a geospatial table containing `geopointshape`, `geolineshape`, or `geopolyshape` objects, then the `mapshow` function throws an error. In these cases, use the `geoshow` function instead.

Z — Data grid

M-by-*N* array

Data grid, specified as an *M*-by-*N* array that may contain NaN values. *Z* is either a georeferenced data grid, or a regular data grid associated with a geographic reference *R*. The size of *x* and *y* must match the size of *Z*.

Data Types: `double`

R — Map reference

map raster reference object | matrix

Map reference, specified as one of the following. For more information about referencing matrices, see “Georeferenced Raster Data”.

Type	Description
Map raster reference object	<p><code>MapCellsReference</code> or <code>MapPostingsReference</code> or <code>GeographicPostingsReference</code> map raster reference object that relates the subscripts of <i>Z</i> to map coordinates. The <code>RasterSize</code> property must be consistent with the size of the data grid, <code>size(Z)</code>.</p> <p>If <i>R</i> is a <code>MapPostingsReference</code> object, then the 'image' and 'texturemap' values of <code>DisplayType</code> are not accepted.</p>
Matrix	<p>3-by-2 numeric matrix that transforms raster row and column indices to or from map coordinates according to:</p> $[x \ y] = [row \ col \ 1] * R$

I — Truecolor, grayscale, or binary image

M-by-*N*-by-3 array | *M*-by-*N* array

Truecolor, grayscale, or binary image, specified as an *M*-by-*N*-by-3 array for truecolor images, or an *M*-by-*N* array for grayscale or binary images. *x* and *y* must be *M*-by-*N* arrays.

X — Indexed image

M-by-*N* array

Indexed image with color map defined by `cmap`, specified as an *M*-by-*N* array. *x* and *y* must be *M*-by-*N* arrays.

cmap — Color map

c-by-3 matrix

Color map of indexed image *X*, specified as an *c*-by-3 numeric matrix. There are *c* colors in the color map, each represented by a red, green, and blue pixel value.

filename — File name

character vector | string scalar

File name, specified as a string scalar or character vector. `mapshow` automatically sets the `DisplayType` parameter according to the format of the data.

Format	DisplayType
Shape file	'point', 'multipoint', 'line', or 'polygon'
GeoTIFF	'image'
TIFF/JPEG/PNG with a world file	'image'
ARC ASCII GRID	'surface' (can be overridden)
SDTS raster	'surface' (can be overridden)

Data Types: char | scalar

ax — Parent axes

axes object

Parent axes, specified as an axes object.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: 'DisplayType', 'point'

DisplayType — Display type

'point' | 'multipoint' | 'line' | 'polygon' | 'image' | 'surface' | 'mesh' | 'texturemap' | 'contour'

Type of graphic display for the data, specified as the comma-separated pair consisting of 'DisplayType' and one of the following values.

Data Format	Display Type	Type of Property
Vector	'point'	<i>line marker</i>
	'multipoint'	<i>line marker</i>
	'line'	<i>line</i>
	'polygon'	<i>patch</i>
Image	'image'	<i>surface</i>
Grid	'surface'	<i>surface</i>
	'mesh'	<i>surface</i>
	'texturemap'	<i>surface</i>
	'contour'	<i>contour</i>

Valid values of `DisplayType` depend on the format of the map data. For example, if the map data is a geolocated image or georeferenced image, then the only valid value of `DisplayType` is 'image'.

Different display types support different map data class types:

Display Type	Supported Class Types
Image	
Surface	single and double
Texture map	All numeric types and logical

SymbolSpec – Symbolization rules

structure

Symbolization rules to be used for displaying vector data, specified as a `symbolSpec` structure returned by `makesymbolSpec`. When both `SymbolSpec` and one or more graphics properties are specified, the graphics properties will override any settings in the `symbolSpec` structure.

To change the default symbolization rule for a `Name, Value` pair in the `symbolSpec` structure, prefix the word 'Default' to the graphics property name.

Output Arguments

h – Parent axes

handle object | modified patch object

Parent axes, returned as a handle to a MATLAB graphics object or, in the case of polygons, a modified patch object. If a `mapstruct` or `shapefile` name is input, `mapshow` returns the handle to an `hggroup` object with one child per feature in the `mapstruct` or `shapefile`. In the case of a polygon `mapstruct` or `shapefile`, each child is a modified patch object; otherwise it is a line object.

Tips

- If you do not want `mapshow` to draw on top of an existing map, create a new figure or subplot before calling it.
- You can use `mapshow` to display vector data in an `axesm` figure. However, you should not subsequently change the map projection using `setm`.
- If you display a polygon, do not set 'EdgeColor' to either 'flat' or 'interp'. This combination may result in a warning.

Version History

Introduced before R2006a

R2021b: Display data from geospatial tables

The `mapshow` function accepts geospatial tables as input.

See Also

Functions

`geoshow` | `makesymbolSpec` | `shaperead`

Objects

`MapCellsReference` | `MapPostingsReference`

Topics

“Create and Display Polygons”

maptriml

Trim lines to latitude-longitude quadrangle

Syntax

```
[lat,lon] = maptriml(lat0,lon0,latlim,lonlim)
```

Description

`[lat,lon] = maptriml(lat0,lon0,latlim,lonlim)` returns *filtered* NaN-delimited vector map data sets from which all points lying outside the desired latitude and longitude limits have been discarded. These limits are specified by the two-element vectors `latlim` and `lonlim`, which have the form `[south-limit north-limit]` and `[west-limit east-limit]`, respectively.

Examples

Trim Lines to Region of Interest

It is not unusual for vector data to extend beyond the geographic region currently of interest. For example, you might have coastline data for the entire world, but are interested in mapping Australia only. In this and other situations, you might want to eliminate unnecessary data from the workspace and from calculations in order to save memory or to speed up processing and display. You can trim line data by simply removing points outside the region of interest by clipping lines at the map frame or to some other defined region. The `maptriml` function returns variables containing only those points that lie within the defined region.

Load the `coastlines` MAT-file. This file contains data for the entire world.

```
load coastlines
```

Define a region of interest centered on Australia.

```
latlim = [-50 0];
lonlim = [105 160];
```

Delete all line data outside these limits, producing line vectors, by using the `maptriml` function.

```
[lineLat,lineLon] = maptriml(coastLat,coastLon,latlim,lonlim);
```

Examine the variables to see how much data has been reduced. The clipped data is only 10% as large as the original data set.

```
whos
```

Name	Size	Bytes	Class	Attributes
coastLat	9865x1	78920	double	
coastLon	9865x1	78920	double	
latlim	1x2	16	double	
lineLat	977x1	7816	double	

```
linelat    977x1    7816 double  
lonlim     1x2      16 double
```

Plot the trimmed line data using a Miller projection.

```
axesm('MapProjection', 'miller', 'Frame', 'on', ...  
'FlatLimit', latlim, 'FlonLimit', lonlim)  
geoshow(linelat, linelat)
```



Version History

Introduced before R2006a

See Also

mapclip | geoclip | maptrim | geocrop

maptrimp

Trim polygons to latitude-longitude quadrangle

Syntax

```
[latTrimmed,lonTrimmed] = maptrimp(lat,lon,latlim,lonlim)
```

Description

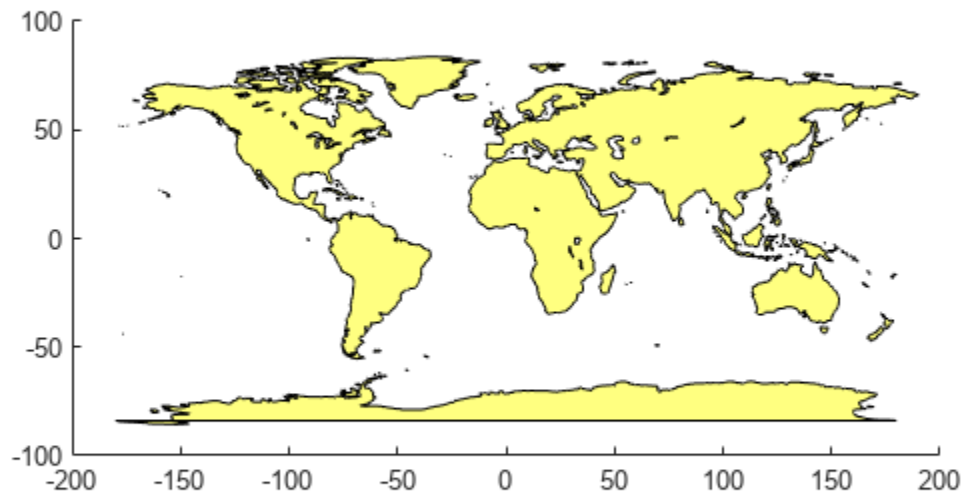
[latTrimmed,lonTrimmed] = maptrimp(lat,lon,latlim,lonlim) trims the polygons in lat and lon to the quadrangle specified by latlim and lonlim. latlim and lonlim are two-element vectors, defining the latitude and longitude limits respectively. lat and lon must be vectors that represent valid polygons.

Examples

Trim Dataset to Specific Geographic Area

Read coastline data and display it on a map.

```
load coastlines  
figure  
mapshow(coastlon,coastlat,'DisplayType','polygon');
```

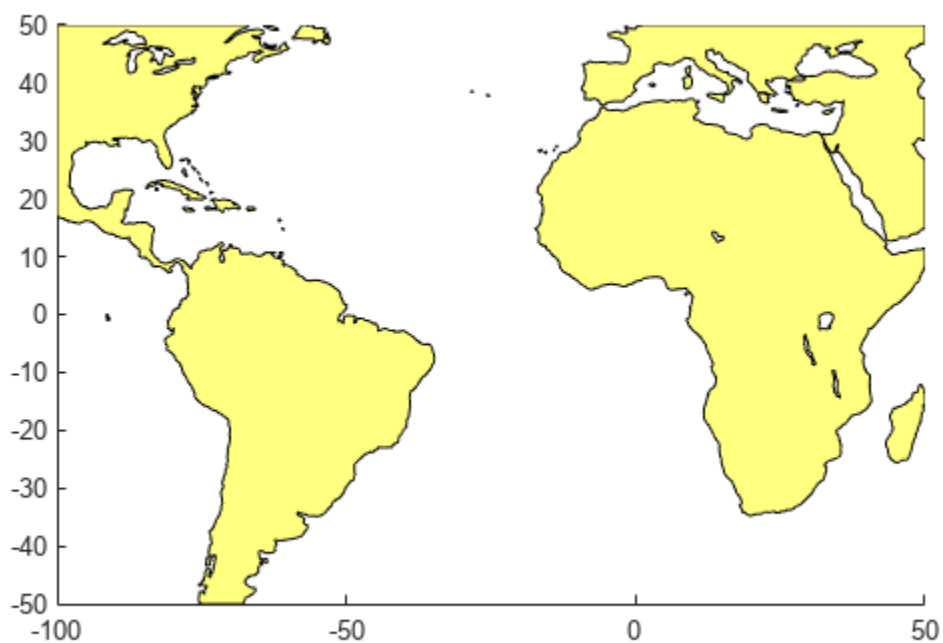


Trim the dataset.

```
latlim = [-50 50];  
lonlim = [-100 50];  
[latTrimmed,lonTrimmed] = maptrimp(coastlat,coastlon, ...  
    latlim, lonlim);
```

Display the trimmed dataset.

```
figure  
mapshow(lonTrimmed,latTrimmed, 'DisplayType', 'polygon');
```



Tips

maptrimp conditions the longitude limits such that:

- `lonlim(2)` always exceeds `lonlim(1)`
- `lonlim(2)` never exceeds `lonlim(1)` by more than 360
- `lonlim(1) < 180` or `lonlim(2) > -180`
- Ensure that if the quadrangle span the Greenwich meridian, then that meridian appears at longitude 0.

Version History

Introduced before R2006a

See Also

mapclip | geoclip | maptriml | geocrop

maptrims

(To be removed) Trim regular data grid to latitude-longitude quadrangle

Note `maptrims` will be removed in a future release. Use the `geocrop` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z_trimmed] = maptrims(Z,R,latlim,lonlim)
[Z_trimmed] = maptrims(Z,R,latlim,lonlim,cellDensity)
[Z_trimmed, R_trimmed] = maptrims(...)
```

Description

`[Z_trimmed] = maptrims(Z,R,latlim,lonlim)` trims a regular data grid `Z` to the region specified by `latlim` and `lonlim`. By default, the output grid `Z_trimmed` has the same sample size as the input. `R` can be a geographic raster reference object, a referencing vector, or a referencing matrix. If `R` is a geographic raster reference object, its `RasterSize` property must be consistent with `size(Z)` and its `RasterInterpretation` must be 'cells'.

If `R` is a referencing vector, it must be a 1-by-3 vector with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

$$[\text{lon } \text{lat}] = [\text{row } \text{col } 1] * R$$

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. `latlim` and `lonlim` are two-element vectors, defining the latitude and longitude limits, respectively. The `latlim` vector has the form:

```
[southern_limit northern_limit]
```

Likewise, the `lonlim` vector has the form:

```
[western_limit eastern_limit]
```

When an individual value in `latlim` or `lonlim` corresponds to a parallel or meridian that runs precisely along cell boundaries, the output grid will extend all the way to that limit. But if a limiting parallel or meridian cuts through a column or row of input cells, then the limit will be adjusted inward. In other words, the requested limits will be truncated as necessary to avoid partial cells.

`[Z_trimmed] = maptrims(Z,R,latlim,lonlim,cellDensity)` uses the scalar `cellDensity` to reduce the size of the output. If `R` is a referencing vector, then `R(1)` must be evenly divisible by

cellDensity. If R is a referencing matrix, then the inverse of each element in the first two rows (containing "deltaLat" and "deltaLon") must be evenly divisible by cellDensity.

[Z_trimmed, R_trimmed] = maptrims(...) returns a referencing vector, matrix, or object for the trimmed data grid. If R is a referencing vector, then R_trimmed is a referencing vector. If R is a referencing matrix, then R_trimmed is a referencing matrix. If R is a geographic raster reference object, then R_trimmed is either a geographic raster reference object (when Z_trimmed is non-empty) or [] (when Z_trimmed is empty).

Examples

Load elevation raster data and a geographic cells reference object. Then, trim the data to the specified latitude and longitude limits.

```
load topo60c
[subgrid,subR] = maptrims(topo60c,topo60cR,...
                        [80.25 85.3],[165.2 170.7])
```

```
subgrid =
    -2826    -2810    -2802    -2793
    -2915    -2913    -2905    -2884
    -3192    -3186    -3165    -3122
    -3399    -3324    -3273    -3214
```

```
subR =
```

```
GeographicCellsReference with properties:
```

```
    LatitudeLimits: [81 85]
    LongitudeLimits: [166 170]
    RasterSize: [4 4]
    RasterInterpretation: 'cells'
    ColumnsStartFrom: 'south'
    RowsStartFrom: 'west'
    CellExtentInLatitude: 1
    CellExtentInLongitude: 1
    RasterExtentInLatitude: 4
    RasterExtentInLongitude: 4
    XIntrinsicLimits: [0.5 4.5]
    YIntrinsicLimits: [0.5 4.5]
    CoordinateSystemType: 'geographic'
    AngleUnit: 'degree'
```

The upper left corner of the grid might differ slightly from that of the requested region. The maptrims function uses the corner coordinates of the first cell inside the limits.

Version History

Introduced before R2006a

R2022a: Warns

Warns starting in R2022a

Some functions that accept referencing vectors or referencing matrices as input issue a warning that they will be removed in a future release, including the maptrims function. Use a geographic

reference object and the `geocrop` function instead. Reference objects have several advantages over referencing vectors and matrices.

- Unlike referencing vectors and matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `GeographicPostingsReference` objects.
- Manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- Manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, first create a reference object for either a raster of cells using the `georefcells` function or a raster of regularly posted samples using the `georefpostings` function. Alternatively, convert from a referencing vector or a referencing matrix to a reference object using the `refvecToGeoRasterReference` or `refmatToGeoRasterReference` function, respectively.

Then, replace instances of the `maptrims` function with the `geocrop` function using these patterns.

Will Be Removed	Recommended
<code>[B,RB] = maptrims(A,R,latlim,lonlim);</code>	<code>[B,RB] = geocrop(A,R,latlim,lonlim)</code>
<code>[B,RB] = maptrims(A,R,latlim,lonlim,cellDensity);</code>	<pre>[B,RB] = geocrop(A,R,latlim,lonlim) latscale = cellDensity * RB.CellExtentInLatitude; lonscale = cellDensity * RB.CellExtentInLongitude; [B,RB] = georesize(B,RB,latscale,lonscale,'nearest');</pre>

The limits of the reference object returned by the `geocrop` function may be larger than the limits returned by the `maptrims` function.

R2020b: To be removed

Not recommended starting in R2020b

The `maptrims` function runs without warning but will be removed in a future release.

See Also

`mapclip` | `geoclip` | `maptriml` | `maptrimp` | `geocrop`

mapview

(Removed) Interactive map viewer

Note The `mapview` function has been removed.

Syntax

`mapview`

Description

`mapview` opens the Map Viewer app in an empty state. Use the Map Viewer to view geospatial data in map (x - y) coordinates. The Map Viewer works with vector, image, and raster data grids in a map coordinate system. You can load data, pan and zoom on the map, control the map scale of your screen display, control the order, visibility, and symbolization of map layers, annotate your map, and click to learn more about individual vector features. `mapview` complements `mapshow` and `geoshow`, which are for constructing maps in ordinary figure windows in a less interactive, script-oriented way.

For usage information, see the following sections.

Importing Data

The Map Viewer opens with no data loaded and an empty map display window. The first step is to import a data set. Use the options in the **File** menu to select data from a file or from the MATLAB workspace:

Import From File

Use the file browsing dialog to open a file in one of the following formats: Shapefile, GeoTIFF, SDTS DEM, Arc ASCII Grid, TIFF, JPEG, or PNG with world file. This option imports the data into the viewer but does not add it to your workspace.

To view standard-format geodata files provided with the toolbox, set your working folder or navigate the Map Viewer Open dialog to `matlabroot/examples/map/data` or `matlabroot/toolbox/map/mapdata`.

Import From Workspace

Images. Use the **Raster Data > Image** import dialog to select a **Referencing matrix or object name** and **Raster data name** for the image from the list of workspace variables. If the image type is truecolor (RGB), specify which band represents the red, green, and blue intensities. (The `RasterInterpretation` of the referencing object must be `'cells'`.)

Data grids. Use the **Raster Data > Grid** import dialog to select X and Y geolocation and data grid array names from the list of workspace variables.

Vector data. Use the **Vector Data > Map coordinates** import dialog to select X and Y variables for map coordinates from the list of workspace variables and identify the type of geometry to be displayed (**Point**, **Line**, or **Polygon**). The X and Y variables can specify multiple line segments or multiple polygons if they contain NaNs at matching locations in the coordinate vectors.

Vector geographic data structure. Use the **Vector Data > Geographic data structure** import dialog to select the structure that contains vector map data from the list of workspace variables.

Once you import your first data set, the Map Viewer automatically sets the limits of its map display window to the spatial extent of the imported data.

Working in Map Coordinates

As you move any of the Map Viewer cursors across the map display area, the coordinate readout in the lower left corners shows you the cursor position in map X and Y coordinates.

The Map Viewer requires that all currently viewed data sets possess the same coordinate system and length units. This is likely to be the case for data sets that originated from a common source. If it is not the case, you will need to adjust coordinates before importing data into the Map Viewer.

If some or all of your data is in geographic coordinates, use `proj fwd` to project latitudes and longitudes to your desired map coordinate system before you import it. When starting from a different projection, you must first unproject to latitude and longitude using `proj inv`, then reproject with `proj fwd`. You might also need to adjust the horizontal datum of your data using, for example, the free GEOTRANS (Geographic Translator) application from the Geospatial Sciences Division of the U.S. National Geospatial-Intelligence Agency (NGA). If you simply need a change of units, multiply by the appropriate conversion factor obtained from `unitsratio`.

`mapview` can also display data in unprojected geographic coordinates, if you consistently substitute longitude for map X and latitude for map Y. Geographic coordinates must be consistently expressed in either degrees or radians (not both at once). When using geographic coordinates, do not specify the viewer's map units (see below); you can only use the Map Viewer's map scale display when working in linear units of length.

Setting Map Units and Scale

If you tell the Map Viewer which length unit you are using, it can calculate an approximate map scale for your onscreen display. Set the map units with either the drop-down menu at the bottom of the display or the **Set Map Units** item in the **Tools** menu.

The scale computed by the Map Viewer is displayed in the window just above the map units drop-down. To change your display scale while keeping the center of the map display fixed, simply edit this text box.

Make sure to format your text in the standard way ($1:N$, where N is a positive number such that a distance on the ground is N times the same distance on your screen, e.g., $1:24000$).

The scale is approximate because it depends on the MATLAB estimate of the size of your screen pixels. It is also approximate if your projection introduces significant distortion. If your data falls in a fairly small area and you use a conformal projection (e.g., UTM with all data in a single zone), the scale will be very consistent across your entire map.

Navigating Your Map

By default, the Map Viewer sets the limits of your map window to match the extent of the first data set that you load. You will probably want to adjust this to see some areas in greater detail.

The Map Viewer provides several tools to control the limits of your map window and the map scale of the data display. Some are familiar from standard MATLAB figure windows.

- **Zoom in:** Drag a box to zoom in on a specific area or click a point to zoom in with that point centered in the map display.
- **Zoom out:** Click a point to zoom out with that point centered in the map display.
- **Pan tool:** Click, hold, and drag to reposition the selected point in the display window, while holding the map scale fixed. Release when you are satisfied with new display limits.
- **Fit to window:** Set the map display to enclose all currently loaded data layers. This is equivalent to selecting **Fit to Window** in the **View** menu.
- **Back to previous view:** Click this button once to return the map scale and display center to their values prior to the most recent zoom, pan, or scale change. Click repeatedly to undo earlier changes. This is equivalent to selecting **Previous View** in the **View** menu.

Another way to zoom in or out while keeping the center of the view fixed at the same map coordinates is to directly edit the map scale box at the bottom of the screen.

Managing Map Layers

Each time you import a set of vectors, an image, or a data grid into the Map Viewer, the new data is stored in a new map layer. The layers form an ordered stack. Each layer is listed as an item in the **Layers** menu, with its position in the menu indicating its position in the stack.

When you import a new layer, the Map Viewer automatically places it at the top of the layer stack. To reposition a layer in the stack, select it in the **Layers** menu, slide right, and select **To Top**, **To Bottom**, **Move Up**, or **Move Down** from the pop-up submenu.

The vector features or raster in a given layer obscure coincident elements of any underlying layers. To control layers that are obscuring one another, you can also toggle layer visibility on and off. Use the item **Visible** in the slide-right menu. Or, simply remove a layer from the Map Viewer via the **Remove** item in the slide-right menu. Remember that even if a layer's visibility is *on*, the layer does not appear if its contents are located completely outside the current display limits or are obscured by another layer.

Symbolizing Vector Features

When point, line, and polygon layers are loaded, the Map Viewer initializes their graphics properties as follows:

Geometry	Properties
Point (line objects)	LineStyle = 'none' Marker = 'x' MarkerEdgeColor = <randomly generated value> MarkerFaceColor = 'none'

Geometry	Properties
Line (line objects)	Color = <randomly generated value> LineStyle = '-' Marker = 'none'
Polygon (patch objects)	EdgeColor = [0 0 0] FaceColor = <randomly generated value>

To override symbolism defaults for a vector layer, use `makesymbolspec` to create a symbol specification in the workspace. A `symbolspec` contains a set of rules for setting vector graphics properties based on the values of feature attributes. For instance, if you have a line layer representing roads of various classes (e.g., major highway, secondary road, etc.), you can create a `symbolspec` to use a different color, line width, or line style for each road class. See the `makesymbolspec` help for examples and to learn how to construct a `symbolspec`. If you regularly work with data sets sharing a common set of feature attributes, you might want to save one or more `symbolspecs` in a MAT-file (or save calls to `makesymbolspec` in a MATLAB program file).

Once you have a `symbolspec` in your workspace, select your vector layer in the **Layers** menu, then slide right and click **Set Symbol Spec**, which opens a dialog box. Use the dialog box to select the `symbolspec` from your workspace.

Getting Information About Vector Features

The **Datatip** tool and the **Info** tool provide different ways to check the attributes of vector features that you select graphically. Before using either tool you must designate one of your vector layers as *active*. (The default active layer is the first one that you imported.) Either use the **Active Layer** drop-down menu at the bottom of your screen or select the layer in the **Layers** menu, slide right, and select **Active**. Having a designated active layer ensures that when you click a feature you don't inadvertently select an overlapping feature from a different layer.

- **Datatip tool:** The **Datatip** tool displays a feature attribute in a text label each time you click a vector feature. By default the attribute is the first one in the layer's attribute list. To change which attribute is used, select the layer in the **Layers** menu, slide right, and click **Set Layer Attribute**. In the dialog that follows, select a different attribute, or **Index**. If you choose **Index**, the Map Viewer displays the one-based index value corresponding to a given feature—based on its position in the input file or workspace array. To remove a text label, right-click it and choose **Delete datatip** from the context menu. Or choose **Delete all datatips** from the context menu or the **Tools** menu.
- **Info tool:** The **Info** tool opens a separate text window each time you click a vector feature. The window displays all the attribute names and values for that feature, in contrast to the **Datatip** tool, which displays only the value of a single attribute. If you need to compare two or more features, simply click each one and view the info windows together. Use its close button to close an info window when you're done with it, or choose **Close All Info Windows** from the **Tools** menu.

Annotating Your Map

Use the **text**, **line**, or **arrow** annotation tools to mark and highlight points of interest on your map, or select the corresponding items in the **Insert** menu. Use the **Select annotations** tool and **Edit** menu to modify or remove your annotations. The Map Viewer manages annotations separately from data layers; annotations always stay on top. Note that annotations cannot be saved as graphic objects, although you can export maps containing annotations to an image format as described below.

Creating and Using Additional Views

Use **New View** on the **File** menu to create an additional Map Viewer window linked to an existing window. Consider using an additional window when you want to see your map at different scales at the same time (e.g., a detailed view plus an overview), or when you want to simultaneously see different areas of the map at large scale. You can create as many additional windows as you need, and close them when you want. Your mapview session ends when you close the last window.


Options for creating a new viewer window include: **Duplicate Current View**, **Full Extent**, **Full Extent of Active Layer**, and **Selected Area**. Click and drag with the **Select area** tool to define a selected area.

A new viewer window differs from existing windows mainly in terms of the visible map extent and scale (it also omits annotations and any labels you added with the datatip tool). You will see the same layers in the same order with the same settings (including the active layer). Updates to layers (insertion/removal, order, visibility, label attribute, and symbolization) in one viewer window are propagated automatically to all the windows with which it is linked. Updates to annotations and datatip labels are not propagated between viewers. If you need two different layer configurations in different windows, launch a second mapview from the command line instead of creating an additional window. The views it contains will not be linked to previous ones.

Exporting Your Map

The Map Viewer allows you to export all or part of your map for use in a publication or on a Web page. Use **File > Save As Raster Map** to export an image of either the current display extent or an area outlined with the **Select area** tool. Select a format (PNG, TIFF, JPEG) from the drop-down menu in the export dialog. For maps including vector layers, PNG (Portable Network Graphics) is often the best choice. This format provides excellent quality, good compression, and is well supported by modern Web browsers. The export process automatically creates a world file (ending with suffix `tfw`, `jgw`, or `pgw`) as well; the pair of files constitute a georeferenced image that itself can be displayed with mapview, mapshow, and many external GIS packages.

Limitations

The **Select area** tool  is not supported in MATLAB Online. To view a particular region on the map, use the **Zoom in**, **Zoom out**, and **Pan** tools instead.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The mapview function has been removed.

R2022a: To be removed

Warns starting in R2022a

The mapview function issues a warning that it will be removed in a future release.

See Also

geoshow | readgeoraster | makesymbolspec | mapshow | shaperead | updategeostruct | worldfileread

mdistort

Display contours of constant map distortion on axesm-based map

Syntax

```
mdistort
mdistort off
mdistort parameter
mdistort(parameter,levels)
mdistort(parameter,levels,gsize)
h = mdistort(...)
```

Description

`mdistort`, with no input arguments, toggles the display of contours of projection-induced distortion on the current axesm-based map. The magnitude of the distortion is reported in percent.

`mdistort off` removes the contours.

`mdistort parameter` displays contours of distortion for the specified parameter. Units are in percent deviation (except for angles for which degrees are used).

Parameter	Value
'area'	
'angles'	maximum angular distortion of right angles
'scale' or 'maxscale'	maximum scale (the default)
'minscale'	minimum scale
'parscale'	scale along the parallels
'merscale'	scale along the meridians
'scaleratio'	ratio of maximum and minimum scale

`mdistort(parameter,levels)` specifies the levels for which the contours are drawn. `levels` is a vector of values as used by `contour`. If empty, the default levels are used.

`mdistort(parameter,levels,gsize)` controls the size of the underlying graticule matrix used to compute the contours. `gsize` is a two-element vector containing the number of rows and columns. If omitted, the default Mapping Toolbox graticule size of [50 100] is assumed.

`h = mdistort(...)` returns a handle to the contour group object containing the contours and text.

Background

Map projections inevitably introduce distortions in the shape and size of objects as they are transformed from three-dimensional spherical coordinates to two-dimensional Cartesian coordinates. The amount and type of distortion vary between projections, over the projection, and with the selection of projection parameters such as standard parallels. This function provides a quantitative graphical display of distortion parameters.

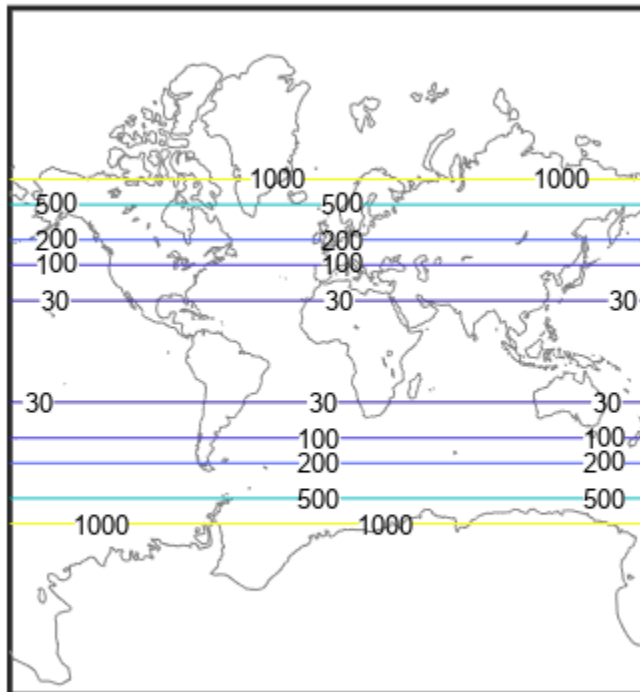
`mdistort` is not intended for use with UTM. Distortion is minimal within a given UTM zone. `mdistort` issues a warning if a UTM projection is encountered.

Examples

View Extreme Area Distortion of Mercator Projection

The extreme area distortion of the Mercator projection. This makes it ill-suited for global displays.

```
figure
axesm mercator
load coastlines
framem;
plotm(coastlat,coastlon,'color',.5*[1 1 1])
mdistort('area',[1 30 100 200 500 1000])
```



View Lines of Distortion for Bonne Projection

View lines of distortion for the Bonne projection.

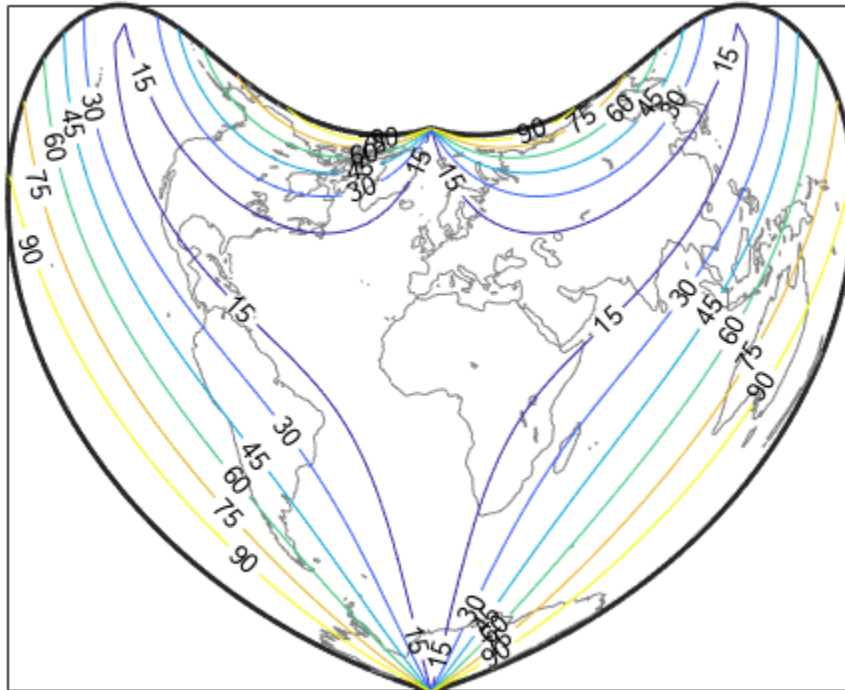
```
figure
axesm bonne
load coastlines
```



```

framem
plotm(coastlat,coastlon,'color',0.5*[1 1 1])
mdistort('angles',0:15:90)

```



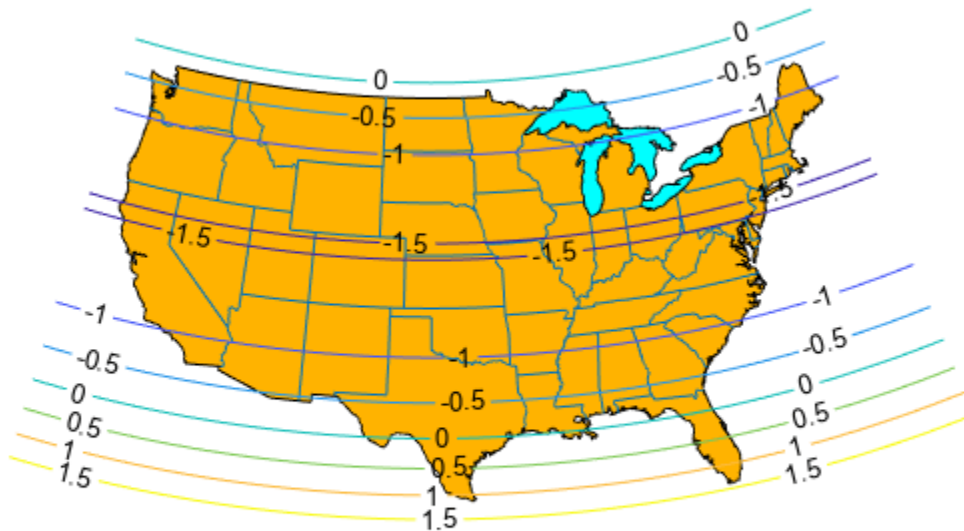
View Distortion of Conic Projection with Properly Chosen Parallels

An equidistant conic projection with properly chosen parallels can map the conterminous United States with less than 1.5% distortion.

```

figure
usamap conus
load conus
patchm(uslat, uslon, [1 0.7 0])
plotm(statelat, statelon)
patchm(gtlakelat, gtlakelon, 'cyan')
framem off; gridm off; mlabel off; plabel off
mdistort('parscale', -2:.5:2)

```



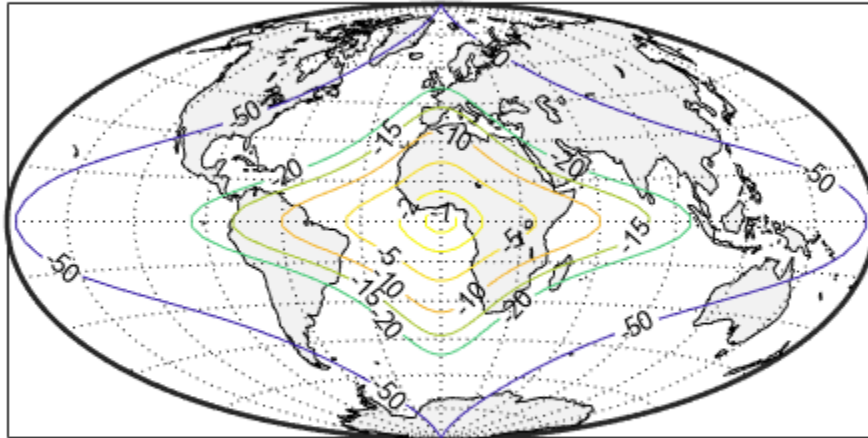
View Contours of Scale Ratios

Create a map in normal aspect using a Hammer projection and plot a graticule and frame. Load the coast data set and plot it as gray patches.

```
figure
axesm('MapProjection','hammer','Grid','on','Frame','on')
load coastlines
patchm(coastlat,coastlon,'FaceColor',[0.95 0.95 0.95])
```

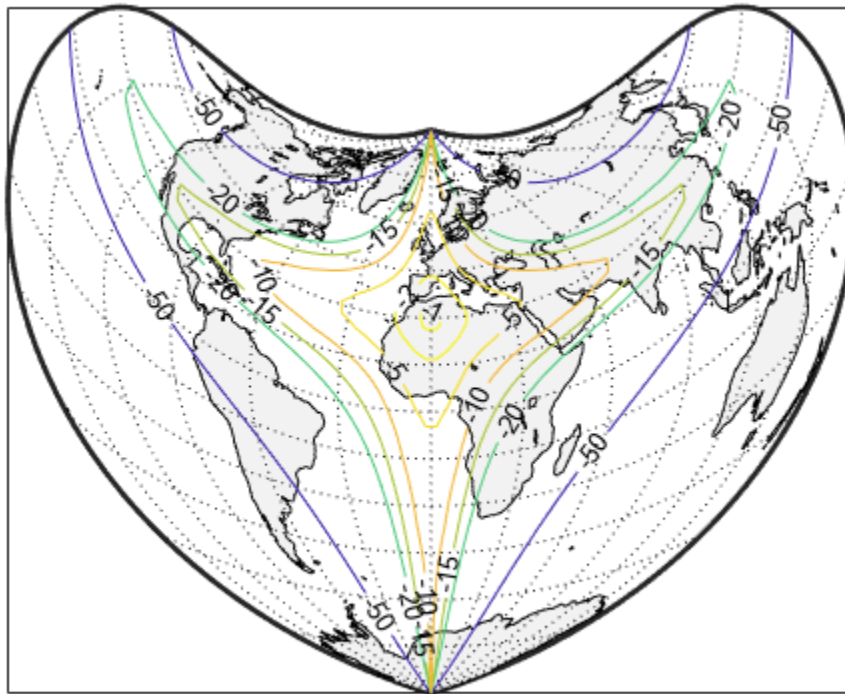
Plot contours of minimum-to-maximum scale ratios by using the `mdistort` function. Notice that the region of minimum distortion is centered around (0,0).

```
mdistort('scaleratio')
```



Repeat this diagram with a Bonne projection in a new figure window. Notice that the region of minimum distortion is centered around (30,0) which is where the single standard parallel is.

```
figure
axesm('MapProjection','bonne','Grid','on','Frame','on')
patchm(coastlat,coastlon,'FaceColor',[0.95 0.95 0.95])
mdistort('scaleratio')
```



Tips

`mdistort` can help in the placement of standard parallels for projections. Standard parallels are generally placed to minimize distortion over the region of interest. The default parallel locations might not be appropriate for maps of smaller regions.

See Also

`tissot` | `distortcalc` | `vfdtran`

meanm

Mean location of geographic coordinates

Syntax

```
[latmean,lonmean] = meanm(lat,lon)
[latmean,lonmean] = meanm(lat,lon,units)
[latmean,lonmean] = meanm(lat,lon,ellipsoid)
```

Description

`[latmean,lonmean] = meanm(lat,lon)` returns row vectors of the geographic mean positions of the columns of the input latitude and longitude points.

`[latmean,lonmean] = meanm(lat,lon,units)` indicates the angular units of the data. The default angle unit is 'degrees'.

`[latmean,lonmean] = meanm(lat,lon,ellipsoid)` specifies the shape of the Earth using `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The default ellipsoid model is a spherical Earth, which is sufficient for most applications.

If a single output argument is used, then `geomeans = [latmean,lonmean]`. This is particularly useful if the original `lat` and `lon` inputs are column vectors.

Background

Finding the mean position of geographic points is more complicated than simply averaging the latitudes and longitudes. `meanm` determines mean position through three-dimensional vector addition. See "Geographic Statistics for Point Locations on a Sphere" in the *Mapping Toolbox User's Guide*.

Examples

Find Mean Position of Geographic Points

Create some random latitudes.

```
rng(0, 'twister')
lats = rand(3)
```

```
lats = 3×3
```

```
    0.8147    0.9134    0.2785
    0.9058    0.6324    0.5469
    0.1270    0.0975    0.9575
```

Create some random longitudes.

```
lons = rand(3)
```

```
lons = 3×3
```

```
0.9649 0.9572 0.1419  
0.1576 0.4854 0.4218  
0.9706 0.8003 0.9157
```

Calculate the mean positions of the input geographic positions.

```
[latmean,lonmean] = meanm(lats,lons,'radians');
```

```
[latmean,lonmean]
```

```
ans = 1×6
```

```
0.6519 0.5581 0.6146 0.7587 0.7351 0.4250
```

See Also

[filterm](#) | [hista](#) | [histr](#) | [stdist](#) | [stdm](#)

meridianarc

Ellipsoidal distance along meridian

Syntax

```
s = meridianarc(phi1,phi2,ellipsoid)
```

Description

`s = meridianarc(phi1,phi2,ellipsoid)` calculates the (signed) distance `s` between latitudes `phi1` and `phi2` along a meridian on the ellipsoid defined by `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. Latitudes `phi1` and `phi2` are in radians. The distance `s` has the same units as the semimajor axis of the ellipsoid. If `phi2` is less than `phi1`, `s` is negative.

Version History

Introduced in R2007a

See Also

`meridianfwd`

meridianfwd

Reckon position along meridian

Syntax

```
phi2 = meridianfwd(phi1,s,ellipsoid)
```

Description

`phi2 = meridianfwd(phi1,s,ellipsoid)` determines the geodetic latitude `phi2` reached by starting at geodetic latitude `phi1` and traveling distance `s` north (positive `s`) or south (negative `s`) along a meridian on the specified ellipsoid. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. Latitudes `phi1` and `phi2` are in radians, and `s` has the same units as the semimajor axis of the ellipsoid.

Version History

Introduced in R2007a

See Also

`meridianarc`

meshgrat

(To be removed) Construct map graticule for surface object display

Note The `meshgrat` function will be removed in a future release. Use the `geographicGrid`, `linspace`, or `ndgrid` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[lat, lon] = meshgrat(Z, R)
[lat, lon] = meshgrat(Z, R, gratsize)
[lat, lon] = meshgrat(lat, lon)
[lat, lon] = meshgrat(latlim, lonlim, gratsize)
[lat, lon] = meshgrat(lat, lon, angleunits)
[lat, lon] = meshgrat(latlim, lonlim, angleunits)
[lat, lon] = meshgrat(latlim, lonlim, gratsize, angleunits)
```

Description

`[lat, lon] = meshgrat(Z, R)` constructs a graticule for use in displaying a regular data grid, `Z`. In typical usage, a latitude-longitude graticule is projected, and the grid is warped to the graticule using MATLAB graphics functions. In this two-argument calling form, the graticule size is equal to the size of `Z`. `R` can be a geographic raster reference object, a referencing vector, or a referencing matrix.

If `R` is a geographic raster reference object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel.

`[lat, lon] = meshgrat(Z, R, gratsize)` produces a graticule of size `gratsize`. `gratsize` is a two-element vector of the form `[number_of_parallels number_of_meridians]`. If `gratsize = []`, then the graticule returned has the default size 50-by-100. (But if `gratsize` is omitted, a graticule of the same size as `Z` is returned.) A finer graticule uses larger arrays and takes more memory and time but produces a higher fidelity map.

`[lat, lon] = meshgrat(lat, lon)` takes the vectors `lat` and `lon` and returns graticule arrays of size `numel(lat)`-by-`numel(lon)`. In this form, `meshgrat` is similar to the MATLAB function `meshgrid`.

`[lat, lon] = meshgrat(latlim, lonlim, gratsize)` returns a graticule mesh of size `gratsize` that covers the geographic limits defined by the two-element vectors `latlim` and `lonlim`.

`[lat, lon] = meshgrat(lat, lon, angleunits)`, `[lat, lon] = meshgrat(latlim, lonlim, angleunits)`, and `[lat, lon] = meshgrat(latlim, lonlim, gratsize, angleunits)` where `angleunits` can be either `'degrees'` (the default) or `'radians'`.

The graticule mesh is a grid of points that are projected on an axesm-based map and to which surface map objects are warped. The fineness, or resolution, of this grid determines the quality of the projection and the speed of plotting. There is no hard and fast rule for sufficient graticule resolution, but in general, cylindrical projections need very few graticules in the longitudinal direction, while complex curve-generating projections require more.

Examples

Make a (coarse) graticule for the entire world:

```
latlim = [-90 90];
lonlim = [-180 180];
[lat,lon] = meshgrat(latlim,lonlim,[3 6])
```

lat =

```
-90.0000 -90.0000 -90.0000 -90.0000 -90.0000 -90.0000
      0      0      0      0      0      0
 90.0000  90.0000  90.0000  90.0000  90.0000  90.0000
```

lon =

```
-180.0000 -108.0000 -36.0000  36.0000 108.0000 180.0000
-180.0000 -108.0000 -36.0000  36.0000 108.0000 180.0000
-180.0000 -108.0000 -36.0000  36.0000 108.0000 180.0000
```

These paired coordinates are the graticule vertices, which are projected according to the requirements of the desired map projection. Then data such as the elevation data in `topo60c` can be warped to the grid.

Version History

R2022b: Warns

Warns starting in R2022b

Some functions that accept referencing vectors or referencing matrices as input issue a warning that they will be removed in a future release, including the `meshgrat` function. Depending on the `meshgrat` function syntax, use the `geographicGrid`, `linspace`, or `ndgrid` function instead.

- If your code uses the `meshgrat` function and a referencing vector or referencing matrix, replace the code by using a geographic raster reference object and the `geographicGrid` function. Reference objects have several advantages over referencing vectors and matrices.
 - Unlike referencing vectors and matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.

For more information about reference object properties, see the `GeographicCellsReference` and `GeographicPostingsReference` objects.

- You can manipulate the limits of rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` function.
- Most functions that accept referencing vectors or matrices as inputs also accept reference objects.

Create a reference object for either a raster of cells using the `georefcells` function or a raster of regularly posted samples using the `georefpostings` function. Alternatively, convert from a referencing vector or a referencing matrix to a reference object using the `refvecToGeoRasterReference` or `refmatToGeoRasterReference` function, respectively.

Replace uses of the `meshgrat` function with the `geographicGrid` function according to these patterns.

Will Be Removed	Recommended
<code>[lat,lon] = meshgrat(A,R);</code>	<code>[lat,lon] = geographicGrid(R);</code>
<code>[lat,lon] = meshgrat(A,R,gratsize);</code>	<code>Rg = R;</code> <code>Rg.RasterSize = gratsize;</code> <code>[lat,lon]= geographicGrid(Rg);</code>

- If your code uses the `meshgrat` function and latitude and longitude vectors, replace the code by using the `ndgrid` function.

Will Be Removed	Recommended
<code>[lat,lon] = meshgrat(lat,lon);</code>	<code>[lat,lon] = ndgrid(lat,lon);</code>

- If your code uses the `meshgrat` function, latitude and longitude limits, and a graticule size, replace the code by using the `linspace` and `ndgrid` functions.

Will Be Removed	Recommended
<code>[lat,lon] = meshgrat(latlim,lonlim,gratsize);</code>	<code>latv = linspace(latlim(1),latlim(2),gratsize(1));</code> <code>lonv = linspace(lonlim(1),lonlim(2),gratsize(2));</code> <code>[lat,lon] = ndgrid(latv,lonv);</code>

R2021a: To be removed

Not recommended starting in R2021a

The `meshgrat` function runs without warning but will be removed in a future release.

See Also

`meshgrid` | `meshm` | `surfacem` | `surfm` | `geographicGrid` | `ndgrid` | `linspace`

meshlstrm

3-D lighted shaded relief of regular data grid on axesm-based map

Syntax

```
meshlstrm(Z,R)
meshlstrm(Z,R,[azim elev])
meshlstrm(Z,R,[azim elev],cmap)
meshlstrm(Z,R,[azim elev],cmap,clim)
h = meshlstrm(...)
```

Description

`meshlstrm(Z,R)` displays the regular data grid `Z` colored according to elevation and surface slopes. Specify `R` as a `GeographicCellsReference` object or a `GeographicPostingsReference` object. The `RasterSize` property of `R` must be consistent with `size(Z)`.

`meshlstrm(Z,R,[azim elev])` displays the regular data grid `Z` with the light coming from the specified azimuth and elevation. Angles are specified in degrees, with the azimuth measured clockwise from North, and elevation up from the zero plane of the surface.

`meshlstrm(Z,R,[azim elev],cmap)` displays the regular data grid `Z` using the specified colormap. The number of grayscales is chosen to keep the size of the shaded colormap below 256. If the vector of azimuth and elevation is empty, the default locations are used. Color axis limits are computed from the data.

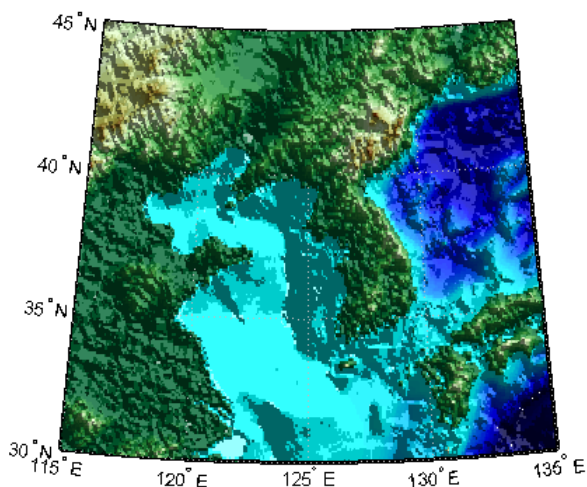
`meshlstrm(Z,R,[azim elev],cmap,clim)` uses the provided color axis limits, which by default are computed from the data.

`h = meshlstrm(...)` returns the handle to the surface drawn.

Examples

Load elevation data and a geographic cells reference object for the Korean peninsula. Create a world map using appropriate latitude and longitude limits for the peninsula. Then, display a lighted shaded relief map. By default, `meshlstrm` applies a colormap appropriate for elevation data.

```
load korea5c
worldmap(korea5c,korea5cR)
meshlstrm(korea5c,korea5cR,[45 65])
```



Tips

This function effectively multiplies two colormaps, one with color based on elevation, the other with a grayscale based on the slope of the surface, to create a new colormap. This produces an effect similar to using a light on a surface, but with all of the visible colors actually in the colormap. Lighting calculations are performed on the unprojected data.

Version History

Introduced before R2006a

R2022b: meshlrm will not accept referencing vectors or referencing matrices as input
Not recommended starting in R2022b

The `meshlrm` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.

- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

See Also

`geographicGrid` | `ndgrid` | `meshm` | `pcolorm` | `surfacem` | `surflm` | `surflsrm`

meshm

Project regular data grid on axesm-based map

Syntax

```
meshm(Z,R)
meshm(Z,R,gratsize)
meshm(Z,R,gratsize,h)
meshm( ____,Name,Value)
s = meshm( ____ )
```

Description

`meshm(Z,R)` displays a surface on the current axesm-based map by warping the regular data grid specified by `Z`, with spatial reference `R`, to a projected graticule mesh. The color of the surface varies according to the values in `Z`. This syntax displays the surface in a horizontal plane with all height values set to 0.

`meshm(Z,R,gratsize)` specifies the size of the graticule mesh as `gratsize`.

`meshm(Z,R,gratsize,h)` displays the surface using the heights specified by `h`.

`meshm(____,Name,Value)` specifies surface properties using one or more name-value pair arguments. For example, `"FaceAlpha",0.5` creates a semitransparent plot.

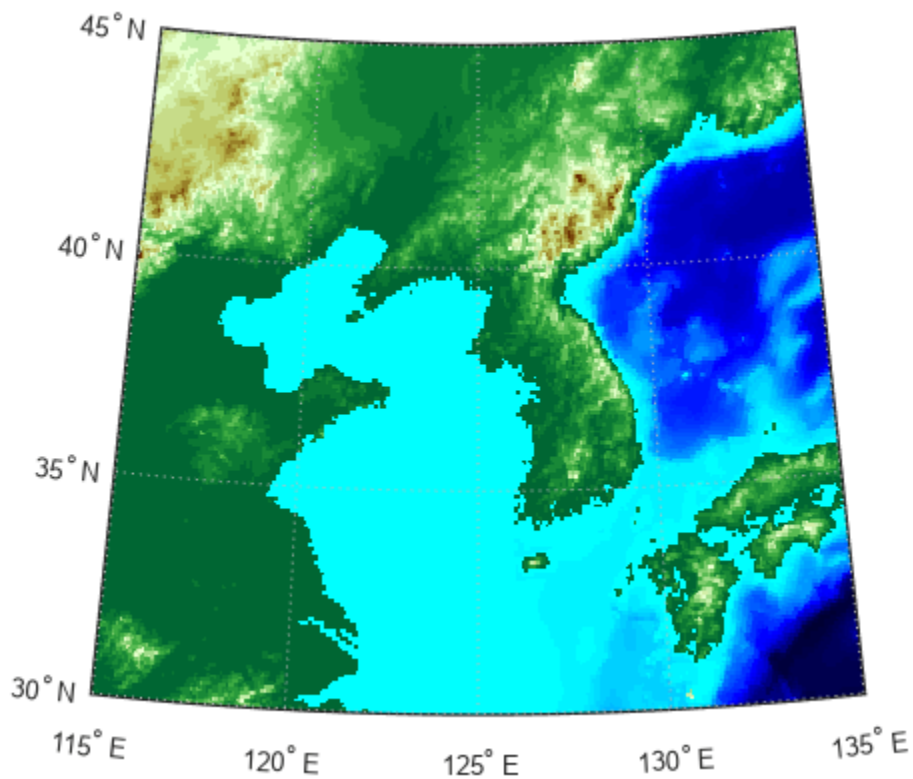
`s = meshm(____)` returns the primitive surface object. Use `s` to modify the plot after creation. For a list of properties, see [Surface Properties](#).

Examples

Display Regular Data Grid on axesm-Based Map

Load elevation data and a geographic cells reference object for the Korean peninsula. Then, display the data on a world map using a colormap appropriate for elevation data.

```
load korea5c
worldmap(korea5c,korea5cR)
meshm(korea5c,korea5cR)
demcmap(korea5c)
```



Display Surface in 3-D

Read elevation data and a geographic postings reference object for a region around South Boulder Peak in Colorado. Crop the data to cover a smaller region.

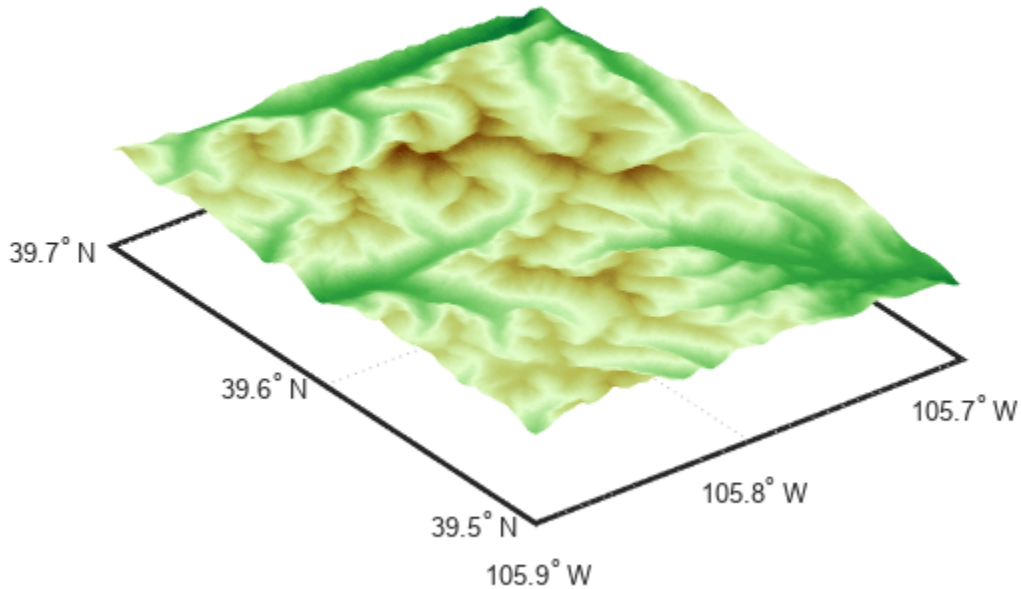
```
[Z,R] = readgeoraster("n39_w106_3arc_v2.dt1", "OutputType", "double");  
[Z,R] = geocrop(Z,R,[39.5 39.7],[-105.9 -105.7]);
```

Display the data as a surface by specifying the graticule size as the size of the raster (`R.RasterSize`) and the height data as the elevation data (`Z`). Apply a colormap appropriate for elevation data.

```
usamap(Z,R)  
meshm(Z,R,R.RasterSize,Z)  
demcmmap(Z)
```

View the region in 3-D.

```
view(3)
```

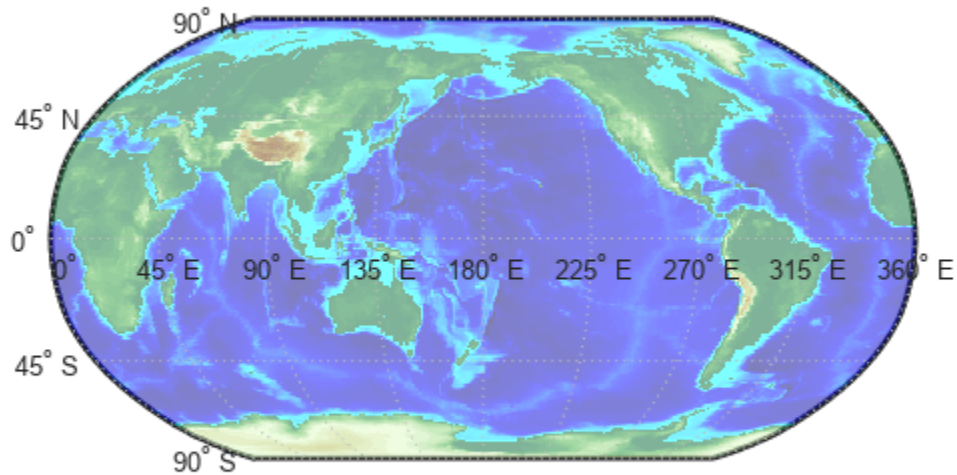
Modify Appearance of Surface Plot

Load world elevation data as an array and a geographic cells reference object. Then, display the data on a world map. Adjust the transparency of the surface plot using the `FaceAlpha` name-value argument.

```
load topo60c
worldmap(topo60c, topo60cR)
meshm(topo60c, topo60cR, "FaceAlpha", 0.5)
```

Apply a colormap appropriate for elevation data.

```
demcmmap(topo60c)
```



Input Arguments

Z — Regular data grid

m-by-n array

Regular data grid, specified as an *m-by-n* array.

R — Spatial reference for Z

GeographicCellsReference object | GeographicPostingsReference object

Spatial reference for Z, specified as a GeographicCellsReference or GeographicPostingsReference object. The RasterSize property of R must be consistent with size(Z).

gratsize — Graticule size

[50 100] (default) | two-element vector | []

Graticule size, specified as one of these options:

- A two-element vector, where the first element indicates the number of parallels and the second element indicates the number of meridians.
- [], which specifies the default graticule size of [50 100]. Use this option when you want to use the default graticule size and specify the h argument.

h — Surface heightscalar | matrix of size `gratsize`

Surface height, specified as a scalar or a matrix of size `gratsize`.

- When you specify a scalar, the `meshm` function displays the grid in the horizontal plane with all height values set to `h`.
- When you specify a matrix of size `gratsize`, the `meshm` function displays each vertex of the graticule mesh at the corresponding height in `h`.

When the `MapProjection` property of the `axesm`-based map is "globe", `h` is referenced to the ellipsoid.

Data Types: `double`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `meshm(Z,R,LineStyle="-")` displays the graticule mesh using solid lines.

Before R2021a, use commas to separate each name and value, and enclose `Name` in quotes.

Example: `meshm(Z,R,"LineStyle","-")` displays the graticule mesh using solid lines.

Note Use name-value arguments to specify values for the properties of the `Surface` object created by this function. The properties listed here are only a subset. For a full list, see `Surface Properties`.



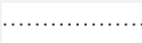

Surface objects created by the `meshm` function have these limitations:

- Setting the `XData`, `YData`, and `ZData` properties of the surface object is not supported.
 - If you set the `UserData` property of the surface and then change the projection of the `axesm`-based map, MATLAB does not reproject the surface.
-

LineStyle — Line style

"none" (default) | "-" | "--" | ":" | "-."

Line style, specified as one of the options listed in this table.

Line Style	Description	Resulting Line
"-"	Solid line	
--"	Dashed line	
:"	Dotted line	
"-."	Dash-dotted line	
"none"	No line	No line

LineWidth — Line width

0.5 (default) | positive value

Line width, specified as a positive value in points, where 1 point = 1/72 of an inch. If the line has markers, then the line width also affects the marker edges.

The line width cannot be thinner than the width of a pixel. If you set the line width to a value that is less than the width of a pixel on your system, the line displays as one pixel wide.

Output Arguments**s — Primitive surface object**

Surface object

Primitive surface object, returned as a Surface object. Use `s` to modify the Surface object after creation. For a list of properties, see Surface Properties.

Surface objects created by the `meshm` function have these limitations:

- Setting the `XData`, `YData`, and `ZData` properties of the surface object is not supported.
- If you set the `UserData` property of the surface and then change the projection of the axesm-based map, MATLAB does not reproject the surface.

Tips

- The `FaceColor` property of the surface object depends on the size of the graticule mesh. The `meshm` function sets `FaceColor` to "flat" when the size of the graticule mesh matches the size of `Z`, and "texturemap" otherwise.
- The `meshm` function projects the graticule mesh using the projection specified by the `MapProjection` property of the axesm-based map. To improve the resolution of the plot, increase the size of the graticule mesh. Increasing the size of the graticule mesh can increase the amount of time MATLAB requires to display the surface.

Version History**Introduced before R2006a****R2022b: meshm will not accept referencing vectors or referencing matrices as input***Not recommended starting in R2022b*

The `meshm` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

See Also

Functions

`geoshow` | `pcolorm` | `surfm`

Topics

“Fit Gridded Data to the Graticule”

mfwdtran

(To be removed) Project geographic features to map coordinates

Note `mfwdtran` will be removed in a future release. In most cases, use the `projfwd` function instead. If the `mapprojection` property of the current `axesm`-based map or specified map projection structure is 'globe', then use the `geodetic2ecef` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[x,y] = mfwdtran(lat,lon)
[x,y,z] = mfwdtran(lat,lon,alt)
[...] = mfwdtran(mstruct,...)
```

Description

`[x,y] = mfwdtran(lat,lon)` applies the forward transformation defined by the map projection in the current `axesm`-based map. You can use this function to convert point locations and line and polygon vertices given in latitudes and longitudes to a planar, projected map coordinate system.

`[x,y,z] = mfwdtran(lat,lon,alt)` applies the forward projection to 3-D input, resulting in 3-D output. If the input `alt` is empty or omitted, then `alt = 0` is assumed.

`[...] = mfwdtran(mstruct,...)` requires a valid map projection structure as the first argument. In this case, no `axesm`-based map is needed.

Examples

Transform Geographic Data into Map Coordinates

Get geographic location data for the District of Columbia.

```
dc = shaperead('usastatelo', 'UseGeoCoords', true,...
    'Selector',{@(name) strcmpi(name,'District of Columbia')},...
    'Name');
lat = [dc.Lat]';
lon = [dc.Lon]';
[lat lon]

ans =

    38.9000  -77.0700
    38.9500  -77.1200
    39.0000  -77.0300
    38.9000  -76.9000
    38.7800  -77.0300
```

```

38.8000 -77.0200
38.8700 -77.0200
38.9000 -77.0700
38.9000 -77.0700
      NaN      NaN

```

Obtain the UTM zone for this point.

```
dczone = utmzone(mean(lat,'omitnan'),mean(lon,'omitnan'))
```

```
dczone =
```

```
    '18S'
```

Set up the UTM coordinate system based on this information.

```
utmstruct = defaultm('utm');
utmstruct.zone = dczone;
utmstruct.geoid = wgs84Ellipsoid;
utmstruct = defaultm(utmstruct);
```

Project the District of Columbia data from geographic coordinates into map coordinates for UTM zone 18S.

```
[x,y] = mfdtran(utmstruct,lat,lon)
```

```
x =
```

```

1.0e+05 *
    3.2049
    3.1629
    3.2421
    3.3524
    3.2367
    3.2459
    3.2476
    3.2049
    3.2049
      NaN

```

```
y =
```

```

1.0e+06 *
    4.3077
    4.3134
    4.3187
    4.3074
    4.2943
    4.2965
    4.3043
    4.3077

```

4.3077
NaN

Version History

Introduced before R2006a

R2023a: Warns

Warns starting in R2023a

The `mfwdtran` function issues a warning that it will be removed in a future release. In most cases, use the `projfwd` function instead. If the `mapprojection` field of the current axesm-based map or specified map projection structure is 'globe', then use the `geodetic2ecef` function instead.

This table shows some typical usages of the `mfwdtran` function and how to update your code to use the `projfwd` function instead.

Will Be Removed	Recommended
<code>[x,y,z] = mfwdtran(lat,lon);</code>	<code>mstruct = gcm; [x,y] = projfwd(mstruct,lat,lon);</code>
<code>[x,y,z] = mfwdtran(mstruct,lat,lon);</code>	<code>[x,y] = projfwd(mstruct,lat,lon);</code>

This table shows some typical usages of the `mfwdtran` function and how to update your code to use the `geodetic2ecef` function instead.

Will Be Removed	Recommended
<code>[x,y,z] = mfwdtran(lat,lon,alt);</code>	<code>mstruct = gcm; [x,y,z] = geodetic2ecef(lat,lon,alt,mstruct.geoid);</code>
<code>[x,y,z] = mfwdtran(mstruct,lat,lon,alt);</code>	<code>[x,y,z] = geodetic2ecef(lat,lon,alt,mstruct.geoid);</code>

If the value of the `mapprojection` field of the map projection structure is listed in this table, then all linear units in the map projection structure must be in meters. In addition, the `projfwd` function returns coordinates in meters. You can convert the coordinates to other units using the `unitsratio` function.

Value	Projection Name
'tranmerc'	Transverse Mercator
'mercator'	Mercator
'lambertstd'	Lambert Conformal Conic
'eqaazim'	Lambert Azimuthal Equal Area
'eqaconicstd'	Albers Equal-Area Conic
'eqdazim'	Azimuthal Equidistant
'eqdconicstd'	Equidistant Conic
'ups'	Polar Stereographic
'stereo'	Oblique Stereographic
'eqdcylin'	Equirectangular
'cassinistd'	Cassini-Soldner

Value	Projection Name
'gnomonic'	Gnomonic
'miller'	Miller Cylindrical
'ortho'	Orthographic
'polyconstd'	Polyconic
'robinson'	Robinson
'sinusoid'	Sinusoidal
'vgrint1'	Van der Grinten
'eqacylin'	Equal Area Cylindrical

R2020b: To be removed

Not recommended starting in R2020b

The mfwdtran function runs without warning but will be removed in a future release.

See Also

defaultm | gcm | projfwd | projinv | vfwdtran | vinvtran | geodetic2ecef

minaxis

Semiminor axis of ellipse

Syntax

```
b = minaxis(semimajor,e)
```

Description

`b = minaxis(semimajor,e)` computes the semiminor axis length `b` of an ellipse or an ellipsoid of revolution given the semimajor axis length `semimajor` and eccentricity `e`.

Examples

Semiminor Axis of Ellipse from Semimajor Axis and Eccentricity

Find the semiminor axis length of an ellipse from the eccentricity and length of the semimajor axis.

```
b = minaxis(6378137,0.0818)
```

```
b = 6.3568e+06
```

Input Arguments

semimajor — Semimajor axis length

numeric scalar

Semimajor axis length, specified as a numeric scalar.

e — Eccentricity of ellipse

numeric scalar

Eccentricity of the ellipse, specified as a numeric scalar. The value of `ecc` must be in the range `[0, 1]`.

Data Types: `single` | `double`

Output Arguments

b — Semiminor axis length

numeric scalar

Semiminor axis length, returned as a numeric scalar. The units of `b` are the same as those of `semimajor`.

Version History

Introduced before R2006a

R2013b: Only numeric scalars will be accepted as input

Not recommended starting in R2013b

The `minaxis` function will not accept vectors or matrices as input in a future release. To update your code, specify a numeric scalar instead.

See Also

`axes2ecc` | `flat2ecc` | `majaxis` | `n2ecc`

minvtran

(To be removed) Unproject features from map to geographic coordinates

Note `minvtran` will be removed in a future release. In most cases, use the `projinv` function instead. If the `mapprojection` field of the current `axesm`-based map or specified map projection structure is 'globe', then use the `ecef2geodetic` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[lat,lon] = minvtran(x,y)
[lat,lon,alt] = minvtran(x,y,z)
[...] = minvtran(mstruct,...)
```

Description

`[lat,lon] = minvtran(x,y)` applies the inverse transformation defined by the map projection in the current `axesm`-based map. Using `minvtran`, you can convert point locations and line and polygon vertices in a planar, projected map coordinate system to latitudes and longitudes.

`[lat,lon,alt] = minvtran(x,y,z)` applies the inverse projection to 3-D input, resulting in 3-D output. If the input `Z` is empty or omitted, then `Z = 0` is assumed.

`[...] = minvtran(mstruct,...)` takes a valid map projection structure as the first argument. In this case, no `axesm`-based map is needed.

Examples

Before using `minvtran`, it is necessary to create a map projection structure. You can do this with `axesm` or the `defaultm` function:

```
mstruct = defaultm('mercator');
mstruct.origin = [38.89 -77.04 0];
mstruct = defaultm(mstruct);
```

The following latitude and longitude data for the District of Columbia is obtained from the `usastatelo` shapefile:

```
dc = shaperead('usastatelo', 'UseGeoCoords', true,...
    'Selector',{@(name) strcmpi(name,'District of Columbia'),...
    'Name'});
lat = [dc.Lat]';
lon = [dc.Lon]';
[lat lon]
```

```
ans =
```

```

38.9000 -77.0700
38.9500 -77.1200
39.0000 -77.0300
38.9000 -76.9000
38.7800 -77.0300
38.8000 -77.0200
38.8700 -77.0200
38.9000 -77.0700
38.9000 -77.0700
      NaN      NaN

```

This data can be projected into Cartesian coordinates of the Mercator projection using the `proj fwd` function:

```

[x,y] = proj fwd(mstruct, lat, lon);
[x y]

```

ans =

```

-0.0004  0.5745
-0.0011  0.5753
 0.0001  0.5762
 0.0019  0.5745
 0.0001  0.5724
 0.0003  0.5727
 0.0003  0.5739
-0.0004  0.5745
-0.0004  0.5745
      NaN      NaN

```

To transform the projected x-y data back into the unprojected geographic system, use the `minvtran` function:

```

[lat2,lon2] = minvtran(mstruct,x,y);
[lat2 lon2]

```

ans =

```

70.1302 -77.0987
70.1729 -77.1969
70.2157 -77.0204
70.1300 -76.7659
70.0276 -77.0205
70.0447 -77.0010
70.1046 -77.0009
70.1302 -77.0987
70.1302 -77.0987
      NaN      NaN

```

Version History

Introduced before R2006a

R2023a: Warns

Warns starting in R2023a

The `minvtran` function issues a warning that it will be removed in a future release. In most cases, use the `projinv` function instead. If the `mapprojection` field of the current axesm-based map or specified map projection structure is 'globe', then use the `ecef2geodetic` function instead.

This table shows some typical uses of the `minvtran` function and how to update your code to use the `projinv` function instead.

Will Be Removed	Recommended
<code>[lat,lon,alt] = minvtran(x,y);</code>	<code>mstruct = gcm; [lat,lon] = projinv(mstruct,x,y);</code>
<code>[lat,lon,alt] = minvtran(mstruct,x,y);</code>	<code>[lat,lon] = projinv(mstruct,x,y);</code>

This table shows some typical uses of the `minvtran` function and how to update your code to use the `ecef2geodetic` function instead.

Will Be Removed	Recommended
<code>[lat,lon,alt] = minvtran(x,y,z);</code>	<code>mstruct = gcm; [lat,lon,alt] = ecef2geodetic(x,y,z,mstruct.geoid);</code>
<code>[lat,lon,alt] = minvtran(mstruct,x,y,z);</code>	<code>[lat,lon,alt] = ecef2geodetic(x,y,z,mstruct.geoid);</code>

If the value of the `mapprojection` field of the map projection structure is listed in this table, then you must specify all linear units in meters, including coordinates and map projection structure fields. After you have projected the coordinates, you can convert them to other units using the `unitsratio` function.

Value	Projection Name
'tranmerc'	Transverse Mercator
'mercator'	Mercator
'lambertstd'	Lambert Conformal Conic
'eqaazim'	Lambert Azimuthal Equal Area
'eqaconicstd'	Albers Equal-Area Conic
'eqdazim'	Azimuthal Equidistant
'eqdconicstd'	Equidistant Conic
'ups'	Polar Stereographic
'stereo'	Oblique Stereographic
'eqdcylin'	Equirectangular
'cassinistd'	Cassini-Soldner
'gnomonic'	Gnomonic
'miller'	Miller Cylindrical
'ortho'	Orthographic
'polyconstd'	Polyconic
'robinson'	Robinson
'sinusoid'	Sinusoidal
'vgrintl'	Van der Grinten

Value	Projection Name
'eqacylin'	Equal Area Cylindrical

R2020b: To be removed

Not recommended starting in R2020b

The minvtran function runs without warning but will be removed in a future release.

See Also

axesm | defaultm | gcm | projfwd | projinv | vfwdtran | vinvtran | ecef2geodetic

mlabel

Control meridian labels on axesm-based map

Syntax

```
mlabel  
mlabel('on')  
mlabel('off')  
mlabel('reset')  
mlabel(parallel)  
mlabel(MapAxesPropertyName,PropertyValue,...)
```

Description

`mlabel` toggles the visibility of meridian labeling on the current axesm-based map.

`mlabel('on')` sets the visibility of meridian labels to 'on'.

`mlabel('off')` sets the visibility of meridian labels to 'off'.

`mlabel('reset')` resets the displayed meridian labels using the currently defined meridian label properties.

`mlabel(parallel)` sets the value of the `MLabelParallel` property of the axesm-based map to the value of `parallel`. This determines the parallel upon which the labels are placed (see axesm). The options for `parallel` are a scalar latitude or 'north', 'south', or 'equator'.

`mlabel(MapAxesPropertyName,PropertyValue,...)` allows paired axesm-based map property names and property values to be passed in. For a complete description of axesm-based map properties, see axesm-Based Map Properties.

Meridian label handles can be returned in `h` if desired.

Version History

Introduced before R2006a

See Also

axesm | mlabelzero22pi | plabel | setm

mlabelzero22pi

Display meridian labels on axesm-based map using range of 0 to 360 degrees

Syntax

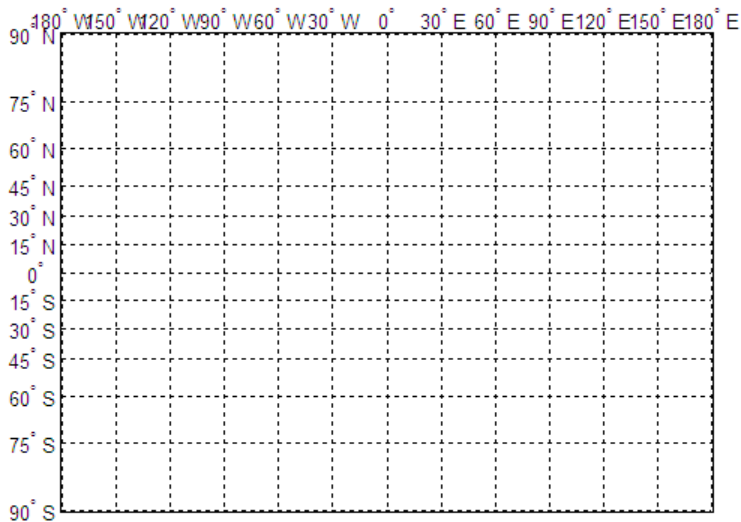
```
mlabelzero22pi
```

Description

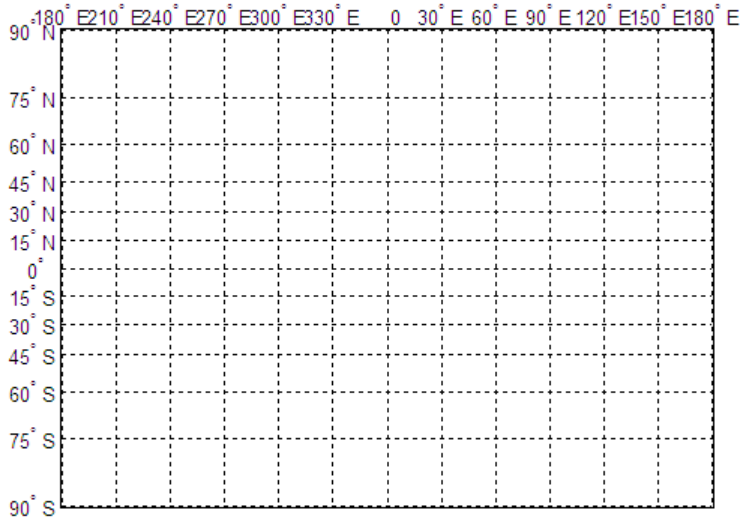
mlabelzero22pi displays longitude labels in the range of 0 to 360 degrees east of the prime meridian.

Examples

```
% create a map
figure('color','w'); axesm('miller','grid','on'); tightmap;
mlabel on; plabel on
```



```
% Display longitude labels in the range of 0 to 360 degrees
mlabelzero22pi
```



Version History

Introduced before R2006a

See Also

`mlabel`

n2ecc

Eccentricity of ellipse from third flattening

Syntax

```
ecc = n2ecc(n)
```

Description

`ecc = n2ecc(n)` computes the eccentricity `ecc` of an ellipse or an ellipsoid of revolution given the third flattening `n`.

Examples

Eccentricity of Ellipse from Third Flattening

Find the eccentricity of an ellipse from the third flattening.

```
ecc = n2ecc(0.0017)
```

```
ecc = 0.0823
```

Input Arguments

n — Third flattening of ellipse

numeric scalar

Third flattening of the ellipse, specified as a numeric scalar. The input `n` is defined as $(a-b)/(a+b)$, where a is the semimajor axis and b is the semiminor axis.

Data Types: `single` | `double`

Output Arguments

ecc — Eccentricity of ellipse

numeric scalar

Eccentricity of the ellipse, returned as a numeric scalar in the range [0, 1].

Version History

Introduced before R2006a

R2013b: Only numeric scalars will be accepted as input

Not recommended starting in R2013b

The `n2ecc` function will not accept vectors or matrices as input in a future release. To update your code, specify a numeric scalar instead.

See Also

axes2ecc | ecc2n

namem

Names of objects on axesm-based map

Syntax

```
obj_names = namem  
obj_names = namem(h)
```

Description

`obj_names = namem` returns the names of all the objects on the current axes. The name of an object is the value of its `Tag` property, if specified. Otherwise, the name of the object is the value of its `Type` property. The values of these properties are either set at object creation or defined using the `tagm` function.

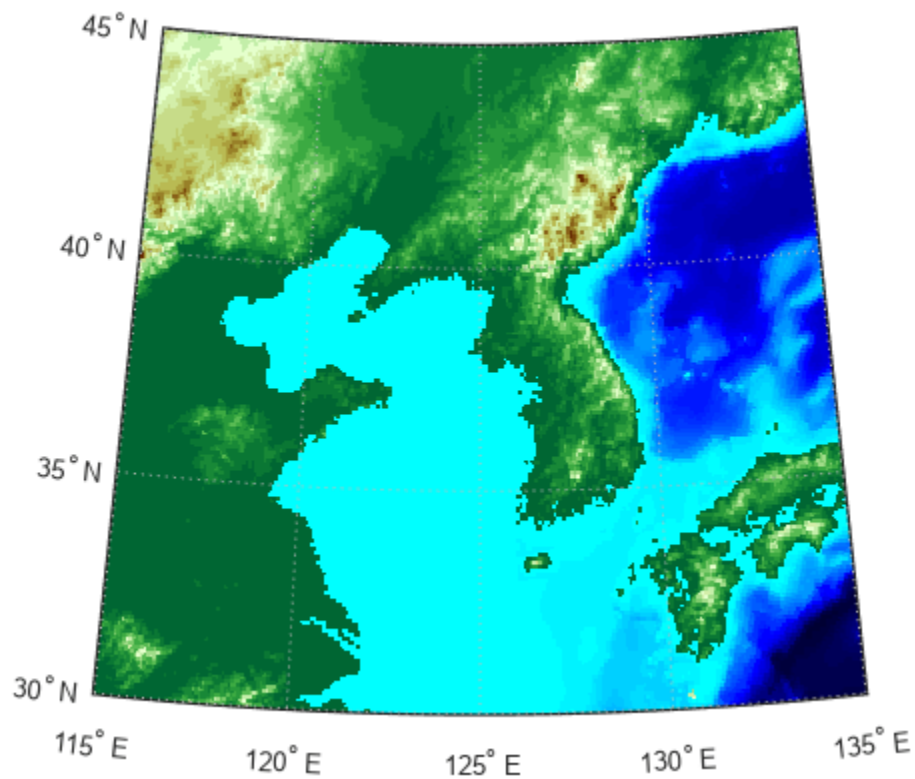
`obj_names = namem(h)` returns the name of the object (or objects) specified by the array, `h`.

Examples

Get List of Graphics Objects in Map Display

Load elevation data and a geographic cells reference object for the Korean peninsula. Then, display the data on a world map.

```
load korea5c  
worldmap(korea5c,korea5cR);  
geoshow(korea5c,korea5cR,'DisplayType','texturemap')  
demcmap(korea5c)
```



Find the names of graphics objects in the figure. The `namem` function returns the names as a character array. Convert the array into a cell array of character vectors using `cellstr`.

```
namesChar = namem
```

```
namesChar = 6x8 char array
```

```
'PLabel' '  
'MLabel' '  
'Parallel'  
'Meridian'  
'surface' '  
'Frame'  '
```

```
namesCell = cellstr(namesChar)
```

```
namesCell = 6x1 cell
```

```
{'PLabel' }  
{'MLabel' }  
{'Parallel'}  
{'Meridian'}  
{'surface' }  
{'Frame'  }
```

Input Arguments

h — Graphics objects

array

Graphics objects, specified as an array.

Output Arguments

obj_names — Names of graphics objects

character array

Names of graphics objects, returned as a character array. `namem` removes duplicate object names from the array.

Note: Use `cellstr(obj_names)` to convert `obj_names` to a cell array of character vectors.

Version History

Introduced before R2006a

See Also

`clma` | `clmo` | `handlem` | `hidem` | `showm` | `tagm`

nanclip

Clip vector data with NaNs at specified pen-down locations

Syntax

```
dataout = nanclip(datain)
dataout = nanclip(datain,pendowncmd)
```

Description

`dataout = nanclip(datain)` and `dataout = nanclip(datain,pendowncmd)` return the pen-down delimited data in the matrix `datain` as NaN-delimited data in `dataout`. When the first column of `datain` equals `pendowncmd`, a segment is started and a NaN is inserted in all columns of `dataout`. The default `pendowncmd` is `-1`.

Pen-down delimited data is a matrix with a first column consisting of pen commands. At the beginning of each segment in the data, this first column has an entry corresponding to a pen-down command. Other entries indicate that the segment is continuing. NaN-delimited data consists of columns of data, each segment of which ends in a NaN in every data column. Since there is no pen command column, the NaN-delimited format can represent the same data in one fewer columns; the remaining columns have more entries, one for each NaN (that is, for each segment).

Examples

```
datain = [-1 45 67; 0 23 54; 0 28 97; -1 47 89; 0 56 12]
```

```
datain =
  -1    45    67           % Begin first segment
   0    23    54
   0    28    97
  -1    47    89           % Begin second segment
   0    56    12
```

```
dataout = nanclip(datain)
```

```
dataout =
  45    67
  23    54
  28    97
 NaN   NaN           % End first segment
  47    89
  56    12
 NaN   NaN           % End second segment
```

Version History

Introduced before R2006a

nanm

(To be removed) Construct regular data grid of NaNs

Note nanm will be removed in a future release. Use the `georefcells` and `NaN` functions instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z,refvec] = nanm(latlim,lonlim,scale)
```

Description

`[Z,refvec] = nanm(latlim,lonlim,scale)` returns a regular data grid consisting entirely of NaNs and a three-element referencing vector for the returned `Z`. The two-element vectors `latlim` and `lonlim` define the latitude and longitude limits of the geographic region. They should be of the form `[south north]` and `[west east]`, respectively. The scalar `scale` specifies the number of rows and columns per degree of latitude and longitude.

Examples

```
[Z,refvec] = nanm([46,51],[-79,-75],1)
```

`Z =`

```

NaN NaN NaN NaN
NaN NaN NaN NaN
NaN NaN NaN NaN
NaN NaN NaN NaN
NaN NaN NaN NaN
refvec =
     1     51    -79
```

Version History

Introduced before R2006a

R2022a: Warns

Warns starting in R2022a

Some functions that return referencing vectors issue a warning that they will be removed in a future release, including the `nanm` function. Instead, create a geographic raster reference object using the `georefcells` function and a matrix of NaN values using the `NaN` function. Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see the `GeographicPostingsReference` object.

- You can manipulate the limits of rasters associated with geographic reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with geographic reference objects using the `georesize` function.
- Most functions that accept referencing vectors as inputs also accept reference objects.

This table shows how to update your code to use the `georefcells` and `NaN` functions instead of the `nanm` function.

Will Be Removed	Recommended
<code>[Z,refvec] = nanm(latlim,lonlim,scale);</code>	<code>R = georefcells(latlim,lonlim,1/scale,1/scale);</code> <code>Z = NaN(R.RasterSize);</code>

R2020b: To be removed

Not recommended starting in R2020b

The `nanm` function runs without warning but will be removed in a future release.

See Also

`ones` | `sparse` | `zeros` | `NaN` | `georefcells`

navfix

Mercator-based navigational fix

Syntax

```
[latfix,lonfix] = navfix(lat,long,az)
[latfix,lonfix] = navfix(lat,long,range,casetype)
[latfix,lonfix] = navfix(lat,long,az_range,casetype)
[latfix,lonfix] = navfix(lat,long,az_range,casetype,drlat,drlon)
```

Description

`[latfix,lonfix] = navfix(lat,long,az)` returns the intersection points of rhumb lines drawn parallel to the observed bearings, `az`, of the landmarks located at the points `lat` and `long` and passing through these points. One bearing is required for each landmark. Each possible pairing of the n landmarks generates one intersection, so the total number of resulting intersection points is the combinatorial $n \text{ choose } 2$. The calculation time therefore grows rapidly with n .

`[latfix,lonfix] = navfix(lat,long,range,casetype)` returns the intersection points of Mercator projection circles with radii defined by `range`, centered on the landmarks located at the points `lat` and `long`. One range value is required for each landmark. Each possible pairing of the n landmarks generates up to two intersections (circles can intersect twice), so the total number of resulting intersection points is the combinatorial $2 \text{ times } (n \text{ choose } 2)$. The calculation time therefore grows rapidly with n . In this case, the variable `casetype` is a vector of 0s the same size as the variable `range`.

`[latfix,lonfix] = navfix(lat,long,az_range,casetype)` combines ranges and bearings. For each element of `casetype` equal to 1, the corresponding element of `az_range` represents an azimuth to the associated landmark. Where `casetype` is a 0, `az_range` is a range.

`[latfix,lonfix] = navfix(lat,long,az_range,casetype,drlat,drlon)` returns for each possible pairing of landmarks only the intersection that lies closest to the dead reckoning position indicated by `drlat` and `drlon`. When this syntax is used, all included landmarks' bearing lines or range arcs must intersect. If any possible pairing fails, the warning `No Fix` is displayed.

Background

This is a navigational function. It assumes that all latitudes and longitudes are in degrees and all distances are in nautical miles. In navigation, piloting is the practice of fixing one's position based on the observed bearing and ranges to fixed landmarks (points of land, lighthouses, smokestacks, etc.) from the navigator's vessel. In conformance with navigational practice, bearings are treated as rhumb lines and ranges are treated as the radii of circles on a Mercator projection.

In practice, at least three azimuths (bearings) and/or ranges are required for a usable fix. The resulting intersections are unlikely to coincide exactly.

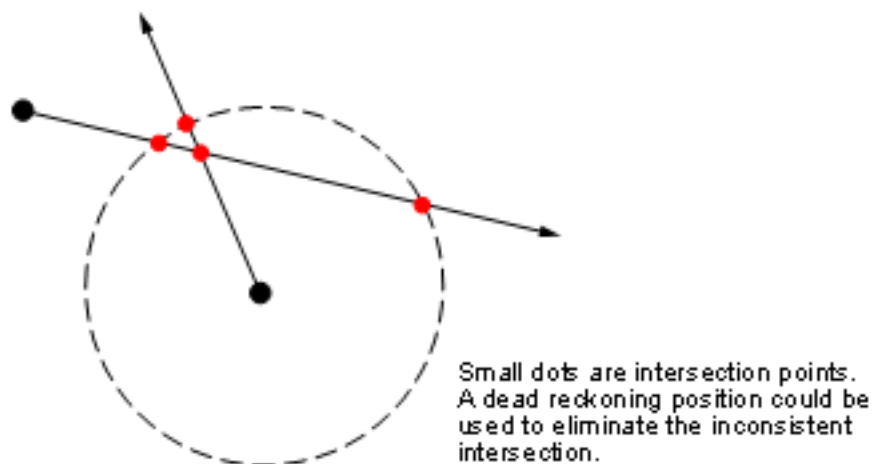
Examples

Imagine you have two landmarks, at (15°N,30.4°W) and (14.8°N,30.1°W). You have a visual bearing to the first of 280° and to the second of 160°. Additionally, you have a range to the second of 12 nm. Find the intersection points:

```
[latfix,lonfix] = navfix([15 14.8 14.8],[-30.4 -30.1 -30.1],...
                        [280 160 12],[1 1 0])
```

```
latfix =
    14.9591      NaN
    14.9680    14.9208
    14.9879      NaN
lonfix =
   -30.1599      NaN
   -30.2121   -29.9352
   -30.1708      NaN
```

Here is an illustration of the geometry:



Limitations

Traditional plotting and the `navfix` function are limited to relatively short distances. Visual bearings are in fact great circle azimuths, not rhumb lines, and range arcs are actually arcs of small circles, not of the planar circles plotted on the chart. However, the mechanical ease of the process and the practical limits of visual bearing ranges and navigational radar ranges (~30 nm) make this limitation moot in practice. The error contributed because of these assumptions is minuscule at that scale.

Tips

The outputs of this function are matrices providing the locations of the intersections for all possible pairings of the n entered lines of bearing and range arcs. These matrices therefore have n -choose-2 rows. In order to allow for two intersections per combination, these matrices have two columns. Whenever there are fewer than two intersections for that combination, one or two NaNs are returned in that row.

When a dead reckoning position is included, these matrices are column vectors.

Version History

Introduced before R2006a

See Also

crossfix | gcxgc | gcxsc | scxsc | rhxrh | polyxpoly | dreckon | gcwaypts | legs | track

ned2aer

Transform local north-east-down coordinates to local spherical

Syntax

```
[az,elev,slantRange] = ned2aer(xNorth,yEast,zDown)
[ ___ ] = ned2aer( ___ ,angleUnit)
```

Description

[az,elev,slantRange] = ned2aer(xNorth,yEast,zDown) transforms the local north-east-down (NED) Cartesian coordinates specified by xNorth, yEast, and zDown to the local azimuth-elevation-range (AER) spherical coordinates specified by az, elev, and slantRange. Both coordinate systems use the same local origin. Each input argument must match the others in size or be scalar.

[___] = ned2aer(___ ,angleUnit) specifies the units for azimuth and elevation. Specify angleUnit as 'degrees' (the default) or 'radians'.

Examples

Calculate AER Coordinates from NED Coordinates

Find the AER coordinates of a landmark with respect to an aircraft, using the NED coordinates of the landmark with respect to the same aircraft.

First, specify the NED coordinates of the landmark. For this example, specify the coordinate values in kilometers.

```
xNorth = -9.1013;
yEast = 4.1617;
zDown = 4.2812;
```

Then, calculate the AER coordinates of the landmark. The azimuth and elevation are specified in degrees. The units for the slant range match the units specified by the NED coordinates. Thus, the slant range is specified in kilometers.

```
[az,elev,slantRange] = ned2aer(xNorth,yEast,zDown)
```

```
az = 155.4271
```

```
elev = -23.1609
```

```
slantRange = 10.8849
```

Reverse the transformation using the aer2ned function.

```
[xNorth,yEast,zDown] = aer2ned(az,elev,slantRange)
```

```
xNorth = -9.1013
```

yEast = 4.1617

zDown = 4.2812

Input Arguments

xNorth — NED x-coordinates

scalar | vector | matrix | N-D array

NED x-coordinates of one or more points in the local NED system, specified as a scalar, vector, matrix, or N-D array.

Data Types: single | double

yEast — NED y-coordinates

scalar | vector | matrix | N-D array

NED y-coordinates of one or more points in the local NED system, specified as a scalar, vector, matrix, or N-D array.

Data Types: single | double

zDown — NED z-coordinates

scalar | vector | matrix | N-D array

NED z-coordinates of one or more points in the local NED system, specified as a scalar, vector, matrix, or N-D array.

Data Types: single | double

angleUnit — Angle units

'degrees' (default) | 'radians'

Angle units, specified as 'degrees' (the default) or 'radians'.

Output Arguments

az — Azimuth angles

scalar | vector | matrix | N-D array

Azimuth angles of one or more points in the local AER system, returned as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Values are specified in degrees within the half-open interval [0 360). To use values in radians, specify the angleUnit argument as 'radians'.

elev — Elevation angles

scalar | vector | matrix | N-D array

Elevation angles of one or more points in the local AER system, returned as a scalar, vector, matrix, or N-D array. Elevations are calculated with respect to the xNorth-yEast plane that contains the local origin. If the local origin is on the surface of the spheroid, then the xNorth-yEast plane is tangent to the spheroid.

Values are specified in degrees within the closed interval [-90 90]. Positive elevations correspond to negative zDown values, and negative elevations correspond to positive zDown values. An elevation of

0 indicates that the point lies in the xNorth-yEast plane. To use values in radians, specify the `angleUnit` argument as `'radians'`.

slantRange — Distances from local origin

scalar | vector | matrix | N-D array

Distances from the local origin, returned as a scalar, vector, matrix, or N-D array. Each distance is calculated along a straight, 3-D, Cartesian line. Values are returned in the units specified by `xNorth`, `yEast`, and `zDown`.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `ned2aer` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`aer2ned` | `enu2aer` | `ned2geodetic` | `ned2ecef`

Topics

“Comparison of 3-D Coordinate Systems”

ned2ecef

Transform local north-east-down coordinates to geocentric Earth-centered Earth-fixed

Syntax

```
[X,Y,Z] = ned2ecef(xNorth,yEast,zDown,lat0,lon0,h0,spheroid)
[ ___ ] = ned2ecef( ___ ,angleUnit)
```

Description

`[X,Y,Z] = ned2ecef(xNorth,yEast,zDown,lat0,lon0,h0,spheroid)` transforms the local north-east-down (NED) Cartesian coordinates specified by `xNorth`, `yEast`, and `zDown` to the geocentric Earth-centered Earth-fixed (ECEF) Cartesian coordinates specified by `X`, `Y`, and `Z`. Specify the origin of the local NED system with the geodetic coordinates `lat0`, `lon0`, and `h0`. Each coordinate input argument must match the others in size or be scalar. Specify `spheroid` as the reference spheroid for the geodetic coordinates.

`[___] = ned2ecef(___ ,angleUnit)` specifies the units for latitude and longitude. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate ECEF Coordinates from NED Coordinates

Find the ECEF coordinates of Mount Mansfield with respect to a nearby aircraft, using the NED coordinates of Mount Mansfield with respect to the geodetic coordinates of the aircraft.

First, specify the reference ellipsoid as WGS84 with length units measured in kilometers. For more information about WGS84, see "Comparison of Reference Spheroids". The units for ellipsoidal height, NED coordinates, and ECEF coordinates must match the units specified by the `LengthUnit` property of the reference spheroid.

```
wgs84 = wgs84Ellipsoid('kilometer');
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is the aircraft. Specify `h0` as ellipsoidal height in kilometers.

```
lat0 = 44.532;
lon0 = -72.782;
h0 = 1.699;
```

Specify the NED coordinates of the point of interest. In this example, the point of interest is Mount Mansfield.

```
xNorth = 1.3343;
yEast = -2.5444;
zDown = 0.3600;
```

Then, calculate the ECEF coordinates of Mount Mansfield. In this example, the results display in scientific notation.

```
[x,y,z] = ned2ecef(xNorth,yEast,zDown,lat0,lon0,h0,wgs84)
```

```
x = 1.3457e+03
```

```
y = -4.3509e+03
```

```
z = 4.4523e+03
```

Reverse the transformation using the `ecef2ned` function.

```
[xNorth,yEast,zDown] = ecef2ned(x,y,z,lat0,lon0,h0,wgs84)
```

```
xNorth = 1.3343
```

```
yEast = -2.5444
```

```
zDown = 0.3600
```

Input Arguments

xNorth — NED x-coordinates

scalar | vector | matrix | N-D array

NED x-coordinates of one or more points in the local NED system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: `single` | `double`

yEast — NED y-coordinates

scalar | vector | matrix | N-D array

NED y-coordinates of one or more points in the local NED system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: `single` | `double`

zDown — NED z-coordinates

scalar | vector | matrix | N-D array

NED z-coordinates of one or more points in the local NED system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: `single` | `double`

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as 'radians'.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h0 — Ellipsoidal height of local origin

scalar | vector | matrix | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

X — ECEF x-coordinates

scalar | vector | matrix | N-D array

ECEF x-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Y — ECEF y-coordinates

scalar | vector | matrix | N-D array

ECEF y-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid`

argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Z — ECEF z-coordinates

scalar | vector | matrix | N-D array

ECEF *z*-coordinates of one or more points in the geocentric ECEF system, returned as a scalar, vector, matrix, or N-D array. Units are specified by the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Tips

To transform vectors instead of coordinate locations, use the `ned2ecefv` function.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `ned2ecef` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`aer2ecef` | `ned2geodetic` | `ecef2ned` | `enu2ecef`

Topics

“Comparison of 3-D Coordinate Systems”

ned2ecefv

Rotate local north-east-down vector to geocentric Earth-centered Earth-fixed

Syntax

```
[U,V,W] = ned2ecefv(uNorth,vEast,wDown,lat0,lon0)
[ ___ ] = ned2ecefv( ___,angleUnit)
```

Description

`[U,V,W] = ned2ecefv(uNorth,vEast,wDown,lat0,lon0)` returns vector components `U`, `V`, and `W` in a geocentric Earth-centered Earth-fixed (ECEF) system corresponding to vector components `uNorth`, `vEast`, and `wDown` in a local north-east-down (NED) system. Specify the origin of the system with the geodetic coordinates `lat0` and `lon0`. Each coordinate input argument must match the others in size or be scalar.

`[___] = ned2ecefv(___,angleUnit)` specifies the units for latitude and longitude. Specify `angleUnit` as 'degrees' (the default) or 'radians'.

Examples

Calculate ECEF Vector Components from NED Components

Find the ECEF velocity components of an aircraft using its NED velocity components.

Specify the geodetic coordinates of the aircraft in degrees and the NED velocity components in kilometers per hour.

```
lat0 = 61.64;
lon0 = 30.70;
```

```
uNorth = -434.0403;
vEast = 152.4451;
wDown = -684.6964;
```

Calculate the ECEF components of the aircraft. The units for the ECEF components match the units for the NED components. Thus, the ECEF components are returned in kilometers per hour. The rotation performed by `ned2ecefv` does not affect the speed of the aircraft.

```
[U,V,W] = ned2ecefv(uNorth,vEast,wDown,lat0,lon0)
```

```
U = 530.2445
```

```
V = 492.1283
```

```
W = 396.3459
```

Reverse the rotation using the `ecef2nedv` function.

```
[uNorth,vEast,wDown] = ecef2nedv(U,V,W,lat0,lon0)
```

```
uNorth = -434.0403  
vEast = 152.4451  
wDown = -684.6964
```

Input Arguments

uNorth — NED x-components

scalar value | vector | matrix | N-D array

NED x-components of one or more vectors in the local NED system, specified as a scalar value, vector, matrix, or N-D array.

Data Types: `single` | `double`

vEast — NED y-components

scalar value | vector | matrix | N-D array

NED y-components of one or more vectors in the local NED system, specified as a scalar value, vector, matrix, or N-D array.

Data Types: `single` | `double`

wDown — NED z-components

scalar value | vector | matrix | N-D array

NED z-components of one or more vectors in the local NED system, specified as a scalar value, vector, matrix, or N-D array.

Data Types: `single` | `double`

lat0 — Geodetic latitude of local origin

scalar | vector | matrix | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

scalar | vector | matrix | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

U — ECEF x-components

scalar value | vector | matrix | N-D array

ECEF x-components of one or more vectors, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by `uNorth`, `vEast`, and `wDown`.

V — ECEF y-components

scalar value | vector | matrix | N-D array

ECEF y-components of one or more vectors, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by `uNorth`, `vEast`, and `wDown`.

W — ECEF z-components

scalar value | vector | matrix | N-D array

ECEF z-components of one or more vectors, returned as a scalar value, vector, matrix, or N-D array. Values are returned in the units specified by `uNorth`, `vEast`, and `wDown`.

Tips

To transform coordinate locations instead of vectors, use the `ned2ecef` function.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `ned2ecefv` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`enu2ecefv` | `ecef2nedv` | `ecef2enuv`

Topics

“Vectors in 3-D Coordinate Systems”

ned2geodetic

Transform local north-east-down coordinates to geodetic

Syntax

```
[lat,lon,h] = ned2geodetic(xNorth,yEast,zDown,lat0,lon0,h0,spheroid)  
[ ___ ] = ned2geodetic( ___ ,angleUnit)
```

Description

[lat,lon,h] = ned2geodetic(xNorth,yEast,zDown,lat0,lon0,h0,spheroid) transforms the local north-east-down (NED) Cartesian coordinates specified by xNorth, yEast, and zDown to the geodetic coordinates specified by lat, lon, and h. Specify the origin of the local NED system with the geodetic coordinates lat0, lon0, and h0. Each coordinate input argument must match the others in size or be scalar. Specify spheroid as the reference spheroid for the geodetic coordinates.

[___] = ned2geodetic(___ ,angleUnit) specifies the units for latitude and longitude. Specify angleUnit as 'degrees' (the default) or 'radians'.

Examples

Calculate Geodetic Coordinates from NED Coordinates

Find the geodetic coordinates of Mount Mansfield with respect to a nearby aircraft, using the NED coordinates of Mount Mansfield with respect to the geodetic coordinates of the aircraft.

First, specify the reference spheroid as WGS84. For more information about WGS84, see “Comparison of Reference Spheroids”. The units for ellipsoidal height and NED coordinates must match the units specified by the LengthUnit property of the reference spheroid. The default length unit for the reference spheroid created by wgs84Ellipsoid is 'meter'.

```
wgs84 = wgs84Ellipsoid;
```

Specify the geodetic coordinates of the local origin. In this example, the local origin is the aircraft. Specify h0 as ellipsoidal height in meters.

```
lat0 = 44.532;  
lon0 = -72.782;  
h0 = 1699;
```

Specify the NED coordinates of the point of interest. In this example, the point of interest is Mount Mansfield.

```
xNorth = 1334.3;  
yEast = -2543.6;  
zDown = 359.65;
```

Then, calculate the geodetic coordinates of Mount Mansfield. The result h is the ellipsoidal height of the mountain in meters. To view the results in standard notation, specify the display format as shortG.


```
format shortG
[lat,lon,h] = ned2geodetic(xNorth,yEast,zDown,lat0,lon0,h0,wgs84)

lat =
    44.544

lon =
   -72.814

h =
    1340
```

Reverse the transformation using the `geodetic2ned` function.

```
[xNorth,yEast,zDown] = geodetic2ned(lat,lon,h,lat0,lon0,h0,wgs84)

xNorth =
    1334.3

yEast =
   -2543.6

zDown =
    359.65
```

Input Arguments

xNorth — NED x-coordinates

scalar | vector | matrix | N-D array

NED x-coordinates of one or more points in the local NED system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: single | double

yEast — NED y-coordinates

scalar | vector | matrix | N-D array

NED y-coordinates of one or more points in the local NED system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid` argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is 'meter'.

Data Types: single | double

zDown — NED z-coordinates

scalar | vector | matrix | N-D array

NED z-coordinates of one or more points in the local NED system, specified as a scalar, vector, matrix, or N-D array. Specify values in units that match the `LengthUnit` property of the `spheroid`

argument. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

Data Types: `single` | `double`

lat0 — Geodetic latitude of local origin

`scalar` | `vector` | `matrix` | N-D array

Geodetic latitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

lon0 — Geodetic longitude of local origin

`scalar` | `vector` | `matrix` | N-D array

Geodetic longitude of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify the values in degrees. To use values in radians, specify the `angleUnit` argument as `'radians'`.

Data Types: `single` | `double`

h0 — Ellipsoidal height of local origin

`scalar` | `vector` | `matrix` | N-D array

Ellipsoidal height of the local origin, specified as a scalar, vector, matrix, or N-D array. The local origin can refer to one point or a series of points (for example, a moving platform). Specify values in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Data Types: `single` | `double`

spheroid — Reference spheroid

`referenceEllipsoid` object | `oblateSpheroid` object | `referenceSphere` object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term `reference spheroid` is used synonymously with `reference ellipsoid`. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

angleUnit — Angle units

`'degrees'` (default) | `'radians'`

Angle units, specified as `'degrees'` (the default) or `'radians'`.

Output Arguments

lat — Geodetic latitude

`scalar` | `vector` | `matrix` | N-D array

Geodetic latitude of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in degrees within the interval $[-90\ 90]$. To use values in radians, specify the `angleUnit` argument as `'radians'`.

lon — Geodetic longitude

scalar | vector | matrix | N-D array

Geodetic longitude of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in degrees within the interval $[-180\ 180]$. To use values in radians, specify the `angleUnit` argument as `'radians'`.

h — Ellipsoidal height

scalar | vector | matrix | N-D array

Ellipsoidal height of one or more points, returned as a scalar, vector, matrix, or N-D array. Values are specified in units that match the `LengthUnit` property of the `spheroid` object. For example, the default length unit for the reference ellipsoid created by `wgs84Ellipsoid` is `'meter'`.

For more information about ellipsoidal height, see “Find Ellipsoidal Height from Orthometric Height”.

Version History

Introduced in R2012b

R2021a: Generate C and C++ code using MATLAB Coder

The `ned2geodetic` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`aer2geodetic` | `enu2geodetic` | `geodetic2ned` | `ned2ecef`

Topics

“Comparison of 3-D Coordinate Systems”

newmap

Set up new map

Syntax

```
newmap  
newmap(proj)  
newmap(target, ___)  
mx = newmap(___)
```

Description

`newmap` creates the default map axes in the current figure. By default, the function creates a world map that uses an Equal Earth projection.

In some cases, the `newmap` function can change the current figure and current axes. For more information, see “Algorithms” on page 1-1253.

`newmap(proj)` specifies the projected coordinate reference system (CRS) for the map.

`newmap(target, ___)` changes or replaces the axes specified by `target` instead of the current axes, in addition to any combination of inputs from the previous syntaxes.

`mx = newmap(___)` returns the `MapAxes` object. Use `mx` to query and modify properties of the `MapAxes` object after creation. For a list of properties, see `MapAxes Properties`.

Examples

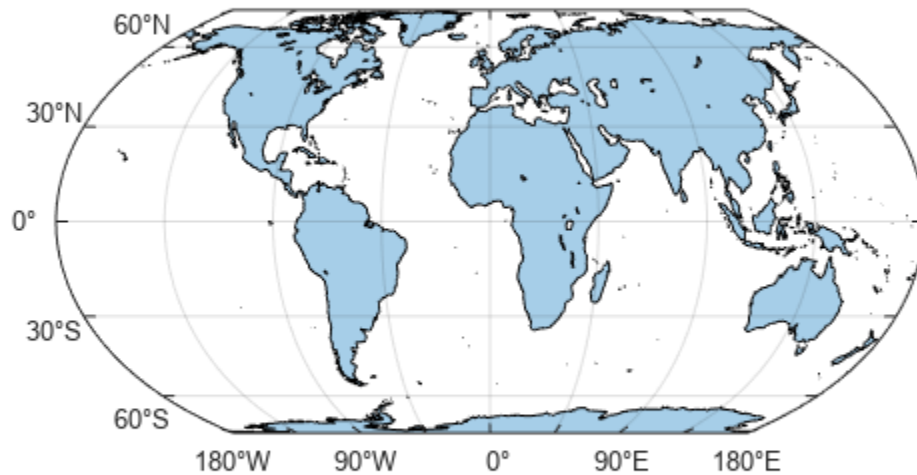
Create Default Map Axes

Create the default map axes. By default, the map axes uses an Equal Earth projection.

```
newmap
```

Read a shapefile containing world land areas into the workspace as a geospatial table. Display the land areas on the map axes.

```
land = readgeotable("landareas.shp");  
geoplot(land)
```



Specify Map Projection of Map Axes

MapAxes objects use projected coordinate reference systems (CRSs) to transform geographic (latitude-longitude) coordinates to projected (xy) coordinates. There are two ways to get a projected CRS:

- Get a projected CRS from a data file.
- Create a projected CRS object by using the `projcrs` function. You can create a projected CRS object from an authority code or from a well-known text string.

Get Projected CRS from File

Read a shapefile of road data into the workspace as a geospatial table. The table represents the roads using line shapes in projected coordinates.

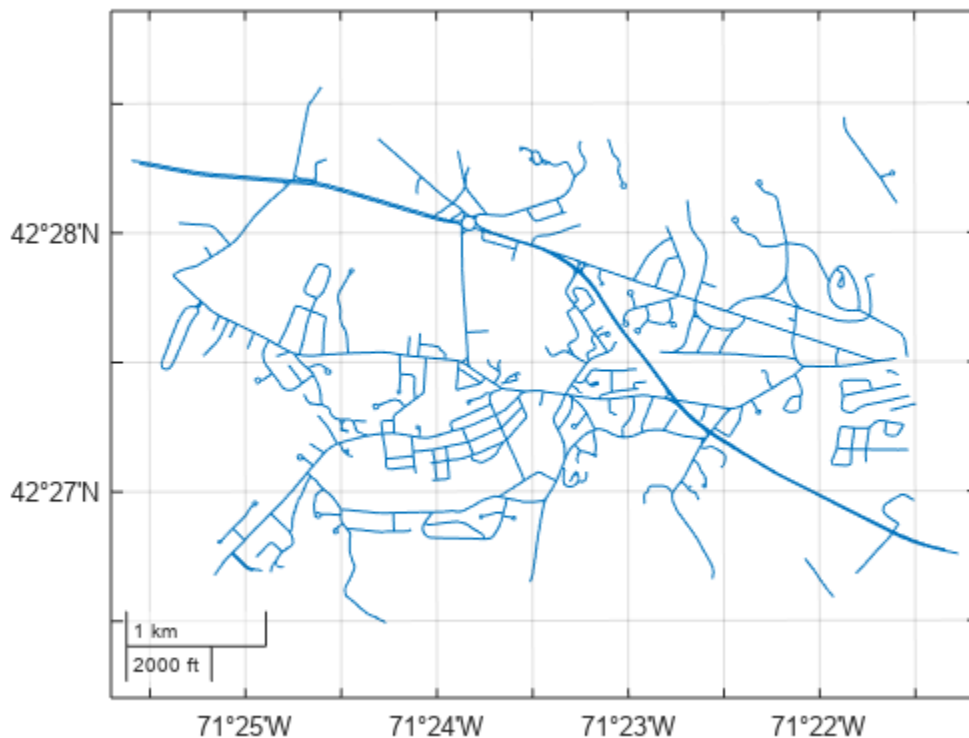
```
roads = readgeotable("concord_roads.shp");
```

Extract the projected CRS from the data file. Then, create a map axes that uses the projected CRS.

```
proj1 = roads.Shape.ProjecteCRS;  
newmap(proj1)
```

Display the data on the map axes.

```
geoplot(roads)
```



Get Projected CRS from Authority Code

Read a shapefile of US states into the workspace as a geospatial table. The table represents the states using polygon shapes in geographic coordinates. Extract the table row representing Alaska.

```
states = readgeotable("usastatehi.shp");  
alaska = states(states.Name == "Alaska",:);
```

Create a projected CRS object appropriate for Alaska. Use the Alaska Albers Equal Area Conic projected CRS, which has the ESRI code 102006. Then, create a map axes that uses the projected CRS.

```
proj2 = projcrs(102006,Authority="ESRI");  
newmap(proj2)
```

Display the Alaska polygon on the map axes.

```
geoplot(alaska)  
geolimits([48 72],[-180 -135])
```



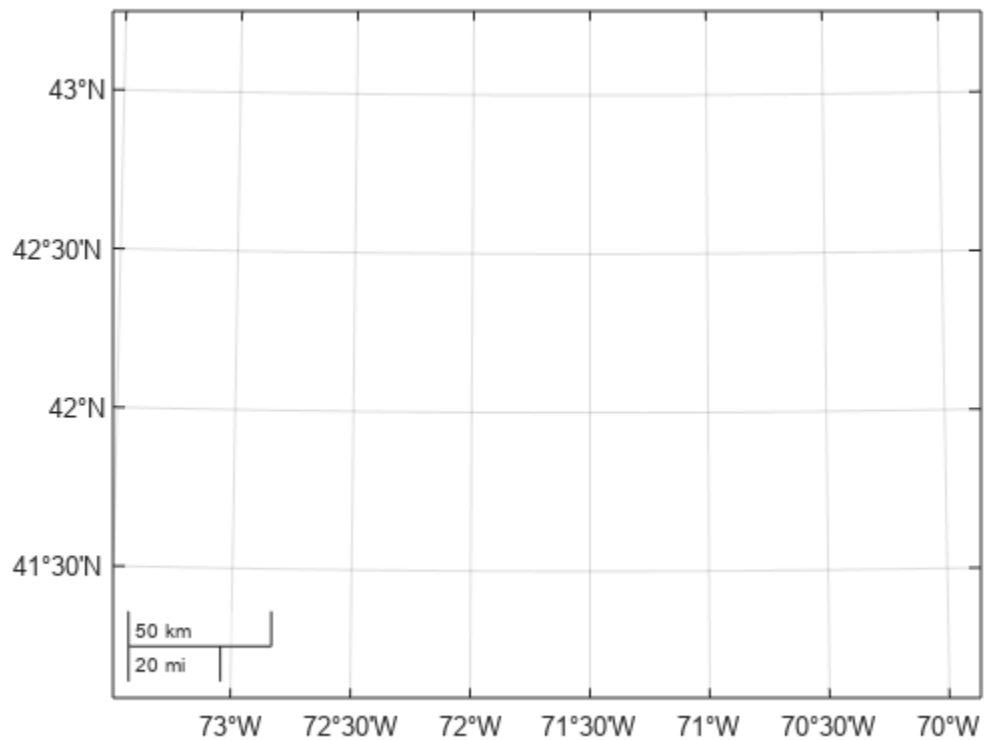
Customize Appearance of Map Axes

Import a shapefile containing road data for Concord, MA into the workspace as a geospatial table. The table represents roads using line shapes in projected coordinates.

```
roads = readgeotable("concord_roads.shp");
```

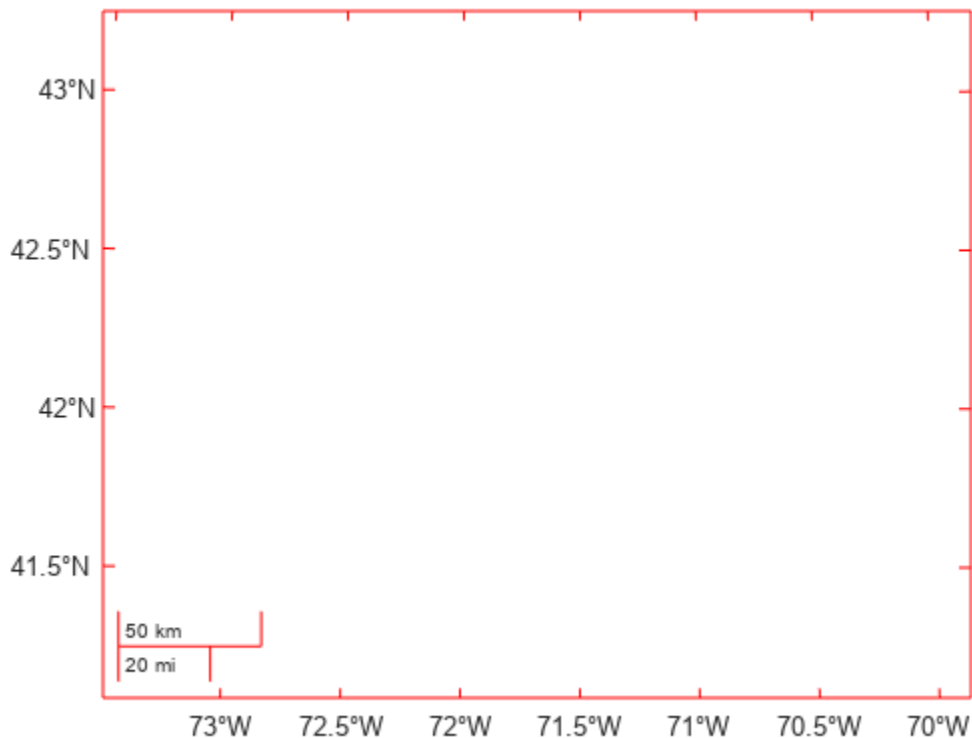
Create a map axes that uses the projected CRS embedded in the data file. Return the MapAxes object as a variable.

```
proj = roads.Shape.Project CRS;  
mx = newmap(proj);
```



Customize the map by setting properties of the `MapAxes` object. Set the tick label format to decimal degrees, remove the graticule lines, and change the outline color.

```
mx.TickLabelFormat = "dd";  
mx.GraticuleLineStyle = "none";  
mx.OutlineColor = "r";
```

Display Map Axes in Tiled Layout

Read a shapefile of US states into the workspace as a geospatial table. The table represents the states using polygon shapes in geographic coordinates. Remove the table rows representing Alaska and Hawaii.

```
states = readgeotable("usastatehi.shp");
idx = states.Name ~= "Alaska" & states.Name ~= "Hawaii";
states = states(idx,:);
```

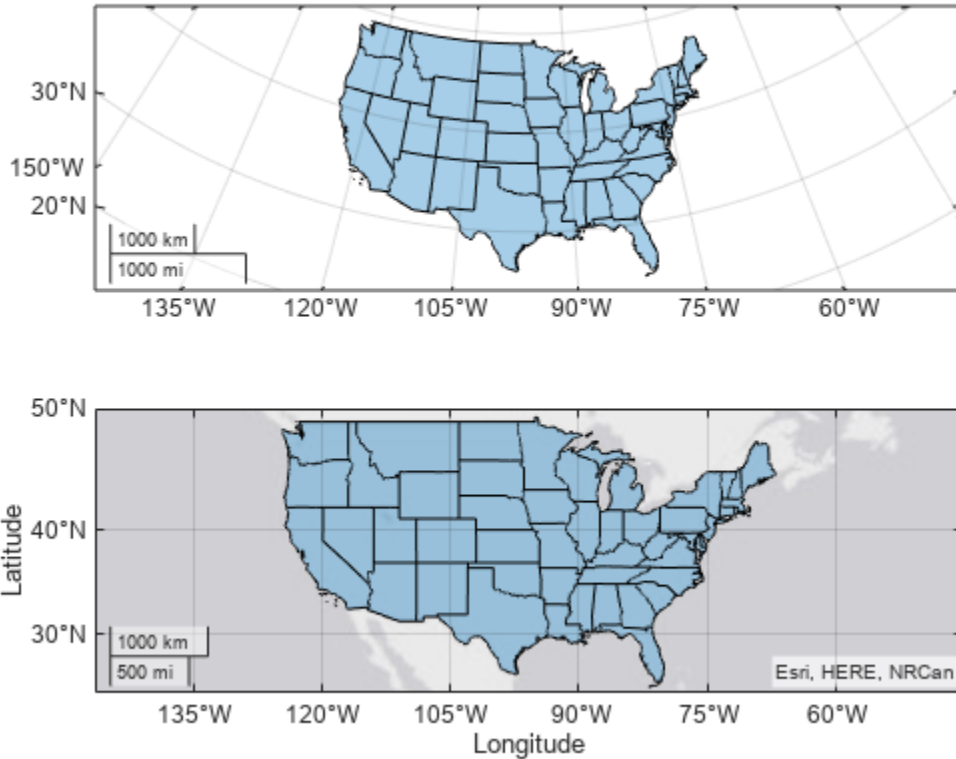
Create a 2-by-1 tiled chart layout.

- In the first tile, display the US states over a map axes that uses a North America Albers Equal Area Conic projection.
- In the second tile, display the US states over a geographic axes, which uses a Web Mercator projection.

```
tiledlayout(2,1)
```

```
nexttile
proj = projcrs(102008,Authority="ESRI");
newmap(proj)
geoplot(states)
```

```
nexttile
geoplot(states)
```



Input Arguments

proj — Projected coordinate reference system

`projcrs(8857)` (default) | `projcrs` object

Projected coordinate reference system (CRS), specified as a `projcrs` object. `MapAxes` objects use the projection method and projection parameters stored in the projected CRS to transform geographic (latitude-longitude) coordinates to projected (*xy*) coordinates.

By default, map axes objects use the World Geodetic System of 1984 (WGS 84) / Equal Earth Greenwich projected CRS, which has the EPSG code 8857.

The projected CRS must have a forward and inverse projection implementation. Most projected CRSs have a forward and inverse projection implementation.

target — Target to change or replace

`Axes` object | `GeographicAxes` object | `MapAxes` object | `Figure` object | `TiledChartLayout` object | ...

Target to change or replace, specified as one of these options:

- An axes object — An `Axes`, `PolarAxes`, `GeographicAxes`, or `MapAxes` object.
- A parent container — A `Figure`, `Panel`, `Tab`, `TiledChartLayout`, or `GridLayout` object.

If you do not specify this argument, then the `newmap` function uses the current axes.

Algorithms

The behavior of the `newmap` function depends on the `NextPlot` properties of the figure and axes.

First, the `newmap` function queries the `NextPlot` property of the figure.

- If you specify the `target` input argument, then the function uses the figure associated with `target`.
- If you do not specify the `target` input argument, then the function uses the current figure. If there is no current figure, then the function creates a new figure.

This table shows how the `newmap` function changes the figure based on the value of `NextPlot`.

Value of <code>NextPlot</code>	Behavior of <code>newmap</code>
"add" (default)	<p>The <code>newmap</code> function:</p> <ul style="list-style-type: none"> • Uses the current figure or the figure associated with <code>target</code> • Does not remove child objects from the figure • Does not reset figure properties
"new"	<p>If you do not specify <code>target</code>, then the <code>newmap</code> function creates a new figure and uses it as the current figure.</p> <p>If you specify <code>target</code>, then the function uses the figure associated with <code>target</code>.</p>
"replacechildren"	<p>The <code>newmap</code> function:</p> <ul style="list-style-type: none"> • Uses the current figure or the figure associated with <code>target</code> • Removes all child objects, which are not hidden, from the figure • Resets the <code>NextPlot</code> property of the figure to "add" <p>This behavior is similar to using the <code>clf</code> function.</p>
"replace"	<p>The <code>newmap</code> function:</p> <ul style="list-style-type: none"> • Uses the current figure or the figure associated with <code>target</code> • Removes all child objects from the figure, even if the child objects are hidden • Resets all figure properties to their defaults, except <code>Position</code>, <code>Units</code>, <code>PaperPosition</code>, and <code>PaperUnits</code> • Resets the <code>NextPlot</code> property of the figure to "add", regardless of user-defined defaults <p>This behavior is similar to using the <code>clf reset</code> syntax of the <code>clf</code> function.</p>

Then, the `newmap` function queries the `NextPlot` property of the axes in the figure.

- If you specify the `target` input argument as an axes, then the function uses `target`.
- If you do not specify the `target` input argument, then the function uses the current axes. If there is no current axes, then the function creates a new `MapAxes` object.

This table shows how the `newmap` function changes the axes based on the value of `NextPlot`.

Value of <code>NextPlot</code>	Behavior of <code>newmap</code>
"replace" (default)	<p>When the axes is a <code>MapAxes</code> object, the <code>newmap</code> function:</p> <ul style="list-style-type: none"> • Uses the specified axes • Removes all child objects from the axes • Resets axes properties, except <code>ProjectedCRS</code>, <code>Position</code> and <code>Units</code>, to their default values <p>When the axes is not a <code>MapAxes</code> object, the <code>newmap</code> function deletes the specified axes and creates a <code>MapAxes</code> object.</p> <p>This behavior is similar to using the <code>cla reset</code> syntax of the <code>cla</code> function.</p>
"add"	<p>When the axes is a <code>MapAxes</code> object, the <code>newmap</code> function:</p> <ul style="list-style-type: none"> • Uses the specified axes • Does not remove child objects from the axes • Does not reset axes properties <p>When the axes is not a <code>MapAxes</code> object, the <code>newmap</code> function returns an error.</p>
"replacechildren"	<p>When the axes is a <code>MapAxes</code> object, the <code>newmap</code> function:</p> <ul style="list-style-type: none"> • Uses the specified axes • Removes all child objects from the axes • Resets the <code>ColorOrderIndex</code> and <code>LineStyleOrderIndex</code> properties of the axes to 1, but does not reset other axes properties <p>When the axes is not a <code>MapAxes</code> object, the <code>newmap</code> function deletes the specified axes and creates a <code>MapAxes</code> object.</p> <p>This behavior is similar to using the <code>cla</code> function.</p>

Value of NextPlot	Behavior of newmap
"replaceall"	<p>When the axes is a MapAxes object, the newmap function:</p> <ul style="list-style-type: none"> • Uses the specified axes • Removes all child objects from the axes • Resets axes properties, except Position and Units, to their default values <p>When the axes is not a MapAxes object, the newmap function deletes the specified axes and creates a MapAxes object.</p> <p>This behavior is similar to using the cla reset syntax of the cla function.</p>

Version History

Introduced in R2023a

See Also

Functions

cla | clf | mapaxes | figure | hold | ishold | tiledlayout | nexttile

Properties

MapAxes Properties

neworig

Orient regular data grid to oblique aspect

Syntax

```
[Z,lat,lon] = neworig(Z0,R,origin)
[Z,lat,lon] = neworig(Z0,R,origin,'forward')
[Z,lat,lon] = neworig(Z0,R,origin,'inverse')
```

Description

`[Z,lat,lon] = neworig(Z0,R,origin)` and `[Z,lat,lon] = neworig(Z0,R,origin,'forward')` will transform regular data grid `Z0` into an oblique aspect, while preserving the matrix storage format. In other words, the oblique map origin is not necessarily at (0,0) in the Greenwich coordinate frame. This allows operations to be performed on the matrix representing the oblique map. For example, azimuthal calculations for a point in a data grid become row and column operations if the data grid is transformed so that the north pole of the oblique map represents the desired point on the globe. Specify `R` as a `GeographicCellsReference` or `GeographicPostingsReference` object. The `RasterSize` property of `R` must be consistent with `size(Z)`.

`[Z,lat,lon] = neworig(Z0,R,origin,'inverse')` transforms the regular data grid from the oblique frame to the Greenwich coordinate frame.

The `neworig` function transforms a regular data grid into a new matrix in an altered coordinate system. An analytical use of the new matrix can be realized in conjunction with the `newpole` function. If a selected point is made the *north pole* of the new system, then when a new matrix is created with `neworig`, each row of the new matrix is a constant distance from the selected point, and each column is a constant azimuth from that point.

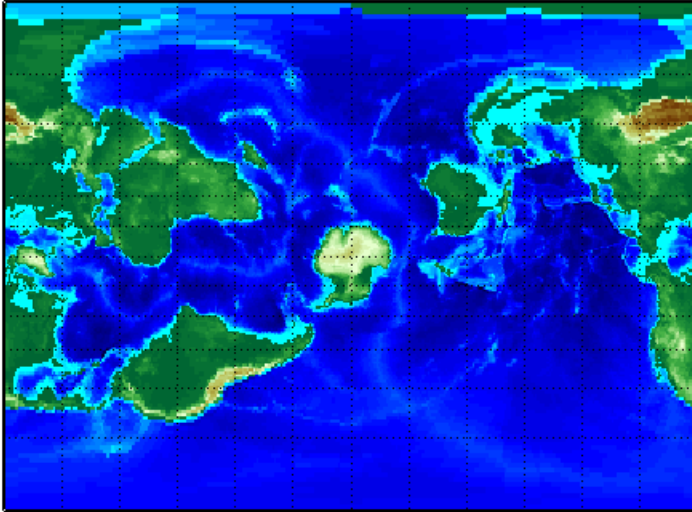
Limitations

`neworig` only supports data grids that cover the entire globe.

Examples

Load elevation raster data and a geographic cells reference object. Then, transform the map so that Sri Lanka is at the North Pole.

```
load topo60c
origin = newpole(7,80);
Z = neworig(topo60c,topo60cR,origin);
axesm miller
gridm on
lat = linspace(-90,90,90);
lon = linspace(-180,180,180);
surfm(lat,lon,Z)
demcmap(topo60c)
tightmap
```



Version History

Introduced before R2006a

R2022b: neworig will not accept referencing vectors or referencing matrices as input

Not recommended starting in R2022b

The `neworig` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

See Also

org2pol | rotatem | geographicToDiscrete

newpole

Origin vector to place specific point at pole

Syntax

```
origin = newpole(polelat,polelon)
origin = newpole(polelat,polelon,units)
```

Description

`origin = newpole(polelat,polelon)` provides the `origin` vector for a transformed coordinate system based upon moving the point (`polelat`, `polelon`) to become the north pole singularity in the new system. The origin is a three-element vector of the form [`latitude longitude orientation`], where the latitude and longitude are the coordinates the new center (`origin`) had in the untransformed system, and the orientation is the azimuth of the true North Pole from the new origin point. For the `newpole` calculation, this orientation is constrained to be always 0°.

`origin = newpole(polelat,polelon,units)` specifies the units of the inputs and output, where `units` is any valid angle unit. The default is 'degrees'.

When developing transverse or oblique projections, you need transformed coordinate systems. One way to define these systems is to establish the point in the original (untransformed) system that will become the new (transformed) *north pole*.

Examples

Take a point and make it the new North Pole:

```
origin = newpole(60,180)

origin =
    30.0000         0         0
```

This makes sense: as a point 30° beyond the true North Pole on the original origin's meridian is pulled up to become the *pole*, the point originally 30° above the origin is pulled down into the origin spot.

See Also

`neworig` | `org2pol` | `putpole`

nm2deg

Convert spherical distance from nautical miles to degrees

Syntax

```
deg = nm2deg(nm)
deg = nm2deg(nm, radius)
deg = nm2deg(nm, sphere)
```

Description

`deg = nm2deg(nm)` converts distances from nautical miles to degrees, as measured along a great circle on a sphere with a radius of 3440.065 nm, the mean radius of the Earth.

`deg = nm2deg(nm, radius)` converts distances from nautical miles to degrees, as measured along a great circle on a sphere having the specified radius.

`deg = nm2deg(nm, sphere)` converts distances from nautical miles to degrees, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Nautical Miles to Degrees on Earth

Convert 500 nautical miles to degrees, as measured along a great circle on the Earth. By default, the `nm2deg` function assumes your input is a measurement of the Earth, which is represented as a sphere with a radius of 3440.065 nautical miles.

```
deg = nm2deg(500)
```

```
deg = 8.3277
```

Convert Nautical Miles to Degrees on Sphere with Specified Radius

Convert 500 nautical miles to degrees, as measured along a great circle on a sphere with a radius of 3432 nautical miles.

```
deg = nm2deg(500, 3432)
```

```
deg = 8.3473
```

Input Arguments

nm — Distance in nautical miles
numeric array

Distance in nautical miles, specified as a numeric array.

Data Types: `single` | `double`

radius — Radius

3440.065 (default) | numeric scalar

Radius of sphere in units of nautical miles, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments

deg — Distance in degrees

numeric array

Distance in degrees, returned as a numeric array.

Data Types: `single` | `double`

Version History

Introduced in R2007a

See Also

`deg2rad` | `rad2deg` | `deg2nm` | `km2deg` | `sm2deg` | `nm2rad`

nm2km

Convert nautical miles to kilometers

Syntax

```
km = nm2km(nm)
```

Description

`km = nm2km(nm)` converts distances from nautical miles to kilometers.

Examples

Convert Nautical Miles to Kilometers

Convert 500 nautical miles to kilometers.

```
km = nm2km(500)
```

```
km = 926
```

Input Arguments

nm — Distance in nautical miles

numeric array

Distance in nautical miles, specified as a numeric array.

Output Arguments

km — Distance in kilometers

numeric array

Distance in kilometers, returned as a numeric array of the same size as `nm`.

Version History

Introduced in R2007a

See Also

Functions

`km2nm` | `deg2km` | `km2deg` | `deg2nm` | `nm2deg`

nm2rad

Convert spherical distance from nautical miles to radians

Syntax

```
rad = nm2rad(nm)
rad = nm2rad(nm, radius)
rad = nm2rad(nm, sphere)
```

Description

`rad = nm2rad(nm)` converts distances from nautical miles to radians, as measured along a great circle on a sphere with a radius of 3440.065 nm, the mean radius of the Earth.

`rad = nm2rad(nm, radius)` converts distances from nautical miles to radians, as measured along a great circle on a sphere having the specified radius.

`rad = nm2rad(nm, sphere)` converts distances from nautical miles to radians, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Nautical Miles to Radians on Earth

Convert 500 nautical miles to radians, as measured along a great circle on the Earth. By default, the `nm2rad` function assumes your input is a measurement of the Earth, which is represented as a sphere with a radius of 3440.065 nautical miles.

```
rad = nm2rad(500)
rad = 0.1453
```

Convert Nautical Miles to Radians on Sphere with Specified Radius

Convert 500 nautical miles to radians, as measured along a great circle on a sphere with a radius of 3432 nautical miles.

```
rad = nm2rad(500, 3432)
rad = 0.1457
```

Input Arguments

nm — Distance in nautical miles
numeric array

Distance in nautical miles, specified as a numeric array.

Data Types: `single` | `double`

radius — Radius

3440.065 (default) | numeric scalar

Radius of sphere in units of nautical miles, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments**rad — Distance in radians**

numeric array

Distance in radians, returned as a numeric array.

Data Types: `single` | `double`

Version History

Introduced in R2007a

See Also

`deg2rad` | `rad2deg` | `rad2nm` | `nm2deg` | `sm2rad` | `km2rad`

nm2sm

Convert nautical to statute miles

Syntax

```
sm = nm2sm(nm)
```

Description

`sm = nm2sm(nm)` converts distances from nautical miles to statute miles.

Examples

Convert Nautical Miles to Statute Miles

Convert 500 nautical miles to statute miles.

```
sm = nm2sm(500)
```

```
sm = 575.3886
```

Input Arguments

nm — Distance in nautical miles

numeric array

Distance in nautical miles, specified as a numeric array.

Output Arguments

sm — Distance in statute miles

numeric array

Distance in statute miles, returned as a numeric array of the same size as `nm`.

Version History

Introduced in R2007a

See Also

Functions

`sm2nm` | `deg2nm` | `nm2deg` | `deg2sm` | `sm2deg`

northarrow

Add north arrow to axesm-based map

Syntax

```
northarrow  
northarrow('property',value,...)
```

Description

northarrow creates a default north arrow.

northarrow('property',value,...) creates a north arrow using the specified property/value pairs. Valid entries for properties are 'latitude', 'longitude', 'facecolor', 'edgecolor', 'linewidth', and 'scaleratio'. The 'latitude' and 'longitude' properties specify the location of the north arrow. The 'facecolor', 'edgecolor', and 'linewidth' properties control the appearance of the north arrow. The 'scaleratio' property represents the size of the north arrow as a fraction of the size of the axes. A 'scaleratio' value of 0.10 creates a north arrow one-tenth (1/10) the size of the axes. You can change the appearance ('facecolor', 'edgecolor', and 'linewidth') of the north arrow using the `set` command.

The northarrow function creates a north arrow symbol at the map origin on the displayed map. You can reposition the north arrow symbol by clicking and dragging its icon. Alternatively, open a dialog box that you can use to change the location of the north arrow by right-clicking or **Ctrl**-clicking the arrow. The orientation of the north arrow is computed for you, and does not need manual adjustment, no matter where you move the symbol.

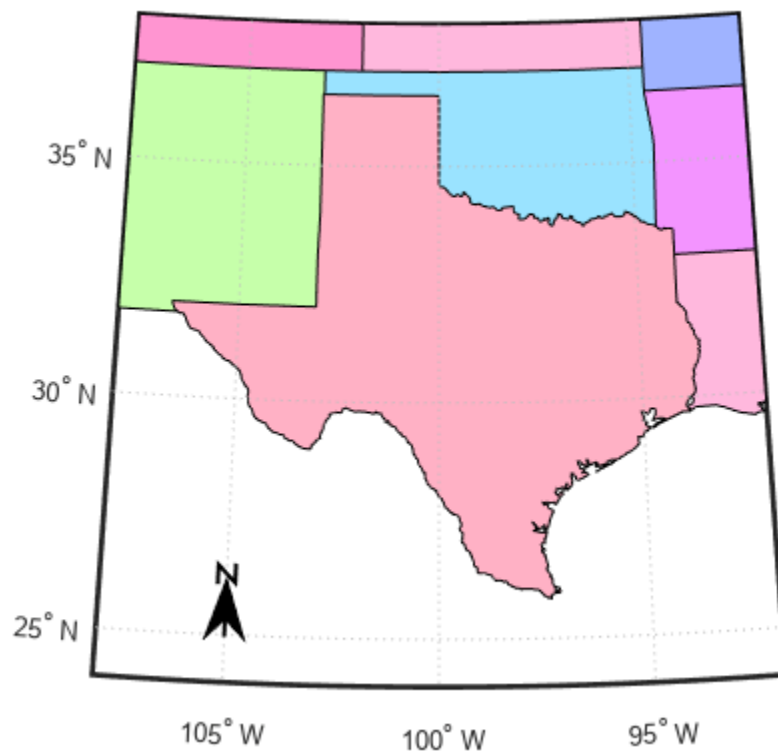
Modifying some of the properties of the north arrow results in replacement of the original object. Use `HANDLEM('NorthArrow')` to get the handles associated with the north arrow.

Examples

Add North Arrow to Map of Texas

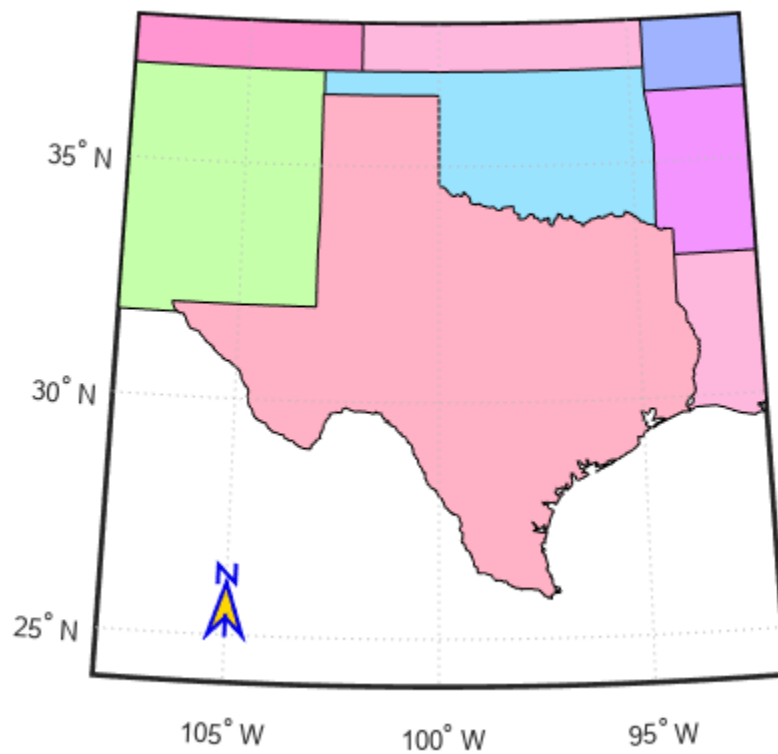
Create a map of Texas. Add the north arrow in the lower left of the map.

```
figure  
usamap("texas")  
states = readgeotable("usastatelo.shp");  
faceColors = makesymbolspec("Polygon",...  
    {'INDEX',[1 numel(states)],'FaceColor',polcmap(height(states))});  
geoshow(states,"DisplayType","polygon","SymbolSpec",faceColors)  
northarrow("Latitude",25,"Longitude",-105,"LineWidth",1.5);
```

Change the edge and face colors of the north arrow.

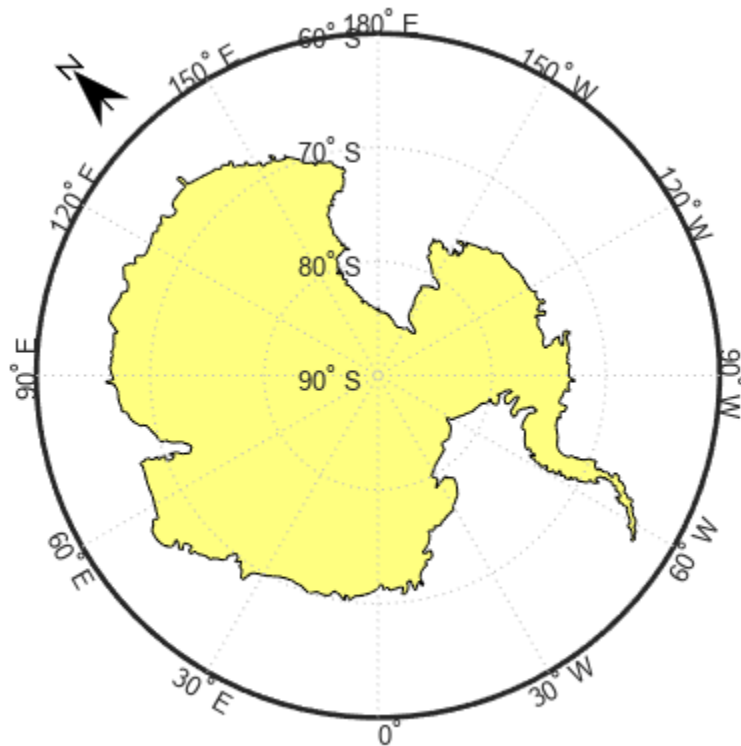
```
h = handlem("NorthArrow");  
set(h, "FaceColor", [1 0.8431 0], "EdgeColor", [0.01 0.01 0.9])
```



Add North Arrows to Map of South Pole

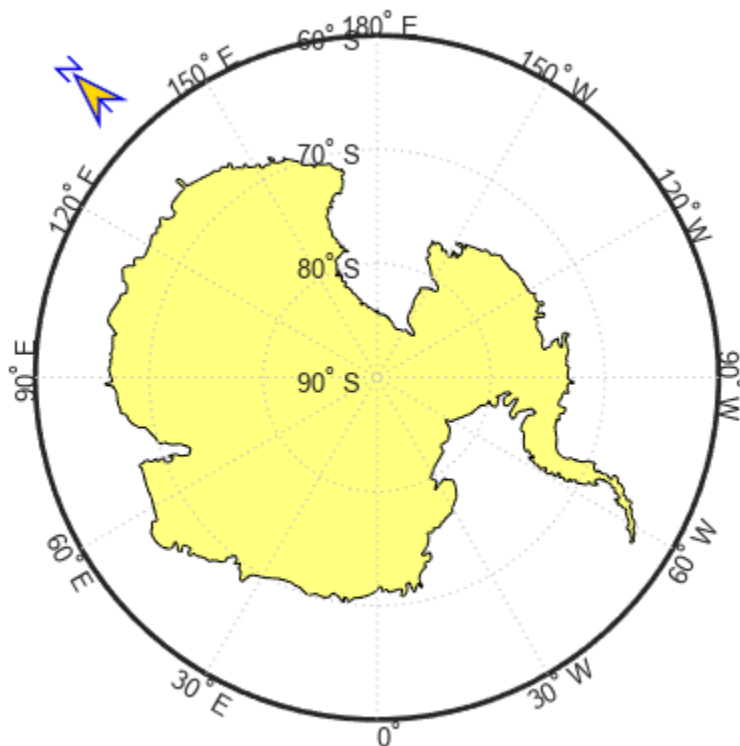
Create a map centered at the South Pole. Add a north arrow at a specified geographic position.

```
GT = readgeotable("landareas.shp");  
antarctica = GT(GT.Name == "Antarctica",:);  
figure  
worldmap("south pole")  
geoshow(antarctica)  
northarrow("latitude",-57,"longitude",135);
```



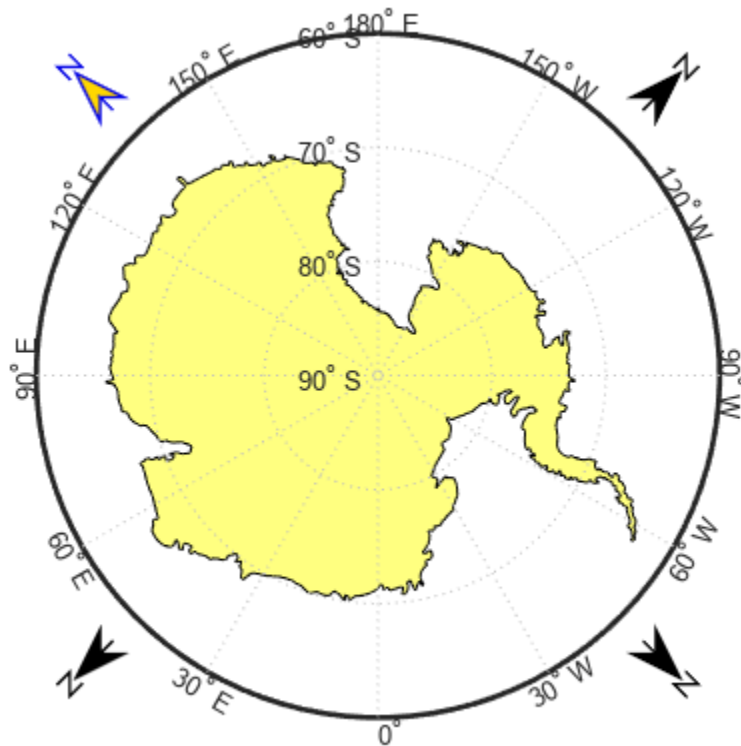
Change the appearance of the north arrow.

```
h = handle("NorthArrow");  
set(h, "FaceColor", [1.000 0.8431 0.0000], ...  
     "EdgeColor", [0.0100 0.0100 0.9000])
```



Show that every direction from the South Pole is north by creating three more north arrows. Note that north arrows are objects in the axes with Cartesian coordinates, not mapping objects. As a result, if you create more than one north arrow, any Mapping Toolbox™ function that manipulates a north arrow will affect only the last one drawn.

```
northarrow("latitude",-57,"longitude",45);  
northarrow("latitude",-57,"longitude",225);  
northarrow("latitude",-57,"longitude",315);
```



Limitations

You can draw multiple north arrows on the map. However, the callbacks will only work with the most recently created north arrow. In addition, since it can be displayed outside the map frame limits, the north arrow is not converted into a “mapped” object. Hence, the location and orientation of the north arrow have to be updated manually if the map origin or projection changes.

Version History

Introduced before R2006a

See Also

scaleruler

npi2pi

(Removed) Wrap longitudes to [-180 180] degree interval

Note The `npi2pi` function has been removed. Use the `wrapTo180` or `wrapToPi` function instead.

Syntax

```
anglout = npi2pi(anglin)
anglout = npi2pi(anglin,units)
anglout = npi2pi(anglin,units,method)
```

Description

`anglout = npi2pi(anglin)` wraps the input angle `anglin` (typically representing a longitude) to lie on the range -180 to 180 (e.g., 270° is renamed -90°).

`anglout = npi2pi(anglin,units)` specifies the angle units with any valid angle units character vector `units`. The default is 'degrees'.

`anglout = npi2pi(anglin,units,method)` allows special alternative computations to be used when `npi2pi` is called from within certain Mapping Toolbox functions. `method` can be one of the following:

- 'exact', for exact wrapping (the default value)
- 'inward', where angles are scaled by a factor of $(1 - \text{deg2rad}(1.0\text{E-}6))$ before wrapping
- 'outward', where angles are scaled by a factor of $(1 + \text{deg2rad}(1.0\text{E-}6))$ before wrapping

Examples

```
npi2pi(315)
```

```
ans =
    -45
```

```
npi2pi(181)
```

```
ans =
   -179
```

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `npi2pi` function has been removed. Use the `wrapTo180` or `wrapToPi` function instead.

R2022a: Warns

Warns starting in R2022a

The `npi2pi` function issues a warning that it will be removed in a future release.

R2007b: To be removed

Not recommended starting in R2007b

The `npi2pi` function runs without warning but will be removed in a future release.

See Also

`wrapToPi` | `wrapTo180`

oblateSpheroid

Oblate ellipsoid of revolution

Description

An `oblateSpheroid` object encapsulates the interrelated intrinsic properties of an oblate ellipsoid of revolution. An oblate spheroid is symmetric about its polar axis and flattened at the poles, and includes the perfect sphere as a special case.

Creation

You can create an `oblateSpheroid` object, `s`, by entering:

```
s = oblateSpheroid;
```

on the command line.

Properties

SemimajorAxis — Equatorial radius of spheroid

1 (default) | positive, finite scalar

Equatorial radius of spheroid, specified as a positive, finite scalar. The value of `SemimajorAxis` is expressed in meters.

When the `SemimajorAxis` property is changed, the `SemiminorAxis` property scales as needed to preserve the shape of the spheroid and the values of shape-related properties including `InverseFlattening` and `Eccentricity`. The only way to change the `SemimajorAxis` property is to set it directly, using dot notation.

Example: 6378137

Data Types: `double`

SemiminorAxis — Distance from center of spheroid to pole

1 (default) | nonnegative, finite scalar

Distance from center of spheroid to pole, specified as a nonnegative, finite scalar. The value of `SemiminorAxis` is always less than or equal to `SemimajorAxis`, and is expressed in meters.

When the `SemiminorAxis` property is changed, the `SemimajorAxis` property remains unchanged, but the shape of the spheroid changes, which is reflected in changes in the values of `InverseFlattening`, `Eccentricity`, and other shape-related properties.

Example: 6356752

Data Types: `double`

InverseFlattening — Reciprocal of flattening

Inf (default) | positive scalar in the range [1, Inf]

Reciprocal of flattening, specified as positive scalar in the range [1, Inf].

The value of inverse flattening, $1/f$, is calculated using `SemimajorAxis` value a and `SemiminorAxis` value b according to $1/f = a/(a-b)$. A value $1/f$ of Inf designates a perfect sphere. As $1/f$ approaches 1, the reference spheroid approaches a flattened disk.

When the `InverseFlattening` property is changed, other shape-related properties update, including `Eccentricity`. The `SemimajorAxis` property remains unchanged, but the value of `SemiminorAxis` adjusts to reflect the new shape.

Example: 300

Data Types: double

Eccentricity — First eccentricity of spheroid

0 (default) | nonnegative scalar in the range [0, 1]

First eccentricity of the spheroid, specified as nonnegative scalar in the range [0, 1].

The value of eccentricity, ecc , is calculated using `SemimajorAxis` value a and `SemiminorAxis` value b according to $ecc = \sqrt{(a^2 - b^2)}/a$. A value ecc of 0 designates a perfect sphere.

When the `Eccentricity` property is changed, other shape-related properties update, including `InverseFlattening`. The `SemimajorAxis` property remains unchanged, but the value of `SemiminorAxis` adjusts to reflect the new shape.

Example: 0.08

Data Types: double

Flattening — Flattening of spheroid

nonnegative scalar in the range [0, 1]

This property is read-only.

Flattening of the spheroid, specified as nonnegative scalar in the range [0, 1].

The value of flattening, f , is calculated using `SemimajorAxis` value a and `SemiminorAxis` value b according to $f = (a-b)/a$.

Data Types: double

ThirdFlattening — Third flattening of spheroid

nonnegative scalar in the range [0, 1]

This property is read-only.

Third flattening of the spheroid, specified as nonnegative scalar in the range [0, 1].

The value of the third flattening, n , is calculated using `SemimajorAxis` value a and `SemiminorAxis` value b according to $n = (a-b)/(a+b)$.

Data Types: double

MeanRadius — Mean radius of the spheroid

positive, finite scalar

This property is read-only.

Mean radius of the spheroid, specified as positive, finite scalar. The `MeanRadius` property is expressed in meters.

The mean radius of the spheroid, r , is calculated using `SemimajorAxis` value a and `SemiminorAxis` value b according to $r = (2a+b)/3$.

Data Types: double

SurfaceArea — Surface area of the spheroid

positive, finite scalar

This property is read-only.

Surface area of the spheroid, specified as positive, finite scalar. The `SurfaceArea` property is expressed in square meters.

Data Types: double

Volume — Volume of the spheroid

positive, finite scalar

This property is read-only.

Volume of the spheroid, specified as positive, finite scalar. The `Volume` property is expressed in cubic meters.

Data Types: double

Examples

Create GRS 80 Ellipsoid

Create a GRS 80 ellipsoid using the `oblateSpheroid` class.

Start with a unit sphere by default.

```
s = oblateSpheroid
```

```
s =
```

```
oblateSpheroid with defining properties:
```

```
    SemimajorAxis: 1  
    SemiminorAxis: 1  
    InverseFlattening: Inf  
    Eccentricity: 0
```

```
and additional properties:
```

```
    Flattening  
    ThirdFlattening  
    MeanRadius  
    SurfaceArea  
    Volume
```

Reset the semimajor axis to match the equatorial radius of the GRS 80 reference ellipsoid.

```
s.SemimajorAxis = 6378137
```

```
s =
```

```
oblateSpheroid with defining properties:
```

```
    SemimajorAxis: 6378137
    SemiminorAxis: 6378137
    InverseFlattening: Inf
    Eccentricity: 0
```

```
and additional properties:
```

```
    Flattening
    ThirdFlattening
    MeanRadius
    SurfaceArea
    Volume
```

The result is a sphere with radius 6,378,137 meters.

Reset the inverse flattening to the standard value for GRS 80, resulting in an oblate spheroid with a semiminor axis consistent with the value, 6,356,752.3141, tabulated in DMA Technical Memorandum 8358.1, "Datums, Ellipsoids, Grids, and Grid Reference Systems."

```
s.InverseFlattening = 298.257222101
```

```
s =
```

```
oblateSpheroid with defining properties:
```

```
    SemimajorAxis: 6378137
    SemiminorAxis: 6356752.31414036
    InverseFlattening: 298.257222101
    Eccentricity: 0.0818191910428158
```

```
and additional properties:
```

```
    Flattening
    ThirdFlattening
    MeanRadius
    SurfaceArea
    Volume
```

Tips

- When you define a spheroid in terms of semimajor and semiminor axes (rather than semimajor axis and inverse flattening, or semimajor axis and eccentricity), a small loss of precision in the last few digits of Flattening, Eccentricity, and ThirdFlattening may occur. This is unavoidable, but does not affect the results of practical computation.

Version History

Introduced in R2012a

R2021a: Generate C and C++ code using MATLAB Coder

The `oblateSpheroid` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`referenceEllipsoid` | `referenceSphere` | `validateLengthUnit`

onem

(To be removed) Construct regular data grid of 1s

Note onem will be removed in a future release. Use the `georefcells` and `ones` functions instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z,refvec] = onem(latlim,lonlim,scale)
```

Description

`[Z,refvec] = onem(latlim,lonlim,scale)` returns a regular data grid consisting entirely of 1s and a three-element referencing vector for the returned data grid, Z. The two-element vectors `latlim` and `lonlim` define the latitude and longitude limits of the geographic region. They should be of the form `[south north]` and `[west east]`, respectively. The scalar `scale` specifies the number of rows and columns per degree of latitude and longitude.

Examples

```
[Z,refvec] = onem([46,51],[-79,-75],1)
```

Z =

```

1     1     1     1
1     1     1     1
1     1     1     1
1     1     1     1
1     1     1     1
```

refvec =

```
1     51    -79
```

Version History

Introduced before R2006a

R2022a: Warns

Warns starting in R2022a

Some functions that return referencing vectors issue a warning that they will be removed in a future release, including the `onem` function. Instead, create a geographic raster reference object using the `georefcells` function and a matrix of ones using the `ones` function. Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see the `GeographicPostingsReference` object.

- You can manipulate the limits of rasters associated with geographic reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with geographic reference objects using the `georesize` function.
- Most functions that accept referencing vectors as inputs also accept reference objects.

This table shows how to update your code to use the `georefcells` and `ones` functions instead of the `onem` function.

Will Be Removed	Recommended
<code>[Z,refvec] = onem(latlim,lonlim,scale);</code>	<code>R = georefcells(latlim,lonlim,1/scale,1/scale);</code> <code>Z = ones(R.RasterSize);</code>

R2020b: To be removed

Not recommended starting in R2020b

The `onem` function runs without warning but will be removed in a future release.

See Also

`NaN` | `sparse` | `zeros` | `georefcells` | `ones`

org2pol

Location of north pole in rotated map

Syntax

```
pole = org2pol(origin)
pole = org2pol(origin,units)
```

Description

`pole = org2pol(origin)` returns the location of the North Pole in terms of the coordinate system after transformation based on the input `origin`. The `origin` is a three-element vector of the form `[latitude longitude orientation]`, where `latitude` and `longitude` are the coordinates that the new center (`origin`) had in the untransformed system, and `orientation` is the azimuth of the true North Pole from the new origin point in the transformed system. The output `pole` is a three-element vector of the form `[latitude longitude meridian]`, which gives the latitude and longitude point in terms of the original untransformed system of the new location of the true North Pole. The meridian is the longitude from the original system upon which the new system is centered.

`pole = org2pol(origin,units)` allows the specification of the angular units of the `origin` vector, where `units` is any valid angle unit. The default is 'degrees'.

When developing transverse or oblique projections, transformed coordinate systems are required. One way to define these systems is to establish the point at which, in terms of the original (untransformed) system, the (transformed) true North Pole will lie.

Examples

Perhaps you want to make (30°N,0°) the new origin. Where does the North Pole end up in terms of the original coordinate system?

```
pole = org2pol([30 0 0])

pole =
    60.0000         0         0
```

This makes sense: pull a point 30° down to the origin, and the North Pole is pulled down 30°. A little less obvious example is the following:

```
pole = org2pol([5 40 30])

pole =
    59.6245    80.0750    40.0000
```

See Also

`neworig` | `putpole`

outlinegeoquad

Polygon outlining geographic quadrangle

Syntax

```
[lat,lon] = outlinegeoquad(latlim,lonlim,dlat,dlon)
```

Description

`[lat,lon] = outlinegeoquad(latlim,lonlim,dlat,dlon)` constructs a polygon that traces the outline of the geographic quadrangle defined by `latlim` and `lonlim`. Such a polygon can be useful for displaying the quadrangle graphically, especially on a projection where the meridians and/or parallels do not project to straight lines. `latlim` is a two-element vector of the form: `[southern-limit northern-limit]` and `lonlim` is a two-element vector of the form: `[western-limit eastern-limit]`. `dlat` is a positive scalar that specifies a minimum vertex spacing in degrees to be applied along the meridians that bound the eastern and western edges of the quadrangle. Likewise, `dlon` is a positive scalar that specifies a minimum vertex spacing in degrees of longitude to be applied along the parallels that bound the northern and southern edges of the quadrangle. The outputs `lat` and `lon` contain the vertices of a simple closed polygon with clockwise vertex ordering.

Examples

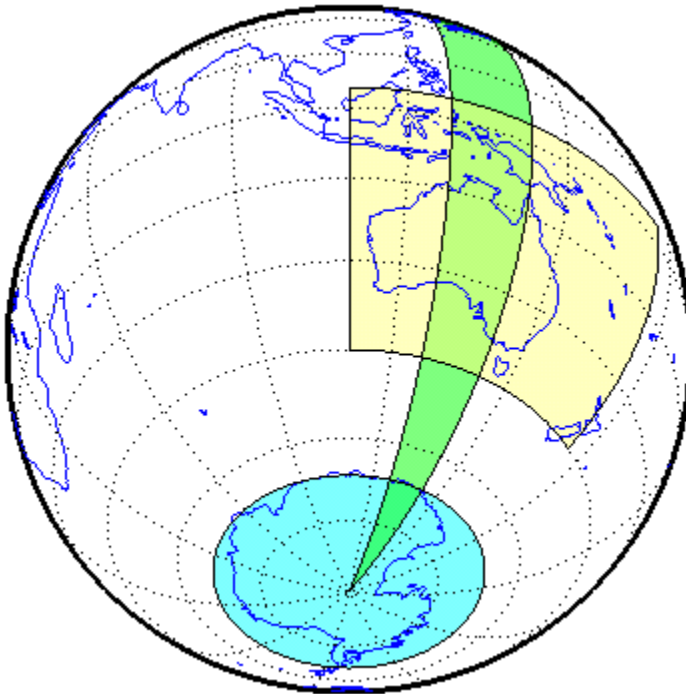
Display the outlines of three geographic quadrangles having very different qualities on top of a simple base map:

```
figure('Color','white')
axesm('ortho','Origin',[-45 110],'frame','on','grid','on')
axis off
load coastlines
geoshow(coastlat, coastlon)

% Quadrangle covering Australia and vicinity
[lat, lon] = outlinegeoquad([-45 5],[110 175],5,5);
geoshow(lat,lon,'DisplayType','polygon','FaceAlpha',0.5);

% Quadrangle covering Antarctic region
antarcticCircleLat = dms2degrees([-66 33 39]);
[lat, lon] = outlinegeoquad([-90 antarcticCircleLat], ...
    [-180 180],5,5);
geoshow(lat,lon,'DisplayType','polygon', ...
    'FaceColor','cyan','FaceAlpha',0.5);

% Quadrangle covering nominal time zone 9 hours ahead of UTC
[lat, lon] = outlinegeoquad([-90 90], 135 + [-7.5 7.5], 5, 5);
geoshow(lat,lon,'DisplayType','polygon', ...
    'FaceColor','green','FaceAlpha',0.5);
```

Tips

All input and output angles are in units of degrees. Choose a reasonably small value for `dlat` (a few degrees, perhaps) when using a projection with curved meridians or curved parallels.

To avoid interpolating extra vertices along meridians or parallels, set `dlat` or `dlon` to a value of `Inf`.

Special Cases

The insertion of additional vertices is suppressed at the poles (that is, if `latlim(1) == -90` or `latlim(2) == 90`. If `lonlim` corresponds to a quadrangle width of exactly 360 degrees (`lonlim == [-180 180]`, for example), then it covers a full latitudinal zone and includes two separate, NaN-separated parts, unless either

- `latlim(1) == -90` or `latlim(2) == 90`, so that only one part is needed—a polygon that follows a parallel clockwise around one of the poles.
- `latlim(1) == -90` and `latlim(2) == 90`, so that the quadrangle encompasses the entire planet. In this case, the quadrangle cannot be represented by a latitude-longitude polygon, and an error results.

Version History

Introduced in R2008a

See Also

`ingeoquad` | `intersectgeoquad`

paperscale

Set figure properties for printing axesm-based map at map scale

Syntax

```
paperscale(paperdist,punits,surfdist,sunits)
paperscale(paperdist,punits,surfdist,sunits,lat,long)
paperscale(paperdist,punits,surfdist,sunits,lat,long,az)
paperscale(paperdist,punits,surfdist,sunits,lat,long,az,gunits)
paperscale(paperdist,punits,surfdist,sunits,lat,long,az,gunits,
radius)
paperscale(scale,...)
[paperXdim,paperYdim] = paperscale(...)
```

Description

`paperscale(paperdist,punits,surfdist,sunits)` sets the figure paper position to print the map in the current axes at the desired scale. The scale is described by the geographic distance that corresponds to a paper distance. For example, a scale of 1 inch = 10 kilometers is specified as `degrees(1, 'inch', 10, 'km')`. See below for an alternate method of specifying the map scale. The surface distance units *sunits* can be any unit recognized by `unitsratio`. The paper units *punits* can be any dimensional units recognized for the figure `PaperUnits` property.

`paperscale(paperdist,punits,surfdist,sunits,lat,long)` sets the paper position so that the scale is correct at the specified geographic location. If omitted, the default is the center of the map limits.

`paperscale(paperdist,punits,surfdist,sunits,lat,long,az)` also specifies the direction along which the scale is correct. If omitted, 90 degrees (east) is assumed.

`paperscale(paperdist,punits,surfdist,sunits,lat,long,az,gunits)` also specifies the units in which the geographic position and direction are given. If omitted, 'degrees' is assumed.

`paperscale(paperdist,punits,surfdist,sunits,lat,long,az,gunits,radius)` uses the last input to determine the radius of the sphere. `radius` can be one of the values supported by `km2deg`, or it can be the (numerical) radius of the desired sphere in `zunits`. If omitted, the default radius of the Earth is used..

`paperscale(scale,...)`, where the numeric scale replaces the two property/value pairs, specifies the scale as a ratio between distance on the sphere and on paper. This is commonly notated on maps as 1:scale (e.g. 1:100 000, or 1:1 000 000). For example, `paperscale(100000)` or `paperscale(100000, lat, long)`.

`[paperXdim,paperYdim] = paperscale(...)` returns the computed paper dimensions. The dimensions are in the paper units specified. For the scale calling form, the returned dimensions are in centimeters.

Background

Maps are usually printed at a size that allows an easy comparison of distances measured on paper to distances on the Earth. The linear ratio between the mapped size of objects to the real size of objects

is called the *map scale*. It is usually expressed as a ratio, such as 1 to 100,000 or 1:100,000 or 1 cm = 1 km. Another way of specifying scale is to call out the printed and real lengths, for example "1 inch = 1 mile."

To ensure your map can be printed correctly, you can specify the printed scale using the `paperscale` function. It modifies the size of the printed area on the page to match the scale. If the resulting dimensions are larger than your paper, you can reduce the amount of empty space around the map using `tightmap` or `zoom`, and by changing the axes position to fill the figure. This also reduces the amount of memory needed to print with the `zbuffer` (raster image) renderer. Be sure to set the paper scale last. For example,

```
set(gca,'Units','Normalized','Position',[0 0 1 1])
tightmap
paperscale(1,'in', 5,'miles')
```

The `paperscale` function also can take a scale denominator as its first and only argument. If you want the map to be printed at 1:20,000,000, type

```
paperscale(2e7)
```

To check the size and extent of text and the relative position of axes, use `previewmap`, which resizes the figure to the printed size.

```
previewmap
```

For more information on printing, see "Printing and Saving".

Examples

The small circle measures 10 cm across when printed.

```
axesm mercator
[lat,lon] = scircle1(0,0,km2deg(5));
plotm(lat,lon)
[x,y] = paperscale(1,'centimeter',1,'km'); [x y]
```

```
ans =
    13.154    12.509
```

```
set(gca,'pos', [ 0 0 1 1])
[x,y] = paperscale(1,'centimeter',1,'km'); [x y]
```

```
ans =
    10.195    10.195
```

Limitations

The relationship between the paper and geographic coordinates holds only as long as there are no changes to the display that affect the axes limits or the relationship between geographic coordinates and projected coordinates. Changes of this type include the ellipsoid or scale factor properties of the `axesm`-based map, or adding elements to the display that cause MATLAB to modify the axes autoscaling. To be sure that the scale is correct, execute `paperscale` just before printing.

Version History

Introduced before R2006a

See Also

printpreview | axesscale | daspectm

parametricLatitude

Convert geodetic to parametric latitude

Syntax

```
beta = parametricLatitude(phi,F)
beta = parametricLatitude(phi,F,angleUnit)
```

Description

`beta = parametricLatitude(phi,F)` returns the parametric latitude corresponding to geodetic latitude `phi` on an ellipsoid with flattening `F`.

`beta = parametricLatitude(phi,F,angleUnit)` specifies the units of input `phi` and output `beta`.

Examples

Convert Geodetic Latitude to Parametric Latitude

Create a reference ellipsoid and then convert the geodetic latitude to parametric latitude. The reference ellipsoid contains a flattening factor.

```
s = wgs84Ellipsoid;
parametricLatitude(45, s.Flattening)

ans =

    44.9038
```

Convert Geodetic Latitude Expressed in Radians to Parametric Latitude

Create a reference ellipsoid and then convert a parametric latitude expressed in radians to geodetic latitude. The reference ellipsoid contains a flattening factor.

```
s = wgs84Ellipsoid;
parametricLatitude(pi/3, s.Flattening, 'radians')

ans =

    1.0457
```

Input Arguments

phi — Geodetic latitude of one or more points

scalar value, vector, matrix, or N-D array

Geodetic latitude of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types: `single` | `double`

F — Flattening of reference spheroid

scalar

Flattening of reference spheroid, specified as a scalar value.

Data Types: `single` | `double`

angleUnit — Unit of measurement for angle

'degrees' (default) | 'radians'

Unit of measurement for angle, specified as 'degrees' or 'radians'.

Data Types: `char` | `string`

Output Arguments

beta — Parametric latitudes of one or more points

scalar value, vector, matrix, or N-D array

Parametric latitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Values are in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Version History

Introduced in R2013a

See Also

Functions

`geocentricLatitude` | `geodeticLatitudeFromParametric`

Objects

`AuthalicLatitudeConverter` | `ConformalLatitudeConverter` | `IsometricLatitudeConverter` | `RectifyingLatitudeConverter`

patchesm

Project patches as individual objects on axesm-based map

Syntax

```
patchesm(lat,lon,cdata)
patchesm(lat,lon,z,cdata)
patchesm(...,'PropertyName',PropertyValue,...)
h = patchesm(...)
```

Description

`patchesm(lat,lon,cdata)` projects 2-D patch objects onto the current axesm-based map. The input latitude and longitude data must be in the same units as specified in the current axesm-based map. The input `cdata` defines the patch face color. If the input vectors are NaN clipped, then multiple patches are drawn each with a single face. Unlike `fillm` and `fill3m`, `patchesm` will always add the patches to the current map regardless of the current hold state.

`patchesm(lat,lon,z,cdata)` projects 3-D planar patches at the uniform elevation given by scalar `z`.

`patchesm(...,'PropertyName',PropertyValue,...)` uses the patch properties supplied to display the patch. Except for `xdata`, `ydata`, and `zdata`, all patch properties available through `patch` are supported by `patchesm`.

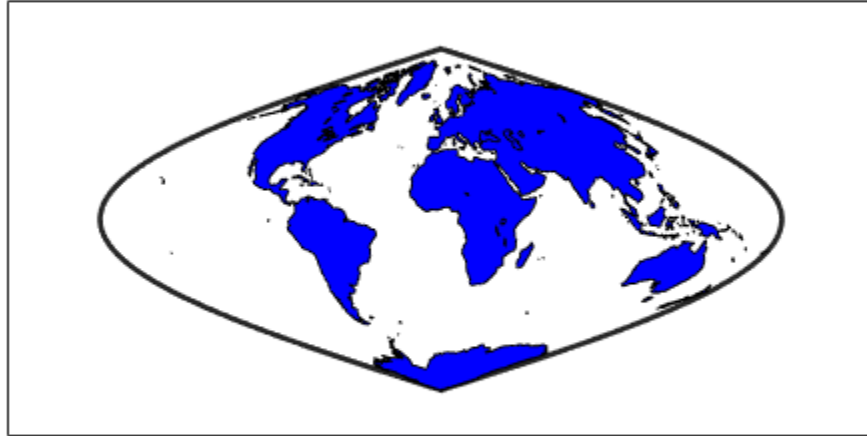
`h = patchesm(...)` returns the handles to the patch objects drawn.

Examples

Plot Distinct Patch Objects on Current Map

Plot coastline data as distinct patch objects.

```
load coastlines
axesm sinusoid;
framem
h = patchesm(coastlat,coastlon,'b');
```



```
% Number of objects created.  
length(h)  
  
ans = 241
```

Tips

Differences between `patchesm` and `patchm`

The `patchesm` function is very similar to the `patchm` function. The significant difference is that in `patchesm`, separate patches (delineated by NaNs in the inputs `lat` and `lon`) are separated and plotted as distinct patch objects on the current `axesm`-based map. The advantage to this is that less memory is required. The disadvantage is that multifaced objects cannot be treated as a single object. For example, the archipelago of the Philippines cannot be treated and handled as a single Handle Graphics® object.

When Patches Are Completely Trimmed Away

Removing graphic objects that fall outside the map frame is called trimming. If, after trimming no polygons remain to be seen within it, `patchesm` creates no patches and returns an empty 1-by-0 list of handles. When this occurs, automatic reprojection of the patch data (by changing the projection or any of its parameters) is not possible. In cases where some polygons are completely trimmed away but not others, handles returned for the trimmed polygons will be empty. No polygons or rings that have been totally trimmed away can be reprojected; to plot them again, you will need to call `patchesm` again with the original data.

Version History

Introduced before R2006a

See Also

geoshow | fill3m | fillm | patchm

patchm

Project patches on axesm-based map

Syntax

```
h = patchm(lat,lon,ldata)
h = patchm(lat,lon,ldata,PropertyName,PropertyValue,...)
h = patchm(lat,lon,PropertyName,PropertyValue,...)
h = patchm(lat,lon,z,ldata)
h = patchm(lat,lon,z,ldata,PropertyName,PropertyValue,...)
```

Description

`h = patchm(lat,lon,ldata)` and `h = patchm(lat,lon,ldata,PropertyName,PropertyValue,...)` project and display patch (polygon) objects defined by their vertices given in `lat` and `lon` on the current axesm-based map. `lat` and `lon` must be vectors. The color data, `ldata`, can be any color data designation supported by the standard MATLAB `patch` function. The object handle or handles, `h`, can be returned.

`h = patchm(lat,lon,PropertyName,PropertyValue,...)` allows any property name/property value pair supported by `patch` to be assigned to the `patchm` object. Except for `XData`, `YData`, and `ZData`, all line properties and styles available through `patch` are supported by `patchm`.

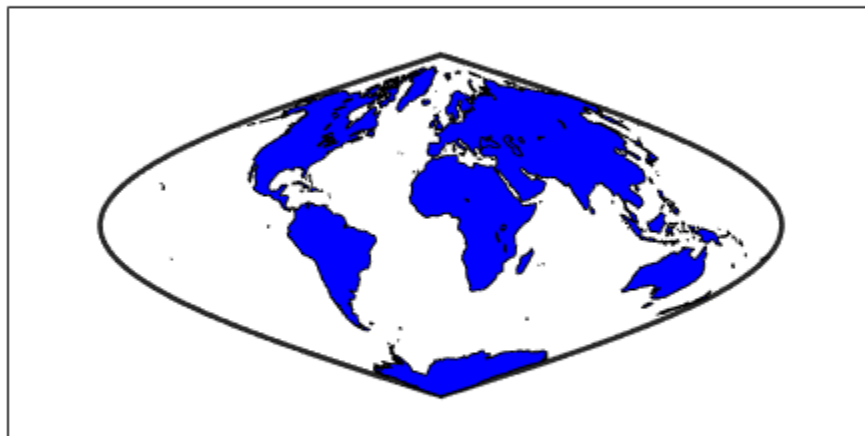
`h = patchm(lat,lon,z,ldata)` and `h = patchm(lat,lon,z,ldata,PropertyName,PropertyValue,...)` allow the assignment of an altitude, `z`, to each patch object. The default altitude is `z = 0`.

Examples

Project Patch Object on Map

Project coastline data as single patch object on a map.

```
load coastlines
axesm sinusoid;
framem
h = patchm(coastlat,coastlon,'b');
```



```
length(h)
```

```
ans = 1
```

Tips

How patchm Works

This Mapping Toolbox function is very similar to the standard MATLAB `patch` function. Like its analog, and unlike higher level functions such as `fillm` and `fill3m`, `patchm` adds patch objects to the current axesm-based map regardless of hold state.

When A Patch Is Completely Trimmed Away

Removing graphic objects that fall outside the map frame is called trimming. If, after trimming to the map frame no polygons remain to be seen within it, `patchm` creates no patches and returns an empty 0-by-1 handle. When this occurs, automatic reprojection of the patch data (by changing the projection or any of its parameters) will not be possible. Instead, after changing the projection, call `patchm` again.

Version History

Introduced before R2006a

See Also

patchesm | fill3m | fillm

pcolorm

Project geolocated data grid in $h = 0$ plane on axesm-based map

Syntax

```
pcolorm(lat,lon,Z)
pcolorm(latlim,lonlim,Z)
pcolorm( ____,Name,Value)
s = pcolorm( ____ )
```

Description

`pcolorm(lat,lon,Z)` displays a surface on the current axesm-based map by warping the geolocated data grid `Z`, with geographic coordinates `lat` and `lon`, to a projected graticule mesh. The color of the surface varies according to the values in `Z`. This function displays the surface in a horizontal plane with all height values set to 0.

`pcolorm(latlim,lonlim,Z)` creates a graticule mesh using the latitude limits `latlim` and the longitude limits `lonlim`.

`pcolorm(____,Name,Value)` specifies surface properties using one or more name-value pair arguments. For example, `"FaceAlpha",0.5` creates a semitransparent plot.

`s = pcolorm(____)` returns the primitive surface object. Use `s` to modify the plot after creation. For a list of properties, see [Surface Properties](#).

Examples

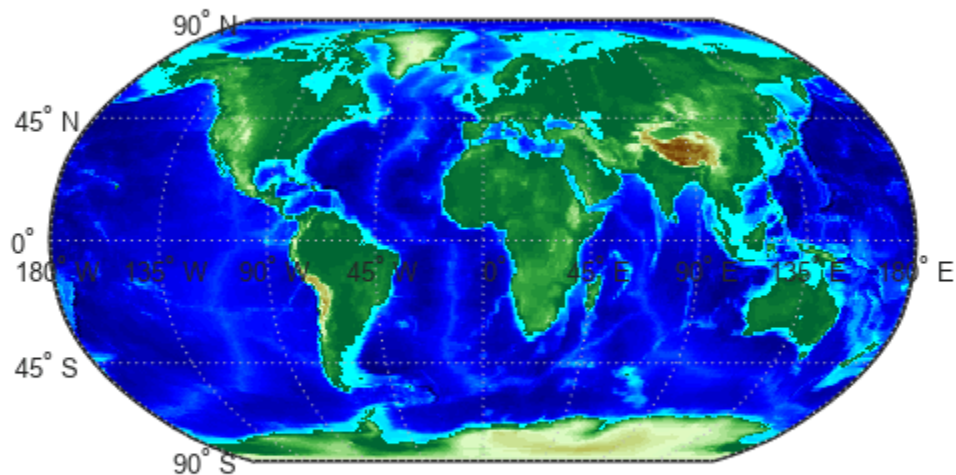
Display Data Grid on axesm-Based Map

Load elevation data and a geographic cells reference object for the Korean peninsula. Extract the latitude and longitude coordinates from the reference object.

```
load topo60c
[topo60c,topo60cR] = geocrop(topo60c,topo60cR,[-90 90],[-180 180]);
[lat,lon] = geographicGrid(topo60cR);
```

Find the latitude and longitude limits of the data. Then, display the data on a world map using a colormap appropriate for elevation data.

```
[latlim,lonlim] = geoquadline(lat,lon);
worldmap world
pcolorm(latlim,lonlim,topo60c)
demcmap(topo60c)
```



Modify Appearance of Surface Plot

Load elevation data and a geographic cells reference object for the Korean peninsula. Extract the latitudes and longitudes from the reference object.

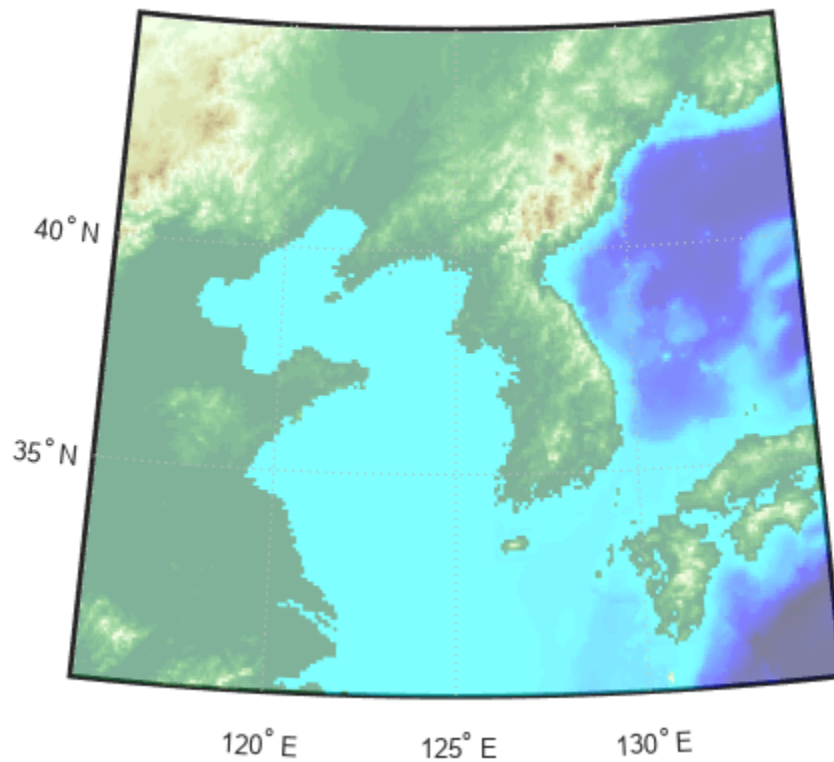
```
load korea5c  
[lat,lon] = geographicGrid(korea5cR);
```

Find the latitude and longitude limits of the data. Then, display the data on a world map. Adjust the transparency of the surface plot using the `FaceAlpha` name-value argument.

```
[latlim,lonlim] = geoquadline(lat,lon);  
worldmap(latlim,lonlim)  
pcolorm(lat,lon,korea5c,"FaceAlpha",0.5)
```

Apply a colormap appropriate for elevation data.

```
demcmap(korea5c)
```



Input Arguments

lat — Latitude coordinates

vector | matrix

Latitude coordinates, specified as a vector or a matrix. The sizes of `lat` and `lon` must match.

- When `lat` and `lon` are matrices of the same size as `Z`, the `pcolorm` function displays each element of `Z` at the location specified by the corresponding elements of `lat` and `lon`.
- When `lat` and `lon` are matrices of a different size than `Z`, the `pcolorm` function creates a graticule mesh of the same size as `lat`.
- When `lat` and `lon` are vectors, the `pcolorm` function creates a graticule mesh of size `length(lat)-by-length(lon)` by replicating `lat` and `lon`.

Data Types: `double`

lon — Longitude coordinates

vector | matrix

Longitude coordinates, specified as a vector or a matrix. The sizes of `lon` and `lat` must match.

- When `lat` and `lon` are matrices of the same size as `Z`, the `pcolorm` function displays each element of `Z` at the location specified by the corresponding elements of `lat` and `lon`.

- When `lat` and `lon` are matrices of a different size than `Z`, the `pcolorm` function creates a graticule mesh of the same size as `lat`.
- When `lat` and `lon` are vectors, the `pcolorm` function creates a graticule mesh of size `length(lat)-by-length(lon)` by replicating `lat` and `lon`.

Data Types: `double`

Z — Geolocated data grid

m-by-n array

Geolocated data grid, specified as an *m-by-n* array.

latlim — Latitude limits for Z

two-element vector

Latitude limits for `Z`, specified as a two-element vector.

The `pcolorm` function uses `latlim` and `lonlim` to create a graticule mesh of size 50-by-100.

Data Types: `double`

lonlim — Longitude limits for Z

two-element vector

Latitude limits for `Z`, specified as a two-element vector.

The `pcolorm` function uses `latlim` and `lonlim` to create a graticule mesh of size 50-by-100.

Data Types: `double`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `pcolorm(lat,lon,Z,LineStyle="-")` displays the graticule mesh using a solid line.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `pcolorm(lat,lon,Z,"LineStyle","-")` displays the graticule mesh using a solid line.

Note Use name-value arguments to specify values for the properties of the `Surface` object created by this function. The properties listed here are only a subset. For a full list, see `Surface Properties`.

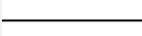
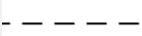
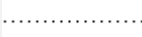
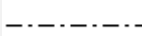
Surface objects created by the `pcolorm` function have these limitations:

- Setting the `XData`, `YData`, and `ZData` properties of the surface object is not supported.
- If you set the `UserData` property of the surface and then change the projection of the axes-based map, MATLAB does not reproject the surface.

LineStyle — Line style

"none" (default) | "-" | "--" | ":" | "-."

Line style, specified as one of the options listed in this table.

Line Style	Description	Resulting Line
"_"	Solid line	
"_ _"	Dashed line	
":"	Dotted line	
"- ."	Dash-dotted line	
"none"	No line	No line

LineWidth — Line width

0.5 (default) | positive value

Line width, specified as a positive value in points, where 1 point = 1/72 of an inch. If the line has markers, then the line width also affects the marker edges.

The line width cannot be thinner than the width of a pixel. If you set the line width to a value that is less than the width of a pixel on your system, the line displays as one pixel wide.

Output Arguments

s — Primitive surface object

Surface object

Primitive surface object, returned as a Surface object. Use `s` to modify the Surface object after creation. For a list of properties, see Surface Properties.

Surface objects created by the `pcolorm` function have these limitations:

- Setting the `XData`, `YData`, and `ZData` properties of the surface object is not supported.
- If you set the `UserData` property of the surface and then change the projection of the axesm-based map, MATLAB does not reproject the surface.

Tips

- The `FaceColor` property of the surface object depends on the size of the graticule mesh. The `pcolorm` function sets `FaceColor` to "flat" when the size of the graticule mesh matches the size of `Z`, and "texturemap" otherwise.
- The `pcolorm` function projects the graticule mesh using the projection specified by the `MapProjection` property of the axesm-based map. To improve the resolution of the plot, increase the size of the graticule mesh. Increasing the size of the graticule mesh can increase the amount of time MATLAB requires to display the surface.

Version History

Introduced before R2006a

See Also

Functions

geoshow | mapshow | surfm | meshm

Topics

“Fit Gridded Data to the Graticule”

pix2latlon

(To be removed) Convert pixel coordinates to latitude-longitude coordinates

Note The `pix2latlon` function will be removed in a future release. Use the `intrinsicToGeographic` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[lat, lon] = pix2latlon(R, row, col)
```

Description

`[lat, lon] = pix2latlon(R, row, col)` calculates latitude-longitude coordinates `lat`, `lon` from pixel coordinates `row`, `col`. `R` is either a 3-by-2 referencing matrix that transforms intrinsic pixel coordinates to geographic coordinates, or a geographic raster reference object. `row` and `col` are vectors or arrays of matching size. The outputs `lat` and `lon` have the same size as `row` and `col`.

Examples

Find the latitude and longitude of the upper left outer corner of a gridded data set.

```
load korea5c
[UL_lat, UL_lon] = pix2latlon(korea5cR, 0.5, 0.5)
```

The output appears as follows:

```
UL_lat =
    30
```

```
UL_lon =
    115
```

Version History

Introduced before R2006a

R2023a: Warns

Warns starting in R2023a

Some functions that accept referencing matrices as input issue a warning that they will be removed in a future release, including the `pix2latlon` function. Use a geographic raster reference object and the `intrinsicToGeographic` function instead. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `GeographicPostingsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` function.
- Most functions that accept referencing matrices as inputs also accept reference objects.

To update your code, first create a reference object for either a raster of cells using the `georefcells` function or a raster of regularly posted samples using the `georefpastings` function. Alternatively, convert from a referencing matrix to a reference object using the `refmatToGeoRasterReference` function.

Then, replace uses of the `pix2latlon` function with the `intrinsicToGeographic` function according to this pattern.

Will Be Removed	Recommended
<code>[lat,lon] = pix2latlon(R,row,col);</code>	<code>[lat,lon] = intrinsicToGeographic(R,col,row);</code>

R2021b: To be removed

Not recommended starting in R2021b

The `pix2latlon` function runs without warning but will be removed in a future release.

See Also

`geographicToIntrinsic` | `intrinsicToWorld` | `intrinsicToGeographic`

pix2map

(To be removed) Convert pixel coordinates to map coordinates

Note The `pix2map` function will be removed in a future release. Use the `intrinsicToWorld` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[x,y] = pix2map(R,row,col)
s = pix2map(R,row,col)
[...] = pix2map(R,p)
```

Description

`[x,y] = pix2map(R,row,col)` calculates map coordinates `x,y` from pixel coordinates `row,col`. `R` is either a 3-by-2 referencing matrix defining a two-dimensional affine transformation from intrinsic pixel coordinates to map coordinates, or a map raster reference object. `row` and `col` are vectors or arrays of matching size. The outputs `x` and `y` have the same size as `row` and `col`.

`s = pix2map(R,row,col)` combines `x` and `y` into a single array `s`. If `row` and `col` are column vectors of length `n`, then `s` is an `n`-by-2 matrix and each row (`s(k,:)`) specifies the map coordinates of a single point. Otherwise, `s` has size `[size(row) 2]`, and `s(k1,k2,...,kn,:)` contains the map coordinates of a single point.

`[...] = pix2map(R,p)` combines `row` and `col` into a single array `p`. If `row` and `col` are column vectors of length `n`, then `p` should be an `n`-by-2 matrix such that each row (`p(k,:)`) specifies the pixel coordinates of a single point. Otherwise, `p` should have size `[size(row) 2]`, and `p(k1,k2,...,kn,:)` should contain the pixel coordinates of a single point.

Examples

```
% Find the map coordinates for the pixel at (100,50).
[X,cmap] = imread('concord_ortho_w.tif');
R = worldfileread('concord_ortho_w.tif','planar',size(X));
[x,y] = pix2map(R,100,50);
```

Version History

Introduced before R2006a

R2023a: Warns

Warns starting in R2023a

Some functions that accept referencing matrices as input issue a warning that they will be removed in a future release, including the `pix2map` function. Use a map raster reference object and the

`intrinsicToWorld` function instead. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns. For more information about reference object properties, see the `MapPostingsReference` and `MapCellsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `mapcrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `mapresize` function.
- Most functions that accept referencing matrices as inputs also accept reference objects.

To update your code, first create a reference object for either a raster of cells using the `maprefcells` function or a raster of regularly posted samples using the `maprefpostings` function. Alternatively, convert from a referencing matrix to a reference object using the `refmatToMapRasterReference` function.

Then, replace uses of the `pix2map` function with the `intrinsicToWorld` function according to these patterns.

Will Be Removed	Recommended
<code>[x,y] = pix2map(R,row,col);</code>	<code>[x,y] = intrinsicToWorld(R,col,row);</code>
<code>s = pix2map(R,row,col);</code>	<p>If <code>row</code> and <code>col</code> are column vectors:</p> <pre>[x,y] = intrinsicToWorld(R,col,row); s = [x y];</pre> <p>If <code>row</code> and <code>col</code> have size <i>M</i>-by-<i>N</i> or 1-by-<i>N</i>:</p> <pre>[x,y] = intrinsicToWorld(R,col,row); s = cat(3,x,y);</pre>
<code>[x,y] = pix2map(R,p);</code>	<p>If <code>p</code> has size <i>N</i>-by-2:</p> <pre>[x,y] = intrinsicToWorld(R,p(:,2),p(:,1));</pre>

R2021b: To be removed

Not recommended starting in R2021b

The `pix2map` function runs without warning but will be removed in a future release.

See Also

`worldToIntrinsic` | `intrinsicToGeographic` | `worldfileread` | `intrinsicToWorld`

pixcenters

(To be removed) Compute pixel centers for georeferenced image or data grid

Note The `pixcenters` function will be removed in a future release. Use the `geographicGrid` or `worldGrid` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[x,y] = pixcenters(R,height,width)
[x,y] = pixcenters(r,sizea)
[x,y] = pixcenters(..., 'makegrid')
```

Description

`[x,y] = pixcenters(R,height,width)` returns the spatial coordinates of a spatially-referenced image or regular gridded data set. `R` is either a 3-by-2 referencing matrix defining a 2-dimensional affine transformation from intrinsic pixel coordinates to map coordinates, or a `MapCellsReference` object. `height` and `width` are the image dimensions. If `r` does not include a rotation (i.e., `r(1,1) = r(2,2) = 0`), then `x` is a 1-by-width vector and `y` is a 1-by-height vector. In this case, the spatial coordinates of the pixel in row `row` and column `col` are given by `x(col)`, `y(row)`. Otherwise, `x` and `y` are each a height-by-width matrix such that `x(col,row)`, `y(col,row)` are the coordinates of the pixel with subscripts `(row,col)`.

`[x,y] = pixcenters(r,sizea)` accepts the size vector `sizea = [height, width, ...]` instead of `height` and `width`.

`[x,y] = pixcenters(info)` accepts a scalar structure array with the fields

'RefMatrix'	3-by-2 referencing matrix
'Height'	Scalar number
'Width'	Scalar number

`[x,y] = pixcenters(..., 'makegrid')` returns `x` and `y` as height-by-width matrices even if `r` is irrotational. This syntax can be helpful when you call `pixcenters` from within a function or script.

Examples

```
[Z,R] = readgeoraster('MtWashington-ft.grd','OutputType','double');
info = georasterinfo('MtWashington-ft.grd');
Z = standardizeMissing(Z,info.MissingDataIndicator);
figure
[x,y] = pixcenters(R,size(Z));
h = surf(x,y,Z);
axis equal
```

```
demcmap(Z)
set(h, 'EdgeColor', 'none')
xlabel('x (easting in meters)')
ylabel('y (northing in meters)')
zlabel('elevation in feet')
```

Tips

`pixcenters` is useful for working with `surf`, `mesh`, or `surface`, and for coordinate transformations.

Version History

Introduced before R2006a

R2022b: Warns

Warns starting in R2022b

Some functions that accept referencing matrices as input issue a warning that they will be removed in a future release, including the `pixcenters` function. Use a raster reference object and the `geographicGrid` or `worldGrid` function instead. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `MapCellsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` or `mapcrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` or `mapresize` function.
- Most functions that accept referencing matrices as inputs also accept reference objects.

Depending on the `pixcenters` function syntax, there are different ways to update your code.

- If the raster is referenced to projected x-y coordinates, use a map raster reference object and the `worldGrid` function. This table shows replacement patterns for the `pixcenters` function syntaxes that specify a referencing matrix `refmat`, scalar structure `info`, or GeoTIFF information structure `geoinfo`. Note that the default behavior of the `pixcenters` function is to return row vectors and the default behavior of the `worldGrid` function is to return 2-D arrays. To return row vectors using the `worldGrid` function, specify the second argument as `'gridvectors'`.

Will Be Removed	Recommended
<code>[X,Y] = pixcenters(refmat,height,width);</code>	<code>R = refmatToMapRasterReference(refmat, ... [height width]);</code> <code>[X,Y] = worldGrid(R, 'gridvectors');</code>
<code>[X,Y] = pixcenters(refmat,rasterSize);</code>	<code>R = refmatToMapRasterReference(refmat,rasterSize);</code> <code>[X,Y] = worldGrid(R, 'gridvectors');</code>
<code>[X,Y] = pixcenters(info);</code>	<code>R = refmatToMapRasterReference(... info.RefMatrix, [info.Height info.Width]);</code> <code>[X,Y] = worldGrid(R, ... 'gridvectors');</code>

Will Be Removed	Recommended
<code>[X,Y] = pixcenters(geoinfo);</code>	<code>[X,Y] = worldGrid(geoinfo.SpatialRef, ... 'gridvectors');</code>

If the TransformationType property of the reference object R is 'affine', the `[x,y] = worldGrid(R, 'gridvectors')` syntax displays a warning. Temporarily suppress the warning by including this code before the call to the worldGrid function.

```
w = warning('off','map.spatialref.fullGridForAffine');
c = onCleanup(@() warning(w));
```

- If the raster is referenced to latitude and longitude coordinates, use a geographic raster reference object and the geographicGrid function. This table shows replacement patterns for function syntaxes that specify a referencing matrix refmat or scalar structure info. Note that the default behavior of the pixcenters function is to return row vectors and the default behavior of the geographicGrid function is to return 2-D arrays. To return row vectors using the geographicGrid function, specify the second argument as 'gridvectors'.

Will Be Removed	Recommended
<code>[lon,lat] = pixcenters(refmat,height,width);</code>	<code>R = refmatToGeoRasterReference(refmat, ... [height width]); [lat,lon] = geographicGrid(R,'gridvectors');</code>
<code>[lon,lat] = pixcenters(refmat,rasterSize);</code>	<code>R = refmatToGeoRasterReference(refmat,rasterSize); [lat,lon] = geographicGrid(R,'gridvectors');</code>
<code>[lon,lat] = pixcenters(info);</code>	<code>R = refmatToGeoRasterReference(... info.RefMatrix, [info.Height info.Width]); [lat,lon] = geographicGrid(R,'gridvectors');</code>

R2021a: To be removed

Not recommended starting in R2021a

The pixcenters function runs without warning but will be removed in a future release.

See Also

Functions

[readgeoraster](#) | [mapoutline](#) | [intrinsicToWorld](#) | [worldfileread](#) | [mapshow](#) | [geographicGrid](#) | [worldGrid](#)

Objects

[MapCellsReference](#)

plabel

Control parallel labels on axesm-based map

Syntax

```
plabel  
plabel('on')  
plabel('off')  
plabel(meridian)  
plabel(MapAxesPropertyName,PropertyValue,...)
```

Description

`plabel` toggles the visibility of parallel labeling on the current axesm-based map.

`plabel('on')` sets the visibility of parallel labels to 'on'.

`plabel('off')` sets the visibility of parallel labels to 'off'.

`plabel('reset')` resets the displayed parallel labels using the currently defined parallel label properties.

`plabel(meridian)` sets the value of the `PLabelMeridian` property of the axesm-based map to the value `meridian`. This determines the meridian upon which the labels are placed (see `axesm`). The options for `meridian` are a scalar longitude or 'east', 'west', or 'prime'.

`plabel(MapAxesPropertyName,PropertyValue,...)` allows paired axesm-based map property names and property values to be passed in. For a complete description of axesm-based map properties, see `axesm-Based Map Properties`.

Parallel label handles can be returned in `h` if desired.

Version History

Introduced before R2006a

See Also

`axesm` | `setm` | `mlabel`

plot3m

Project 3-D lines and points on axesm-based map

Syntax

```
plot3m(lat,lon,z)
plot3m(lat,lon,z,LineStyle)
plot3m(lat,lon,z,Name,Value)
p = plot3m(____)
```

Description

`plot3m(lat,lon,z)` projects the lines specified by `lat`, `lon`, and `z` onto the current axesm-based map.

`plot3m(lat,lon,z,LineStyle)` creates the plot using the specified line style, marker, and color.

`plot3m(lat,lon,z,Name,Value)` specifies line properties using one or more name-value pair arguments. For example, "Color", "red" creates a red plot.

`p = plot3m(____)` returns the line objects. Use `p` to modify the plot after it is created. For a list of properties, see Line Properties.

Examples

Display 3-D Line over Terrain Data

Read sample data containing the latitude, longitude, and height coordinates of a UAV. Find the latitude and longitude limits of the data, including a latitude-longitude buffer of 0.02 degrees.

```
GT = readgeotable("sample_uavtrack.gpx","Layer","track_points");
lat = GT.Shape.Latitude;
lon = GT.Shape.Longitude;
h = GT.Elevation;
```

```
[latlim,lonlim] = geoquadline(lat,lon);
[latlim,lonlim] = bufgeoquad(latlim,lonlim,0.02,0.02);
```

Read terrain elevation data, in meters, for the region from the Web Map Service (WMS) server hosted by MathWorks®.

```
layers = wmsfind("mathworks","SearchField","serverurl");
elevation = refine(layers,"elevation");
[Z,R] = wmsread(elevation,"Latlim",latlim,"Lonlim",lonlim, ...
    "ImageFormat","image/bil");
Z = double(Z);
```

Prepare an axesm-based map of the region. Remove all labels and grid lines.

```
figure
usamap(Z,R)
```

```
framem off  
mlabel off  
plabel off  
gridm off
```

Display the terrain elevation data as a surface. Specify a colormap appropriate for elevation data.

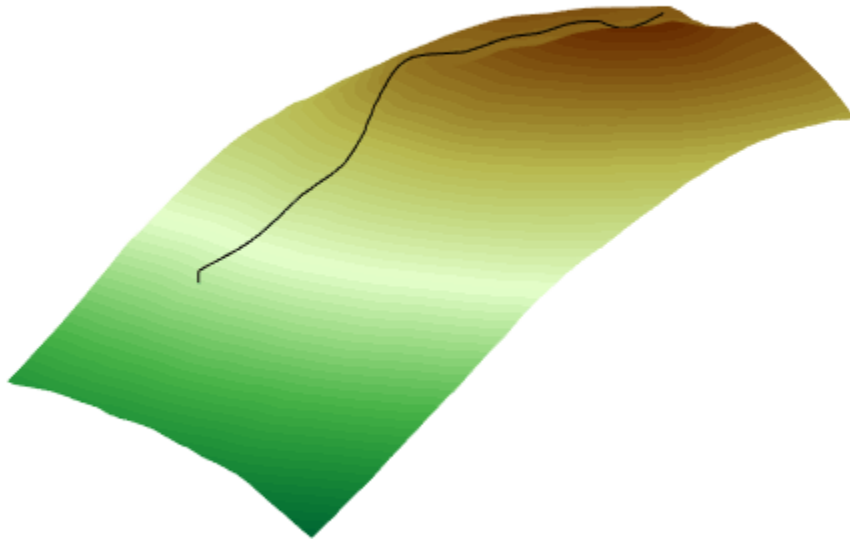
```
geoshow(Z,R,"DisplayType","surface")  
demcmmap(Z)
```

Plot the terrain elevation data over the surface.

```
plot3m(lat,lon,h,"k")
```

View the map in 3-D. Vertically exaggerate the terrain by a factor of 5.

```
view([-130 15])  
daspectm("meters",5)
```



Project 3-D Lines on axesm-Based Map

Read two data sets into the workspace:

- A grid of world geoid heights from the Earth Gravitational Model of 1996. The variable N specifies geoid heights in meters, and the variable R is the spatial reference for N.

- A MAT file containing global coastline coordinates. The variables within the MAT file, `coastlat` and `coastlon`, specify latitude and longitude coordinates, respectively.

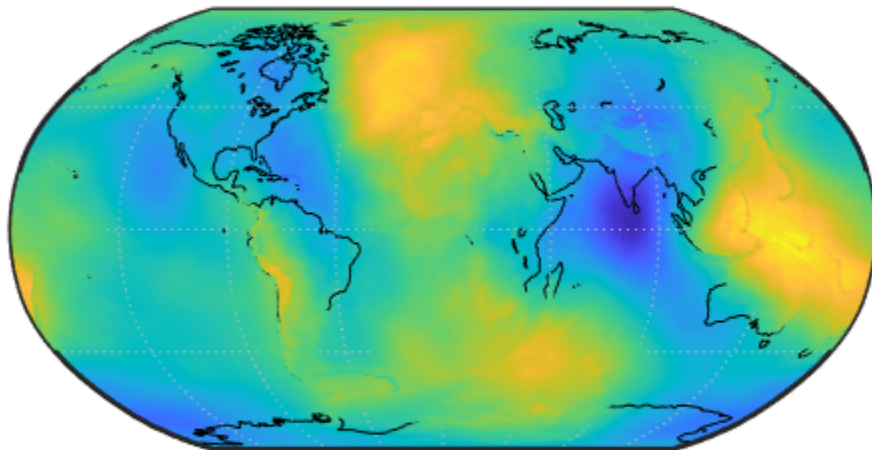
```
[N,R] = egm96geoid;
load coastlines
```

Create a world map.

```
figure
worldmap world
plabel off
mlabel off
```

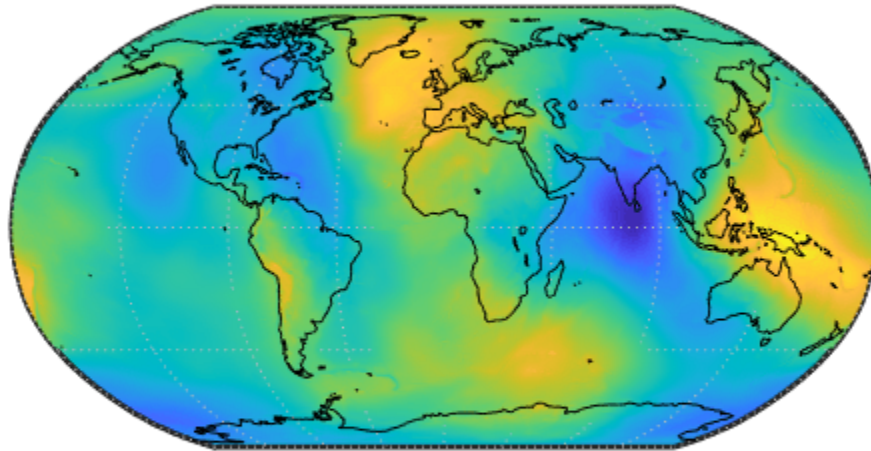
Display the geoid heights as a 3-D surface. Then, display the coastline coordinates as a 2-D black line.

```
geoshow(N,R,"DisplayType","surface")
plotm(coastlat,coastlon,"k")
```



In some places, the coastlines are obscured by the surface. Display the coastline coordinates again, this time using a 3-D line. Specify the height of the line using a value that is 1 meter more than the maximum geoid height.

```
h = max(max(N)) + 1;
plot3m(coastlat,coastlon,h,"k")
```



Input Arguments

lat — Latitude coordinates

scalar | vector | matrix

Latitude coordinates, specified as a scalar, vector, or matrix. The sizes of `lat` and `lon` must match. Specify `lat` in the units indicated by the `AngleUnits` property of the axesm-based map.

The size and shape of `lat` depends on the type of plot you want to create.

Type of Plot	How to Specify Coordinates
Single point	Specify <code>lat</code> , <code>lon</code> , and <code>z</code> as scalars and include a marker. For example: <code>plot3m(1,2,3,"o")</code>
One set of points	Specify <code>lat</code> and <code>lon</code> as vectors of the same length. Specify <code>z</code> as a scalar or as a vector of the same length as <code>lat</code> and <code>lon</code> . For example: <code>plot3m([1 2 3],[4 5 6],[7 8 9])</code>
Multiple sets of points (using vectors)	Specify <code>lat</code> and <code>lon</code> as vectors of the same length. Specify <code>z</code> as a scalar or as a vector of the same length as <code>lat</code> and <code>lon</code> . Use <code>NaN</code> values to separate the sets of points. For example: <code>plot3m([1 2 3 NaN 1 2 3],[4 5 6 NaN 7 8 9],[10 11 12 NaN 13 14 15])</code>

Type of Plot	How to Specify Coordinates
Multiple sets of points (using matrices)	Specify <code>lat</code> and <code>lon</code> as matrices of the same size. Specify <code>z</code> as a scalar or as a matrix of the same size as <code>lat</code> and <code>lon</code> . For example: <code>plot3m([1 2 3; 1 2 3],[4 5 6; 7 8 9],[10 11 12; 13 14 15])</code>

Data Types: double

lon — Longitude coordinates

scalar | vector | matrix

Longitude coordinates, specified as a scalar, vector, or matrix. The sizes of `lon` and `lat` must match. Specify `lon` in the units indicated by the `AngleUnits` property of the axesm-based map.

The size and shape of `lon` depends on the type of plot you want to create.

Type of Plot	How to Specify Coordinates
Single point	Specify <code>lat</code> , <code>lon</code> , and <code>z</code> as scalars and include a marker. For example: <code>plot3m(1,2,3,"o")</code>
One set of points	Specify <code>lat</code> and <code>lon</code> as vectors of the same length. Specify <code>z</code> as a scalar or as a vector of the same length as <code>lat</code> and <code>lon</code> . For example: <code>plot3m([1 2 3],[4 5 6],[7 8 9])</code>
Multiple sets of points (using vectors)	Specify <code>lat</code> and <code>lon</code> as vectors of the same length. Specify <code>z</code> as a scalar or as a vector of the same length as <code>lat</code> and <code>lon</code> . Use <code>NaN</code> values to separate the sets of points. For example: <code>plot3m([1 2 3 NaN 1 2 3],[4 5 6 NaN 7 8 9],[10 11 12 NaN 13 14 15])</code>
Multiple sets of points (using matrices)	Specify <code>lat</code> and <code>lon</code> as matrices of the same size. Specify <code>z</code> as a scalar or as a matrix of the same size as <code>lat</code> and <code>lon</code> . For example: <code>plot3m([1 2 3; 1 2 3],[4 5 6; 7 8 9],[10 11 12; 13 14 15])</code>

Data Types: double

z — Heights

scalar | vector of same size as `lat` and `lon` | matrix of same size as `lat` and `lon`

Heights, specified as a scalar, a vector of the same size as `lat` and `lon`, or a matrix of the same size as `lat` and `lon`.

In most cases, the units of `z` are arbitrary. When the `MapProjection` property of the axesm-based map is "globe", `z` is referenced to the ellipsoid. In this case, specify `z` using the length unit of the ellipsoid.

Data Types: double

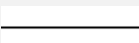



LineStyle — Line style, marker, and color
















string scalar | character vector

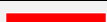

Line style, marker, and color, specified as a string scalar or character vector containing symbols. The symbols can appear in any order. You do not need to specify all three characteristics (line style,







marker, and color). For example, if you omit the line style and specify the marker, then the plot shows only the marker and no line.

Example: `--or` is a red dashed line with circle markers.

Line Style	Description	Resulting Line
"_"	Solid line	
"--"	Dashed line	
":"	Dotted line	
"-."	Dash-dotted line	

Marker	Description	Resulting Marker
"o"	Circle	
"+"	Plus sign	
"*"	Asterisk	
"."	Point	
"x"	Cross	
"-"	Horizontal line	
" "	Vertical line	
"square"	Square	
"diamond"	Diamond	
"^"	Upward-pointing triangle	
"v"	Downward-pointing triangle	
">"	Right-pointing triangle	
"<"	Left-pointing triangle	
"pentagram"	Pentagram	
"hexagram"	Hexagram	

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	

Color Name	Short Name	RGB Triplet	Appearance
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `plot3m(lat, lon, z, LineStyle="--")` displays dashed lines.

Before R2021a, use commas to separate each name and value, and enclose `Name` in quotes.

Example: `plot3m(lat, lon, z, "LineStyle", "--")` displays dashed lines.

Note Use name-value arguments to specify values for the properties of the `Line` object created by this function. The properties listed here are only a subset. For a full list, see [Line Properties](#).

Setting the `XData`, `YData`, and `ZData` properties of the line object is not supported.

Color — Color



[0 0.4470 0.7410] (default) | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...



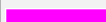



Color, specified as an RGB triplet, a hexadecimal color code, a color name, or a short name. The color you specify sets the line color. It also sets the marker edge color when the `MarkerEdgeColor` property is set to 'auto'.

For a custom color, specify an RGB triplet or a hexadecimal color code.




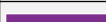



- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

LineWidth — Line width

0.5 (default) | positive value

Line width, specified as a positive value in points, where 1 point = 1/72 of an inch. If the line has markers, then the line width also affects the marker edges.

The line width cannot be thinner than the width of a pixel. If you set the line width to a value that is less than the width of a pixel on your system, the line displays as one pixel wide.

MarkerSize — Marker size

6 (default) | positive value

Marker size, specified as a positive value in points, where 1 point = 1/72 of an inch.

MarkerEdgeColor — Marker outline color

"auto" (default) | RGB triplet | hexadecimal color code | "r" | "g" | "b" | ...







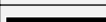

Marker outline color, specified as "auto", an RGB triplet, a hexadecimal color code, a color name, or a short name. The default value of "auto" uses the same color as the Color property.

For a custom color, specify an RGB triplet or a hexadecimal color code.








- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].

- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

MarkerFaceColor — Marker fill color

"none" (default) | "auto" | RGB triplet | hexadecimal color code | "r" | "g" | "b" | ...





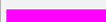



Marker fill color, specified as "auto", an RGB triplet, a hexadecimal color code, a color name, or a short name. The "auto" option uses the same color as the Color property of the parent axes. If you specify "auto" and the axes plot box is invisible, the marker fill color is the color of the figure.

For a custom color, specify an RGB triplet or a hexadecimal color code.








- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case

sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

Output Arguments

p — Line objects

array of Line objects

Line objects, returned as an array of Line objects. Use p to modify the Line objects after creation. For a list of properties, see Line Properties.

Setting the XData, YData, and ZData properties of the line objects is not supported.

Version History

Introduced before R2006a

See Also

Functions

geoshow | geoplot3 | plotm | linem

plotm

Project 2-D lines and points on axesm-based map

Syntax

```
plotm(lat,lon)
plotm([lat lon])
plotm(lat,lon,LineStyle)
plotm(lat,lon,Name,Value)
h = plotm(____)
```

Description

`plotm(lat,lon)` displays projected line objects on the current axesm-based map. Specify the latitude and longitude coordinates of the line using `lat` and `lon`.

To display 2-D line plots on geographic axes or map axes, use the `geoplot` function instead.

`plotm([lat lon])` allows the latitude and longitude coordinates to be packed into a single two-column matrix.

`plotm(lat,lon,LineStyle)` specifies the line style, marker, and color.

`plotm(lat,lon,Name,Value)` uses name-value pair arguments to specify any number of Line Properties except for `XData`, `YData`, and `ZData`. `Name` is the property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Property names can be abbreviated, and case does not matter.

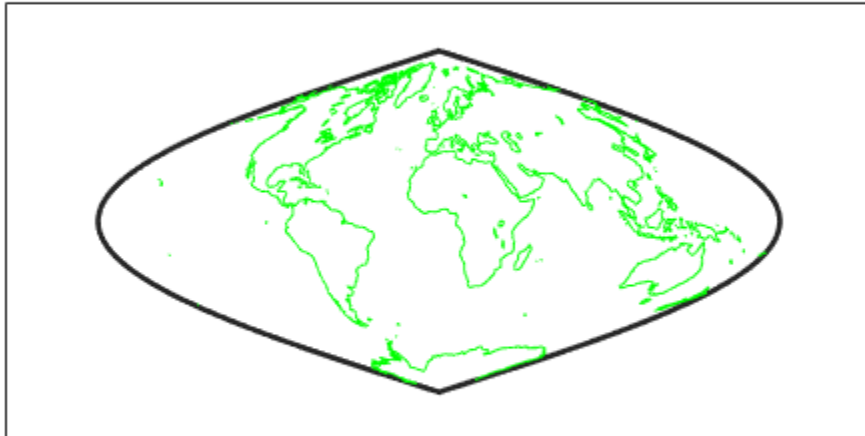
`h = plotm(____)` returns a handle to the displayed line.

Examples

Plot Coastlines on Map

First, load coastline data into the workspace and create a map. Then, plot the data. The `plotm` function uses the NaN values in `coastlat` and `coastlon` to break the data into separate lines.

```
load coastlines
ax = axesm('sinusoid','Frame','on');
plotm(coastlat,coastlon,'g')
```



Input Arguments

lat, lon — Latitude or longitude vector

numeric vector

Latitude or longitude vector, specified as a numeric vector. Specify values in units that match the `AngleUnits` property of the `axesm`-based map. `lat` and `lon` must be the same size.

Create breaks in lines or polygons using `NaN` values. For example, this code plots the first three elements, skips the fourth element, and draws another line using the last three elements.




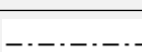
```
lat = [0 1 2 NaN 4 5 6];
lon = [0 1 2 NaN 3 4 5];
axesm('UTM','Zone','31N','Frame','on')
plotm(lat,lon)
```
















LineStyle — Line style, marker, and color






string scalar | character vector



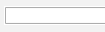
Line style, marker, and color, specified as a string scalar or character vector containing symbols. The symbols can appear in any order. You do not need to specify all three characteristics (line style, marker, and color). For example, if you omit the line style and specify the marker, then the plot shows only the marker and no line.

Example: `"- -or"` is a red dashed line with circle markers.

Line Style	Description	Resulting Line
"_"	Solid line	
"--"	Dashed line	
":"	Dotted line	
"-."	Dash-dotted line	

Marker	Description	Resulting Marker
"o"	Circle	
"+"	Plus sign	
"*"	Asterisk	
"."	Point	
"x"	Cross	
_"	Horizontal line	
"	Vertical line	
"square"	Square	
"diamond"	Diamond	
"^"	Upward-pointing triangle	
"v"	Downward-pointing triangle	
">"	Right-pointing triangle	
"<"	Left-pointing triangle	
"pentagram"	Pentagram	
"hexagram"	Hexagram	

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	

Color Name	Short Name	RGB Triplet	Appearance
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Output Arguments

h — Handle to displayed line

handle object

Handle to the displayed line, returned as a handle to a MATLAB graphics object.

Tips

When you pass two points to the `plotm` function, the function projects the locations of each point on the map and displays a straight line that connects them, regardless of the map projection or the distance between the points. To display a projected geodesic or rhumbline curve between two points, first insert intermediate points using the `track2` function.

Version History

Introduced before R2006a

See Also

`linem` | `plot` | `plot3m`

Point Properties

Geographic point appearance and behavior

Description

Point properties control the appearance and behavior of a `Point` object. By changing property values, you can modify certain aspects of the point. Use dot notation to query and set properties.

```
shape = geointshape(1:10,1:10);
p = geoplot(shape);
c = p.Marker;
p.Marker = "*";
```

Properties




Markers

Marker — Marker symbol

'.' (default) | 'o' | '+' | '*' | 'x' | ...

Marker symbol, specified as one of the options listed in this table:

Marker	Description	Resulting Marker
"o"	Circle	○
"+"	Plus sign	+
"*"	Asterisk	*
."	Point	•
"x"	Cross	×
"_"	Horizontal line	—
" "	Vertical line	
"square"	Square	□
"diamond"	Diamond	◇
"^"	Upward-pointing triangle	△
"v"	Downward-pointing triangle	▽
">"	Right-pointing triangle	▷

Marker	Description	Resulting Marker
"<"	Left-pointing triangle	
"pentagram"	Pentagram	
"hexagram"	Hexagram	
"none"	No markers	Not applicable

MarkerSize – Marker size

6 (default) | positive value

Marker size, specified as a positive value in points, where 1 point = 1/72 of an inch.

MarkerEdgeColor – Marker outline color









[0 0 0] (default) | 'flat' | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...

Marker outline color, specified as 'flat', an RGB triplet, a hexadecimal color code, a color name, or a short name. The 'flat' option uses colors from the ColorData property. When the `geoplot` function sets the ColorData property, MATLAB updates this property to 'flat'.








For a custom color, specify an RGB triplet or a hexadecimal color code.

- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

Example: [0.5 0.5 0.5]

Example: 'blue'

Example: '#D2F9A7'

MarkerFaceColor — Marker fill color




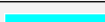




'none' (default) | 'flat' | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...

Marker fill color, specified as 'flat', an RGB triplet, a hexadecimal color code, a color name, or a short name. The 'flat' option use colors from the ColorData property.








For a custom color, specify an RGB triplet or a hexadecimal color code.

- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

Example: [0.3 0.2 0.1]

Example: 'green'

Example: '#D2F9A7'

MarkerEdgeAlpha — Marker outline transparency

1 (default) | scalar in range [0, 1]

Marker outline transparency, specified as a scalar in the range [0, 1]. A value of 1 is opaque and 0 is completely transparent. Values between 0 and 1 are semitransparent.

MarkerFaceAlpha — Marker fill transparency

1 (default) | scalar in range [0, 1]

Marker fill transparency, specified as a scalar in the range [0, 1]. A value of 1 is opaque and 0 is completely transparent. Values between 0 and 1 are semitransparent.

Color Data

ColorData — Marker colors

[] (default) | numeric vector

Marker colors, specified as a numeric vector that linearly maps to the colors in the current colormap. The plot uses a different color for each element of ShapeData. Specify ColorData as a vector the same length as ShapeData.

The ColorData property controls the fill colors of the markers when the MarkerFaceColor property has a value of 'flat'. The ColorData property also controls the outline colors of the markers when the MarkerEdgeColor property has a value of 'flat'.

ColorDataMode — Control how ColorData is set

'auto' (default) | 'manual'

Control how the ColorData property is set, specified as one of these values:

- 'auto' — MATLAB controls the value of the ColorData property.
- 'manual' — You manually control the value of the ColorData property. When you set the ColorData property, MATLAB sets this property to 'manual'.

To specify colors using the ColorVariable property, this property must have a value of 'auto'.

SeriesIndex — Series index

non-negative integer

Series index, specified as a non-negative integer. This property is useful for reassigning the marker colors of several `Point` objects so that they match each other. By default, the `SeriesIndex` property of a `Point` object is a number that corresponds to the order of creation of the object, starting at 1.

MATLAB uses the number to calculate indices for assigning colors when you call plotting functions. The indices refer to the rows of the arrays stored in the `ColorOrder` property of the axes.

MATLAB automatically updates the marker color of the `Point` object when you change its `SeriesIndex`, or when you change the `ColorOrder` property on the axes. However, the following conditions must be true for the changes to have any effect:

- The `ColorDataMode` property on the `Point` object has a value of `'auto'`.
- Either the `MarkerEdgeColor` or `MarkerFaceColor` property on the `Point` object has a value of `'flat'`.
- The `SeriesIndex` property on the `Point` object is greater than 0.
- The `NextSeriesIndex` property on the axes object is greater than 0.

Shape Data**ShapeData — Point shapes**empty `geopointshape` object (default) | `geopointshape` or `mappointshape` object | vector of `geopointshape` or `mappointshape` objects

Point shapes, specified as a `geopointshape` or `mappointshape` object or as a vector of `geopointshape` or `mappointshape` objects. For `mappointshape` objects, the value of the `ProjectedCRS` property must not be empty.

When you pass shape objects or a geospatial table to the `geoplot` function, the `geoplot` function sets the value of `ShapeData`.

ShapeDataMode — Control how ShapeData is set`'auto'` (default) | `'manual'`

Control how the `ShapeData` property is set, specified as one of these values:

- `'auto'` — MATLAB automatically updates the `ShapeData` property based on the `SourceTable` and `ShapeVariable` properties. When you pass a geospatial table to the `geoplot` function, MATLAB sets this property to `'auto'`.
- `'manual'` — You manually control the value of the `ShapeData` property. When you set the `ShapeData` property or pass shape objects to the `geoplot` function, MATLAB sets this property to `'manual'`.

Table Data**SourceTable — Source table**

geospatial table

Source table containing the data to plot, specified as a geospatial table. A geospatial table is a `table` or `timetable` object that contains a `Shape` variable and attribute variables. For more information about geospatial tables, see “Create Geospatial Tables”.

ShapeVariable — Table variable containing shape objects

table variable index

Table variable containing the shape objects, specified as a table variable index. The table variable must contain `geopointshape` or `mappointshape` objects. For `mappointshape` objects, the value of the `ProjectedCRS` property must not be empty.

When you pass a geospatial table to the `geoplot` function, the value of this property is `'Shape'`. When you set this property, MATLAB updates the `ShapeData` property.

This table lists the different indexing schemes you can use to specify the table variable.

Indexing Scheme	Examples
Variable name: <ul style="list-style-type: none"> A string scalar or character vector. A <code>pattern</code> object. The pattern object must refer to only one variable. 	<ul style="list-style-type: none"> <code>"A"</code> or <code>'A'</code> — A variable called A <code>"Var"+digitsPattern(1)</code> — The variable with the name "Var" followed by a single digit
Variable index: <ul style="list-style-type: none"> An index number that refers to the location of a variable in the table. A logical vector. Typically, this vector is the same length as the number of variables, but you can omit trailing <code>0</code> or <code>false</code> values. 	<ul style="list-style-type: none"> <code>3</code> — The third variable from the table <code>[false false true]</code> — The third variable
Variable type: A <code>vartype</code> subscript that selects a table variable of a specified type. The subscript must refer to only one variable.	<ul style="list-style-type: none"> <code>vartype("double")</code> — The variable containing values of type <code>double</code>

ColorVariable — Table variable containing color data

table variable index

Table variable containing the color data, specified as a variable index into the source table.

Specifying the Table Index

Use any of these indexing schemes to specify the desired variable.

Indexing Scheme	Examples
Variable name: <ul style="list-style-type: none"> A string scalar or character vector. A <code>pattern</code> object. The pattern object must refer to only one variable. 	<ul style="list-style-type: none"> <code>"A"</code> or <code>'A'</code> — A variable called A <code>"Var"+digitsPattern(1)</code> — The variable with the name "Var" followed by a single digit

Indexing Scheme	Examples
Variable index: <ul style="list-style-type: none"> An index number that refers to the location of a variable in the table. A logical vector. Typically, this vector is the same length as the number of variables, but you can omit trailing 0 or false values. 	<ul style="list-style-type: none"> 3 — The third variable from the table [false false true] — The third variable
Variable type: A <code>vartype</code> subscript that selects a table variable of a specified type. The subscript must refer to only one variable.	<ul style="list-style-type: none"> <code>vartype("double")</code> — The variable containing values of data type double

Specifying Color Data

The `ColorVariable` property controls the fill colors of the markers when the `MarkerFaceColor` property has a value of 'flat'. The `ColorVariable` property also controls the outline colors of the markers when the `MarkerEdgeColor` property has a value of 'flat'.

Specify the color data values as a numeric vector that linearly maps to the colors in the current colormap. The plot uses a different color for each element of `ShapeData`.

When you set the `ColorVariable` property, MATLAB updates the `ColorData` property.

Legend

DisplayName — Legend label

' ' (default) | character vector | string scalar

Legend label, specified as a character vector or string scalar. The legend does not display until you call the `legend` command. If you do not specify the text, then `legend` sets the label using the form 'dataN'.

Annotation — Control for including or excluding object from legend

Annotation object

This property is read-only.

Control for including or excluding the object from a legend, returned as an `Annotation` object. Set the underlying `IconDisplayStyle` property to one of these values:

- 'on' — Include the object in the legend (default).
- 'off' — Do not include the object in the legend.

For example, to exclude a graphics object, `go`, from the legend set the `IconDisplayStyle` property to 'off'.

```
go.Annotation.LegendInformation.IconDisplayStyle = 'off';
```

Alternatively, you can control the items in a legend using the `legend` function. Specify the first input argument as a vector of the graphics objects to include. If you do not specify an existing graphics object in the first input argument, then it does not appear in the legend. However, graphics objects

added to the axes after the legend is created do appear in the legend. Consider creating the legend after creating all the plots to avoid extra items.

Interactivity

Visible — State of visibility

'on' (default) | on/off logical value

State of visibility, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to true, and 'off' is equivalent to false. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Display the object.
- 'off' — Hide the object without deleting it. You still can access the properties of an invisible object.

ContextMenu — Context menu

empty `GraphicsPlaceholder` array (default) | `ContextMenu` object

Context menu, specified as a `ContextMenu` object. Use this property to display a context menu when you right-click the object. Create the context menu using the `uicontextmenu` function.

Note If the `PickableParts` property is set to 'none' or if the `HitTest` property is set to 'off', then the context menu does not appear.

Selected — Selection state

'off' (default) | on/off logical value

Selection state, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to true, and 'off' is equivalent to false. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Selected. If you click the object when in plot edit mode, then MATLAB sets its `Selected` property to 'on'. If the `SelectionHighlight` property also is set to 'on', then MATLAB displays selection handles around the object.
- 'off' — Not selected.

SelectionHighlight — Display of selection handles

'on' (default) | on/off logical value

Display of selection handles when selected, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to true, and 'off' is equivalent to false. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Display selection handles when the `Selected` property is set to 'on'.
- 'off' — Never display selection handles, even when the `Selected` property is set to 'on'.

Callbacks

ButtonDownFcn — Mouse-click callback

' ' (default) | function handle | cell array | character vector

Mouse-click callback, specified as one of these values:

- Function handle
- Cell array containing a function handle and additional arguments
- Character vector that is a valid MATLAB command or function, which is evaluated in the base workspace (not recommended)

Use this property to execute code when you click the object. If you specify this property using a function handle, then MATLAB passes two arguments to the callback function when executing the callback:

- Clicked object — Access properties of the clicked object from within the callback function.
- Event data — Empty argument. Replace it with the tilde character (~) in the function definition to indicate that this argument is not used.

For more information on how to use function handles to define callback functions, see “Create Callbacks for Graphics Objects”.

Note If the `PickableParts` property is set to 'none' or if the `HitTest` property is set to 'off', then this callback does not execute.

CreateFcn — Creation function

' ' (default) | function handle | cell array | character vector

Object creation function, specified as one of these values:

- Function handle.
- Cell array in which the first element is a function handle. Subsequent elements in the cell array are the arguments to pass to the callback function.
- Character vector containing a valid MATLAB expression (not recommended). MATLAB evaluates this expression in the base workspace.

For more information about specifying a callback as a function handle, cell array, or character vector, see “Create Callbacks for Graphics Objects”.

This property specifies a callback function to execute when MATLAB creates the object. MATLAB initializes all property values before executing the `CreateFcn` callback. If you do not specify the `CreateFcn` property, then MATLAB executes a default creation function.

Setting the `CreateFcn` property on an existing component has no effect.

If you specify this property as a function handle or cell array, you can access the object that is being created using the first argument of the callback function. Otherwise, use the `gcbo` function to access the object.

DeleteFcn — Deletion function

' ' (default) | function handle | cell array | character vector

Object deletion function, specified as one of these values:

- Function handle.
- Cell array in which the first element is a function handle. Subsequent elements in the cell array are the arguments to pass to the callback function.
- Character vector containing a valid MATLAB expression (not recommended). MATLAB evaluates this expression in the base workspace.

For more information about specifying a callback as a function handle, cell array, or character vector, see “Create Callbacks for Graphics Objects”.

This property specifies a callback function to execute when MATLAB deletes the object. MATLAB executes the `DeleteFcn` callback before destroying the properties of the object. If you do not specify the `DeleteFcn` property, then MATLAB executes a default deletion function.

If you specify this property as a function handle or cell array, you can access the object that is being deleted using the first argument of the callback function. Otherwise, use the `gcbo` function to access the object.

Callback Execution Control

Interruptible — Callback interruption

'on' (default) | on/off logical value

Callback interruption, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to `true`, and 'off' is equivalent to `false`. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

This property determines if a running callback can be interrupted. There are two callback states to consider:

- The running callback is the currently executing callback.
- The interrupting callback is a callback that tries to interrupt the running callback.

MATLAB determines callback interruption behavior whenever it executes a command that processes the callback queue. These commands include `drawnow`, `figure`, `uifigure`, `getframe`, `waitfor`, and `pause`.

If the running callback does not contain one of these commands, then no interruption occurs. MATLAB first finishes executing the running callback, and later executes the interrupting callback.

If the running callback does contain one of these commands, then the `Interruptible` property of the object that owns the running callback determines if the interruption occurs:

- If the value of `Interruptible` is 'off', then no interruption occurs. Instead, the `BusyAction` property of the object that owns the interrupting callback determines if the interrupting callback is discarded or added to the callback queue.
- If the value of `Interruptible` is 'on', then the interruption occurs. The next time MATLAB processes the callback queue, it stops the execution of the running callback and executes the interrupting callback. After the interrupting callback completes, MATLAB then resumes executing the running callback.

Note Callback interruption and execution behave differently in these situations:

- If the interrupting callback is a `DeleteFcn`, `CloseRequestFcn`, or `SizeChangedFcn` callback, then the interruption occurs regardless of the `Interruptible` property value.
 - If the running callback is currently executing the `waitfor` function, then the interruption occurs regardless of the `Interruptible` property value.
 - If the interrupting callback is owned by a `Timer` object, then the callback executes according to schedule regardless of the `Interruptible` property value.
-

Note When an interruption occurs, MATLAB does not save the state of properties or the display. For example, the object returned by the `gca` or `gcf` command might change when another callback executes.

BusyAction — Callback queuing

'queue' (default) | 'cancel'

Callback queuing, specified as 'queue' or 'cancel'. The `BusyAction` property determines how MATLAB handles the execution of interrupting callbacks. There are two callback states to consider:

- The running callback is the currently executing callback.
- The interrupting callback is a callback that tries to interrupt the running callback.

The `BusyAction` property determines callback queuing behavior only when both of these conditions are met:

- The running callback contains a command that processes the callback queue, such as `drawnow`, `figure`, `uifigure`, `getframe`, `waitfor`, or `pause`.
- The value of the `Interruptible` property of the object that owns the running callback is 'off'.

Under these conditions, the `BusyAction` property of the object that owns the interrupting callback determines how MATLAB handles the interrupting callback. These are possible values of the `BusyAction` property:

- 'queue' — Puts the interrupting callback in a queue to be processed after the running callback finishes execution.
- 'cancel' — Does not execute the interrupting callback.

PickableParts — Ability to capture mouse clicks

'visible' (default) | 'none'

Ability to capture mouse clicks, specified as one of these values:

- 'visible' — Capture mouse clicks when visible. The `Visible` property must be set to 'on' and you must click a part of the `Point` object that has a defined color. You cannot click a part that has an associated color property set to 'none'. If the plot contains markers, then the entire marker is clickable if either the edge or the fill has a defined color. The `HitTest` property determines if the `Point` object responds to the click or if an ancestor does.
- 'none' — Cannot capture mouse clicks. Clicking the `Point` object passes the click to the object below it in the current view of the figure window. The `HitTest` property of the `Point` object has no effect.

HitTest — Response to captured mouse clicks

'on' (default) | on/off logical value

Response to captured mouse clicks, specified as 'on' or 'off', or as numeric or logical 1 (true) or 0 (false). A value of 'on' is equivalent to true, and 'off' is equivalent to false. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- 'on' — Trigger the `ButtonDownFcn` callback of the `Point` object. If you have defined the `ContextMenu` property, then invoke the context menu.
- 'off' — Trigger the callbacks for the nearest ancestor of the `Point` object that has one of these:
 - `HitTest` property set to 'on'
 - `PickableParts` property set to a value that enables the ancestor to capture mouse clicks

Note The `PickableParts` property determines if the `Point` object can capture mouse clicks. If it cannot, then the `HitTest` property has no effect.

BeingDeleted — Deletion status

on/off logical value

This property is read-only.

Deletion status, returned as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

MATLAB sets the `BeingDeleted` property to 'on' when the `DeleteFcn` callback begins execution. The `BeingDeleted` property remains set to 'on' until the component object no longer exists.

Check the value of the `BeingDeleted` property to verify that the object is not about to be deleted before querying or modifying it.

Parent/Child**Parent — Parent**

GeographicAxes object | MapAxes object

Parent, specified as a `GeographicAxes` object or `MapAxes` object.

Children — Childrenempty `GraphicsPlaceholder` array

The object has no children. You cannot set this property.

HandleVisibility — Visibility of object handle

'on' (default) | 'off' | 'callback'

Visibility of the object handle in the `Children` property of the parent, specified as one of these values:

- 'on' — Object handle is always visible.
- 'off' — Object handle is invisible at all times. This option is useful for preventing unintended changes by another function. Set the `HandleVisibility` to 'off' to temporarily hide the handle during the execution of that function.

- `'callback'` — Object handle is visible from within callbacks or functions invoked by callbacks, but not from within functions invoked from the command line. This option blocks access to the object at the command line, but permits callback functions to access it.

If the object is not listed in the `Children` property of the parent, then functions that obtain object handles by searching the object hierarchy or querying handle properties cannot return it. Examples of such functions include the `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close` functions.

Hidden object handles are still valid. Set the root `ShowHiddenHandles` property to `'on'` to list all object handles regardless of their `HandleVisibility` property setting.

Identifiers

Type — Type of graphics object

`'point'`

This property is read-only.

Type of graphics object, returned as `'point'`. Use this property to find all objects of a given type within a plotting hierarchy, for example, searching for the type using `findobj`.

Tag — Object identifier

`''` (default) | character vector | string scalar

Object identifier, specified as a character vector or string scalar. You can specify a unique `Tag` value to serve as an identifier for an object. When you need access to the object elsewhere in your code, you can use the `findobj` function to search for the object based on the `Tag` value.

UserData — User data

`[]` (default) | array

User data, specified as any MATLAB array. For example, you can specify a scalar, vector, matrix, cell array, character array, table, or structure. Use this property to store arbitrary data on an object.

If you are working in App Designer, create public or private properties in the app to share data instead of using the `UserData` property. For more information, see “Share Data Within App Designer Apps”.

Version History

Introduced in R2022a

See Also

Functions

`geoplot`

Objects

`geopointshape` | `mappointshape`

Properties

`GeographicAxes` Properties | `MapAxes` Properties

Topics

“Access Property Values”

“Graphics Object Properties”

polcmap

Create colormap appropriate to political regions

Syntax

```
polcmap
polcmap(ncolors)
polcmap(ncolors,maxsat)
polcmap(ncolors,huelimits,saturationlimits,valuelimits)
cmap = polcmap( ___ )
```

Description

`polcmap` applies a random, muted colormap to the current figure. The size of the colormap is the same as the existing colormap. This function is useful for creating colormaps that help you distinguish one political region from its neighbors.

`polcmap(ncolors)` creates a colormap with the specified number of colors.

`polcmap(ncolors,maxsat)` controls the maximum saturation of the colors.

`polcmap(ncolors,huelimits,saturationlimits,valuelimits)` controls the hue, saturation, and value of the colors. `polcmap` randomly selects values within the limit vectors. These are two-element vectors of the form `[min max]`. Valid values range from 0 to 1. As the hue varies from 0 to 1, the resulting color varies from red, through yellow, green, cyan, blue, and magenta, back to red. When the saturation is 0, the colors are unsaturated; they are simply shades of gray. When the saturation is 1, the colors are fully saturated; they contain no white component. As the value varies from 0 to 1, the brightness increases.

`cmap = polcmap(___)` returns the colormap without applying it to the figure.

Examples

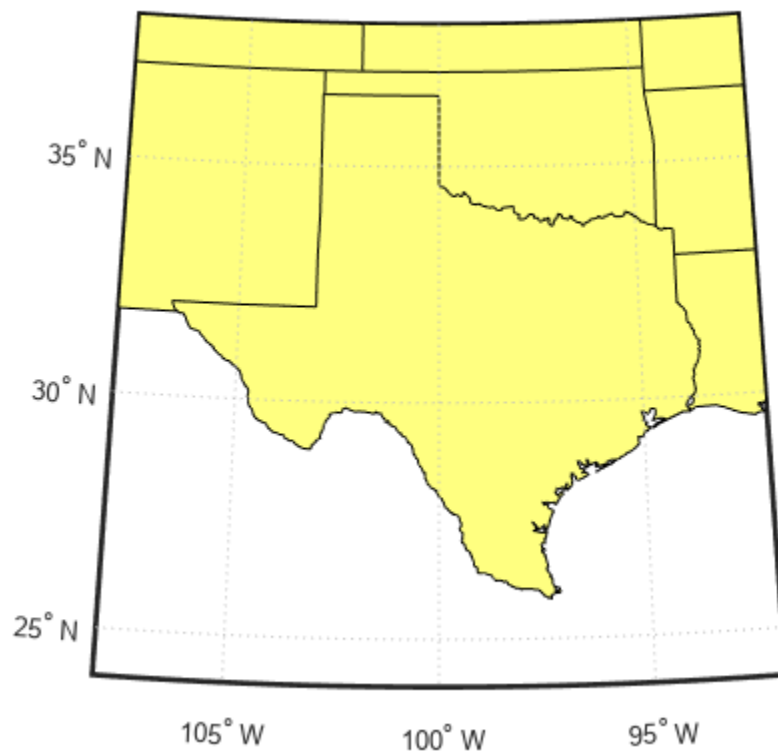
Color Patches Using Random, Muted Colormap

Create a map using a Lambert conformal conic projection and map limits covering Texas.

```
figure
usamap("texas")
```

Read state boundaries from a shapefile into a geospatial table. Display the boundaries on the map, noting that the default face color is yellow.

```
states = readgeotable("usastatelo.shp");
geoshow(states,"DisplayType","polygon")
```

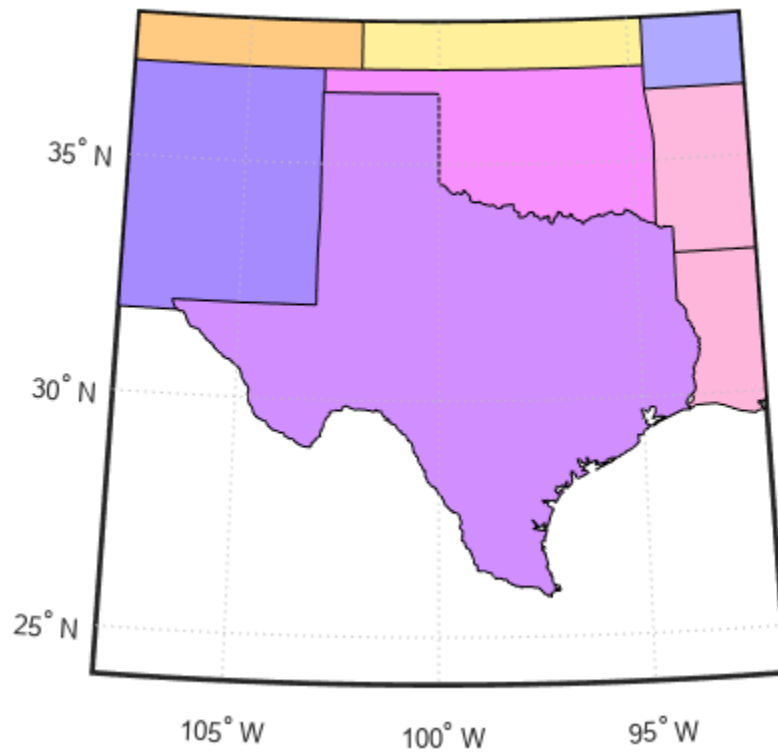



Define the colors you want to apply to the shapes (`states`) in a symbol specification. Use `polcmap` to create a colormap the same size as the number of rows in the geospatial table. `polcmap` creates a palette of muted colors.

```
h = height(states);
faceColors = makesymbolspec("Polygon", ...
    {'INDEX',[1 h], 'FaceColor', polcmap(h)});
```

Display the map again using the symbol specification to color the patches (`states`) in the map. The colors you obtain for this example can vary each time you run this example because `polcmap` computes them randomly.

```
geoshow(states, "DisplayType", "polygon", "SymbolSpec", faceColors)
```



Specify Number and Saturation of Colors

Read state boundaries from a shapefile into a geospatial table. Set to a variable the number of rows in the table.

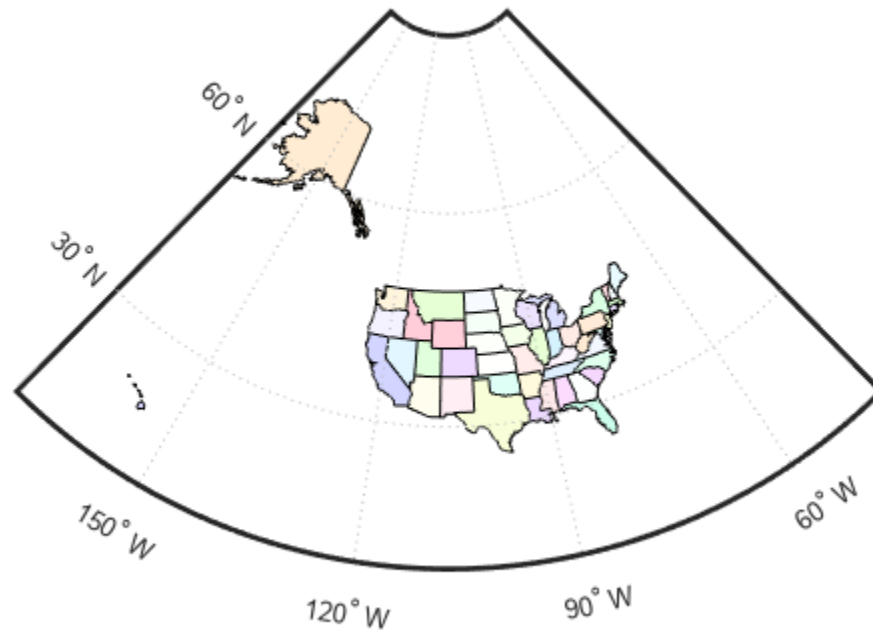
```
states = readgeotable("usastatelo.shp");
h = height(states);
```

Create a colormap with 256 colors and a maximum saturation of 0.2. To ensure that the colormap is always the same, seed the MATLAB® random number function using the `rng` function and a fixed value of your choice.

```
rng(0)
cmap = polcmap(256,0.2);
```

Use the colormap to display the state boundaries on a map of North America.

```
figure
worldmap na
faceColors = makesymbolspec("Polygon",{ 'INDEX',[1 h], 'FaceColor',cmap});
geoshow(states,"SymbolSpec",faceColors)
```



Input Arguments

ncolors — Number of colors in the color map

numeric scalar

Number of colors in the color map, specified as a numeric scalar.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

maxsat — Maximum saturation of colors

0.5 (default) | numeric scalar

Maximum saturation of colors, specified as a numeric scalar. Larger maximum saturation values produce brighter, more saturated colors.

Data Types: `single` | `double` | `logical` | `char`

huelimits — Color range limits

[0 1] (default) | two-element vector

Color range limits, specified as a two-element vector of the form `[min max]`. Values range from 0 to 1.0. As the hue varies from 0 to 1, the resulting color varies from red, through yellow, green, cyan, blue, and magenta, back to red.

Data Types: `single` | `double`

saturationlimits — Color saturation limits

[.25 .5] (default) | two-element vector

Color saturation limits, specified as a two-element vector of the form [min max]. Values range from 0 to 1.0. When the saturation is 0, the colors are unsaturated; they are simply shades of gray. When the saturation is 1, the colors are fully saturated; they contain no white component.

Data Types: `single` | `double`**valuelimits — Brightness of colors**

[1 1] (default) | two-element vector

Brightness of colors, specified as a two-element vector of the form [min max]. Values range from 0 to 1.0. As the value varies from 0 to 1, the brightness increases.

Data Types: `single` | `double`**Output Arguments****cmap — Colormap***m*-by-3 numeric array

Colormap, returned as an *m*-by-3 numeric array of class `double` or class `single`, depending on the type of the input.

Tips

- You cannot use `polcmap` to alter the colors of displayed patches drawn by `geoshow` or `mapshow`. The patches must have been rendered by `displaym`. However, you can color patches using `polcmap` when you call `geoshow` or `mapshow` (see “Color Patches Using Random, Muted Colormap” on page 1-1338).

Version History

Introduced before R2006a

See Also`demcmap` | `colormap` | `lcolorbar`

poly2ccw

Convert polygon vertices to counterclockwise order

Syntax

```
[x2,y2] = poly2ccw(x1,y1)
```

Description

`[x2,y2] = poly2ccw(x1,y1)` arranges the Cartesian vertices of the polygon defined by `x1` and `y1` so the vertices are in counterclockwise order.

Examples

Convert Vertices to Counterclockwise Order

Specify a polygon using vertices in clockwise order. Close the polygon by repeating the first vertex at the end of the list.

```
x1 = [0 1 4 3 0];
y1 = [0 1 3 2 0];
ispolycw(x1,y1)
```

```
ans = logical
      1
```

Arrange the vertices so they are in counterclockwise order.

```
[x2,y2] = poly2ccw(x1,y1);
ispolycw(x2,y2)
```

```
ans = logical
      0
```

Input Arguments

x1 — x-coordinates of polygon

numeric vector | cell array of numeric vectors

x-coordinates of the polygon, specified as a numeric vector or a cell array of numeric vectors.

- Define one polygon by specifying a vector, such as `[39 45 19 39]`.
- Define multiple polygons by using one of these options:
 - Specify a vector and separate the polygons using NaN values, such as `[37 46 31 20 37 NaN 45 49 35 32 45 NaN 35 40 42 35]`. The NaN values in `x1` must correspond to the NaN values in `y1`.

- Specify a cell array of vectors, such as {[37 46 31 20 37],[45 49 35 32 45],[35 40 42 35]}. The size of the vector in each cell of `x1` must match the size of the vector in the corresponding cell of `y1`.

The size and type of `x1` must match the size and type of `y1`.

y1 — y-coordinates of polygon

numeric vector | cell array of numeric vectors

y-coordinates of the polygon, specified as a numeric vector or a cell array of numeric vectors.

- Define one polygon by specifying a vector, such as [-113 -49 -100 -113].
- Define multiple polygons by using one of these options:
 - Specify a vector and separate the polygons using NaN values, such as [69 90 105 79 69 NaN 6 52 43 14 6 NaN 18 32 22 18]. The NaN values in `y1` must correspond to the NaN values in `x1`.
 - Specify a cell array of vectors, such as {[69 90 105 79 69],[6 52 43 14 6],[18 32 22 18]}. The size of the vector in each cell of `y1` must match the size of the vector in the corresponding cell of `x1`.

The size and type of `y1` must match the size and type of `x1`.

Output Arguments

x2 — x-coordinates in counterclockwise order

numeric vector | cell array of numeric vectors

x-coordinates in counterclockwise order, returned as a numeric vector or a cell array of numeric vectors.

When `x1` and `y1` define multiple polygons, the `poly2ccw` function converts the coordinates of each individual polygon to counterclockwise order.

The size and type of `x2` matches the size and type of `x1`.

Data Types: double

y2 — y-coordinates in counterclockwise order

numeric vector | cell array of numeric vectors

y-coordinates in counterclockwise order, returned as a numeric vector or a cell array of numeric vectors.

When `x1` and `y1` define multiple polygons, the `poly2ccw` function converts the coordinates of each individual polygon to counterclockwise order.

The size and type of `y2` matches the size and type of `y1`.

Data Types: double

Tips

You can specify geographic coordinates as input to the `poly2ccw` function when the polygon does not cross the Antimeridian or contain a pole. A polygon contains a pole when the longitude data spans

360 degrees. To use geographic coordinates as input, specify `x1` using the longitude vector and `y1` using the latitude vector.

Version History

Introduced before R2006a

See Also

Functions

`poly2cw` | `ispolycw`

Objects

`mappolyshape` | `geopolyshape`

Topics

“Create and Display Polygons”

poly2cw

Convert polygon vertices to clockwise order

Syntax

```
[x2,y2] = poly2cw(x1,y1)
```

Description

`[x2,y2] = poly2cw(x1,y1)` arranges the Cartesian vertices of the polygon defined by `x1` and `y1` so the vertices are in clockwise order.

Examples

Convert Vertices to Clockwise Order

Specify a polygon using vertices in counterclockwise order. Close the polygon by repeating the first vertex at the end of the list.

```
x1 = [0 3 4 1 0];  
y1 = [0 2 3 1 0];  
ispolycw(x1,y1)
```

```
ans = logical  
     0
```

Arrange the vertices so they are in clockwise order.

```
[x2,y2] = poly2cw(x1,y1);  
ispolycw(x2,y2)
```

```
ans = logical  
     1
```

Input Arguments

x1 — x-coordinates of polygon

numeric vector | cell array of numeric vectors

x-coordinates of the polygon, specified as a numeric vector or a cell array of numeric vectors.

- Define one polygon by specifying a vector, such as `[39 45 19 39]`.
- Define multiple polygons by using one of these options:
 - Specify a vector and separate the polygons using NaN values, such as `[37 46 31 20 37 NaN 45 49 35 32 45 NaN 35 40 42 35]`. The NaN values in `x1` must correspond to the NaN values in `y1`.

- Specify a cell array of vectors, such as {[37 46 31 20 37],[45 49 35 32 45],[35 40 42 35]}. The size of the vector in each cell of `x1` must match the size of the vector in the corresponding cell of `y1`.

The size and type of `x1` must match the size and type of `y1`.

y1 — y-coordinates of polygon

numeric vector | cell array of numeric vectors

y-coordinates of the polygon, specified as a numeric vector or a cell array of numeric vectors.

- Define one polygon by specifying a vector, such as [-113 -49 -100 -113].
- Define multiple polygons by using one of these options:
 - Specify a vector and separate the polygons using NaN values, such as [69 90 105 79 69 NaN 6 52 43 14 6 NaN 18 32 22 18]. The NaN values in `y1` must correspond to the NaN values in `x1`.
 - Specify a cell array of vectors, such as {[69 90 105 79 69],[6 52 43 14 6],[18 32 22 18]}. The size of the vector in each cell of `y1` must match the size of the vector in the corresponding cell of `x1`.

The size and type of `y1` must match the size and type of `x1`.

Output Arguments

x2 — x-coordinates in clockwise order

numeric vector | cell array of numeric vectors

x-coordinates in clockwise order, returned as a numeric vector or a cell array of numeric vectors.

When `x1` and `y1` define multiple polygons, the `poly2cw` function converts the coordinates of each individual polygon to clockwise order.

The size and type of `x2` matches the size and type of `x1`.

Data Types: double

y2 — y-coordinates in clockwise order

numeric vector | cell array of numeric vectors

y-coordinates in clockwise order, returned as a numeric vector or a cell array of numeric vectors.

When `x1` and `y1` define multiple polygons, the `poly2cw` function converts the coordinates of each individual polygon to clockwise order.

The size and type of `y2` matches the size and type of `y1`.

Data Types: double

Tips

You can specify geographic coordinates as input to the `poly2cw` function when the polygon does not cross the Antimeridian or contain a pole. A polygon contains a pole when the longitude data spans 360 degrees. To use geographic coordinates as input, specify `x1` using the longitude vector and `y1` using the latitude vector.

Version History

Introduced before R2006a

See Also

Functions

poly2ccw | ispolycw

Objects

mappolyshape | geopolyshape

Topics

“Create and Display Polygons”

poly2fv

Convert polygon coordinates to patch faces and vertices

Syntax

```
[F,V] = poly2fv(x,y)
```

Description

`[F,V] = poly2fv(x,y)` converts the polygon coordinates defined by `x` and `y` into the triangular polygon regions defined by `V` and `F`, where `V` contains the vertices and `F` determines the vertices to connect.

You can use the outputs of this function to display polygon regions by using the `patch` function.

Examples

Convert Coordinates to Patch Faces and Vertices

Specify the `xy`-coordinates of three polygons:

- A rectangle with vertices in a clockwise order.
- A square with vertices in a counterclockwise order.
- A triangle with vertices in a counterclockwise order.

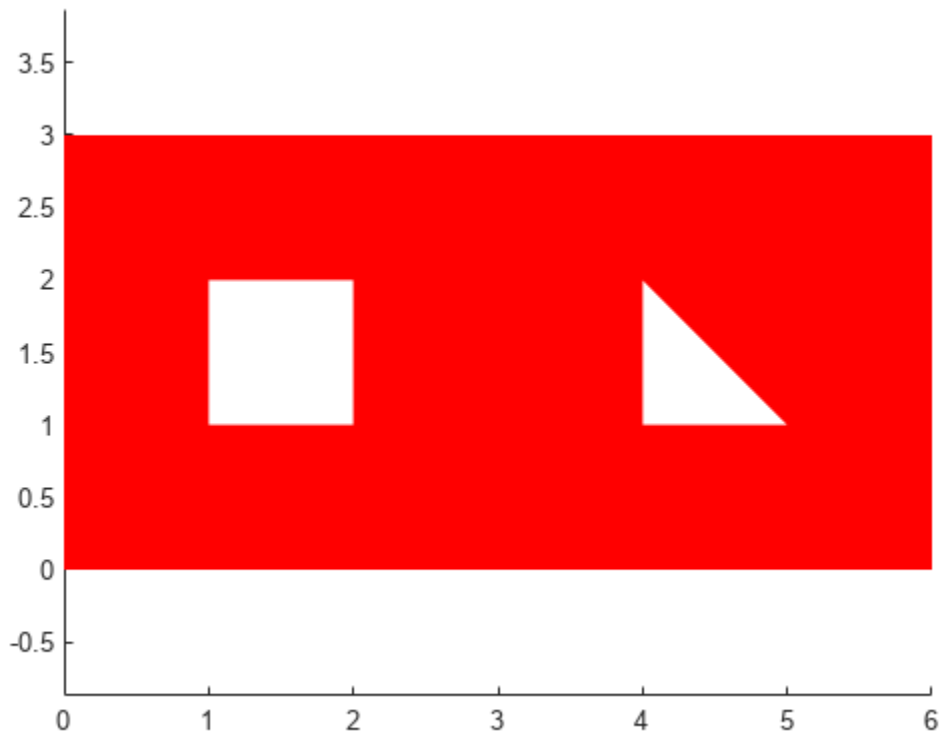
```
x1 = [0 0 6 6 0];
y1 = [0 3 3 0 0];
x2 = [1 2 2 1 1];
y2 = [1 1 2 2 1];
x3 = [4 5 4 4];
y3 = [1 1 2 1];
```

Convert the coordinates to patch faces and vertices.

```
[F,V] = poly2fv({x1,x2,x3},{y1,y2,y3});
```

Display the patch.

```
figure
patch("Faces",F,"Vertices",V,"FaceColor","r","EdgeColor","none")
axis equal
```



Input Arguments

x — x-coordinates of polygon

numeric vector | cell array of numeric vectors

x-coordinates of the polygon, specified as a numeric vector or a cell array of numeric vectors.

- Define one polygon by specifying a vector, such as [39 45 19 39].
- Define multiple polygons by using one of these options:
 - Specify a vector and separate the polygons using NaN values, such as [37 46 31 20 37 NaN 45 49 35 32 45 NaN 35 40 42 35]. The NaN values in x must correspond to the NaN values in y.
 - Specify a cell array of vectors, such as {[37 46 31 20 37],[45 49 35 32 45],[35 40 42 35]}. The size of the vector in each cell of x must match the size of the vector in the corresponding cell of y.

The size and type of x must match the size and type of y.

y — y-coordinates of polygon

numeric vector | cell array of numeric vectors

y-coordinates of the polygon, specified as a numeric vector or a cell array of numeric vectors.

- Define one polygon by specifying a vector, such as [-113 -49 -100 -113].
- Define multiple polygons by using one of these options:
 - Specify a vector and separate the polygons using NaN values, such as [69 90 105 79 69 NaN 6 52 43 14 6 NaN 18 32 22 18]. The NaN values in y must correspond to the NaN values in x.
 - Specify a cell array of vectors, such as {[69 90 105 79 69],[6 52 43 14 6],[18 32 22 18]}. The size of the vector in each cell of y must match the size of the vector in the corresponding cell of x.

The size and type of y must match the size and type of x.

Output Arguments

F — Polygon face definitions

three-column matrix

Polygon face definitions, returned as a three-column matrix that determines which vertices in V to connect. The poly2fv function creates triangular faces.

Data Types: double

V — Polygon vertices

two-column matrix

Polygon vertices, returned as a two-column matrix. Each row of the matrix contains the xy-coordinates of a vertex.

Data Types: double

Tips

Most Mapping Toolbox functions assume that clockwise-ordered vertices define external polygon edges and counterclockwise-ordered vertices define internal polygon edges. Although the poly2fv function ignores vertex order, you can ensure consistency with other functions by following this convention.

Version History

Introduced before R2006a

R2019b: Order of polygon vertices might be different

Behavior changed in R2019b

The poly2fv function might return polygon vertices in a different order. The polygons that these vertices define are geometrically equivalent to those in previous releases.

See Also

Functions

patch | poly2cw | poly2ccw | ispolycw

Objects

mappolyshape | geoplyshape

Topics

“Create and Display Polygons”

polybool

Set operations on polygonal regions

Note `polybool` is not recommended. Use `polyshape` instead. For more information, see “Compatibility Considerations”.

Syntax

```
[x,y] = polybool(flag,x1,y1,x2,y2)
```

Description

`[x,y] = polybool(flag,x1,y1,x2,y2)` performs the polygon set operation identified by `flag`. The result is output using the same format as the input. Geographic data that encompasses a pole cannot be used directly. Use `flatearthpoly` to convert polygons that contain a pole to Cartesian coordinates.

Most Mapping Toolbox functions adhere to the convention that individual contours with clockwise-ordered vertices are external contours and individual contours with counterclockwise-ordered vertices are internal contours. Although the `polybool` function ignores vertex order, follow this convention when creating contours to ensure consistency with other functions.

Examples

Set Operations on Two Overlapping Circular Regions

```
theta = linspace(0, 2*pi, 100);
x1 = cos(theta) - 0.5;
y1 = -sin(theta);    % -sin(theta) to make a clockwise contour
x2 = x1 + 1;
y2 = y1;
[xa, ya] = polybool('union', x1, y1, x2, y2);
[xb, yb] = polybool('intersection', x1, y1, x2, y2);
[xc, yc] = polybool('xor', x1, y1, x2, y2);
[xd, yd] = polybool('subtraction', x1, y1, x2, y2);
```

```
subplot(2, 2, 1)
patch(xa, ya, 1, 'FaceColor', 'r')
axis equal, axis off, hold on
plot(x1, y1, x2, y2, 'Color', 'k')
title('Union')
```

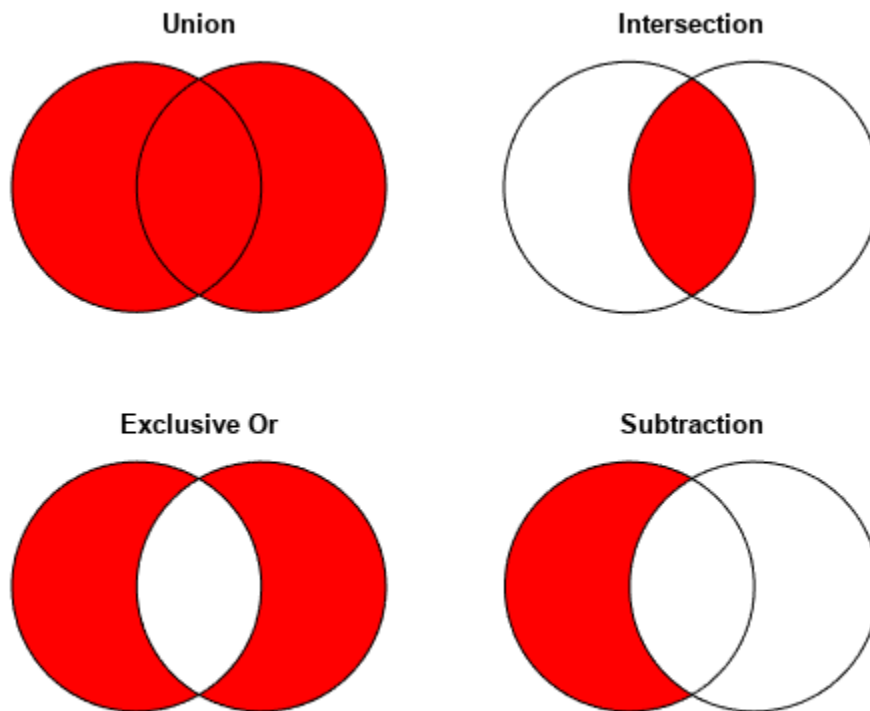
```
subplot(2, 2, 2)
patch(xb, yb, 1, 'FaceColor', 'r')
axis equal, axis off, hold on
plot(x1, y1, x2, y2, 'Color', 'k')
title('Intersection')
```

```
subplot(2, 2, 3)
```

```
% The output of the exclusive-or operation consists of disjoint
% regions. It can be plotted as a single patch object using the
% face-vertex form. Use poly2fv to convert a polygonal region
% to face-vertex form.
```

```
[f, v] = poly2fv(xc, yc);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
      'EdgeColor', 'none')
axis equal, axis off, hold on
plot(x1, y1, x2, y2, 'Color', 'k')
title('Exclusive Or')
```

```
subplot(2, 2, 4)
patch(xd, yd, 1, 'FaceColor', 'r')
axis equal, axis off, hold on
plot(x1, y1, x2, y2, 'Color', 'k')
title('Subtraction')
```



Set Operations on Regions with Holes

```
Ax = {[1 1 6 6 1], [2 5 5 2 2], [2 5 5 2 2]};
Ay = {[1 6 6 1 1], [2 2 3 3 2], [4 4 5 5 4]};
subplot(2, 3, 1)
[f, v] = poly2fv(Ax, Ay);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
      'EdgeColor', 'none')
```



```

axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Ax), plot(Ax{k}, Ay{k}, 'Color', 'k'), end
title('A')

Bx = {[0 0 7 7 0], [1 3 3 1 1], [4 6 6 4 4]};
By = {[0 7 7 0 0], [1 1 6 6 1], [1 1 6 6 1]};
subplot(2, 3, 4);
[f, v] = poly2fv(Bx, By);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
      'EdgeColor', 'none')
axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Bx), plot(Bx{k}, By{k}, 'Color', 'k'), end
title('B')

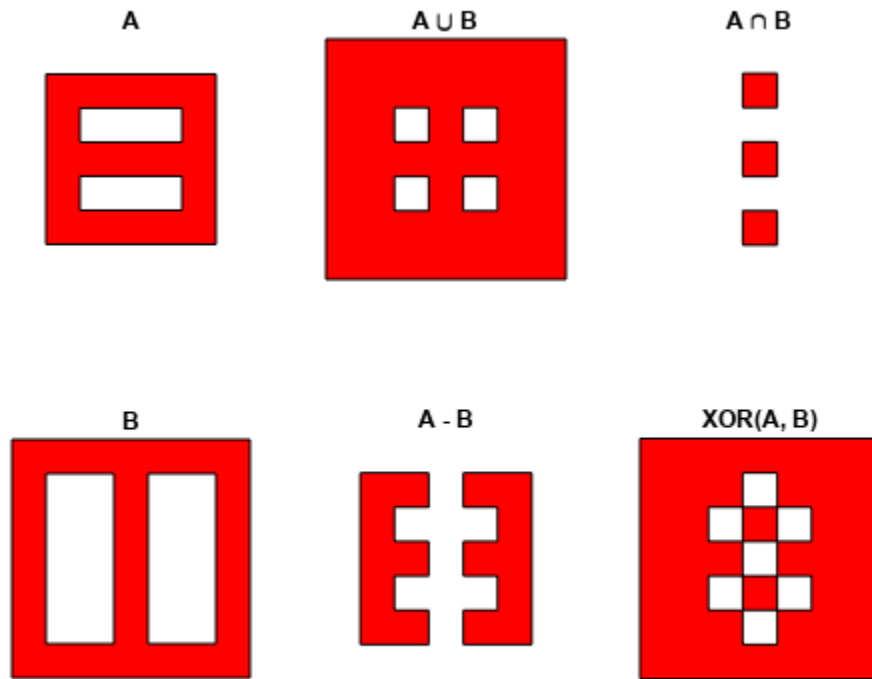
subplot(2, 3, 2)
[Cx, Cy] = polybool('union', Ax, Ay, Bx, By);
[f, v] = poly2fv(Cx, Cy);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
      'EdgeColor', 'none')
axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Cx), plot(Cx{k}, Cy{k}, 'Color', 'k'), end
title('A \cup B')

subplot(2, 3, 3)
[Dx, Dy] = polybool('intersection', Ax, Ay, Bx, By);
[f, v] = poly2fv(Dx, Dy);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
      'EdgeColor', 'none')
axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Dx), plot(Dx{k}, Dy{k}, 'Color', 'k'), end
title('A \cap B')

subplot(2, 3, 5)
[Ex, Ey] = polybool('subtraction', Ax, Ay, Bx, By);
[f, v] = poly2fv(Ex, Ey);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
      'EdgeColor', 'none')
axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Ex), plot(Ex{k}, Ey{k}, 'Color', 'k'), end
title('A - B')

subplot(2, 3, 6)
[Fx, Fy] = polybool('xor', Ax, Ay, Bx, By);
[f, v] = poly2fv(Fx, Fy);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
      'EdgeColor', 'none')
axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Fx), plot(Fx{k}, Fy{k}, 'Color', 'k'), end
title('XOR(A, B)')

```



Input Arguments

flag — Polygon set operation

'intersection' | 'and' | '&' | 'union' | 'or' | '|' | '+' | 'plus' | 'subtraction' | 'minus' | '-' | 'exclusiveor' | 'xor'

Polygon set operation, specified as one of the following values.

Operation					
Region intersection	'intersection'	'and'	'&'		
Region union	'union'	'or'	' '	'+'	'plus'
Region subtraction	'subtraction'	'minus'	'-'		
Region exclusiveor	'exclusiveor'	'xor'			

Data Types: char | string

x1 — Polygon contours

NaN-delimited vector | cell array

Polygon contours, specified as a NaN-delimited vector or cell array.

Data Types: double

x2 — Polygon contours

NaN-delimited vector | cell array

Polygon contours, specified as a NaN-delimited vector or cell array.

Data Types: double

y1 — Polygon contours

NaN-delimited vector | cell array

Polygon contours, specified as a NaN-delimited vector or cell array.

Data Types: double

y2 — Polygon contours

NaN-delimited vector | cell array

Polygon contours, specified as a NaN-delimited vector or cell array.

Data Types: double

Output Arguments

x — Polygon contour after set operation

NaN-delimited vector | cell array

Polygon contour after set operation, returned as a NaN-delimited vector or cell array. The output returns in the same format as the input.

y — Polygon contour after set operation

NaN-delimited vector | cell array

Polygon contour after set operation, returned as a NaN-delimited vector or cell array. The output returns in the same format as the input.

Tips

- Numerical problems can occur when the polygons have a large offset from the origin. To avoid this issue, translate the coordinates to a location closer to the origin before performing the operation. Then, undo the translation after completing the operation. For example:

```
[x,y] = polybool(flag,x1-xt,y1-yt,x2-xt,y2-yt);
```

```
x = x+xt;
```

```
y = y+yt;
```

Version History

Introduced before R2006a

R2018a: polybool is not recommended

Not recommended starting in R2018a

`polybool` is not recommended. Use `polyshape` instead.

To replace calls to `polybool`, create `polyshape` objects to represent the shapes, call the appropriate `polyshape` object function for the equivalent Boolean operation, and then call the `polyshape` boundary object function. For example, this call to `polybool` specifies the union operation as the first argument.

```
[Cx,Cy] = polybool('union',Ax,Ay,Bx,By)
```

To update this usage, create separate `polyshape` objects for each shape and then use the `union` object function associated with the `polyshape` object. `polyshape` supports the Boolean operations supported by `polybool`: union, intersection, subtraction, and exclusive OR. Use the `polyshape` boundary object function to return `Cx` and `Cy`. See `polyshape` for a complete list of object functions, including `plot`.

```
A = polyshape(Ax,Ay,'Simplify',false);  
B = polyshape(Bx,By,'Simplify',false);  
C = union(A,B);  
[Cx,Cy] = boundary(C);
```

Note that the polygon vertex order is likely to differ between the output from `polybool` and the output from the call to `boundary`, because there is no single right answer. (Even in a simple one-region polygon, the vertices can be permuted cyclically without affecting the underlying geometry.) In addition, if the geometries of the inputs are not perfectly clean (free from self-intersections, etc.), then the `polyshape` union operation may make small changes that are not necessarily performed in `polybool`.

See Also

`bufferm` | `flatearthpoly` | `ispolycw` | `poly2ccw` | `polyjoin` | `polysplit` | `poly2fv` | `poly2cw` | `polyshape`

polycut

Polygon branch cuts for holes

Syntax

```
[lat2,long2] = polycut(lat,long)
```

Description

`[lat2,long2] = polycut(lat,long)` connects the contour and holes of polygons using optimal branch cuts. Polygons are input as NaN-delimited vectors, or as cell arrays containing individual polygons in each element with the outer face separated from the subsequent inner faces by NaNs. Multiple polygons outputs are separated by NaNs.

Version History

Introduced before R2006a

See Also

`polyshape` | `polysplit` | `polyjoin`

Polygon Properties

Geographic polygon appearance and behavior

Description

Polygon properties control the appearance and behavior of a Polygon object. By changing property values, you can modify certain aspects of the polygon. Use dot notation to query and set properties.

```
shape = geopolyshape([1 10 1 1],[1 1 10 1] );
pg = geoplots(shape);
c = pg.FaceColor;
pg.FaceColor = "r";
```

Properties

Polygon

FaceColor — Polygon fill color

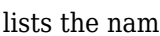
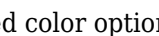


[0 0 0] (default) | 'flat' | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...

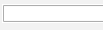
Polygon fill color, specified as 'flat', an RGB triplet, a hexadecimal color code, a color name, or a short name. The 'flat' option uses colors from the ColorData property. When the geoplots function sets the ColorData property, MATLAB updates this property to 'flat'.

For a custom color, specify an RGB triplet or a hexadecimal color code.

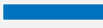






- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

Example: `pg.FaceColor = [0.1 0.5 0.2];`

Example: `pg.FaceColor = 'white';`

Example: `pg.FaceColor = 'none';`

EdgeColor — Polygon outline color




[0 0 0] (default) | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...






Polygon outline color, specified as an RGB triplet, a hexadecimal color code, a color name, or a short name.

For a custom color, specify an RGB triplet or a hexadecimal color code.


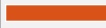

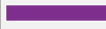

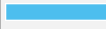

- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

Example: [0.5 0.5 0.5]

Example: 'blue'

Example: '#D2F9A7'

FaceAlpha – Polygon fill transparency

0.35 (default) | scalar in range [0, 1]

Polygon fill transparency, specified as a scalar in the range [0, 1]. A value of 1 is opaque and 0 is completely transparent. Values between 0 and 1 are semitransparent.

When the `geoplot` function sets the `ColorData` property, MATLAB updates this property to 1.

EdgeAlpha – Polygon outline transparency




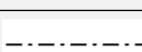
1 (default) | scalar in range [0, 1]

Polygon outline transparency, specified as a scalar in the range [0, 1]. A value of 1 is opaque and 0 is completely transparent. Values between 0 and 1 are semitransparent.

LineStyle – Line style

"-" (default) | "--" | ":" | "-." | "none"

Line style, specified as one of the options listed in this table.

Line Style	Description	Resulting Line
"_"	Solid line	
"--"	Dashed line	
":"	Dotted line	
"-."	Dash-dotted line	
"none"	No line	No line

LineWidth — Line width

0.5 (default) | positive value

Line width, specified as a positive value in points, where 1 point = 1/72 of an inch.

The line width cannot be thinner than the width of a pixel. If you set the line width to a value that is less than the width of a pixel on your system, the line displays as one pixel wide.

Color Data**ColorData — Polygon colors**

[] (default) | numeric vector

Polygon colors, specified as a numeric vector that linearly maps to the colors in the current colormap. The plot uses a different color for each element of ShapeData. Specify ColorData as a vector the same length as ShapeData.

The ColorData property controls the fill colors of the polygons when the FaceColor property has a value of 'flat'.

ColorDataMode — Control how ColorData is set

'auto' (default) | 'manual'

Control how the ColorData property is set, specified as one of these values:

- 'auto' — MATLAB controls the value of the ColorData property.
- 'manual' — You manually control the value of the ColorData property. When you set the ColorData property, MATLAB sets this property to 'manual'.

To specify colors using the ColorVariable property, this property must have a value of 'auto'.

SeriesIndex — Series index

non-negative integer

Series index, specified as a non-negative integer. This property is useful for reassigning the colors of several Polygon objects so that they match each other. By default, the SeriesIndex property of a Polygon object is a number that corresponds to the order of creation of the object, starting at 1.

MATLAB uses the number to calculate indices for assigning colors when you call plotting functions. The indices refer to the rows of the arrays stored in the ColorOrder property of the axes.

MATLAB automatically updates the color of the `Polygon` object when you change its `SeriesIndex`, or when you change `ColorOrder` property on the axes. However, the following conditions must be true for the changes to have any effect:

- The `ColorDataMode` property on the `Polygon` object has a value of `'auto'`.
- The `FaceColor` property on the `Polygon` object has a value of `'flat'`.
- The `SeriesIndex` property on the `Polygon` object is greater than 0.
- The `NextSeriesIndex` property on the axes object is greater than 0.

Shape Data

ShapeData — Polygon shapes

empty `geopolyshape` object (default) | `geopolyshape` or `mappolyshape` object | vector of `geopolyshape` or `mappolyshape` objects

Polygon shapes, specified as a `geopolyshape` or `mappolyshape` object or as a vector of `geopolyshape` or `mappolyshape` objects. For `mappolyshape` objects, the value of the `ProjectedCRS` property must not be empty.

When you pass shape objects or a geospatial table to the `geoplot` function, the `geoplot` function sets the value of `ShapeData`.

ShapeDataMode — Control how ShapeData is set

`'auto'` (default) | `'manual'`

Control how the `ShapeData` property is set, specified as one of these values:

- `'auto'` — MATLAB automatically updates the `ShapeData` property based on the `SourceTable` and `ShapeVariable` properties. When you pass a geospatial table to the `geoplot` function, MATLAB sets this property to `'auto'`.
- `'manual'` — You manually control the value of the `ShapeData` property. When you set the `ShapeData` property or pass shape objects to the `geoplot` function, MATLAB sets this property to `'manual'`.

Table Data

SourceTable — Source table

geospatial table

Source table containing the data to plot, specified as a geospatial table. A geospatial table is a `table` or `timetable` object that contains a `Shape` variable and attribute variables. For more information about geospatial tables, see “Create Geospatial Tables”.

ShapeVariable — Table variable containing shape objects

table variable index

Table variable containing the shape objects, specified as a table variable index. The table variable must contain `geopolyshape` or `mappolyshape` objects. For `mappolyshape` objects, the value of the `ProjectedCRS` property must not be empty.

When you pass a geospatial table to the `geoplot` function, the value of this property is `'Shape'`. When you set this property, MATLAB updates the `ShapeData` property.

This table lists the different indexing schemes you can use to specify the table variable.

Indexing Scheme	Examples
Variable name: <ul style="list-style-type: none"> • A string scalar or character vector. • A pattern object. The pattern object must refer to only one variable. 	<ul style="list-style-type: none"> • "A" or 'A' — A variable called A • "Var"+digitsPattern(1) — The variable with the name "Var" followed by a single digit
Variable index: <ul style="list-style-type: none"> • An index number that refers to the location of a variable in the table. • A logical vector. Typically, this vector is the same length as the number of variables, but you can omit trailing 0 or false values. 	<ul style="list-style-type: none"> • 3 — The third variable from the table • [false false true] — The third variable
Variable type: A vartype subscript that selects a table variable of a specified type. The subscript must refer to only one variable.	<ul style="list-style-type: none"> • vartype("double") — The variable containing values of type double

ColorVariable — Table variable containing color data

table variable index

Table variable containing the color data, specified as a variable index into the source table.

Specifying the Table Index

Use any of these indexing schemes to specify the desired variable.

Indexing Scheme	Examples
Variable name: <ul style="list-style-type: none"> • A string scalar or character vector. • A pattern object. The pattern object must refer to only one variable. 	<ul style="list-style-type: none"> • "A" or 'A' — A variable called A • "Var"+digitsPattern(1) — The variable with the name "Var" followed by a single digit
Variable index: <ul style="list-style-type: none"> • An index number that refers to the location of a variable in the table. • A logical vector. Typically, this vector is the same length as the number of variables, but you can omit trailing 0 or false values. 	<ul style="list-style-type: none"> • 3 — The third variable from the table • [false false true] — The third variable
Variable type: A vartype subscript that selects a table variable of a specified type. The subscript must refer to only one variable.	<ul style="list-style-type: none"> • vartype("double") — The variable containing values of data type double

Specifying Color Data

Specifying the ColorVariable property controls the fill colors of the polygons when the FaceColor property has a value of 'flat'.

Specify the values as a numeric vector that linearly maps to the colors in the current colormap. The plot uses a different color for each element of `ShapeData`.

When you set the `ColorVariable` property, MATLAB updates the `ColorData` property.

Legend

DisplayName — Legend label

' ' (default) | character vector | string scalar

Legend label, specified as a character vector or string scalar. The legend does not display until you call the `legend` command. If you do not specify the text, then legend sets the label using the form `'dataN'`.

Annotation — Control for including or excluding object from legend

Annotation object

This property is read-only.

Control for including or excluding the object from a legend, returned as an `Annotation` object. Set the underlying `IconDisplayStyle` property to one of these values:

- `'on'` — Include the object in the legend (default).
- `'off'` — Do not include the object in the legend.

For example, to exclude a graphics object, `go`, from the legend set the `IconDisplayStyle` property to `'off'`.

```
go.Annotation.LegendInformation.IconDisplayStyle = 'off';
```

Alternatively, you can control the items in a legend using the `legend` function. Specify the first input argument as a vector of the graphics objects to include. If you do not specify an existing graphics object in the first input argument, then it does not appear in the legend. However, graphics objects added to the axes after the legend is created do appear in the legend. Consider creating the legend after creating all the plots to avoid extra items.

Interactivity

Visible — State of visibility

'on' (default) | on/off logical value

State of visibility, specified as `'on'` or `'off'`, or as numeric or logical `1` (`true`) or `0` (`false`). A value of `'on'` is equivalent to `true`, and `'off'` is equivalent to `false`. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- `'on'` — Display the object.
- `'off'` — Hide the object without deleting it. You still can access the properties of an invisible object.

ContextMenu — Context menu

empty `GraphicsPlaceholder` array (default) | `ContextMenu` object

Context menu, specified as a `ContextMenu` object. Use this property to display a context menu when you right-click the object. Create the context menu using the `uicontextmenu` function.

Note If the `PickableParts` property is set to `'none'` or if the `HitTest` property is set to `'off'`, then the context menu does not appear.

Selected — Selection state

`'off'` (default) | on/off logical value

Selection state, specified as `'on'` or `'off'`, or as numeric or logical 1 (true) or 0 (false). A value of `'on'` is equivalent to true, and `'off'` is equivalent to false. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- `'on'` — Selected. If you click the object when in plot edit mode, then MATLAB sets its `Selected` property to `'on'`. If the `SelectionHighlight` property also is set to `'on'`, then MATLAB displays selection handles around the object.
- `'off'` — Not selected.

SelectionHighlight — Display of selection handles

`'on'` (default) | on/off logical value

Display of selection handles when selected, specified as `'on'` or `'off'`, or as numeric or logical 1 (true) or 0 (false). A value of `'on'` is equivalent to true, and `'off'` is equivalent to false. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- `'on'` — Display selection handles when the `Selected` property is set to `'on'`.
- `'off'` — Never display selection handles, even when the `Selected` property is set to `'on'`.

Callbacks

ButtonDownFcn — Mouse-click callback

`''` (default) | function handle | cell array | character vector

Mouse-click callback, specified as one of these values:

- Function handle
- Cell array containing a function handle and additional arguments
- Character vector that is a valid MATLAB command or function, which is evaluated in the base workspace (not recommended)

Use this property to execute code when you click the object. If you specify this property using a function handle, then MATLAB passes two arguments to the callback function when executing the callback:

- Clicked object — Access properties of the clicked object from within the callback function.
- Event data — Empty argument. Replace it with the tilde character (~) in the function definition to indicate that this argument is not used.

For more information on how to use function handles to define callback functions, see “Create Callbacks for Graphics Objects”.

Note If the `PickableParts` property is set to `'none'` or if the `HitTest` property is set to `'off'`, then this callback does not execute.

CreateFcn — Creation function`' '` (default) | function handle | cell array | character vector

Object creation function, specified as one of these values:

- Function handle.
- Cell array in which the first element is a function handle. Subsequent elements in the cell array are the arguments to pass to the callback function.
- Character vector containing a valid MATLAB expression (not recommended). MATLAB evaluates this expression in the base workspace.

For more information about specifying a callback as a function handle, cell array, or character vector, see “Create Callbacks for Graphics Objects”.

This property specifies a callback function to execute when MATLAB creates the object. MATLAB initializes all property values before executing the `CreateFcn` callback. If you do not specify the `CreateFcn` property, then MATLAB executes a default creation function.

Setting the `CreateFcn` property on an existing component has no effect.

If you specify this property as a function handle or cell array, you can access the object that is being created using the first argument of the callback function. Otherwise, use the `gcbo` function to access the object.

DeleteFcn — Deletion function`' '` (default) | function handle | cell array | character vector

Object deletion function, specified as one of these values:

- Function handle.
- Cell array in which the first element is a function handle. Subsequent elements in the cell array are the arguments to pass to the callback function.
- Character vector containing a valid MATLAB expression (not recommended). MATLAB evaluates this expression in the base workspace.

For more information about specifying a callback as a function handle, cell array, or character vector, see “Create Callbacks for Graphics Objects”.

This property specifies a callback function to execute when MATLAB deletes the object. MATLAB executes the `DeleteFcn` callback before destroying the properties of the object. If you do not specify the `DeleteFcn` property, then MATLAB executes a default deletion function.

If you specify this property as a function handle or cell array, you can access the object that is being deleted using the first argument of the callback function. Otherwise, use the `gcbo` function to access the object.

Callback Execution Control**Interruptible — Callback interruption**`'on'` (default) | on/off logical value

Callback interruption, specified as `'on'` or `'off'`, or as numeric or logical 1 (true) or 0 (false). A value of `'on'` is equivalent to `true`, and `'off'` is equivalent to `false`. Thus, you can use the value

of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

This property determines if a running callback can be interrupted. There are two callback states to consider:

- The running callback is the currently executing callback.
- The interrupting callback is a callback that tries to interrupt the running callback.

MATLAB determines callback interruption behavior whenever it executes a command that processes the callback queue. These commands include `drawnow`, `figure`, `uifigure`, `getframe`, `waitfor`, and `pause`.

If the running callback does not contain one of these commands, then no interruption occurs. MATLAB first finishes executing the running callback, and later executes the interrupting callback.

If the running callback does contain one of these commands, then the `Interruptible` property of the object that owns the running callback determines if the interruption occurs:

- If the value of `Interruptible` is `'off'`, then no interruption occurs. Instead, the `BusyAction` property of the object that owns the interrupting callback determines if the interrupting callback is discarded or added to the callback queue.
- If the value of `Interruptible` is `'on'`, then the interruption occurs. The next time MATLAB processes the callback queue, it stops the execution of the running callback and executes the interrupting callback. After the interrupting callback completes, MATLAB then resumes executing the running callback.

Note Callback interruption and execution behave differently in these situations:

- If the interrupting callback is a `DeleteFcn`, `CloseRequestFcn`, or `SizeChangedFcn` callback, then the interruption occurs regardless of the `Interruptible` property value.
 - If the running callback is currently executing the `waitfor` function, then the interruption occurs regardless of the `Interruptible` property value.
 - If the interrupting callback is owned by a `Timer` object, then the callback executes according to schedule regardless of the `Interruptible` property value.
-

Note When an interruption occurs, MATLAB does not save the state of properties or the display. For example, the object returned by the `gca` or `gcf` command might change when another callback executes.

BusyAction — Callback queuing

`'queue'` (default) | `'cancel'`

Callback queuing, specified as `'queue'` or `'cancel'`. The `BusyAction` property determines how MATLAB handles the execution of interrupting callbacks. There are two callback states to consider:

- The running callback is the currently executing callback.
- The interrupting callback is a callback that tries to interrupt the running callback.

The `BusyAction` property determines callback queuing behavior only when both of these conditions are met:

- The running callback contains a command that processes the callback queue, such as `drawnow`, `figure`, `uifigure`, `getframe`, `waitfor`, or `pause`.
- The value of the `Interruptible` property of the object that owns the running callback is `'off'`.

Under these conditions, the `BusyAction` property of the object that owns the interrupting callback determines how MATLAB handles the interrupting callback. These are possible values of the `BusyAction` property:

- `'queue'` — Puts the interrupting callback in a queue to be processed after the running callback finishes execution.
- `'cancel'` — Does not execute the interrupting callback.

PickableParts — Ability to capture mouse clicks

`'visible'` (default) | `'none'`

Ability to capture mouse clicks, specified as one of these values:

- `'visible'` — Capture mouse clicks only when visible. The `Visible` property must be set to `'on'`. The `HitTest` property determines if the `Polygon` object responds to the click or if an ancestor does.
- `'none'` — Cannot capture mouse clicks. Clicking the `Polygon` object passes the click to the object behind it in the current view of the figure window. The `HitTest` property of the `Polygon` object has no effect.

HitTest — Response to captured mouse clicks

`'on'` (default) | on/off logical value

Response to captured mouse clicks, specified as `'on'` or `'off'`, or as numeric or logical 1 (`true`) or 0 (`false`). A value of `'on'` is equivalent to `true`, and `'off'` is equivalent to `false`. Thus, you can use the value of this property as a logical value. The value is stored as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

- `'on'` — Trigger the `ButtonDownFcn` callback of the `Polygon` object. If you have defined the `ContextMenu` property, then invoke the context menu.
- `'off'` — Trigger the callbacks for the nearest ancestor of the `Polygon` object that has one of these:
 - `HitTest` property set to `'on'`
 - `PickableParts` property set to a value that enables the ancestor to capture mouse clicks

Note The `PickableParts` property determines if the `Polygon` object can capture mouse clicks. If it cannot, then the `HitTest` property has no effect.

BeingDeleted — Deletion status

on/off logical value

This property is read-only.

Deletion status, returned as an on/off logical value of type `matlab.lang.OnOffSwitchState`.

MATLAB sets the `BeingDeleted` property to `'on'` when the `DeleteFcn` callback begins execution. The `BeingDeleted` property remains set to `'on'` until the component object no longer exists.

Check the value of the `BeingDeleted` property to verify that the object is not about to be deleted before querying or modifying it.

Parent/Child

Parent — Parent

`GeographicAxes` object | `MapAxes` object

Parent, specified as a `GeographicAxes` object or `MapAxes` object.

Children — Children

empty `GraphicsPlaceholder` array

The object has no children. You cannot set this property.

HandleVisibility — Visibility of object handle

`'on'` (default) | `'off'` | `'callback'`

Visibility of the object handle in the `Children` property of the parent, specified as one of these values:

- `'on'` — Object handle is always visible.
- `'off'` — Object handle is invisible at all times. This option is useful for preventing unintended changes by another function. Set the `HandleVisibility` to `'off'` to temporarily hide the handle during the execution of that function.
- `'callback'` — Object handle is visible from within callbacks or functions invoked by callbacks, but not from within functions invoked from the command line. This option blocks access to the object at the command line, but permits callback functions to access it.

If the object is not listed in the `Children` property of the parent, then functions that obtain object handles by searching the object hierarchy or querying handle properties cannot return it. Examples of such functions include the `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close` functions.

Hidden object handles are still valid. Set the root `ShowHiddenHandles` property to `'on'` to list all object handles regardless of their `HandleVisibility` property setting.

Identifiers

Type — Type of graphics object

`'polygon'`

This property is read-only.

Type of graphics object, returned as `'polygon'`. Use this property to find all objects of a given type within a plotting hierarchy, for example, searching for the type using `findobj`.

Tag — Object identifier

`''` (default) | character vector | string scalar

Object identifier, specified as a character vector or string scalar. You can specify a unique `Tag` value to serve as an identifier for an object. When you need access to the object elsewhere in your code, you can use the `findobj` function to search for the object based on the `Tag` value.

UserData — User data

[] (default) | array

User data, specified as any MATLAB array. For example, you can specify a scalar, vector, matrix, cell array, character array, table, or structure. Use this property to store arbitrary data on an object.

If you are working in App Designer, create public or private properties in the app to share data instead of using the `UserData` property. For more information, see “Share Data Within App Designer Apps”.

Version History

Introduced in R2022a

See Also

Functions

`geoplot`

Objects

`geopolyshape` | `mappolyshape`

Properties

`GeographicAxes Properties` | `MapAxes Properties`

Topics

“Access Property Values”

“Graphics Object Properties”

polyjoin

Convert line or polygon parts from cell arrays to vector form

Syntax

```
[lat,lon] = polyjoin(latcells,loncells)
```

Description

`[lat,lon] = polyjoin(latcells,loncells)` converts polygons from cell array format to column vector format. In cell array format, each element of the cell array is a vector that defines a separate polygon.

Examples

```
latcells = {[1 2 3]'; 4; [5 6 7 8 NaN 9]'};
loncells = {[9 8 7]'; 6; [5 4 3 2 NaN 1]'};
[lat,lon] = polyjoin(latcells,loncells);
[lat lon]
```

```
ans =
     1     9
     2     8
     3     7
    NaN    NaN
     4     6
    NaN    NaN
     5     5
     6     4
     7     3
     8     2
    NaN    NaN
     9     1
```

Tips

A polygon may consist of an outer contour followed by holes separated with `NaNs`. In vector format, each vector may contain multiple faces separated by `NaNs`. There is no structural distinction between outer contours and holes in vector format.

Version History

Introduced before R2006a

See Also

polyshape | polysplit

Topics

“Create and Display Polygons”

polymerge

Merge line segments with matching endpoints

Syntax

```
[latMerged, lonMerged] = polymerge(lat, lon)
[latMerged, lonMerged] = polymerge(lat, lon, tol)
[latMerged, lonMerged] = polymerge(lat, lon, tol, outputFormat)
```

Description

`[latMerged, lonMerged] = polymerge(lat, lon)` accepts a multipart line in latitude-longitude with vertices stored in arrays `lat` and `lon`, and merges the parts wherever a pair of end points coincide. For this purpose, an end point can be either the first or last vertex in a given part. When a pair of parts are merged, they are combined into a single part and the duplicate common vertex is removed. If two first vertices coincide or two last vertices coincide, then the vertex order of one of the parts will be reversed. A merge is applied anywhere that the end points of exactly two distinct parts coincide, so that an indefinite number of parts can be chained together in a single call to `polymerge`. If three or more distinct parts share a common end point, however, the choice of which parts to merge is ambiguous and therefore none of the corresponding parts are connected at that common point.

The inputs `lat` and `lon` can be column or row vectors with NaN-separated parts (and identical NaN locations in each array), or they can be cell arrays with each part in a separate cell. The form of the output arrays, `latMerged` and `lonMerged`, matches the inputs in this regard.

`[latMerged, lonMerged] = polymerge(lat, lon, tol)` combines line segments whose endpoints are separated by less than the circular tolerance, `tol`. `tol` has the same units as the polygon input.

`[latMerged, lonMerged] = polymerge(lat, lon, tol, outputFormat)` allows you to request either the NaN-separated vector form for the output (set `outputFormat` to `'vector'`), or the cell array form (set `outputFormat` to `'cell'`).

Examples

Link Line Segments with Common Endpoints into Polygons

Construct column vectors representing coordinate values. The vectors use NaN separators to define four line segments.

```
lat = [3 2 NaN 1 2 NaN 5 6 NaN 3 4]';
lon = [13 12 NaN 11 12 NaN 15 16 NaN 13 14]';
```

Concatenate the segments with matching endpoints. Three of the line segments have overlapping end points, so `polymerge` returns two line segments.

```
[latm, lonm] = polymerge(lat,lon)
```

```
latm = 8×1
```

```
1  
2  
3  
4  
NaN  
5  
6  
NaN
```

```
lonm = 8×1
```

```
11  
12  
13  
14  
NaN  
15  
16  
NaN
```

Version History

Introduced before R2006a

See Also

[polyjoin](#) | [polysplit](#)

Topics

“Create and Display Polygons”

polysplit

Convert line or polygon parts from vector form to cell arrays

Syntax

```
[latcells,loncells] = polysplit(lat,lon)
```

Description

`[latcells,loncells] = polysplit(lat,lon)` returns the NaN-delimited segments of the vectors `lat` and `lon` as N-by-1 cell arrays with one polygon segment per cell. `lat` and `lon` must be the same size and have identically-placed NaNs. The polygon segments are column vectors if `lat` and `lon` are column vectors, and row vectors otherwise.

Examples

Extract and Join Polygons or Line Segments

Create two NaN-delimited arrays in the form of column vectors.

```
lat = [45.6 -23.47 78 NaN 43.9 -67.14 90 -89]';
lon = [13 -97.45 165 NaN 0 -114.2 -18 0]';
```

Split the column vectors into individual line segment cell arrays at the NaN separators using `polysplit`.

```
[latc,lonc] = polysplit(lat,lon)
```

```
latc=2×1 cell array
    {3×1 double}
    {4×1 double}
```

```
lonc=2×1 cell array
    {3×1 double}
    {4×1 double}
```

Inspect the contents of the cell arrays. Note that each cell array element contains a segment of the original line.

```
[latc{1} lonc{1}]
```

```
ans = 3×2
```

```
    45.6000    13.0000
   -23.4700   -97.4500
    78.0000   165.0000
```

```
[latc{2} lonc{2}]
```

```
ans = 4x2
    43.9000         0
   -67.1400  -114.2000
    90.0000   -18.0000
   -89.0000         0
```

You can reverse the process by using the `polyjoin` function.

```
[lat2,lon2] = polyjoin(latc,lonc);
```

Compare the original and joined segments. By definition, the logical comparison is false for the NaN delimiters.

```
[lat lon] == [lat2 lon2]
```

```
ans = 8x2 logical array
```

```
 1  1
 1  1
 1  1
 0  0
 1  1
 1  1
 1  1
 1  1
```

Test for global equality, including NaN values.

```
isequaln(lat,lat2) & isequaln(lon,lon2)
```

```
ans = logical
     1
```

Version History

Introduced before R2006a

See Also

`isShapeMultipart` | `polyshape` | `polyjoin`

Topics

“Create and Display Polygons”

polyxpoly

Intersection points for lines or polygon edges

Syntax

```
[xi,yi] = polyxpoly(x1,y1,x2,y2)
[xi,yi,ii] = polyxpoly(____)
[xi,yi] = polyxpoly(____,'unique')
```

Description

`[xi,yi] = polyxpoly(x1,y1,x2,y2)` returns the intersection points of two polylines in a planar, Cartesian system, with vertices defined by `x1`, `y1`, `x2` and `y2`. The output arguments, `xi` and `yi`, contain the *x*- and *y*-coordinates of each point at which a segment of the first polyline intersects a segment of the second. In the case of overlapping, collinear segments, the intersection is actually a line segment rather than a point, and both endpoints are included in `xi`, `yi`.

`[xi,yi,ii] = polyxpoly(____)` returns a two-column array of line segment indices corresponding to the intersection points. The *k*-th row of `ii` indicates which polyline segments give rise to the intersection point `xi(k)`, `yi(k)`.

To remember how these indices work, just think of segments and vertices as fence sections and posts. The *i*-th fence section connects the *i*-th post to the (*i*+1)-th post. In general, letting *i* and *j* denote the scalar values comprised by the *k*-th row of `ii`, the intersection indicated by that row occurs where the *i*-th segment of the first polyline intersects the *j*-th segment of the second polyline. But when an intersection falls precisely on a vertex of the first polyline, then *i* is the index of that vertex. Likewise with the second polyline and the index *j*. In the case of an intersection at the *i*-th vertex of the first line, for example, `xi(k)` equals `x1(i)` and `yi(k)` equals `y1(i)`. In the case of intersections between vertices, *i* and *j* can be interpreted as follows: the segment connecting `x1(i)`, `y1(i)` to `x1(i+1)`, `y1(i+1)` intersects the segment connecting `x2(j)`, `y2(j)` to `x2(j+1)`, `y2(j+1)` at the point `xi(k)`, `yi(k)`.

`[xi,yi] = polyxpoly(____,'unique')` filters out duplicate intersections, which may result if the input polylines are self-intersecting.

Examples

Find Intersection Points Between Rectangle and Polyline

Define and fill a rectangular area in the plane.

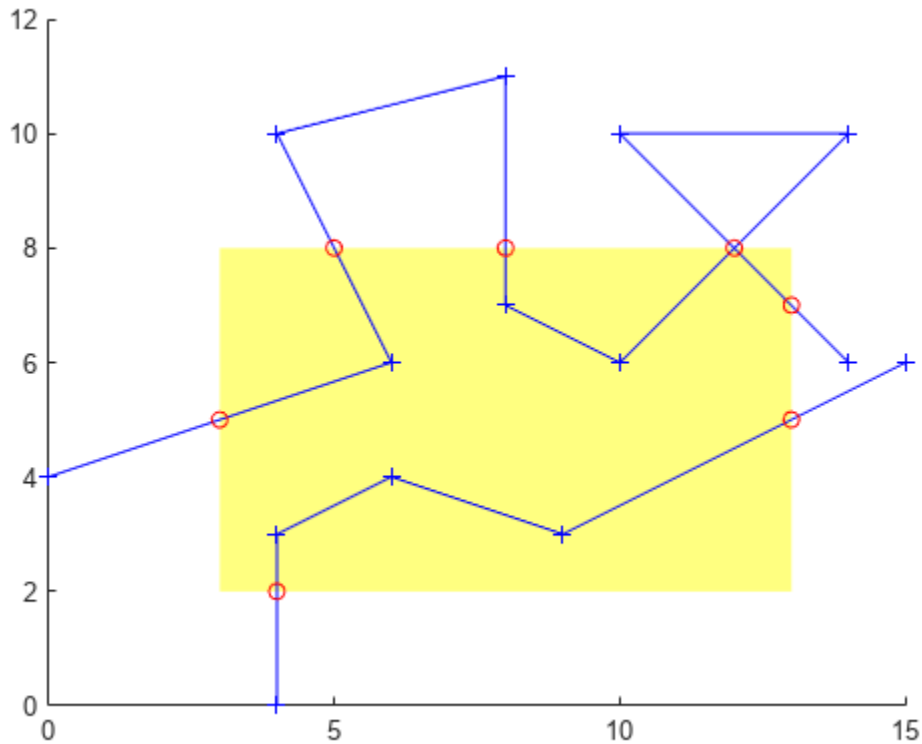
```
xlimit = [3 13];
ylimit = [2 8];
xbox = xlimit([1 1 2 2 1]);
ybox = ylimit([1 2 2 1 1]);
mapshow(xbox,ybox,'DisplayType','polygon','LineStyle','none')
```

Define and display a two-part polyline.

```
x = [0 6 4 8 8 10 14 10 14 NaN 4 4 6 9 15];
y = [4 6 10 11 7 6 10 10 6 NaN 0 3 4 3 6];
mapshow(x,y, 'Marker', '+')
```

Intersect the polyline with the rectangle.

```
[xi,yi] = polyxpoly(x,y,xbox,ybox);
mapshow(xi,yi, 'DisplayType', 'point', 'Marker', 'o')
```



Display the intersection points; note that the point (12, 8) appears twice because of a self-intersection near the end of the first part of the polyline.

```
[xi yi]
```

```
ans = 8x2
```

```
3.0000 5.0000
5.0000 8.0000
8.0000 8.0000
12.0000 8.0000
12.0000 8.0000
13.0000 7.0000
13.0000 5.0000
4.0000 2.0000
```

You can suppress this duplicate point by using the 'unique' option.

```
[xi,yi] = polyxpoly(x,y,xbox,ybox,'unique');
[xi yi]

ans = 7×2

    3.0000    5.0000
    5.0000    8.0000
    8.0000    8.0000
   12.0000    8.0000
   13.0000    7.0000
   13.0000    5.0000
    4.0000    2.0000
```

Find Intersection Points Between State Border and Small Circle

Read state polygons into a geospatial table. Create a subtable that contains the California polygon. Display the polygon on a map.

```
states = readgeotable("usastatehi.shp");
row = states.Name == "California";
california = states(row,:);
```

```
figure
usamap("california")
geoshow(california,"FaceColor","none")
```

Define a small circle centered off the coast of California.

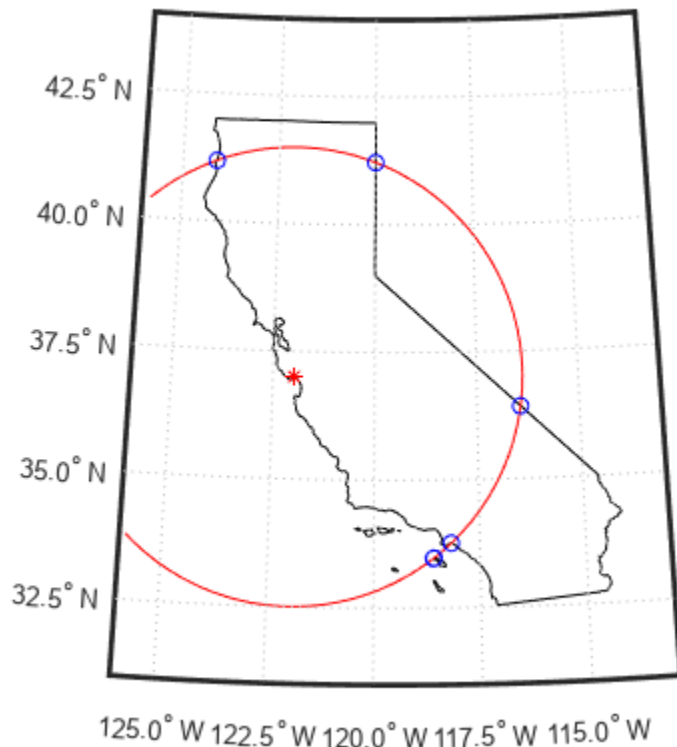
```
lat0 = 37;
lon0 = -122;
rad = 500;
[latc,lonc] = scircle1(lat0,lon0,km2deg(rad));
plotm(lat0,lon0,"r*")
plotm(latc,lonc,"r")
```

Extract the latitude and longitude coordinates of the California polygon from the geospatial table.

```
T = geotable2table(california,["Latitude","Longitude"]);
[lat,lon] = polyjoin(T.Latitude',T.Longitude');
```

Find the intersection points between the state of California and the small circle.

```
[loni,lati] = polyxpoly(lon,lat,lonc,latc);
plotm(lati,loni,"bo")
```



Input Arguments

x1, y1, x2, y2 — Coordinates of polylines

numeric vector

x- or y-coordinates of points in the first or second polyline, specified as a numeric vector. For a given polyline, the x- and y-coordinate vectors must be the same length.

Output Arguments

xi, yi — Coordinates of intersection points

numeric column vector

x- or y-coordinates of intersection points, specified as a numeric column vector.

ii — line segment indices

numeric vector

Line segment indices of intersection points, specified as a numeric vector.

Tips

- If the spacing between points is large, the intersections calculated by the `polyxpoly` function and the intersections shown on a map display might be different. This is a result of differences

between straight lines in the unprojected and projected coordinates. Similarly, there might be differences between the polyxpoly result and intersections that assume great circles or rhumb lines between points.

Version History

Introduced before R2006a

See Also

crossfix | gcxgc | gcxsc | navfix | rhxrh | scxsc

previewmap

View figure at printed size

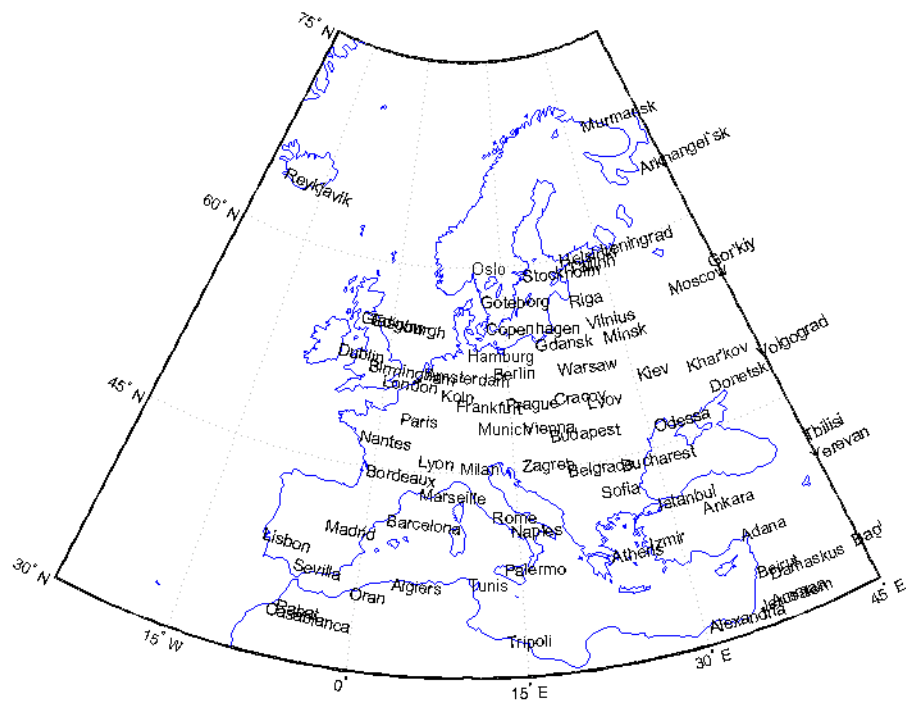
Description

The appearance of a map onscreen can differ from the final printed output. This results from the difference in the size and shape of the figure window and the area the figure occupies on the printed page. A map that appears readable on screen might be cluttered when the printed output is smaller. Likewise, the relative position of multiple axes can appear different when printed. This function resizes the figure to the printed size.

Examples

Is the text small enough to avoid overlapping in a map of Europe?

```
figure
worldmap europe
land=shaperead('landareas.shp','UseGeoCoords',true);
geoshow([land.Lat],[land.Lon])
m=gcm;
latlim = m.maplatlimit;
lonlim = m.maplonlimit;
BoundingBox = [lonlim(1) latlim(1);lonlim(2) latlim(2)];
cities=shaperead('worldcities.shp', ...
    'BoundingBox',BoundingBox,'UseGeoCoords',true);
for index=1:numel(cities)
    h=textm(cities(index).Lat, cities(index).Lon, ...
        cities(index).Name);
    trimcart(h)
    rotatetext(h)
end
orient landscape
tightmap
axis off
previewmap
```



Limitations

The figure cannot be made larger than the screen.

Tips

previewmap changes the size of the current figure to match the printed output. If the resulting figure size exceeds the screen size, the figure is enlarged as much as possible.

Version History

Introduced before R2006a

See Also

printpreview | paperscale | axesscale

projcrs

Projected coordinate reference system object

Description

A projected coordinate reference system (CRS) provides information that assigns Cartesian x and y map coordinates to physical locations. Projected CRSs consist of a geographic CRS and several parameters that are used to transform coordinates to and from the geographic CRS. For more information about geographic CRSs, see `geocrs`.

Creation

You can create a projected CRS object in several ways:

- Import raster data by using `readgeoraster`, and then query the `ProjectedCRS` property of the returned raster reference object.
- Import vector data by using the `readgeotable` function, and then query the `ProjectedCRS` property of the shape objects in the returned geospatial table.
- Get information about a shapefile by using the `shapeinfo` function, and then query the `CoordinateReferenceSystem` field of the returned structure.
- Use the `projcrs` function (described here).

Syntax

```
p = projcrs(code)
p = projcrs(code,"Authority",authority)
p = projcrs(wkt)
```

Description

`p = projcrs(code)` creates a projected CRS object using the EPSG code specified by `code`.

`p = projcrs(code,"Authority",authority)` creates a projected CRS object using the specified code and authority.

`p = projcrs(wkt)` creates a projected CRS object using the well-known text (WKT) string representation specified by `wkt`.

Input Arguments

code — Projected CRS code

positive integer | string scalar | character vector

Projected CRS code, specified as a positive integer, string scalar, or character vector. By default, the `projcrs` function assumes the `code` argument is an EPSG code. To specify other types of codes, use the `Authority` name-value argument.

To refer to an EPSG or ESRI code, specify this argument as a positive integer. To refer to an IGNF code, specify this argument as a string scalar or character vector.

For information on valid EPSG codes, see the EPSG home page.

authority — Organization that manages definition of CRS

"EPSG" (default) | "ESRI" | "IGNF"

Organization that manages the definition of the CRS, specified as "EPSG", "ESRI", or "IGNF". Each organization maintains a list of codes associated with specific CRSs.

If you do not specify an authority, then the `proj crs` function uses "EPSG".

wkt — Well-known text

string scalar | character vector

Well-known text (WKT), specified as a string scalar or character vector. You can specify WKT using either the WKT 1 or WKT 2 standard.

The parameters listed in the `ProjectionParameters` property use the WKT 2 standard, even if you specify text that uses the WKT 1 standard.

Properties

Name — CRS name

string scalar

CRS name, specified as a string scalar.

Changing the value of a projection parameter stored in the `ProjectionParameters` property can automatically change the value of this property to "". If you manually change the value of the `Name` property, then changing a projection parameter does not automatically change this property.

Data Types: `string`

GeographicCRS — Geographic CRS

`geocrs` object

This property is read-only.

Geographic CRS, returned as a `geocrs` object. A geographic CRS consists of a datum (including its ellipsoid), prime meridian, and angular unit of measurement.

LengthUnit — Length unit

string scalar

This property is read-only.

Length unit, returned as a string scalar. Possible values include "meter" and "U.S. survey foot".

Data Types: `string`

ProjectionMethod — Projection method

string scalar

This property is read-only.

Projection method, returned as a string scalar. Possible values include "Lambert Conic Conformal (2SP)" and "Transverse Mercator".

Data Types: string

ProjectionParameters — Projection parameters

ProjectionParameters object

Projection parameters, specified as a ProjectionParameters object. The parameters in a ProjectionParameters object use the WKT 2 standard, even if the supplied wkt argument uses the WKT 1 standard.

You can access and change individual projection parameters using dot notation. For example, create a projcrs object and access the LatitudeOfFalseOrigin parameter.

```
p = projcrs(26986);
p.ProjectionParameters.LatitudeOfFalseOrigin
```

This table describes common projection parameters, including those used by the Lambert Conformal Conic and Transverse Mercator projection methods. Other projection methods might use different parameters than those listed. Other projection methods might have ranges for valid values that are narrower than those listed.

Parameter	Description
EastingAtFalseOrigin	Easting at the false origin, specified as a number in the units specified by LengthUnit. A projected CRS often uses a false origin such that all coordinates within the CRS have positive values. The easting at the false origin is with respect to the grid origin at (0, 0).
FalseEasting	False easting, specified as a number in the units specified by LengthUnit. A projected CRS often uses a false easting to shift the y-axis of the map grid so that the x-coordinates have positive values.
FalseNorthing	False northing, specified as a number in the units specified by LengthUnit. A projected CRS often uses a false northing to shift the x-axis of the map grid so that the y-coordinates have positive values.
LatitudeOf1stStandardParallel	Latitude of the first standard parallel, in degrees, specified as a number in the range [-90, 90]. Standard parallels are the parallels at which the cone or cylinder used in a conic or cylindrical projection intersects the reference spheroid.

Parameter	Description
LatitudeOf2ndStandardParallel	Latitude of the second standard parallel, in degrees, specified as a number in the range [-90, 90]. Standard parallels are the parallels at which the cone or cylinder used in a conic or cylindrical projection intersects the reference spheroid.
LatitudeOfFalseOrigin	Latitude of false origin, in degrees, specified as a number in the range [-90, 90]. A projected CRS typically uses a false origin such that all coordinates within the CRS have positive values.
LatitudeOfNaturalOrigin	Latitude of the natural origin, in degrees, specified as a number in the range [-90, 90]. The natural origin is the grid origin without the shift by a false northing or easting.
LongitudeOfFalseOrigin	Longitude of false origin, in degrees, specified as a number in the range [-180, 180]. A projected CRS typically uses a false origin such that all coordinates within the CRS have positive values.
LongitudeOfNaturalOrigin	Longitude of the natural origin, in degrees, specified as a number in the range [-180, 180]. The natural origin is the grid origin without the shift by a false northing or easting.
NorthingAtFalseOrigin	Northing at the false origin, specified as a number in the units specified by LengthUnit. A projected CRS typically uses a false origin such that all coordinates within the CRS have positive values. The northing at the false origin is with respect to the grid origin at (0, 0).
ScaleFactorAtNaturalOrigin	Scale factor at the natural origin, specified as a number with no units in the range [0.9, 1.1]. The natural origin is the grid origin without the shift by a false northing or easting. A projected CRS typically uses a scale factor (a number close to 1) to balance scale distortion across the area covered by the coordinate system.

When you change the value of a projection parameter, the `projcrs` object removes the name, area of use, and authority from the WKT associated with the object. As a result, changing the value of a projection parameter can automatically change the value of the `Name` property to "".

Object Functions

`projfwd` Project latitude-longitude coordinates to x-y map coordinates
`projinv` Unproject x-y map coordinates to latitude-longitude coordinates
`wktstring` Well-known text string
`isequal` Compare two `projcrs` or `geocrs` objects for equivalence

Examples

Get Projected CRS from EPSG Code

Create a projected CRS object by specifying an EPSG code.

```
p = projcrs(5325)

p =
  projcrs with properties:
      Name: "ISN2004 / Lambert 2004"
  GeographicCRS: [1x1 geocrs]
  ProjectionMethod: "Lambert Conic Conformal (2SP)"
      LengthUnit: "meter"
  ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

Get Projected CRS from ESRI Code

Create a projected CRS object from an ESRI code by using the `Authority` name-value argument.

```
p = projcrs(53026,"Authority","ESRI")

p =
  projcrs with properties:
      Name: "Sphere_Stereographic"
  GeographicCRS: [1x1 geocrs]
  ProjectionMethod: "Stereographic"
      LengthUnit: "meter"
  ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

Get Projected CRS from IGNF Code

Create a projected CRS object from an IGNF code by using the `Authority` name-value argument. Specify the code using a string scalar or character vector.

```
p = projcrs("UTM39SW84","Authority","IGNF")

p =
  projcrs with properties:
      Name: "WGS84 UTM SUD FUSEAU 39"
  GeographicCRS: [1x1 geocrs]
  ProjectionMethod: "Transverse Mercator"
      LengthUnit: "meter"
  ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

Get Projected CRS from Projection File

Import a WKT projection file as a character vector by using the `fileread` function. Then create a projected CRS object by specifying the vector.

```
wkt = fileread('MtWashington-ft.prj');
p = projcrs(wkt)

p =
  projcrs with properties:
      Name: "UTM Zone 19, Northern Hemisphere"
  GeographicCRS: [1x1 geocrs]
  ProjectionMethod: "Transverse Mercator"
      LengthUnit: "meter"
  ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

Get Projected CRS from Imported Raster Data

Import raster data as an array and a map reference object using the `readgeoraster` function. Then, get the projected CRS by querying the `ProjectedCRS` property of the reference object.

```
[Z,R] = readgeoraster('boston.tif');
R.ProjectedCRS

ans =
  projcrs with properties:
      Name: "NAD83 / Massachusetts Mainland"
  GeographicCRS: [1x1 geocrs]
  ProjectionMethod: "Lambert Conic Conformal (2SP)"
      LengthUnit: "U.S. survey foot"
  ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

Alternatively, return information about the same file as a `RasterInfo` object using the `georasterinfo` function. Then, get the projected CRS by querying the `CoordinateReferenceSystem` property of the object.

```
info = georasterinfo('boston.tif');
info.CoordinateReferenceSystem

ans =
  projcrs with properties:
      Name: "NAD83 / Massachusetts Mainland"
  GeographicCRS: [1x1 geocrs]
  ProjectionMethod: "Lambert Conic Conformal (2SP)"
      LengthUnit: "U.S. survey foot"
  ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

Change Projection Parameters of Projected CRS

Get the projection parameters for a projected CRS by creating a `projcrs` object and querying its `ProjectionParameters` property.

```
p = projcrs(32644);
parameters = p.ProjectionParameters

parameters =
  ProjectionParameters object with parameters:

    LatitudeOfNaturalOrigin: 0
    LongitudeOfNaturalOrigin: 81
    ScaleFactorAtNaturalOrigin: 0.9996
    FalseEasting: 500000
    FalseNorthing: 0
```

Query an individual projection parameter by using dot notation.

```
p.ProjectionParameters.ScaleFactorAtNaturalOrigin

ans = 0.9996
```

Change the value of a projection parameter by using dot notation (*since R2023a*).

```
p.ProjectionParameters.LongitudeOfNaturalOrigin = 87;
```

Tips

When you compare two `ProjectionParameters` objects by using the `isequal` function, the function might return `0` (`false`), even when the parameter values are the same. Instead, compare `ProjectionParameters` objects by comparing the `projcrs` objects or by comparing the parameter values directly.

Version History

Introduced in R2020b

R2023a: Change `ProjectionParameters` and `Name` properties

Change the values of projection parameters for a projected CRS by changing parameters of the object stored in the `ProjectionParameters` property. Change the name of a projected CRS by setting the `Name` property.

In previous releases, the `ProjectionParameters` and `Name` properties were read-only.

See Also

Functions

`fileread` | `projfwd` | `projinv`

Objects

geocrs

Topics

“Change Projection and Projection Parameters”

External Websites

EPSG home page

project

(Removed) Project displayed map graphics object

Note The `project` function has been removed. Use the `proj fwd` function instead.

Syntax

```
project(h)
project(h, 'xy')
project(h, 'yx')
```

Description

`project(h)` takes unprojected objects with handles `h` that are displayed on `axesm`-based maps and projects them. For example, `project` takes a line created on an `axesm`-based map with the `plot` function and projects it as though it had been created with the `plotm` function. This can be useful if a standard MATLAB function was accidentally executed. The map structure of the existing `axesm`-based map determines the specifics of the projection. If `h` is the handle of the `axesm`-based map, then all the children of `h` are projected. Do not attempt this if any children of `h` have already been projected!

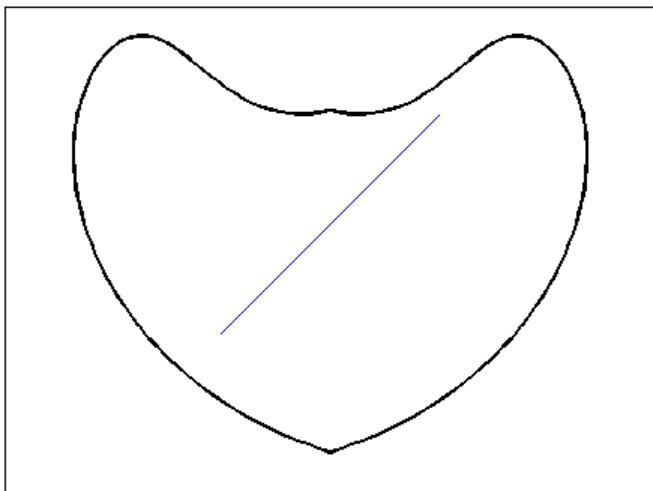
`project(h, 'xy')` specifies that the `XData` of the unprojected objects corresponds to longitudes and the `YData` to latitudes. This is the default assumption.

`project(h, 'yx')` specifies that the `XData` of the unprojected objects corresponds to latitudes and the `YData` to longitudes.

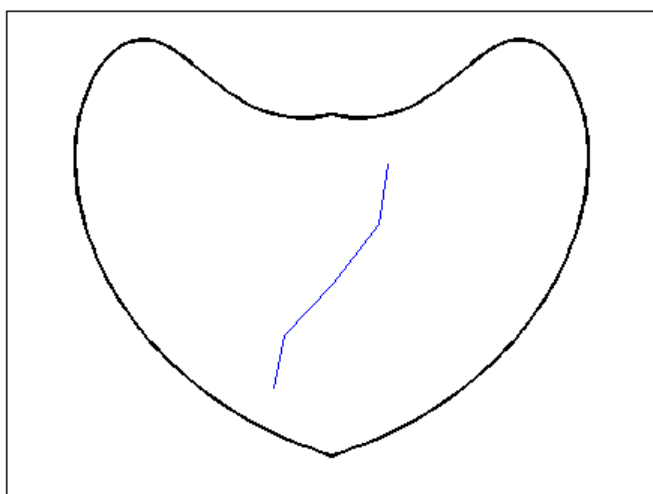
Examples

Create an axes, plot a line, then project it:

```
axesm('bonne','AngleUnits','radians');framem;
h = plot([-1 -.5 0 .5 1],[-1 -.5 0 .5 1]);
```

`project(h)`



The line is straight in x - y space, but when converted to a projected map object, it bends with the projection.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `project` function has been removed. Use the `proj fwd` function instead.

R2022a: Warns

Warns starting in R2022a

The `project` function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The `project` function runs without warning but will be removed in a future release.

See Also

`projfwd`

projfwd

Project latitude-longitude coordinates to x-y map coordinates

Syntax

```
[x,y] = projfwd(proj,lat,lon)
```

Description

`[x,y] = projfwd(proj,lat,lon)` transforms the latitude-longitude coordinates specified by `lat` and `lon` to the `x` and `y` map coordinates in the projected coordinate reference system specified by `proj`. Specify `proj` using a `projcrs` object (*since R2020b*), a map projection structure, or a GeoTIFF information structure.

Examples

Project Latitude-Longitude Coordinates to x-y

Project latitude-longitude coordinates to x-y coordinates by specifying a map projection. Then, display the projected coordinates on a map.

To do this, first specify the latitude and longitude coordinates of landmarks in Boston. Specify the coordinates in the NAD83 geographic CRS.

```
lat = [42.3604 42.3691 42.3469 42.3480 42.3612];
lon = [-71.0580 -71.0710 -71.0623 -71.0968 -71.0941];
```

Then, import a GeoTIFF image of Boston as an array and a map cells reference object. Get information about the map projection by querying the `ProjectedCRS` property of the reference object. Verify that the geographic CRS underlying the projected CRS is NAD83.

```
[A,R] = readgeoraster('boston.tif');
proj = R.ProjectedCRS;
proj.GeographicCRS.Name
```

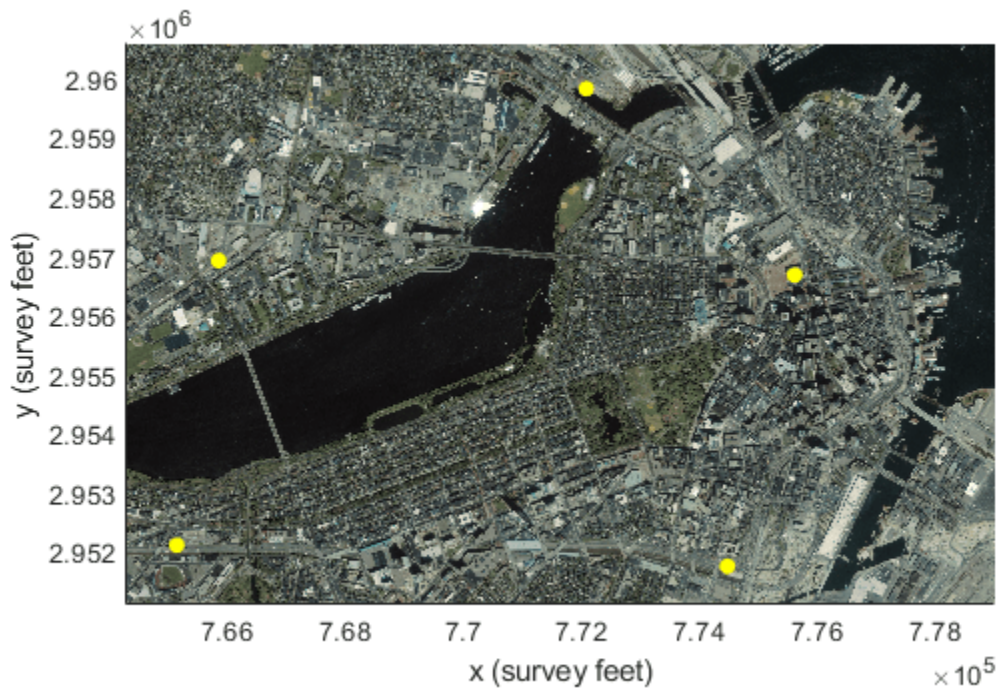
```
ans =
"NAD83"
```

Project the latitude-longitude coordinates to x-y coordinates using the same projected CRS as the GeoTIFF image.

```
[x,y] = projfwd(proj,lat,lon);
```

Display the GeoTIFF image and the projected coordinates on the same map. Change the marker symbol and color of the coordinates so they are more visible. Then, add axis labels.

```
mapshow(A,R)
mapshow(x,y,'DisplayType','point','Marker','o',...
'MarkerFaceColor','y','MarkerEdgeColor','none')
xlabel('x (survey feet)')
ylabel('y (survey feet)')
```



Input Arguments

proj — Map projection

`projcrs` object | scalar map projection structure | scalar GeoTIFF information structure

Map projection, specified as a `projcrs` object (*since R2020b*), a scalar map projection structure (`mstruct`), or a GeoTIFF information structure. For more information about map projection structures, see `defaultm`. For more information about GeoTIFF information structures, see `geotiffinfo`.

Data Types: `struct`

lat — Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes, specified as a scalar value, vector, matrix, or N-D array, in units of degrees. The size of `lat` and `lon` must match.

Data Types: `single` | `double`

lon — Geodetic longitudes

scalar value | vector | matrix | N-D array

Geodetic longitudes, specified as a scalar value, vector, matrix, or N-D array, in units of degrees. The size of `lat` and `lon` must match.

Data Types: `single` | `double`

Output Arguments

x — Projected x-coordinates

scalar value | vector | matrix | N-D array

Projected x-coordinates, returned as a scalar value, vector, matrix, or N-D array.

y — Projected y-coordinates

scalar value | vector | matrix | N-D array

Projected y-coordinates, returned as a scalar value, vector, matrix, or N-D array.

Tips

If the geographic CRS of `lat` and `lon` does not match the geographic CRS of `proj`, then the values of `x` and `y` may be inaccurate. When `proj` is a `projcrs` object, you can find its geographic CRS by querying its `GeographicCRS` property. For example, this code shows how to create a `projcrs` object from EPSG code 32610 and find the associated geographic CRS.

```
proj = projcrs(32610);
proj.GeographicCRS.Name
```

```
ans =
    'WGS 84'
```

Version History

Introduced before R2006a

R2022b: projfwd shows improved performance on Windows with repeated use of projection

The `projfwd` and `projinv` functions show improved performance on Windows when used multiple times in the same MATLAB session with the same `projcrs` object or map projection structure as input.

For example, this code is about 1.67 times faster than in the previous release. The code:

- Gets the grid coordinates for a DTED file
- Projects and unprojects the coordinates using a `projcrs` object
- Gets the grid coordinates for a different DTED file
- Measures the time required to project and unproject the coordinates using the same `projcrs` object

```
function timingTest
    infol = georasterinfo("n39_w106_3arc_v2.dtl");
    R1 = infol.RasterReference;
    [latGrid1,lonGrid1] = geographicGrid(R1);
```

```
p = projcrs(4088);
[xfwd1,yfwd1] = projfwd(p,latGrid1,lonGrid1);
[latinv1,loninv1] = projinv(p,xfwd1,yfwd1);

info2 = georasterinfo("n40_w106_3arc_v2.dt1");
R2 = info2.RasterReference;
[latGrid2,lonGrid2] = geographicGrid(R2);

tic
[xfwd2,yfwd2] = projfwd(p,latGrid2,lonGrid2);
[latinv2,loninv2] = projinv(p,xfwd2,yfwd2);
toc
end
```

The approximate execution times are:

- **R2022a:** 0.70 s
- **R2022b:** 0.42 s

This code was timed on a Windows 10 Intel Xeon CPU W-2133 @ 3.6 GHz test system, by calling the function `timingTest`.

R2020b: Project coordinates using projcrs objects and additional map projection structures

Project coordinates by specifying a `projcrs` object. A `projcrs` object enables you to transform coordinates using projection methods not available in earlier releases, such as Hotine Oblique Mercator.

Additionally, you can project coordinates by specifying a map projection structure with any valid `mapprojection` field. For a list of `mapprojection` field options, use the `maplist` or `maps` function.

See Also

Functions

`geotiffinfo` | `projinv` | `projlist`

Objects

`projcrs`

Topics

“Project and Display Raster Data”

“Transform Coordinates to a Different Projected CRS”

projinv

Unproject x-y map coordinates to latitude-longitude coordinates

Syntax

```
[lat,lon] = projinv(proj,x,y)
```

Description

`[lat,lon] = projinv(proj,x,y)` transforms the map coordinates specified by `x` and `y` in the projected coordinate reference system specified by `proj` to the latitude-longitude coordinates `lat` and `lon`. Specify `proj` using a `projcrs` object (*since R2020b*), a map projection structure, or a GeoTIFF information structure.

Examples

Unproject x-y Coordinates to Latitude-Longitude

Unproject x-y coordinates to latitude-longitude coordinates by specifying the projected CRS of the x-y coordinates. Then, display the latitude-longitude coordinates on geographic axes.

To do this, first import a shapefile containing the x- and y-coordinates of roads in Concord, MA. Get information about the shapefile as a structure. Find the projected CRS for the coordinates by accessing the `CoordinateReferenceSystem` field of the structure.

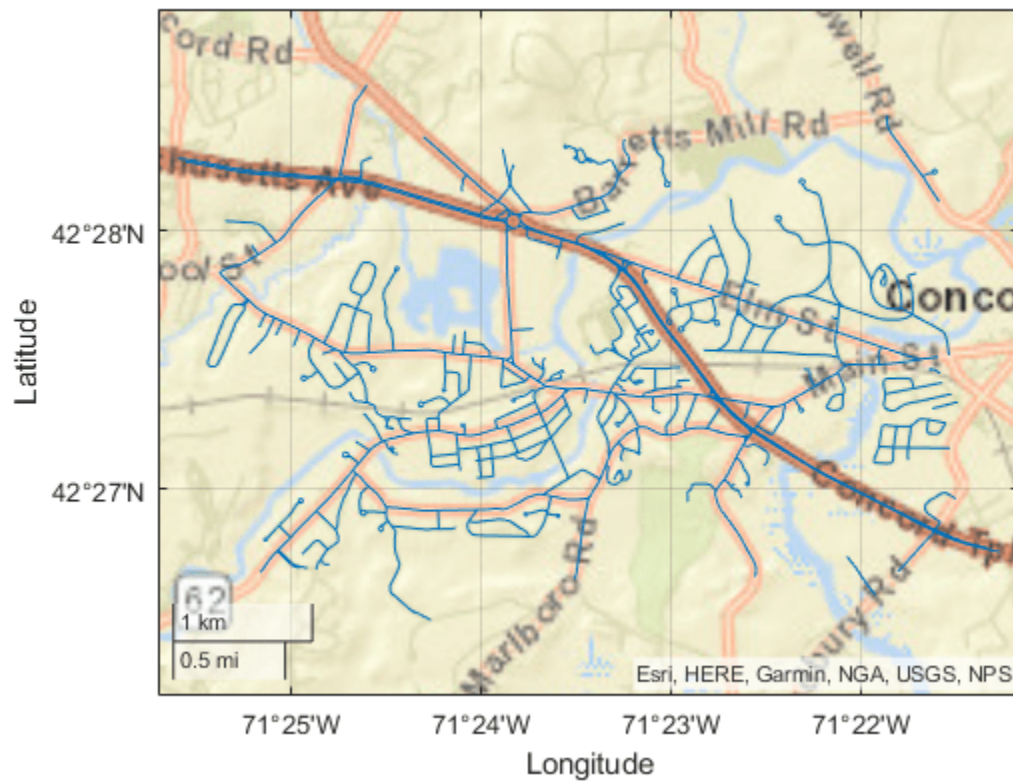
```
roads = shaperead('concord_roads.shp');  
x = [roads.X];  
y = [roads.Y];  
info = shapeinfo('concord_roads.shp');  
proj = info.CoordinateReferenceSystem;
```

Unproject the x-y coordinates to latitude-longitude coordinates.

```
[lat,lon] = projinv(proj,x,y);
```

Display the coordinates on geographic axes.

```
figure  
geoplot(lat,lon)  
hold on  
geobasemap('streets')
```



The geographic CRS of the x - y coordinates used in this example is NAD83. You can find the geographic CRS that underlies a projected CRS by querying the `GeographicCRS` property.

```
proj.GeographicCRS.Name
```

```
ans =  
"NAD83"
```

The geographic CRS underlying the 'streets' basemap is WGS84. NAD83 and WGS84 are similar, but not identical. Therefore, at high zoom levels the coordinates and basemap may appear misaligned.

Input Arguments

proj — Map projection

`projcrs` object | scalar map projection structure | scalar GeoTIFF information structure

Map projection, specified as a `projcrs` object (*since R2020b*), a scalar map projection structure (`mstruct`), or a GeoTIFF information structure. For more information about map projection structures, see `defaultm`. For more information about GeoTIFF information structures, see `geotiffinfo`.

Data Types: `struct`

x — Projected x -coordinates

scalar value | vector | matrix | N-D array

Projected x-coordinates, specified as a scalar value, vector, matrix, or N-D array. The size of x and y must match.

Data Types: `single` | `double`

y — Projected y-coordinates

scalar value | vector | matrix | N-D array

Projected y-coordinates, specified as a scalar value, vector, matrix, or N-D array. The size of x and y must match.

Data Types: `single` | `double`

Output Arguments

lat — Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes, returned as a scalar value, vector, matrix, or N-D array, in units of degrees.

The geographic CRS of `lat` matches the geographic CRS of `proj`. If `proj` is a `projcrs` object, then you can find its geographic CRS by querying its `GeographicCRS` property. For example, this code shows how to create a `projcrs` object from EPSG code 32610 and find the associated geographic CRS.

```
proj = projcrs(32610);
proj.GeographicCRS.Name
```

```
ans =
```

```
    "WGS 84"
```

lon — Geodetic longitudes

scalar value | vector | matrix | N-D array

Geodetic longitudes, returned as a scalar value, vector, matrix, or N-D array, in units of degrees.

The geographic CRS of `lat` matches the geographic CRS of `proj`. If `proj` is a `projcrs` object, then you can find its geographic CRS by querying its `GeographicCRS` property. For example, this code shows how to create a `projcrs` object from EPSG code 32610 and find the associated geographic CRS.

```
proj = projcrs(32610);
proj.GeographicCRS.Name
```

```
ans =
```

```
    "WGS 84"
```

Version History

Introduced before R2006a

R2022b: `projinv` shows improved performance on Windows with repeated use of projection

The `projinv` and `projfwd` functions show improved performance on Windows when used multiple times in the same MATLAB session with the same `projcrs` object or map projection structure as input.

For example, this code is about 1.67 times faster than in the previous release. The code:

- Gets the grid coordinates for a DTED file
- Projects and unprojects the coordinates using a `projcrs` object
- Gets the grid coordinates for a different DTED file
- Measures the time required to project and unproject the coordinates using the same `projcrs` object

```
function timingTest
    info1 = georasterinfo("n39_w106_3arc_v2.dt1");
    R1 = info1.RasterReference;
    [latGrid1,lonGrid1] = geographicGrid(R1);

    p = projcrs(4088);
    [xfwd1,yfwd1] = projfwd(p,latGrid1,lonGrid1);
    [latin1,loninv1] = projinv(p,xfwd1,yfwd1);

    info2 = georasterinfo("n40_w106_3arc_v2.dt1");
    R2 = info2.RasterReference;
    [latGrid2,lonGrid2] = geographicGrid(R2);

    tic
    [xfwd2,yfwd2] = projfwd(p,latGrid2,lonGrid2);
    [latin2,loninv2] = projinv(p,xfwd2,yfwd2);
    toc
end
```

The approximate execution times are:

- **R2022a:** 0.70 s
- **R2022b:** 0.42 s

This code was timed on a Windows 10 Intel Xeon CPU W-2133 @ 3.6 GHz test system, by calling the function `timingTest`.

R2020b: Unproject coordinates using `projcrs` objects and additional map projection structures

Unproject coordinates by specifying a `projcrs` object. A `projcrs` object enables you to transform coordinates using projection methods not available in earlier releases, such as Hotine Oblique Mercator.

Additionally, you can unproject coordinates by specifying a map projection structure with any valid `mapprojection` field. For a list of `mapprojection` field options, use the `maplist` or `maps` function.

See Also

Functions

`geotiffinfo` | `projfwd` | `projlist`

Objects

projcrs

Topics

“Project and Display Raster Data”

“Transform Coordinates to a Different Projected CRS”

projlist

GeoTIFF info structure support for `proj fwd` and `proj inv`

Syntax

```
projlist(listmode)  
S = projlist(listmode)
```

Description

`projlist(listmode)` displays a table of projection names, IDs, and availability. `listmode` can be 'mapprojection', 'geotiff', 'geotiff2mstruct', or 'all'. The default value is 'mapprojection'.

`S = projlist(listmode)` returns a structure array containing projection names, IDs, and availability. The output of `projlist` for each `listmode` is described below:

- `mapprojection` — Lists the projection IDs that `proj fwd` and `proj inv` use the PROJ library to implement. Starting in R2020b, you can use any valid map projection ID with `proj fwd` and `proj inv`. Return a list of valid map projection IDs using the `maplist` function. The output structure contains these fields.
 - `Name` — Projection name
 - `MapProjection` — Projection ID
- `geotiff` — Lists the GeoTIFF projection IDs that are available for use with `proj fwd` and `proj inv`. The output structure contains these fields.
 - `GeoTIFF` — GeoTIFF projection ID
 - `Available`— Logical array with values 1 or 0
- `geotiff2mstruct` — Lists the GeoTIFF projection IDs that are available for use with `geotiff2mstruct`. The output structure contains these fields.
 - `GeoTIFF` — GeoTIFF projection ID
 - `MapProjection` — Projection ID
- `all` — Lists the map and GeoTIFF projection IDs that are available for use with `proj fwd` and `proj inv`. The output structure contains these fields.
 - `GeoTIFF` — GeoTIFF projection ID
 - `MapProjection` — Projection ID
 - `info` — Logical array with values 1 or 0
 - `mstruct` — Logical array with values 1 or 0

Examples

```
s=projlist
```

```
s =
```

```
1x19 struct array with fields:
```

```
    Name  
    MapProjection
```

```
s=projlist('geotiff2mstruct')
```

```
s =
```

```
1x19 struct array with fields:
```

```
    GeoTIFF  
    MapProjection
```

Version History

Introduced before R2006a

See Also

[geotiff2mstruct](#) | [projfwd](#) | [projinv](#) | [maplist](#) | [maps](#)

properties

Return property names of geographic or planar vector

Syntax

```
prop = properties(v)
```

Description

`prop = properties(v)` returns the property names of the geographic or planar vector `v`.

Examples

View All Properties of a Mapshape Vector

Create a mapshape vector.

```
ms = mapshape(shaperead('tsunamis.shp', 'UseGeoCoords', true));
```

Display all properties of the mapshape vector. This includes the `Geometry` and `Metadata` collection properties, the `X` and `Y` required mapshape `Vertex` properties, and all dynamic properties.

```
properties(ms)
```

Properties for class mapshape:

```
Geometry
Metadata
X
Y
Lon
Lat
Year
Month
Day
Hour
Minute
Second
Val_Code
Validity
Cause_Code
Cause
Eq_Mag
Country
Location
Max_Height
Iida_Mag
Intensity
Num_Deaths
Desc_Deaths
```

Input Arguments

v — Geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Geographic or planar vector, specified as a geopoint, geoshape, mappoint, or mapshape object.

Output Arguments

prop — Property names

cell array

Property names of geographic or planar vector *v*, returned as a cell array.

Version History

Introduced in R2012a

See Also

disp | fieldnames

putpole

Origin vector to place north pole at specified point

Syntax

```
origin = putpole(pole)
origin = putpole(pole,units)
```

Description

`origin = putpole(pole)` returns an origin vector required to transform a coordinate system in such a way as to put the true North Pole at a point specified by the three- (or two-) element vector `pole`. This vector is of the form `[latitude longitude meridian]`, specifying the coordinates in the original system at which the true North Pole is to be placed in the transformed system. The meridian is the longitude upon which the new system is to be centered, which is the new pole longitude if omitted. The output is a three-element vector of the form `[latitude longitude orientation]`, where the latitude and longitude are the coordinates in the untransformed system of the new origin, and the orientation is the azimuth of the true North Pole in the transformed system.

`origin = putpole(pole,units)` allows the specification of the angular units of the origin vector, where `units` is any valid angle unit. The default is 'degrees'.

Examples

Pull the North Pole down the 0° meridian by 30° to 60°N. What is the resulting origin vector?

```
origin = putpole([60 0])

origin =
    30.0000         0         0
```

This makes sense: when the pole slid down 30°, the point that was 30° north of the origin slid down to become the origin. Following is a less obvious transformation:

```
origin = putpole([60 80 0]) % constrain to original central
                          % meridian

origin =
    4.9809         0    29.6217

origin = putpole([60 80 40]) % constrain to arbitrary meridian

origin =
    4.9809    40.0000    29.6217
```

Tips

When developing transverse or oblique projections, you need transformed coordinate systems. One way to define these systems is to establish the point in the original (untransformed) system that will become the new (transformed) origin.

Version History

Introduced before R2006a

See Also

neworig | org2pol

quiver3m

Project 3-D quiver plot on axesm-based map

Syntax

```
quiver3m(lat,lon,z,dlat,dlon,dz)
quiver3m(lat,lon,z,dlat,dlon,dz,scale)
quiver3m(lat,lon,z,dlat,dlon,dz,LineStyle)
quiver3m(lat,lon,z,dlat,dlon,dz,LineStyle,scale)
quiver3m(lat,lon,z,dlat,dlon,dz,LineStyle,"filled")
quiver3m(lat,lon,z,dlat,dlon,dz,LineStyle,scale,"filled")
h = quiver3m(____)
```

Description

`quiver3m(lat,lon,z,dlat,dlon,dz)` plots a 3-D quiver plot on the current axesm-based map. The quiver plot has arrows with directional components `dlat`, `dlon`, and `dz` at the geographic coordinates specified by `lat` and `lon` with altitude `z`. For example, the first arrow originates from the point `lat(1)`, `lon(1)`, and `z(1)`, extends in the direction of the latitude axis according to `dlat(1)`, extends in the direction of the longitude axis according to `dlon(1)`, and extends in the direction of the z-axis according to `dz(1)`. By default, the function scales the arrow lengths so that they do not overlap.

`quiver3m(lat,lon,z,dlat,dlon,dz,scale)` adjusts the length of arrows:

- When `scale` is a positive number, the function automatically adjusts the lengths of arrows so they do not overlap, then stretches them by a factor of `scale`. For example, a `scale` of 2 doubles the length of arrows, and a `scale` of 0.5 halves the length of arrows.
- When `scale` is "off" or 0, such as `quiver3m(lat,lon,z,dlat,dlon,dz,"off")`, the function does not perform automatic scaling.

`quiver3m(lat,lon,z,dlat,dlon,dz,LineStyle)` specifies the line style, marker, and color. Markers appear at the points specified by `lat`, `lon`, and `z`. If you specify a marker using `LineStyle`, the function does not display arrowheads.

`quiver3m(lat,lon,z,dlat,dlon,dz,LineStyle,scale)` adjusts the lengths of the arrows and specifies the line style, marker, and color.

`quiver3m(lat,lon,z,dlat,dlon,dz,LineStyle,"filled")` fills the markers specified by `LineStyle`.

`quiver3m(lat,lon,z,dlat,dlon,dz,LineStyle,scale,"filled")` adjusts the lengths of the arrows and fills the markers and fills the markers specified by `LineStyle`.

`h = quiver3m(____)` returns the quiver plot, using any combination of input arguments from the previous syntaxes.

Examples

Project 3-D Quiver Plot on Map

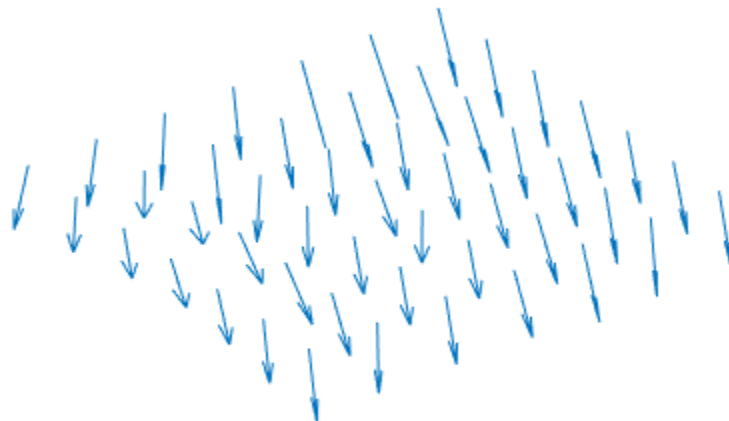
Load sample data that represents air currents into the workspace, and select a subset of the data. Specify `lon` and `dz` by scaling the original data.

```
load wind
lat = y(13:19,13:19,1);
lon = -x(13:19,13:19,1);
z = z(13:19,13:19,1);
dlat = v(13:19,13:19,1);
dlon = u(13:19,13:19,1);
dz = 500*w(13:19,13:19,1);
```

Create a map and display a 3-D quiver plot of the subset you selected. The matrices `lat`, `lon`, and `z` represent the location of the base of each arrow, and `dlat`, `dlon`, and `dz` represent the directional components of each arrow. By default, the `quiver3m` function shortens the arrows so they do not overlap.

```
figure
axesm miller
axis off

quiver3m(lat,lon,z,dlat,dlon,dz)
view(3)
```



Input Arguments

lat — Latitude coordinates of bases of arrows

scalar | vector | matrix

Latitude coordinates of the bases of the arrows, specified as a scalar, a vector, or a matrix.

The sizes of `lat`, `lon`, `z`, `dlat`, `dlon`, and `dz` must match.

Specify this argument using units that match the `AngleUnits` property of the axesm-based map.

Data Types: `double`

lon — Longitude coordinates of bases of arrows

scalar | vector | matrix

Longitude coordinates of the bases of the arrows, specified as a scalar, a vector, or a matrix.

The sizes of `lat`, `lon`, `z`, `dlat`, `dlon`, and `dz` must match.

Specify this argument using units that match the `AngleUnits` property of the axesm-based map.

Data Types: `double`

z — Altitudes of bases of arrows

scalar | vector | matrix

Altitudes of the bases of the arrows, specified as a scalar, a vector, or a matrix.

The sizes of `lat`, `lon`, `z`, `dlat`, `dlon`, and `dz` must match.

When the `MapProjection` property of the axesm-based map is `'globe'`, `z` is referenced to the ellipsoid.

The units of `z` must match the units of `dz`.

Data Types: `double`

dlat — Latitude components of arrows

scalar | vector | matrix

Latitude components of the arrows, specified as a scalar, vector, or matrix.

The sizes of `lat`, `lon`, `z`, `dlat`, `dlon`, and `dz` must match.

Specify this argument using units that match the `AngleUnits` property of the axesm-based map.

Data Types: `single` | `double`

dlon — Longitude components of arrows

scalar | vector | matrix

Longitude components of the arrows, specified as a scalar, vector, or matrix.

The sizes of `lat`, `lon`, `z`, `dlat`, `dlon`, and `dz` must match.

Specify this argument using units that match the `AngleUnits` property of the axesm-based map.

Data Types: `single` | `double`

dz — Altitude components of arrows

scalar | vector | matrix

Altitude components of the arrows, specified as a scalar, vector, or matrix.

The sizes of `lat`, `lon`, `z`, `dlat`, `dlon`, and `dz` must match.

When the `MapProjection` property of the axesm-based map is `'globe'`, `dz` is referenced to the ellipsoid.

The units of `dz` must match the units of `z`.

Data Types: `single` | `double`





LineStyleSpec — Line style, marker, and color








character vector | string scalar

Line style, marker, and color, specified as a character vector or string scalar containing symbols. The symbols can appear in any order. You do not need to specify all three characteristics (line style, marker, and color).





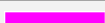


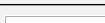
If you specify a marker using `LineStyleSpec`, then the `quiver3m` function does not display arrowheads.

Example: `--or` is a red dashed line with circle markers

Line Style	Description	Resulting Line
"_"	Solid line	
"--"	Dashed line	
":"	Dotted line	
"-."	Dash-dotted line	

Marker	Description	Resulting Marker
"o"	Circle	
"+"	Plus sign	
"*"	Asterisk	
"."	Point	
"x"	Cross	
"-"	Horizontal line	
" "	Vertical line	

Marker	Description	Resulting Marker
"square"	Square	□
"diamond"	Diamond	◇
"^"	Upward-pointing triangle	△
"v"	Downward-pointing triangle	▽
">"	Right-pointing triangle	▷
"<"	Left-pointing triangle	◁
"pentagram"	Pentagram	☆
"hexagram"	Hexagram	☆

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

scale — Arrow scaling factor

nonnegative number | "off"

Arrow scaling factor, specified as a nonnegative number or "off". By default, the `quiver3m` function automatically scales the arrows so they do not overlap. The `quiver3m` function applies the specified scaling factor after it automatically scales the arrows.

To turn off automatic scaling, specify `scale` as "off" or 0. When you specify either of these values, the function plots the arrows from (lat, lon, z) to $(lat+dlat, lon+dlon, z+dz)$.

Output Arguments

h — Quiver plot

vector of Line objects

Quiver plot, returned as a vector of Line objects.

Version History

Introduced before R2006a

See Also

Functions

quiverm | quiver3

quiverm

Project 2-D quiver plot on axesm-based map

Syntax

```
quiverm(lat,lon,dlat,dlon)
quiverm(lat,lon,dlat,dlon,scale)
quiverm(lat,lon,dlat,dlon,LineStyle)
quiverm(lat,lon,dlat,dlon,LineStyle,"filled")
quiverm(lat,lon,dlat,dlon,LineStyle,scale,"filled")
h = quiverm( ___ )
```

Description

`quiverm(lat,lon,dlat,dlon)` creates a quiver plot on the current axesm-based map. The quiver plot has arrows with directional components `dlat` and `dlon` at the geographic coordinates specified by `lat` and `lon`. For example, the first arrow originates from the point `lat(1)` and `lon(1)`, extends horizontally according to `dlon(1)`, and extends vertically according to `dlat(1)`. By default, the function scales the arrow lengths so that they do not overlap.

`quiverm(lat,lon,dlat,dlon,scale)` adjusts the lengths of the arrows:

- When `scale` is a positive number, the function automatically adjusts the lengths of arrows so they do not overlap, then stretches them by a factor of `scale`. For example, a `scale` of 2 doubles the length of arrows, and a `scale` of 0.5 halves the length of arrows.
- When `scale` is "off" or 0, such as `quiverm(lat,lon,dlat,dlon,"off")`, the function does not perform automatic scaling.

`quiverm(lat,lon,dlat,dlon,LineStyle)` specifies the line style, marker, and color. Markers appear at the points specified by `lat` and `lon`. If you specify a marker using `LineStyle`, the function does not display arrowheads.

`quiverm(lat,lon,dlat,dlon,LineStyle,"filled")` fills the markers specified by `LineStyle`.

`quiverm(lat,lon,dlat,dlon,LineStyle,scale,"filled")` adjusts the lengths of the arrows and fills the markers specified by `LineStyle`.

`h = quiverm(___)` returns the quiver plot, using any combination of input arguments from the previous syntaxes.

Examples

Project Quiver Plot on Map

Load sample data that represents air currents into the workspace, and select a subset of the data.

```
load("wind","x","y","u","v")
lat = y(11:22,11:22,1);
lon = x(11:22,11:22,1);
```

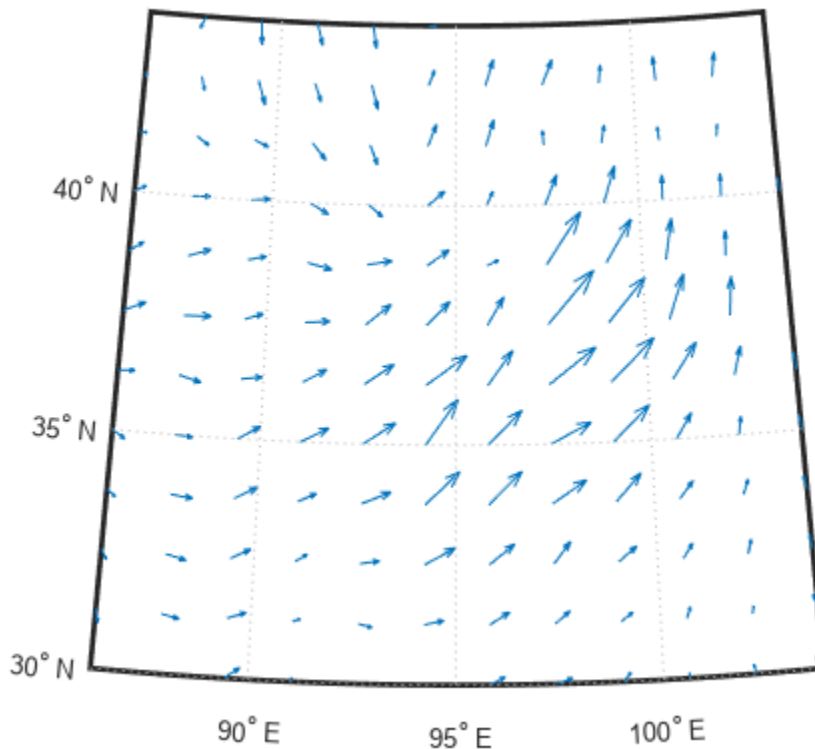


```
dlat = v(11:22,11:22,1);
dlon = u(11:22,11:22,1);
```

Create a map and display a quiver plot of the subset you selected. The matrices `lat` and `lon` represent the location of the base of each arrow, and `dlat` and `dlon` represent the directional components of each arrow. By default, the `quiverm` function shortens the arrows so they do not overlap.

```
figure
[latlim,lonlim] = geoquadline(lat,lon);
usamap(latlim,lonlim)

quiverm(lat,lon,dlat,dlon)
```



Input Arguments

lat — Latitude coordinates of bases of arrows

scalar | vector | matrix

Latitude coordinates of the bases of the arrows, specified as a scalar, a vector, or a matrix.

The sizes of `lat`, `lon`, `dlat`, and `dlon` must match.

Specify this argument using units that match the `AngleUnits` property of the axesm-based map.

Data Types: double

lon — Longitude coordinates of bases of arrows

scalar | vector | matrix

Longitude coordinates of the bases of the arrows, specified as a scalar, a vector, or a matrix.

The sizes of lat, lon, dlat, and dlon must match.

Specify this argument using units that match the AngleUnits property of the axesm-based map.

Data Types: double

dlat — Latitude components of arrows

scalar | vector | matrix

Latitude components of the arrows, specified as a scalar, vector, or matrix.

The sizes of lat, lon, dlat, and dlon must match.

Specify this argument using units that match the AngleUnits property of the axesm-based map.

Data Types: single | double

dlon — Longitude components of arrows

scalar | vector | matrix

Longitude components of the arrows, specified as a scalar, vector, or matrix.

The sizes of lat, lon, dlat, and dlon must match.

Specify this argument using units that match the AngleUnits property of the axesm-based map.

Data Types: single | double

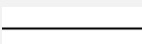



LineStyle — Line style, marker, and color

character vector | string scalar





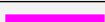
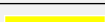

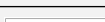
Line style, marker, and color, specified as a character vector or string scalar containing symbols. The symbols can appear in any order. You do not need to specify all three characteristics (line style, marker, and color).

If you specify a marker using LineSpec, then the quiverm function does not display arrowheads.

Example: "--or" is a red dashed line with circle markers

Line Style	Description	Resulting Line
"_"	Solid line	
"--"	Dashed line	
":"	Dotted line	
"-.""	Dash-dotted line	

Marker	Description	Resulting Marker
"o"	Circle	○
"+"	Plus sign	+
"*"	Asterisk	*
"."	Point	•
"x"	Cross	×
"_"	Horizontal line	—
" "	Vertical line	
"square"	Square	□
"diamond"	Diamond	◇
"^"	Upward-pointing triangle	△
"v"	Downward-pointing triangle	▽
">"	Right-pointing triangle	▷
"<"	Left-pointing triangle	◁
"pentagram"	Pentagram	☆
"hexagram"	Hexagram	☆

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

scale — Arrow scaling factor

nonnegative scalar | "off"

Arrow scaling factor, specified as a nonnegative scalar or "off". By default, the `quiverm` function automatically scales the arrows so they do not overlap. The `quiverm` function applies the specified scaling factor after it automatically scales the arrows.

To turn off automatic scaling, specify `scale` as "off" or 0. When you specify either of these values, the function plots the arrows from (lat, lon) to (lat+dlat, lon+dlon).

Output Arguments

h — Quiver plot

vector of Line objects

Quiver plot, returned as a vector of Line objects.

Version History

Introduced before R2006a

See Also

Functions

quiver3m | quiver

rad2km

Convert spherical distance from radians to kilometers

Syntax

```
km = rad2km(rad)
km = rad2km(rad, radius)
km = rad2km(rad, sphere)
```

Description

`km = rad2km(rad)` converts distances from radians to kilometers, as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`km = rad2km(rad, radius)` converts distances from radians to kilometers, as measured along a great circle on a sphere having the specified radius.

`km = rad2km(rad, sphere)` converts distances from radians to kilometers, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Radians to Kilometers on Earth

Find the circumference of the Earth in kilometers. By default, the `rad2km` function assumes your input is a measurement of the Earth, which is represented as sphere with a radius of 6371 kilometers.

```
km = rad2km(2*pi)
km = 4.0030e+04
```

Convert Radians to Kilometers on Mars

Find the circumference of Mars in kilometers.

```
km = rad2km(2*pi, 'mars')
km = 2.1300e+04
```

Input Arguments

rad — Distance in radians

numeric array

Distance in radians, specified as a numeric array.

Data Types: `single` | `double`

radius — Radius

6371 (default) | numeric scalar

Radius of sphere in units of kilometers, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments**km — Distance in kilometers**

numeric array

Distance in kilometers, returned as a numeric array.

Data Types: single | double

Version History**Introduced in R2007a****See Also**

deg2rad | rad2deg | rad2nm | rad2sm | deg2km | km2rad

rad2nm

Convert spherical distance from radians to nautical miles

Syntax

```
nm = rad2nm(rad)
nm = rad2nm(rad,radius)
nm = rad2nm(rad,sphere)
```

Description

`nm = rad2nm(rad)` converts distances from radians to nautical miles, as measured along a great circle on a sphere with a radius of 3440.065 nm, the mean radius of the Earth.

`nm = rad2nm(rad,radius)` converts distances from radians to nautical miles, as measured along a great circle on a sphere having the specified radius.

`nm = rad2nm(rad,sphere)` converts distances from radians to nautical miles, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Radians to Nautical Miles on Earth

Find the circumference of the Earth in nautical miles. By default, the `rad2nm` function assumes your input is a measurement of the Earth, which is represented as a sphere with a radius of 3440.065 nautical miles.

```
nm = rad2nm(2*pi)
nm = 2.1615e+04
```

Convert Radians to Nautical Miles on Sphere with Specified Radius

Find the circumference of a sphere with a radius of 3432 nautical miles.

```
nm = rad2nm(2*pi,3432)
nm = 2.1564e+04
```

Input Arguments

rad — Distance in radians

numeric array

Distance in radians, specified as a numeric array.

Data Types: `single` | `double`

radius — Radius

3440.065 (default) | numeric scalar

Radius of sphere in units of nautical miles, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments**nm — Distance in nautical miles**

numeric array

Distance in nautical miles, returned as a numeric array.

Data Types: `single` | `double`

Version History

Introduced in R2007a

See Also

`deg2rad` | `rad2deg` | `rad2sm` | `rad2km` | `nm2rad` | `deg2nm`

rad2sm

Convert spherical distance from radians to statute miles

Syntax

```
sm = rad2sm(rad)
sm = rad2sm(rad,radius)
sm = rad2sm(rad,sphere)
```

Description

`sm = rad2sm(rad)` converts distances from radians to statute miles, as measured along a great circle on a sphere with a radius of 3958.748 sm, the mean radius of the Earth.

`sm = rad2sm(rad,radius)` converts distances from radians to statute miles, as measured along a great circle on a sphere having the specified radius.

`sm = rad2sm(rad,sphere)` converts distances from radians to statute miles, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Arc Length to Statute Miles

How long is a trip around the equator in statute miles?

```
sm = rad2sm(2*pi)
sm = 2.4874e+04
```

How about on Jupiter?

```
sm = rad2sm(2*pi,'jupiter')
sm = 2.7283e+05
```

Input Arguments

rad — Distance in radians

numeric array

Distance in radians, specified as a numeric array.

Data Types: `single` | `double`

radius — Radius

3958.748 (default) | numeric scalar

Radius of sphere in units of statute miles, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments**sm — Distance in statute miles**

numeric array

Distance in statute miles, returned as a numeric array.

Data Types: single | double

Version History

Introduced in R2007a

See Also

deg2rad | rad2deg | rad2km | deg2sm | rad2nm | sm2rad

radtodeg

(Not recommended) Convert angles from radians to degrees

Note radtodeg is not recommended. Use the rad2deg function instead. For more information, see “Compatibility Considerations”.

Syntax

```
angleInDegrees = radtodeg(angleInRadians)
```

Description

angleInDegrees = radtodeg(angleInRadians) converts angle units from radians to degrees.

Examples

Convert Radians to Degrees

Convert pi radians to degrees.

```
angleInDegrees = radtodeg(pi)
```

```
angleInDegrees =
```

```
    180
```

Input Arguments

angleInRadians — Angle in radians

scalar | vector | matrix | N-D array

Angle in radians, specified as a scalar, vector, matrix, or N-D array.

Version History

Introduced in R2009b

R2015b: radtodeg is not recommended

Not recommended starting in R2015b

The radtodeg function is not recommended. Use the rad2deg function instead.

To update your code, replace instances of the radtodeg function with the rad2deg function.

While the radtodeg function accepts input arguments of integer types such as uint8, the rad2deg function accepts only single- and double-precision types. You can convert integer types to single- or double-precision types by using the single or double function.

See Also
rad2deg

RasterInfo

Information about geospatial raster data file

Description

RasterInfo objects contain information about geographic or projected raster data files, such as their file format, their native data type, and how they represent missing data.

Creation

Create a RasterInfo object using `georasterinfo`.

Properties

Filename — Path to data file

string array

This property is read-only.

Path to data file and any supporting files, returned as a `string` array.

Data Types: `string`

FileModifiedDate — Modification date of files

datetime array

This property is read-only.

Modification date of the data file and any supporting files, returned as a `datetime` array. The order of modification dates in `FileModifiedDate` corresponds to the order of files in `Filename`.

Data Types: `datetime`

FileSize — File size

array

This property is read-only.

File size of the data file and any supporting files, returned as an array. The order of file sizes in `FileSize` corresponds to the order of files in `Filename`.

Data Types: `double`

FileFormat — File format name

string scalar

This property is read-only.

File format name, returned as a `string` scalar. For a list of supported file formats, see `georasterinfo`.

Data Types: `string`

RasterSize — Dimensions of raster data

two-element vector

This property is read-only.

Dimensions of the raster data embedded in the file, returned as a two-element vector, `[m n]`, where `m` is the number of rows and `n` is the number of columns.

Data Types: `double`

NumBands — Number of bands

positive integer

This property is read-only.

Number of bands, returned as a positive integer.

When you read raster data using the `readgeoraster` function, the array it returns is of size `M-by-N-by-P`, where `P` is the value of `NumBands`.

Data Types: `double`

NativeFormat — Data type embedded in file

string scalar

This property is read-only.

Data type of the data embedded in the file, returned as a string scalar. To read data using a different data type, call `readgeoraster` and specify the `'OutputType'` name-value pair.

Data Types: `string`

MissingDataIndicator — Value indicating missing data

integer

This property is read-only.

Value indicating missing data, returned as an integer. You can replace missing data with NaN values using the `standardizeMissing` function.

```
[A,R] = readgeoraster('MtWashington-ft.grd');  
info = georasterinfo('MtWashington-ft.grd');  
m = info.MissingDataIndicator;  
A = standardizeMissing(A,m);
```

Data Types: `double`

Categories — Category names

string array

This property is read-only.

Category names, returned as a string array.

The value of `Categories` may be empty, even when the data is grouped into categories.

Data Types: `string`

ColorType — Color type of image

'indexed' | 'grayscale' | 'truecolor' | 'CMYK' | 'HSL' | 'unknown'

This property is read-only.

Color type of image, returned as one of these values:

- 'indexed' - Indexed image.
- 'grayscale' - Grayscale intensity image.
- 'truecolor' - True color image using RGB color space.
- 'CMYK' - Image using CMYK color space.
- 'HSL' - Image using HSL color space.
- 'unknown' - Unknown color type, or raster data does not represent an image.

Data Types: `string`

Colormap — Colormap

n-by-3 matrix

This property is read-only.

Colormap associated with an indexed image, returned as a *n*-by-3 matrix with values in the range [0,1]. Each row of `Colormap` is a three-element RGB triplet that specifies the red, green, and blue components of a single color of the colormap. The value of `Colormap` is empty unless the value of `ColorType` is 'indexed'.

Data Types: `double`

RasterReference — Spatial reference

`GeographicCellsReference` object | `GeographicPostingsReference` object |
`MapCellsReference` object | `MapPostingsReference` object

This property is read-only.

Spatial reference for the raster data, returned as a `GeographicCellsReference` object, `GeographicPostingsReference` object, `MapCellsReference` object, or `MapPostingsReference` object. The value of `RasterReference` depends on the raster data contained in the file:

- If the raster data is referenced to a geographic coordinate system, then `RasterReference` is a `GeographicCellsReference` object or `GeographicPostingsReference` object.
- If the raster data is referenced to a projected coordinate system, then `RasterReference` is a `MapCellsReference` object or `MapPostingsReference` object.

If the file does not contain enough information to determine whether the data is projected or geographic, then `RasterReference` is a `MapCellsReference` or `MapPostingsReference` object. If a file contains no valid spatial reference information, then `RasterReference` is empty.

Regardless of the file format, the `ColumnsStartFrom` property of the reference object returned by `RasterReference` has a value of 'north'.

CoordinateReferenceSystem — Coordinate reference system

[] (default) | projcrs object | geocrs object

This property is read-only.

Coordinate reference system (CRS), returned as a `geocrs` or `projcrs` object. The value of `CoordinateReferenceSystem` depends on the raster data contained in the file:

- If the raster data is referenced to a geographic coordinate system, then `CoordinateReferenceSystem` is a `geocrs` object.
- If the raster data is referenced to a projected coordinate system, then `CoordinateReferenceSystem` is a `projcrs` object.
- If the file does not contain valid coordinate reference system information, then `CoordinateReferenceSystem` is empty.

Metadata — Metadata

structure

This property is read-only.

Metadata, returned as a structure of additional information that is specific to the data file. The data in the file determines the field names and values of the structure. In most cases, each field of `Metadata` contains a string. When a GeoTIFF file contains RPC coefficient tags, `Metadata` includes an `RPCCoefficientTag` field that contains an `RPCCoefficientTag` object.

This property applies to only those file formats that can have metadata. For example, DTED files may contain metadata such as the datum, coordinates of the data origin, and absolute accuracy.

Examples

Get GeoTIFF Image Information

Get information about a GeoTIFF image by creating a `RasterInfo` object. Find the native data type embedded in the file by accessing the `NativeFormat` property of the `RasterInfo` object.

```
info = georasterinfo('boston.tif');  
info.NativeFormat
```

```
ans =  
"uint8"
```

The data used in this example includes material copyrighted by GeoEye, all rights reserved.

Version History

Introduced in R2020a

See Also

`readgeoraster` | `georasterinfo`

Topics

“Find Geospatial Raster Data”

rcurve

Ellipsoidal radii of curvature

Syntax

```
r = rcurve(ellipsoid,lat)
r = rcurve('parallel',ellipsoid,lat)
r = rcurve('meridian',ellipsoid,lat)
r = rcurve('transverse',ellipsoid,lat)
r = rcurve(..., angleunits)
```

Description

`r = rcurve(ellipsoid,lat)` and `r = rcurve('parallel',ellipsoid,lat)` return the parallel radius of curvature at the latitude `lat` for a reference ellipsoid defined by `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. `r` is in units of length consistent with those used for the semimajor axis. `lat` is in 'degrees'.

`r = rcurve('meridian',ellipsoid,lat)` returns the meridional radius of curvature, which is the radius of curvature in the plane of a meridian at the latitude `lat`.

`r = rcurve('transverse',ellipsoid,lat)` returns the transverse radius of curvature, which is the radius of a curvature in a plane normal to the surface of the ellipsoid and normal to a meridian, at the latitude `lat`.

`r = rcurve(..., angleunits)` specifies the units of the input `lat`. `angleunits` can be 'degrees' or 'radians'.

Examples

The radii of curvature of the default ellipsoid at 45°, in kilometers:

```
r = rcurve('transverse',referenceEllipsoid('earth','km'),...
          45,'degrees')
```

```
r =
  6.3888e+03
```

```
r = rcurve('meridian',referenceEllipsoid('earth','km'),...
          45,'degrees')
```

```
r =
  6.3674e+03
```

```
r = rcurve('parallel',referenceEllipsoid('earth','km'),...
          45,'degrees')
```

```
r =
  4.5024e+03
```

Version History

Introduced before R2006a

See Also

rsphere

readfields

(Removed) Read fields or records from fixed-format files

Note The `readfields` function has been removed. Depending on the file format, use the `readmatrix` function, the `readtable` function, or a different file import function. For more information about common supported file formats and their import functions, see “Supported File Formats for Import and Export”.

Syntax

```
struc = readfields(fname,fstruc)
struc = readfields(fname,fstruc,recordIDs)
struc = readfields(fname,fstruc,fieldIDs)
struc = readfields(fname,fstruc,recordIDs,mformat)
struc = readfields(fname,fstruc,recordIDs,mformat,fid)
struc = readfields(fname,fstruc,recordIDs,mformat,fid,'sparse')
```

Description

`struc = readfields(fname,fstruc)` reads all the records from a fixed format file. *fname* is a character vector containing the name of the file. If it is empty, the file is selected interactively. *fstruc* is a structure defining the format of the file. The contents of *fstruc* are described below. The result is returned in a structure.

`struc = readfields(fname,fstruc,recordIDs)` reads only the records specified in the vector *recordIDs*. For example, *recordIDs* = [1 2 3 4]. All the fields in the selected records are read.

`struc = readfields(fname,fstruc,fieldIDs)` reads only the fields specified in the cell array *fieldIDs*. For example, *fieldIDs* = {1 2 4}. The selected fields are read from all the records. *fieldIDs* can be used in place of *recordIDs* in all calling forms.

`struc = readfields(fname,fstruc,recordIDs,mformat)` opens the file with the specified machine format. *mformat* must be recognized by `fopen`.

`struc = readfields(fname,fstruc,recordIDs,mformat,fid)` reads from a file that is already open. *fid* is the file identifier returned by `fopen`. The records are read starting from the current location in the file.

`struc = readfields(fname,fstruc,recordIDs,mformat,fid,'sparse')` disables error messages when the number of elements read does not agree with the stated format of the file. This is useful for formatted files with empty fields. Use *fid* = [] for files that are not already open. This option is only compatible with reading selected records.

Background

Map data is often provided as binary or ASCII files with a fixed format. Writing your own functions to read the data into the MATLAB workspace can be difficult and time-consuming, particularly for binary files. This function allows you to read the data by simply specifying the format of the file.

Examples

Write a binary file and read it.

```
fid = fopen('testbin','wb');
for i = 1:3
    fwrite(fid,['character' num2str(i) ],'char');
    fwrite(fid,i,'int8');
    fwrite(fid,[i i],'int16');
    fwrite(fid,i,'integer*4');
    fwrite(fid,i,'real*8');
end
fclose(fid);

fs(1).length = 10;fs(1).type = 'char';fs(1).name = 'field 1';
fs(2).length = 1;fs(2).type = 'int8'; fs(2).name = 'field 2';
fs(3).length = 2;fs(3).type = 'int16';fs(3).name = 'field 3';
fs(4).length = 1;fs(4).type = 'integer*4';fs(4).name = 'field 4';
fs(5).length = 1;fs(5).type = 'float64'; fs(5).name = 'field 5';

s = readfields('testbin',fs);

s(1)
ans =
    field1: 'character1'
    field2: 1
    field3: [1 1]
    field4: 1
    field5: 1
```

Limitations

Formatted numbers must stay within the width specified for them. Files must have a size that is an integer multiple of the computed record length. This is potentially a problem for formatted files on DOS platforms that use a carriage return/linefeed line ending everywhere except the last record. File sizes are not checked when an open file is provided.

Tips

The format of the file is described in the input argument `fstruc`. `fstruc` is a structure with one entry for every field in the file. `fstruc` has three required fields: `length`, `name`, and `type`. For fields containing binary data of the type that would be read by `fread`, `length` is the number of elements to be read, `name` is a character vector containing the field name under which the read data is stored in the output structure, and `type` is a format recognized by `fread`. Repetition modifiers such as `'40*char'` are *not* supported. Fields with empty field names are omitted from the output.

The following `fstruc` definition is for a file with a 40-character field, a field containing two integers, and a field with a single-precision floating-point number.

```
fstruc(1).length = 40;
fstruc(1).name = 'character Field'; % spaces will be suppressed
filestruc(1).type = 'char';

fstruc(2).length = 2;
fstruc(2).name = 'integer Field'; % spaces will be suppressed
fstruc(2).type = 'int16';

fstruc(3).length = 1;
fstruc(3).name = 'float Field'; % spaces will be suppressed
fstruc(3).type = 'real*4';
```

The `type` can also be a `fscanf` and `sscanf`-style format of the form `'%nX'`, where `n` is the number of characters within which the formatted data is found, and `X` is the conversion character such as `'g'` or

'd'. For formatted fields, the length entry in `fstruc` is the number of elements, each of which has the width specified in the type. Fortran-style double-precision output such as '`0.0D00`' can be read using a type such as '`%nD`', where `n` is the number of characters per element. This is an extension to the C-style formats accepted by `sscanf`. Users unfamiliar with C should note that '`%d`' is preferred over '`%i`' for formatted integers. MATLAB syntax follows C in interpreting '`%i`' integers with leading zeros as octal. Line-ending characters in ASCII files must also be counted in the `fstruc` specification. Note that the number of line-ending characters differs across platforms.

A field specification for a formatted field with two integers each six characters wide would be of the form

```
fstruc(4).length = 2;  
fstruc(4).name = 'Elevation Units';  
fstruc(4).type = '%6d'
```

To summarize, `length` is the number of elements for binary numbers, the number of characters, and the number of elements for formatted data.

You can omit fields from all output by providing an empty character vector ('') for the `fstruc` name field.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `readfields` function has been removed. Depending on the file format, use the `readmatrix` function, the `readtable` function, or a different file import function. For more information about common supported file formats and their import functions, see “Supported File Formats for Import and Export”.

R2022a: Warns

Warns starting in R2022a

The `readfields` function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The `readfields` function runs without warning but will be removed in a future release.

See Also

`readmatrix` | `readtable` | `textread` | `dlmread`

Topics

“Supported File Formats for Import and Export”

readfk5

(Removed) Read Fifth Fundamental Catalog of Stars

Note The `readfk5` function has been removed.

Syntax

```
struc = readfk5(filename)
struc = readfk5(filename, struc)
```

Description

`struc = readfk5(filename)` reads the FK5 file and returns the contents in a structure. Each star is an element in the structure, with the different data items stored in appropriately named fields.

`struc = readfk5(filename, struc)` appends the data in the file to the existing structure `struc`.

Background

The Fifth Fundamental Catalog of Stars (FK5), Parts I and II, is a compilation of data on more than 4500 stars. The catalog contains positions, errors in positions, proper motions, and characteristics such as magnitudes, spectral types, parallaxes, and radial velocities. There are also cross-references to the identities of stars in other catalogs. It was compiled by researchers at the Astronomisches Rechen-Institut in Heidelberg.

Examples

```
FK5 = readfk5('FK5.dat');
FK5e = readfk5('FK5_ext.dat');
whos
```

Name	Size	Bytes	Class
FK5	1x1535	5042752	struct array
FK5e	1x3117	10226424	struct array

FK5e(1)

```
ans =
    FK5: 2003
    RAh: 0
    RAm: 5
    RAs: 1.1940
    pmRA: 0.6230
    DEd: 27
    DEm: 40
    DEs: 29.0100
    pmDE: -1.1100
    RAh1950: 0
    RAm1950: 2
    RAs1950: 26.5900
```

```
pmRA1950: 0.6210
DEd1950: 27
DEm1950: 23
DEs1950: 47.4400
pmDE1950: -1.1100
EpRA1900: 51.7200
  e_RAs: 2
  e_pmRA: 9
EpDE1900: 46.8200
  e_DEs: 3.4000
  e_pmDE: 14
  Vmag: 6.4700
  n_Vmag: ''
  SpType: 'G5'
 plx: []
  RV: 12
  AGK3R: '38'
  SRS: ''
  HD: '225292'
  DM: 'BD+26 4744'
  GC: '48'
```

Tips

Positions are given in terms of right ascension and declination. The Fifth Fundamental Catalog of Stars (FK5), Parts I and II data and documentation are available over the Internet by anonymous ftp.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The readfk5 function has been removed.

R2022a: Warns

Warns starting in R2022a

The readfk5 function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The readfk5 function runs without warning but will be removed in a future release.

See Also

dms2degrees | scatterm

readBasemapImage

Read image from geographic basemap

Syntax

```
[A,R,attrib] = readBasemapImage(basemap,latlim,lonlim)
[ ___ ] = readBasemapImage(basemap,mapCenter)
[ ___ ] = readBasemapImage( ___,zoomLevel)
[ ___ ] = readBasemapImage(basemap,mapCenter,zoomLevel,rasterSize)
```

Description

`[A,R,attrib] = readBasemapImage(basemap,latlim,lonlim)` reads an image A from the basemap specified by `basemap` for the geographic limits specified by `latlim` and `lonlim`. The output argument `R` contains spatial referencing information for the array and the output argument `attrib` contains the basemap attribution. This syntax returns an image using the highest possible zoom level with a maximum size of 2048-by-2048-by-3.

`[___] = readBasemapImage(basemap,mapCenter)` reads the basemap at the map center specified by `mapCenter`. This syntax returns an image using the highest possible zoom level with a maximum size of 1024-by-1024-by-3.

`[___] = readBasemapImage(___,zoomLevel)` reads the basemap for the zoom level specified by `zoomLevel`. You can use the `zoomLevel` argument with any combination of input arguments from the previous syntaxes.

`[___] = readBasemapImage(basemap,mapCenter,zoomLevel,rasterSize)` reads the basemap at the specified map center and zoom level and returns an image of size `rasterSize`.

Examples

Read Image from Basemap by Specifying Latitude and Longitude Limits

Read an image of the "streets" basemap for an area in Boston. Specify the area using latitude and longitude limits.

```
latlim = [42.3441 42.3658];
lonlim = [-71.0939 -71.0585];
[A,RA,attribA] = readBasemapImage("streets",latlim,lonlim);
```

Display the image on a map with no axis labels.

```
figure
mapshow(A,RA)
axis off
```

Add a title and subtitle. Wrap the attribution text.

```
title("Satellite Imagery of Boston")
```

```
tA = "Attribution: " + attribA;  
tA = string(textwrap(tA,65));  
subtitle(tA)
```

Satellite Imagery of Boston

Attribution: Harvard University, City of Boston, City of Cambridge, Esri, HERE, Garmin, INCREMENT P, Intermap, NGA, USGS

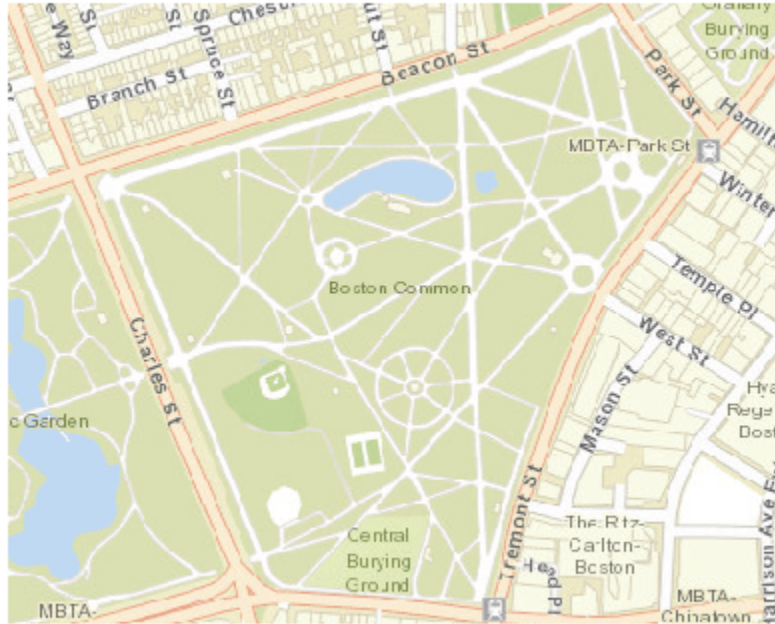


The text is difficult to read because the resolution of the image is greater than the resolution of the figure. View the details of the image by zooming in. Zoom in to an area around Boston Common by changing the xy-limits of the map. Specify the limits in world coordinates.

```
xlim([-7.9115e+06 -7.9105e+06])  
ylim([5.2139e+06 5.2147e+06])
```

Satellite Imagery of Boston

Attribution: Harvard University, City of Boston, City of Cambridge, Esri, HERE, Garmin, INCREMENT P, Intermap, NGA, USGS



Alternatively, you can improve the readability of the map by reading the basemap image at a different zoom level. Read another basemap image using a zoom level of 14.

```
[B,RB,attribB] = readBasemapImage("streets",latlim,lonlim,14);
```

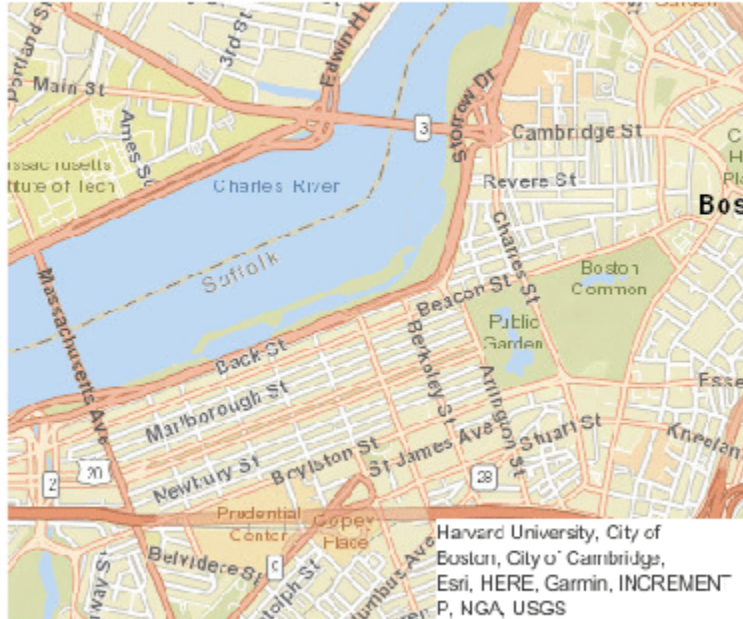
```
figure
mapshow(B,RB)
axis off
```

```
title("Satellite Imagery of Boston at Different Zoom Level")
```

```
tB = "Attribution: " + attribB;
tB = string(textwrap(tB,65));
subtitle(tB)
```

Satellite Imagery of Boston at Different Zoom Level

Attribution: Harvard University, City of Boston, City of Cambridge, Esri, HERE, Garmin, INCREMENT P, NGA, USGS



Read Image from Basemap by Specifying Map Center

Read an image for an area centered around a crop circle from the "satellite" basemap.

```
mapcenter = [37.7149 -98.5954];
[A,RA,attribA] = readBasemapImage("satellite",mapcenter);
```

Display the image on a map with no axis labels.

```
figure
mapshow(A,RA)
title("Satellite Imagery of Crop Circle")
subtitle("Attribution: " + attribA)
axis off
```

Satellite Imagery of Crop Circle

Attribution: Maxar



The `readBasemapImage` function reads the image using the highest possible zoom level. Capture a larger area by using a different zoom level. Read another basemap image using a zoom level of 15.

```
[B,RB,attribB] = readBasemapImage("satellite",mapcenter,15);
```

```
figure  
mapshow(B,RB)  
title("Satellite Imagery of Multiple Crop Circles")  
subtitle("Attribution: " + attribB)  
axis off
```

Satellite Imagery of Multiple Crop Circles

Attribution: Maxar



Specify Size of Basemap Image

Read an image of size 1000-by-2000 from the "satellite" basemap. Center the image around a crop circle and use a basemap zoom level of 15.

```
rasterSize = [1000 2000];  
[A,RA,attrib] = readBasemapImage("satellite",[37.7149 -98.5954],15,rasterSize);
```

Display the image on a map with no axis labels.

```
figure  
mapshow(A,RA)  
title("Basemap Image of Size 1000-by-2000")  
subtitle("Attribution: " + attrib)  
axis off
```


Basemap Image of Size 1000-by-2000

Attribution: Maxar



Read Image from Custom Basemap

Add the OpenStreetMap® [1] on page 1-1451 basemap to the list of basemaps available for use with mapping functions. After you add the basemap, you do not need to add it again in future sessions.

```
name = "openstreetmap";
url = "https://basemaps.arcgis.com/arcgis/rest/services/OpenStreetMap_v2/VectorTileServer/tile/$";
style = "https://www.arcgis.com/sharing/rest/content/items/3e1a00aee81496587988075fe529f71/resources";
addCustomBasemap(name,url,Style=style)
```

Read an image of the OpenStreetMap basemap for an area in Boston.

```
latlim = [42.3441 42.3658];
lonlim = [-71.0939 -71.0585];
[A,RA,attrib] = readBasemapImage(name,latlim,lonlim);
```

Display the image on a map with no axis labels. Wrap the subtitle text.

```
figure
mapshow(A,RA)
axis off
title("OpenStreetMap Basemap for Boston")

t = "Attribution:" + attrib;
```

```
t = string(textwrap(t,80));  
subtitle(t,"FontSize",8)
```

OpenStreetMap Basemap for Boston

Attribution: Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

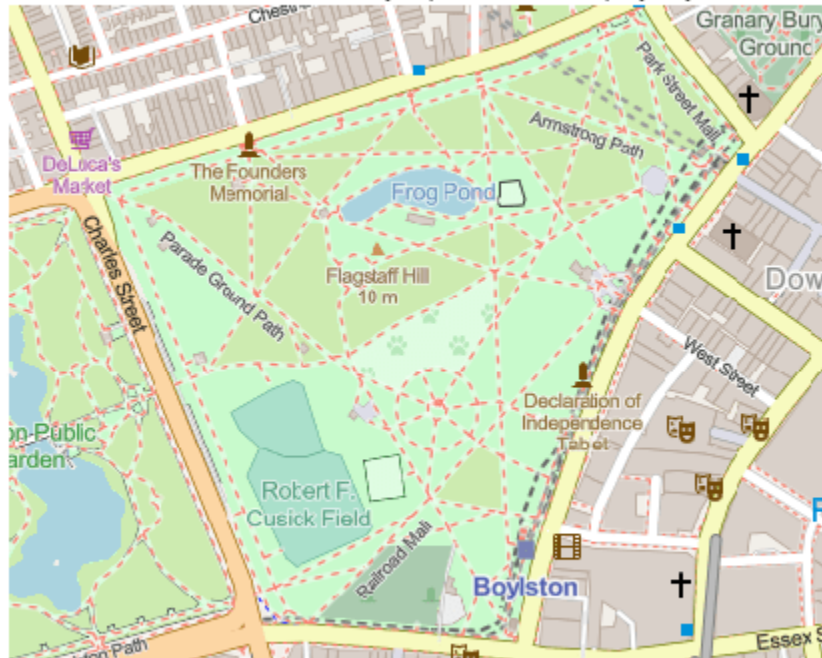


View details of the image for an area around Boston Common by changing the xy-limits.

```
xlim([-7.9115e+06 -7.9105e+06])  
ylim([5.2139e+06 5.2147e+06])
```


OpenStreetMap Basemap for Boston

Attribution: Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri



[1] "OpenStreetMap - Overview." ArcGIS Online. Accessed December 8, 2022. <https://www.arcgis.com/home/item.html?id=3e1a00a0ae81496587988075fe529f71>.

Save Basemap Image as GeoTIFF File

Read an image of the "satellite" basemap for an area in Boston.

```
latlim = [42.3441 42.3658];
lonlim = [-71.0939 -71.0585];
[A,RA,attribA] = readBasemapImage("satellite",latlim,lonlim);
```

Save the image as a GeoTIFF file by using the `geotiffwrite` function.

- The `readBasemapImage` function spatially references the image using the Web Mercator projected coordinate reference system (CRS) with EPSG code 3857. Specify the CRS by using the `CoordRefSysCode` name-value argument.
- Include the attribution by specifying the `ImageDescription` TIFF tag.

```
tag = struct("ImageDescription",attribA);
geotiffwrite("satelliteBoston.tif",A,RA,CoordRefSysCode=3857,TiffTags=tag)
```

Read the GeoTIFF file and display it on a map with no axis labels.

```
[B,BR] = readgeoraster("satelliteBoston.tif");  
figure  
mapshow(B,BR)  
title("Satellite Imagery of Boston")  
axis off
```

Read the attribution from the GeoTIFF file and display it in a subtitle.

```
info = imfinfo("satelliteBoston.tif");  
attribB = info.ImageDescription;  
subtitle("Attribution: " + attribB)
```

Satellite Imagery of Boston

Attribution: Maxar



Display Basemap Image with Transparency

When the opacity of a basemap obscures your data, you can attract attention to the data rather than the basemap by making the basemap transparent.

Read an image of the "satellite" basemap for an area around the MathWorks Lakeside Campus in Natick, MA.

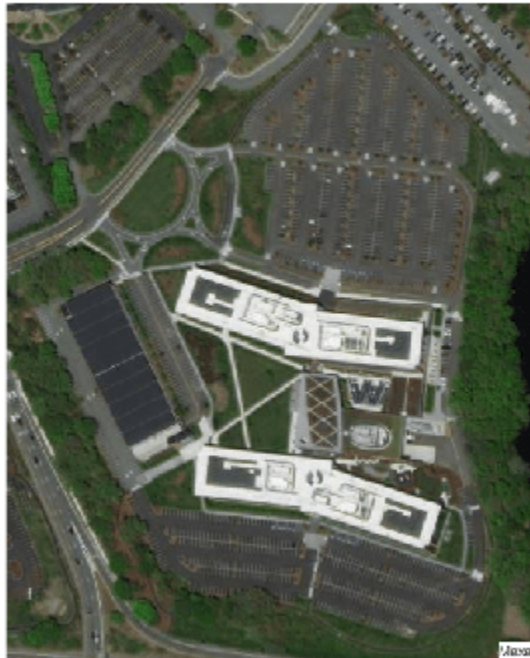
```
latlim = [42.2994 42.3035];  
lonlim = [-71.3774 -71.3729];  
[A,RA,attrib] = readBasemapImage("satellite",latlim,lonlim,17);
```

Display the image on a map with no axis labels. Specify an output argument for the mapshow function so you can access the image object it returns.

```
figure
h = mapshow(A,RA);
hold on
title("Satellite Imagery of Lakeside Campus")
subtitle("Attribution: " + attrib)
axis off
```

Satellite Imagery of Lakeside Campus

Attribution: Maxar



Make the image semi-transparent by setting the AlphaData property of the image object to a value between 0 and 1.

```
h.AlphaData = 0.6;
```

Satellite Imagery of Lakeside Campus

Attribution: Maxar


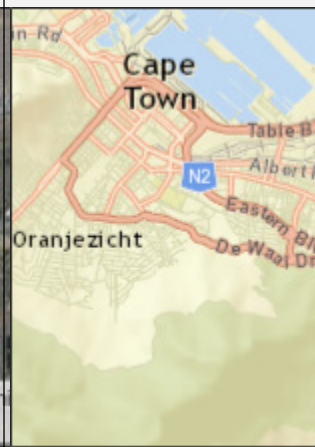


Input Arguments




basemap — Basemap

"satellite" | "streets" | "streets-light" | "streets-dark" | custom basemap | ...

Basemap, specified as one of the values listed in the table. Six of the basemaps in the table are tiled data sets created using Natural Earth. Five of the basemaps are high-zoom-level maps hosted by Esri.

	<p>"satellite"</p> <p>Full global basemap composed of high-resolution satellite imagery.</p> <p>Hosted by Esri.</p> <p>Earthstar Geograph CNES/Airbus DS</p>		<p>"streets"</p> <p>General-purpose road map that emphasizes accurate, legible styling of roads and transit networks.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, NGA, USGS</p>
---	--	--	--

	<p>"streets-light"</p> <p>Map designed to provide geographic context while highlighting user data on a light background.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, NGA, USGS</p>		<p>"streets-dark"</p> <p>Map designed to provide geographic context while highlighting user data on a dark background.</p> <p>Hosted by Esri.</p> <p>Esri, HERE, Garmin, NGA, USGS</p>
	<p>"topographic"</p> <p>General-purpose map with styling to depict topographic features.</p> <p>Hosted by Esri.</p> <p>Esri South Africa, HERE, Garmin, USGS, NGA</p>		<p>"landcover"</p> <p>Map that combines satellite-derived land cover data, shaded relief, and ocean-bottom relief. The light, natural palette is suitable for thematic and reference maps.</p> <p>Created using Natural Earth.</p>
	<p>"colorterrain"</p> <p>Shaded relief map blended with a land cover palette. Humid lowlands are green and arid lowlands are brown.</p> <p>Created using Natural Earth.</p>		<p>"grayterrain"</p> <p>Terrain map in shades of gray. Shaded relief emphasizes both high mountains and micro-terrain found in lowlands.</p> <p>Created using Natural Earth.</p>

	<p>"bluegreen"</p> <p>Two-tone, land-ocean map with light green land areas and light blue water areas.</p> <p>Created using Natural Earth.</p>		<p>"grayland"</p> <p>Two-tone, land-ocean map with gray land areas and white water areas.</p> <p>Created using Natural Earth.</p>
	<p>"darkwater"</p> <p>Two-tone, land-ocean map with light gray land areas and dark gray water areas. This basemap is installed with MATLAB.</p> <p>Created using Natural Earth.</p>	<p>Not applicable.</p>	<p>Custom basemap added using the <code>addCustomBasemap</code> function.</p>

All basemaps except "darkwater" require internet access. The "darkwater" basemap is included with MATLAB and Mapping Toolbox.

If you do not have consistent access to the internet, you can download the basemaps created using Natural Earth onto your local system by using the Add-On Explorer. The basemaps hosted by Esri are not available for download. For more information about downloading basemaps, see "Use Basemaps in Offline Environments".

The basemaps hosted by Esri update periodically. As a result, you might see differences in your visualizations over time.

Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

latlim — Latitude limits

numeric two-element vector

Latitude limits, specified as a numeric two-element vector of the form `[slat nlat]`, where `slat` is the southern limit in degrees and `nlat` is the northern limit in degrees. Both `slat` and `nlat` must be in the range `[-90, 90]`.

lonlim — Longitude limits

numeric two-element vector

Latitude limits, specified as a numeric two-element vector of the form `[wlon elon]`, where `wlon` is the western limit in degrees and `elon` is the eastern limit in degrees.

mapCenter — Map center

numeric two-element vector

Map center, specified as a numeric two-element vector containing latitude and longitude coordinates.

zoomLevel — Zoom level

numeric scalar

Zoom level, specified as a numeric scalar in the range `[0, 25]`.

The `readBasemapImage` function rounds the zoom level to the nearest integer.

The `readBasemapImage` reduces the zoom level in these situations:

- When you specify a zoom level that makes the output argument `A` bigger than the maximum allowable size.
- When you specify a zoom level that is greater than the maximum zoom level of the basemap. The basemaps hosted by Esri have a maximum zoom level of 25. The basemaps created using Natural Earth have a maximum zoom level of 7.

rasterSize — Raster size

positive integer | two-element vector of positive integers

Raster size, specified as one of these options.

- A positive integer, `m`, where `m` is the number of rows and columns in the output image.
- A two-element vector of positive integers, `[m n]`, where `m` is the number of rows and `n` is the number of columns in the output image.

Each element must be in the range `[64, 2048]`.

Output Arguments

A — RGB image

numeric array

RGB image, returned as an `m-by-n-by-3` numeric array.

R — Spatial reference

`MapCellsReference` object

Spatial reference for `A`, returned as a `MapCellsReference` object with coordinates in the Web Mercator (WGS 84 / Pseudo-Mercator) projected coordinate reference system (CRS) with EPSG code 3857.

You can find information about the projected CRS by querying the `ProjectedCRS` property of `R`.

```
[A,R,attrib] = readBasemapImage("satellite",[37.7149 -98.5954]);
R.ProjectedCRS
```

ans =

projcrs with properties:

```
Name: "WGS 84 / Pseudo-Mercator"  
GeographicCRS: [1x1 geocrs]  
ProjectionMethod: "Popular Visualisation Pseudo Mercator"  
LengthUnit: "meter"  
ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

attrib — Basemap attribution

string scalar

Basemap attribution, returned as a string scalar. The `readBasemapImage` function embeds the attribution in the lower-right corner of the image.

When you read an image from a basemap created using Natural Earth, this argument is empty.

Tips

- Do not crop attributions out of basemap images. If the attribution is not readable, then display the attribution somewhere else on the figure, such as in the title.
- If you do not know the basemap, latitude-longitude limits, map center, or zoom level you want, you can open and explore a geographic axes by using the `geoaxes` function.

- Change the basemap by using the `geobasemap` function.
- Get the latitude-longitude limits by using the `geolimits` function.
- Get the map center by querying the `MapCenter` property of the axes.

```
gx = geoaxes;  
gx.MapCenter
```

- Get the zoom level by querying the `ZoomLevel` property of the axes.

```
gx = geoaxes;  
gx.MapCenter
```

Version History

Introduced in R2022a

See Also

Functions

`readgeoraster` | `wmsread` | `addCustomBasemap` | `mapshow` | `imshow`

Objects

`MapCellsReference` | `projcrs`

Topics

“Create Common Plots over Basemap Images”

“Display Data over Basemaps When Internet Access Is Intermittent”

“Change Projection of Basemap Image”

readgeoraster

Read geospatial raster data file

Syntax

```
[A,R] = readgeoraster(filename)
[A,R] = readgeoraster( ____,Name,Value)
[ ____,cmap] = readgeoraster( ____)
```

Description

[A,R] = readgeoraster(filename) creates an array by reading geographic or projected raster data from a file. The output argument R contains spatial referencing information for the array. Supported file formats include Esri Binary Grid, Esri GridFloat, GeoTIFF, and DTED. For a full list of supported formats, see “Supported Formats and Extensions” on page 1-1465.

[A,R] = readgeoraster(____,Name,Value) specifies options using one or more Name, Value pair arguments.

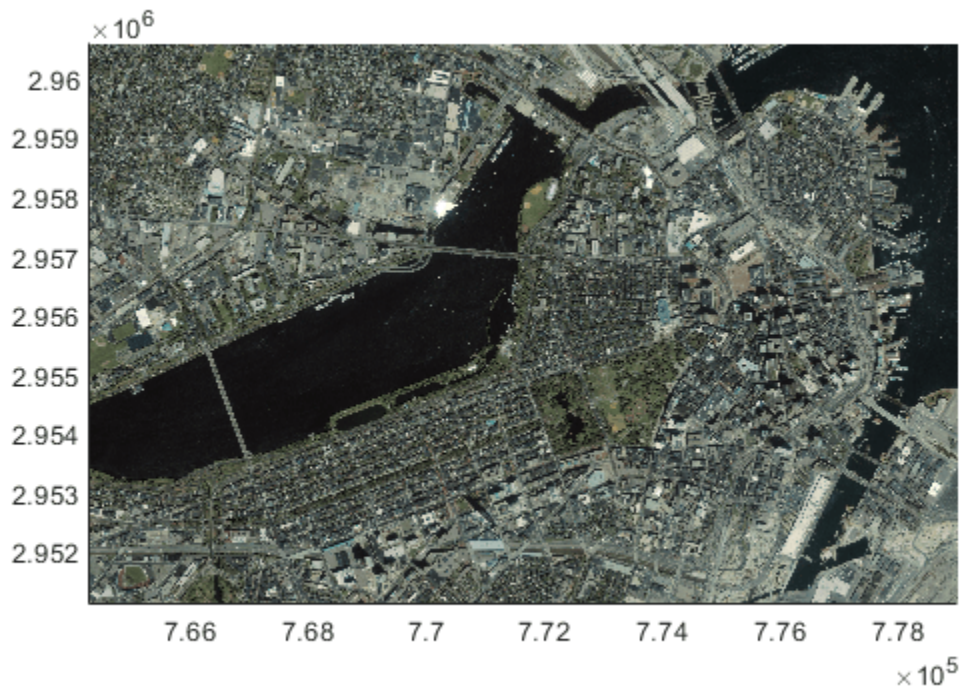
[____,cmap] = readgeoraster(____) also returns the colormap of A.

Examples

Read and Display GeoTIFF Image

Read a GeoTIFF image of Boston as an array and a map cells reference object. The array is of size 2881-by-4481-by-3 and specifies the red, green, and blue components of the image. Display the image using the mapshow function.

```
[A,R] = readgeoraster('boston.tif');
mapshow(A,R)
```



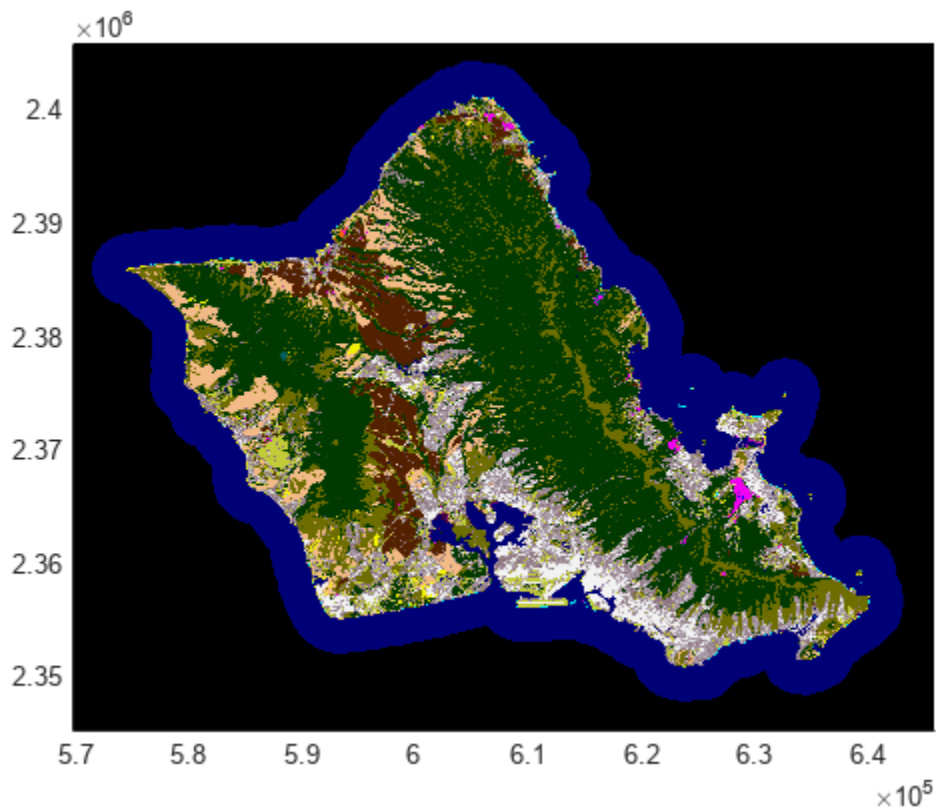
The data used in this example includes material copyrighted by GeoEye, all rights reserved.

Read and Display Land Cover Classification

Read and display a land cover classification of Oahu, Hawaii.

First, read the land cover data as an array, a map cells reference object, and a colormap. The elements of `A` index into the colormap. Each row of the colormap specifies the red, green, and blue components of a single color. Then, display the land cover data.

```
[A,R,cmap] = readgeoraster('oahu_landcover.img');  
mapshow(A,cmap,R)
```



The data used in this example is courtesy of the National Oceanic and Atmospheric Administration (NOAA).

Read and Display Elevation Data

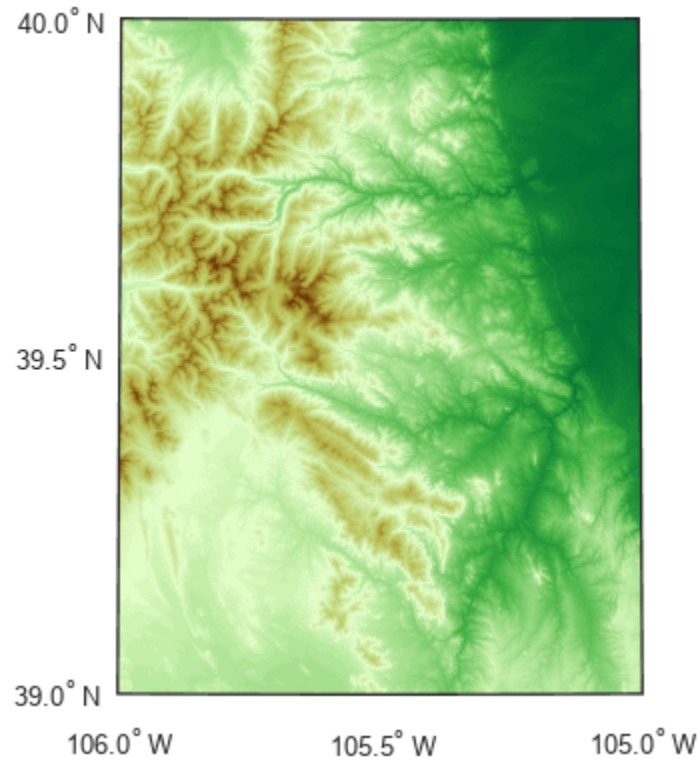
Read and display elevation data for an area around South Boulder Peak in Colorado.

Read the elevation data as an array and a geographic postings reference object. To display the data as a surface, the `geoshow` function requires data of type `double` or `single`. In this case, preserve precision by specifying the output type as `"double"`.

```
[A,R] = readgeoraster("n39_w106_3arc_v2.dt1","OutputType","double");
```

Create a map by specifying the latitude and longitude limits of the data. Then, display the data as a surface using the `geoshow` function. Apply a colormap appropriate for elevation data using the `demcmap` function.

```
latlim = R.LatitudeLimits;
lonlim = R.LongitudeLimits;
usamap(latlim,lonlim)
geoshow(A,R,"DisplayType","surface")
demcmap(A)
```



The elevation data used in this example is courtesy of the US Geological Survey.

Replace Missing Data with NaN Values

Raster data sets sometimes indicate missing data values using a large negative number. Import raster data, find the missing data indicator, and then replace missing data with NaN values.

Import raster data and a reference object using the `readgeoraster` function. Find the missing data indicator using the `georasterinfo` function.

```
[A,R] = readgeoraster('MtWashington-ft.grd');  
info = georasterinfo('MtWashington-ft.grd');  
m = info.MissingDataIndicator
```

```
m = -32766
```

Verify the raster data contains missing data using the `ismember` function. The `ismember` function returns logical 1 (true) if the raster contains the missing data indicator.

```
ismember(m,A)
```

```
ans = logical  
     1
```

Replace the missing data with NaN values using the `standardizeMissing` function.

```
A = standardizeMissing(A,m);
```

Input Arguments

filename — Name of file to read

character vector | string scalar

Name of the file to read, specified as a character vector or string scalar. The form of `filename` depends on the location of your file.

- If the file is in your current folder or in a folder on the MATLAB path, then specify the name of the file, such as `'myFile.dem'`.
- If the file is not in the current folder or in a folder on the MATLAB path, then specify the full or relative path name, such as `'C:\myfolder\myFile.tif'` or `'dataDir\myFile.dat'`.

For a list of supported file formats, see “Supported Formats and Extensions” on page 1-1465.

Data Types: `char` | `string`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `'OutputType','double','Bands',1:2`

OutputType — Data type for A

'native' (default) | 'single' | 'double' | 'int32' | ...

Data type for `A`, specified as the comma-separated pair consisting of `'OutputType'` and a character vector or string scalar containing one of these values: `'native'`, `'single'`, `'double'`, `'int16'`, `'int32'`, `'int64'`, `'uint8'`, `'uint16'`, `'uint32'`, `'uint64'`, or `'logical'`.

The default for `'OutputType'` is `'native'`, which returns `A` using the native data type embedded in `filename`. Using a data type other than `'native'` may result in a loss of precision.

Example: `'OutputType','double'`

Data Types: `char` | `string`

Bands — Bands to read

'all' (default) | positive integer | vector of positive integers

Bands to read, specified as the comma-separated pair consisting of `'Bands'` and `'all'`, a positive integer, or a vector of positive integers. For example, if you specify the value 3, `readgeoraster` reads the third band in the file. Bands are returned in the specified order.

The default for `'Bands'` is `'all'`, where `readgeoraster` reads all bands in the file.

Example: `'Bands',3`

CoordinateSystemType — Coordinate system type for R`'auto' (default) | 'geographic' | 'planar'`

Coordinate system type for R, specified as one of these values:

- `'auto'` - Returns R as a raster reference object determined by the contents of the file.
- `'geographic'` - Returns R as a geographic cells or postings reference object.
- `'planar'` - Returns R as a map cells or postings reference object.

Specify the coordinate system type when your data does not contain projection information.

Example: `'CoordinateSystemType', 'geographic'`

Output Arguments**A — Georeferenced image or data grid**`numeric array`

Georeferenced image or data grid, returned as an M -by- N or M -by- N -by- P numeric array.

By default, the data type of A matches the native data type embedded in `filename`. Specify a data type using the `'OutputType'` name-value pair.

Regardless of how the data is encoded, the first row of A represents the northernmost data, and the last row of A represents the southernmost data.

R — Spatial reference`GeographicCellsReference object | GeographicPostingsReference object |
MapCellsReference object | MapPostingsReference object`

Spatial reference for A, returned as a `GeographicCellsReference` object, `GeographicPostingsReference` object, `MapCellsReference` object, or `MapPostingsReference` object. The value of R depends on the data in `filename`:

- If the data in `filename` is referenced to a geographic coordinate system, then R is a `GeographicCellsReference` object or `GeographicPostingsReference` object.
- If the data in `filename` is referenced to a projected coordinate system, then R is a `MapCellsReference` object or `MapPostingsReference` object.

If the file does not contain enough information to determine whether the data is projected or geographic, then R is a `MapCellsReference` or `MapPostingsReference` object. If a file contains no valid spatial reference information, then R is empty. You can specify the spatial reference as `'geographic'` or `'planar'` using the `'CoordinateSystemType'` name-value pair.

cmap — Colormap `n -by-3 matrix`

Colormap associated with an indexed image, returned as a n -by-3 numeric matrix with values in the range [0,1]. Each row of `cmap` is a three-element RGB triplet that specifies the red, green, and blue components of a single color in the colormap. The value of `cmap` is empty unless A is an indexed image.

More About

Supported Formats and Extensions

The `readgeoraster` and `georasterinfo` functions support these file formats and extensions. In some cases, you can read supported file formats using extensions other than the ones listed.

File Format	Extension
GeoTIFF	.tif or .tiff
Esri Binary Grid	.adf
Esri ASCII Grid	.asc or .grd
Esri GridFloat	.flt
DTED	.dt0, .dt1, or .dt2
SDTS	.DDF
USGS DEM	.dem
ER Mapper ERS	.ers
ENVI	.dat
ERDAS IMAGINE	.img
Vertical Mapper Numeric Grid	.grd
Vertical Mapper Classified Grid	.grc
SRTM Height	.hgt

Some file formats consist of a data file and multiple supporting files. For example, Esri GridFloat files may have supporting header files (.hdr). When you read a data file with supporting files using `readgeoraster` or `georasterinfo`, specify the extension of the data file.

File formats may be referred to using different names. For example, the Esri GridFloat format may also be referred to as Esri .hdr Labelled or ITT ESRI .hdr RAW Raster. The Esri Binary Grid format may also be referred to as ArcGrid Binary, Esri ArcGIS Binary Grid, or Esri ArcInfo Grid.

Tips

- Some functions require input arguments of type `single` or `double`, such as the `geoshow` function for displaying surfaces. To use the output of `readgeoraster` with these functions, specify the output type as 'single' or 'double' using the 'OutputType' name-value pair.
- Regardless of the file format, the array returned by `readgeoraster` has columns starting from north and the `ColumnsStartFrom` property of the reference object has a value of 'north'.

Version History

Introduced in R2020a

R2021b: Read SRTM Height data

The `readgeoraster` function can read SRTM Height data files with extension `.hgt`.

R2021a: Read data in Vertical Mapper Grid formats

The `readgeoraster` function can read data in the Vertical Mapper Numeric Grid and Vertical Mapper Classified Grid formats.

See Also

Functions

`readgeotable` | `georasterinfo`

Topics

“Find Geospatial Raster Data”

readgeotable

Read geospatial table from vector data file

Syntax

```
T = readgeotable(filename)
T = readgeotable(filename,Name=Value)
```

Description

`T = readgeotable(filename)` creates a geospatial table by reading geographic or projected vector data from a file. Supported file formats include shapefile, KML, and Esri file geodatabase. For a full list of supported formats, see “Supported Formats and Extensions” on page 1-1475.

`T = readgeotable(filename,Name=Value)` specifies options using name-value arguments. For example, specify the coordinate system type using the `CoordinateSystemType` name-value argument.

Examples

Read Shapefile as Geospatial Table

Read a shapefile, containing a network of roads in Concord, MA, into the workspace as a geospatial table.

```
T = readgeotable("concord_roads.shp");
```

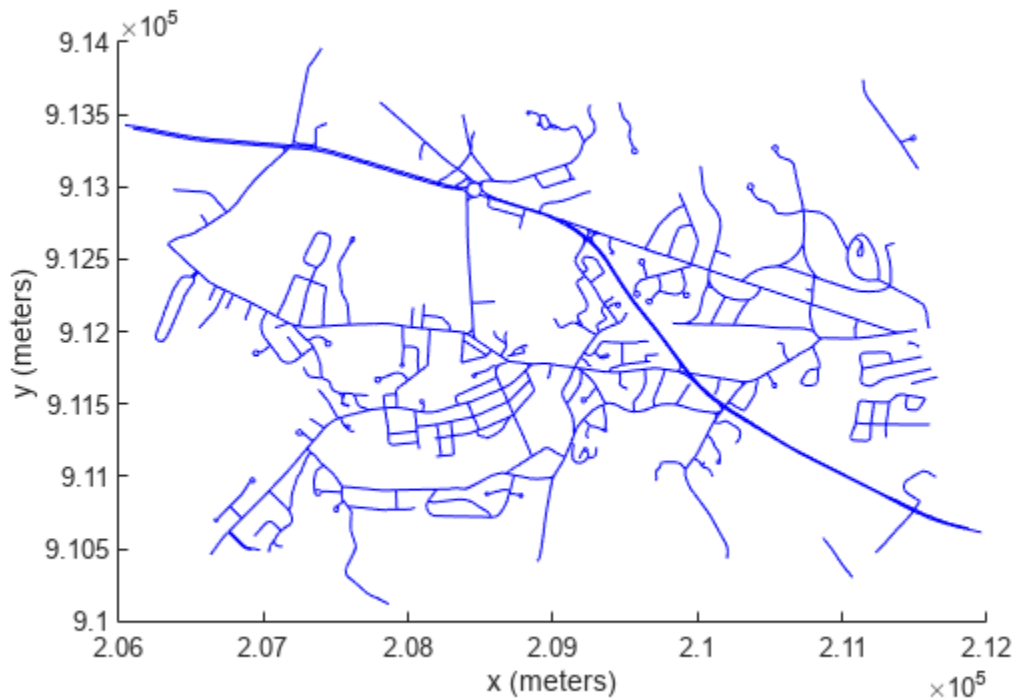
The `Shape` variable of the table contains information about the road shapes, including the coordinate reference system (CRS). The road shapes in this shapefile use a projected CRS.

```
T.Shape.ProjectedCRS
```

```
ans =
    projcrs with properties:
        Name: "NAD83 / Massachusetts Mainland"
        GeographicCRS: [1x1 geocrs]
        ProjectionMethod: "Lambert Conic Conformal (2SP)"
        LengthUnit: "meter"
        ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

Display the roads on a map.

```
mapshow(T)
xlabel("x (meters)")
ylabel("y (meters)")
```



Read Shapefile with No Projection File

An optional projection file (.prj) determines the coordinate system type for a shapefile. When your shapefile does not have a projection file, but you know the coordinate system type, you can specify it by using the `CoordinateSystemType` name-value argument.

Read a shapefile called `tsunamis.shp`, containing information about tsunami events, into the workspace. The metadata accompanying the file indicates that the shapefile uses geographic coordinates.

```
T = readgeotable("tsunamis.shp",CoordinateSystemType="geographic");
```

View the `Shape` variable of the geospatial table. The tsunami source locations are stored as points.

```
T.Shape
```

```
ans =
    162x1 geopointshape array with properties:

        NumPoints: [162x1 double]
        Latitude: [162x1 double]
        Longitude: [162x1 double]
        Geometry: "point"
    CoordinateSystemType: "geographic"
```

```
GeographicCRS: []
```

Plot the source locations on a web map.

```
wmmarker(T)
```



Read Layers from GPX Files

GPX files can contain up to five layers: waypoints, tracks, track points, routes, and route points. When you read a layer containing track points or route points, the geospatial table contains an ID variable that associates the points with a track or route.

Import the tracks layer of a GPX file with two tracks. The Shape variable for each track is a `geolineshape` object.

```
T = readgeotable("sample_tracks.gpx", Layer="tracks")
```

```
T=2x3 table
      Shape
```

```
      Name
```

<code>geolineshape</code>	"Track logs from walking the perimeter of the MathWorks campus in Natick on M
<code>geolineshape</code>	"Track logs from biking from Concord to the MathWorks campus in Natick on Jun

View the shape of each track. The first track has one segment and the second track has five segments.

T.Shape(1)

```
ans =  
  geolineshape with properties:  
      NumParts: 1  
      Geometry: "line"  
  CoordinateSystemType: "geographic"  
      GeographicCRS: [1x1 geocrs]
```

T.Shape(2)

```
ans =  
  geolineshape with properties:  
      NumParts: 5  
      Geometry: "line"  
  CoordinateSystemType: "geographic"  
      GeographicCRS: [1x1 geocrs]
```

Import the track points layer. The `Shape` variable for each point is a `geopointshape` object.

```
T2 = readgeotable("sample_tracks.gpx",Layer="track_points");  
T2.Shape
```

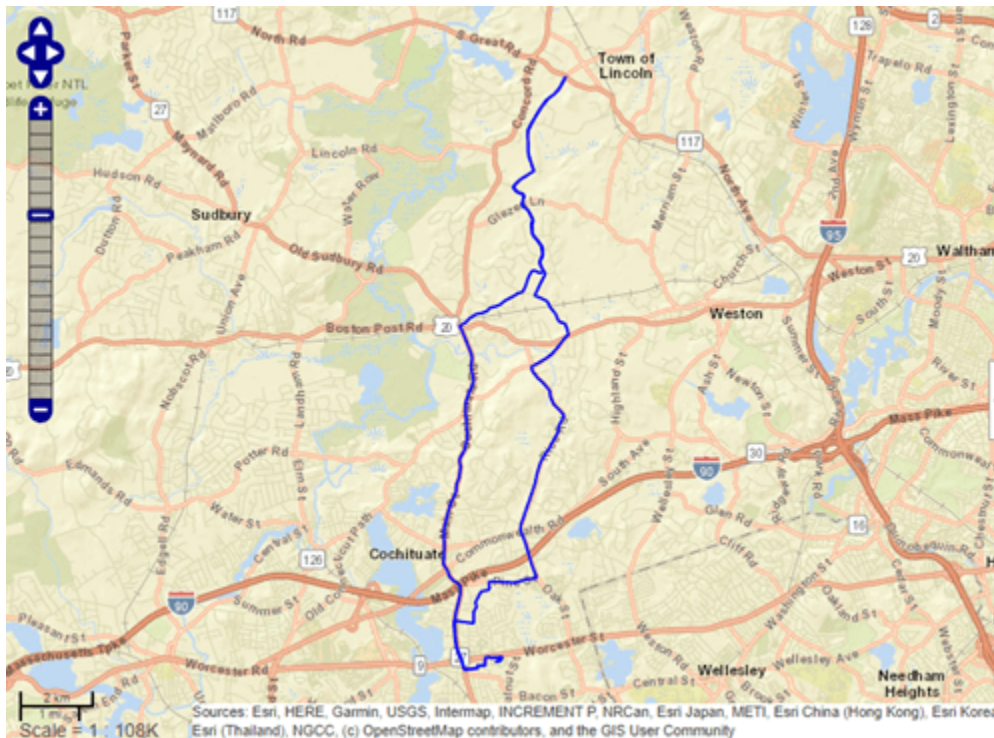
```
ans =  
  2586x1 geopointshape array with properties:  
      NumPoints: [2586x1 double]  
      Latitude: [2586x1 double]  
      Longitude: [2586x1 double]  
      Geometry: "point"  
  CoordinateSystemType: "geographic"  
      GeographicCRS: [1x1 geocrs]
```

Create a subtable that contains points in the second track only. For this file, points in the second track have a `TrackFID` value of 1.

```
rows = (T2.TrackFID == 1);  
T3 = T2(rows,:);
```

Plot the points in the subtable as a blue line.

```
wmline(T3,Color="b")
```



Read GeoJSON File from Web Service

Read GeoJSON data from a website and save it in the file `storms.geojson`. The data contains day 1 convective outlooks from the NOAA/NWS Storm Prediction Center. For more information about convective outlooks, see [1] on page 1-1473. For links to the data, see [2] on page 1-1473.

```
websave("storms.geojson", "https://www.spc.noaa.gov/products/outlook/day1otlk_cat.lyr.geojson");
```

Read the data into a geospatial table. If the file contains no data for the `readgeotable` function to read, such as when there are no severe thunderstorm threats, create a geospatial table with an empty polygon shape instead.

```
try
  GT = readgeotable("storms.geojson");
catch
  GT = table(geopolyshape, "No Data", "none", VariableNames=["Shape" "LABEL2" "fill"]);
end
```

View the `Shape` variable of the geospatial table. The table stores the geographic areas as polygons.

```
GT.Shape
```

```
ans=3x1 object
```

```
3x1 geopolyshape array with properties:
```

```
NumRegions: [3x1 double]
NumHoles: [3x1 double]
Geometry: "polygon"
```

```
CoordinateSystemType: "geographic"  
GeographicCRS: [1x1 geocrs]
```

Day 1 convective outlooks change from day to day, so your results can be different.

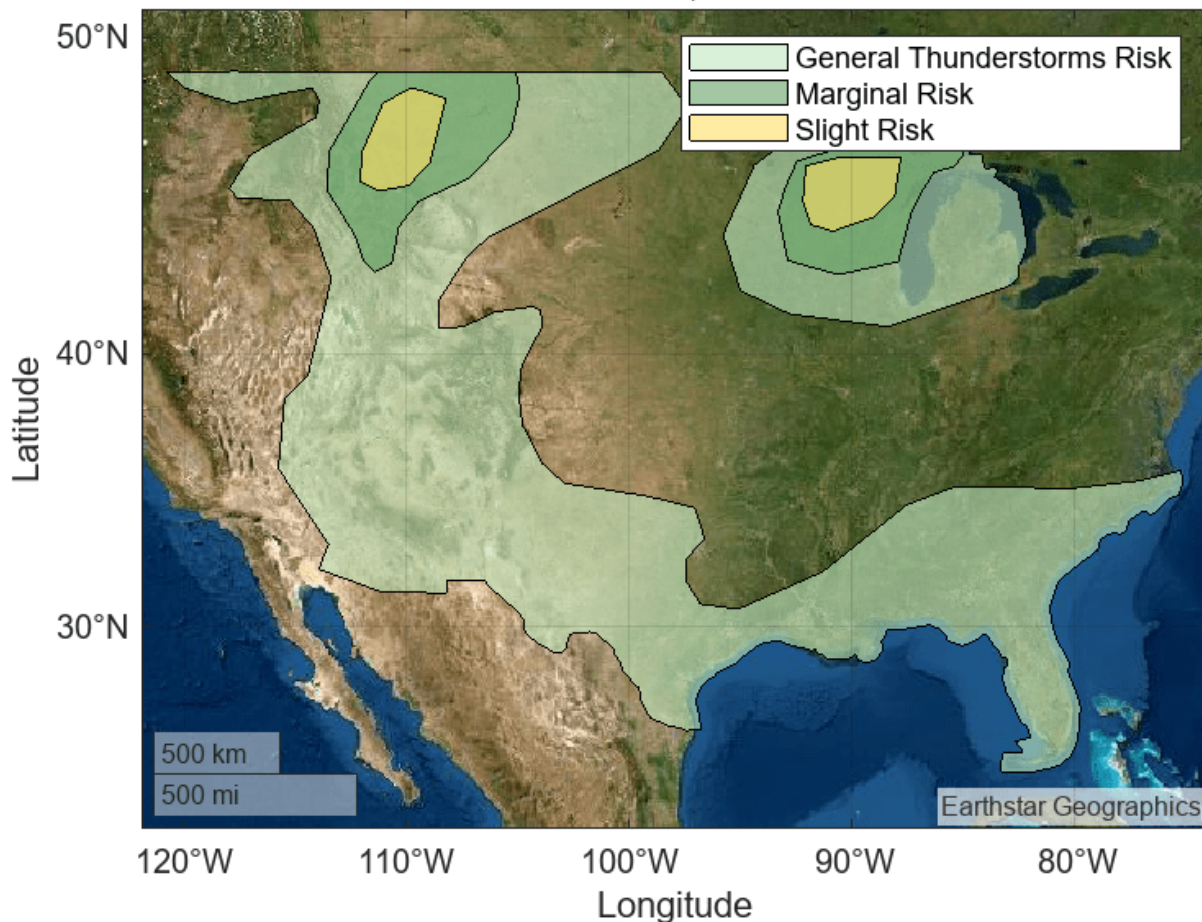
Display the convective outlooks over a satellite basemap. To create a legend from the thunderstorm risk categories, plot each row of the table as a separate polygon.

```
figure  
geobasemap satellite  
hold on  
for k = 1:height(GT)  
    row = GT(k,:);  
    geoplot(row, "DisplayName", row.LABEL2, "FaceColor", row.fill)  
end  
legend  
alpha(0.6)
```

Add a title, including the access date.

```
dt = datetime("today",Format="MMMM d, yyyy");  
title("Day 1 Convective Outlooks",string(dt))
```


Day 1 Convective Outlooks June 28, 2022



[1] "SPC Products." NOAA/National Weather Service Storm Prediction Center. Accessed June 28, 2022. <https://www.spc.noaa.gov/misc/about.html>.

[2] "SPC Shapefile/KML/KMZ Links." NOAA/National Weather Service Storm Prediction Center. Accessed June 28, 2022. <https://www.spc.noaa.gov/gis/>.

Input Arguments

filename — Name of file to read

character vector | string scalar

Name of the file to read, specified as a character vector or string scalar. The form of `filename` depends on the location of your file.

- If the file is in your current folder or in a folder on the MATLAB path, then specify the name of the file, such as "myFile.shp".

- If the file is not in the current folder or in a folder on the MATLAB path, then specify the full or relative path name, such as "C:\myfolder\myFile.gpx" or "dataDir\myFile.kml".

For a list of supported file formats, see “Supported Formats and Extensions” on page 1-1475.

To read an Esri file geodatabase, you must either specify the full or relative path name or include the geodatabase in your current folder.

Data Types: `char` | `string`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `readgeotable("sample_tracks.gpx", Layer="track_points")` reads the track points layer from the GPX file.

Layer — Layer to read

positive integer | string scalar | character vector

Layer to read when the file contains multiple layers, specified as a positive integer, a string scalar, or a character vector. If you specify an integer, then it must be less than or equal to the number of vector layers in the file.

The layers contained in a file depend on the file format. Shapefiles have one layer. The content of Esri file geodatabases and GeoJSON files determines the number of layers and the names of the layers. Each folder and subfolder of KML files corresponds to layers, and the folder names match the layer names.

For GPX files, specify the layer as one of these options:

- "waypoints" — Waypoints.
- "tracks" — Track lines.
- "track_points" — Track points. When you read track points, the geospatial table contains an ID variable, `TrackFID`, that associates each point with a track.
- "routes" — Route lines.
- "route_points" — Route points. When you read route points, the geospatial table contains an ID variable, `RouteFID`, that associates each point with a route.

Data Types: `single` | `double` | `char` | `string`

CoordinateSystemType — Coordinate system type

"auto" (default) | "geographic" | "planar"

Coordinate system type, specified as one of these values:

- "auto" — Create the Shape table variable based on the contents of the file.
- "geographic" — Create the Shape table variable using `geopointshape`, `geolineshape`, and `geopolyshape` objects.
- "planar" — Create the Shape table variable using `mappointshape`, `maplineshape`, and `mappolyshape` objects.

Specify the coordinate system type when the `readgeotable` function is unable to detect the coordinate system type.

For shapefiles, the coordinate system type is determined by an optional projection file (`.prj`). If your shapefile does not have a projection file, you can try to determine the coordinate system type using one of these options:

- Refer to the metadata.
- Ask your data provider.
- Return information about the shapefile as a structure by using the `shapeinfo` function. Then, view the limits of the data by querying the `BoundingBox` field of the structure. The limits might help you predict the coordinate system type.

VariableNamingRule — Flag to preserve variable names

"preserve" (default) | "modify"

Flag to preserve variable names, specified as one of these options:

- "preserve" — Preserve variable names that are not valid MATLAB identifiers, such as variable names that include spaces and non-ASCII characters.
- "modify" — Convert invalid variable names, as identified by the `isvarname` function, to valid MATLAB identifiers.

Data Types: `char` | `string`

Output Arguments

T — Geospatial table

geospatial table

Geospatial table, returned as a geospatial table. A geospatial table is a `table` object with a `Shape` variable and attribute variables.

- The `Shape` variable contains 2-D information about point, line, and polygon shapes. The `Shape` variable can contain combinations of shape types. All the shapes have the same coordinate reference system (CRS).

The `readgeotable` function represents shapes with coordinates in geographic CRSs by using `geopointshape`, `geolineshape`, and `geopolyshape` objects.

The `readgeotable` function represents shapes with coordinates in projected CRSs by using `mappointshape`, `maplineshape`, and `mappolyshape` objects.

- The attribute variables contain data such as names, classifications, and measurements.

When the data file contains CRS information, the `readgeotable` function stores the information as a `projcrs` or `geocrs` object within each shape object.

More About

Supported Formats and Extensions

The `readgeotable` function supports these file formats and extensions.

File Format	Extension
Esri file geodatabase	.gdb
GeoJSON	.json or .geojson
GPX	.gpx
KML	.kml
Shapefile	.shp

Some file formats consist of a main file and multiple supporting files. For example, shapefiles include a main file (.shp), an index file (.shx), and an attribute file (.dbf). When you read a data file with supporting files using the `readgeotable` function, specify the extension of the main file.

When the file contains 3-D points, lines, or polygons, the function reads only the 2-D information into the `Shape` variable of the geospatial table.

For GeoJSON files, all attributes apply to all rows in the geospatial table, even when the GeoJSON file does not apply an attribute to all elements. When the file does not apply an attribute to an element, the corresponding cell in the geospatial table contains a missing data value.

For GPX files, Garmin® extensions are not supported.

For KML files, the `readgeotable` function reads only shapes, names, and descriptions into the geospatial table.

Version History

Introduced in R2021b

See Also

Functions

`readgeoraster` | `readtable` | `websave`

Topics

“Create Geospatial Tables”

“Find Geospatial Vector Data”

readmtx

(Removed) Read matrix stored in file

Note The `readmtx` function has been removed. Depending on the file format, use the `readmatrix` function, the `readtable` function, or a different file import function. For more information about common supported file formats and their import functions, see “Supported File Formats for Import and Export”.

Syntax

```

mtx = readmtx(fname,nrows,ncols,precision)
mtx = readmtx(fname,nrows,ncols,precision,readrows,readcols)
mtx = readmtx(fname,nrows,ncols,precision,... readrows,readcols,mformat)
mtx = readmtx(fname,nrows,ncols,precision,...
readrows,readcols,mformat,nheadbytes)
mtx = readmtx(fname,nrows,ncols,precision,...
readrows,readcols,mformat,nheadbytes,nRowHeadBytes)
mtx = readmtx(fname,nrows,ncols,precision,...
readrows,readcols,mformat,nheadbytes,nRowHeadBytes,nRowTrailBytes)
mtx = readmtx(fname,nrows,ncols,precision,...
readrows,readcols,mformat,nheadbytes,nRowHeadBytes,...
nRowTrailBytes,nFileTrailBytes)
mtx = readmtx(fname,nrows,ncols,precision,...
readrows,readcols,mformat,nheadbytes,nRowHeadBytes,...
nRowTrailBytes,nFileTrailBytes,recordlen)

```

Description

`mtx = readmtx(fname,nrows,ncols,precision)` reads a matrix stored in a file. The file contains only a matrix of numbers with the dimensions *nrows* by *ncols* stored with the specified *precision*. Recognized *precision* values are described below.

`mtx = readmtx(fname,nrows,ncols,precision,readrows,readcols)` reads a subset of the matrix. *readrows* and *readcols* specify which rows and columns are to be read. They can be vectors containing the row or column numbers, or two-element vectors of the form [*start end*], which are expanded using the colon operator to *start:end*. To read just two rows or columns, without expansion by the colon operator, provide the indices as a column matrix.

`mtx = readmtx(fname,nrows,ncols,precision,... readrows,readcols,mformat)` specifies the machine format used to write the file. *mformat* can be any recognized by `fopen`. This option is used to automatically swap bytes for files written on platforms with a different byte ordering.

`mtx = readmtx(fname,nrows,ncols,precision,... readrows,readcols,mformat,nheadbytes)` skips the file header, whose length is specified in bytes.

`mtx = readmtx(fname,nrows,ncols,precision,...
readrows,readcols,mformat,nheadbytes,nRowHeadBytes)` also skips a header that precedes every row of the matrix. The length of the header is specified in bytes.

`mtx = readmtx(fname,nrows,ncols,precision,...
readrows,readcols,mformat,nheadbytes,nRowHeadBytes,nRowTrailBytes)` also skips a trailer that follows every row of the matrix. The length of the trailer is specified in bytes.

`mtx = readmtx(fname,nrows,ncols,precision,...
readrows,readcols,mformat,nheadbytes,nRowHeadBytes,...
nRowTrailBytes,nFileTrailBytes)` accounts for the length of data following the matrix. The sizes of the components of the matrix are used to compute an expected file size, which is compared to the actual file size.

`mtx = readmtx(fname,nrows,ncols,precision,...
readrows,readcols,mformat,nheadbytes,nRowHeadBytes,...
nRowTrailBytes,nFileTrailBytes,recordlen)` overrides the record length calculated from the precision and number of columns, and instead uses the record length given in bytes. This is used for formatted data with extra spaces or line breaks in the matrix.

Background

Map data is often provided as binary or ASCII files with a fixed format. Writing your own functions to read the data into the MATLAB workspace can be difficult and time-consuming, particularly for binary files. This function allows you to read the data by simply specifying the format of the file.

Examples

Write and read a binary matrix file:

```
fid = fopen('binmat','w');  
fwrite(fid,1:100,'int16');  
fclose(fid);  
mtx = readmtx('binmat',10,10,'int16')
```

```
mtx =  
  1   2   3   4   5   6   7   8   9  10  
 11  12  13  14  15  16  17  18  19  20  
 21  22  23  24  25  26  27  28  29  30  
 31  32  33  34  35  36  37  38  39  40  
 41  42  43  44  45  46  47  48  49  50  
 51  52  53  54  55  56  57  58  59  60  
 61  62  63  64  65  66  67  68  69  70  
 71  72  73  74  75  76  77  78  79  80  
 81  82  83  84  85  86  87  88  89  90  
 91  92  93  94  95  96  97  98  99 100
```

```
mtx = readmtx('binmat',10,10,'int16',[2 5],3:2:9)
```

```
mtx =  
 13  15  17  19  
 23  25  27  29  
 33  35  37  39  
 43  45  47  49
```

Limitations

Every row of the matrix must have the same number of elements.

Tips

This function reads files that have a general format consisting of a header, a matrix, and a trailer. Each row of the matrix can have a certain number of bytes of extraneous information preceding or following the matrix data.

Both binary and formatted data files can be read. If the file is binary, the precision argument is a format recognized by `fread`. Repetition modifiers such as `'40*char'` are *not* supported. If the file is formatted, precision is a `fscanf` and `sscanf`-style format of the form `'%nX'`, where `n` is the number of characters within which the formatted data is found, and `X` is the conversion character such as `'g'` or `'d'`. Fortran-style double-precision output such as `'0.0D00'` can be read using a precision such as `'%nD'`, where `n` is the number of characters per element. This is an extension to the C-style format `s` accepted by `sscanf`. Users unfamiliar with C should note that `'%d'` is preferred over `'%i'` for formatted integers. MATLAB syntax follows C in interpreting `'%i'` integers with leading zeros as octal. Formatted files with line endings need to provide the number of trailing bytes per row, which can be 1 for platforms with carriage returns *or* linefeed (Macintosh, UNIX®), or 2 for platforms with carriage returns *and* linefeeds (DOS).

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `readmtx` function has been removed. Depending on the file format, use the `readmatrix` function, the `readtable` function, or a different file import function. For more information about common supported file formats and their import functions, see “Supported File Formats for Import and Export”.

R2022a: Warns

Warns starting in R2022a

The `readmtx` function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The `readmtx` function runs without warning but will be removed in a future release.

See Also

`readmatrix` | `readtable` | `textread` | `dlmread`

Topics

“Supported File Formats for Import and Export”

reckon

Point at specified azimuth and range on sphere or ellipsoid

Syntax

```
[lat2,lon2] = reckon(lat1,lon1,arclen,az)
[lat2,lon2] = reckon(lat1,lon1,arclen,az,ellipsoid)
[lat2,lon2] = reckon( ____,units)
[lat2,lon2] = reckon(method, ____)
```

Description

`[lat2,lon2] = reckon(lat1,lon1,arclen,az)` finds the coordinates of the point at the spherical distance `arclen` and azimuth `az` from the point with coordinates `lat1` and `lon1`. This syntax references the coordinates to a sphere, assumes that all input arguments are in degrees, and assumes a great circle azimuth.

`[lat2,lon2] = reckon(lat1,lon1,arclen,az,ellipsoid)` specifies the reference ellipsoid for the coordinates. This syntax assumes that `arclen` is a linear distance in the units of the semimajor axis of the reference ellipsoid.

`[lat2,lon2] = reckon(____,units)` specifies the angle units, in addition to any combination of input arguments from the previous syntaxes.

`[lat2,lon2] = reckon(method, ____,)`, where `method` is "rh", indicates that `az` is a rhumb line azimuth. The default for `method` is "gc", which indicates that `az` is a great circle azimuth (for a sphere) or a geodesic azimuth (for an ellipsoid).

Examples

Find Point Given Azimuth and Range

Find the coordinates of the point 600 nautical miles northwest of London. Convert 600 nautical miles to a spherical distance in degrees by using the `nm2deg` function. A northwest direction has an azimuth of 315 degrees.

```
arclen = nm2deg(600);
az = 315;
[lat,lon] = reckon(51.5,0,arclen,az)
```

```
lat = 57.8999
```

```
lon = -13.3507
```

Find Point on Ellipsoid Given Azimuth and Range

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of nautical miles.

```
wgs84 = wgs84Ellipsoid("nm");
```

Find the coordinates of the point 600 nautical miles northwest of London. Reference the coordinates to the ellipsoid. When you specify a reference ellipsoid as input to the `reckon` function, specify the arc length as a linear distance. A northwest direction has an azimuth of 315 degrees.

```
arclen = 600;  
az = 315;  
[lat,lon] = reckon(51.5,0,arclen,az,wgs84)  
  
lat = 57.8953  
lon = -13.3015
```

Input Arguments

lat1 — Latitude of input point

scalar | array

Latitude of the input point, specified as a scalar or array.

You can specify `lat1`, `lon1`, `arclen`, and `az` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

lon1 — Longitude of input point

scalar | array

Longitude of the input point, specified as a scalar or array.

You can specify `lat1`, `lon1`, `arclen`, and `az` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

az — Azimuth from input point to output point

scalar | array

Azimuth from the input point to the output point, measured clockwise from north, specified as a scalar or array.

You can specify `lat1`, `lon1`, `arclen`, and `az` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

arclen — Length of arc

scalar | array

Length of the arc connecting the input point and output point, specified as a scalar or array.

- When you do not specify a reference ellipsoid as input, specify `arclen` as a spherical distance in degrees. You can specify a spherical distance in radians by using the `units` argument.
- When you specify a reference ellipsoid as input, specify `arclen` as a linear distance in the units of the semimajor axis of the ellipsoid.

You can specify `lat1`, `lon1`, `arclen`, and `az` using a combination of scalars and arrays, as long as the arrays are of the same size. The function expands the scalar inputs to match the size of the array inputs.

Data Types: `single` | `double`

units — Angle unit

`"degrees"` (default) | `"radians"`

Angle unit, specified as one of these options:

- `"degrees"` — Degrees
- `"radians"` — Radians

If you do not specify a reference ellipsoid, this argument determines the angle units for the coordinates, arc length, and azimuth. If you specify a reference ellipsoid, this argument only determines the angle units for the coordinates and the azimuth.

Data Types: `char` | `string`

ellipsoid — Reference ellipsoid

`[1 0]` (default) | `referenceSphere` object | `referenceEllipsoid` object | `oblateSpheroid` object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element vector of the form `[semimajor_axis eccentricity]`, where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of `[1 0]` represents the unit sphere.

method — Type of curve connecting input point and output point

`"gc"` (default) | `"rh"`

Type of curve connecting the input point and output point, specified as one of these options:

- `"gc"` — `az` is a great circle azimuth (for spheres) or a geodesic azimuth (for ellipsoids).
- `"rh"` — `az` is a rhumb line azimuth.

For more information about rhumb lines and great circles, see “Comparison of Rhumb Lines and Great Circles”.

Data Types: `char` | `string`

Output Arguments

lat2 — Latitude of output point

`scalar` | `array`

Latitude of the output point, returned as a scalar or an array that matches the size of the largest latitude or longitude input.

lon2 — Longitude of output point

scalar | array

Longitude of the output point, returned as a scalar or an array that matches the size of the largest latitude or longitude input.

Version History

Introduced before R2006a

See Also**Functions**

azimuth | distance

Topics

"Comparison of Rhumb Lines and Great Circles"

map.geodesy.RectifyingLatitudeConverter

Convert between geodetic and rectifying latitudes

Description

A `RectifyingLatitudeConverter` object provides conversion methods between geodetic and rectifying latitudes for an ellipsoid with a given third flattening.

The rectifying latitude maps an ellipsoid (oblate spheroid) to a sphere while preserving the distances along the meridians. Rectifying latitudes are used when implementing map projections, such as Equidistant Cylindrical, that preserve such distances.

Creation

Syntax

```
converter = map.geodesy.RectifyingLatitudeConverter  
converter = map.geodesy.RectifyingLatitudeConverter(spheroid)
```

Description

`converter = map.geodesy.RectifyingLatitudeConverter` returns a `RectifyingLatitudeConverter` object for a sphere and sets the `ThirdFlattening` property to 0.

`converter = map.geodesy.RectifyingLatitudeConverter(spheroid)` returns a rectifying latitude converter object and sets the `ThirdFlattening` property to match the specified spheroid object.

Input Arguments

spheroid — Reference spheroid

referenceEllipsoid object | oblateSpheroid object | referenceSphere object

Reference spheroid, specified as a `referenceEllipsoid` object, `oblateSpheroid` object, or `referenceSphere` object. The term reference spheroid is used synonymously with reference ellipsoid. To create a reference spheroid, use the creation function for the object. To specify the reference ellipsoid for WGS84, use the `wgs84Ellipsoid` function.

For more information about reference spheroids, see “Comparison of Reference Spheroids”.

Example: `spheroid = referenceEllipsoid('GRS 80');`

Properties

ThirdFlattening — Third flattening of an ellipsoid

numeric scalar

Third flattening of an ellipsoid, specified as a numeric scalar. `ThirdFlattening` is in the interval $[0, \text{ecc2n}(0.5)]$, or approximately $[0, 0.071797]$. (Flatter spheroids are possible in theory, but do not occur in practice and are not supported.)

Data Types: `double`

Object Functions

`forward` Convert geodetic latitude to authalic, conformal, isometric, or rectifying latitude
`inverse` Convert authalic, conformal, isometric, or rectifying latitude to geodetic latitude

Examples

Create a Rectifying Latitude Converter Object and Set Property

```
grs80 = referenceEllipsoid('GRS 80');  
  
conv1 = map.geodesy.RectifyingLatitudeConverter;  
conv1.ThirdFlattening = grs80.ThirdFlattening  
  
conv1 =  
    RectifyingLatitudeConverter with properties:  
        ThirdFlattening: 0.0017
```

Create a Rectifying Latitude Converter Object, Specifying Spheroid

```
grs80 = referenceEllipsoid('GRS 80');  
  
conv2 = map.geodesy.RectifyingLatitudeConverter(grs80)  
  
conv2 =  
    RectifyingLatitudeConverter with properties:  
        ThirdFlattening: 0.0017
```

Version History

Introduced in R2013a

See Also

Functions

`geocentricLatitude` | `parametricLatitude`

Objects

`AuthalicLatitudeConverter` | `ConformalLatitudeConverter` |
`IsometricLatitudeConverter`

reducem

Reduce density of points in vector data

Syntax

```
[latout,lonout] = reducem(latin,lonin)
[latout,lonout] = reducem(latin,lonin,tol)
[latout,lonout,cerr] = reducem(...)
[latout,lonout,cerr,tol] = reducem(...)
```

Description

`[latout,lonout] = reducem(latin,lonin)` reduces the number of points in vector map data. In this case the tolerance is computed automatically.

`[latout,lonout] = reducem(latin,lonin,tol)` uses the provided tolerance. The units of the tolerance are degrees of arc on the surface of a sphere.

`[latout,lonout,cerr] = reducem(...)` in addition returns a measure of the error introduced by the simplification. The output `cerr` is the difference in the arc length of the original and reduced data, normalized by the original length.

`[latout,lonout,cerr,tol] = reducem(...)` also returns the tolerance used in the reduction, which is useful when the tolerance is computed automatically.

Examples

Compare Original and Reduced Borders

Compare the original and reduced borders of the District of Columbia from the shapefile `usastatehi.shp`.

Extract the borders of the District of Colombia.

```
dc = shaperead('usastatehi.shp',...
    'UseGeoCoords', true,...
    'Selector',{@(name) ...
        strcmpi(name,'district of columbia'),'Name'});
lat = extractfield(dc, 'Lat');
lon = extractfield(dc, 'Lon');
```

Reduce the number of points in the border.

```
[latreduced, lonreduced] = reducem(lat, lon);
```

Display the original and reduced borders.

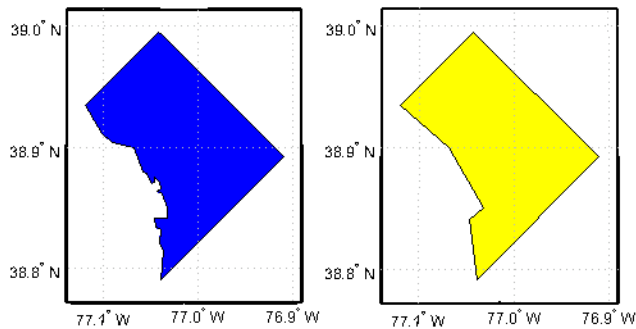
```
lonlim = dc.BoundingBox(:,1)' + [-0.02 0.02];
latlim = dc.BoundingBox(:,2)' + [-0.02 0.02];
```

```

subplot(1,2,1)
usamap(latlim, lonlim); axis off
geoshow(lat, lon,...
        'DisplayType', 'polygon', 'FaceColor', 'blue')

subplot(1,2,2)
usamap(latlim, lonlim); axis off
geoshow(latreduced, lonreduced,...
        'DisplayType', 'polygon', 'FaceColor', 'yellow')

```



Simplify Polygon and Line Data

Simplifying polygon and line data can speed up certain calculations without making any noticeable impact on the data. One way to approach simplification is to use `reducem` with the default tolerance value and view the output. If the results do not meet your requirements, repeat the operation, increasing or decreasing the tolerance value to achieve the result you desire. The `reducem` function returns the tolerance value used.

Extract Massachusetts coastlines and state borders from the `usastatehi.shp` shapefile.

```

ma = shaperead('usastatehi.shp','UseGeoCoords',true, ...
              'Selector', {@(name)strcmpr(name,'Massachusetts'),'Name'});
masslat = ma.Lat;
masslon = ma.Lon;

```

The result is a pair of vectors that outline the state with 957 vertices.

```
numel(masslat)
```

```
ans = 957
```

Simplify Line Data Using Default Tolerance

Simplify the outline by using the `reducem` function with the default tolerance value.

```
[masslat1, masslon1, cerr, tol] = reducem(masslat', masslon');
```

Inspect the results. The number of vertices has been reduced to 252. The vectors have been reduced to about a quarter of their original lengths.

```
numel(masslat1)
```

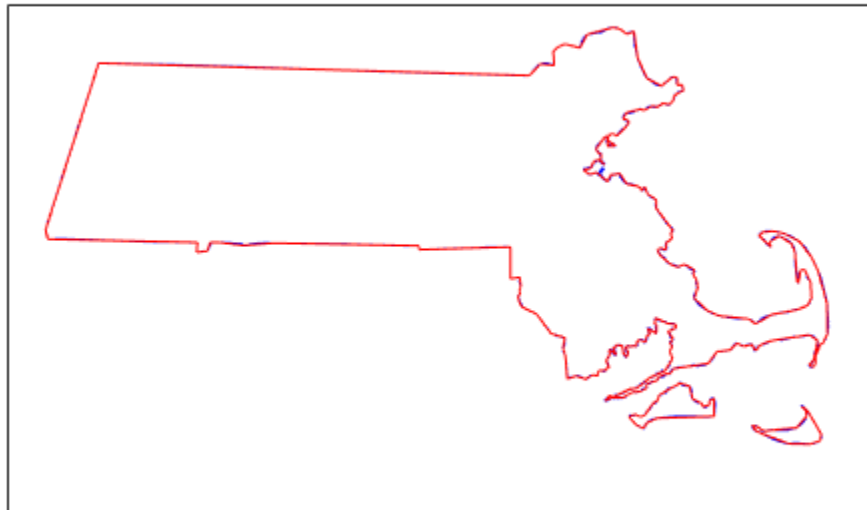
```
ans = 252
numel(masslat1)/numel(masslat)
ans = 0.2633
```

Examine the error and tolerance values returned by `reducem`. The `cerr` value indicates that `reducem` has reduced the total length of the outline by about 3.3 percent. The tolerance that `reducem` used to achieve this reduction was 0.006 degrees, or about 660 meters.

```
[cerr tol]
ans = 1×2
    0.0331    0.0060
```

Plot the reduced outline in red over the original outline in blue, using `geoshow`. At this resolution, it's hard to see any difference between the original outline and the reduced outline.

```
figure
axesm('MapProjection', 'eqdcyl', 'MapLatLim', [41.1 43.0],...
      'MapLonLim', [-73.6, -69.8], 'Frame', 'off', 'Grid', 'off');
geoshow(masslat, masslon, 'DisplayType', 'line', 'color', 'blue')
geoshow(masslat1, masslon1, 'DisplayType', 'line', 'color', 'red')
```



To get a better look at the two outlines, use `xlim` and `ylim` to zoom in on a portion of the map. Notice how the reduced outline conforms to the general contours of the original map but loses a lot of the detail.

```
axesm('MapProjection', 'eqdcyl', 'MapLatLim', [41.1 43.0],...
      'MapLonLim', [-73.6, -69.8], 'Frame', 'off', 'Grid', 'off');
xlim([0.0104 0.0198])
ylim([0.7202 0.7264])
geoshow(masslat, masslon, 'DisplayType', 'line', 'color', 'blue')
geoshow(masslat1, masslon1, 'DisplayType', 'line', 'color', 'red')
```



Simplify Line Data Using Specified Tolerance

Perform the operation again, this time doubling the tolerance value.

```
[masslat2, masslon2, cerr2, tol2] = reducem(masslat', masslon', 0.012);
numel(masslat2)
```

```
ans = 157
```

```
numel(masslat2)/numel(masslat)
```

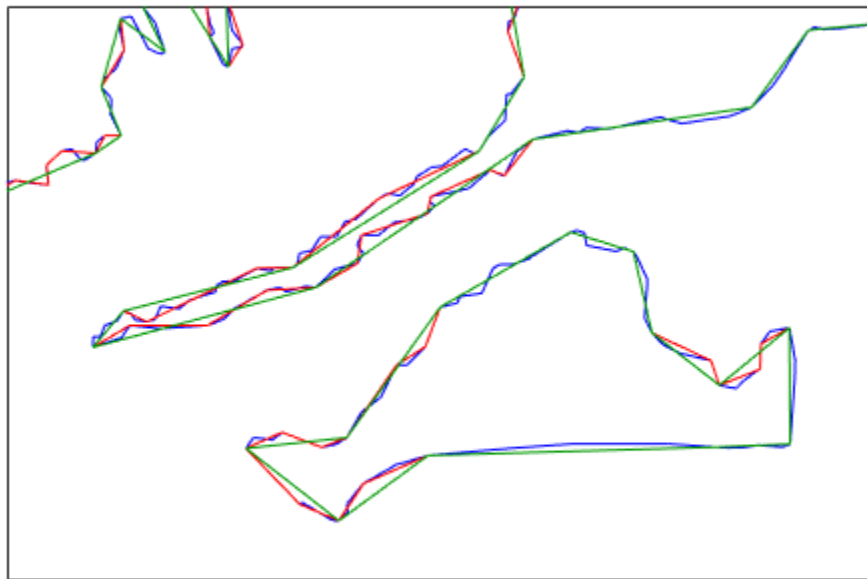
```
ans = 0.1641
```

Examine the error and tolerance values returned by `reducem`. This time, the `cerr` value indicates that `reducem` has reduced the total length of the outline by about 5.2 percent. The tolerance that `reducem` used to achieve this reduction was 0.012 degrees.

```
[cerr2 tol2]
ans = 1×2
    0.0517    0.0120
```

Plot this reduced outline in dark green over the original outline in blue. Note how this reduced outline maintains the general shape of the original map but loses much of the fine detail.

```
geoshow(masslat2, masslon2, 'DisplayType', 'line', 'color', [0 .6 0])
```



Tips

Vector data is reduced using the Douglas-Peucker line simplification algorithm. This method recursively subdivides a polygon until a run of points can be replaced by a straight line segment, with no point in that run deviating from the straight line by more than the tolerance. The distances used to decide on which runs of points to eliminate are computed in a Plate Carrée projection.

Reduced geographic data might not always be appropriate for display. If all intermediate points in a data set are reduced, then lines appearing straight in one projection are incorrectly displayed as straight lines in others.

Version History

Introduced before R2006a

See Also

Functions

interp | georesize

Topics

“Simplify Vector Coordinate Data”

referenceEllipsoid

Reference ellipsoid

Description

A `referenceEllipsoid` object encapsulates a reference ellipsoid, modeled as an oblate spheroid with three additional properties: name, unit of length of the semi-major and semi-minor axes, and a numerical EPSG code.

Creation

There are several ways to create reference ellipsoid objects, including:

- Create a `geocrs` object, and then query its `Spheroid` property.
- Create a `projcrs` object, access the `geocrs` object contained in its `GeographicCRS` property, and then query the `Spheroid` property of the `geocrs`.
- Create a reference ellipsoid for the World Geodetic System of 1984 (WGS84) by using the `wgs84Ellipsoid` function.
- Use the `referenceEllipsoid` function (described here).

Syntax

```
E = referenceEllipsoid
E = referenceEllipsoid(name)
E = referenceEllipsoid(code)
E = referenceEllipsoid(name, lengthUnit)
E = referenceEllipsoid(code, lengthUnit)
```

Description

`E = referenceEllipsoid` creates a `referenceEllipsoid` object that represents the unit sphere.

`E = referenceEllipsoid(name)` creates a `referenceEllipsoid` object corresponding to `name`. `name` is case-insensitive. The values of the `SemimajorAxis` and `SemiminorAxis` properties are in meters.

`E = referenceEllipsoid(code)` creates a `referenceEllipsoid` object corresponding to the numerical EPSG code, `code`. The unit of length used for the `SemimajorAxis` and `SemiminorAxis` properties depends on the ellipsoid selected, and is indicated in the property `LengthUnit`.

`E = referenceEllipsoid(name, lengthUnit)` and

`E = referenceEllipsoid(code, lengthUnit)` create a `referenceEllipsoid` object with the `SemimajorAxis` and `SemiminorAxis` properties in the specified unit of length, `LengthUnit`. The unit of length can be any length unit supported by the `validateLengthUnit` function.

Input Arguments

name — Name of the reference ellipsoid

'Unit Sphere' (default) | character vector | string scalar

Name of the reference ellipsoid, specified as one of the values in the “Names of EPSG Ellipsoids” on page 1-1500 table.

Data Types: char | string

code — Numerical EPSG code

[] (default) | integer between 7000 and 8000

Numerical EPSG code, specified as an empty vector or an integer between 7000 and 8000, although not all integers in this range are valid numerical EPSG codes. For information on valid EPSG codes, see the EPSG home page.

Data Types: double

lengthUnit — Length unit

' ' (default) | character vector | string scalar

Length unit, specified as a character vector or string scalar. You can specify any length unit that is supported by the `validateLengthUnit` function.

Value	Unit Name
"m", "meter", "meters", "metre", "metres"	Meters
"cm", "centimeter", "centimeters", "centimetre", "centimetres"	Centimeters
"mm", "millimeter", "millimeters", "millimetre", "millimetres"	Millimeters
"micron", "microns"	Microns
"km", "kilometer", "kilometers", "kilometre", "kilometers"	Kilometers
"nm", "naut mi", "nautical mile", "nautical miles"	Nautical miles
"ft", "international ft", "foot", "international foot", "feet", "international feet"	Feet
"in", "inch", "inches"	Inches
"yd", "yds", "yard", "yards"	Yards
"mi", "mile", "miles", "international mile", "international miles"	Miles
"sf", "survey ft", "US survey ft", "U.S. survey ft", "survey foot", "US survey foot", "U.S. survey foot", "survey feet", "US survey feet", "U.S. survey feet"	U.S. survey feet

Value	Unit Name
"sm", "survey mile", "survey miles", "statute mile", "statute miles", "US survey mile", "US survey miles", "U.S. survey mile(s)", "U.S. survey miles"	U.S. survey miles (statute miles)
"Clarke's foot", "Clarkes foot"	Clarke's feet
"German legal metre", "German legal meter"	German legal metres
"Indian foot"	Indian feet

Data Types: char | string

Properties

Code — Numerical EPSG code

[] (default) | integer between 7000 and 8000

Numerical EPSG code, specified as an empty vector or an integer between 7000 and 8000, although not all integers in this range are valid numerical EPSG codes. For information on valid EPSG codes, see the EPSG home page.

When the reference ellipsoid represents the unit sphere or a custom ellipsoid, Code is an empty vector ([]).

Example: 7030

Data Types: double

Name — Name of the reference ellipsoid

'Unit Sphere' (default) | character vector | string scalar

Name of the reference ellipsoid, specified as a character vector or string scalar. When you create a reference ellipsoid by specifying its name, use one of the values in the “Names of EPSG Ellipsoids” on page 1-1500 table.

When the reference ellipsoid represents the unit sphere, Name is the character vector 'Unit Sphere'.

Example: 'World Geodetic System 1984'

Data Types: char | string

LengthUnit — Unit of length for the ellipsoid axes

' ' (default) | character vector | string scalar

Unit of length for the ellipsoid axes, specified as a character vector. The character vector can be empty, or it can be any unit of length accepted by the `validateLengthUnit` function.

When the reference ellipsoid represents the unit sphere, LengthUnit is the empty character vector ''.

Example: 'km'

Data Types: char | string

SemimajorAxis — Equatorial radius of ellipsoid

1 (default) | positive, finite scalar

Equatorial radius of ellipsoid, specified as a positive, finite scalar. The `SemimajorAxis` property is expressed in units of length specified by `LengthUnit`.

When the `SemimajorAxis` property is changed, the `SemiminorAxis` property scales as needed to preserve the shape of the ellipsoid and the values of shape-related properties including `InverseFlattening` and `Eccentricity`. The only way to change the `SemimajorAxis` property is to set it directly, using dot notation.

Example: 6378137

Data Types: double

SemiminorAxis — Distance from center of ellipsoid to pole

1 (default) | nonnegative, finite scalar

Distance from center of ellipsoid to pole, specified as a nonnegative, finite scalar. The value of `SemiminorAxis` is always less than or equal to `SemimajorAxis`, and is expressed in units of length specified by `LengthUnit`.

When the `SemiminorAxis` property is changed, the `SemimajorAxis` property remains unchanged, but the shape of the ellipsoid changes, which is reflected in changes in the values of `InverseFlattening`, `Eccentricity`, and other shape-related properties.

Example: 6356752

Data Types: double

InverseFlattening — Reciprocal of flattening

Inf (default) | positive scalar in the range [1, Inf]

Reciprocal of flattening, specified as positive scalar in the range [1, Inf].

The value of inverse flattening, $1/f$, is calculated using `SemimajorAxis` value a and `SemiminorAxis` value b according to $1/f = a/(a-b)$. A value $1/f$ of Inf designates a perfect sphere. As $1/f$ approaches 1, the reference ellipsoid approaches a flattened disk.

When the `InverseFlattening` property is changed, other shape-related properties update, including `Eccentricity`. The `SemimajorAxis` property remains unchanged, but the value of `SemiminorAxis` adjusts to reflect the new shape.

Example: 300

Data Types: double

Eccentricity — First eccentricity of ellipsoid

0 (default) | nonnegative scalar in the range [0, 1]

First eccentricity of the ellipsoid, specified as nonnegative scalar in the range [0, 1].

The value of eccentricity, ecc , is calculated using `SemimajorAxis` value a and `SemiminorAxis` value b according to $ecc = \sqrt{a^2 - b^2}/a$. A value ecc of 0 designates a perfect sphere.

When the `Eccentricity` property is changed, other shape-related properties update, including `InverseFlattening`. The `SemimajorAxis` property remains unchanged, but the value of `SemiminorAxis` adjusts to reflect the new shape.

Example: 0.08

Data Types: double

Flattening – Flattening of ellipsoid

nonnegative scalar in the range [0, 1]

This property is read-only.

Flattening of the ellipsoid, specified as nonnegative scalar in the range [0, 1].

The value of flattening, f , is calculated using SemimajorAxis value a and SemiminorAxis value b according to $f = (a-b)/a$.

Data Types: double

ThirdFlattening – Third flattening of ellipsoid

nonnegative scalar in the range [0, 1]

This property is read-only.

Third flattening of the ellipsoid, specified as nonnegative scalar in the range [0, 1].

The value of the third flattening, n , is calculated using SemimajorAxis value a and SemiminorAxis value b according to $n = (a-b)/(a+b)$.

Data Types: double

MeanRadius – Mean radius of the ellipsoid

positive, finite scalar

This property is read-only.

Mean radius of the ellipsoid, specified as positive, finite scalar. The MeanRadius property is expressed in units of length specified by LengthUnit.

The mean radius of the ellipsoid, r , is calculated using SemimajorAxis value a and SemiminorAxis value b according to $r = (2a+b)/3$.

Data Types: double

SurfaceArea – Surface area of the ellipsoid

positive, finite scalar

This property is read-only.

Surface area of the ellipsoid, specified as positive, finite scalar. The SurfaceArea property is expressed in units of area consistent the unit of length specified by the LengthUnit property.

Data Types: double

Volume – Volume of the ellipsoid

positive, finite scalar

This property is read-only.

Volume of the ellipsoid, specified as positive, finite scalar. The Volume property is expressed in units of volume consistent with the unit of length specified by the LengthUnit property.

Data Types: double

Examples

Construct GRS80 Reference Ellipsoid

Create a reference ellipsoid object by specifying the name of the ellipsoid.

```
e = referenceEllipsoid('GRS 1980')
```

```
e =
referenceEllipsoid with defining properties:
```

```

        Code: 7019
        Name: 'GRS 1980'
    LengthUnit: 'meter'
    SemimajorAxis: 6378137
    SemiminorAxis: 6356752.31414036
    InverseFlattening: 298.257222101
    Eccentricity: 0.0818191910428158
```

and additional properties:

```

    Flattening
    ThirdFlattening
    MeanRadius
    SurfaceArea
    Volume
```

Create the same reference ellipsoid object by specifying the EPSG code 7019.

```
e = referenceEllipsoid(7019)
```

```
e =
referenceEllipsoid with defining properties:
```

```

        Code: 7019
        Name: 'GRS 1980'
    LengthUnit: 'meter'
    SemimajorAxis: 6378137
    SemiminorAxis: 6356752.31414036
    InverseFlattening: 298.257222101
    Eccentricity: 0.0818191910428158
```

and additional properties:

```

    Flattening
    ThirdFlattening
    MeanRadius
    SurfaceArea
    Volume
```

Create a reference ellipsoid object, specifying the units. For length unit, you can specify any unit of length accepted by the `validateLengthUnit` function.

```
e = referenceEllipsoid('GRS80', 'km')
e =
referenceEllipsoid with defining properties:
    Code: 7019
    Name: 'GRS 1980'
    LengthUnit: 'kilometer'
    SemimajorAxis: 6378.137
    SemiminorAxis: 6356.75231414036
    InverseFlattening: 298.257222101
    Eccentricity: 0.0818191910428158
and additional properties:
    Flattening
    ThirdFlattening
    MeanRadius
    SurfaceArea
    Volume
```

Create a reference ellipsoid, specifying the `GeoTIFFCodes.Ellipsoid` field from a file.

```
info = geotiffinfo('boston.tif');
e = referenceEllipsoid(info.GeoTIFFCodes.Ellipsoid)
e =
referenceEllipsoid with defining properties:
    Code: 7019
    Name: 'GRS 1980'
    LengthUnit: 'meter'
    SemimajorAxis: 6378137
    SemiminorAxis: 6356752.31414036
    InverseFlattening: 298.257222101
    Eccentricity: 0.0818191910428158
and additional properties:
    Flattening
    ThirdFlattening
    MeanRadius
    SurfaceArea
    Volume
```

Create Custom Model for Planet

Create a custom reference ellipsoid by modifying the properties of a default reference ellipsoid.

```
customPlanet = referenceEllipsoid;
customPlanet.Name = 'Tiny Planet';
customPlanet.LengthUnit = 'meter';
customPlanet.SemimajorAxis = 8000;
customPlanet.SemiminorAxis = 7900
```



```
customPlanet =
referenceEllipsoid with defining properties:
```

```

    Code: []
    Name: 'Tiny Planet'
    LengthUnit: 'meter'
    SemimajorAxis: 8000
    SemiminorAxis: 7900
    InverseFlattening: 80
    Eccentricity: 0.157619002661481
```

and additional properties:

```

    Flattening
    ThirdFlattening
    MeanRadius
    SurfaceArea
    Volume
```

Get Reference Ellipsoid from Coordinate Reference System

You can get a reference ellipsoid from a geographic coordinate reference system (CRS) or a projected CRS.

Get Ellipsoid from Geographic CRS

Read a shapefile containing world cities into the workspace as a geospatial table. The table represents the cities using shape objects in geographic coordinates.

```
GT = readgeotable("worldcities.shp");
```

Get a geographic CRS from the shape objects by querying the GeographicCRS property. Then, get the reference ellipsoid by querying the Spheroid property of the CRS.

```
gcrs1 = GT.Shape.GeographicCRS;
E1 = gcrs1.Spheroid
```

```
E1 =
referenceEllipsoid with defining properties:
```

```

    Code: 7030
    Name: 'WGS 84'
    LengthUnit: 'meter'
    SemimajorAxis: 6378137
    SemiminorAxis: 6356752.31424518
    InverseFlattening: 298.257223563
    Eccentricity: 0.0818191908426215
```

and additional properties:

```

    Flattening
    ThirdFlattening
    MeanRadius
    SurfaceArea
```

Volume

Get Ellipsoid from Projected CRS

Get information about a GeoTIFF image of Boston by using the `georasterinfo` function. The file contains raster data in projected coordinates.

```
info = georasterinfo("boston.tif");
```

Get a projected CRS from the returned `RasterInfo` object by querying the `CoordinateReferenceSystem` property. Get the geographic CRS from the projected CRS by querying the `GeographicCRS` property. Then, get the reference ellipsoid by querying the `Spheroid` property of the geographic CRS.

```
pcrs = info.CoordinateReferenceSystem;
gcrs2 = pcrs.GeographicCRS;
E2 = gcrs2.Spheroid
```

```
E2 =
referenceEllipsoid with defining properties:
```

```

        Code: 7019
        Name: 'GRS 1980'
        LengthUnit: 'meter'
        SemimajorAxis: 6378137
        SemiminorAxis: 6356752.31414036
        InverseFlattening: 298.257222101
        Eccentricity: 0.0818191910428158
```

```
and additional properties:
```

```

        Flattening
        ThirdFlattening
        MeanRadius
        SurfaceArea
        Volume
```

More About

Names of EPSG Ellipsoids

All of the nearly 60 codes in the EPSG ellipsoid table are supported. A subset of these ellipsoids can be created by specifying their name. The short and long names of these ellipsoids, along with their corresponding code, appear in the table. You can create a reference ellipsoid by specifying either its code, short name, or long name.

EPSG Code	Short Name	Long Name
—	'unitsphere'	'Unit Sphere'
7035	'sphere'	'Sphere'
7019	'grs80'	'GRS 1980'
7030	'wgs84'	'WGS 84'

EPSG Code	Short Name	Long Name
7015	'everest'	'Everest 1830 (1837 Adjustment)'
7004	'bessel'	'Bessel 1841'
7001	'airy1830'	'Airy 1830'
7002	'airy1849'	'Airy Modified 1849'
7008	'clarke66'	'Clarke 1866'
7012	'clarke80'	'Clarke 1880 (RGS)'
7022	'international'	'International 1924'
7024	'krasovsky'	'Krassowsky 1940'
7043	'wgs72'	'WGS 72'
—	'wgs60'	'World Geodetic System 1960'
—	'iau65'	'International Astronomical Union 1965'
—	'wgs66'	'World Geodetic System 1966'
—	'iau68'	'International Astronomical Union 1968'
7030	'earth'	'WGS 84'
—	'sun'	'Sun'
—	'moon'	'Moon'
—	'mercury'	'Mercury'
—	'venus'	'Venus'
—	'mars'	'Mars'
—	'jupiter'	'Jupiter'
—	'saturn'	'Saturn'
—	'uranus'	'Uranus'
—	'neptune'	'Neptune'
—	'pluto'	'Pluto'

Tips

- When you define an ellipsoid in terms of semimajor and semiminor axes (rather than semimajor axis and inverse flattening, or semimajor axis and eccentricity), a small loss of precision in the last few digits of Flattening, Eccentricity, and ThirdFlattening may occur. This is unavoidable, but does not affect the results of practical computation.

Version History

Introduced in R2012a

R2020b: Name property for some ReferenceEllipsoid objects has changed

Behavior changed in R2020b

Starting in R2020b, the Name property of referenceEllipsoid objects always contains the names of the ellipsoids as they appear in the EPSG Geodetic Database. In R2020a and previous releases, the value of the Name property depended on the name or code you used to create the object.

For example, create two referenceEllipsoid objects using the WGS84 reference system. Create the first object by specifying its EPSG code, and create the second object by specifying its name. In R2020b and later releases the value of the Name property is the same for both referenceEllipsoid objects. In R2020a and earlier releases the value of the Name property is not the same.

```
r1 = referenceEllipsoid(7030);
r2 = referenceEllipsoid('World Geodetic System 1984');
r1.Name
r2.Name
```

R2020b and later	R2020a and earlier
ans = 'WGS 84'	ans = 'WGS 84'
ans = 'WGS 84'	ans = 'World Geodetic System 1984'

If you have existing code in which you create a reference ellipsoid object by specifying a name to the referenceEllipsoid creation function, you do not need to update your code to correspond to a name in the EPSG Geodetic Database.

For more information about the EPSG Geodetic Database, see the EPSG home page.

See Also

oblateSpheroid | referenceSphere | validateLengthUnit | wgs84Ellipsoid | geocrs

referenceSphere

Reference sphere

Description

A `referenceSphere` object represents a sphere with a specific name and radius that you can use in map projections and other geodetic operations.

Creation

There are several ways to create reference sphere objects, including:

- Create a `geocrs` object, and then query its `Spheroid` property.
- Create a `projcrs` object, access the `geocrs` object contained in its `GeographicCRS` property, and then query the `Spheroid` property of the `geocrs`.
- Use the `referenceSphere` function (described here).

Syntax

```
S = referenceSphere
S = referenceSphere(name)
S = referenceSphere(name,lengthUnit)
```

Description

`S = referenceSphere` creates a `referenceSphere` object that represents the unit sphere.

`S = referenceSphere(name)` creates a `referenceSphere` object corresponding to the specified spherical body given by `name`. The radius of the reference sphere is in meters.

`S = referenceSphere(name,lengthUnit)` creates a `referenceSphere` object with radius in the specified unit of length, `LengthUnit`. The unit of length can be any length unit supported by the `validateLengthUnit` function.

Input Arguments

name — Name of predefined reference sphere

'Unit Sphere' (default) | 'earth' | 'sun' | 'moon' | ...

Name of predefined reference sphere, specified as 'earth', 'sun', 'moon', 'mercury', 'venus', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', 'pluto', or 'unit sphere'. The name argument is not case-sensitive.

Data Types: char | string

lengthUnit — Length unit

' ' (default) | character vector | string scalar

Length unit, specified as a character vector or string scalar. You can specify any length unit that is supported by the `validateLengthUnit` function.

Value	Unit Name
"m", "meter", "meters", "metre", "metres"	Meters
"cm", "centimeter", "centimeters", "centimetre", "centimetres"	Centimeters
"mm", "millimeter", "millimeters", "millimetre", "millimetres"	Millimeters
"micron", "microns"	Microns
"km", "kilometer", "kilometers", "kilometre", "kilometers"	Kilometers
"nm", "naut mi", "nautical mile", "nautical miles"	Nautical miles
"ft", "international ft", "foot", "international foot", "feet", "international feet"	Feet
"in", "inch", "inches"	Inches
"yd", "yds", "yard", "yards"	Yards
"mi", "mile", "miles", "international mile", "international miles"	Miles
"sf", "survey ft", "US survey ft", "U.S. survey ft", "survey foot", "US survey foot", "U.S. survey foot", "survey feet", "US survey feet", "U.S. survey feet"	U.S. survey feet
"sm", "survey mile", "survey miles", "statute mile", "statute miles", "US survey mile", "US survey miles", "U.S. survey mile(s)", "U.S. survey miles"	U.S. survey miles (statute miles)
"Clarke's foot", "Clarkes foot"	Clarke's feet
"German legal metre", "German legal meter"	German legal metres
"Indian foot"	Indian feet

Data Types: `char` | `string`

Properties

Name — Name of reference sphere

'Unit Sphere' (default) | `character vector` | `string scalar`

Name of the reference sphere, specified as a `string scalar` or `character vector`.

Example: 'Sun'

Data Types: `char` | `string`

LengthUnit — Unit of length of the radius`' ' (default) | character vector | string scalar`

Unit of length of the radius, specified as a string scalar or character vector. You can specify any unit of length accepted by the `validateLengthUnit` function. When the reference sphere represents the unit sphere, `LengthUnit` is the empty character vector `''`.

Example: `'km'`

Data Types: `char` | `string`

Radius — Radius of the sphere`positive, finite scalar`

Radius of the sphere, specified as positive, finite scalar.

Data Types: `double`

SemimajorAxis — Equatorial radius of the sphere`1 (default) | positive, finite scalar`

This property is read-only.

Equatorial radius of the sphere, specified as a positive, finite scalar. The value of `SemimajorAxis` is equal to the value of `Radius`.

Data Types: `double`

SemiminorAxis — Distance from center of sphere to pole`1 (default) | positive, finite scalar`

This property is read-only.

Distance from center of sphere to pole, specified as a positive, finite scalar. The value of `SemiminorAxis` is equal to the value of `Radius`.

Data Types: `double`

InverseFlattening — Reciprocal of flattening`Inf (default)`

This property is read-only.

Reciprocal of flattening, specified as the value `Inf`.

Data Types: `double`

Eccentricity — First eccentricity of sphere`0 (default)`

This property is read-only.

First eccentricity of the sphere, specified as the value `0`.

Data Types: `double`

Flattening — Flattening of sphere`0 (default)`

This property is read-only.

Flattening of the sphere, specified as the value 0.

Data Types: double

ThirdFlattening — Third flattening of sphere

0 (default)

This property is read-only.

Third flattening of the sphere, specified as the value 0.

Data Types: double

MeanRadius — Mean radius of the sphere

positive, finite scalar

This property is read-only.

Mean radius of the sphere, specified as positive, finite scalar. The value of `MeanRadius` is equal to the value of `Radius`.

Data Types: double

SurfaceArea — Surface area of the sphere

positive, finite scalar

This property is read-only.

Surface area of the sphere, specified as positive, finite scalar.

The `SurfaceArea` property is expressed in units of area consistent with the unit of length specified by the `LengthUnit` property.

Data Types: double

Volume — Volume of the sphere

positive, finite scalar

This property is read-only.

Volume of the sphere, specified as positive, finite scalar.

The `Volume` property is expressed in units of volume consistent with the unit of length specified by the `LengthUnit` property.

Data Types: double

Examples

Create Model of Earth in Kilometers

Construct a reference sphere that models the Earth as a sphere with a radius of 6371000 meters. Note that the unit of length is meters.

```
s = referenceSphere('Earth')
```



```
s =
```

```
referenceSphere with defining properties:
```

```
    Name: 'Earth'  
    LengthUnit: 'meter'  
    Radius: 6371000
```

```
and additional properties:
```

```
SemimajorAxis  
SemiminorAxis  
InverseFlattening  
Eccentricity  
Flattening  
ThirdFlattening  
MeanRadius  
SurfaceArea  
Volume
```

Switch the unit of length in the reference sphere to kilometers.

```
s.LengthUnit = 'kilometer'
```

```
s =
```

```
referenceSphere with defining properties:
```

```
    Name: 'Earth'  
    LengthUnit: 'kilometer'  
    Radius: 6371
```

```
and additional properties:
```

```
SemimajorAxis  
SemiminorAxis  
InverseFlattening  
Eccentricity  
Flattening  
ThirdFlattening  
MeanRadius  
SurfaceArea  
Volume
```

Determine the surface area of the sphere in square kilometers.

```
s.SurfaceArea
```

```
ans =
```

```
5.1006e+08
```

Find the volume of the sphere in cubic kilometers.

```
s.Volume
```

```
ans =  
1.0832e+12
```

Create Custom Model for Planet

Create a custom reference sphere for a planet by modifying the properties of a default reference sphere.

```
customPlanet = referenceSphere;  
customPlanet.Name = 'Tiny Planet';  
customPlanet.LengthUnit = 'meter';  
customPlanet.Radius = 8000  
  
customPlanet =  
  
referenceSphere with defining properties:  
  
    Name: 'Tiny Planet'  
    LengthUnit: 'meter'  
    Radius: 8000
```

and additional properties:

```
SemimajorAxis  
SemiminorAxis  
InverseFlattening  
Eccentricity  
Flattening  
ThirdFlattening  
MeanRadius  
SurfaceArea  
Volume
```

Get Reference Sphere from Coordinate Reference System

Create a geographic CRS for the moon, which has the ESRI code 104903. Then, get the reference sphere by querying the Spheroid property of the geographic CRS.

```
gcrs1 = geocrs(104903, "Authority", "ESRI");  
S1 = gcrs1.Spheroid  
  
S1 =  
referenceSphere with defining properties:  
  
    Name: 'Moon_2000_IAU_IAG'  
    LengthUnit: 'meter'  
    Radius: 1737400
```

and additional properties:

```
SemimajorAxis  
SemiminorAxis  
InverseFlattening
```

Eccentricity
Flattening
ThirdFlattening
MeanRadius
SurfaceArea
Volume

Version History

Introduced in R2012a

See Also

[oblateSpheroid](#) | [referenceEllipsoid](#) | [validateLengthUnit](#)

refine

Refine search of WMS layers

Syntax

```
refined = refine(layers,querystr)
refined = refine( __ ,Name,Value,...)
```

Description

`refined = refine(layers,querystr)` searches fields of Web map service layers, `layers`, for a partial match with the string or character vector in `querystr`. By default, `refine` searches the `Layer` or `LayerName` properties but you can include other fields in the search using the `SearchFields` parameter.

`refined = refine(__ ,Name,Value,...)` modifies the search based on the values of the named parameters.

Examples

Refine Search by Text

Find layers in the WMS Database that contain information about temperature.

```
temperature = wmsfind('temperature');
```

Refine the search of temperature layers to find only those layers that contain annual temperature information.

```
annual = refine(temperature,'annual');
```

Refine the search of temperature layers to find layers containing only sea surface temperatures.

```
sst = refine(temperature,'sea surface');
```

Refine the search of sea surface temperature layers to include only layers that include annual information.

```
annual_and_sst = refine(sst,'annual');
annual_or_sst = [sst;annual];
```

Input Arguments

layers — Layers to search

array of `WMSLayer` objects

Layers to search, specified as an array of `WMSLayer` objects.

querystr — Characters to search for in WMSLayer object fields

character vector | string

Characters to search for in `WMSLayer` object fields, specified as a string or character vector. `querystr` can contain the asterisk wildcard character (*).

Example: 'temperature'

Data Types: char | string

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: 'IgnoreCase', false

SearchFields — Fields to search in the WMSLayer objects

'layer' (default) | 'server' | 'layertitle' | 'layername' | 'servertitle' | 'serverurl' | 'any' | 'abstract'

Fields to search in the `WMSLayer` objects, specified as a string, string array, character vector, or cell array of character vectors. The function searches the values of the specified fields in the `WMSLayer` objects for a partial or exact match with `querystr`. Multiple options may be included in a string array or cell array of character vectors.

The table lists valid values of `searchFields`.

Field	Behavior
'layer'	Search both the <code>LayerTitle</code> and the <code>LayerName</code> fields.
'layername'	Search the <code>LayerName</code> field in the <code>WMSLayer</code> objects. The layer name is an abbreviated form of the <code>LayerTitle</code> field and is the keyword the server uses to retrieve the layer.
'layertitle'	Search the <code>LayerTitle</code> field in the <code>WMSLayer</code> objects. The layer title includes descriptive information about a layer and facilitates understanding the meaning of the raster values of the layer.
'server'	Search the <code>ServerURL</code> in the <code>WMSLayer</code> objects. The server URL and layer information facilitate the reading of raster layers by the function <code>wms read</code> .
'servertitle'	Search the <code>ServerTitle</code> field in the <code>WMSLayer</code> objects. A server title includes descriptive information about the server.
'serverurl'	Search the <code>ServerURL</code> in the <code>WMSLayer</code> objects. The server URL and layer information facilitate the reading of raster layers by the function <code>wms read</code> .
'abstract'	Search the <code>abstract</code> field in the <code>WMSLayer</code> objects.
'any'	Search all fields.

Data Types: char | string

MatchType — Strictness of match`'partial' (default) | 'exact'`

Strictness of match, specified as the string or character vector `'partial'` or `'exact'`. If `'MatchType'` is `'exact'` and `querystr` is `'*'`, a match occurs when the search field matches the character `'*'`.

Data Types: `char` | `string`

IgnoreCase — Ignore case when comparing field values to querystr`true (default) | false`

Ignore case when comparing field values to `querystr`, specified as the logical value `true` or `false`.

Data Types: `logical`

Output Arguments**refined — Refined layers**`array of WMSLayer objects`

Refined layers, returned as an array of `WMSLayer` objects. Each layer in the array has a searched field that matches the text query, `querystr`.

Version History**Introduced in R2009b****See Also**`wmsfind` | `refineLimits`

refineLimits

Refine search of WMS layers based on geographic limits

Syntax

```
refined = refineLimits(layers,Name,Value,...)
```

Description

`refined = refineLimits(layers,Name,Value,...)` searches for elements of Web map service layers, `layers`, that match specific latitude or longitude limits. The results include a given layer only if the quadrangle specified by the optional 'Latlim' and 'Lonlim' parameters fully contains the boundary quadrangle, as defined by the `Latlim` and `Lonlim` properties. Partial overlap does not result in a match. All angles are in units of degrees.

Examples

Refine Search by Geographic Limits

Find layers in the WMS Database that contain information about hurricanes.

```
layers = wmsfind('hurricane');  
num_layers = length(layers)  
  
num_layers = 79
```

Refine the search by finding layers that are in the western hemisphere.

```
refined = refineLimits(layers, ...  
    'Latlim',[-90 90],'Lonlim',[-180 0]);  
num_refined = length(refined)  
  
num_refined = 32
```

Note that the refined array contains fewer layers.

Your results might be different because the WMS Database changes each release.

Find Layers Containing Global Elevation Data

Search the WMS Database for layers containing elevation data.

```
elevation = wmsfind('elevation');
```

Refine the search by specifying latitude and longitude limits.

```
latlim = [-90, 90];  
lonlim = [-180, 180];
```

```
globalElevation = ...  
    refineLimits(elevation, 'Latlim', latlim, 'Lonlim', lonlim);
```

Display the server titles as a column vector. Your results might be different because the WMS Database changes each release.

```
serverTitles(globalElevation)'  
  
ans = 5x1 cell  
    {'CubeSERV WMS' }  
    {'NASA Earth Observations (NEO) WMS' }  
    {'Web Map Service for data hosted by MathWorks' }  
    {'World Map' }  
    {'World Map' }
```

Input Arguments

layers — Layers to search

array of WMSLayer object

Layers to search, specified as an array of WMSLayer objects.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: 'Latlim', [0 90]

Latlim — Latitudinal limits to search

two-element vector

Latitudinal limits to search, specified as a two-element vector. `Latlim` is in the form `[southern_limit northern_limit]` or a scalar value representing the latitude of a single point.

Example: [-90, 90]

Lonlim — Longitudinal limits to search

numeric scalar | two-element numeric vector

Longitudinal limits to search, specified as a numeric scalar or two-element numeric vector. `Lonlim` is in the form `[western_limit eastern_limit]` or a scalar value representing the longitude of a single point.

Example: [-180, 180]

Output Arguments

refined — Refined layers

array of WMSLayer objects

Refined layers, specified as an array of `WMSLayer` objects. Each layer in the array has a boundary quadrangle that is fully contained in the quadrangle defined by the specified `'Latlim'` and `'Lonlim'` parameters.

Tips

- The default value of `[]` for either `'Latlim'` or `'Lonlim'` implies that all layers match the criteria. For example, if you specify the following, then the results include all the layers that cover the northern hemisphere.

```
refineLimits(layer,'Latlim', [0 90], 'Lonlim', [])
```

Version History

Introduced in R2009b

See Also

`wmsfind` | `refine`

refmat2vec

(To be removed) Convert referencing matrix to referencing vector

Note `refmat2vec` will be removed in a future release. Instead, convert referencing matrices to geographic raster reference objects using the `refmatToGeoRasterReference` function. For more information, see “Compatibility Considerations”.

Syntax

```
refvec = refmat2vec(R,s)
```

Description

`refvec = refmat2vec(R,s)` converts a referencing matrix, `R`, to the three-element referencing vector `refvec`. `R` is a 3-by-2 referencing matrix defining a two-dimensional affine transformation from pixel coordinates to spatial coordinates. `s` is the size of the array (data grid) that is being referenced. `refvec` is a 1-by-3 referencing vector having elements [cells/degree north-latitude west-longitude] with latitude and longitude limits specified in degrees.

Examples

```
% Convert a sample referencing matrix to a  
% referencing vector.  
N = rand(180,360);  
refmat = [0 1; 1 0; -0.5 -90.5];  
V = refmat2vec(refmat,size(N));
```

Version History

Introduced before R2006a

R2022a: Warns

Warns starting in R2022a

Some functions that return referencing vectors issue a warning that they will be removed in a future release, including the `refmat2vec` function. Instead, convert referencing matrices to geographic raster reference objects using the `refmatToGeoRasterReference` function. Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see the `GeographicPostingsReference` object.
- You can manipulate the limits of rasters associated with geographic reference objects using the `geocrop` function.

- You can manipulate the size and resolution of rasters associated with geographic reference objects using the `georesize` function.
- Most functions that accept referencing vectors as inputs also accept reference objects.

To update your code, replace instances of the `refmat2vec` function with the `refmatToGeoRasterReference` function.

```
rasterRef = refmatToGeoRasterReference(refmat,rasterSize);
```

R2020b: To be removed

Not recommended starting in R2020b

The `refmat2vec` function runs without warning but will be removed in a future release.

See Also

`refmatToGeoRasterReference`

refvec2mat

(To be removed) Convert referencing vector to referencing matrix

Note `refvec2mat` will be removed in a future release. Instead, convert referencing vectors to geographic raster reference objects using the `refvecToGeoRasterReference` function. For more information, see “Compatibility Considerations”.

Syntax

```
R = refvec2mat(refvec,s)
```

Description

`R = refvec2mat(refvec,s)` converts a referencing vector, `refvec`, to the referencing matrix `R`. `refvec` is a 1-by-3 referencing vector having elements [`cells/degree north-latitude west-longitude`] with latitude and longitude limits specified in degrees. `s` is the size of the array (data grid) that is being referenced. `R` is a 3-by-2 referencing matrix defining a two-dimensional affine transformation from pixel coordinates to spatial coordinates.

Examples

```
% Create a sample data set and referencing vector
N = rand(180,360);
refvec = [1 90 0];
% Convert the referencing vector to a referencing matrix
R = refvec2mat(refvec,size(N));
```

Version History

Introduced before R2006a

R2022a: Warns

Warns starting in R2022a

Some functions that return referencing matrices issue a warning that they will be removed in a future release, including the `refvec2mat` function. Instead, convert referencing vectors to geographic raster reference objects using the `refvecToGeoRasterReference` function. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see the `GeographicPostingsReference` object.
- You can manipulate the limits of rasters associated with geographic reference objects using the `geocrop` function.

- You can manipulate the size and resolution of rasters associated with geographic reference objects using the `georesize` function.
- Most functions that accept referencing matrices as inputs also accept reference objects.

To update your code, replace instances of the `refvec2mat` function with the `refvecToGeoRasterReference` function.

```
R = refvecToGeoRasterReference(refvec, rasterSize);
```

R2020b: To be removed

Not recommended starting in R2020b

The `refvec2mat` function runs without warning but will be removed in a future release.

See Also

`refvecToGeoRasterReference`

refmatToGeoRasterReference

Convert referencing matrix to geographic raster reference object

Syntax

```
R = refmatToGeoRasterReference(refmat, rasterSize)
R = refmatToGeoRasterReference(refmat, rasterSize, rasterInterpretation)
```

```
R = refmatToGeoRasterReference( ____, funcName)
R = refmatToGeoRasterReference( ____, funcName, varName)
R = refmatToGeoRasterReference( ____, funcName, varName, argIndex)
R = refmatToGeoRasterReference(Rin, rasterSize, ____)
```

Description

Create Reference Object

`R = refmatToGeoRasterReference(refmat, rasterSize)` converts the referencing matrix `refmat` into a reference object for a raster of cells referenced to geographic coordinates, using the raster size `rasterSize`.

`R = refmatToGeoRasterReference(refmat, rasterSize, rasterInterpretation)` specifies the geometric nature of the raster. When the raster contains posting point samples referenced to geographic coordinates, specify `rasterInterpretation` as "postings". The default for `rasterInterpretation` is "cells", which specifies a raster of cells.

Note Instead of converting a referencing matrix to a reference object, you can create a reference object directly.

- Create a reference object for a raster of cells referenced to geographic coordinates by using the `georefcells` function.
 - Create a reference object for a raster of posting points referenced to geographic coordinates by using the `georefpostings` function.
-

Validate Inputs

`R = refmatToGeoRasterReference(____, funcName)`, when `refmat` or `rasterSize` is invalid, includes the specified function name in generated error identifiers. This syntax uses any combination of input arguments from previous syntaxes, and is useful when you want to both validate and convert a referencing matrix. For more information about validating inputs, see the `validateattributes` function.

`R = refmatToGeoRasterReference(____, funcName, varName)` includes the specified variable name in generated error messages.

`R = refmatToGeoRasterReference(____, funcName, varName, argIndex)` includes the position of the referencing matrix in generated error messages.

`R = refmatToGeoRasterReference(Rin, rasterSize, ___)` verifies that the `RasterSize` property of the geographic raster reference object `Rin` matches `rasterSize`, and then returns `Rin` in `R`.

Examples

Convert Referencing Matrix to Geographic Raster Reference Object

Specify a sample referencing matrix and the size of a sample raster. Then, convert the referencing matrix to a geographic raster reference object.

```
refmat = [0 1; 1 0; -0.5 -90.5];
rasterSize = [180 360];
R = refmatToGeoRasterReference(refmat, rasterSize)
```

```
R =
    GeographicCellsReference with properties:
```

```

        LatitudeLimits: [-90 90]
        LongitudeLimits: [0 360]
        RasterSize: [180 360]
    RasterInterpretation: 'cells'
        ColumnsStartFrom: 'south'
        RowsStartFrom: 'west'
    CellExtentInLatitude: 1
    CellExtentInLongitude: 1
    RasterExtentInLatitude: 180
    RasterExtentInLongitude: 360
        XIntrinsicLimits: [0.5 360.5]
        YIntrinsicLimits: [0.5 180.5]
    CoordinateSystemType: 'geographic'
        GeographicCRS: []
        AngleUnit: 'degree'
```

For comparison, create an equivalent reference object directly by using the `georefcells` function.

```
R2 = georefcells([-90 90],[0 360],rasterSize)
```

```
R2 =
    GeographicCellsReference with properties:
```

```

        LatitudeLimits: [-90 90]
        LongitudeLimits: [0 360]
        RasterSize: [180 360]
    RasterInterpretation: 'cells'
        ColumnsStartFrom: 'south'
        RowsStartFrom: 'west'
    CellExtentInLatitude: 1
    CellExtentInLongitude: 1
    RasterExtentInLatitude: 180
    RasterExtentInLongitude: 360
        XIntrinsicLimits: [0.5 360.5]
        YIntrinsicLimits: [0.5 180.5]
    CoordinateSystemType: 'geographic'
```

```
GeographicCRS: []  
AngleUnit: 'degree'
```

Input Arguments

refmat — Referencing matrix

3-by-2 matrix

Referencing matrix, specified as a 3-by-2 matrix. A referencing matrix defines a transformation that maps intrinsic coordinates to geographic coordinates.

Specify `refmat` so that $[lon\ lat] = [x\ y\ 1] \cdot refmat$, where x and y specify a location in intrinsic coordinates and lat and lon specify the same location in geographic coordinates.

When combined with `rasterSize`, the referencing matrix must create valid latitude and longitude limits. The columns and rows of the referencing matrix must align with meridians and parallels, respectively.

Data Types: `double`

rasterSize — Number of rows and columns

two-element vector

Number of rows and columns of the raster, specified as a two-element vector of the form $[m\ n]$, where m is the number of rows and n is the number of columns.

For convenience, you can specify this argument as a vector with more than two elements, such as the size of an RGB image (m -by- n -by-3). The `refmatToGeoRasterReference` function uses only the first two elements of the size vector.

rasterInterpretation — Geometric nature of raster

"cells" (default) | "postings"

Geometric nature of the raster, specified as one of these options:

- "cells" — The raster is a grid of quadrangular cells. The boundary of the raster is made up of the outermost boundaries of the outermost cells.
- "postings" — The raster is a grid of posting point samples. The boundary of the raster is made up of sampling points along the edge of the raster.

For more information about cells and posting points, see "Spatially Reference Imported Rasters".

The corresponding `RasterInterpretation` property of the reference object is read-only after you create the object.

Data Types: `char` | `string`

funcName — Name of function for validation

character vector | string scalar

Name of the function for validation, specified as a character vector or as a string scalar. If you specify an empty character vector, `' '`, or the `<missing>` string, then the `refmatToGeoRasterReference` function ignores the `funcName` input.

Data Types: char | string

varName — Name of input variable

character vector | string scalar

Name of the input variable, specified as a character vector or a string scalar. If you specify an empty character vector, ' ', or the <missing> string, then the refmatToGeoRasterReference function ignores the varName input.

Data Types: char | string

argIndex — Position of input argument

positive integer

Position of the input argument, specified as a positive integer.

Data Types: double

Rin — Geographic raster reference object

GeographicCellsReference object | GeographicPostingsReference object

Geographic raster reference object, specified as a GeographicCellsReference or GeographicPostingsReference object.

If you specify both Rin and rasterInterpretation, the RasterInterpretation property of Rin must match the value of rasterInterpretation.

Output Arguments

R — Geographic raster reference object

GeographicCellsReference object | GeographicPostingsReference object

Geographic raster reference object, returned as a GeographicCellsReference or GeographicPostingsReference object. The value of R depends on the value of the rasterInterpretation argument.

rasterInterpretation	R
"cells"	GeographicCellsReference object
"postings"	GeographicPostingsReference object

Version History

Introduced in R2011a

See Also

Functions

georefcells | georefpostings | refvecToGeoRasterReference

Topics

“Spatially Reference Imported Rasters”

refmatToMapRasterReference

Convert referencing matrix to map raster reference object

Syntax

```
R = refmatToMapRasterReference(refmat, rasterSize)
R = refmatToMapRasterReference(refmat, rasterSize, rasterInterpretation)
```

```
R = refmatToMapRasterReference( ____, funcName)
R = refmatToMapRasterReference( ____, funcName, varName)
R = refmatToMapRasterReference( ____, funcName, varName, argIndex)
R = refmatToMapRasterReference(Rin, rasterSize, ____)
```

Description

Create Reference Object

`R = refmatToMapRasterReference(refmat, rasterSize)` converts the referencing matrix `refmat` into a reference object for a raster of cells referenced to planar coordinates, using the raster size `rasterSize`.

`R = refmatToMapRasterReference(refmat, rasterSize, rasterInterpretation)` specifies the geometric nature of the raster. When the raster contains posting point samples referenced to planar coordinates, specify `rasterInterpretation` as "postings". The default for `rasterInterpretation` is "cells", which specifies a raster of cells.

Note Instead of converting a referencing matrix to a reference object, you can create a reference object directly.

- Create a reference object for a raster of cells referenced to planar coordinates by using the `maprefcells` function.
 - Create a reference object for a raster of posting points referenced to planar coordinates by using the `maprefpostings` function.
-

Validate Inputs

`R = refmatToMapRasterReference(____, funcName)`, when `refmat` or `rasterSize` is invalid, includes the specified function name in generated error identifiers. This syntax uses any combination of input arguments from previous syntaxes, and is useful when you want to both validate and convert a referencing matrix. For more information about validating inputs, see the `validateattributes` function.

`R = refmatToMapRasterReference(____, funcName, varName)` includes the specified variable name in generated error messages.

`R = refmatToMapRasterReference(____, funcName, varName, argIndex)` includes the position of the referencing matrix in generated error messages.

`R = refmatToMapRasterReference(Rin, rasterSize, ___)` verifies that the `RasterSize` property of the map raster reference object `Rin` matches `rasterSize`, and then returns `Rin` in `R`.

Examples

Convert Referencing Matrix to Map Raster Reference Object

Specify a sample referencing matrix and the size of a sample raster. Then, convert the referencing matrix to a map raster reference object.

```
refmat = [0 -1; 1 0; 208999.5 913000.5];
rasterSize = [2000 2000];
R = refmatToMapRasterReference(refmat, rasterSize)
```

```
R =
  MapCellsReference with properties:
        XWorldLimits: [209000 211000]
        YWorldLimits: [911000 913000]
        RasterSize: [2000 2000]
  RasterInterpretation: 'cells'
        ColumnsStartFrom: 'north'
        RowsStartFrom: 'west'
  CellExtentInWorldX: 1
  CellExtentInWorldY: 1
  RasterExtentInWorldX: 2000
  RasterExtentInWorldY: 2000
        XIntrinsicLimits: [0.5 2000.5]
        YIntrinsicLimits: [0.5 2000.5]
  TransformationType: 'rectilinear'
  CoordinateSystemType: 'planar'
        ProjectedCRS: []
```

For comparison, create a reference object directly by using the `maprefcells` function.

```
xlimits = [209000 211000];
ylimits = [911000 913000];
R2 = maprefcells(xlimits, ylimits, rasterSize, "ColumnsStartFrom", "north")
```

```
R2 =
  MapCellsReference with properties:
        XWorldLimits: [209000 211000]
        YWorldLimits: [911000 913000]
        RasterSize: [2000 2000]
  RasterInterpretation: 'cells'
        ColumnsStartFrom: 'north'
        RowsStartFrom: 'west'
  CellExtentInWorldX: 1
  CellExtentInWorldY: 1
  RasterExtentInWorldX: 2000
  RasterExtentInWorldY: 2000
        XIntrinsicLimits: [0.5 2000.5]
        YIntrinsicLimits: [0.5 2000.5]
```

```
TransformationType: 'rectilinear'  
CoordinateSystemType: 'planar'  
ProjectedCRS: []
```

Input Arguments

refmat — Referencing matrix

3-by-2 matrix

Referencing matrix, specified as a 3-by-2 matrix. A referencing matrix defines a transformation that maps intrinsic coordinates to world coordinates.

Specify `refmat` so that $[x_w \ y_w] = [x_i \ y_i \ 1] \cdot \text{refmat}$, where (x_i, y_i) is a location in intrinsic coordinates and (x_w, y_w) is the same location in world coordinates.

Data Types: double

rasterSize — Number of rows and columns

two-element vector

Number of rows and columns of the raster, specified as a two-element vector of the form $[m \ n]$, where m is the number of rows and n is the number of columns.

For convenience, you can specify this argument as a vector with more than two elements, such as the size of an RGB image (m -by- n -by-3). The `refmatToMapRasterReference` function uses only the first two elements of the size vector.

rasterInterpretation — Geometric nature of raster

"cells" (default) | "postings"

Geometric nature of the raster, specified as one of these options:

- "cells" — The raster is a grid of quadrangular cells. The boundary of the raster is made up of the outermost boundaries of the outermost cells.
- "postings" — The raster is a grid of posting point samples. The boundary of the raster is made up of sampling points along the edge of the raster.

For more information about cells and posting points, see "Spatially Reference Imported Rasters".

The corresponding `RasterInterpretation` property of the reference object is read-only after you create the object.

Data Types: char | string

funcName — Name of function for validation

character vector | string scalar

Name of the function for validation, specified as a character vector or as a string scalar. If you specify an empty character vector, `' '`, or the `<missing>` string, then the `refmatToMapRasterReference` function ignores the `funcName` input.

Data Types: char | string

varName — Name of input variable

character vector | string scalar

Name of the input variable, specified as a character vector or a string scalar. If you specify an empty character vector, ' ', or the <missing> string, then the refmatToMapRasterReference function ignores the varName input.

Data Types: char | string

argIndex — Position of input argument

positive integer

Position of the input argument, specified as a positive integer.

Data Types: double

Rin — Map raster reference object

MapCellsReference object | MapPostingsReference object

Map raster reference object, specified as a MapCellsReference or MapPostingsReference object.

If you specify both Rin and rasterInterpretation, the RasterInterpretation property of Rin must match the value of rasterInterpretation.

Output Arguments**R — Map raster reference object**

MapCellsReference object | MapPostingsReference object

Map raster reference object, returned as a MapCellsReference or MapPostingsReference object. The value of R depends on the value of the rasterInterpretation argument.

rasterInterpretation	R
"cells"	MapCellsReference object
"postings"	MapPostingsReference object

Version History

Introduced in R2011a

See Also**Functions**

maprefcells | maprefpostings

Topics

"Spatially Reference Imported Rasters"

refmatToWorldFileMatrix

Convert referencing matrix to world file matrix

Syntax

```
W = refmatToWorldFileMatrix(refmat)
```

Description

`W = refmatToWorldFileMatrix(refmat)` converts the referencing matrix `refmat` to the world file matrix `W`.

Note You can also create a world file matrix from a raster reference object.

- Convert a reference object to a world file matrix by using the `worldFileMatrix` function.
 - Convert a reference object to a world file matrix and write the matrix to a file by using the `worldfilewrite` function.
-

Examples

Convert Referencing Matrix to World File Matrix

Specify a sample referencing matrix. Then, convert the referencing matrix to a world file matrix.

```
refmat = [0 1; 1 0; -0.5 -90.5];
W = refmatToWorldFileMatrix(refmat)
```

```
W = 2×3
```

```
    1.0000         0    0.5000
         0    1.0000   -89.5000
```

Input Arguments

refmat — Referencing matrix

3-by-2 matrix

Referencing matrix, specified as a 3-by-2 matrix. A referencing matrix defines a transformation that maps intrinsic coordinates to world or geographic coordinates.

- For world coordinates, specify `refmat` so that $[x_w \ y_w] = [x_i \ y_i \ 1] \cdot refmat$, where (x_i, y_i) is a location in intrinsic coordinates and (x_w, y_w) is the same location in world coordinates.
- For geographic coordinates, specify `refmat` so that $[lon \ lat] = [x \ y \ 1] \cdot refmat$, where x and y specify a location in intrinsic coordinates and `lat` and `lon` specify the same location in geographic coordinates.

Data Types: double

Output Arguments

W — World file matrix

2-by-3 matrix

World file matrix, returned as a 2-by-3 matrix.

Version History

Introduced in R2011a

See Also

Functions

[worldfileread](#) | [worldFileMatrix](#) | [worldfilewrite](#)

Topics

“Spatially Reference Imported Rasters”

refvecToGeoRasterReference

Convert referencing vector to geographic raster reference object

Syntax

```
R = refvecToGeoRasterReference(refvec, rasterSize)
```

```
R = refvecToGeoRasterReference( ____, funcName)
```

```
R = refvecToGeoRasterReference( ____, funcName, varName)
```

```
R = refvecToGeoRasterReference( ____, funcName, varName, argIndex)
```

```
R = refvecToGeoRasterReference(Rin, rasterSize, ____)
```

Description

Create Reference Object

`R = refvecToGeoRasterReference(refvec, rasterSize)` converts the referencing vector `refvec` into a reference object for a raster of cells referenced to geographic coordinates, using the raster size `rasterSize`.

Note Instead of converting a referencing vector to a reference object, you can create a reference object directly.

- Create a reference object for a raster of cells referenced to geographic coordinates by using the `georefcells` function.
 - Create a reference object for a raster of posting points referenced to geographic coordinates by using the `georefpostings` function.
-

Validate Inputs

`R = refvecToGeoRasterReference(____, funcName)`, when `refvec` or `rasterSize` is invalid, includes the specified function name in generated error identifiers. This syntax uses any combination of input arguments from previous syntaxes, and is useful when you want to both validate and convert a referencing vector. For more information about validating inputs, see the `validateattributes` function.

`R = refvecToGeoRasterReference(____, funcName, varName)` includes the specified variable name in generated error messages.

`R = refvecToGeoRasterReference(____, funcName, varName, argIndex)` includes the position of the referencing vector in generated error messages.

`R = refvecToGeoRasterReference(Rin, rasterSize, ____)` verifies that the `RasterSize` property of the geographic raster reference object `Rin` matches `rasterSize`, and then returns `Rin` in `R`.

Examples

Convert Referencing Vector to Geographic Raster Reference Object

Specify a referencing vector for a 180-by-240 grid that contains 12 cells per degree for an area around the Korean Peninsula. Then, convert the referencing vector to a geographic raster reference object.

```
refvec = [12 45 115];
rasterSize = [180 240];
R = refvecToGeoRasterReference(refvec,rasterSize)
```

```
R =
    GeographicCellsReference with properties:
```

```

        LatitudeLimits: [30 45]
        LongitudeLimits: [115 135]
        RasterSize: [180 240]
    RasterInterpretation: 'cells'
        ColumnsStartFrom: 'south'
        RowsStartFrom: 'west'
    CellExtentInLatitude: 1/12
    CellExtentInLongitude: 1/12
    RasterExtentInLatitude: 15
    RasterExtentInLongitude: 20
        XIntrinsicLimits: [0.5 240.5]
        YIntrinsicLimits: [0.5 180.5]
    CoordinateSystemType: 'geographic'
        GeographicCRS: []
        AngleUnit: 'degree'
```

For comparison, create an equivalent reference object directly by using the `georefcells` function.

```
R2 = georefcells([30 45],[115 135],rasterSize)
```

```
R2 =
    GeographicCellsReference with properties:
```

```

        LatitudeLimits: [30 45]
        LongitudeLimits: [115 135]
        RasterSize: [180 240]
    RasterInterpretation: 'cells'
        ColumnsStartFrom: 'south'
        RowsStartFrom: 'west'
    CellExtentInLatitude: 1/12
    CellExtentInLongitude: 1/12
    RasterExtentInLatitude: 15
    RasterExtentInLongitude: 20
        XIntrinsicLimits: [0.5 240.5]
        YIntrinsicLimits: [0.5 180.5]
    CoordinateSystemType: 'geographic'
        GeographicCRS: []
        AngleUnit: 'degree'
```

Input Arguments

refvec — Referencing vector

three-element vector

Referencing vector, specified as a three-element vector such that:

- `1/refvec(1)` specifies the extent of individual raster cells in latitude and longitude.
- `refvec(2)` specifies the latitude of the northwest corner of the raster.
- `refvec(3)` specifies the longitude of the northwest corner of the raster.

When combined with `rasterSize`, the referencing vector must create valid latitude and longitude limits.

Data Types: `double`

rasterSize — Number of rows and columns

two-element vector

Number of rows and columns of the raster, specified as a two-element vector of the form `[m n]`, where `m` is the number of rows and `n` is the number of columns.

For convenience, you can specify this argument as a vector with more than two elements, such as the size of an RGB image (*m-by-n-by-3*). The `refvecToGeoRasterReference` function uses only the first two elements of the size vector.

funcName — Name of function for validation

character vector | string scalar

Name of the function for validation, specified as a character vector or as a string scalar. If you specify an empty character vector, `' '`, or the `<missing>` string, then the `refvecToGeoRasterReference` function ignores the `funcName` input.

Data Types: `char` | `string`

varName — Name of input variable

character vector | string scalar

Name of the input variable, specified as a character vector or a string scalar. If you specify an empty character vector, `' '`, or the `<missing>` string, then the `refvecToGeoRasterReference` function ignores the `varName` input.

Data Types: `char` | `string`

argIndex — Position of input argument

positive integer

Position of the input argument, specified as a positive integer.

Data Types: `double`

Rin — Geographic raster reference object

`GeographicCellsReference` object | `GeographicPostingsReference` object

Geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object.

Output Arguments

R — Geographic raster reference object

GeographicCellsReference object | GeographicPostingsReference object

Geographic raster reference object, returned as a GeographicCellsReference or GeographicPostingsReference object.

The refvecToGeoRasterReference function returns a GeographicPostingsReference object only when you specify Rin as a GeographicPostingsReference object. Otherwise, the function returns a GeographicCellsReference object.

Version History

Introduced in R2011a

See Also

Functions

georefcells | georefpostings

Topics

“Spatially Reference Imported Rasters”

removeCustomBasemap

Remove custom basemap

Syntax

```
removeCustomBasemap(basemapName)
```

Description

`removeCustomBasemap(basemapName)` removes the custom basemap specified by `basemapName` from the list of available basemaps.

If the custom basemap specified by `basemapName` has not been previously added using the `addCustomBasemap` function, the `removeCustomBasemap` function returns an error.

Examples

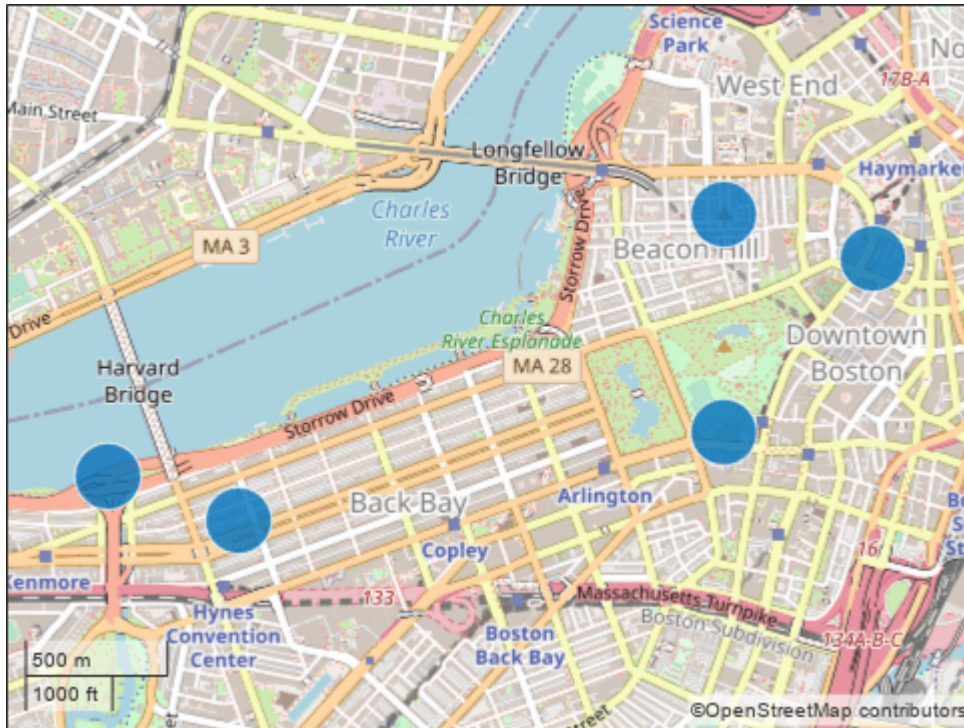
Remove Custom Basemap

Add a custom basemap to view locations on an OpenStreetMap® basemap.

```
name = "openstreetmap";  
url = "a.tile.openstreetmap.org/{z}/{x}/{y}.png";  
copyright = char(uint8(169));  
attribution = copyright + "OpenStreetMap contributors";  
addCustomBasemap(name,url,"Attribution",attribution)
```

Use the custom basemap with a geographic bubble chart.

```
lat = [42.3501 42.3515 42.3598 42.3584 42.3529];  
lon = [-71.0870 -71.0926 -71.0662 -71.0598 -71.0662];  
gb = geobubble(lat,lon,"Basemap","openstreetmap", ...  
    "BubbleWidthRange",25,"MapLayout","maximized", ...  
    "ZoomLevel",14);
```



Remove the custom basemap.

```
removeCustomBasemap(name)
```

Input Arguments

basemapName — Name of custom basemap

string scalar | character vector

Name of the custom basemap to remove, specified as a string scalar or character vector. You define the basemap name when you add the basemap using the `addCustomBasemap` function.

Data Types: string | char

Version History

Introduced in R2018b

See Also

`geoaxes` | `geobasemap` | `geobubble` | `geodensityplot` | `geoplot` | `geoscat` | `addCustomBasemap` | `webmap`

removeCustomTerrain

Remove custom terrain data

Syntax

```
removeCustomTerrain(terrainName)
```

Description

`removeCustomTerrain(terrainName)` removes the custom terrain data specified by the user-defined `terrainName`. You can use this function to remove terrain data that is no longer needed. The terrain data to be removed must have been previously added using `addCustomTerrain`.

Examples

Display Custom Terrain Using Geographic Globe

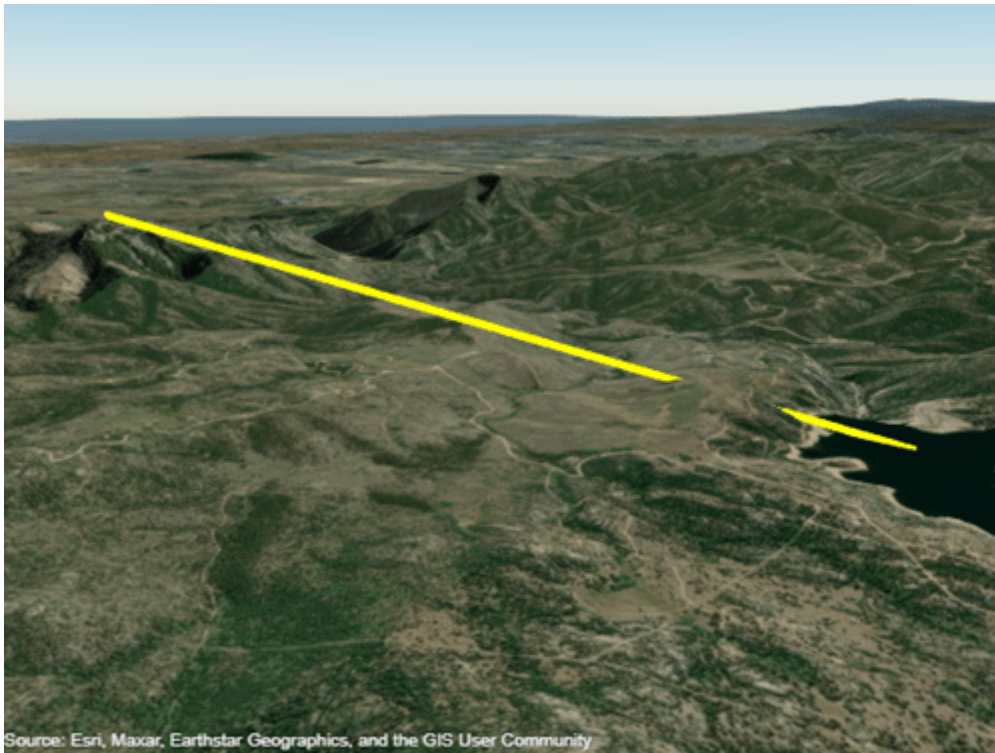
Display a line from the surface of Gross Reservoir to a point above South Boulder Peak using custom terrain.

First, add terrain for an area around South Boulder Peak by calling `addCustomTerrain` and specifying a DTED file. The DTED file is from the SRTM Void Filled data set, available from the US Geological Survey. Name the terrain "southboulderpeak".

```
addCustomTerrain("southboulderpeak", "n39_w106_3arc_v2.dt1")
```

Create a geographic globe. Specify the terrain by name, using the "Terrain" argument of the `geoglobe` function. Then, plot the line. Tilt the view by holding **Ctrl** and dragging.

```
uif = uifigure;  
g = geoglobe(uif, "Terrain", "southboulderpeak");  
  
lat = [39.95384 39.95];  
lon = [-105.29916 -105.3608];  
hTerrain = [10 0];  
geoplot3(g, lat, lon, hTerrain, "y", "HeightReference", "Terrain", "LineWidth", 3)
```



Close the geographic globe and remove the custom terrain.

```
close(uif)
removeCustomTerrain("southboulderpeak")
```

Input Arguments

terrainName — User-defined identifier for terrain data

string scalar | character vector

User-defined identifier for terrain data previously added using `addCustomTerrain`, specified as a string scalar or a character vector.

Data Types: char | string

Version History

Introduced in R2020a

See Also

`addCustomTerrain` | `geoglobe`

Topics

“Access Basemaps and Terrain for Geographic Globe”

removeExtraNaNSeparators

Clean up NaN separators in polygons and lines

Syntax

```
[xdata, ydata] = removeExtraNaNSeparators(xdata,ydata)
[xdata, ydata, zdata] = removeExtraNaNSeparators(xdata,ydata,zdata)
```

Description

[xdata, ydata] = removeExtraNaNSeparators(xdata,ydata) removes NaNs from the vectors xdata and ydata, leaving only isolated NaN separators. If present, one or more leading NaNs are removed entirely. If present, a single trailing NaN is preserved. NaNs are removed, but never added, so if the input lacks a trailing NaN, so will the output. xdata and ydata must match in size and have identical NaN locations.

[xdata, ydata, zdata] = removeExtraNaNSeparators(xdata,ydata,zdata) removes NaNs from the vectors xdata, ydata, and zdata, leaving only isolated NaN separators and optionally, if consistent with the input, a single trailing NaN.

Examples

```
xin = [NaN NaN 1:3 NaN 4:5 NaN NaN NaN 6:9 NaN NaN];
yin = xin;
[xout, yout] = removeExtraNaNSeparators(xin, yin);
xout
```

```
xout =
     1     2     3 NaN     4     5 NaN     6     7     8     9 NaN
```

```
xin = [NaN 1:3 NaN NaN 4:5 NaN NaN NaN 6:9]'
yin = xin;
zin = xin;
[xout, yout, zout] = removeExtraNaNSeparators(xin, yin, zin);
xout
```

```
xout =
     1
     2
     3
    NaN
     4
     5
    NaN
     6
     7
     8
     9
```


Version History

Introduced in R2006a

removeToolBarMapButton

Remove map button from toolbar

Syntax

```
removeToolBarMapButton(tb)  
removeToolBarMapButton(tb,"basemap")
```

Description

`removeToolBarMapButton(tb)` removes all map buttons from the axes toolbar `tb`.

`removeToolBarMapButton(tb,"basemap")` remove the basemap picker from the axes toolbar.

Examples

Add and Remove Map Buttons from Toolbar

Create a figure by using the `uifigure` function. Place a geographic axes in the figure.

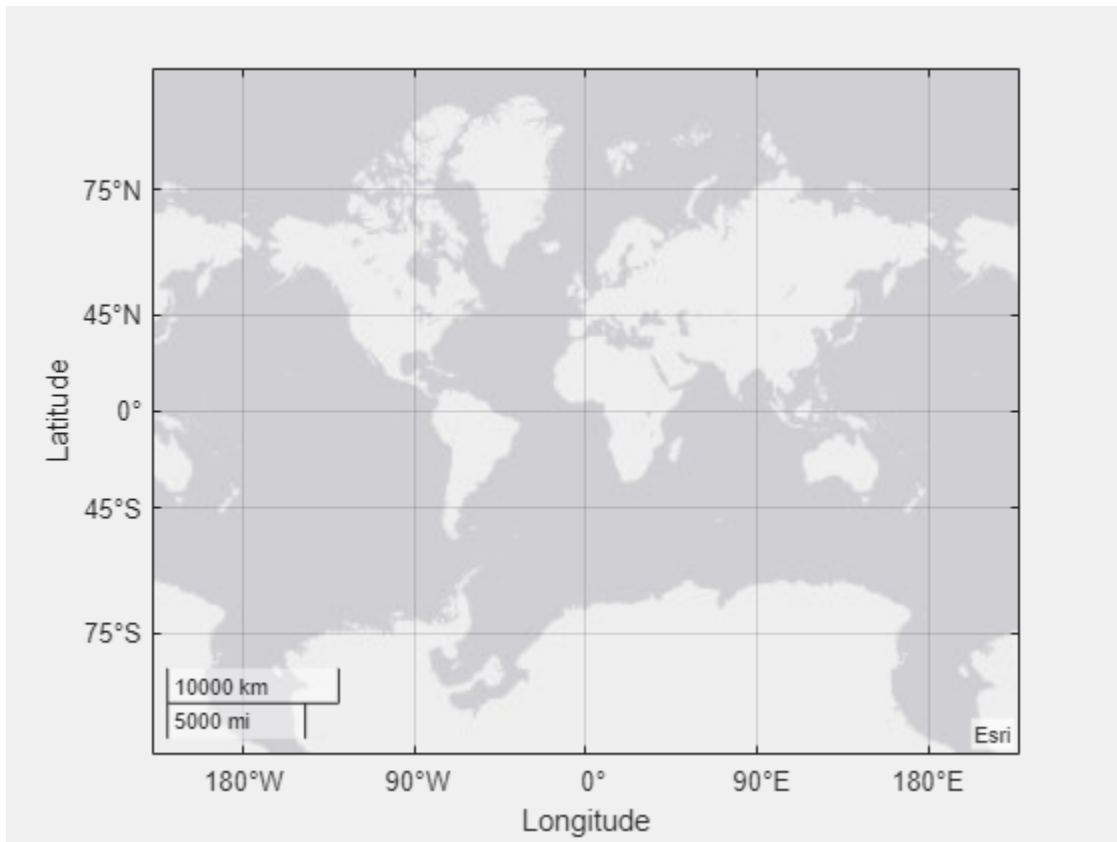
```
uif = uifigure;  
gx = geoaxes(uif);
```

Create a custom axes toolbar. Add all map buttons to the toolbar.

```
tb = axtoolbar(gx,"default");  
addToolBarMapButton(tb)
```

Remove all map buttons from the toolbar.

```
removeToolBarMapButton(tb)
```



Input Arguments

tb — Axes toolbar

AxesToolBar object | array of AxesToolBar objects

Axes toolbar, specified as an AxesToolBar object or an array of AxesToolBar objects.

Version History

Introduced in R2021b

See Also

Functions

addToolBarMapButton | axtoolbar | geoaxes | geobasemap

Topics

“Access Basemaps for Geographic Axes and Charts”

resize

(To be removed) Resize regular data grid

Note `resize` will be removed in a future release. Use the `georesize` or `imresize` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
Zscaled = resize(Z, scale)
Zscaled = resize(Z, [numrows numcols])
[Zscaled, Rscaled] = resize(Z, scale, R)
[Zscaled, Rscaled] = resize(Z, [numrows numcols], R)
[___] = resize(___ , method)
[___] = resize(___ , method, n)
[___] = resize(___ , h)
```

Description

`Zscaled = resize(Z, scale)` returns a regular data grid `Zscaled` that is `scale` times the size of the input, `Z`. `resize` uses interpolation to resample to a new sample density (cell size). By default, `resize` uses nearest neighbor interpolation.

`Zscaled = resize(Z, [numrows numcols])` resizes `Z` to have `numrows` rows and `numcols` columns.

`[Zscaled, Rscaled] = resize(Z, scale, R)` and

`[Zscaled, Rscaled] = resize(Z, [numrows numcols], R)` resizes a regular data grid that is spatially referenced by `R`.

`[___] = resize(___ , method)` specifies alternate interpolation methods.

`[___] = resize(___ , method, n)` applies a low-pass filter of size `n`-by-`n` before bilinear or bicubic interpolation to reduce aliasing.

`[___] = resize(___ , h)` applies 2-D FIR filter `h` to the data grid before resizing, for all interpolation methods.

Examples

Resize Regular Data Grid

Define a sample data grid.

```
Z = [1 2; 3 4]
```

```
Z = 2×2
```

```

1   2
3   4

```

Double the size of the grid using nearest neighbor interpolation.

```
neargrid = resizing(Z,2)
```

```
neargrid = 4x4
```

```

1   1   2   2
1   1   2   2
3   3   4   4
3   3   4   4

```

Double the size of the grid using bilinear interpolation.

```
bilingrid = resizing(Z,2,'bilinear')
```

```
bilingrid = 4x4
```

```

1.0000   1.3333   1.6667   2.0000
1.6667   2.0000   2.3333   2.6667
2.3333   2.6667   3.0000   3.3333
3.0000   3.3333   3.6667   4.0000

```

Resize the grid to have three rows and two columns using bicubic interpolation.

```
bicubgrid = resizing(bilingrid,[3 2],'bicubic')
```

```
bicubgrid = 3x2
```

```

0.7406   1.2994
1.6616   2.3462
1.9718   2.5306

```

Input Arguments

Z — Regular data grid

M-by-*N* numeric array

Regular data grid, specified as an *M*-by-*N* numeric array that may contain NaN values. Z is either a georeferenced data grid, or a regular data grid associated with a geographic reference R.

scale — Resizing scale factor

positive scalar

Resizing scale factor, specified as a positive scalar. If `scale` is between 0 and 1, then the size of `Zscaled` is smaller than the size of Z. If `scale` is greater than 1, then the size of `Zscaled` is larger. For example, if `scale` is 0.5, then the number of rows and the number of columns are halved.

[numrows numcols] — Output grid size

1-by-2 vector of positive integers

Output grid size, specified as a 1-by-2 vector of positive integers.

R – Geographic reference

geographic raster reference object | vector | matrix

Geographic reference, specified as one of the following. For more information about referencing vectors and matrices, see “Georeferenced Raster Data”.

Type	Description
Geographic raster reference object	GeographicCellsReference geographic raster reference object that relates the subscripts of Z to geographic coordinates. The RasterSize property must be consistent with the size of the data grid, size(Z). The RasterInterpretation must be 'cells'.
Vector	1-by-3 numeric vector with elements: [cells/degree northern_latitude_limit western_longitude_limit] Note When R is a referencing vector, then the argument [nrows ncols] is not supported and the resizing factor scale must be a scalar.
Matrix	3-by-2 numeric matrix that transforms raster row and column indices to or from geographic coordinates according to: [lon lat] = [row col 1] * R R defines a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which lat or lon contain NaN. All angles are in units of degrees.

method – Interpolation method

'nearest' (default) | 'bilinear' | 'bicubic'

Interpolation method, specified as one of the following.

Method	Description
'nearest'	Nearest neighbor interpolation
'bilinear'	Bilinear interpolation
'bicubic'	Bicubic interpolation

Note If the grid size is being reduced (that is, when scale is less than 1 or [numrows numcols] is less than the size of the input grid) and method is 'bilinear' or 'bicubic', then resizem applies a low-pass filter before interpolation to reduce aliasing. The default filter size is 11-by-11. You can specify a different length for the default filter using the n argument. You can specify a nondefault filter using the h argument.

Data Types: char | string

n — Low-pass filter size

11 (default) | nonnegative integer

Low-pass filter size, specified as a nonnegative integer. The filter size is n-by-n. If n is 0, or if method is 'nearest', then `resizem` does not perform low-pass filtering.

h — 2-D FIR filter

numeric matrix

2-D FIR filter, specified as a numeric matrix. You can define a FIR filter using Image Processing Toolbox functions such as `ftrans2`, `fwind1`, `fwind2`, or `fsamp2`.

Output Arguments**Zscaled — Rescaled data grid**

numeric array

Rescaled data grid, returned as a numeric array.

Rscaled — Rescaled geographic reference

geographic raster reference object | vector | matrix

Rescaled geographic reference, returned as a geographic raster reference object, numeric vector, or numeric matrix, consistent with the format of R.

Version History**Introduced before R2006a****R2022a: Warns***Warns starting in R2022a*

Some functions that accept referencing vectors or referencing matrices as input issue a warning that they will be removed in a future release, including the `resizem` function. Use a geographic reference object and the `georesize` function instead. If your data is not geographically referenced, then use the `imresize` function instead. Reference objects have several advantages over referencing vectors and matrices.

- Unlike referencing vectors and matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `GeographicPostingsReference` objects.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, first create a reference object for either a raster of cells using the `georefcells` function or a raster of regularly posted samples using the `georefpostings` function. Alternatively, convert from a referencing vector or referencing matrix to a reference object using the `refvecToGeoRasterReference` or `refmatToGeoRasterReference` function, respectively.

Then, replace uses of the `resizem` function with the `georesize` function. This table shows typical uses of the `resizem` function and how to update your code to use the `georesize` function instead.

Note that the default method of interpolation for the `georesize` function is 'cubic' instead of 'nearest'.

Will Be Removed	Recommended
<code>[B,RB] = resizem(A, scale, R);</code>	<code>[B,RB] = georesize(A, R, scale, 'nearest');</code>
<code>[B,RB] = resizem(A, [numrows numcols], R);</code>	<pre>latscale = numrows / R.RasterSize(1); lonscale = numcols / R.RasterSize(2); [B,RB] = georesize(A, R, latscale, lonscale, 'nearest');</pre>
<code>[B,RB] = resizem(A, scale, R, method);</code>	<code>[B,RB] = georesize(A, R, scale, method);</code>
<code>[B,RB] = resizem(A, [numrows numcols], R, method);</code>	<pre>latscale = numrows / R.RasterSize(1); lonscale = numcols / R.RasterSize(2); [B,RB] = georesize(A, R, latscale, lonscale, method);</pre>

If your data is not geographically referenced, then use the `imresize` function instead. This table shows typical uses of the `resizem` function without reference object information and how to update your code to use the `imresize` function instead.

Will Be Removed	Recommended
<code>B = resizem(A, scale, R);</code>	<code>B = imresize(A, scale);</code>
<code>B = resizem(A, [numrows numcols], R);</code>	<code>B = imresize(A, [numrows numcols]);</code>
<code>B = resizem(A, scale, R, method);</code>	<code>B = imresize(A, scale, method);</code>
<code>B = resizem(A, [numrows numcols], R, method);</code>	<code>B = imresize(A, [numrows numcols], method);</code>

R2020b: To be removed

Not recommended starting in R2020b

The `resizem` function runs without warning but will be removed in a future release.

See Also

`filter2` | `georesize` | `imresize`

rhxrh

Intersection points for pairs of rhumb lines

Syntax

```
[newlat,newlong] = rhxrh(lat1,lon1,az1,lat2,lon2,az2)
[newlat,newlon] = rhxrh(lat1,lon1,az1,lat2,lon2,az2,units)
```

Description

[newlat,newlong] = rhxrh(lat1,lon1,az1,lat2,lon2,az2) returns in newlat and newlon the location of the intersection point for each pair of rhumb lines input in *rhumb line notation*. For example, the first line in the pair passes through the point (lat1,lon1) and has a constant azimuth of az1. When the two rhumb lines are identical or do not intersect (conditions that are not, in general, apparent by inspection), two NaNs are returned instead and a warning is displayed. The inputs must be column vectors.

[newlat,newlon] = rhxrh(lat1,lon1,az1,lat2,lon2,az2,units) specifies the units used, where units is any valid units. The default units are 'degrees'.

For any pair of rhumb lines, there are three possible intersection conditions: the lines are identical, they intersect once, or they do not intersect at all (except at the poles, where all nonequatorial rhumb lines meet—this is not considered an intersection). rhxrh does not allow multiple rhumb line intersections, although it is possible to construct cases in which such a condition occurs. See the following discussion of Limitations on page 1-1547.

Rhumb line notation consists of a point on the line and the constant azimuth of the line.

Examples

Calculate Point of Intersection of Two Paths

Given a starting point at (10°N,56°W), a plane maintains a constant heading of 35°. Another plane starts at (0°,10°W) and proceeds at a constant heading of 310° (-50°). Where would their two paths cross each other?

Calculate Point of Intersection

Use the rhxrh function to calculate the point of intersection of two paths.

```
[newlat,newlon] = rhxrh(10,-56,35,0,-10,310)
```

```
newlat = 26.9774
```

```
newlon = -43.4088
```

Limitations

Rhumb lines are specifically helpful in navigation because they represent lines of constant heading, whereas great circles have, in general, continuously changing heading. In fact, the Mercator

projection was originally designed so that rhumb lines plot as straight lines, which facilitates both manual plotting with a straightedge and numerical calculations using a Cartesian planar representation. When a rhumb line proceeds off the left or right *edge* of this representation at some latitude, it reappears on the other edge at the same latitude and continues on the same slope. For rhumb lines where this occurs—for example, one with a heading of 85° —it is easy to imagine another rhumb line, say one with a heading of 0° , repeatedly intersecting the first. The real-world uses of rhumb lines make this merely an intellectual exercise, however, for in practice it is always clear which *crossing* line segment is relevant. The function `rhxrh` returns at most one intersection, selecting in each case that line segment containing the input starting point for its computation.

Version History

Introduced before R2006a

See Also

`gcxgc` | `gcxsc` | `scxsc` | `crossfix` | `polyxpoly` | `navfix`

rmfield

Remove dynamic property from geographic or planar vector

Syntax

```
vout = rmfield(vin,name)
vout = rmfield(vin,names)
```

Description

`vout = rmfield(vin,name)` removes the dynamic property specified by name from the geographic or planar vector `vin`.

`vout = rmfield(vin,names)` removes all dynamic properties specified by names from `vin`.

Note `rmfield` cannot remove Metadata, and Geometry properties from any geographic or planar vector. Further, it cannot remove Latitude and Longitude properties from `geopoint` and `geoshape` objects, nor X and Y properties from `mappoint` and `mapshape` objects.

Examples

Remove a Single Property from a Geopoint Vector

Create a geopoint vector with dynamic properties.

```
gp = geopoint([42 42.2],[-110.5 -110.7],'Temperature',[65.6 63.2],'Humidity',[44 41])
```

```
gp =
  2x1 geopoint vector with properties:

  Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
  Feature properties:
    Latitude: [42 42.2000]
    Longitude: [-110.5000 -110.7000]
    Temperature: [65.6000 63.2000]
    Humidity: [44 41]
```

Remove only the Humidity property from the geopoint vector.

```
gp2 = rmfield(gp,'Humidity')

gp2 =
  2x1 geopoint vector with properties:

  Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
```

```

Feature properties:
  Latitude: [42 42.2000]
  Longitude: [-110.5000 -110.7000]
  Temperature: [65.6000 63.2000]

```

Remove Multiple Properties from a Mapshape Vector

Create a mapshape vector.

```
ms = mapshape(shaperead('tsunamis.shp'))
```

```

ms =
162x1 mapshape vector with properties:

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Vertex properties:
(162 features concatenated with 161 delimiters)
  X: [128.3000 NaN -156 NaN 157.9500 NaN 143.8500 NaN -155 NaN -82.4000 NaN 159.5000
  Y: [-3.8000 NaN 19.5000 NaN -9.0200 NaN 42.1500 NaN 19.1000 NaN 43.1000 NaN 52.7500
Feature properties:
  Year: [1950 1951 1951 1952 1952 1952 1952 1953 1953 1953 1953 1954 1954 1955 1956 195
  Month: [10 8 12 3 3 5 11 3 6 9 11 6 10 4 11 3 6 7 1 4 7 11 11 5 8 8 1 3 3 5 11 2 7 8 4
  Day: [8 21 22 4 17 6 4 18 27 14 25 26 NaN 19 2 9 22 28 19 22 10 6 12 4 17 18 13 20 2
  Hour: [3 10 NaN 1 3 NaN 16 NaN NaN 0 17 NaN NaN 20 NaN 14 23 8 14 NaN 6 22 20 7 21 6
  Minute: [23 57 NaN 22 58 NaN 58 NaN NaN 26 48 NaN NaN 24 NaN 22 50 40 7 NaN 15 58 23 16
  Second: [NaN NaN NaN 41 NaN NaN NaN NaN NaN 36 NaN NaN NaN NaN NaN 31.9000 23 NaN NaN
  Val_Code: [2 4 2 4 4 1 4 3 3 4 4 1 2 4 3 4 3 4 4 2 4 4 2 4 4 4 4 4 4 4 4 4 4 2 4 NaN 4 4
  Validity: {1x162 cell}
  Cause_Code: [1 1 6 1 1 9 1 1 6 3 1 9 0 1 1 1 1 1 1 1 3 1 1 1 0 3 1 1 1 1 1 1 1 1 1 1 1 1
  Cause: {1x162 cell}
  Eq_Mag: [7.6000 6.9000 NaN 8.1000 4.5000 NaN 9 5.8000 NaN 6.8000 7.4000 NaN NaN 7.1000
  Country: {1x162 cell}
  Location: {1x162 cell}
  Max_Height: [2.8000 3.6000 6 6.5000 1 1.5200 18 1.5000 1.4000 3 3 3 18.2800 1 1.2000 15.2400
  Iida_Mag: [1.5000 1.8000 2.6000 2.7000 NaN NaN 4.2000 0.6000 0.5000 1 1.6000 NaN 4.2000 NaN
  Intensity: [1.5000 NaN NaN 2 NaN NaN 4 NaN 1 1.5000 1.5000 NaN NaN NaN 3 3.5000 NaN 1.5000
  Num_Deaths: [NaN NaN NaN 33 NaN NaN 2236 NaN NaN NaN NaN 7 NaN 3 NaN NaN NaN NaN NaN 5
  Desc_Deaths: [NaN NaN NaN 1 NaN NaN 3 NaN NaN NaN NaN 1 NaN 1 NaN NaN NaN NaN NaN NaN 1 NaN

```

Attempt to remove multiple properties from the mapshape vector.

```
s2 = rmfield(ms,{'Geometry','Second','Minute','intensity'})
```

```

s2 =
162x1 mapshape vector with properties:

Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Vertex properties:
(162 features concatenated with 161 delimiters)
  X: [128.3000 NaN -156 NaN 157.9500 NaN 143.8500 NaN -155 NaN -82.4000 NaN 159.5000

```

```

Y: [-3.8000 NaN 19.5000 NaN -9.0200 NaN 42.1500 NaN 19.1000 NaN 43.1000 NaN 52.7500
Feature properties:
Year: [1950 1951 1951 1952 1952 1952 1952 1953 1953 1953 1953 1954 1954 1955 1956 1957
Month: [10 8 12 3 3 5 11 3 6 9 11 6 10 4 11 3 6 7 1 4 7 11 11 5 8 8 1 3 3 5 11 2 7 8 4
Day: [8 21 22 4 17 6 4 18 27 14 25 26 NaN 19 2 9 22 28 19 22 10 6 12 4 17 18 13 20 2
Hour: [3 10 NaN 1 3 NaN 16 NaN NaN 0 17 NaN NaN 20 NaN 14 23 8 14 NaN 6 22 20 7 21 6
Val_Code: [2 4 2 4 4 1 4 3 3 4 4 1 2 4 3 4 3 4 4 2 4 4 4 4 4 4 4 4 4 4 4 4 2 4 NaN 4 4
Validity: {1x162 cell}
Cause_Code: [1 1 6 1 1 9 1 1 6 3 1 9 0 1 1 1 1 1 1 1 3 1 1 1 0 3 1 1 1 1 1 1 1 1 1 1 8 1 11
Cause: {1x162 cell}
Eq_Mag: [7.6000 6.9000 NaN 8.1000 4.5000 NaN 9 5.8000 NaN 6.8000 7.4000 NaN NaN 7.1000
Country: {1x162 cell}
Location: {1x162 cell}
Max_Height: [2.8000 3.6000 6 6.5000 1 1.5200 18 1.5000 1.4000 3 3 3 18.2800 1 1.2000 15.2400
Iida_Mag: [1.5000 1.8000 2.6000 2.7000 NaN NaN 4.2000 0.6000 0.5000 1 1.6000 NaN 4.2000 NaN
Intensity: [1.5000 NaN NaN 2 NaN NaN 4 NaN 1 1.5000 1.5000 NaN NaN NaN 3 3.5000 NaN 1.5000
Num_Deaths: [NaN NaN NaN 33 NaN NaN 2236 NaN NaN NaN NaN 7 NaN 3 NaN NaN NaN NaN NaN NaN 5
Desc_Deaths: [NaN NaN NaN 1 NaN NaN 3 NaN NaN NaN NaN 1 NaN 1 NaN NaN NaN NaN NaN NaN 1 NaN

```

The **Second** and **Minute** properties have been removed successfully. Note that the **Geometry** property still exists because it cannot be removed. Also, **Intensity** has not been removed because property names are case-sensitive.

Input Arguments

vin — Input geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Input geographic or planar vector, specified as a **geopoint**, **geoshape**, **mappoint**, or **mapshape** object.

name — Name of single property to remove

character vector

Name of a single property to remove, specified as a character vector. The property in **name** is case sensitive.

names — Name of multiple properties to remove

cell array of character vectors

Name of multiple properties to remove, specified as a cell array of character vectors. The properties in **names** are case-sensitive.

Output Arguments

vout — Output geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Output geographic or planar vector, returned as a **geopoint**, **geoshape**, **mappoint**, or **mapshape** object. The object type of **vout** matches the object type of **vin**.

Version History

Introduced in R2012a

See Also

append | isfield | rmprop

rmprop

Remove property from geographic or planar vector

Syntax

```
vout = rmprop(vin,name)
vout = rmprop(vin,names)
```

Description

`vout = rmprop(vin,name)` removes the property specified by `name` from the geographic or planar vector `vin`.

`vout = rmprop(vin,names)` removes all properties specified by `names` from `vin`.

Note `rmprop` cannot remove Metadata, and Geometry properties from any geographic or planar vector. Further, it cannot remove Latitude and Longitude properties from `geopoint` and `geoshape` objects, nor X and Y properties from `mappoint` and `mapshape` objects.

Examples

Remove Single Property from a Geoshape Vector

Create a geoshape vector with dynamic properties.

```
gs = geoshape(shaperead('worldcities.shp', 'UseGeoCoords', true))
```

```
gs =
  318x1 geoshape vector with properties:

  Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
  Vertex properties:
    (318 features concatenated with 317 delimiters)
    Latitude: [5.2985 NaN 24.6525 NaN 5.6106 NaN 37.0613 NaN 9.0235 NaN -34.6645 NaN 12.8767 NaN
    Longitude: [-3.9509 NaN 54.7589 NaN -0.2121 NaN 35.3894 NaN 38.7575 NaN 138.8528 NaN 44.5408 NaN
  Feature properties:
    Name: {1x318 cell}
```

Remove only the Name property from the geoshape vector.

```
gs2 = rmprop(gs, 'Name')
```

```
gs2 =
  318x1 geoshape vector with properties:

  Collection properties:
    Geometry: 'point'
```

```
Metadata: [1x1 struct]
Vertex properties:
(318 features concatenated with 317 delimiters)
Latitude: [5.2985 NaN 24.6525 NaN 5.6106 NaN 37.0613 NaN 9.0235 NaN -34.6645 NaN 12.8767 NaN
Longitude: [-3.9509 NaN 54.7589 NaN -0.2121 NaN 35.3894 NaN 38.7575 NaN 138.8528 NaN 44.5408
```

Remove Multiple Properties from a Mappoint Vector

Create a mappoint vector.

```
mp = mappoint(-33.961,18.484, 'Name', 'Cape Town', 'Temperature', 64)
```

```
mp =
1x1 mappoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: -33.9610
  Y: 18.4840
  Name: 'Cape Town'
  Temperature: 64
```

Attempt to remove multiple properties from the mappoint vector.

```
s2 = rmfield(mp,{'X', 'Name', 'temperature'})
```

```
s2 =
1x1 mappoint vector with properties:
```

```
Collection properties:
  Geometry: 'point'
  Metadata: [1x1 struct]
Feature properties:
  X: -33.9610
  Y: 18.4840
  Temperature: 64
```

The Name property has been removed successfully. Note that the X property still exists because it cannot be removed. Also, the Temperature property still exists because property names are case-sensitive.

Input Arguments

vin — Input geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Input geographic or planar vector, specified as a geopoint, geoshape, mappoint, or mapshape object.

name — Name of single property to remove

character vector

Name of a single property to remove, specified as a character vector. The character vector is case sensitive.

names — Name of multiple properties to remove

cell array of character vectors

Name of multiple properties to remove, specified as a cell array of character vectors. The character vectors are case-sensitive.

Output Arguments**vout — Output geographic or planar vector**

geopoint, geoshape, mappoint, or mapshape object

Output geographic or planar vector, returned as a geopoint, geoshape, mappoint, or mapshape object. The object type of vout matches the object type of vin.

Version History**Introduced in R2012a****See Also**

append | isprop | rmfield

rotatem

Transform vector map data to new origin and orientation

Syntax

```
[lat1,lon1] = rotatem(lat,lon,origin,'forward')
[lat1,lon1] = rotatem(lat,lon,origin,'inverse')
[lat1,lon1] = rotatem(lat,lon,origin,'forward',units)
[lat1,lon1] = rotatem(lat,lon,origin,'forward',units)
```

Description

`[lat1,lon1] = rotatem(lat,lon,origin,'forward')` transforms latitude and longitude data (`lat` and `lon`) to their new coordinates (`lat1` and `lon1`) in a coordinate system resulting from Euler angle rotations as specified by `origin`. The input `origin` is a three- (or two-) element vector having the form [`latitude longitude orientation`]. The latitude and longitude are the coordinates of the point in the original system, which is the center of the output system. The orientation is the azimuth from the new origin point to the original North Pole in the new system. If `origin` has only two elements, the orientation is assumed to be 0° . This `origin` vector might be the output of `putpole` or `newpole`.

`[lat1,lon1] = rotatem(lat,lon,origin,'inverse')` transforms latitude and longitude data (`lat` and `lon`) in a coordinate system *that has been transformed* by Euler angle rotations specified by `origin` to their coordinates (`lat1` and `lon1`) in the coordinate system *from which they were originally transformed*. In a sense, this *undoes* the 'forward' process. Be warned, however, that if data is rotated forward and then inverted, the final data might not be identical to the original. This is because of roundoff and *data collapse* at the original and intermediate singularities (the poles).

`[lat1,lon1] = rotatem(lat,lon,origin,'forward',units)` and `[lat1,lon1] = rotatem(lat,lon,origin,'forward',units)` specify the angle units of the data, where *units* is any recognized angle unit. The default is 'radians'. Note that this default is different from that of most functions.

The `rotatem` function transforms vector map data to a new coordinate system.

An analytical use of the new data can be realized in conjunction with the `newpole` function. If a selected point is made the *north pole* of the new system, then when new vector data is created with `rotatem`, the distance of every data point from this new north pole is its new colatitude (90° minus latitude). The absolute difference in the great circle azimuths between every pair of points from their new *pole* is the same as the difference in their new longitudes.

Examples

What are the coordinates of Rio de Janeiro ($23^\circ\text{S}, 43^\circ\text{W}$) in a coordinate system in which New York ($41^\circ\text{N}, 74^\circ\text{W}$) is made the North Pole? Use the `newpole` function to get the origin vector associated with putting New York at the pole:

```
nylat = 41; nylon = -74;
riolat = -23; riolon = -43;
```

```
origin = newpole(nylat,nylon);  
[riolat1,riolon1] = rotatem(riolat,riolon,origin,...  
                           'forward','degrees')
```

```
riolat1 =  
    19.8247  
riolon1 =  
   -149.7375
```

What does this mean? For one thing, the colatitude of Rio in this new system is its distance from New York. Compare the distance between the original points and the new colatitude:

```
dist = distance(nylat,nylon,riolat,riolon)
```

```
dist =  
    70.1753
```

```
90-riolat1
```

```
ans =  
    70.1753
```

Version History

Introduced before R2006a

See Also

[neworig](#) | [newpole](#) | [org2pol](#) | [putpole](#)

rotatetext

Rotate text to projected graticule on axesm-based map

Syntax

```
rotatetext  
rotatetext(objects)  
rotatetext(objects, 'inverse')
```

Description

`rotatetext` rotates displayed text objects to account for the curvature of the graticule. The objects are selected interactively from a graphical user interface.

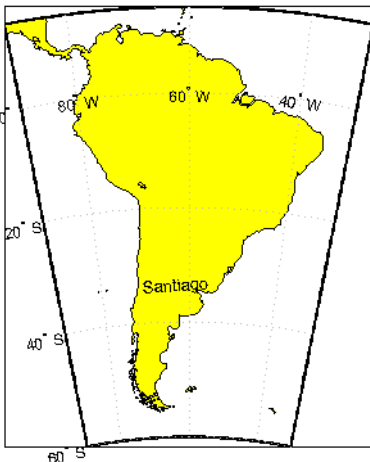
`rotatetext(objects)` rotates the selected objects. `objects` can be a name recognized by `handlem` or a vector of handles to displayed text objects.

`rotatetext(objects, 'inverse')` removes the rotation added by an earlier use of `rotatetext`. If omitted, 'forward' is assumed.

Examples

Add text to a map and rotate the text to the graticule.

```
figure  
worldmap('south america')  
geoshow('landareas.shp', 'facecolor', 'yellow')  
cities = shaperead('worldcities.shp', 'UseGeoCoords', true);  
Santiago = strcmp('Santiago', {cities(:).Name});  
h=textm(cities(Santiago).Lat, cities(Santiago).Lon, ...  
        'Santiago');  
rotatetext(h)
```



Tips

You can rotate meridian and parallel labels automatically by setting the `LabelRotation` property of the axesm-based map to `'on'`.

Version History

Introduced before R2006a

See Also

`vfdtran` | `vinvtran`

roundn

(Not recommended) Round to multiple of 10^n

Note The `roundn` function is not recommended. Use the `round` function instead. For more information, see “Compatibility Considerations”.

Syntax

`Y = roundn(X,n)`

Description

`Y = roundn(X,n)` rounds each element of `X` to the nearest multiple of 10^n .

Examples

Round to Nearest Hundredth

Round `pi` to the nearest hundredth.

```
Y = roundn(pi,-2)
```

```
Y =
```

```
    3.1400
```

Input Arguments

X — Input array

scalar | vector | matrix | multidimensional array

Input array, specified as a scalar, vector, matrix, or multidimensional array. For complex values of `X`, the function rounds the real and imaginary parts independently.

Data Types: `single` | `double`

Complex Number Support: Yes

n — Exponent of 10

scalar integer

Exponent of 10, specified as a scalar integer.

Version History

Introduced before R2006a

R2014b: `roundn` is not recommended

Not recommended starting in R2014b

The `roundn` function is not recommended. Use the `round` function instead. Note that when you update your code, you must reverse the sign of `n`.

Not Recommended	Recommended
<code>Y = roundn(X,n)</code>	<code>Y = round(X, -n)</code>

See Also

`round`

RPCCoefficientTag

Rational Polynomial Coefficients Tag

Description

RPCCoefficientTag contains the Rational Polynomial Coefficients (RPC) TIFF tag, which describes the relationship of latitude, longitude, and height locations with row and column locations in an image.

The RPCCoefficientTag object contains properties with names and permissible values corresponding to the tag elements listed in the technical note *RPCs in GeoTIFF* technical note, viewable at http://geotiff.maptools.org/rpc_prop.html.

Creation

- Read an RPCCoefficientTag object from a GeoTIFF file by using the `georasterinfo` or `geotiffinfo` function.
- Create an RPCCoefficientTag object by using the `map.geotiff.RPCCoefficientTag` function.

Properties

BiasErrorInMeters — Root mean square bias error in meters per horizontal axis

-1 (default) | nonnegative scalar

Root mean square bias error in meters per horizontal axis, specified as the number -1 or a nonnegative scalar. The value is -1 only if BiasErrorInMeters is not specified

Data Types: double

RandomErrorInMeters — Root mean square random error in meters per horizontal axis

-1 (default) | nonnegative scalar

Root mean square random error in meters, specified as the number -1 or a nonnegative scalar. The value is -1 only if RandomErrorInMeters is not specified.

Data Types: double

LineOffset — Line offset in pixels

0 (default) | nonnegative scalar

Line offset in pixels, specified as a nonnegative scalar, with a value of 0 by default.

Data Types: double

SampleOffset — Sample offset in pixels

0 (default) | nonnegative scalar

Sample offset in pixels, specified as a nonnegative scalar, with a value of 0 by default.

Data Types: double

GeodeticLatitudeOffset — Geodetic latitude offset in degrees

0 (default) | numeric scalar

Geodetic latitude offset in degrees, specified as a numeric scalar. The value can range from $-90 \leq \text{value} \leq 90$.

Data Types: double

GeodeticLongitudeOffset — Geodetic longitude offset in degrees

0 (default) | numeric scalar

Geodetic longitude offset in degrees, specified as a numeric scalar. The value can range from $-180 \leq \text{value} \leq 180$.

Data Types: double

GeodeticHeightOffset — Geodetic height offset in meters

0 (default) | numeric scalar

Geodetic height offset in meters, specified as a numeric scalar.

Data Types: double

LineScale — Line scale factor in pixels

1 (default) | positive scalar

Line scale factor in pixels, specified as a positive scalar.

Data Types: double

SampleScale — Sample scale factor in pixels

1 (default) | positive scalar

Sample scale factor in pixels, specified as a positive scalar.

Data Types: double

GeodeticLatitudeScale — Geodetic latitude scale in degrees

1 (default) | positive scalar

Geodetic latitude scale in degrees, specified as a positive scalar in the range (0,90].

Data Types: double

GeodeticLongitudeScale — Geodetic longitude scale in degrees

1 (default) | positive scalar

Geodetic longitude scale in degrees, specified as positive scalar in the range (0, 180].

Data Types: double

GeodeticHeightScale — Geodetic height scale factor in meters

1 (default) | positive scalar

Geodetic height scale factor in meters, specified as a positive scalar.

Data Types: double

LineNumeratorCoefficients – Coefficients for the polynomial in the numerator of the $r(n)$ equation

20-element row vector of zeros (default) | 20-element row vector

Coefficients for the polynomial in the numerator of the $r(n)$ equation, specified as a 20-element row vector of class `double`.

Data Types: `double`

LineDenominatorCoefficients – Coefficients for the polynomial in the denominator of the $r(n)$ equation

20-element row vector of zeros (default) | 20-element row vector

Coefficients for the polynomial in the denominator of the $r(n)$ equation, specified as a 20-element row vector of class `double`.

Data Types: `double`

SampleNumeratorCoefficients – Coefficients for the polynomial in the numerator of the $c(n)$ equation

20-element row vector of zeros (default) | 20-element row vector

Coefficients for the polynomial in the numerator of the $c(n)$ equation, specified as a 20-element row vector of class `double`.

Data Types: `double`

SampleDenominatorCoefficients – Coefficients for the polynomial in the denominator of the $c(n)$ equation

20-element row vector of zeros (default) | 20-element row vector

Coefficients for the polynomial in the denominator of the $c(n)$ equation, specified as a 20-element row vector of class `double`.

Data Types: `double`

Methods

`double` Convert TIFF tag property values to row vector of doubles

Version History

Introduced in R2015b

See Also

`georasterinfo` | `geotiffinfo` | `geotiffwrite` | `Tiff`

rsphere

Radii of auxiliary spheres

Syntax

```

r = rsphere('biaxial',ellipsoid)
r = rsphere('biaxial',ellipsoid,method)
r = rsphere('triaxial',ellipsoid)
r = rsphere('triaxial',ellipsoid,method)
r = rsphere('eqavol',ellipsoid)
r = rsphere('authalic',ellipsoid)
r = rsphere('rectifying',ellipsoid)
r = rsphere('curve',ellipsoid,lat)
r = rsphere('curve',ellipsoid,lat,method)
r = rsphere('euler',lat1,lon1,lat2,lon2,ellipsoid)
r = rsphere('curve', ..., angleUnits)
r = rsphere('euler', ..., angleUnits)

```

Description

`r = rsphere('biaxial',ellipsoid)` computes the arithmetic mean i.e., $(a+b)/2$ where a and b are the semimajor and semiminor axes of the specified ellipsoid. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`.

`r = rsphere('biaxial',ellipsoid,method)` computes the arithmetic mean if `method` is 'mean' and the geometric mean, $\sqrt{a*b}$, if `method` is 'norm'.

`r = rsphere('triaxial',ellipsoid)` computes the triaxial arithmetic mean of the semi-major axes, a , and semi-minor axes, b of the ellipsoid, $(2*a+b)/3$.

`r = rsphere('triaxial',ellipsoid,method)` computes the arithmetic mean if `method` is 'mean' and the triaxial geometric mean, $(a^2*b)^{(1/3)}$, if `method` is 'norm'.

`r = rsphere('eqavol',ellipsoid)` returns the radius of a sphere with a volume equal to that of the ellipsoid.

`r = rsphere('authalic',ellipsoid)` returns the radius of a sphere with a surface area equal to that of the ellipsoid.

`r = rsphere('rectifying',ellipsoid)` returns the radius of a sphere with meridional distances equal to those of the ellipsoid.

`r = rsphere('curve',ellipsoid,lat)` computes the arithmetic mean of the transverse and meridional radii of curvature at the latitude, `lat`. `lat` is in degrees.

`r = rsphere('curve',ellipsoid,lat,method)` computes an arithmetic mean if `method` is 'mean' and a geometric mean if `method` is 'norm'.

`r = rsphere('euler', lat1, lon1, lat2, lon2, ellipsoid)` computes the Euler radius of curvature at the midpoint of the geodesic arc defined by the endpoints (`lat1, lon1`) and (`lat2, lon2`). `lat1, lon1, lat2,` and `lon2` are in degrees.

`r = rsphere('curve', ..., angleUnits)` and `r = rsphere('euler', ..., angleUnits)` where `angleUnits` specifies the units of the latitude and longitude inputs as either 'degrees' or 'radians'.

Examples

Different criteria result in different spheres:

```
r = rsphere('biaxial', referenceEllipsoid('earth', 'km'))
```

```
r =  
    6.3674e+03
```

```
r = rsphere('triaxial', referenceEllipsoid('earth', 'km'))
```

```
r =  
    6.3710e+03
```

```
r = rsphere('curve', referenceEllipsoid('earth', 'km'))
```

```
r =  
    6.3781e+03
```

Version History

Introduced before R2006a

See Also

`rcurve`

satbath

(To be removed) Read 2-minute terrain/bathymetry from Smith and Sandwell

Note `satbath` will be removed in a future release. Use `readgeoraster` instead. For more information, see “Compatibility Considerations”.

Syntax

```
[latgrat, longrat, z] = satbath
[latgrat, longrat, z] = satbath(scalefactor)
[latgrat, longrat, z] = satbath(scalefactor, latlim, lonlim)
[latgrat, longrat, z] = satbath(scalefactor, latlim, lonlim, gsize)
```

Description

`[latgrat, longrat, z] = satbath` reads the global topography file for the entire world (`topo_8.2.img`), returning every 50th point. The result is returned as a geolocated data grid. If you use a different version of the global topography file, you need to rename it to “`topo_8.2.img`”. If the file is not found on the MATLAB path, a dialog opens to request the file.

`[latgrat, longrat, z] = satbath(scalefactor)` returns the data for the entire world, subsampled by the integer `scalefactor`. A `scalefactor` of 10 returns every 10th point. The matrix at full resolution has 6336 by 10800 points.

`[latgrat, longrat, z] = satbath(scalefactor, latlim, lonlim)` returns data for the specified region. The returned data extends slightly beyond the requested area. If omitted, the entire area covered by the data file is returned. The limits are two-element vectors in units of degrees, with `latlim` in the range `[-90 90]` and `lonlim` in the range `[-180 180]`.

`[latgrat, longrat, z] = satbath(scalefactor, latlim, lonlim, gsize)` controls the size of the graticule matrices. `gsize` is a two-element vector containing the number of rows and columns desired. If omitted, a graticule the size of the data grid is returned.

Background

This is a global bathymetric model derived from ship soundings and satellite altimetry by W.H.F. Smith and D.T. Sandwell. The model was developed by iteratively adjusting gravity anomaly data from Geosat and ERS-1 against historical track line soundings. This technique takes advantage of the fact that gravity mirrors the large variations in the ocean floor as small variations in the height of the ocean's surface. The computational procedure uses the ship track line data to calibrate the scaling between the observed surface undulations and the inferred bathymetry. Land elevations are reduced-resolution versions of GTOPO30 data.

Examples

Read the data for the Falklands Islands (Islas Malvinas) at full resolution.

```
[latgrat, longrat, mat] = satbath(1, [-55 -50], [-65 -55]);  
whos
```

Name	Size	Bytes	Class
latgrat	247x301	594776	double array
longrat	247x301	594776	double array
mat	247x301	594776	double array

Tips

Land elevations are given in meters above mean sea level. The data is stored in a Mercator projection grid. As a result, spatial resolution varies with latitude. The grid spacing is 2 minutes (about 4 kilometers) at the equator.

This data is available over the Internet, but subject to copyright. The data file is binary, and should be transferred with no line-ending conversion or byte swapping. This function carries out any byte swapping that might be required. The data requires about 133 MB uncompressed.

The data and documentation are available over the Internet via `http` and anonymous `ftp`. Download the latest version of file `topo_x.2.img`, where `x` is the version number, and rename it `topo_8.w.img` for compatibility with the `satbath` function.

`satbath` returns a geolocated data grid rather than a regular data grid and a referencing vector or matrix. This is because the data is in a Mercator projection, with columns evenly spaced in longitude, but with decreasing spacing for rows at higher latitudes. Referencing vectors and matrices assume that the number of cells per degrees of latitude and longitude are both constant across a data grid.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: “Find Geospatial Data Online”.

Version History

Introduced before R2006a

R2021b: Warns

Warns starting in R2021b

Some raster reading functions that return latitude-longitude grids issue a warning that they will be removed in a future release, including `satbath`. Instead, use `readgeoraster`, which returns a map raster reference object. Reference objects have several advantages over latitude-longitude grids.

- Unlike latitude-longitude grids, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns. For more information about reference object properties, see `MapCellsReference` and `MapPostingsReference`.
- You can manipulate the limits of rasters associated with reference objects using the `mapcrop` function.

- You can manipulate the size and resolution of rasters associated with reference objects using the `mapresize` function.

This table shows some typical usages of `satbath` and how to update your code to use `readgeoraster` instead. Unlike `satbath`, which requires a single file with extension `.img`, the `readgeoraster` function requires both a data file with extension `.ers` and a supporting file with extension `.img`. When you call `readgeoraster`, specify the file with extension `.ers`.

Will Be Removed	Recommended
<code>[latgrat, longrat, z] = satbath;</code>	<code>[Z,R] = readgeoraster(filename);</code>
<code>[latgrat, longrat, z] = satbath(scalefactor);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>[Z,R] = georesize(Z,R,1/scalefactor);</code>
<code>[latgrat, longrat, z] = satbath(scalefactor, latlim, lonlim);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>[Z,R] = geocrop(Z,R,latlim,lonlim);</code> <code>[Z,R] = georesize(Z,R,1/scalefactor);</code>

The `readgeoraster` function returns data using the native data type embedded in the file. Return a different data type by specifying the 'OutputType' name-value pair. For example, use `[Z,R] = readgeoraster(filename, 'OutputType', 'double')`.

The `readgeoraster` function does not automatically replace missing data with NaN values. If your data set uses large negative numbers to indicate missing data, you can replace them with NaN values using the `standardizeMissing` function.

```
[Z,R] = readgeoraster('MtWashington-ft.grd');
info = georasterinfo('MtWashington-ft.grd');
m = info.MissingDataIndicator;
Z = standardizeMissing(Z,m);
```

R2020a: To be removed

Not recommended starting in R2020a

The `satbath` function runs without warning but will be removed in a future release.

See Also

`egm96geoid` | `readgeoraster` | `georasterinfo`

scaleruler

Add or modify graphic scale on axesm-based map

Syntax

```
scaleruler
scaleruler on
scaleruler off
scaleruler(Name,Value)
gs = scaleruler( ___ )
```

Description

`scaleruler` toggles the display of the graphic scale on the current axesm-based map. A graphic scale shows distances on the ground at the correct size for the projection. If the map does not have a graphic scale, then `scaleruler` adds one. If the map has one or more graphic scales, then `scaleruler` removes them.

`scaleruler on` adds a graphic scale to the current axesm-based map. You can add multiple graphic scales to the same axesm-based map.

`scaleruler off` removes all graphic scales from the current axesm-based map.

`scaleruler(Name,Value)` adds a graphic scale to the current axesm-based map and specifies properties using name-value arguments. For example, `"RulerStyle","patches"` displays a graphic scale with alternating black and white rectangles.

`gs = scaleruler(___)` returns the graphic scale. Modify the properties of the graphic scale after you create it by using `gs` as an input to the `setm` function.

Examples

Add Graphic Scale to Map

Create a map display of Florida.

```
usamap("Florida")
geoshow("usastatelo.shp","FaceColor","yellow")
```

Add a graphic scale. Change the location of the scale by setting the `XLoc` and `YLoc` properties. Specify tick locations using the `MajorTick` property.

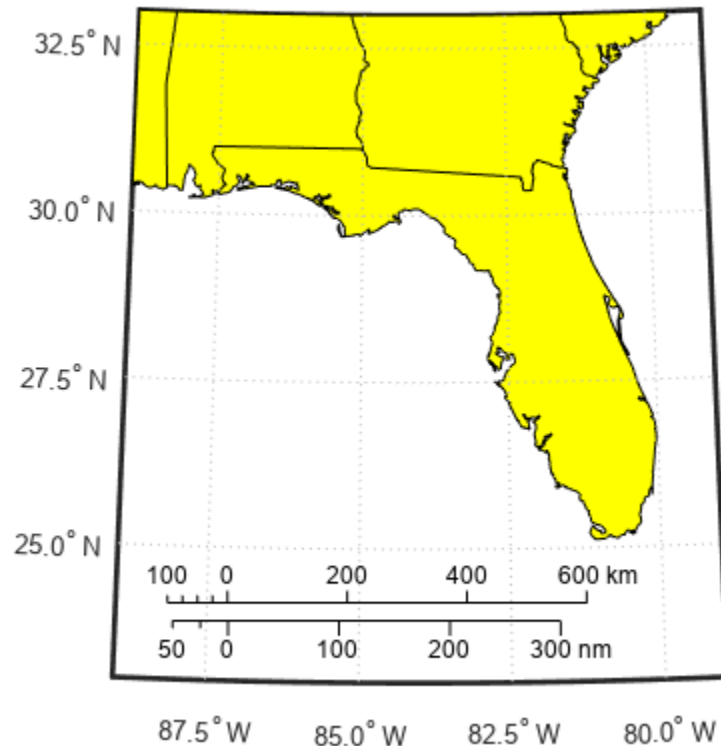
```
gs1 = scaleruler;
setm(gs1,"XLoc",-3.21e5,"YLoc",2.81e6,"MajorTick",0:200:600)
```

Add a second graphic scale that shows distance in nautical miles. Change the direction of the tick marks and text by setting the `TickDir` property.

```
gs2 = scaleruler("Units","nm");
setm(gs2,"XLoc",-3.2e5,"YLoc",2.78e6,"TickDir","down", ...
```



```
"MajorTick",0:100:300,"MinorTick",0:25:50, ...
"MajorTickLength",km2nm(25),"MinorTickLength",km2nm(12.5))
```



Customize Appearance of Graphic Scale

Create a map of Texas and the surrounding states. Your map might look different because the `polcmap` function randomizes colors.

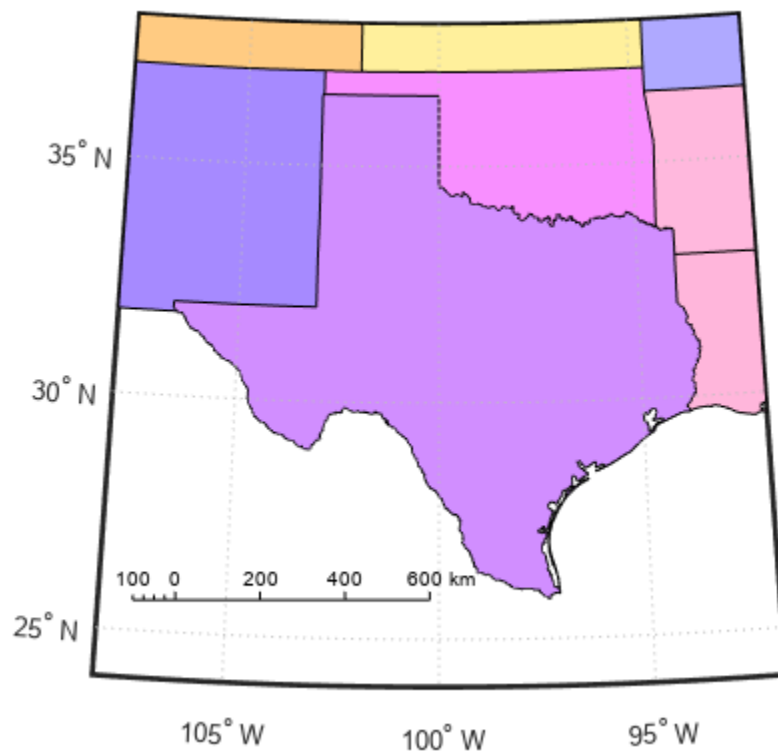
```
states = readgeotable("usastatehi.shp");
usamap("Texas")

h = height(states);
faceColors = makesymbolspec("Polygon",{ 'INDEX',[1 h], 'FaceColor',polcmap(h)});

geoshow(states,"DisplayType","polygon","SymbolSpec",faceColors)
```

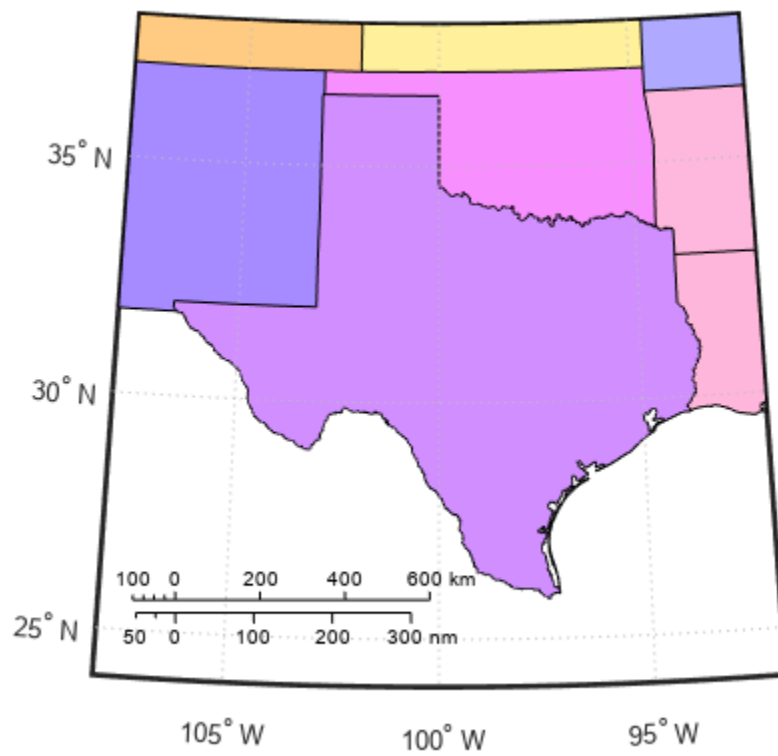
Add a graphic scale. By default, the graphic scale displays values in kilometers. Change the location, adjust the major tick marks, and set the font size to 8 points.

```
scaleruler on
gs1 = handle("scaleruler1");
setm(gs1,"XLoc",-6.2e5,"YLoc",3.03e6,"MajorTick",0:200:600,"FontSize",8)
```



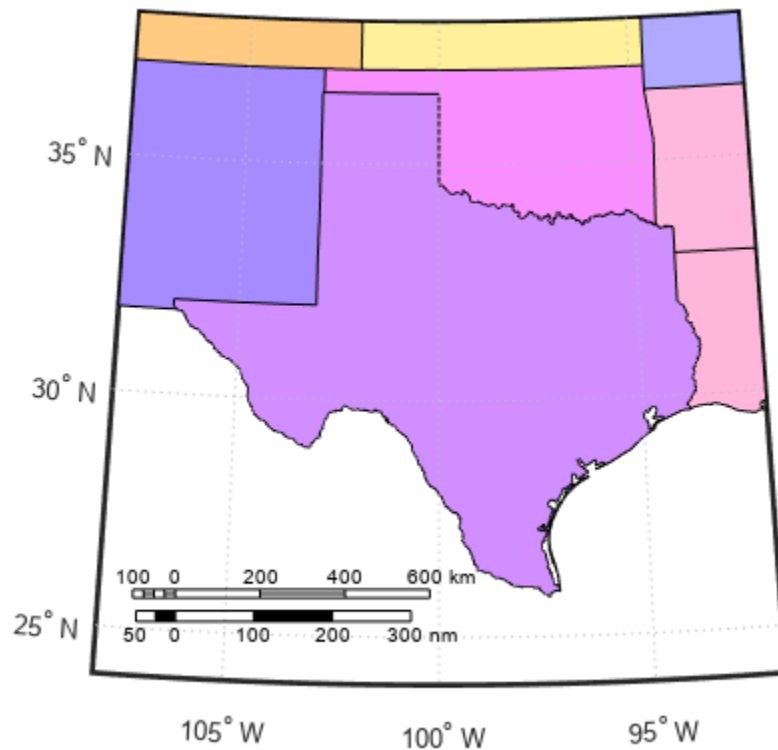
Create a second graphic scale using units of nautical miles. Adjust the major and minor tick marks.

```
scaleruler("Units","nm")
gs2 = handlem("scaleruler2");
setm(gs2,"XLoc",-6.2e5,"YLoc",3.0e6,"MajorTick",0:100:300,"MinorTick",0:25:50, ...
      "TickDir","down","MajorTickLength",km2nm(25),"MinorTickLength",km2nm(12.5),"FontSize",8)
```



Change the ruler styles.

```
setm(gs1, "RulerStyle", "lines")  
setm(gs2, "RulerStyle", "patches")
```



Input Arguments

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `scaleruler("Units","nm")` creates a graphic scale that displays units in nautical miles

Ticks and Labels

MajorTick — Major tick mark locations

numeric vector

Major tick mark locations, specified as a numeric vector in the units specified by the `Units` property of the graphic scale.

MajorTickLabel — Major tick mark labels

cell array of character vectors

Major tick mark labels, specified as a cell array of character vectors. The number of character vectors must match the number of major tick locations. By default, the graphic scale uses labels identical to the major tick mark locations.

MajorTickLength — Major tick mark length

numeric scalar

Major tick mark length, specified as a numeric scalar in the units specified by the `Units` property of the graphic scale.

MinorTick — Minor tick mark locations

numeric vector

Minor tick mark locations, specified as a numeric vector in the units specified by the `Units` property of the graphic scale.

MinorTickLabel — Minor tick mark labels

cell array of character vectors

Minor tick mark labels, specified as a cell array of character vectors. The number of character vectors must match the number of minor tick locations. By default, the graphic scale uses labels identical to the last minor tick mark location.

MinorTickLength — Minor tick mark length

numeric scalar

Minor tick mark length, specified as a numeric scalar in the units specified by the `Units` property of the graphic scale.

TickDir — Direction of tick marks and tick labels

"up" (default) | "down"

Direction of tick marks and tick labels, specified as one of these options:

- "up" — Display tick marks and tick labels above the baseline.
- "down" — Display tick marks and tick labels below the baseline.

TickMode — Selection mode for ticks

"auto" (default) | "manual"

Selection mode for ticks, specified as one of these options:

- "auto" — MATLAB chooses the ticks. Setting `TickMode` to "auto" clears any specified ticks and replaces them with default values.
- "manual" — You manually control the ticks. When you specify any tick properties, MATLAB sets `TickMode` to "manual".

Label — Label

character vector | string scalar

Label that displays along the graphic scale, specified as a character vector or string scalar. You can use the label to indicate the scale of the map, for example "1:50,000,000".

Font**FontName — Font name**

supported font name | "FixedWidth"

Font name, specified as a supported font name. To display and print text properly, you must choose a font that your system supports. The default font depends on your operating system and locale.

To use a fixed-width font that looks good in any locale, use "FixedWidth". The fixed-width font relies on the root `FixedWidthFontName` property. Setting the root `FixedWidthFontName` property causes an immediate update of the display to use the new font.

FontAngle – Character slant

"normal" (default) | "italic"

Character slant, specified as "normal" or "italic".

FontSize – Font size

9 (default) | positive scalar

Font size, specified as a positive scalar in point units. One point equals 1/72 of an inch. To change the font units, use the `FontUnits` argument.

FontUnits – Font size units

"points" (default) | "inches" | "centimeters" | "normalized" | "pixels"

Font size units, specified as one of the values in this table.

Units	Description
"points"	Points. One point equals 1/72 of an inch.
"inches"	Inches.
"centimeters"	Centimeters.
"normalized"	Interpret font size as a fraction of the axes plot box height. If you resize the axes, the font size changes accordingly. For example, if the <code>FontSize</code> is 0.1 in normalized units, then the text is 1/10 of the plot box height.
"pixels"	<p>Pixels.</p> <p>Starting in R2015b, distances in pixels are independent of your system resolution on Windows and Macintosh systems:</p> <ul style="list-style-type: none"> • On Windows systems, a pixel is 1/96 of an inch. • On Macintosh systems, a pixel is 1/72 of an inch. <p>On Linux systems, the size of a pixel is determined by your system resolution.</p>

If you set both the font size and the font units in one function call, you must specify `FontUnits` first so that the axes correctly interprets the specified font size.

FontWeight – Character thickness

"normal" (default) | "bold"

Character thickness, specified as "normal" or "bold".

MATLAB uses `FontWeight` to select a font from those available on your system. Not all fonts have a bold weight. Therefore, specifying a bold font weight can still result in the normal font weight.

Position

XLoc — Horizontal location of graphic scale

numeric scalar

Horizontal location of the graphic scale within the axes, specified as a numeric scalar in Cartesian projected coordinates. To view the Cartesian grid labels, use the `showaxes` function.

You can also interactively move the graphic scale by using your mouse.

YLoc — Vertical location of graphic scale

numeric scalar

Vertical location of the graphic scale within the axes, specified as a numeric scalar in Cartesian projected coordinates. To view the Cartesian grid labels, use the `showaxes` function.

You can also interactively move the graphic scale by using your mouse.

Color and Styling

Color — Color of graphic scale, tick marks, and text

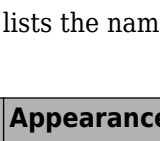
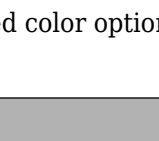
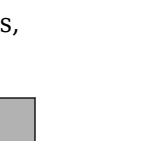

[0 0 0] (default) | RGB triplet | hexadecimal color code | color name | 'r' | 'g' | 'b' | ...

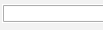
Color of the graphic scale, tick marks, and text, specified as an RGB triplet, a hexadecimal color code, a color name, or a short name.

For a custom color, specify an RGB triplet or a hexadecimal color code.

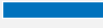
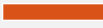

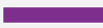
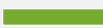
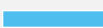

- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	
[0.6350 0.0780 0.1840]	"#A2142F"	

RulerStyle — Style of graphic scale

"ruler" (default) | "lines" | "patches"

Style of the graphic scale, specified as one of these options:

- "ruler" — Resembles the x-axis of an Axes object.
- "lines" — Displays three horizontal lines across the tick marks.
- "patches" — Alternates black and white rectangles in place of lines and tick marks.

LineWidth — Line width

0.5 (default) | numeric scalar

Line width of graphic scale, specified as a numeric scalar in point units.

Scaling

Azimuth — Azimuth of scale computation

0 (default) | numeric scalar

Azimuth of the scale computation, specified as a numeric scalar in the angle units of the current axesm-based map. Within a projection, the scale of a map varies with geographic location and azimuth. This value controls the azimuth along which MATLAB computes the scaling between geographic and projected coordinates.

Lat — Latitude of scale computation

center of displayed map (default) | numeric scalar

Latitude of the scale computation, specified as a numeric scalar in the angle units of the current axesm-based map. Within a projection, the scale of a map varies with geographic location and azimuth. This value controls the latitude along which MATLAB computes the scaling between geographic and projected coordinates.

Long — Longitude of scale computation

center of displayed map (default) | numeric scalar

Longitude of the scale computation, specified as a numeric scalar in the angle units of the current axesm-based map. Within a projection, the scale of a map varies with geographic location and azimuth. This value controls the longitude along which MATLAB computes the scaling between geographic and projected coordinates.

Radius — Name or radius of reference sphere

"earth" (default) | "sun" | "moon" | "mercury" | numeric scalar | ...

Name or radius of reference sphere, specified as "sun", "moon", "mercury", "venus", "earth", "mars", "jupiter", "saturn", "uranus", "neptune", "pluto", or a numeric scalar in units specified by the Units property of the graphic scale. This value controls the scaling between angular and surface distances.

Units — Surface distance units

"kilometer" | "kilometers" | "km" | "degree" | "degrees" | "deg" | ...

Surface distance units, specified as one of these options:

- These angular units.

Value	Unit Name
"degree", "degrees", "deg"	Degrees
"radian", "radians", "rad"	Radians

- Any length unit supported by the validateLengthUnit function.

Value	Unit Name
"m", "meter", "meters", "metre", "metres"	Meters
"cm", "centimeter", "centimeters", "centimetre", "centimetres"	Centimeters
"mm", "millimeter", "millimeters", "millimetre", "millimetres"	Millimeters
"micron", "microns"	Microns
"km", "kilometer", "kilometers", "kilometre", "kilometers"	Kilometers
"nm", "naut mi", "nautical mile", "nautical miles"	Nautical miles
"ft", "international ft", "foot", "international foot", "feet", "international feet"	Feet
"in", "inch", "inches"	Inches
"yd", "yds", "yard", "yards"	Yards
"mi", "mile", "miles", "international mile", "international miles"	Miles

Value	Unit Name
"sf", "survey ft", "US survey ft", "U.S. survey ft", "survey foot", "US survey foot", "U.S. survey foot", "survey feet", "US survey feet", "U.S. survey feet"	U.S. survey feet
"sm", "survey mile", "survey miles", "statute mile", "statute miles", "US survey mile", "US survey miles", "U.S. survey mile(s)", "U.S. survey miles"	U.S. survey miles (statute miles)
"Clarke's foot", "Clarkes foot"	Clarke's feet
"German legal metre", "German legal meter"	German legal metres
"Indian foot"	Indian feet

This argument is case insensitive.

Output Arguments

gs — Graphic scale

Group object

Graphic scale, returned as a Group object. Modify the properties of a graphic scale by using `gs` as an input to the `setm` function. Query the properties of a graphic scale by using `gs` as an input to the `getm` function.

Tips

In addition to the syntax `scaleruler off`, you can remove graphic scales from an `axesm`-based map by using one of these methods:

- `clmo scaleruler` — Remove all graphic scales.
- `clmo scalerulerN` — Remove the *N*th graphic scale, such as `clmo scaleruler2`.
- `delete(gs)` — Remove the graphic scale specified by `gs`.
- `delete(handlem("scalerulerN"))` — Remove the *N*th graphic scale, such as `delete(handlem("scaleruler2"))`.

Version History

Introduced before R2006a

See Also

Functions

`setm` | `getm` | `distance` | `axesscale` | `northarrow`

scatterm

Project scatter plot on axesm-based map

Syntax

```
scatterm(lat,lon)
scatterm(lat,lon,sz)
scatterm(lat,lon,sz,c)
scatterm( __ , "filled")
scatterm( __ ,mkr)
scatterm(abm, __ )
h = scatterm( __ )
```

Description

`scatterm(lat,lon)` creates a scatter plot on the current axesm-based map with circular markers at the geographic locations specified by `lat` and `lon`.

To display scatter plots on geographic axes or map axes, use the `geosscatter` function instead.

`scatterm(lat,lon,sz)` specifies the circle sizes.

`scatterm(lat,lon,sz,c)` specifies the circle colors.

`scatterm(__ , "filled")` fills in the circles, in addition to any of the input argument combinations in the previous syntaxes.

`scatterm(__ ,mkr)` specifies the marker type.

`scatterm(abm, __)` plots into the specified axesm-based map `abm` instead of into the current axesm-based map. The option `abm` must precede any of the input argument combinations in the previous syntaxes.

`h = scatterm(__)` returns the scatter plot.

Examples

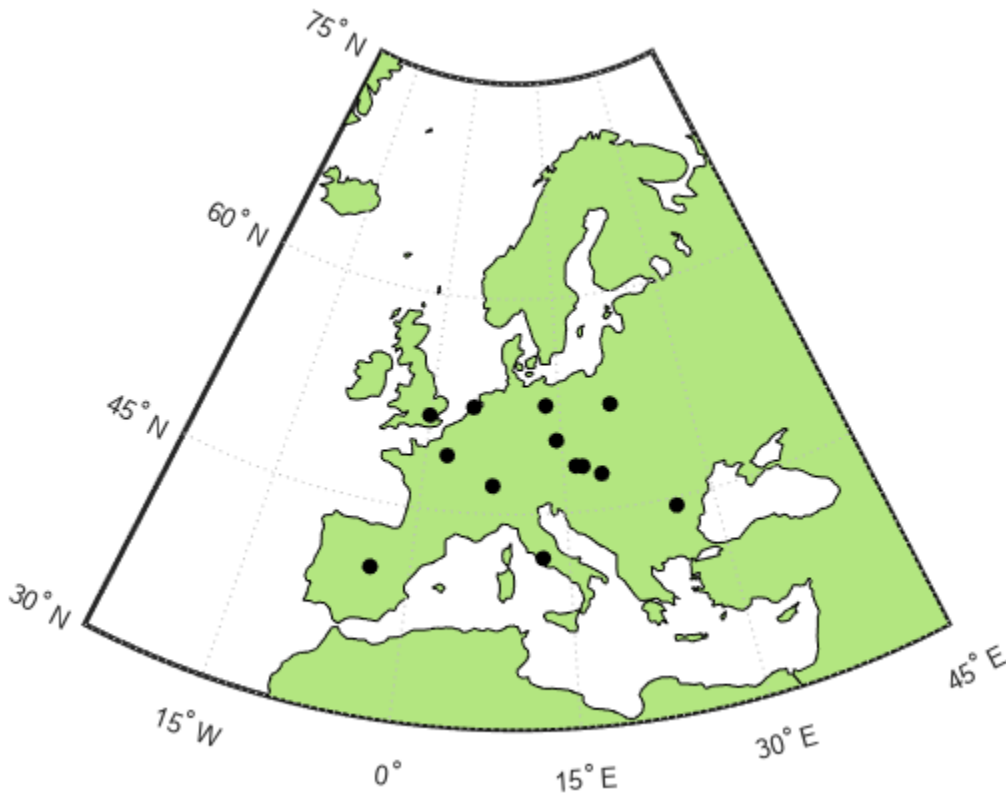
Project Scatter Plot on Map

Create a map of Europe.

```
load coastlines
worldmap europe
geoshow(coastlat,coastlon,"DisplayType","polygon", ...
        "FaceColor",[0.7 0.9 0.5])
```

Project the locations of European capitals onto the map using filled, black markers.

```
[lat,lon] = readvars("european_capitals.txt");
scatterm(lat,lon,"filled","k")
```



Specify Marker Size

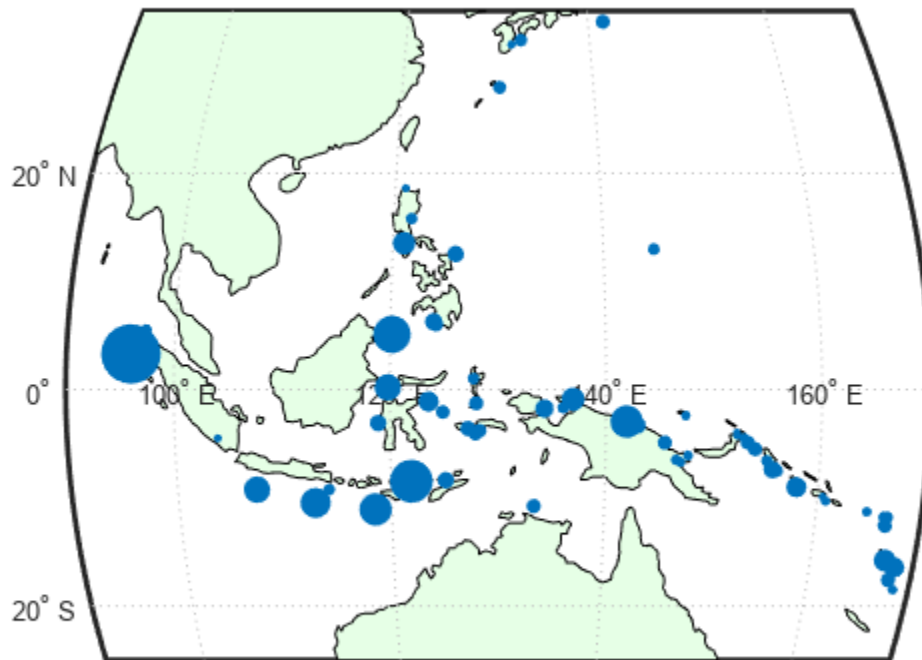
Create a map for a region containing Southeast Asia.

```
load coastlines
worldmap([-25 35],[90 170])
geoshow(coastlat,coastlon,"DisplayType","polygon", ...
        "FaceColor",[0.9 1 0.9])
```

Project the locations of tsunami events onto the map using filled markers. Specify the marker sizes using the maximum heights of the tsunamis.

```
GT = readgeotable("tsunamis.shp","CoordinateSystemType","geographic");
lat = GT.Shape.Latitude;
lon = GT.Shape.Longitude;
h = GT.Max_Height;

scatterm(lat,lon,10*h,"filled")
```



Input Arguments

lat — Latitude coordinates

scalar | vector

Latitude coordinates, specified as a scalar or vector. The size of `lat` must match the size of `lon`.

Data Types: single | double

lon — Longitude coordinates

scalar | vector

Longitude coordinates, specified as a scalar or vector. The size of `lon` must match the size of `lat`.

Data Types: single | double

sz — Marker size

36 (default) | numeric scalar | numeric vector | []

Marker size, specified as one of these options. The size controls the area of each marker in points squared.

- A numeric scalar — Use a uniform marker size.
- A numeric vector — Use a different marker size for each data point. The vector must be the same length as `lat` and `lon`.

- Empty brackets ([]) — Use the default marker size of 36 points squared. Use this option when you want to specify `c` and use the default marker size.

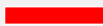



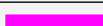



c — Marker color

RGB triplet | three-column matrix of RGB triplets | vector | "r" | "g" | "b" | ...

Marker color, specified as one of these options.

- RGB triplet or color name — Plot all markers with the same color.
- Three-column matrix of RGB triplets — Use different colors for each marker. Each row of the matrix specifies an RGB triplet color for the corresponding marker. The number of rows must equal the lengths of `lat` and `lon`.
- Vector — Use different colors for each marker and linearly map values in `c` to the current colormap. The length of `c` must equal the length of `lat` and `lon`.

An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range $[0, 1]$; for example, $[0.4 \ 0.6 \ 0.7]$. Alternatively, you can specify some common colors by name. This table lists the named color options and equivalent RGB triplets.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

"filled" — Option to fill interior of markers




"filled"

Option to fill the interior of the markers, specified as "filled". Use this option with markers that have a face, such as "o" or "square". When you use this option with markers that do not have a face, such as "+", "*", ".", and "x", the function does not display any markers.

mkr — Marker symbol

"o" (default) | "+" | "*" | "." | "x" | ...

Marker symbol, specified as one of the values listed in this table.

Marker	Description	Resulting Marker
"o"	Circle	
"+"	Plus sign	
"*"	Asterisk	

Marker	Description	Resulting Marker
"."	Point	•
"x"	Cross	×
"_"	Horizontal line	—
" "	Vertical line	
"square"	Square	□
"diamond"	Diamond	◇
"^"	Upward-pointing triangle	△
"v"	Downward-pointing triangle	▽
">"	Right-pointing triangle	▷
"<"	Left-pointing triangle	◁
"pentagram"	Pentagram	☆
"hexagram"	Hexagram	☆

abm — axesm-based map

map created using `axesm`, `worldmap`, or `usamap`

axesm-based map, specified as a map created using the `axesm`, `worldmap`, or `usamap` function.

Output Arguments

h — Scatter plot

Group object

Scatter plot, returned as a Group object.

Version History

Introduced before R2006a

See Also

Functions

`geoshow` | `geoscatter` | `scatter` | `stem3m`

scircle1

Small circle from center and radius

Syntax

```
[lat,lon] = scircle1(lat0,lon0,r)
[lat,lon] = scircle1(lat0,lon0,r,az)
[lat,lon] = scircle1(lat0,lon0,r,az,ellipsoid)
[lat,lon] = scircle1( ____,units)
[lat,lon] = scircle1(lat0,lon0,r,az,ellipsoid,units,npts)
[lat,lon] = scircle1(method, ____)
mat = scircle1( ____)
```

Description

`[lat,lon] = scircle1(lat0,lon0,r)` finds the latitude and longitude coordinates of a small circle. Specify the geographic coordinates of the center of the small circle using `lat0` and `lon0`. Specify the radius of the small circle using `r`. This syntax assumes that the radius is a spherical distance in degrees.

`[lat,lon] = scircle1(lat0,lon0,r,az)` finds coordinates for the section of the small circle specified by `az`.

`[lat,lon] = scircle1(lat0,lon0,r,az,ellipsoid)` specifies the reference ellipsoid to use for the coordinates. This syntax assumes that the radius of the small circle is a linear measurement in the same units as the semimajor axis of `ellipsoid`.

`[lat,lon] = scircle1(____,units)` specifies the angle units `units` of the inputs and outputs, in addition to any combination of input arguments from the previous syntaxes.

`[lat,lon] = scircle1(lat0,lon0,r,az,ellipsoid,units,npts)` specifies the number of points `npts` to include in the small circle.

`[lat,lon] = scircle1(method, ____,)` where `method` is "rh", specifies that distances from the center of the small circle are rhumb line distances. The default for `method` is "gc", which specifies that distances from the center of the small circle are great circle distances (for a sphere) or geodesic distances (for an ellipsoid).

`mat = scircle1(____,)` returns the latitude and longitude coordinates of the small circle in the matrix `mat`.

Examples

Find Coordinates of Small Circle

Find the latitude and longitude coordinates of a small circle centered on Ottawa with a radius of 4°.

```
lat0 = 45.4215;
lon0 = -75.6972;
```



```
r = 4;
[lat,lon] = scircle1(lat0,lon0,r);
```

Plot the small circle on a map using a thick line.

```
geoplot(lat,lon,"LineWidth",2)
geobasemap streets
```



Find Coordinates of Partial Small Circle

Find the latitude and longitude coordinates of a full small circle centered on Tokyo with a radius of 5° .

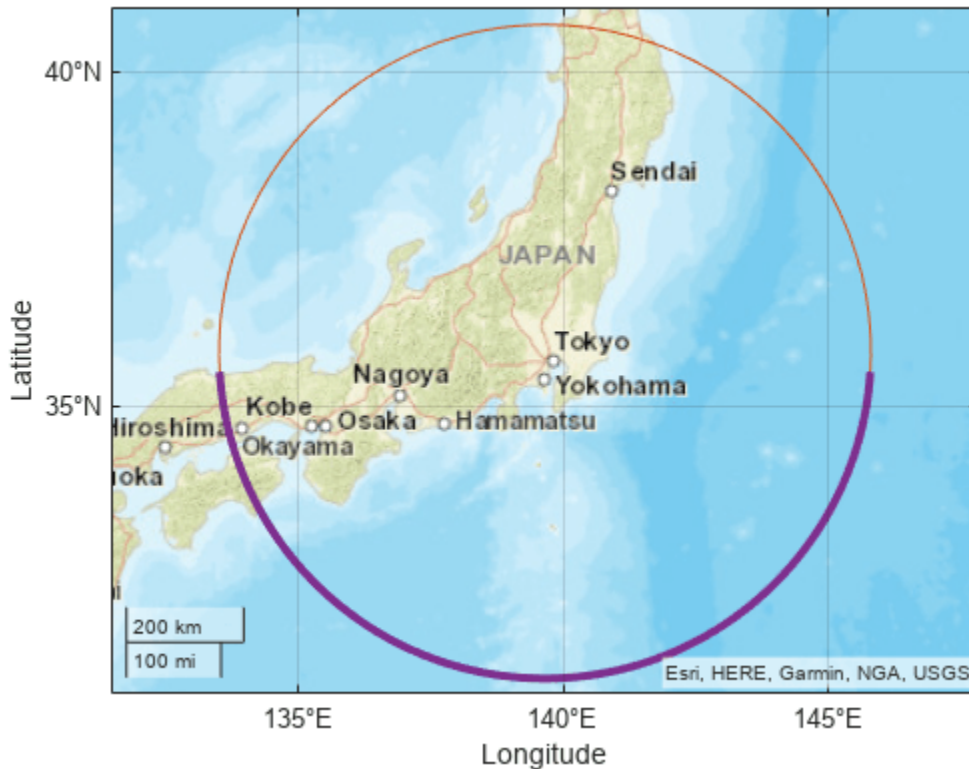
```
lat0 = 35.6762;
lon0 = 139.6503;
r = 5;
[lat1,lon1] = scircle1(lat0,lon0,r);
```

Find the coordinates of a partial small circle, in this case the section of the circle between 90° from north and 270° from north.

```
az = [90 270];
[lat2,lon2] = scircle1(lat0,lon0,r,az);
```

Display both the full circle and the partial circle on a map. Use a thick line for the partial circle.

```
geoplot(lat1,lon1,"Color",[0.8500 0.3250 0.0980])
hold on
geoplot(lat2,lon2,"Color",[0.4940 0.1840 0.5560],"LineWidth",3)
geobasemap streets
```



Find Coordinates of Small Circle on Reference Ellipsoid

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of kilometers.

```
wgs84 = wgs84Ellipsoid("km");
```

Find the latitude and longitude coordinates of a small circle centered on Boston with a radius of 100 kilometers. Find the coordinates of the full small circle by specifying the fourth argument as [].

```
lat0 = 42.3601;
lon0 = -71.0589;
r = 100;
[lat,lon] = scircle1(lat0,lon0,r,[],wgs84);
```

Plot the small circle on a map using a thick, black line.

```
geoplot(lat,lon,"k","LineWidth",2)
geobasemap streets
```



Find Coordinates of Multiple Small Circles

You can use the `scircle1` function to find the coordinates of multiple small circles with the same center or with different centers.

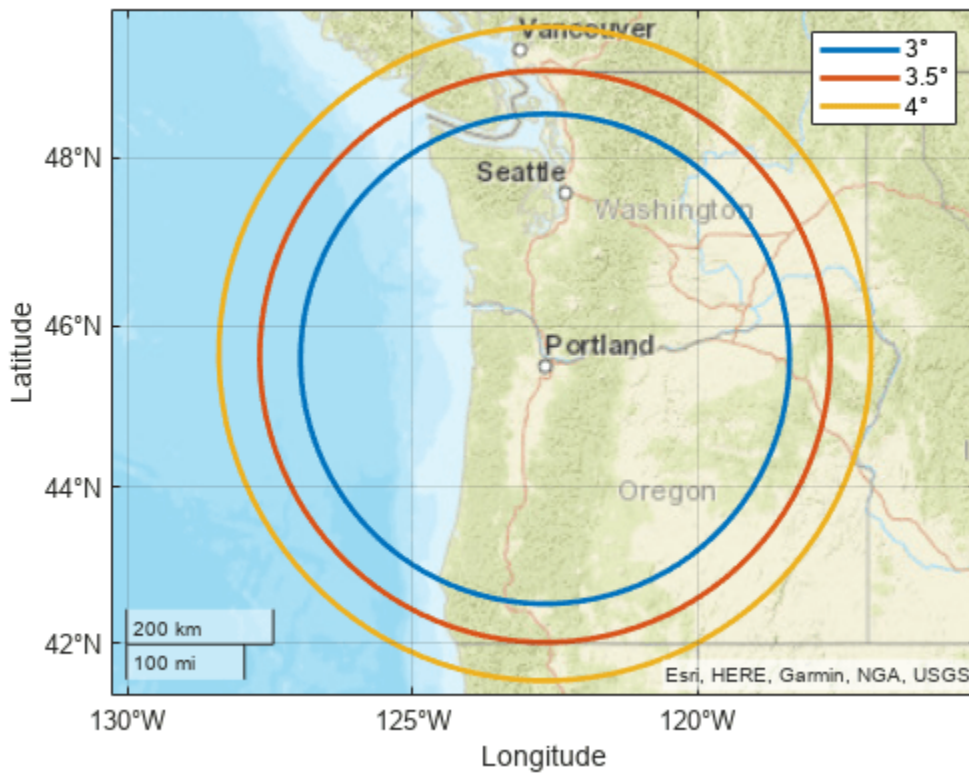
Multiple Small Circles with the Same Center

Find the coordinates of three small circles centered on Portland, Oregon. Specify the radii of the small circles as 3° , 3.5° , and 4° .

```
lat0 = 45.5152;
lon0 = -122.6784;
r = [3 3.5 4]';
[lat,lon] = scircle1(lat0,lon0,r);
```

Display the small circles on a map using thick lines. Differentiate the circles by including the radii in a legend.

```
geobasemap streets
hold on
for i=1:size(lat,2)
    geoplot(lat(:,i),lon(:,i),"LineWidth",2,"DisplayName",string(r(i))+char(176))
end
legend
```



Multiple Small Circles with the Different Centers

Find the coordinates of three small circles with different centers.

- Center the first small circle on Boston and specify the radius as 3° .
- Center the second small circle on New York City and specify the radius as 4° .
- Center the third small circle on Chicago and specify the radius as 5° .

```
lat0 = [42.3601 40.7128 41.8781]';
lon0 = [-71.0589 -74.0060 -87.6298]';
cities = ["Boston" "New York City" "Chicago"];
r = [3 4 5]';
[lat,lon] = scircle1(lat0,lon0,r);
```

Display the small circles on a map using thick lines. Differentiate the circles by including the city names in a legend.

```
figure
geobasemap streets
hold on
for i=1:size(lat,2)
    geoplot(lat(:,i),lon(:,i),"LineWidth",2,"DisplayName",cities(i))
end
legend
```



Input Arguments

lat0 — Latitude of center of small circle

scalar | column vector

Latitude of the center of the small circle, specified as a scalar or a column vector.

- To find the coordinates of multiple small circles with the same center, specify `lat0` and `lon0` as scalars and specify `r` as a column vector. The number of elements in the column vector is the number of small circles.
- To find the coordinates of multiple small circles with different centers, specify `lat0`, `lon0`, and `r` as column vectors of the same size.

The sizes of `lat0` and `lon0` must match.

Data Types: `single` | `double`

lon0 — Longitude of center of small circle

scalar | column vector

Longitude of the center of the small circle, specified as a scalar or a column vector.

- To find the coordinates of multiple small circles with the same center, specify `lat0` and `lon0` as scalars and specify `r` as a column vector. The number of elements in the column vector is the number of small circles.

- To find the coordinates of multiple small circles with different centers, specify `lat0`, `lon0`, and `r` as column vectors of the same size.

The sizes of `lat0` and `lon0` must match.

Data Types: `single` | `double`

r — Radius of small circle

scalar | column vector

Radius of the small circle, specified as scalar or column vector.

When `lat0` and `lon0` are column vectors, the number of elements in `r` must match the number of elements in `lat0` and `lon0`.

Data Types: `single` | `double`

az — Azimuth indicating section of small circle to find

`[]` (default) | column vector | two-column matrix

Azimuth indicating the section of the small circle to find, specified as one of these options:

- A column vector — Find coordinates of the small circle from north to the specified azimuth. Each element of `az` corresponds to an element of `r`. The size of `az` must match the number of small circles.
- A two-column matrix — Find coordinates of the small circle between the azimuth in the first column and the azimuth in the second column. Each row of `az` corresponds to an element of `r`. The number of rows in `az` must match the number of small circles.

Azimuths are measured clockwise from north.

The default value of `[]` specifies a full small circle.

Data Types: `single` | `double`

ellipsoid — Reference ellipsoid

`[1 0]` (default) | `referenceSphere` object | `referenceEllipsoid` object | `oblateSpheroid` object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element numeric vector of the form `[semimajor_axis eccentricity]`, where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of `[1 0]` represents the unit sphere.

units — Angle unit

`"degrees"` (default) | `"radians"`

Angle unit, specified as one of these options:

- `"degrees"` — Degrees
- `"radians"` — Radians

If you do not specify a reference ellipsoid, this argument determines the angle units for the input and output coordinates, the radius, and the azimuth. If you specify a reference ellipsoid, this argument determines the angle units for only the input and output coordinates and the azimuth.

Data Types: `char` | `string`

npts — Number of points

100 (default) | `scalar`

Number of points to include in the small circle, specified as a scalar. If you specify more than one small circle, then the function finds `npts` points per small circle.

method — Type of distance from center of small circle

"gc" (default) | "rh"

Type of distance from the center of the small circle, specified as one of these options:

- "gc" — Use the great circle distance.
- "rh" — Use the rhumb line distance.

Data Types: `char` | `string`

Output Arguments

lat — Latitude coordinates of small circle

`column vector` | `matrix`

Latitude coordinates of the small circle, returned as a column vector with `npts` elements or a matrix of size `npts-by-m`, where m is the number of small circles.

lon — Longitude coordinates of small circle

`column vector` | `matrix`

Longitude coordinates of the small circle, returned as a column vector with `npts` elements or a matrix of size `npts-by-m`, where m is the number of small circles.

mat — Latitude and longitude coordinates of small circle

`matrix`

Latitude and longitude coordinates of the small circle, returned as a matrix equivalent to `[lat lon]`.

More About

Small Circle

A *small circle* is the set of points with the same surface distance from a given center. Examples of small circles include the set of points exactly 100 miles from the Washington Monument, parallels on the globe, and meridians on the globe.

Version History

Introduced before R2006a

See Also

Functions

scircle2 | scircleg | ellipse1

Topics

“Generate Small Circles”

scircle2

Small circle from center and point on perimeter

Syntax

```
[lat,lon] = scircle2(lat0,lon0,latP,lonP)
[lat,lon] = scircle2(lat0,lon0,latP,lonP,ellipsoid)
[lat,lon] = scircle2( ____,units)
[lat,lon] = scircle2(lat0,lon0,latP,lonP,ellipsoid,units,npts)
[lat,lon] = scircle2(method, ____)
mat = scircle2( ____)
```

Description

`[lat,lon] = scircle2(lat0,lon0,latP,lonP)` finds the latitude and longitude coordinates of a small circle. Specify the geographic coordinates of the center of the small circle using `lat0` and `lon0`. Specify a point on the perimeter of the small circle using `latP` and `lonP`. This syntax assumes that the coordinates are referenced to a sphere.

`[lat,lon] = scircle2(lat0,lon0,latP,lonP,ellipsoid)` specifies the reference ellipsoid ellipsoid for the coordinates.

`[lat,lon] = scircle2(____,units)` specifies the angle units `units` of the inputs and outputs, in addition to any combination of input arguments from the previous syntaxes.

`[lat,lon] = scircle2(lat0,lon0,latP,lonP,ellipsoid,units,npts)` specifies the number of points `npts` to include in the small circle.

`[lat,lon] = scircle2(method, ____,)` where `method` is "rh", specifies that distances from the center of the small circle are rhumb line distances. The default for `method` is "gc", which specifies that distances from the center of the small circle are great circle distances (for a sphere) or geodesic distances (for an ellipsoid).

`mat = scircle2(____,)` returns the latitude and longitude coordinates of the small circle in the matrix `mat`.

Examples

Find Coordinates of Small Circle

Find the latitude and longitude coordinates of a small circle centered on Ottawa with Toronto on the perimeter.

```
lat0 = 45.4215;
lon0 = -75.6972;
latP = 43.6532;
lonP = -79.3832;
[lat,lon] = scircle2(lat0,lon0,latP,lonP);
```

Plot the small circle on a map using a thick line.

```
geoplot(lat,lon,"LineWidth",2)
geobasemap streets
```



Find Coordinates of Small Circle on Reference Ellipsoid

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of kilometers.

```
wgs84 = wgs84Ellipsoid("km");
```

Find the latitude and longitude coordinates of a small circle centered on Boston with Albany at the perimeter.

```
lat0 = 42.3601;
lon0 = -71.0589;
latP = 42.6526;
lonP = -73.7562;
[lat,lon] = scircle2(lat0,lon0,latP,lonP,wgs84);
```

Plot the small circle on a map using a thick black line.

```
geoplot(lat,lon,"k","LineWidth",2)
geobasemap streets
```



Find Coordinates of Multiple Small Circles

You can use the `scircle2` function to find the coordinates of multiple small circles with the same center or with different centers.

Multiple Small Circles with the Same Center

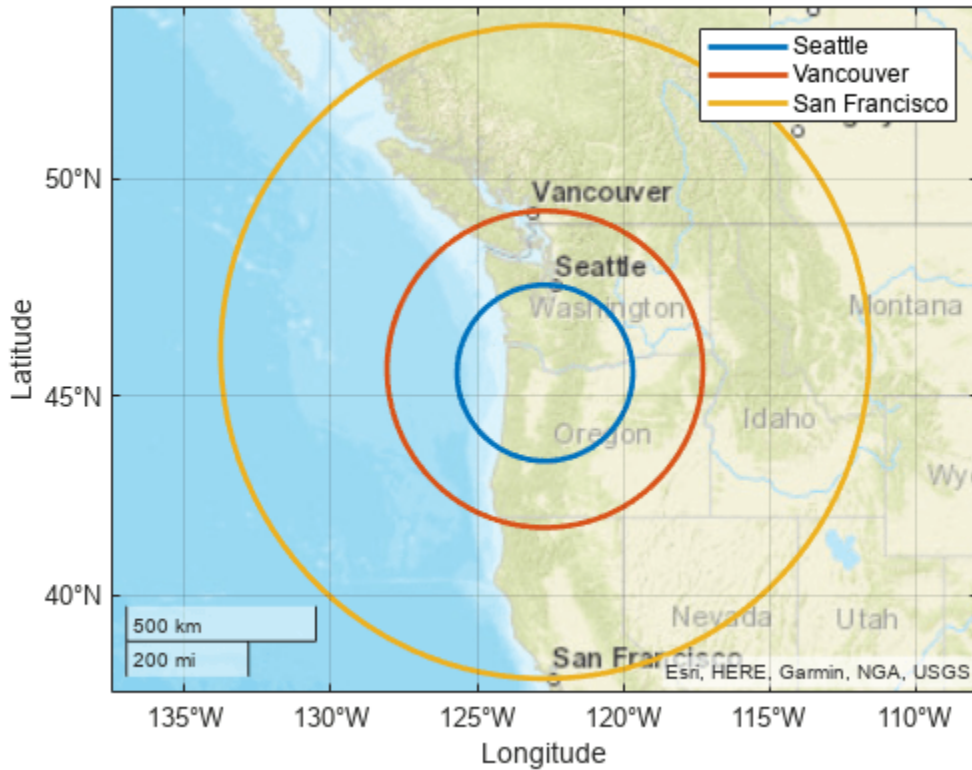
Find the coordinates of three small circles centered on Portland, Oregon. Specify points on the perimeters of the circles using the coordinates of Seattle, Vancouver, and Calgary.

```
lat0 = 45.5152;
lon0 = -122.6784;
latP = [47.6062 49.2827 37.7749]';
lonP = [-122.3321 -123.1207 -122.4194]';
cities = ["Seattle" "Vancouver" "San Francisco"];
[lat,lon] = scircle2(lat0,lon0,latP,lonP);
```

Display the small circles on a map using thick lines. Differentiate the circles by including the perimeter cities in a legend.

```
geobasemap streets
hold on
for i=1:size(lat,2)
    geoplot(lat(:,i),lon(:,i),"LineWidth",2,"DisplayName",cities(i))
```

```
end
legend
```



Multiple Small Circles with the Different Centers

Find the coordinates of three small circles with different centers.

- The first small circle is centered on Boston and has New York City on its perimeter.
- The second small circle is centered on Washington, DC and has Philadelphia on its perimeter.
- The third small circle is centered on Chicago and has St. Louis on its perimeter.

```
lat0 = [42.3601 38.9072 41.8781]';
lon0 = [-71.0589 -77.0369 -87.6298]';
latP = [40.7128 39.9526 38.627]';
lonP = [-74.0060 -75.1652 -90.1994]';
[lat,lon] = scircle2(lat0,lon0,latP,lonP);
cities = ["Boston and New York City" "Washington, DC and Philadelphia" "Chicago and St. Louis"];
```

Display the small circles on a map using thick lines. Differentiate the circles by including the city name pairs in a legend.

```
figure
geobasemap streets
hold on
for i=1:size(lat,2)
    geoplots(lat(:,i),lon(:,i),"LineWidth",2,"DisplayName",cities(i))
```

end
legend



Input Arguments

lat0 — Latitude of center of small circle

scalar | column vector

Latitude of the center of the small circle, specified as a scalar or a column vector.

- To find the coordinates of multiple small circles with the same center, specify `lat0` and `lon0` as scalars and specify `latP` and `lonP` as column vectors. The number of elements in the column vectors is the number of small circles.
- To find the coordinates of multiple small circles with different centers, specify `lat0`, `lon0`, and `latP` and `lonP` as column vectors of the same size.

The sizes of `lat0` and `lon0` must match.

Data Types: double

lon0 — Longitude of center of small circle

scalar | column vector

Longitude of the center of the small circle, specified as a scalar or a column vector.

- To find the coordinates of multiple small circles with the same center, specify `lat0` and `lon0` as scalars and specify `latP` and `lonP` as column vectors. The number of elements in the column vectors is the number of small circles.
- To find the coordinates of multiple small circles with different centers, specify `lat0`, `lon0`, and `latP` and `lonP` as column vectors of the same size.

The sizes of `lat0` and `lon0` must match.

Data Types: `double`

latP — Latitude of point on perimeter of small circle

scalar | column vector

Latitude of a point on the perimeter of the small circle, specified as a scalar or a column vector.

When `lat0` and `lon0` are column vectors, the number of elements in `latP` must match the number of elements in `lat0` and `lon0`.

The sizes of `latP` and `lonP` must match.

Data Types: `double`

lonP — Longitude of point on perimeter of small circle

scalar | column vector

Longitude of a point on the perimeter of the small circle, specified as a scalar or a column vector.

When `lat0` and `lon0` are column vectors, the number of elements in `lonP` must match the number of elements in `lat0` and `lon0`.

The sizes of `latP` and `lonP` must match.

Data Types: `double`

ellipsoid — Reference ellipsoid

[1 0] (default) | `referenceSphere` object | `referenceEllipsoid` object | `oblateSpheroid` object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element numeric vector of the form [`semimajor_axis` `eccentricity`], where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of [1 0] represents the unit sphere.

units — Angle unit

"degrees" (default) | "radians"

Angle unit, specified as one of these options:

- "degrees" — Degrees
- "radians" — Radians

Data Types: `char` | `string`

npts — Number of points

100 (default) | scalar

Number of points to include in the small circle, specified as a scalar. If you specify more than one small circle, then the function finds `npts` points per small circle.

Data Types: `double`

method — Type of distance from center of small circle

"gc" (default) | "rh"

Type of distance from the center of the small circle, specified as one of these options:

- "gc" — Use the great circle distance.
- "rh" — Use the rhumb line distance.

Data Types: `char` | `string`

Output Arguments

lat — Latitude coordinates of small circle

column vector | matrix

Latitude coordinates of the small circle, returned as a column vector with `npts` elements or a matrix of size `npts-by-m`, where m is the number of small circles.

lon — Longitude coordinates of small circle

column vector | matrix

Longitude coordinates of the small circle, returned as a column vector with `npts` elements or a matrix of size `npts-by-m`, where m is the number of small circles.

mat — Latitude and longitude coordinates of small circle

matrix

Latitude and longitude coordinates of the small circle, returned as a matrix equivalent to `[lat lon]`.

More About

Small Circle

A *small circle* is the set of points with the same surface distance from a given center. Examples of small circles include the set of points exactly 100 miles from the Washington Monument and parallels on the globe.

Version History

Introduced before R2006a

See Also

Functions

`scircle1` | `scircleg` | `ellipse1`

Topics

“Generate Small Circles”

scircleg

Add small circle to axesm-based map using mouse

Syntax

```
h = scircleg(ncirc)
h = scircleg(ncirc,npts)
h = scircleg(ncirc,LineStyle)
h = scircleg(ncirc,PropertyName,PropertyValue,...)
[lat,lon] = scircleg(ncirc,npts,...)
h = scircleg(track,ncirc,...)
```

Description

`h = scircleg(ncirc)` brings forward the current axesm-based map and waits for the user to make $(2 * \text{ncirc})$ mouse clicks. The output `h` is a vector of handles for the `ncirc` small circles, which are then displayed.

`h = scircleg(ncirc,npts)` specifies the number of plotting points to be used for each small circle. `npts` is 100 by default.

`h = scircleg(ncirc,LineStyle)` specifies the line style, marker, and color on page 1-1604.

`h = scircleg(ncirc,PropertyName,PropertyValue,...)` allows property name/property value pairs to be set, where *PropertyName* and *PropertyValue* are recognized by the `line` function.

`[lat,lon] = scircleg(ncirc,npts,...)` returns the coordinates of the plotted points rather than the handles of the small circles. Successive circles are stored in separate columns of `lat` and `lon`.

`h = scircleg(track,ncirc,...)` specifies the logic with which ranges are calculated. If `track` is 'gc' (the default), great circle distance is used. If `track` is 'rh', rhumb line distance is used.

This function is used to define small circles for display using mouse clicks. For each circle, two clicks are required: one to mark the center of the circle and one to mark any point on the circle itself, thereby defining the radius.


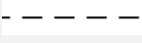
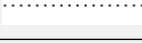
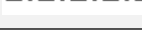
Background
















A small circle is the locus of all points an equal surface distance from a given center. For true small circles, this distance is always calculated in a great circle sense; however, the `scircleg` function allows a locus to be calculated using distances in a rhumb line sense as well. You can modify the circle after creation by **shift**+clicking it. The circle is then in edit mode, during which you can change the size and position by dragging control points, or by entering values into a control panel. **Shift**+clicking again exits edit mode.

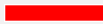



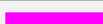
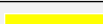

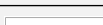
More About

Line Style, Marker, and Color

Specify the line style, marker, and color as a character vector or string containing symbols. The symbols can appear in any order. You do not need to specify all three characteristics (line style, marker, and color). For example, specify a red dashed line using `'--r'`.

Line Style	Description	Resulting Line
"_"	Solid line	
"--"	Dashed line	
":"	Dotted line	
"-.""	Dash-dotted line	

Marker	Description	Resulting Marker
"o"	Circle	
"+"	Plus sign	
"*"	Asterisk	
"."	Point	
"x"	Cross	
"_"	Horizontal line	
" "	Vertical line	
"square"	Square	
"diamond"	Diamond	
"^"	Upward-pointing triangle	
"v"	Downward-pointing triangle	
">"	Right-pointing triangle	
"<"	Left-pointing triangle	
"pentagram"	Pentagram	
"hexagram"	Hexagram	

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Version History

Introduced before R2006a

See Also

scircle1 | scircle2

SCXSC

Intersection points for pairs of small circles

Syntax

```
[lat,lon] = scxsc(lat1,lon1,range1,lat2,lon2,range2)
[lat,lon] = scxsc(lat1,lon1,range1,lat2,lon2,range2,units)
latlon = scxsc(____)
```

Description

`[lat,lon] = scxsc(lat1,lon1,range1,lat2,lon2,range2)` returns in `lat` and `lon` the locations where pairs of small circles intersect. The small circles are defined using *small circle notation*, which consists of a center point and a radius in units of angular arc length. For example, the first small circle in a pair would be centered on the point `(lat1,lon1)` with a radius of `range1` (in angular units).

For any pair of small circles, there are four possible intersection conditions: the circles are identical, they do not intersect, they are tangent to each other and hence they intersect once, or they intersect twice.

`[lat,lon] = scxsc(lat1,lon1,range1,lat2,lon2,range2,units)` specifies the angular units used for all inputs, where `units` is any valid angular unit.

`latlon = scxsc(____)` returns a single output consisting of the concatenated latitude and longitude coordinates of the small circle intersection points.

Examples

Find Intersection Points of Two Small Circles

Given a small circle centered at $(10^{\circ}\text{S}, 170^{\circ}\text{W})$ with a radius of 20° (~1200 nautical miles), where does it intersect with a small circle centered at $(3^{\circ}\text{N}, 179^{\circ}\text{E})$, with a radius of 15° (~900 nautical miles)?

```
[newlat,newlon] = scxsc(-10,-170,20,3,179,15)
```

```
newlat =
```

```
    -8.8368    9.8526
```

```
newlon =
```

```
   169.7578  -167.5637
```

Note that in this example, the two small circles cross the date line.

Input Arguments

lat1, lon1 — Center coordinate of first small circle

numeric scalar | n -element numeric vector

Latitude or longitude coordinate of the center of the first small circle in each pair, specified as one of these values.

- A numeric scalar to find the intersection of a single pair of small circles.
- A n -element numeric vector to find the intersection of n pairs of small circles.

lat1 and lon1 must have the same length.

Example: -10

Example: [-10 20 90 -45]

range1 — Radius of first small circle

positive numeric scalar | n -element vector of positive numbers

Radius of the first small circle of each pair, in angular units, specified as one of these values.

- A positive numeric scalar to find the intersection of a single pair of small circles.
- A n -element vector of positive numbers to find the intersection of n pairs of small circles. The length of range1 matches the length of lat1 and lon1.

Example: 20

Example: [20 10 45 45]

lat2, lon2 — Center coordinate of second small circle

numeric scalar | numeric vector

Latitude or longitude coordinate of the center of the second small circle in each pair, specified as one of these values.

- A numeric scalar to find the intersection of a single pair of small circles.
- A n -element numeric vector to find the intersection of n pairs of small circles.

lat2 and lon2 must have the same length as lat1 and lon1.

Example: 3

Example: [3 30 85 -45]

range2 — Radius of second small circle

positive numeric scalar | n -element vector of positive numbers

Radius of the second small circle of each pair, in angular units, specified as one of these values.

- A positive numeric scalar to find the intersection of a single pair of small circles.
- A n -element vector of positive numbers to find the intersection of n pairs of small circles. The length of range2 matches the length of lat2 and lon2.

Example: 15

Example: [15 15 45 50]

units — Angular units

'degrees' (default) | 'radians'

Angular units, specified as 'degrees' or 'radians'.

Output Arguments

lat, lon — Coordinates of small circle intersections

2-element vector | n -by-2 matrix

Coordinates of small circle intersections, returned as one of the following.

- 2-element vector when you find the intersection of a single pair of small circles.
- n -by-2 matrix when you find the intersection of n pairs of small circles.

If a pair of small circles do not intersect, or are identical, then `scxsc` displays a warning and returns NaNs for the latitude and longitude coordinates of the intersection points. If a pair of small circles are tangent, then the single intersection point is returned twice.

latlon — Concatenated coordinates of small circle intersections

4-element vector | n -by-4 matrix

Concatenated coordinates of small circle intersections, returned as one of the following. This output is identical to [`lat lon`].

- 4-element vector when you find the intersection of a single pair of small circles.
- n -by-4 matrix when you find the intersection of n pairs of small circles.

If a pair of small circles do not intersect, or are identical, then `scxsc` displays a warning and returns NaNs for the latitude and longitude coordinates of the intersection points. If a pair of small circles are tangent, then the single intersection point is returned twice.

Tips

Great circles are a subset of small circles — a great circle is just a small circle with a radius of 90° . This provides two methods of notation for defining great circles. *Great circle notation* consists of a point on the circle and an azimuth at that point. *Small circle notation* for a great circle consists of a center point and a radius of 90° (or its equivalent in radians).

Version History

Introduced before R2006a

See Also

`gc2sc` | `gcxgc` | `gcxsc` | `rhxrh` | `crossfix` | `polyxpoly`

sdtsdemread

(To be removed) Read data from SDTS raster/DEM data set

Note `sdtsdemread` will be removed in a future release. Use `readgeoraster` instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z, R] = sdtsdemread(filename)
```

Description

`[Z, R] = sdtsdemread(filename)` reads data from an SDTS DEM data set. `Z` is a matrix containing the elevation values. `R` is a referencing matrix. NaNs are assigned to elements of `Z` corresponding to null data values or fill data values in the cell module.

`filename` can be the name of the SDTS catalog directory file (`*CATD.DDF`) or the name of any of the other files in the data set. `filename` can include the directory name; otherwise `filename` is searched for in the current directory and the MATLAB path. If any of the files specified in the catalog directory are missing, `sdtsdemread` fails.

Tips

Elevation values can be imported with `sdtsdemread` from DEMs that use the SPRE Raster Profile (in use since January, 2001) as well as from older SDTS DEM data sets. Under this profile, elevations can be encoded either as 32-bit floating-point numbers (when their units are “decimal meters”), or as 16-bit integers (when units are “feet” or “meters”). The output class from `sdtsdemread` for both types of elevation encoding is `double`.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: “Find Geospatial Data Online”.

Version History

Introduced before R2006a

R2021b: Warns

Warns starting in R2021b

Raster reading functions that return referencing matrices issue a warning that they will be removed in a future release, including `sdtsdemread`. Instead, use `readgeoraster`, which returns a raster reference object. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns. For examples of reference object properties, see `GeographicCellsReference` and `MapPostingsReference`.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` or `mapcrop` functions.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` or `mapresize` functions.
- Most functions that accept referencing matrices as input also accept reference objects.

To update your code, change instances of the function name `sdtsemread` to `readgeoraster` and specify an extension for the data file. The `readgeoraster` function returns data using the native data type embedded in the file. Return a different data type by specifying the 'OutputType' name-value pair.

```
[Z,R] = readgeoraster(filename, 'OutputType', 'double');
```

The `readgeoraster` function does not automatically replace missing data with NaN values. If your data set uses large negative numbers to indicate missing data, replace them with NaN values using the `standardizeMissing` function.

```
[Z,R] = readgeoraster(filename);  
info = georasterinfo(filename);  
m = info.MissingDataIndicator;  
Z = standardizeMissing(Z,m);
```

R2020a: To be removed

Not recommended starting in R2020a

The `sdtsemread` function runs without warning but will be removed in a future release.

See Also

`mapshow` | `sdtseminfo` | `readgeoraster` | `georasterinfo`

sdtsinfo

Information about SDTS data set

Syntax

```
info = sdtsinfo(filename)
```

Description

`info = sdtsinfo(filename)` returns a structure whose fields contain information about the contents of a SDTS data set.

`filename` is a string scalar or character vector that specifies the name of the SDTS catalog directory file, such as `7783CATD.DDF`. The file name can also include the directory name. If `filename` does not include the directory, then it must be in the current directory or in a directory on the MATLAB path. If `sdtsinfo` cannot find the SDTS catalog file, it returns an error.

If any of the other files in the data set as specified by the catalog file is missing, a warning message is returned. Subsequent calls to read data from the file might also fail.

Field Descriptions

The `info` structure contains the following fields:

Filename	Name of the catalog directory file of the SDTS transfer set, specified as a character vector.
Title	Name of the data set, specified as a character vector.
ProfileID	Profile Identifier, e.g., 'SRPE: SDTS RASTER PROFILE and EXTENSIONS', specified as a character vector.
ProfileVersion	Profile Version Identifier, e.g., 'VER 1.1 1998 01', specified as a character vector.
MapDate	Date associated with the cartographic information contained in the data set, specified as a character vector.
DataCreationDate	Creation date of the data set, specified as a character vector.
HorizontalDatum	Horizontal datum to which the data is referenced, specified as a character vector.
MapRefSystem	Projection and reference system used, specified as one of the following values: 'GEO', 'SPCS', 'UTM', 'UPS', or ''.
ZoneNumber	Scalar value representing the zone number
XResolution	Scalar value representing the X component of the horizontal coordinate resolution
YResolution	Scalar value representing the Y component of the horizontal coordinate resolution
NumberOfRows	Scalar value representing the number of rows of the DEM

NumberOfCols	Scalar value representing the number of columns of the DEM
HorizontalUnits	Units used for the horizontal coordinate values, specified as a character vector.
VerticalUnits	Units used for the vertical coordinate values, specified as a character vector.
MinElevation	Scalar value of the minimum elevation value for the data set
MaxElevation	Scalar value of the maximum elevation value for the data set

Version History

Introduced before R2006a

See Also

georasterinfo | readgeoraster

sectorg

(To be removed) Display sector of small circle on axesm-based map using mouse

Note The `sectorg` function will be removed in a future release. Use the `scircle1` function instead.

Syntax

`sectorg`

Description

`sectorg` prompts the user to indicate by two successive mouse clicks two points that define the center and radius of a small circle arc. By default, the angular width of the sector is 60°. The sector is constructed using the vector defined by the mouse clicks as the reference azimuth (defined to run through the center of the sector).

Once a sector has been drawn, **Shift**+clicking on it displays four control points (center point, arc resize, radial resize, and rotation controls), and the associated **Sector** control window. You can graphically interact with sectors as follows:

- To translate the circle, click and drag the center (o) control.
- To change the arc size, click and drag the resize control (square).
- To change the radial size of the sector, click and drag the radial control (down triangle).
- To rotate the arc, click and drag the rotation control (x).

You can also modify a selected sector by entering the appropriate values in the **Sector** control window and then pressing **Enter** or clicking the **Close** button. Display of the control panel is toggled by **Shift**+clicking the sector. If you select multiple sectors, a separate **Sector** control window will appear for each one.

Tips

Sector control windows are superimposed at the same location. A valid axesm-based map must exist prior to running this function.

Version History

Introduced before R2006a

R2022b: To be removed

Not recommended starting in R2022b

The `sectorg` function runs without warning, but will be removed in a future release. Use the `scircle1` function instead.

See Also

scircle1 | scircleg | trackg

setltn

(To be removed) Convert data grid rows and columns to latitude-longitude

Note The `setltn` function will be removed in a future release. Use the `intrinsicToGeographic` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[lat, lon] = setltn(Z, R, row, col)
[lat, lon, indxPointOutsideGrid] = setltn(Z, R, row, col)
latlon = setltn(Z, R, row, col)
```

Description

`[lat, lon] = setltn(Z, R, row, col)` returns the latitude and longitudes associated with the input row and column coordinates of the regular data grid `Z`. `R` can be a geographic raster reference object, a referencing vector, or a referencing matrix.

If `R` is a geographic raster reference object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Points falling outside the grid are ignored in `row` and `col`. All input angles are in degrees.

`[lat, lon, indxPointOutsideGrid] = setltn(Z, R, row, col)` returns the indices of the elements of the `row` and `col` vectors that lie outside the input grid. The outputs `lat` and `lon` always ignore these points; the third output accounts for them.

`latlon = setltn(Z, R, row, col)` returns the coordinates in a single two-column matrix of the form `[latitude longitude]`.

Examples

Load elevation raster data and a geographic cells reference object. Then, find the coordinates of row 45 and column 65.

```
load topo60c
[lat,lon,indxPointOutsideGrid] = setltn(topo60c,topo60cR,45,65)
```

```
lat =
    -45.5000

lon =
    64.5000

indxPointOutsideGrid =
    []
```

The third output argument is empty because the point is valid.

Version History

Introduced before R2006a

R2022b: Warns

Warns starting in R2022b

Some functions that accept referencing vectors or referencing matrices as input issue a warning that they will be removed in a future release, including the `setltn` function. Use a geographic raster reference object and the `intrinsicToGeographic` function instead. Reference objects have several advantages over referencing vectors and matrices.

- Unlike referencing vectors and matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `GeographicPostingsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` function.
- Most functions that accept referencing vectors or matrices as inputs also accept reference objects.

To update your code, first create a reference object for either a raster of cells using the `georefcells` function or a raster of regularly posted samples using the `georefpostings` function. Alternatively, convert from a referencing vector or a referencing matrix to a reference object using the `refvecToGeoRasterReference` or `refmatToGeoRasterReference` function, respectively.

Then, replace uses of the `setltn` function with the `intrinsicToGeographic` function according to these patterns. Note that the `intrinsicToGeographic` function does not round the row and column coordinates. Additionally, the `intrinsicToGeographic` function extrapolates points outside the raster limits instead of discarding them.

Will Be Removed	Recommended
<code>[lat,lon] = setltn(A,R,row,col);</code>	<code>[lat,lon] = intrinsicToGeographic(R, ... round(col),round(row)); lat(~contains(R,lat,lon)) = []; lon(~contains(R,lat,lon)) = [];</code>

Will Be Removed	Recommended
<pre>[lat,lon,indxPointOutsideGrid] = setltn(A,R,row,col);</pre>	<pre>[lat,lon] = intrinsicToGeographic(R, ... round(col),round(row)); lat(~contains(R,lat,lon)) = []; lon(~contains(R,lat,lon)) = []; indxPointOutsideGrid = find(~contains(R,lat,lon));</pre>
<pre>latlon = setltn(A,R,row,col);</pre>	<pre>[lat,lon] = intrinsicToGeographic(R, ... round(col),round(row)); lat(~contains(R,lat,lon)) = []; lon(~contains(R,lat,lon)) = []; latlon = [lat(:) lon(:)];</pre>

R2021a: To be removed

Not recommended starting in R2021a

The `setltn` function runs without warning but will be removed in a future release.

See Also

`geointerp` | `geographicToDiscrete` | `intrinsicToGeographic`

setm

Set properties of axesm-based map and graphics objects

Syntax

```
setm(abm,propname,propval)  
setm(gs,propname,propval)  
setm(txt,"MapPosition",pos)  
setm(surf,"Graticule",lat,lon,alt)  
setm(mesh,"MeshGrat",npts,alt)
```

Description

`setm(abm,propname,propval)` sets the property `propname` of the axesm-based map `abm` to the value `propval`. You can set multiple properties and their values at a time by using comma-separated pairs. For a full list of axesm-based map property names and valid values, see [axesm-Based Map Properties](#).

`setm(gs,propname,propval)` sets the property `propname` of the graphic scale `gs` to the value `propval`. You can set multiple properties and their values at a time by using comma-separated pairs. For a full list of graphic scale property names and valid values, see [scaleruler](#).

`setm(txt,"MapPosition",pos)` sets the position of the projected text `txt` to the position `pos`.

`setm(surf,"Graticule",lat,lon,alt)` warps the graticule of the projected surface `surf` to the vertices specified by `lat` and `lon` and the altitudes specified by `alt`.

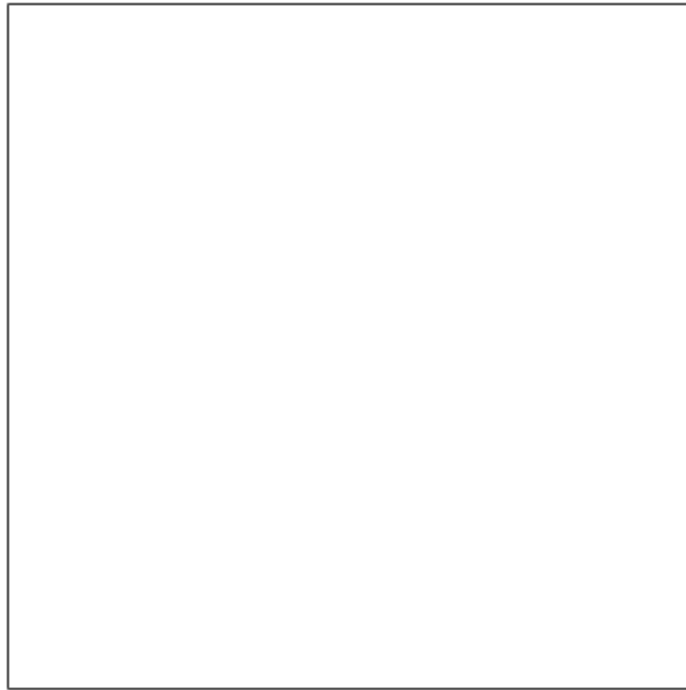
`setm(mesh,"MeshGrat",npts,alt)` warps the mesh graticule of the projected surface `mesh` using the graticule size `npts` and the altitude `alt`. This syntax requires that you create `mesh` by using the `meshm` function.

Examples

Set Properties of axesm-Based Map

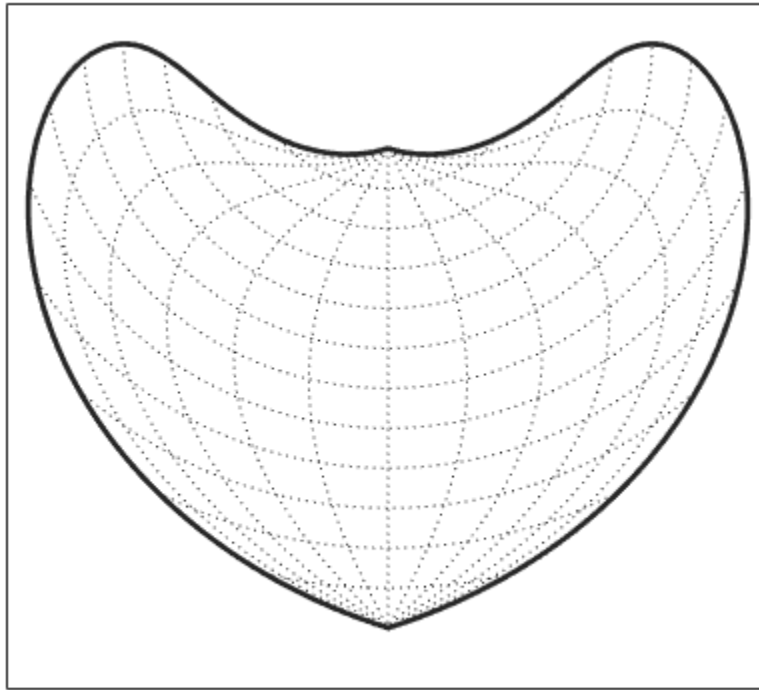
Create an axesm-based map using a Bonne projection.

```
axesm bonne
```

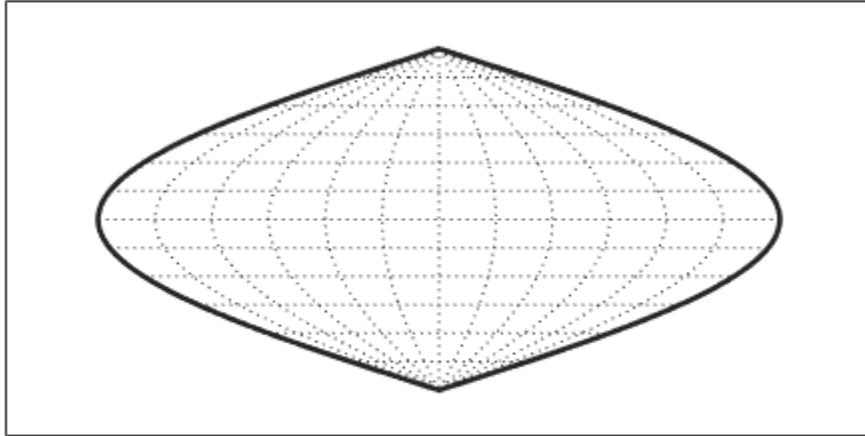
View the frame and grid by setting the Frame and Grid properties.

```
abm = gca;  
setm(abm, "Frame", "on", "Grid", "on")
```



The standard Bonne projection has a standard parallel at 30°N. Change the projection to a sinusoidal projection by setting the standard parallel to 0°.

```
setm(abm, "MapParallels", 0)
```



Input Arguments

abm — axesm-based map

map created using `axesm`, `worldmap`, or `usamap`

axesm-based map, specified as a map created using the `axesm`, `worldmap`, or `usamap` function.

gs — Graphic scale

Group object created using `scaleruler`

Graphic scale, specified as a Group object created using the `scaleruler` function.

propname — Property name

character vector | string scalar

Property name, specified as a character vector or a string scalar. For a full list of axesm-based map property names and valid values, see `axesm-Based Map Properties`. For a full list of graphic scale property names and valid values, see `scaleruler`.

Data Types: `char` | `string`

propval — Property value

array

Property value, specified as an array. For a full list of axesm-based map property names and valid values, see axesm-Based Map Properties. For a full list of graphic scale property names and valid values, see scaleruler.

txt — Projected text

Text object

Projected text, specified as a Text object created using the textm function.

pos — Text position

two-element vector | three-element vector

Text position, specified as a two-element vector of the form [lat lon] or a three-element vector of the form [lat lon alt], where lat specifies the latitude, lon specifies the longitude, and alt specifies the altitude. When you specify a two-element vector, the setm function assumes that alt is 0.

Data Types: single | double

surf — Projected surface created from geolocated data grid

Surface object

Projected surface created from a geolocated data grid, specified as a Surface object displayed on an axesm-based map. Functions that project surfaces onto axesm-based maps include surfm and surfm.

lat — Latitude coordinates of graticule vertices

matrix

Latitude coordinates of the graticule vertices, specified as a matrix.

The sizes of lat and lon must match.

Data Types: single | double

lon — Longitude coordinates of graticule vertices

matrix

Longitude coordinates of the graticule vertices, specified as a matrix.

The sizes of lat and lon must match.

Data Types: single | double

alt — Altitude of graticule vertices

numeric scalar | numeric matrix

Altitude of the graticule vertices, specified as a numeric scalar or a numeric matrix.

- When you specify a scalar, the altitude applies to each graticule vertex.
- When you specify a matrix, the size of alt must match the size of lat and lon or match the value of npts.

mesh — Projected surface created from regular data grid

Surface object created using meshm

Projected surface created from a regular data grid, specified as a `Surface` object created using the `meshm` function.

npts — Size of graticule

two-element numeric vector

Size of the graticule, specified as a two-element numeric vector `[p m]`, where `p` specifies the number of parallels and `m` specifies the number of meridians.

Version History

Introduced before R2006a

See Also

Functions

`getm` | `axesm` | `worldmap` | `usamap` | `scaleruler`

Properties

`axesm`-Based Map Properties

setpostn

(To be removed) Convert latitude-longitude to data grid rows and columns

Note The `setpostn` function will be removed in a future release. Use the `geographicToDiscrete` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
[row, col] = setpostn(Z, R, lat, lon)
indx = setpostn(...)
[row, col, indxPointOutsideGrid] = setpostn(...)
```

Description

`[row, col] = setpostn(Z, R, lat, lon)` returns the row and column indices of the regular data grid `Z` for the points specified by the vectors `lat` and `lon`. `R` can be a geographic raster reference object, a referencing vector, or a referencing matrix.

If `R` is a geographic raster reference object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Points falling outside the grid are ignored in `row` and `col`. All input angles are in degrees.

`indx = setpostn(...)` returns the indices of `Z` corresponding to the points in `lat` and `lon`. Points falling outside the grid are ignored in `indx`.

`[row, col, indxPointOutsideGrid] = setpostn(...)` returns the indices of `lat` and `lon` corresponding to points outside the grid. These points are ignored in `row` and `col`.

Examples

Load elevation raster data and a geographic cells reference object. Then, find the matrix coordinates of Denver, Colorado.

```
load topo60c
[row, col] = setpostn(topo60c, topo60cR, 39.7, 105)
```

```
row =
    130

col =
    105
```

Version History

Introduced before R2006a

R2022b: Warns

Warns starting in R2022b

Some functions that accept referencing vectors or referencing matrices as input issue a warning that they will be removed in a future release, including the `setpostn` function. Use a geographic raster reference object and the `geographicToDiscrete` function instead. Reference objects have several advantages over referencing vectors and matrices.

- Unlike referencing vectors and matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `GeographicPostingsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` function.
- Most functions that accept referencing vectors or matrices as inputs also accept reference objects.

To update your code, first create a reference object for either a raster of cells using the `georefcells` function or a raster of regularly posted samples using the `georefpostings` function. Alternatively, convert from a referencing vector or a referencing matrix to a reference object using the `refvecToGeoRasterReference` or `refmatToGeoRasterReference` function, respectively.

Then, replace uses of the `setpostn` function with the `geographicToDiscrete` function according to these patterns. Note that the `geographicToDiscrete` function includes NaN values in `row` and `col` for points outside the raster limits instead of discarding them. Additionally, the `geographicToDiscrete` function does not issue a warning for points outside the raster limits.

Will Be Removed	Recommended
<code>[row,col] = setpostn(A,R,lat,lon);</code>	<code>[row,col] = geographicToDiscrete(R,lat,lon);</code> <code>n = isnan(row);</code> <code>row(n) = [];</code> <code>col(n) = [];</code>
<code>indx = setpostn(A,R,lat,lon);</code>	<code>[row,col] = geographicToDiscrete(R,lat,lon);</code> <code>indx = sub2ind(R.RasterSize,row,col);</code>

Will Be Removed	Recommended
<pre>[row,col,indexPointOutsideGrid] = setpostn(A,R,lat,lon)</pre>	<pre>geographicToDiscrete(R,lat,lon); n = isnan(row); row(n) = []; col(n) = []; indexPointOutsideGrid = find(n);</pre>

R2021a: To be removed

Not recommended starting in R2021a

The setpostn function runs without warning but will be removed in a future release.

See Also

geographicToDiscrete | geographicToIntrinsic | intrinsicToGeographic

servers

Return URLs of unique WMS servers

Syntax

```
serverURLs = servers(layers)
```

Description

`serverURLs = servers(layers)` returns the URLs of unique servers associated with Web map service layers, `layers`.

Examples

Find Unique URLs of Servers

Search the WMS Database for government servers. Set the unique URLs to a variable.

```
layers = wmsfind('*.gov*', 'SearchField', 'serverurl');
serverURLs = servers(layers);
```

List Server URLs and Number of Layers

Search the WMS Database for servers that contain information about clouds. Set the unique server URLs to a variable.

```
temperature = wmsfind('clouds');
serverURLs = servers(temperature);
```

Display the server URLs and the number of layers that reference the URL.

```
for k=1:numel(serverURLs)
    querystr = serverURLs{k};
    layers = refine(temperature, querystr, ...
        'SearchFields', 'serverurl');
    fprintf('Server URL\n%s\n', layers(1).ServerURL);
    fprintf('Number of layers: %d\n\n', numel(layers));
end
```

```
Server URL
https://discl.gsfc.nasa.gov/daac-bin/wms_omi?
```

```
Number of layers: 2
```

```
Server URL
https://geoservice.dlr.de/eoc/imagery/wms?
```

```
Number of layers: 1
```

Server URL
`https://svs.gsfc.nasa.gov/cgi-bin/wms?`

Number of layers: 8

Your results might be different because the WMS Database changes each release.

Input Arguments

layers — Layers to provide server URLs

array of `WMSLayer` objects

Layers to provide server URLs, specified as an array of `WMSLayer` objects.

Output Arguments

serverURLs — URLs of unique servers

cell array of character vectors

URLs of unique servers, returned as a cell array of character vectors.

Version History

Introduced in R2009b

See Also

`wmsfind` | `refine` | `serverTitles`

serverTitles

Return titles of unique WMS servers

Syntax

```
titles = serverTitles(layers)
```

Description

`titles = serverTitles(layers)` returns the titles of unique servers associated with Web map service layers, `layers`.

Examples

List Titles of Unique Servers

Search the WMS Database for government servers. Set the titles of unique servers to a variable.

```
layers = wmsfind('*.gov*', 'SearchField', 'serverurl');
titles = serverTitles(layers);
```

Display the first ten servers titles as a column vector.

```
titles(1:10)'
```

```
ans = 10x1 cell
    {'MapPlace OGC WMS 1.1.1 Compliant Server'      }
    {'OPENDATA_VCGI_BOUNDARIES_SP_NOCACHE_v2'      }
    {'Open_Data_OPENDATA_ANR_CADAstral_SP_NOCACHE_v2'}
    {'OPENDATA_ANR_ECOLOGIC_SP_NOCACHE_v1'         }
    {'OPENDATA_ANR_EMERGENCY_SP_NOCACHE_v2'        }
    {'OPENDATA_ANR_ENVIRON_SP_NOCACHE_v2'          }
    {'OPENDATA_ANR_FACILITIES_SP_NOCACHE_v2'       }
    {'OPENDATA_ANR_GEOLOGIC_SP_NOCACHE_v3'         }
    {'Open_Data_OPENDATA_ANR_TOURISM_SP_NOCACHE_v2' }
    {'OPENDATA_ANR_UTILITY_SP_NOCACHE_v1'          }
```

Your results might be different because the WMS Database changes each release.

Input Arguments

layers — Layers to provide server URLs

array of WMSLayer objects

Layers to provide server URLs, specified as an array of WMSLayer objects.

Output Arguments

titles — **Titles of unique WMS servers**

cell array of character vectors

Titles of unique WMS servers, returned as a cell array of character vectors.

Version History

Introduced in R2009b

See Also

wmsfind | servers

shaderel

Construct cdata and colormap for shaded relief

Syntax

```
[cindx,cimap,clim] = shaderel(X,Y,Z,cmap)
[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev])
[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev],cmapl)
[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev],cmapl,clim)
```

Description

`[cindx,cimap,clim] = shaderel(X,Y,Z,cmap)` constructs the colormap and color indices to allow a surface to be displayed in colored shaded relief. The colors are proportional to the magnitude of Z , but modified by shades of gray based on the surface normals to simulate surface lighting. This representation allows both large and small-scale differences to be seen. X , Y , and Z define the surface. `cmap` is the colormap used to create the new shaded colormap `cimap`. `cindx` is a matrix of color indices to `cimap`, based on the elevation and surface normal of the Z matrix element. `clim` contains the color axis limits.

`[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev])` places the light at the specified azimuth and elevation. By default, the direction of the light is East (90° azimuth) at an elevation of 45° .

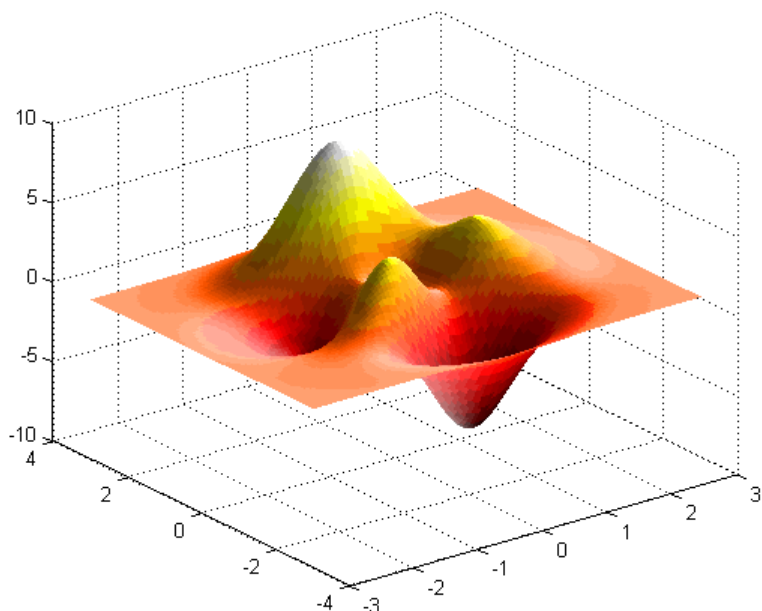
`[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev],cmapl)` chooses the number of grays to give a `cimap` of length `cmapl`. By default, the number of grayscales is chosen to keep the shaded colormap below 256. If the vector of azimuth and elevation is empty, the default locations are used.

`[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev],cmapl,clim)` uses the color limits to index Z into `cmap`.

Examples

Display the peaks surface with a shaded colormap:

```
[X,Y,Z] = peaks(100);
cmap = hot(16);
[cindx,cimap,clim] = shaderel(X,Y,Z,cmap);
surf(X,Y,Z,cindx); colormap(cimap); caxis(clim)
shading flat
```



Tips

This function effectively multiplies two colormaps, one with color based on elevation, the other with a grayscale based on the slope of the surface, to create a new colormap. This produces an effect similar to using a light on a surface, but with all of the visible colors actually in the colormap. Lighting calculations are performed on the unprojected data.

Version History

Introduced before R2006a

See Also

[colormap](#) | [light](#) | [meshlsm](#) | [surf](#) | [surflsm](#)

shapeinfo

Information about shapefile

Syntax

```
info = shapeinfo(filename)
```

Description

`info = shapeinfo(filename)` returns a structure, `info`, whose fields contain information about the contents of a shapefile. `filename` can be the base name or the full name of any one of the component files. `shapeinfo` reads all three files as long as they exist in the same folder and the unit of length or angle is not specified. If the main file (with extension `.SHP`) is missing, `shapeinfo` returns an error. If either of the other files is missing, `shapeinfo` returns a warning.

Examples

Get CRS Information from Shapefile

Get projected or geographic CRS information from a shapefile by using the `shapeinfo` function.

First, return information about a shapefile as a structure. For this example, specify a shapefile that uses projected coordinates. Then, get information about the coordinate reference system by querying the `CoordinateReferenceSystem` field of the structure.

```
S = shapeinfo('boston_placenames.shp');
S.CoordinateReferenceSystem

ans =
    projcrs with properties:
        Name: "NAD83 / Massachusetts Mainland"
        GeographicCRS: [1x1 geocrs]
        ProjectionMethod: "Lambert Conic Conformal (2SP)"
        LengthUnit: "meter"
        ProjectionParameters: [1x1 map.crs.ProjectionParameters]
```

Note that the value of the `CoordinateReferenceSystem` field is a `projcrs` object because the shapefile uses projected coordinates.

Input Arguments

filename — File name

string scalar | character vector

File name of the shapefile, specified as a string scalar or character vector. `filename` can be the base name or the full name of any one of the component files.

Output Arguments

info — Information about shapefile contents

structure

Information about shapefile contents, returned as a structure contains the following fields.

Filename	Char array containing the names of the files that were read
ShapeType	Character vector containing the shape type
BoundingBox	Numerical array of size 2-by- <i>N</i> that specifies the minimum (row 1) and maximum (row 2) values for each dimension of the spatial data in the shapefile
Attributes	Structure array of size 1-by- <code>numAttributes</code> that describes the attributes of the data. The structure contains these fields: <ul style="list-style-type: none">• Name — Character vector containing the attribute name as given in the xBASE table• Type — Character vector specifying the MATLAB class of the attribute data returned by <code>shaperead</code>. The following attribute (xBASE) types are supported: Numeric, Floating, Character, and Date
NumFeatures	The number of spatial features in the shapefile
CoordinateReferenceSystem	Coordinate reference system (CRS), returned as a <code>geocrs</code> or <code>projcrs</code> object. The value of <code>CoordinateReferenceSystem</code> depends on the data contained in the file: <ul style="list-style-type: none">• If the data is referenced to a geographic coordinate system, then <code>CoordinateReferenceSystem</code> is a <code>geocrs</code> object.• If the data is referenced to a projected coordinate system, then <code>CoordinateReferenceSystem</code> is a <code>projcrs</code> object.• If the file does not contain valid coordinate reference system information, then <code>CoordinateReferenceSystem</code> is empty.

Version History

Introduced before R2006a

See Also

`shaperead` | `shapewrite`

Topics

“Geographic Data Structures”

shaperead

Read vector features and attributes from shapefile

Syntax

```
S = shaperead(filename)
S = shaperead(filename,Name,Value)
[S,A] = shaperead( ___ )
```

Description

`S = shaperead(filename)` reads the shapefile, `filename`, and returns an N -by-1 geographic data structure array in projected map coordinates (a `mapstruct`). The geographic data structure combines geometric and feature attribute information. `shaperead` supports the ordinary 2-D shape types: 'Point', 'Multipoint', 'PolyLine', and 'Polygon'.

`S = shaperead(filename,Name,Value)` returns a subset of the shapefile contents in `S`, as determined by the name-value pair arguments. Use `RecordNumbers`, `BoundingBox`, and `Selector` to select which features to read. If you use more than one of these parameters in the same call, you receive the intersection of the records that match the individual specifications. For instance, if you specify values for both `RecordNumbers` and `BoundingBox`, you import only those features with record numbers that appear in your list and that also have bounding boxes intersecting the specified bounding box.

If you do not specify any parameters, `shaperead` returns an entry for every non-null feature and creates a field for every attribute.

`[S,A] = shaperead(___)` returns an N -by-1 geographic data structure array, `S`, containing geometric information, and a parallel N -by-1 attribute structure array, `A`, containing feature attribute information.

Examples

Read Entire Shapefile

Read the entire shapefile called `concord_hydro_line.shp`, including the attributes in `concord_hydro_line.dbf`. The `shaperead` function returns a `mapstruct` with x and y coordinate vectors.

```
S = shaperead('concord_hydro_line.shp')
```

S=237×1 struct array with fields:

```
Geometry
BoundingBox
X
Y
LENGTH
```

Read Portion of Shapefile Based on Bounding Box

Specify a bounding box to limit the data returned by `shaperead`. In addition, specify the names of the attributes you want to read.

```
bbox = [2.08 9.11; 2.09 9.12] * 1e5;  
S = shaperead('concord_roads.shp', 'BoundingBox', bbox, ...  
             'Attributes', {'STREETNAME', 'CLASS'})
```

```
S=87x1 struct array with fields:  
  Geometry  
  BoundingBox  
  X  
  Y  
  STREETNAME  
  CLASS
```

Read road data by class from shapefile

Read road data only for class 4 and higher road segments that are at least 200 meters in length. Note the use of an anonymous function in the selector.

```
S = shaperead('concord_roads.shp', 'Selector', ...  
             {@(v1,v2) (v1 >= 4) && (v2 >= 200)}, 'CLASS', 'LENGTH')
```

```
S=115x1 struct array with fields:  
  Geometry  
  BoundingBox  
  X  
  Y  
  STREETNAME  
  RT_NUMBER  
  CLASS  
  ADMIN_TYPE  
  LENGTH
```

Determine the number of roads of each class.

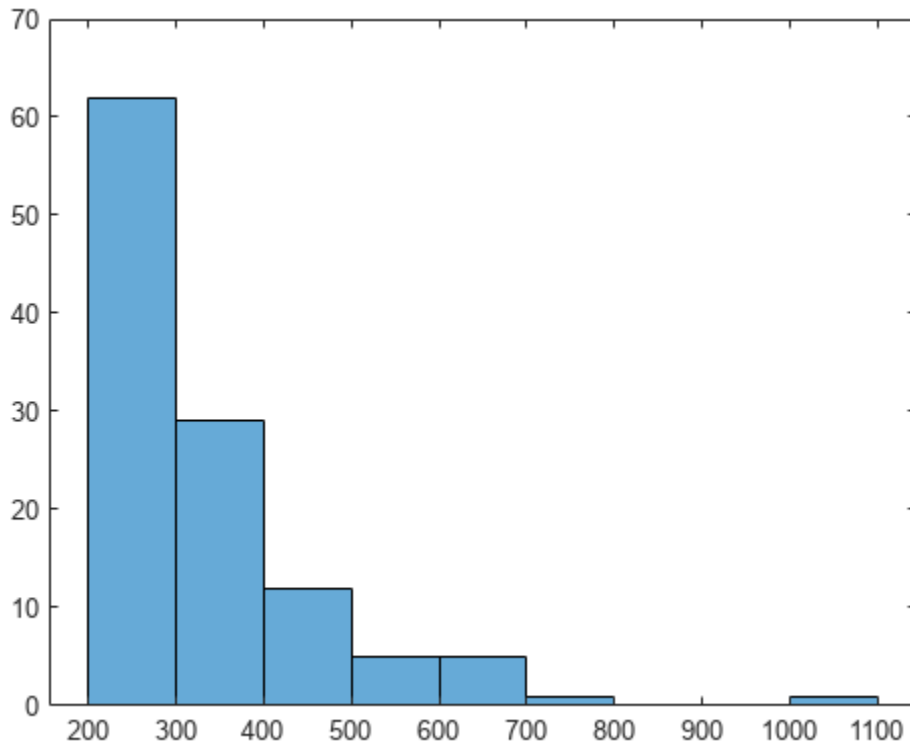
```
n = histcounts([S.CLASS], 'BinLimits', [1 7], 'BinMethod', 'integer')
```

```
n = 1x7
```

```
    0     0     0     7    93    15     0
```

Display a histogram of the number of roads that fall in each category of length.

```
figure  
histogram([S.LENGTH])
```



Read Shapefile with Geographic Coordinates

Specify that a shapefile uses latitude and longitude coordinates using the 'UseGeoCoords' name-value pair.

For instance, return information about a shapefile as a structure. Verify the shapefile uses latitude and longitude coordinates by querying the `CoordinateReferenceSystem` field. The shapefile uses latitude and longitude coordinates if the field contains a `geocrs` object.

```
info = shapeinfo('landareas.shp');
crs = info.CoordinateReferenceSystem
```

```
crs =
    geocrs with properties:
        Name: "WGS 84"
        Datum: "World Geodetic System 1984"
        Spheroid: [1x1 referenceEllipsoid]
        PrimeMeridian: 0
        AngleUnit: "degree"
```

Read the shapefile by using the `shaperead` function. Indicate that the shapefile uses latitude and longitude coordinates using the 'UseGeoCoords' name-value pair.

```
S = shaperead('landareas.shp','UseGeoCoords',true)
```

```
S=537×1 struct array with fields:  
  Geometry  
  BoundingBox  
  Lon  
  Lat  
  Name
```

Note that the `shaperead` function returns a geographic data structure with latitude and longitude fields (a `geostruct`).

Input Arguments

filename — File name

character vector | string scalar

File name, specified as a string scalar or character vector. `filename` refers to the base name or full name of one of the component files in a shapefile. If the main file (with extension `.shp`) is missing, `shaperead` throws an error. If either of the other files is missing, `shaperead` issues a warning.

Make sure that your machine is set to the same character encoding scheme as the data you are importing. For example, if you are trying to import a shapefile that contains Japanese characters, configure your machine to support the Shift-JIS encoding scheme.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `'Attributes',{'STREETNAME','LENGTH'}`

RecordNumbers — Record numbers

vector of integers

Record numbers, specified as the comma-separated pair consisting of `'RecordNumbers'` and a vector of integers. Use the parameter `RecordNumbers` to import only features with listed record numbers.

Data Types: `double`

BoundingBox — Bounding box

2-by-2 matrix

Bounding box, specified as the comma-separated pair consisting of `'BoundingBox'` and a 2-by-2 matrix. `BoundingBox` has the form `[xmin,ymin;xmax,ymax]`, for map coordinates, or `[lonmin,latmin;lonmax,latmax]` for geographic coordinates. Use the parameter `BoundingBox` to import only features whose bounding boxes intersect the specified box. The `shaperead` function does not trim features that partially intersect the box.

Data Types: `double`

Selector — Selector

cell array

Selector, specified as the comma-separated pair consisting of 'Selector' and a cell array containing a function handle and one or more attribute names. The function must return a logical scalar. Use the Selector parameter to import only features for which the function, when applied to the corresponding attribute values, returns true. For more information about function handles, see "Create Function Handle".

Attributes — Attribute names

cell array

Attribute names, specified as the comma-separated pair consisting of 'Attributes' and a cell array of attribute names. Use the parameter Attributes to include listed attributes and set the order of attributes in the structure array. Use {} to omit all attributes.

UseGeoCoords — Flag to return shapefile contents in a geostruct

false (default) | true

Flag to return shapefile contents in a geostruct, specified as the comma-separated pair consisting of 'UseGeoCoords' and false or true.

When UseGeoCoords is set to true, the shapefile contents are returned in a geostruct. Use this parameter when you know that the x- and y- coordinates in the shapefile actually represent longitude and latitude data.

To determine whether a shapefile uses latitude and longitude data, first use the `shapeinfo` function to return information about the shapefile as a structure. Then query the `CoordinateReferenceSystem` field of the structure. The shapefile uses geographic coordinates if `CoordinateReferenceSystem` is a `geocrs` object.

This code shows how to query the `CoordinateReferenceSystem` field of a structure associated with the shapefile `landareas.shp`.

```
info = shapeinfo('landareas.shp');
info.CoordinateReferenceSystem
```

Output Arguments**S — Vector geographic features***N*-by-1 geographic data structure array

Vector geographic features, returned as an *N*-by-1 map geographic data structure array. Unless `UseGeoCoords` is true, *S* is a `mapstruct` and contains an element for each non-null, spatial feature in the shapefile.

A — Feature attribute information*N*-by-1 attribute structure array

Feature attribute information, returned as an *N*-by-1 attribute structure array corresponding to array *S*.

The fields in the output structure arrays *S* and *A* depend on the type of shape contained in the file and the names and types of attributes included in the file. The `shaperead` function supports the following

four attribute types: numeric and floating (stored as type double in MATLAB) and character and date (stored as char array).

Tips

To get information about the coordinate reference system (CRS) associated with a shapefile, use the `shapeinfo` function.

Version History

Introduced before R2006a

See Also

`shapeinfo` | `shapewrite` | `readgeotable`

Topics

“Geographic Data Structures”

“Find Geospatial Data Online”

shapewrite

Write geographic vector data structure to shapefile

Syntax

```
shapewrite(S,filename)
shapewrite(S,filename,'DbfSpec',dbfspec)
```

Description

`shapewrite(S,filename)` writes the vector geographic features stored in `S` to the file specified by `filename` in shapefile format.

`shapewrite(S,filename,'DbfSpec',dbfspec)` writes a shapefile in which the content and layout of the DBF file is controlled by `dbfspec`, a DBF specification.

Examples

Write Feature Data to Shapefile

Import a shapefile, remove a subset of the data, and write the modified data to a new shapefile.

Get information about a shapefile as a structure. The shapefile contains a network of road segments in Concord, MA.

```
shapeinfo("concord_roads.shp")
ans = struct with fields:
    Filename: [3x84 char]
    ShapeType: 'PolyLine'
    BoundingBox: [2x2 double]
    NumFeatures: 609
    Attributes: [5x1 struct]
    CoordinateReferenceSystem: [1x1 projcrs]
```

The `NumFeatures` field indicates that the shapefile contains 609 features.

Import the shapefile as a geospatial table.

```
GT = readgeotable("concord_roads.shp");
```

The `CLASS` attribute of the shapefile includes information about road types. For example, a value of 2 indicates a multilane highway and a value of 6 indicates a minor road. Create a subtable containing major roads such that the value of `CLASS` is less than 4.

```
rows = GT.CLASS < 4;
majorGT = GT(rows,:);
```

Export the geospatial table as a shapefile.

```
shapewrite(majorGT,"main_concord_roads.shp")
```

Get information about the new shapefile as a structure.

```
shapeinfo("main_concord_roads.shp")
```

```
ans = struct with fields:
    Filename: [3x89 char]
    ShapeType: 'PolyLine'
    BoundingBox: [2x2 double]
    NumFeatures: 107
    Attributes: [5x1 struct]
    CoordinateReferenceSystem: []
```

The new shapefile has 107 features instead of 609 features.

Write Data Stored in Planar Point Vector to Shapefile

Read a shapefile containing a vector of world cities. Store the data as a planar point vector using the `mappoint` function.

```
S = shaperead("worldcities.shp");
p = mappoint(S)
```

```
p =
318x1 mappoint vector with properties:

Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
Feature properties:
    X: [-3.9509 54.7589 -0.2121 35.3894 38.7575 138.8528 44.5408 72.2474 30.4098 3.0397 7
    Y: [5.2985 24.6525 5.6106 37.0613 9.0235 -34.6645 12.8767 22.7778 31.3044 36.7870 43.3
    Name: {1x318 cell}
```

Append Paderborn, Germany to the point vector.

```
x = 51.715254;
y = 8.75213;
p = append(p,x,y,"Name","Paderborn")
```

```
p =
319x1 mappoint vector with properties:

Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
Feature properties:
    X: [-3.9509 54.7589 -0.2121 35.3894 38.7575 138.8528 44.5408 72.2474 30.4098 3.0397 7
    Y: [5.2985 24.6525 5.6106 37.0613 9.0235 -34.6645 12.8767 22.7778 31.3044 36.7870 43.3
    Name: {1x319 cell}
```

The size of `p` has increased by 1.

Write the updated point vector to a shapefile.

```
shapewrite(p, "worldcities_updated.shp")
```

Input Arguments

S — Vector geographic features

geospatial table | mappoint vector | mapshape vector | mapstruct vector | geopoint vector | geoshape vector | geostruct vector

Vector geographic features, specified as one of the following:

- A geospatial table. The `shapewrite` function does not support geospatial tables containing more than one type of shape object. For more information about geospatial tables, see “Create Geospatial Tables”.
- A `mappoint` vector.
- A `mapshape` vector.
- A map structure array (`mapstruct`) with X and Y coordinate fields.
- A `geopoint` vector.
- A `geoshape` vector.
- A geographic structure array (`geostruct`) with Lat and Lon fields.

S has the following restrictions on its attribute fields:

- Each attribute field value must be either a real, finite, scalar `double` or a character vector.
- The type of a given attribute must be consistent across all features.
- If S is a geospatial table containing `geopointshape`, `geolineshape`, or `geopolyshape` objects, a `geopoint` vector, a `geoshape` vector, or a geographic structure array, the `shapewrite` function writes the latitude and longitude values as Y and X coordinates, respectively.
- If a given attribute is integer-valued for all features, `shapewrite` writes it to the [`basename` '.dbf'] file as an integer. If an attribute is non-integer-valued for any feature, `shapewrite` writes it as a fixed point decimal value with six digits to the right of the decimal place.

filename — File name

string scalar | character vector

File name and location of the shapefile to create, specified as a string scalar or character vector. If the file name includes a file extension, it must be '.shp' or '.SHP'. `shapewrite` creates three output files: [`basename` '.shp'], [`basename` '.shx'], and [`basename` '.dbf'], where `basename` is `filename` without its extension.

dbfspec — Feature attributes to include in shapefile

scalar structure

Feature attributes to include in the shapefile, specified as a scalar MATLAB structure containing one field for each feature attribute. Assign to that field a scalar structure with the following four fields:

- `FieldName` — The field name to be used in the file
- `FieldType` — The field type to be used in the file: 'N' (numeric) or 'C' (character)

- `FieldLength` — The field length in the file, in bytes
- `FieldDecimalCount` — For numeric fields, the number of digits to the right of the decimal place

To create a DBF spec, call `makedbfspec` and then modify the output to remove attributes or change the `FieldName`, `FieldLength`, or `FieldDecimalCount` for one or more attributes.

To include an attribute in the output file, specify a field in `dbfspec` with the same name as the attribute is specified in `S`.

Tips

- The xBASE (.dbf) file specifications require that `geostruct` and `mapstruct` attribute names are truncated to 11 characters when copied as DBF field names. Consider shortening long field names before calling `shapewrite`. By doing this, you make field names in the DBF file more readable and avoid introducing duplicate names as a result of truncation.
- Remember to set your character encoding scheme to match that of the geographic data structure you are exporting. For instance, if you are exporting a map that displays Japanese text, configure your machine to support Shift-JIS character encoding.

Version History

Introduced before R2006a

R2022b: shapewrite truncates text when length exceeds 254 characters or value of FieldLength

Behavior changed in R2022b

When a text attribute contains more than 254 characters, the `shapewrite` function issues a warning and truncates the text to 254 characters. In previous releases, the `shapewrite` function did not truncate the text and, as a result, created a file that does not conform to shapefile specifications.

When a text attribute contains more characters than the value stored in the `FieldLength` field of the `dbfspec` argument, the `shapewrite` function issues a warning and truncates the text to the number of characters equal to the value of `FieldLength`. In previous releases, the `shapewrite` function issued an error.

R2021b: Write geospatial tables to shapefile format

The `shapewrite` function accepts geospatial tables as input.

See Also

`makedbfspec` | `shapeinfo` | `shaperead`

Topics

“Geographic Data Structures”

showaxes

Toggle display of coordinate axes on axesm-based map

Syntax

```
showaxes(action)
showaxes
```

Description

`showaxes(action)` modifies the Cartesian axes based on the value of *action*, as defined in the Inputs section below.

`showaxes` toggles between displaying the default axes ticks on the MATLAB Cartesian axes and removing the axes ticks.

Input Arguments

action

A character vector or RGB triple that specifies how to modify the Cartesian axes

Default:

Value	Action
'on'	Displays the MATLAB Cartesian axes and default axes ticks
'off'	Removes the axes ticks from the MATLAB Cartesian axes
'hide'	Hides the Cartesian axes
'show'	Shows the Cartesian axes
'reset'	Sets the Cartesian axes to the default settings
'boxoff'	Removes axes ticks, color, and box from the Cartesian axes
<i>colorstr</i>	Sets the Cartesian axes to the color specified by <i>colorstr</i>
<i>colorvec</i>	Uses <i>colorvec</i> to set the Cartesian axes color

Version History

Introduced before R2006a

See Also

axesm

showm

Show objects on axesm-based map

Syntax

```
showm  
showm(obj)  
showm(objType)
```

Description

showm opens a dialog box that enables you to interactively select objects to show. The showm function hides objects by setting their `Visible` property to "on".

showm(obj) shows the specified objects.

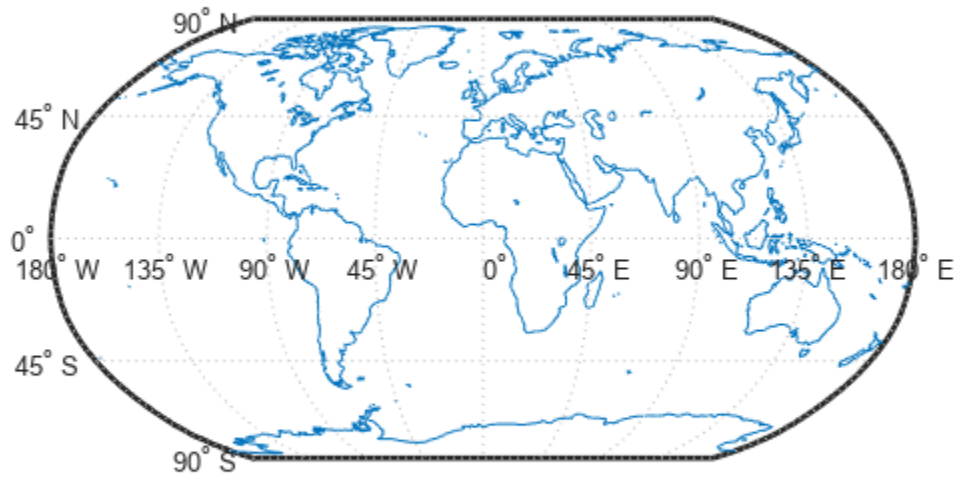
showm(objType) shows objects of the specified type.

Examples

Hide and Show Objects on Map

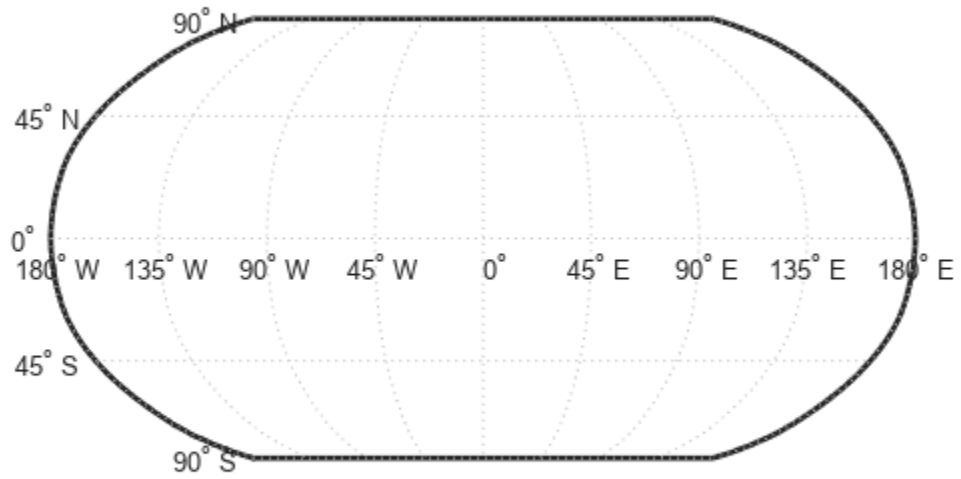
Load a MAT file containing the coordinates of global coastlines into the workspace. Create a world map, and then plot the coastline data.

```
load coastlines  
figure  
worldmap world  
p = plotm(coastlat,coastlon);
```



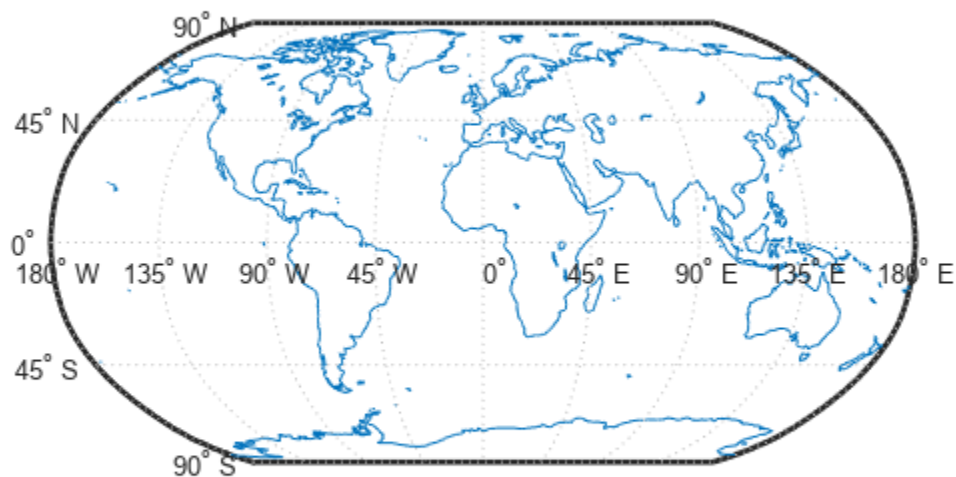
Hide the plotted data.

```
hidem(p)
```



Show the plotted data again.

`showm(p)`



Input Arguments

obj – Objects to show

array of graphics objects

Objects to show, specified as an array of graphics objects.

objType – Type of graphics object to show

"all" | "clabel" | "contour" | "fillcontour" | "frame" | ...

Type of graphics object to show, specified as one of these options.

Option	Description
"all"	All children
"clabel"	Contour labels
"contour"	hggroup containing contours
"fillcontour"	hggroup containing filled contours
"frame"	Map frame
"grid"	Map grid lines
"hggroup"	All hggroup objects

Option	Description
"hidden"	Hidden objects
"image"	Untagged image objects
"light"	Untagged light objects
"line"	Untagged line objects
"map"	All objects on the map, excluding the frame and grid
"meridian"	Longitude grid lines
"mlabel"	Longitude labels
"parallel"	Latitude grid lines
"plabel"	Latitude labels
"patch"	Untagged patch objects
"scaleruler"	Scale rulers
"surface"	Untagged surface objects
"text"	Untagged text objects
"tissot"	Tissot indicatrices
"visible"	Visible objects

Data Types: char | string

Version History

Introduced before R2006a

See Also

clma | clmo | handlem | hidem

size

Return size of geographic or planar vector

Syntax

```
sz = size(v)  
sz = size(v,dim)  
[m, n] = size(v)
```

Description

`sz = size(v)` returns the vector `[length(v), 1]`.

`sz = size(v,dim)` returns the length of geographic or planar vector `v` in the dimension specified by `dim`.

`[m, n] = size(v)` returns the length of `v` for `m` and 1 for `n`.

Examples

Find the Size of a Mapshape Vector

Create a mapshape vector from a `structArray`.

```
structArray = shaperead('worlddrivers.shp');  
ms = mapshape(structArray)
```

```
ms =  
  128x1 mapshape vector with properties:
```

```
  Collection properties:
```

```
    Geometry: 'line'
```

```
    Metadata: [1x1 struct]
```

```
  Vertex properties:
```

```
    (128 features concatenated with 127 delimiters)
```

```
      X: [126.7796 126.5321 126.3121 126.2383 126.0362 NaN NaN 126.0362 125.1356 124.7906 124.7906 ...]
```

```
      Y: [73.4571 73.0669 72.8343 72.6010 72.2894 NaN NaN 72.2894 72.3784 72.4620 72.5086 72.5086 ...]
```

```
  Feature properties:
```

```
    Name: {1x128 cell}
```

Get the size of the mapshape vector.

```
sz = size(ms)
```

```
sz = 1x2
```

```
    128     1
```

Input Arguments

v — Geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Geographic or planar vector, specified as a `geopoint`, `geoshape`, `mappoint`, or `mapshape` object.

dim — Dimension to measure length

positive integer scalar

Dimension to measure length of vector `v`, specified as a positive integer scalar.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

Output Arguments

sz — Size of geographic or planar vector

nonnegative integer scalar or two-element vector

Size of vector `v`, returned as a nonnegative integer scalar or a two-element vector.

- When `dim` is not specified, `sz` is the two-element vector `[length(v), 1]`.
- When `dim` is 1, `sz` is a scalar equal to the length of `v`.
- When `dim` \geq 2, `sz` is 1.

Data Types: `double`

m — Size of vector in first dimension

nonnegative integer scalar

Size of vector `v` in the first dimension, returned as a nonnegative integer scalar. `m` is `length(v)`.

Data Types: `double`

n — Size of vector in second dimension

1

Size of vector `v` in the second dimension, returned as the value 1.

Data Types: `double`

Version History

Introduced in R2012a

See Also

`length` | `isprop`

sizem

(To be removed) Row and column dimensions needed for regular data grid

Note `sizem` will be removed in a future release. Instead, create a geographic raster reference object, and then query its `RasterSize` property. For more information, see “Compatibility Considerations”.

Syntax

```
[r,c] = sizem(latlim,lonlim,scale)
rc = sizem(latlim,lonlim,scale)
[r,c,refvec] = sizem(latlim,lonlim,scale)
```

Description

`[r,c] = sizem(latlim,lonlim,scale)` returns the required size for a regular data grid lying between the latitude and longitude limits specified by the two-element input vectors `latlim` and `lonlim`, which are of the form [south-limit north-limit] and [west-limit and east-limit], respectively. The `scale` is the desired cells-per-degree measure of the desired data grid.

`rc = sizem(latlim,lonlim,scale)` returns the size of the matrix in one two-element vector.

`[r,c,refvec] = sizem(latlim,lonlim,scale)` also returns the three-element referencing vector geolocating the desired regular data grid.

Examples

How large a matrix would be required for a map of the world at a scale of 25 matrix cells per degree? (That's $25 \times 25 = 625$ cells per “square” degree.)

```
[r,c] = sizem([90,-90],[-180,180],25)
```

```
r =
    4500
c =
    9000
```

Bear in mind for memory purposes — $9000 \times 4500 = 4.05 \times 10^7$ entries!

Version History

Introduced before R2006a

R2022a: Warns

Warns starting in R2022a

Some functions that return referencing vectors issue a warning that they will be removed in a future release, including the `sizem` function. Instead, create a geographic raster reference object using the `georefcells` function, and then query its `RasterSize` property. Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see the `GeographicPostingsReference` object.
- You can manipulate the limits of rasters associated with geographic reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with geographic reference objects using the `georesize` function.
- Most functions that accept referencing vectors as inputs also accept reference objects.

This table shows how to update your code to use the `georefcells` function instead of the `sizem` function.

Will Be Removed	Recommended
<code>[nrows,ncols] = sizem(latlim,lonlim,scale);</code>	<code>R = georefcells(latlim,lonlim,1/scale,1/scale);</code> <code>nrows = R.RasterSize(1);</code> <code>ncols = R.RasterSize(2);</code>

R2020b: To be removed

Not recommended starting in R2020b

The `sizem` function runs without warning but will be removed in a future release.

See Also

`findm` | `NaN` | `ones` | `sparse` | `zeros` | `georefcells`

sizesMatch

Package: `map.rasterref`

Determine if geographic or map raster object and image or raster are size-compatible

Syntax

```
tf = sizesMatch(R,A)
```

Description

`tf = sizesMatch(R,A)` determines whether geographic or map raster R is size-compatible with image or raster A.

Examples

Check If Image and Geographic Raster Are Size-Compatible

Create a `GeographicPostingsReference` raster reference object.

```
latlim = [0 90];
lonlim = [-180 180];
rasterSize = [91 361];
R = georefpostings(latlim,lonlim,rasterSize,'ColumnsStartFrom','north')
```

```
R =
  GeographicPostingsReference with properties:
```

```

    LatitudeLimits: [0 90]
   LongitudeLimits: [-180 180]
      RasterSize: [91 361]
 RasterInterpretation: 'postings'
   ColumnsStartFrom: 'north'
    RowsStartFrom: 'west'
SampleSpacingInLatitude: 1
SampleSpacingInLongitude: 1
  RasterExtentInLatitude: 90
  RasterExtentInLongitude: 360
    XIntrinsicLimits: [1 361]
    YIntrinsicLimits: [1 91]
CoordinateSystemType: 'geographic'
    GeographicCRS: []
      AngleUnit: 'degree'
```

Create an arbitrary image (raster) with dimensions 91-by-361. Confirm that the image size is compatible with the geographic raster reference object.

```
A = ones(91,361);
tf_A = sizesMatch(R,A)
```

```
tf_A = logical  
      1
```

Create an image of a different size. Confirm that this new image is not size-compatible with the geographic raster reference object.

```
B = ones(90,361);  
tf_B = sizesMatch(R,B)  
  
tf_B = logical  
      0
```

Input Arguments

R — Geographic or map raster

GeographicCellsReference object | GeographicPostingsReference object |
MapCellsReference object | MapPostingsReference object

Geographic or map raster, specified as a GeographicCellsReference, GeographicPostingsReference, MapCellsReference, or MapPostingsReference object.

A — Image or raster

numeric array or raster object

Image or raster, specified as a numeric array or raster object.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64 |
logical | geographic raster object | map raster object

Output Arguments

tf — Flag indicating geographic or map raster is size-compatible with image or raster

logical scalar

Flag indicating geographic or map raster is size-compatible with image or raster, returned as a logical scalar. `tf` is True when `R.RasterSize` is equal to `[size(A,1) size(A,2)]` or `A.RasterSize`.

Data Types: logical

Version History

Introduced in R2013b

sm2deg

Convert spherical distance from statute miles to degrees

Syntax

```
deg = sm2deg(sm)
deg = sm2deg(sm, radius)
deg = sm2deg(sm, sphere)
```

Description

`deg = sm2deg(sm)` converts distances from statute miles to degrees, as measured along a great circle on a sphere with a radius of 3958.748 sm, the mean radius of the Earth.

`deg = sm2deg(sm, radius)` converts distances from statute miles to degrees, as measured along a great circle on a sphere having the specified radius.

`deg = sm2deg(sm, sphere)` converts distances from statute miles to degrees, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Statute Miles to Degrees on Earth

Convert 500 statute miles to degrees, as measured along a great circle on the Earth. By default, the `sm2deg` function assumes your input is a measurement of the Earth, which is represented as a sphere with a radius of 3958.748 statute miles.

```
deg = sm2deg(500)
deg = 7.2366
```

Convert Statute Miles to Degrees on Mars

Convert 500 statute miles to degrees, as measured along a great circle on Mars.

```
deg = sm2deg(500, 'mars')
deg = 13.6001
```

Input Arguments

sm — Distance in statute miles

numeric array

Distance in statute miles, specified as a numeric array.

Data Types: `single` | `double`

radius — Radius

3958.748 (default) | numeric scalar

Radius of sphere in units of statute miles, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments**deg — Distance in degrees**

numeric array

Distance in degrees, returned as a numeric array.

Data Types: `single` | `double`

Version History

Introduced in R2007a

See Also

`deg2rad` | `rad2deg` | `deg2sm` | `sm2rad` | `km2deg` | `nm2deg`

sm2km

Convert statute miles to kilometers

Syntax

```
km = sm2km(sm)
```

Description

`km = sm2km(sm)` converts distances from statute miles to kilometers.

Examples

Convert Statute Miles to Kilometers

Convert 500 statute miles to kilometers.

```
km = sm2km(500)
```

```
km = 804.6736
```

Input Arguments

sm — Distance in statute miles

numeric array

Distance in statute miles, specified as a numeric array.

Output Arguments

km — Distance in kilometers

numeric array

Distance in kilometers, returned as a numeric array of the same size as `sm`.

Version History

Introduced in R2007a

See Also

Functions

`km2sm` | `deg2km` | `km2deg` | `deg2sm` | `sm2deg`

sm2nm

Convert statute to nautical miles

Syntax

```
nm = sm2nm(sm)
```

Description

`nm = sm2nm(sm)` converts distances from statute miles to nautical miles.

Examples

Convert Statute Miles to Nautical Miles

Convert 500 statute miles to nautical miles.

```
nm = sm2nm(500)
```

```
nm = 434.4890
```

Input Arguments

sm — Distance in statute miles

numeric array

Distance in statute miles, specified as a numeric array.

Output Arguments

nm — Distance in nautical miles

numeric array

Distance in nautical miles, returned as a numeric array of the same size as `sm`.

Version History

Introduced in R2007a

See Also

Functions

`nm2sm` | `deg2nm` | `nm2deg` | `deg2sm` | `sm2deg`

sm2rad

Convert spherical distance from statute miles to radians

Syntax

```
rad = sm2rad(sm)
rad = sm2rad(sm,radius)
rad = sm2rad(sm,sphere)
```

Description

`rad = sm2rad(sm)` converts distances from statute miles to radians, as measured along a great circle on a sphere with a radius of 3958.748 sm, the mean radius of the Earth.

`rad = sm2rad(sm,radius)` converts distances from statute miles to radians, as measured along a great circle on a sphere having the specified radius.

`rad = sm2rad(sm,sphere)` converts distances from statute miles to radians, as measured along a great circle on a sphere approximating an object in the Solar System.

Examples

Convert Statute Miles to Radians on Earth

Convert 500 statute miles to radians, as measured along a great circle on the Earth. By default, the `sm2rad` function assumes your input is a measurement of the Earth, which is represented as a sphere with a radius of 3958.748 statute miles.

```
rad = sm2rad(500)
rad = 0.1263
```

Convert Statute Miles to Radians on Mars

Convert 500 statute miles to radians, as measured along a great circle on Mars.

```
rad = sm2rad(500,'mars')
rad = 0.2374
```

Input Arguments

sm — Distance in statute miles

numeric array

Distance in statute miles, specified as a numeric array.

Data Types: `single` | `double`

radius — Radius

3958.748 (default) | numeric scalar

Radius of sphere in units of statute miles, specified as a numeric scalar.

sphere — Sphere

'sun' | 'moon' | 'mercury' | 'venus' | 'earth' | ...

Sphere approximating an object in the Solar System, specified as one of the following values: 'sun', 'moon', 'mercury', 'venus', 'earth', 'mars', 'jupiter', 'saturn', 'uranus', 'neptune', or 'pluto'. The value of sphere is case-insensitive.

Output Arguments**rad — Distance in radians**

numeric array

Distance in radians, returned as a numeric array.

Data Types: `single` | `double`

Version History

Introduced in R2007a

See Also

`deg2rad` | `rad2deg` | `sm2deg` | `nm2rad` | `km2rad` | `rad2sm`

spcread

(Removed) Read columns of data from ASCII text file

Note The `spcread` function has been removed. Use the `readmatrix` function instead.

Syntax

```
mat = spcread
mat = spcread(filename)
mat = spcread(cols)
```

Description

`mat = spcread` reads an ASCII file of space-delimited data in two columns and returns the data in a matrix, `mat`. The file is selected by dialog box.

`mat = spcread(filename)` specifies the file from which to read by its name, given as the character vector `filename`.

`mat = spcread(cols)` specifies the number of columns of space-delimited data in the file with the integer `cols`. The default value of `cols` is 2.

Tips

The `spcread` function is similar to the standard MATLAB function `dlmread`. `spcread`, however, is much faster at reading large data sets of the type common for geographic purposes.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `spcread` function has been removed. Use the `readmatrix` function instead.

R2022a: Warns

Warns starting in R2022a

The `spcread` function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The `spcread` function runs without warning but will be removed in a future release.

See Also

readmatrix | nanclip

spzgeom

(To be removed) Construct sparse regular data grid of 0s

Note spzgeom will be removed in a future release. Use the `georefcells` and `sparse` functions instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z,refvec] = spzgeom(latlim,lonlim,scale)
```

Description

`[Z,refvec] = spzgeom(latlim,lonlim,scale)` returns a sparse regular data grid consisting entirely of 0s and a three-element referencing vector for the returned `Z`. The two-element vectors `latlim` and `lonlim` define the latitude and longitude limits of the geographic region. They should be of the form `[south north]` and `[west east]`, respectively. The scalar `scale` specifies the number of rows and columns per degree of latitude and longitude.

Examples

```
[Z,refvec] = spzgeom([46,51],[-79,-75],1)
```

```
Z =
    All zero sparse: 5-by-4
refvec =
     1     51    -79
```

Version History

Introduced before R2006a

R2022a: Warns

Warns starting in R2022a

Some functions that return referencing vectors issue a warning that they will be removed in a future release, including the `spzgeom` function. Instead, create a geographic raster reference object using the `georefcells` function and a sparse matrix of all zeros using the `sparse` function. Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see the `GeographicPostingsReference` object.
- You can manipulate the limits of rasters associated with geographic reference objects using the `geocrop` function.

- You can manipulate the size and resolution of rasters associated with geographic reference objects using the `georesize` function.
- Most functions that accept referencing vectors as inputs also accept reference objects.

This table shows how to update your code to use the `georefcalls` and `sparse` functions instead of the `spzgeom` function.

Will Be Removed	Recommended
<code>[Z,refvec] = spzgeom(latlim,lonlim,scale);</code>	<code>R = georefcalls(latlim,lonlim,1/scale,1/scale);</code> <code>Z = sparse(R.RasterSize(1),R.RasterSize(2));</code>

R2020b: To be removed

Not recommended starting in R2020b

The `spzgeom` function runs without warning but will be removed in a future release.

See Also

`NaN` | `ones` | `zeros` | `sparse` | `georefcalls`

stdist

Standard distance of geographic points

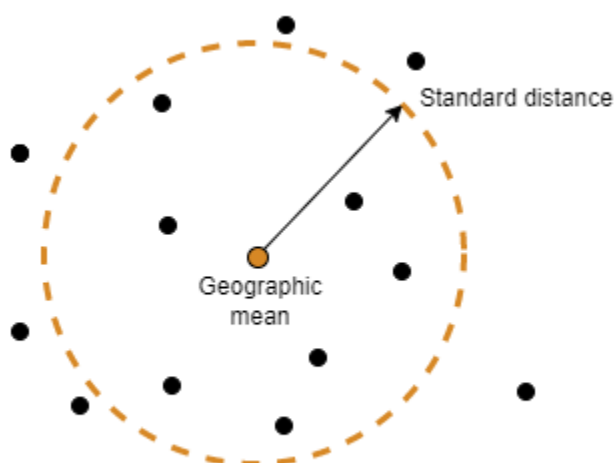
Syntax

```
dist = stdist(lat,lon)
dist = stdist(lat,lon,units)
dist = stdist(lat,lon,ellipsoid)
dist = stdist(lat,lon,ellipsoid,units)
dist = stdist(lat,lon,ellipsoid,units,method)
```

Description

`dist = stdist(lat,lon)` computes the standard distance of the geographic points specified by `lat` and `lon`. This syntax references the points to a unit sphere, assumes the points are specified in degrees, and returns the standard distance in degrees.

Standard distance measures the dispersion of great-circle distances from each point to the geographic mean (centroid) of the points. For more information about the geographic mean, see `meanm`.



`dist = stdist(lat,lon,units)` specifies the angle units `units` for the points and standard distance.

`dist = stdist(lat,lon,ellipsoid)` specifies the reference ellipsoid for the geographic points. This syntax returns the standard distance as a linear distance in the same units as the semimajor axis of the reference ellipsoid.

`dist = stdist(lat,lon,ellipsoid,units)` specifies the reference ellipsoid and units for the geographic points. This syntax returns the standard distance as a linear distance in the same units as the semimajor axis of the reference ellipsoid.

`dist = stdist(lat,lon,ellipsoid,units,method)` specifies the calculation method. By default, the function calculates the average great-circle distance of the points from the geographic mean of the points.

Examples

Calculate Standard Distance of Geographic Points

Specify the latitude and longitude coordinates of Paris, London, Rome, Madrid, Berlin, and Athens.

```
lat = [48.87 51.52 41.93 40.43 52.43 38.02];  
lon = [2.41 -0.13 12.5 -3.68 13.08 23.52];
```

Find the standard distance of the points.

```
dist = stdist(lat,lon)
```

```
dist = 8.1833
```

Compare the `stdist` function to the `stdm` function, which independently calculates the standard deviations for the latitudes and longitudes.

```
[latdev,londev] = stdm(lat,lon)
```

```
latdev = 6.1805
```

```
londev = 7.5871
```

Calculate Standard Distance of Geographic Points on Ellipsoid

Specify the latitude and longitude coordinates of Paris, London, Rome, Madrid, Berlin, and Athens.

```
lat = [48.87 51.52 41.93 40.43 52.43 38.02];  
lon = [2.41 -0.13 12.5 -3.68 13.08 23.52];
```

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of kilometers.

```
wgs84 = wgs84Ellipsoid("km");
```

Find the standard distance of the points referenced to the ellipsoid. When you specify a reference ellipsoid as input, the `stdist` function returns the standard distance in the same length unit as the ellipsoid.

```
dist = stdist(lat,lon,wgs84)
```

```
dist = 911.0339
```

Calculate Standard Distance Using Specified Method

Specify the latitude and longitude coordinates of Paris, London, Rome, Madrid, Berlin, and Athens.

```
lat = [48.87 51.52 41.93 40.43 52.43 38.02];
lon = [2.41 -0.13 12.5 -3.68 13.08 23.52];
```

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of kilometers.

```
wgs84 = wgs84Ellipsoid("km");
```

Find the standard distance of the points using a quadratic calculation method.

```
distQ = stdist(lat,lon,wgs84,"degrees","quadratic")
```

```
distQ = 976.4035
```

Find the standard distance of the point using a cubic calculation method.

```
distC = stdist(lat,lon,wgs84,"degrees","cubic")
```

```
distC = 1.0398e+03
```

Input Arguments

lat — Latitude coordinates

vector | matrix

Latitude coordinates, specified as a vector or a matrix.

Data Types: double

lon — Longitude coordinates

vector | matrix

Longitude coordinates, specified as a vector or a matrix.

Data Types: double

units — Angle unit

"degrees" (default) | "radians"

Angle unit, specified as one of these options:

- "degrees" — Degrees
- "radians" — Radians

If you do not specify a reference ellipsoid, this argument determines the angle units for the input points and the output standard distance. If you specify a reference ellipsoid, this argument only determines the angle units for the input points.

Data Types: char | string

ellipsoid — Reference ellipsoid

[1 0] (default) | referenceSphere object | referenceEllipsoid object | oblateSpheroid object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element vector of the form `[semimajor_axis eccentricity]`, where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of `[1 0]` represents the unit sphere.

method — Calculation method

`"linear"` (default) | `"quadratic"` | `"cubic"`

Calculation method, specified as one of these options:

- `"linear"` — `dist` is the average of the great-circle distances from each geographic point to the geographic mean of the points.
- `"quadratic"` — `dist` is the square root of the average of the squared great-circle distances.
- `"cubic"` — `dist` is the cube root of the average of the cubed great-circle distances.

Data Types: `char` | `string`

Output Arguments

dist — Standard distance of geographic points

`scalar` | `row vector`

Standard distance of the geographic points, returned as a scalar or a row vector.

- When `lat` and `lon` are vectors, `dist` is a scalar.
- When `lat` and `lon` are matrices, `dist` is a row vector. Each element of the vector is the standard distance for the corresponding column of `lat` and `lon`.

Data Types: `double`

Version History

Introduced in R2006a

See Also

Functions

`meanm` | `stdm`

Topics

“Geographic Statistics for Point Locations on a Sphere”

stdm

Standard deviation of geographic points

Syntax

```
[latdev,londev] = stdm(lat,lon)
[latdev,londev] = stdm(lat,lon,units)
[latdev,londev] = stdm(lat,lon,ellipsoid)
[latdev,londev] = stdm(lat,lon,ellipsoid,units)
mat = stdm(____)
```

Description

`[latdev,londev] = stdm(lat,lon)` calculates the standard deviations `latdev` and `londev` of the geographic points specified by `lat` and `lon`. This syntax references the points to a unit sphere, assumes the points are specified in degrees, and returns the standard deviations in degrees.

`[latdev,londev] = stdm(lat,lon,units)` specifies the angle units `units` for the points and standard deviations.

`[latdev,londev] = stdm(lat,lon,ellipsoid)` specifies the reference ellipsoid for the geographic points. This syntax returns the standard deviations as linear distances in the same units as the semimajor axis of the reference ellipsoid.

`[latdev,londev] = stdm(lat,lon,ellipsoid,units)` specifies the reference ellipsoid and units for the geographic points. This syntax returns the standard deviations as linear distances in the same units as the semimajor axis of the reference ellipsoid.

`mat = stdm(____)` returns the standard deviations of the geographic points in the matrix `mat`, using any combination of input arguments from the previous syntaxes.

Examples

Calculate Standard Deviation of Geographic Points

Specify the latitude and longitude coordinates of Paris, London, Rome, Madrid, Berlin, and Athens.

```
lat = [48.87 51.52 41.93 40.43 52.43 38.02];
lon = [2.41 -0.13 12.5 -3.68 13.08 23.52];
```

Find the standard deviations of the latitude and longitude coordinates.

```
[latdev,londev] = stdm(lat,lon)
```

```
latdev = 6.1805
```

```
londev = 7.5871
```

Compare the `stdm` function to the `stdist` function, which calculates the standard distance of the points.

```
dist = stdist(lat,lon)
dist = 8.1833
```

Calculate Standard Deviation of Geographic Points on Ellipsoid

Specify the latitude and longitude coordinates of Paris, London, Rome, Madrid, Berlin, and Athens.

```
lat = [48.87 51.52 41.93 40.43 52.43 38.02];
lon = [2.41 -0.13 12.5 -3.68 13.08 23.52];
```

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of kilometers.

```
wgs84 = wgs84Ellipsoid("km");
```

Find the standard deviations of the points referenced to the ellipsoid. When you specify a reference ellipsoid as input, the `stdm` function returns the standard deviations in the same length unit as the ellipsoid.

```
[latdev,londev] = stdm(lat,lon,wgs84)
latdev = 688.0321
londev = 845.8243
```

Input Arguments

lat — Latitude coordinates

vector | matrix

Latitude coordinates, specified as a vector or a matrix. The sizes of `lat` and `lon` must match.

Data Types: `single` | `double`

lon — Longitude coordinates

vector | matrix

Longitude coordinates, specified as a vector or a matrix. The sizes of `lon` and `lat` must match.

Data Types: `single` | `double`

units — Angle unit

"degrees" (default) | "radians"

Angle unit, specified as one of these options:

- "degrees" — Degrees
- "radians" — Radians

If you do not specify a reference ellipsoid, this argument determines the angle units for the input points and the output standard deviations. If you specify a reference ellipsoid, this argument only determines the angle units for the input points.

Data Types: `char` | `string`

ellipsoid — Reference ellipsoid

[1 0] (default) | referenceSphere object | referenceEllipsoid object | oblateSpheroid object | two-element numeric vector

Reference ellipsoid, specified as a referenceSphere object, a referenceEllipsoid object, an oblateSpheroid object, or a two-element vector of the form [semimajor_axis eccentricity], where semimajor_axis is the length of the semimajor axis and eccentricity is the eccentricity. The values semimajor_axis and eccentricity must be of data type double.

The default value of [1 0] represents the unit sphere.

Output Arguments**latdev — Standard deviation of latitude coordinates**

scalar | row vector

Standard deviation of the latitude coordinates, returned as a scalar or a row vector. The size of latdev depends on the sizes of lat and lon.

- When lat and lon are vectors, latdev is a scalar.
- When lat and lon are matrices, latdev is a row vector. Each element of the vector is the standard deviation for the corresponding column of lat.

The function calculates the standard deviation of the latitude coordinates using angular measurements.

londev — Standard deviation of longitude coordinates

row vector

Standard deviation of the longitude coordinates, returned as a scalar or a row vector. The size of londev depends on the sizes of lat and lon.

- When lat and lon are vectors, londev is a scalar.
- When lat and lon are matrices, londev is a row vector. Each element of the vector is the standard deviation for the corresponding column of lon.

The function calculates the standard deviation of the longitude coordinates using departure distances. For more information about departure, see departure.

mat — Standard deviation of latitude and longitude coordinates

row vector

Standard deviation of the latitude and longitude coordinates, returned as a matrix equivalent to [latdev londev].

Algorithms

- The function calculates the mean position of the latitude and longitude coordinates using the meanm function.
- The function normalizes the standard deviations by $n-1$, where n is the number of geographic points.

Version History

Introduced before R2006a

See Also

Functions

departure | meanm | stdist

Topics

“Geographic Statistics for Point Locations on a Sphere”

stem3m

Project stem plot on axesm-based map

Syntax

```
h = stem3m(lat,lon,z)
h = stem3m(lat,lon,z,LineStyle)
h = stem3m(lat,lon,z,PropertyName,PropertyValue,...)
```

Description

`h = stem3m(lat,lon,z)` displays a stem plot on the current axesm-based map. Stems are located at the points (lat,lon) and extend from an altitude of 0 to the values of z. The coordinate inputs should be in the same `AngleUnits` as the axesm-based map. It is important to note that the selection of z-values will greatly affect the 3-D look of the plot. Regardless of `AngleUnits`, the x and y limits of the axesm-based map are at most $-\pi$ to $+\pi$ and $-\pi/2$ to $+\pi/2$, respectively. This means that for most purposes, appropriate z values would be on the order of 1 to 3, not 10 to 30. The axes `DataAspectRatio` property can be used to adjust the appearance of the graphic. The handles of the displayed stem lines can be returned in h.

`h = stem3m(lat,lon,z,LineStyle)` specifies the line style, marker, and color on page 1-1676.

`h = stem3m(lat,lon,z,PropertyName,PropertyValue,...)` allows any property/value pair recognized by the MATLAB line function to be specified for the stems.

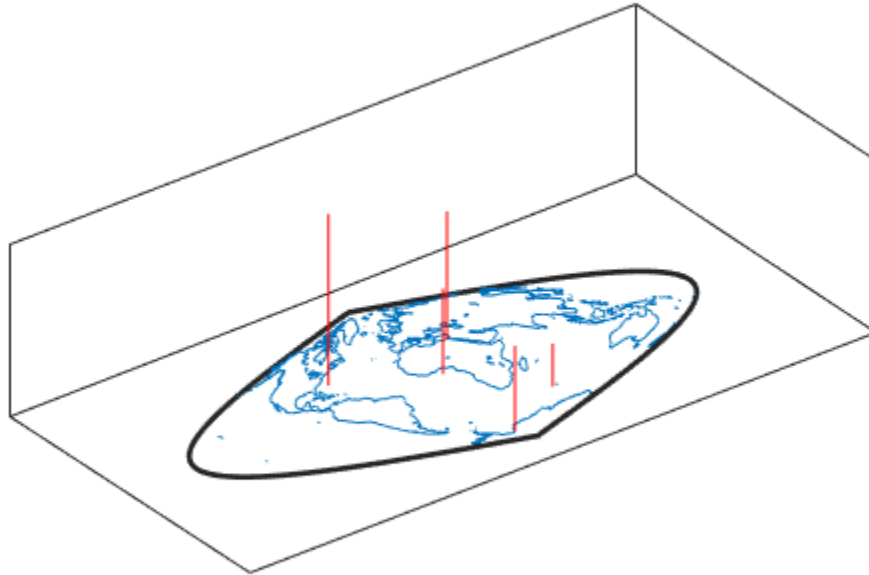
A stem plot displays data as lines extending normal to the xy-plane, in this case, on a map.

Examples

Project Stem Plot on Map

Project a stem plot on a map.

```
load coastlines
axesm sinusoid;
view(3)
h = framem;
set(h,'zdata',zeros(size(coastlat)))
plotm(coastlat,coastlon)
ptlat = [0 30 30 -50 -78]';
ptlon = [0 30 -70 65 -35]';
ptz = [1 1.5 2 .5 1]';
stem3m(ptlat,ptlon,ptz,'r-')
```



More About

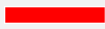



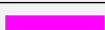
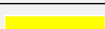


Line Style, Marker, and Color

Specify the line style, marker, and color as a character vector or string containing symbols. The symbols can appear in any order. You do not need to specify all three characteristics (line style, marker, and color). For example, specify a red dashed line using `'--r'`.

Line Style	Description	Resulting Line
"_"	Solid line	
"--"	Dashed line	
":"	Dotted line	
"-."	Dash-dotted line	

Marker	Description	Resulting Marker
"o"	Circle	
"+"	Plus sign	

Marker	Description	Resulting Marker
"*"	Asterisk	*
","	Point	•
"x"	Cross	×
"_"	Horizontal line	—
" "	Vertical line	
"square"	Square	□
"diamond"	Diamond	◇
"^"	Upward-pointing triangle	△
"v"	Downward-pointing triangle	▽
">"	Right-pointing triangle	▷
"<"	Left-pointing triangle	◁
"pentagram"	Pentagram	☆
"hexagram"	Hexagram	☆

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Version History

Introduced before R2006a

See Also

scatterm

str2angle

Convert strings to angles in degrees

Syntax

```
angle = str2angle(str)
```

Description

`angle = str2angle(str)` converts text representing latitude or longitude angles to numeric angles in degrees.

Examples

Convert String Arrays to Degrees

Create a string array containing these latitudes and longitudes. Specify each angle using a different format.

- 23 degrees, 30 minutes, 0 seconds north of the equator
- 23 degrees, 30 minutes, 0 seconds south of the equator
- 123 degrees, 30 minutes, 0 seconds east of the prime meridian
- 123 degrees, 30 minutes, 0 seconds west of the prime meridian

```
str = ["23°30'00"N" "23-30-00S" "123d30m00sE" "1233000W"];
```

Convert the string array to a numeric array in degrees.

```
angle = str2angle(str)
```

```
angle = 4×1
```

```
    23.5000  
   -23.5000  
   123.5000  
  -123.5000
```

Input Arguments

str — Text that represents latitude or longitude angles

character vector | string scalar | cell array of character vectors | string array

Text that represents latitude or longitude angles, specified as a character vector, a string scalar, a cell array of character vectors, or a string array.

Specify angles in degrees-minutes-seconds using one of the formats in this table. Specify positive latitudes using N, negative latitudes using S, positive longitudes using E, and negative longitudes using W.

Format	Example
Use ° for degrees, ' for minutes, and " for seconds.	"123°30'00"W"
Use d for degrees, m for minutes, and s for seconds.	"123d30m00sW"
Use - to separate degrees, minutes, and seconds.	"123-30-00W"
Omit symbols that separate degrees, minutes, and seconds (packed DMS). This format does not support fractional seconds.	"1233000W"

When `str` contains more than one angle, you can use more than one angle format.

Specifying directions by using positive (+) or negative (-) signs is not supported.

Data Types: `char` | `string` | `cell`

Output Arguments

angle — Angles in degrees

numeric scalar | numeric column vector

Angles in degrees, returned as a numeric scalar or numeric column vector. If `str` is a character vector or string scalar, then `angle` is a numeric scalar. If `str` is a cell array of character arrays or a string array, then `angle` is a numeric column vector with the same number of elements as `str`.

Data Types: `double`

Version History

Introduced before R2006a

See Also

Functions

`angl2str` | `dist2str` | `str2double`

Topics

"Angle Representations and Angular Units"

struct

Convert geographic or planar vector to scalar structure

Syntax

```
s = struct(v)
```

Description

`s = struct(v)` converts the geographic or planar vector `v` to a scalar structure, `s`.

Examples

Convert a Mappoint Vector into a Structure

Create a mappoint vector.

```
mp = mappoint(shaperead('tsunamis.shp'))
```

```
mp =
```

```
162x1 mappoint vector with properties:
```

```
Collection properties:
```

```
Geometry: 'point'
```

```
Metadata: [1x1 struct]
```

```
Feature properties:
```

```
X: [128.3000 -156 157.9500 143.8500 -155 -82.4000 159.5000 156.5000 147.4000 178.2000 ...]
Y: [-3.8000 19.5000 -9.0200 42.1500 19.1000 43.1000 52.7500 50 -2.4000 -18.3000 34 ...]
Year: [1950 1951 1951 1952 1952 1952 1952 1953 1953 1953 1953 1954 1954 1955 1956 1957 ...]
Month: [10 8 12 3 3 5 11 3 6 9 11 6 10 4 11 3 6 7 1 4 7 11 11 5 8 8 1 3 3 5 11 2 7 8 4 ...]
Day: [8 21 22 4 17 6 4 18 27 14 25 26 NaN 19 2 9 22 28 19 22 10 6 12 4 17 18 13 20 23 ...]
Hour: [3 10 NaN 1 3 NaN 16 NaN NaN 0 17 NaN NaN 20 NaN 14 23 8 14 NaN 6 22 20 7 21 6 ...]
Minute: [23 57 NaN 22 58 NaN 58 NaN NaN 26 48 NaN NaN 24 NaN 22 50 40 7 NaN 15 58 23 16 ...]
Second: [NaN NaN NaN 41 NaN NaN NaN NaN NaN 36 NaN NaN NaN NaN NaN 31.9000 23 NaN NaN ...]
Val_Code: [2 4 2 4 4 1 4 3 3 4 4 1 2 4 3 4 3 4 4 2 4 4 4 4 4 4 4 4 4 4 4 4 2 4 NaN 4 4 ...]
Validity: {1x162 cell}
Cause_Code: [1 1 6 1 1 9 1 1 6 3 1 9 0 1 1 1 1 1 1 1 3 1 1 1 0 3 1 1 1 1 1 1 1 1 1 8 1 1 1 ...]
Cause: {1x162 cell}
Eq_Mag: [7.6000 6.9000 NaN 8.1000 4.5000 NaN 9 5.8000 NaN 6.8000 7.4000 NaN NaN 7.1000 ...]
Country: {1x162 cell}
Location: {1x162 cell}
Max_Height: [2.8000 3.6000 6 6.5000 1 1.5200 18 1.5000 1.4000 3 3 3 18.2800 1 1.2000 15.2400 ...]
Iida_Mag: [1.5000 1.8000 2.6000 2.7000 NaN NaN 4.2000 0.6000 0.5000 1 1.6000 NaN 4.2000 NaN ...]
Intensity: [1.5000 NaN NaN 2 NaN NaN 4 NaN 1 1.5000 1.5000 NaN NaN NaN 3 3.5000 NaN 1.5000 ...]
Num_Deaths: [NaN NaN NaN 33 NaN NaN 2236 NaN NaN NaN NaN 7 NaN 3 NaN NaN NaN NaN NaN 5 ...]
Desc_Deaths: [NaN NaN NaN 1 NaN NaN 3 NaN NaN NaN NaN 1 NaN 1 NaN NaN NaN NaN NaN NaN 1 NaN ...]
```

Convert the mappoint vector into a structure.

```
s = struct(mp)
```


struct2geotable

Convert structure array to geospatial table

Syntax

```
GT = struct2geotable(S)
GT = struct2geotable(S,coordinateSystemType,fnames)
GT = struct2geotable(S,Name=Value)
```

Description

`GT = struct2geotable(S)` converts the structure array `S` to a geospatial table `GT`. The function creates the `Shape` variable of `GT` by using the latitude-longitude or `x-y` coordinates in `S`. Each field of `S` is a variable of `GT`.

`GT = struct2geotable(S,coordinateSystemType,fnames)` creates the `Shape` variable of `GT` by using the coordinate system type `coordinateSystemType` and structure array fields `fnames`.

`GT = struct2geotable(S,Name=Value)` specifies options using name-value arguments. For example, specify that coordinates represent points, lines, or polygons by using the `GeometryType` name-value argument.

Examples

Convert Structure Array to Geospatial Table

Read a shapefile containing hydrographic data for Concord, MA, as a structure array. Import only the polygons with an area greater than 100 square kilometers. The `x-` and `y-`coordinates are in the `X` and `Y` fields of the structure.

```
areafilterfcn = @(areafilter) (areafilter > 100000);
S = shaperead("concord_hydro_area.shp", ...
    Selector={areafilterfcn,'AREA'});
```

Get the coordinate reference system for the data.

```
info = shapeinfo("concord_hydro_area.shp");
crs = info.CoordinateReferenceSystem;
```

Convert the structure array to a geospatial table. The `struct2geotable` function detects the `X` and `Y` fields and uses them to create the `Shape` variable. Specify the coordinate reference system for the `Shape` variable.

```
GT = struct2geotable(S, ...
    CoordinateReferenceSystem=crs);
```

View the shape object in the second row of the table. Shape object properties contain information such as the number of holes.

```
GT.Shape(2)
```

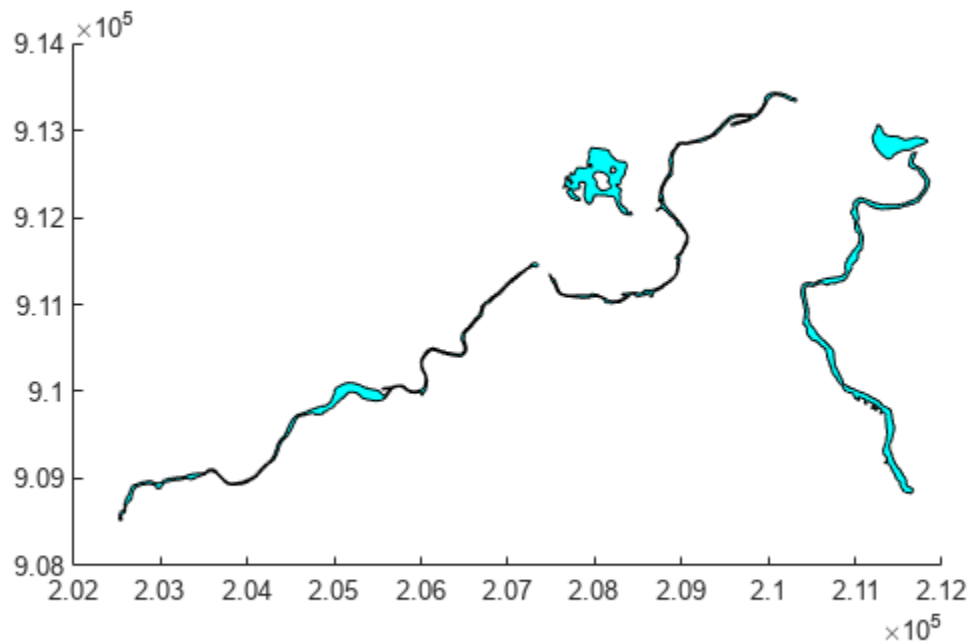


```
ans =
  mappolyshape with properties:

      NumRegions: 1
      NumHoles: 3
      Geometry: "polygon"
  CoordinateSystemType: "planar"
  ProjectedCRS: [1x1 projcrs]
```

Display the polygons.

```
mapshow(GT,FaceColor="c")
```



Specify Fields Containing Coordinate Data

Create a sample structure array containing the locations of cities. The Lats field contains latitudes, the Lons field contains longitudes, and the Names field contains names.

```
lats = {35.7082, -22.8842, 51.5074, 39.9042, 37.9838};
lons = {139.6401, -43.3882, -0.1278, 116.4074, 23.7275};
n = {'Tokyo', 'Rio de Janeiro', 'London', 'Beijing', 'Athens'};
S = cell2struct([lats;lons;n], {'Lats', 'Lons', 'Names'}, 1)
```

```
S=5x1 struct array with fields:
  Lats
```

```
Lons
Names
```

Convert the structure array to a geospatial table. The `struct2geotable` function does not automatically detect the field names `Lats` and `Lons`. Specify the coordinate system type as `"geographic"` and the field names containing the coordinates.

```
GT = struct2geotable(S,"geographic",["Lats" "Lons"])
```

```
GT=5x4 table
```

Shape	Lats	Lons	Names
(35.7082°N, 139.6401°E)	35.708	139.64	{'Tokyo' }
(22.8842°S, 43.3882°W)	-22.884	-43.388	{'Rio de Janeiro' }
(51.5074°N, 0.1278°W)	51.507	-0.1278	{'London' }
(39.9042°N, 116.4074°E)	39.904	116.41	{'Beijing' }
(37.9838°N, 23.7275°E)	37.984	23.727	{'Athens' }

View the `Shape` variable of the geospatial table.

```
GT.Shape
```

```
ans =
  5x1 geopointshape array with properties:
    NumPoints: [5x1 double]
    Latitude: [5x1 double]
    Longitude: [5x1 double]
    Geometry: "point"
    CoordinateSystemType: "geographic"
    GeographicCRS: []
```

Input Arguments

S — Input structure array

structure array

Input structure array.

The `struct2geotable` function detects the coordinates when the structure array fields have these names, ignoring case.

- Latitude coordinates — `Latitude` or `Lat`
- Longitude coordinates — `Longitude`, `Lon`, or `Long`
- x-coordinates — `X`
- y-coordinates — `Y`

If you specify an input structure array with a field called `Shape`, then the `struct2geotable` function overwrites it.

Data Types: `struct`

coordinateSystemType — Coordinate system type`"planar" | "geographic"`

Coordinate system type, specified as one of these options:

- `"planar"` — Coordinates are in a planar coordinate system.
- `"geographic"` — Coordinates are in a geographic coordinate system.

Data Types: `string`

fnames — Names of structure array fields`two-element string vector`

Names of the structure array fields used to create the `Shape` variable of the geospatial table, specified as a two-element string vector, such as `["Lats" "Lons"]`. The fields contain latitude-longitude or *x-y* coordinates.

Data Types: `string`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `struct2geotable(S, CoordinateReferenceSystem=geocrs(4326))` specifies the geographic CRS as the World Geodetic System of 1984, which has EPSG code 4326.

CoordinateReferenceSystem — Coordinate reference system`projcrs object | geocrs object`

Coordinate reference system (CRS) to use when creating the `Shape` variable of the geospatial table, specified as a `projcrs` or `geocrs` object.

Specify a `projcrs` object when `coordinateSystemType` is `"planar"` and specify a `geocrs` object when `coordinateSystemType` is `"geographic"`.

GeometryType — Geometry type`"point" (default) | "line" | "polygon"`

Geometry type of the coordinate fields, specified as one of these options:

- `"point"` — The coordinate fields represent points.
- `"line"` — The coordinate fields represent lines.
- `"polygon"` — The coordinate fields represent polygons.

When you specify the geometry type as `"polygon"`, the `struct2geotable` function assumes that the coordinates define polygons with a valid topology. A polygon has a valid topology when:

- Region interiors are to the right as you trace boundaries from vertex to vertex.
- The boundaries have no self-intersections.

In general, the outer boundaries of polygons with a valid topology have vertices in a clockwise order and the interior holes have vertices in a counterclockwise order.

The `struct2geotable` function detects the geometry type when the input structure array has a `Geometry` field with a value of `'Point'`, `'Multipoint'`, `'Line'`, or `'Polygon'`.

Output Arguments

GT — Output geospatial table

geospatial table

Output geospatial table. A geospatial table is a `table` or `timetable` object with a `Shape` variable that contains `geopointshape`, `geolineshape`, `geopolyshape`, `mappointshape`, `maplineshape`, or `mappolyshape` objects.

For an input structure array with M elements and N fields, the size of GT is M -by- $(N + 1)$.

Tips

- When the input structure has latitude-longitude fields and x - y fields, the `struct2geotable` function creates the geospatial table using the latitude-longitude fields. Create the geospatial table using the x - y fields by specifying the `coordinateSystemType` and `fnames` arguments.
- When you know that a shapefile contains latitude and longitude coordinates and read the shapefile using the `shaperead` function, you must specify the `UseGeoCoords` argument as `true`. Otherwise, the structure array contains `X` and `Y` fields instead of `Lat` and `Lon` fields. As a result, the `struct2geotable` function creates the `Shape` variable of the geospatial table using planar shape objects such as `mappointshape` instead of geographic shape objects such as `geopointshape`.

Version History

Introduced in R2021b

See Also

Functions

`readgeotable` | `table2geotable`

Topics

“Create Geospatial Tables”

surfacem

Project and add geolocated data grid to axesm-based map

Syntax

```
surfacem(lat,lon,Z)
surfacem(latlim,lonlim,Z)
surfacem(lat,lon,Z,alt)
surfacem(...,prop1,val1,prop2,val2,...)
h = surfacem(...)
```

Description

`surfacem(lat,lon,Z)` constructs a surface to represent the data grid `Z` in the current `axesm`-based map. The surface lies flat in the horizontal plane with its `CData` property set to `Z`. The vectors or 2-D arrays `lat` and `lon` define the latitude-longitude graticule mesh on which `Z` is displayed. For a complete description of the various forms that `lat` and `lon` can take, see `surfm`.

`surfacem(latlim,lonlim,Z)` defines the graticule using the latitude and longitude limits `latlim` and `lonlim`. These limits should match the geographic extent of the data grid `Z`. The two-element vector `latlim` has the form:

```
[southern_limit northern_limit]
```

Likewise, `lonlim` has the form:

```
[western_limit eastern_limit]
```

A latitude-longitude graticule of size 50-by-100 is constructed. The surface `FaceColor` property is `'texturemap'`, except when `Z` is precisely 50-by-100, in which case it is `'flat'`.

`surfacem(lat,lon,Z,alt)` sets the `ZData` property of the surface to `'alt'`, resulting in a 3-D surface. `lat` and `lon` must result in a graticule mesh that matches `alt` in size. `CData` is set to `Z`. `Facecolor` is `'texturemap'`, unless `Z` matches `alt` in size, in which case it is `'flat'`.

`surfacem(...,prop1,val1,prop2,val2,...)` applies additional MATLAB graphics properties to the surface via property/value pairs. You can specify any property accepted by the `surface` function, except `XData`, `YData`, and `ZData`.

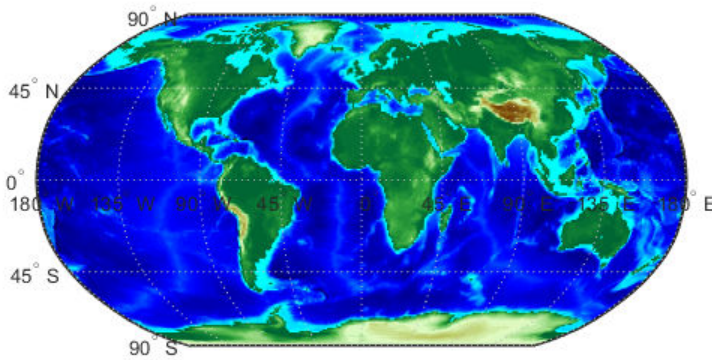
`h = surfacem(...)` returns a handle to the surface object.

Note Unlike `meshm` and `surfm`, `surfacem` always adds a surface to the current axes, regardless of hold state.

Examples

Load elevation raster data and a geographic cells reference object. Then, display the data as a surface.

```
load topo60c
[topo60c,topo60cR] = geocrop(topo60c,topo60cR,[-90 90],[-180,180]);
[lat,lon] = geographicGrid(topo60cR);
worldmap world
surfacem(lat,lon,topo60c)
demcmap(topo60c)
```



Version History

Introduced before R2006a

See Also

geoshow | meshm | pcolorm | surfm

surflm

3-D shaded surface with lighting on axesm-based map

Syntax

```
surflm(lat,lon,Z)
surflm(latlim,lonlim,Z)
surflm(...,s)
surflm(...,s,k)
h = surflm(...)
```

Description

`surflm(lat,lon,Z)` and `surflm(latlim,lonlim,Z)` are the same as `surf(...)` except that they highlight the surface with a light source. The default light source (45 degrees counterclockwise from the current view) and reflectance constants are the same as in `surf`.

`surflm(...,s)` and `surflm(...,s,k)` use a light source vector, `s`, and a vector of reflectance constants, `k`. For more information on `s` and `k`, see the help for `surf`.

`h = surflm(...)` returns a handle to the surface object.

Examples

Display 3-D Shaded Surface with Lighting

Display a 3-D shaded surface with lighting on a map. To do this, first load elevation raster data and a geographic cells reference object. Get the coordinates of coastlines.

```
load topo60c
[topo60c,topo60cR] = geocrop(topo60c,topo60cR,[-90 90],[-180 180]);
load coastlines
```

Create a map using a Miller projection. Remove the background by calling `axis off`.

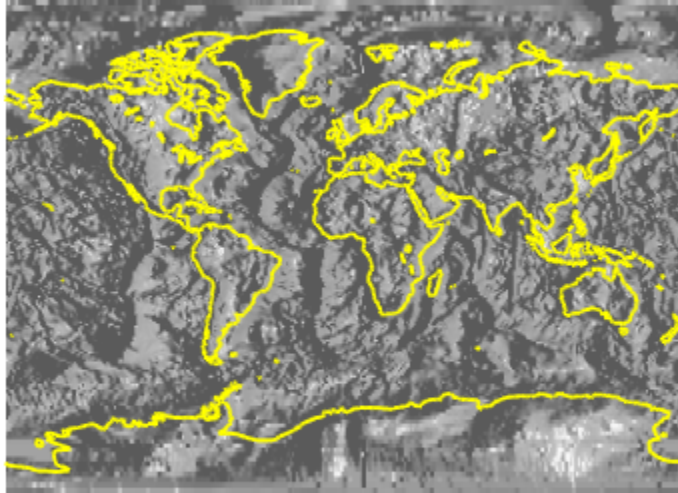
```
axesm miller
axis off
```

Create a latitude-longitude mesh from the raster using the `geographicGrid` function. Then, display the elevation data as a shaded surface with lighting. Apply a grayscale colormap.

```
[lat,lon] = geographicGrid(topo60cR);
surflm(lat,lon,topo60c)
colormap(gray)
```

Display the coastlines over the surface.

```
plotm(coastlat,coastlon,max(topo60c(:)),...
      'LineWidth',1.5,'Color','y')
```



Tips

`surf1m` is like `surf`, except that it shades the monochrome map surface with a light source, and the only allowed graticule is the size of the data matrix.

Version History

Introduced before R2006a

See Also

`surf`

surflsrm

3-D lighted shaded relief of geolocated data grid on axesm-based map

Syntax

```
surflsrm(lat,long,Z)
surflsrm(lat,long,Z,[azim elev])
surflsrm(lat,long,Z,[azim elev],cmap)
surflsrm(lat,long,Z,[azim elev],cmap,clim)
h = surflsrm(...)
```

Description

`surflsrm(lat,long,Z)` displays the geolocated data grid, colored according to elevation and surface slopes. The current axes must have a valid map projection definition.

`surflsrm(lat,long,Z,[azim elev])` displays the geolocated data grid with the light coming from the specified azimuth and elevation. Lighting is applied before the data is projected. Angles are in degrees, with the azimuth measured clockwise from North, and elevation up from the zero plane of the surface. By default, the direction of the light source is east (90° azimuth) at an elevation of 45°.

`surflsrm(lat,long,Z,[azim elev],cmap)` displays the geolocated data grid using the provided colormap. The number of grayscales is chosen to keep the size of the shaded colormap below 256. By default, the colormap is constructed from 16 colors and 16 grays. If the vector of azimuth and elevation is empty, the default locations are used.

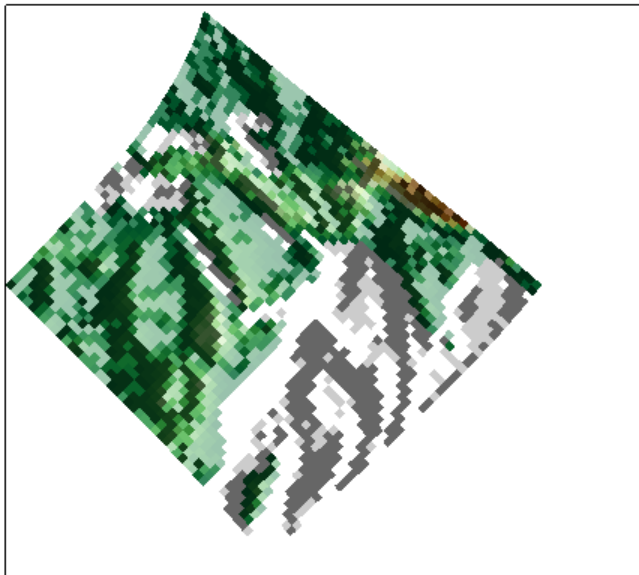
`surflsrm(lat,long,Z,[azim elev],cmap,clim)` uses the provided color axis limits, which are, by default, automatically computed from the data.

`h = surflsrm(...)` returns the handle to the surface drawn.

Examples

Create a new colormap using `demcmap` with white colors for the sea and default colors for land. Use this colormap for the lighted shaded relief map of the Middle East region:

```
load mapmtx
[cmap,clim] = demcmap(map1,[],[1 1 1],[]);
axesm loximuth
surflsrm(lt1,lg1,map1,[],cmap,clim)
```



Tips

This function effectively multiplies two colormaps, one with color based on elevation, the other with a grayscale based on the slope of the surface, to create a new colormap. This produces an effect similar to using a light on a surface, but with all of the visible colors actually in the colormap. Lighting calculations are performed on the unprojected data.

Version History

Introduced before R2006a

See Also

`meshlsrm` | `meshm` | `pcolorm` | `shaderel` | `surfacem` | `surflm` | `surfm`

surfm

Project geolocated data grid on axesm-based map

Syntax

```
surfm(lat,lon,Z)
surfm(latlim,lonlim,Z)
surfm(lat,lon,Z,h)
surfm( ____,Name,Value)
s = surfm( ____ )
```

Description

`surfm(lat,lon,Z)` displays a surface on the current axesm-based map by warping the geolocated data grid `Z`, with geographic coordinates `lat` and `lon`, to a projected graticule mesh. The color of the surface varies according to the values in `Z`. This syntax displays the surface in a horizontal plane with all height values set to 0.

`surfm(latlim,lonlim,Z)` creates a graticule mesh using the latitude limits `latlim` and the longitude limits `lonlim`.

`surfm(lat,lon,Z,h)` displays the surface using the heights specified by `h`.

`surfm(____,Name,Value)` specifies surface properties using one or more name-value pair arguments. For example, "FaceAlpha", 0.5 creates a semitransparent plot.

`s = surfm(____)` returns the primitive surface object. Use `s` to modify the plot after creation. For a list of properties, see Surface Properties.

Examples

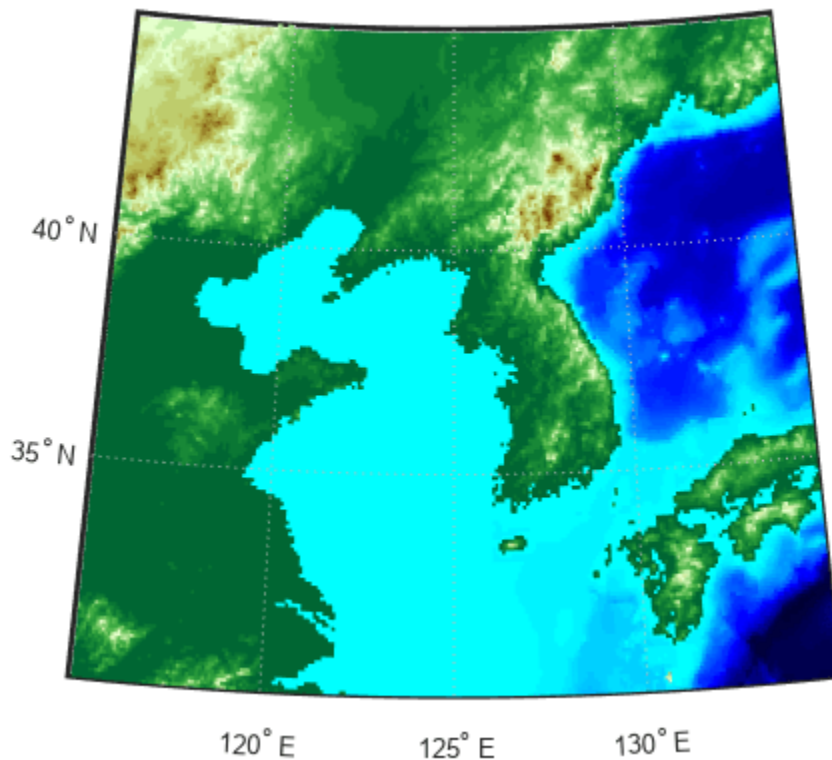
Display Geolocated Data Grid on axesm-Based Map

Load elevation data and a geographic cells reference object for the Korean peninsula. Extract the latitude and longitude coordinates from the reference object.

```
load korea5c
[lat,lon] = geographicGrid(korea5cR);
```

Find the latitude and longitude limits of the data. Then, display the data on a world map using a colormap appropriate for elevation data.

```
[latlim,lonlim] = geoquadline(lat,lon);
worldmap(latlim,lonlim)
surfm(latlim,lonlim,korea5c)
demcmap(korea5c)
```



Display Surface in 3-D

Read elevation data and a geographic postings reference object for a region around South Boulder Peak in Colorado. Crop the data to cover a smaller region. Extract the latitude and longitude coordinates from the reference object.

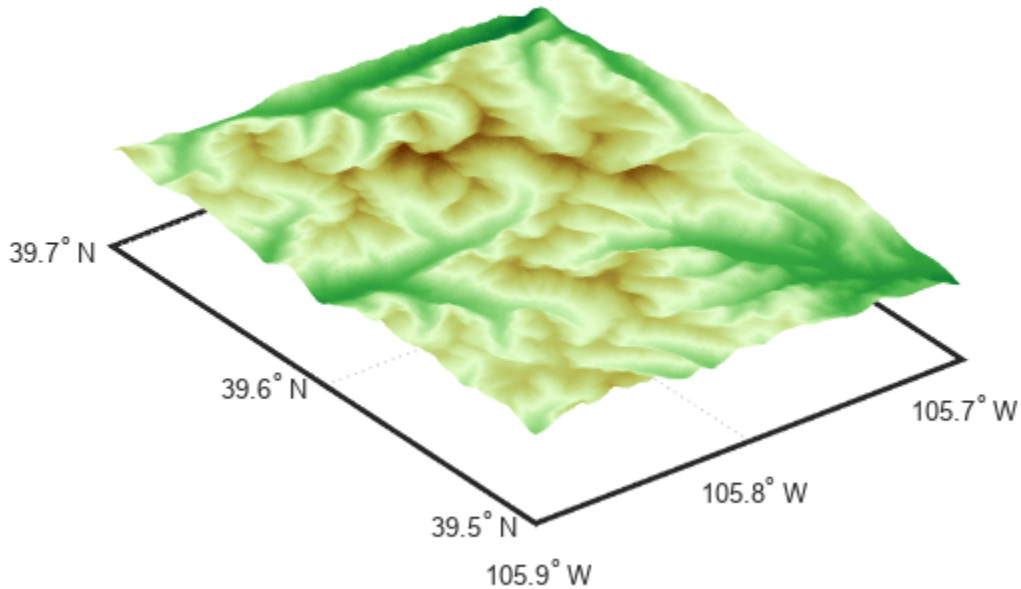
```
[Z,R] = readgeoraster("n39_w106_3arc_v2.dt1", "OutputType", "double");
[Z,R] = geocrop(Z,R,[39.5 39.7],[-105.9 -105.7]);
[lat,lon] = geographicGrid(R);
```

Get the latitude and longitude limits of the data. Then, display the data as a surface by specifying the height data as the elevation data (Z). Apply a colormap appropriate for elevation data.

```
[latlim,lonlim] = geoquadline(lat,lon);
usamap(latlim,lonlim)
surfm(lat,lon,Z,Z)
demcmap(Z)
```

View the region in 3-D.

```
view(3)
```



Modify Appearance of Surface Plot

Load elevation data and a geographic cells reference object for the Korean peninsula. Extract the latitudes and longitudes from the reference object.

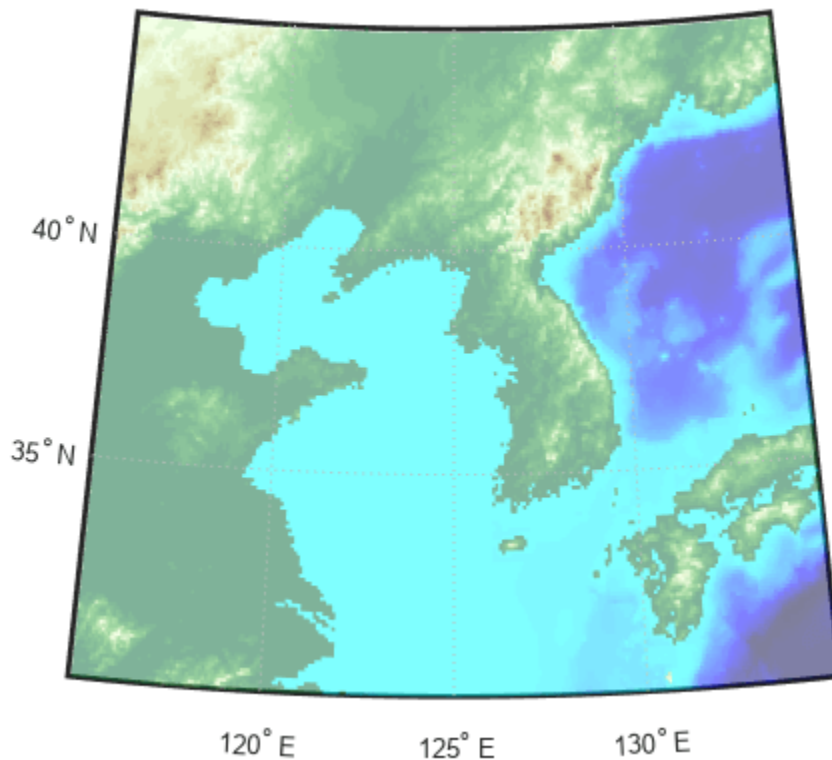
```
load korea5c
[lat,lon] = geographicGrid(korea5cR);
```

Find the latitude and longitude limits of the data. Then, display the data on a world map. Adjust the transparency of the surface plot using the `FaceAlpha` name-value argument.

```
[latlim,lonlim] = geoquadline(lat,lon);
worldmap(latlim,lonlim)
surfm(lat,lon,korea5c,"FaceAlpha",0.5)
```

Apply a colormap appropriate for elevation data.

```
demcmap(korea5c)
```



Input Arguments

lat — Latitude coordinates

vector | matrix

Latitude coordinates, specified as a vector or a matrix. The sizes of `lat` and `lon` must match.

- When `lat` and `lon` are matrices of the same size as `Z`, the `surf` function displays each element of `Z` at the location specified by the corresponding elements of `lat` and `lon`.
- When `lat` and `lon` are matrices of a different size than `Z`, the `surf` function creates a graticule mesh of the same size as `lat`.
- When `lat` and `lon` are vectors, the `surf` function creates a graticule mesh of size `length(lat)-by-length(lon)` by replicating `lat` and `lon`.

Data Types: `double`

lon — Longitude coordinates

vector | matrix

Longitude coordinates, specified as a vector or a matrix. The sizes of `lon` and `lat` must match.

- When `lat` and `lon` are matrices of the same size as `Z`, the `surf` function displays each element of `Z` at the location specified by the corresponding elements of `lat` and `lon`.

- When `lat` and `lon` are matrices of a different size than `Z`, the `surfm` function creates a graticule mesh of the same size as `lat`.
- When `lat` and `lon` are vectors, the `surfm` function creates a graticule mesh of size `length(lat)-by-length(lon)` by replicating `lat` and `lon`.

Data Types: `double`

Z — Geolocated data grid

m-by-n array

Geolocated data grid, specified as an *m-by-n* array.

latlim — Latitude limits for Z

two-element vector

Latitude limits for `Z`, specified as a two-element vector of the form `[latmin latmax]`, where `latmax` is greater than `latmin`.

The `surfm` function uses `latlim` and `lonlim` to create a graticule mesh of the same size as `Z`.

Data Types: `double`

lonlim — Longitude limits for Z

two-element vector

Longitude limits for `Z`, specified as a two-element vector of the form `[lonmin lonmax]`, where `lonmax` is greater than `lonmin`.

The `surfm` function uses `latlim` and `lonlim` to create a graticule mesh of the same size as `Z`.

Data Types: `double`

h — Surface heights

scalar | matrix

Surface heights, specified as a scalar or a matrix.

- When you specify a scalar, the `surfm` function displays the grid in the horizontal plane with all height values set to `h`.
- When you specify a matrix, the `surfm` function displays each vertex of the graticule mesh at the corresponding height in `h`. The size of the matrix must match the size of the graticule mesh.

When the `MapProjection` property of the axesm-based map is "globe", `h` is referenced to the ellipsoid.

Data Types: `double`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `surfm(lat,lon,Z,LineStyle="-")` displays the graticule mesh using a solid line.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `surf(lat,lon,Z,"LineStyle","-")` displays the graticule mesh using a solid line.

Note Use name-value arguments to specify values for the properties of the `Surface` object created by this function. The properties listed here are only a subset. For a full list, see `Surface Properties`.

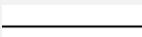



Surface objects created by the `surf` function have these limitations:

- Setting the `XData`, `YData`, and `ZData` properties of the surface object is not supported.
- If you set the `UserData` property of the surface and then change the projection of the axes-based map, MATLAB does not reproject the surface.

LineStyle – Line style

"none" (default) | "-" | "--" | ":" | "-."

Line style, specified as one of the options listed in this table.

Line Style	Description	Resulting Line
" - "	Solid line	
" - - "	Dashed line	
" : "	Dotted line	
" - . "	Dash-dotted line	
"none"	No line	No line

LineWidth – Line width

0.5 (default) | positive value

Line width, specified as a positive value in points, where 1 point = 1/72 of an inch. If the line has markers, then the line width also affects the marker edges.

The line width cannot be thinner than the width of a pixel. If you set the line width to a value that is less than the width of a pixel on your system, the line displays as one pixel wide.

Output Arguments

s – Primitive surface object

Surface object

Primitive surface object, returned as a `Surface` object. Use `s` to modify the `Surface` object after creation. For a list of properties, see `Surface Properties`.

Surface objects created by the `surf` function have these limitations:

- Setting the `XData`, `YData`, and `ZData` properties of the surface object is not supported.
- If you set the `UserData` property of the surface and then change the projection of the axes-based map, MATLAB does not reproject the surface.

Tips

- The `FaceColor` property of the surface object depends on the size of the graticule mesh. The `surfm` function sets `FaceColor` to "flat" when the size of the graticule mesh matches the size of `Z`, and "texturemap" otherwise.
- The `surfm` function projects the graticule mesh using the projection specified by the `MapProjection` property of the `axesm`-based map. To improve the resolution of the plot, increase the size of the graticule mesh. Increasing the size of the graticule mesh can increase the amount of time MATLAB requires to display the surface.

Version History

Introduced before R2006a

See Also

Functions

`geoshow` | `pcolorm` | `meshm` | `geographicGrid`

Topics

"Fit Gridded Data to the Graticule"

table2geotable

Convert table to geospatial table

Syntax

```
GT = table2geotable(T)
GT = table2geotable(T,coordinateSystemType,varnames)
GT = table2geotable( ____,Name=Value)
```

Description

`GT = table2geotable(T)` converts the table or timetable `T` to a geospatial table `GT`. The function creates the `Shape` variable of `GT` by using the latitude-longitude or `x-y` coordinates in `T`. Each variable of `T` is a variable of `GT`.

`GT = table2geotable(T,coordinateSystemType,varnames)` creates the `Shape` variable of `GT` by using the coordinate system type `coordinateSystemType` and table variables `varnames`. Use this syntax to create the `Shape` variable from well-known text (WKT) string representations of geometry or from coordinate data.

`GT = table2geotable(____,Name=Value)` specifies options using name-value arguments. For example, specify that coordinates represent points, lines, or polygons by using the `GeometryType` name-value argument. Use this syntax with any of the input arguments in the previous syntaxes.

Examples

Convert Table to Geospatial Table

Import data about tsunami events as a table. The latitude and longitude coordinates of the origin points are in the `Latitude` and `Longitude` table variables.

```
T = readtable("tsunamis.xlsx");
```

Convert the table to a geospatial table. The `table2geotable` function detects the `Latitude` and `Longitude` variables and uses them to create the `Shape` variable.

```
GT = table2geotable(T);
```

View the `Shape` variable.

```
GT.Shape
```

```
ans =
    162x1 geopointshape array with properties:
        NumPoints: [162x1 double]
        Latitude: [162x1 double]
        Longitude: [162x1 double]
        Geometry: "point"
        CoordinateSystemType: "geographic"
```

```
GeographicCRS: []
```

Convert Table with WKT Strings to Geospatial Table

Create a sample table. The first table variable (`WKTString`) contains the WKT string representation of geometry for lines in planar coordinates. The second variable (`Name`) contains names.

```
wkt1 = "LINESTRING (210320.1875 913333.8125,210320.140625 913366.6875)";
wkt2 = "LINESTRING (210320.4375 913170.9375,210320.34375 913231.1875)";
name1 = "Line 1";
name2 = "Line 2";
T = table([wkt1;wkt2],[name1;name2],VariableNames={'WKTString','Name'})
```

`T=2x2 table`

	WKTString	Name
	"LINESTRING (210320.1875 913333.8125,210320.140625 913366.6875) "	"Line 1"
	"LINESTRING (210320.4375 913170.9375,210320.34375 913231.1875) "	"Line 2"

Convert the table to a geospatial table. Create the `Shape` variable of the table by using the WKT strings. For this example, specify the projected CRS as World Equidistant Cylindrical, which has the EPSG authority code 4087.

```
GT = table2geotable(T,"planar","WKTString", ...
    CoordinateReferenceSystem=projcrs(4087))
```

`GT=2x3 table`
`Shape`

	WKTString	Name
<code>maplineshape</code>	"LINESTRING (210320.1875 913333.8125,210320.140625 913366.6875) "	"Line 1"
<code>maplineshape</code>	"LINESTRING (210320.4375 913170.9375,210320.34375 913231.1875) "	"Line 2"

View the `Shape` variable of the geospatial table.

`GT.Shape`

`ans=2x1 object`

2x1 `maplineshape` array with properties:

```
    NumParts: [2x1 double]
    Geometry: "line"
    CoordinateSystemType: "planar"
    ProjectedCRS: [1x1 projcrs]
```

Input Arguments

T — Input table

table object | timetable object

Input table, specified as a `table` or `timetable` object.

The `table2geotable` function detects the coordinates when the table variables have these names, ignoring case.

- Latitude coordinates — `Latitude` or `Lat`
- Longitude coordinates — `Longitude`, `Lon`, or `Long`
- x-coordinates — `X`
- y-coordinates — `Y`

If you specify an input table with a variable called `Shape`, then the `table2geotable` function overwrites it.

Data Types: `table`

coordinateSystemType — Coordinate system type

`"planar" | "geographic"`

Coordinate system type, specified as one of these options:

- `"planar"` — Coordinates are in a planar coordinate system.
- `"geographic"` — Coordinates are in a geographic coordinate system.

Data Types: `string`

varnames — Names of table variables

`string scalar | two-element string vector`

Names of the table variables used to create the `Shape` variable of the geospatial table, specified as a string scalar or two-element string vector.

- Create the `Shape` variable from one table variable that contains WKT string representations of geometry by specifying `varnames` as a string scalar, such as `"WKT"`
- Create the `Shape` variable from two table variables that contain latitude-longitude or x-y coordinates by specifying `varnames` as a two-element string vector, such as `["Lats" "Lons"]`.

Data Types: `string`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Example: `table2geotable(T, CoordinateReferenceSystem=geocrs(4326))` specifies the geographic CRS as the World Geodetic System of 1984, which has EPSG code 4326.

CoordinateReferenceSystem — Coordinate reference system

`projcrs object | geocrs object`

Coordinate reference system (CRS) to use when creating the `Shape` variable of the geospatial table, specified as a `projcrs` or `geocrs` object.

Specify a `projcrs` object when `coordinateSystemType` is `"planar"` and specify a `geocrs` object when `coordinateSystemType` is `"geographic"`.

GeometryType — Geometry type`"point" (default) | "line" | "polygon"`

Geometry type of the coordinate variables, specified as one of these options:

- `"point"` — The coordinate fields represent points.
- `"line"` — The coordinate fields represent lines.
- `"polygon"` — The coordinate fields represent polygons.

When you specify the geometry type as `"polygon"`, the `table2geotable` function assumes that the coordinates define polygons with a valid topology. A polygon has a valid topology when:

- Region interiors are to the right as you trace boundaries from vertex to vertex.
- The boundaries have no self-intersections.

In general, the outer boundaries of polygons with a valid topology have vertices in a clockwise order and the interior holes have vertices in a counterclockwise order.

If you specify `varnames` as a table variable containing WKT string representations of geometry, then the `table2geotable` function ignores this argument.

Output Arguments**GT — Output geospatial table**`geospatial table`

Output geospatial table. A geospatial table is a `table` or `timetable` object with a `Shape` variable that contains `geopointshape`, `geolineshape`, `geopolyshape`, `mappointshape`, `maplineshape`, or `mappolyshape` objects.

For an input table of size M -by- N , the size of GT is M -by- $(N + 1)$.

Tips

- When the input table has latitude-longitude fields and x - y variables, the `table2geotable` function creates the geospatial table using the latitude-longitude variables. Create the geospatial table using the x - y variables by specifying the `coordinateSystemType` and `varnames` arguments.

Version History**Introduced in R2021b****See Also****Functions**`geotable2table` | `readgeotable` | `readtable` | `table2timetable`**Topics**

"Create Geospatial Tables"

tagm

Set Tag property of objects on axesm-based map

Syntax

```
tagm(obj,tagstr)
```

Description

tagm(obj,tagstr) sets the Tag property of the objects in obj to the values in tagstr.

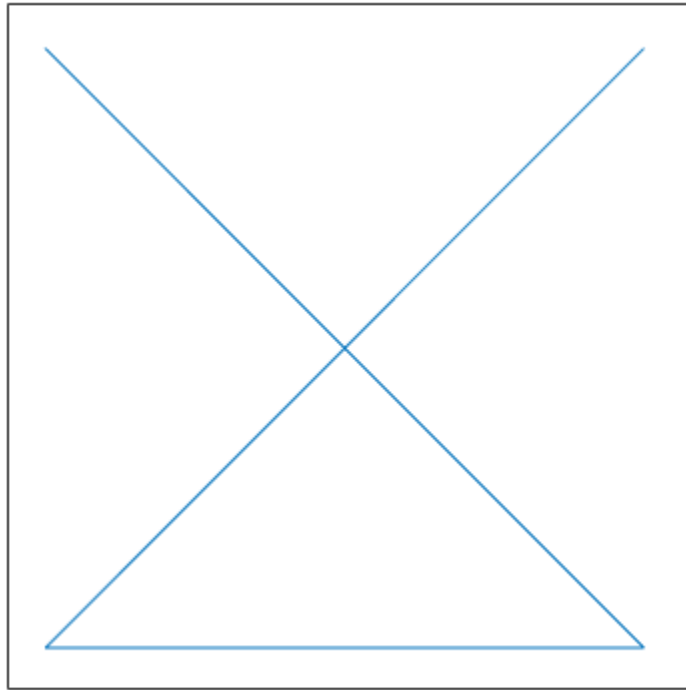
The namem and handlem functions use the Tag property to identify objects on axesm-based maps.

Examples

Set Tag Property of Objects on axesm-based Map

Create a line and view its name.

```
axesm miller  
lats = [3 2 1 1 2 3];  
longs = [7 8 9 7 8 9];  
h = plotm(lats,longs);
```



```
untagged = namem(h)
```

```
untagged =  
'line'
```

Rename the `line` by using the `tagm` function.

```
tagm(h, "newName")  
tagged = namem(h)
```

```
tagged =  
'newName'
```

Input Arguments

obj – Objects to tag

array of graphics objects

Objects to tag, specified as an array of graphics objects. Each graphics object must have a `Tag` property.

tagstr – Tag

character vector | string scalar | character matrix

Tag, specified as a character vector, string scalar, or character matrix.

- To use the same tag for all the objects in `obj`, specify `tagstr` as a character vector or a string scalar.
- To use a different tag for each object in `obj`, specify `tagstr` as a character matrix. The number of rows in the matrix must match the number of objects in `obj`.

Version History

Introduced before R2006a

See Also

`showm` | `handlem` | `namem` | `clma` | `clmo`

tbase

(To be removed) Read 5-minute global terrain elevations from TerrainBase

Note tbase will be removed in a future release. Use `readgeoraster` instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z,refvec] = tbase(scalefactor)
[Z,refvec] = tbase(scalefactor,latlim,lonlim)
```

Description

`[Z,refvec] = tbase(scalefactor)` reads the data for the entire world, reducing the resolution of the data by the specified scale factor. The result is returned as a regular data grid and an associated three-element referencing vector.

`[Z,refvec] = tbase(scalefactor,latlim,lonlim)` reads the data for the part of the world within the latitude and longitude limits. The limits must be two-element vectors in units of degrees.

Background

TerrainBase is a global model of terrain and bathymetry on a regular 5-minute grid (approximately 10 km resolution). It is a compilation of the public domain data from almost 20 different sources, including the DCW-DEM and ETOPO5. The data set was created by the National Geophysical Data Center and World Data Center-A for Solid Earth Geophysics in Boulder, Colorado.

Examples

Read Data for a Region at Full Resolution

Set the scale factor to 1 and set the longitude and latitude limits. This example reads the data for Korea and Japan.

```
scalefactor = 1;
latlim = [30 45];
lonlim = [115 145];
```

Read the data and view the size of the returned variables.

```
[Z,refvec] = tbase(scalefactor,latlim,lonlim);
whos
```

Name	Size	Bytes	Class
------	------	-------	-------

Z	180x360	518400	double array
refvec	1x3	24	double array

Version History

Introduced before R2006a

R2021b: Warns

Warns starting in R2021b

Support for reading the TerrainBase Global Terrain Model will be removed. In addition, raster reading functions that return referencing vectors issue a warning that they will be removed in a future release, including `tbase`. Use a supported data set and return a raster reference object using `readgeoraster` instead.

Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see `GeographicCellsReference` and `MapPostingsReference`.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` or `mapcrop` functions.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` or `mapresize` functions.
- Most functions that accept referencing vectors as input also accept reference objects.

For information about finding data sets, see “Find Geospatial Raster Data”.

R2020a: To be removed

Not recommended starting in R2020a

The `tbase` function runs without warning but will be removed in a future release.

See Also

`readgeoraster` | `georasterinfo`

textm

Project text onto axesm-based map

Syntax

```
textm(lat,lon,txt)
textm(lat,lon,z,txt)
textm( ____,Name,Value)
t = textm( ____ )
```

Description

`textm(lat,lon,txt)` projects the text in `txt` onto the current axesm-based map at the latitude-longitude locations specified by `lat` and `lon`. To add text to one point, specify `lat` and `lon` as scalars. To add text to multiple points, specify `lat` and `lon` as vectors of equal length.

To add text to geographic axes or map axes, use the `text` function instead.

`textm(lat,lon,z,txt)` positions the text at the altitudes in `z`.

`textm(____,Name,Value)` specifies options for the text using one or more name-value arguments, in addition to any combination of arguments from previous syntaxes.. For example, `"FontSize",14` sets the font size to 14 points.

`t = textm(____)` returns one or more `Text` objects, in addition to any combination of arguments from previous syntaxes. Use `t` to modify properties of the `Text` objects after creation. For a list of properties and descriptions, see `Text Properties`.

Examples

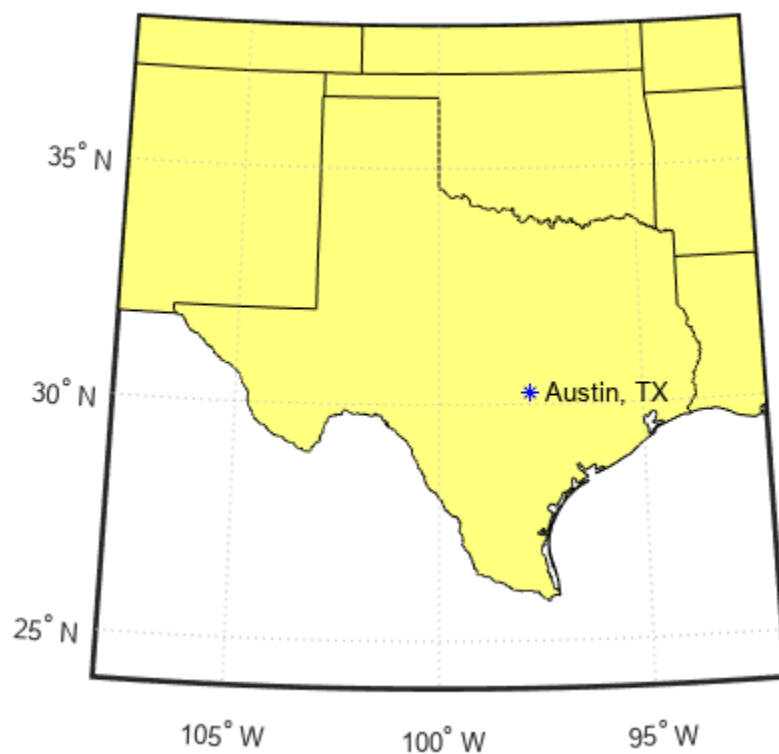
Add Text Description to Map

Import a shapefile containing USA state polygons into the workspace as a geospatial table. Create a map of Texas.

```
GT = readgeotable("usastatehi.shp");
usamap texas
geoshow(GT)
```

Label the city of Austin by adding a star marker and a text description.

```
lat = 30.2672;
lon = -97.7431;
geoshow(lat,lon,"Marker","*")
textm(lat,lon," Austin, TX")
```



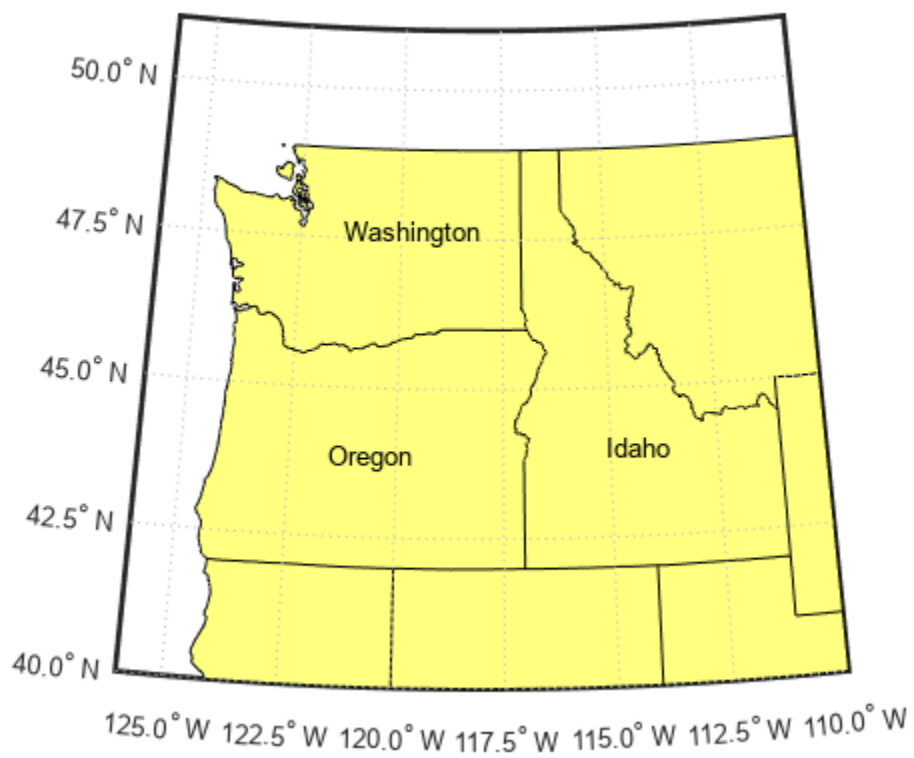
Add Text to Multiple Data Points

Import a shapefile containing USA state polygons into the workspace as a geospatial table. Create a map of Oregon, Idaho, and Washington.

```
GT = readgeotable("usastatehi.shp");  
usamap(["OR" "ID" "WA"])  
geoshow(GT)
```

Label the states by adding text.

```
lat = [43.86 44.01 47.59];  
lon = [-121.56 -115.12 -121.42];  
txt = ["Oregon" "Idaho" "Washington"];  
textm(lat,lon,txt)
```



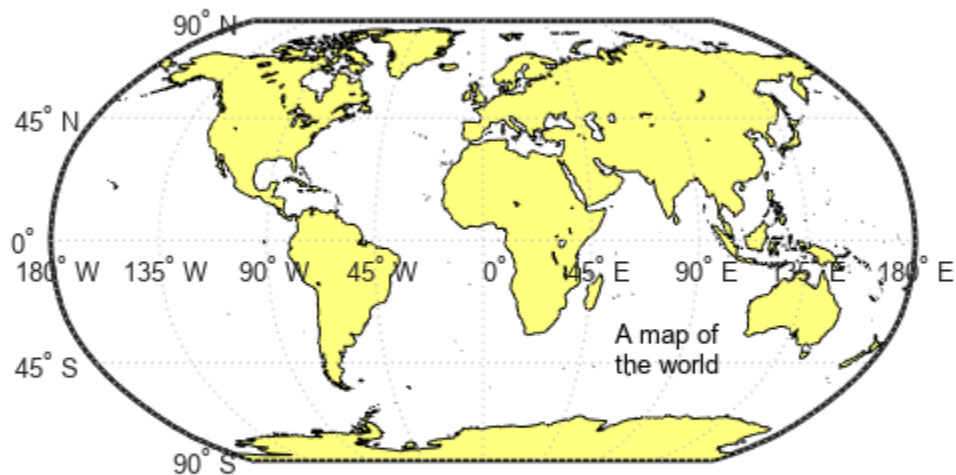
Display Multiline Text

Import a shapefile containing world land areas into the workspace as a geospatial table. Create a map.

```
GT = readgeotable("landareas.shp");  
worldmap world  
geoshow(GT)
```

Add one text description to the map. Display multiline text by specifying txt as a string array.

```
txt = ["A map of" "the world"];  
textm(-40,60,txt)
```



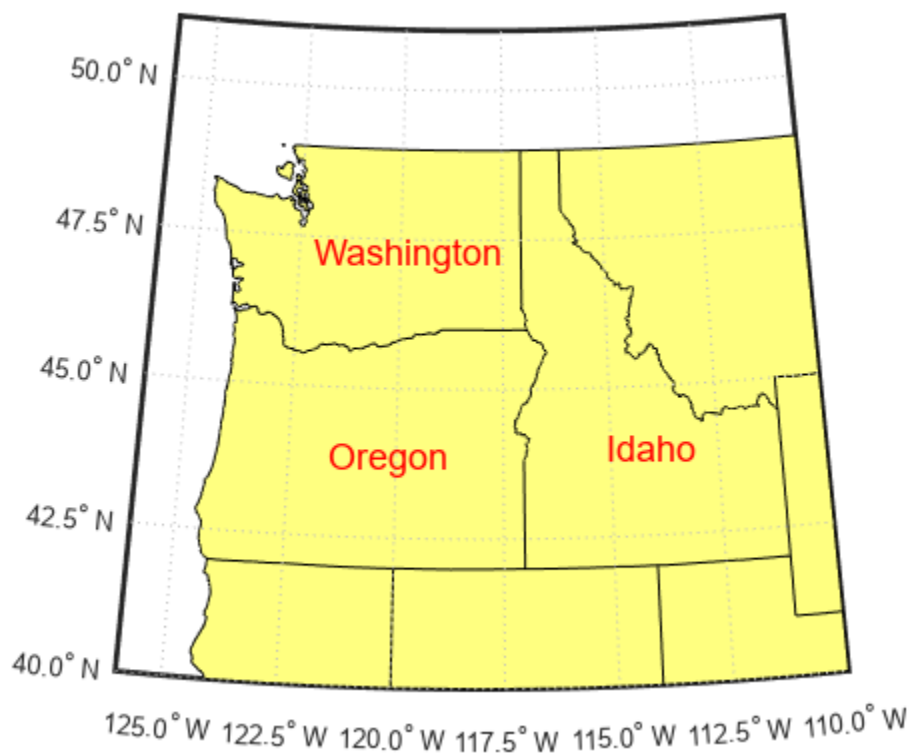
Specify Text Color and Size

Import a shapefile containing USA state polygons into the workspace as a geospatial table. Create a map of Oregon, Idaho, and Washington.

```
GT = readgeotable("usastatehi.shp");  
usamap(["OR" "ID" "WA"])  
geoshow(GT)
```

Label the states by adding text. Use red, size 14 font.

```
lat = [43.86 44.01 47.25];  
lon = [-121.56 -115.12 -122.15];  
txt = ["Oregon" "Idaho" "Washington"];  
textm(lat,lon,txt,"Color","red","FontSize",14)
```



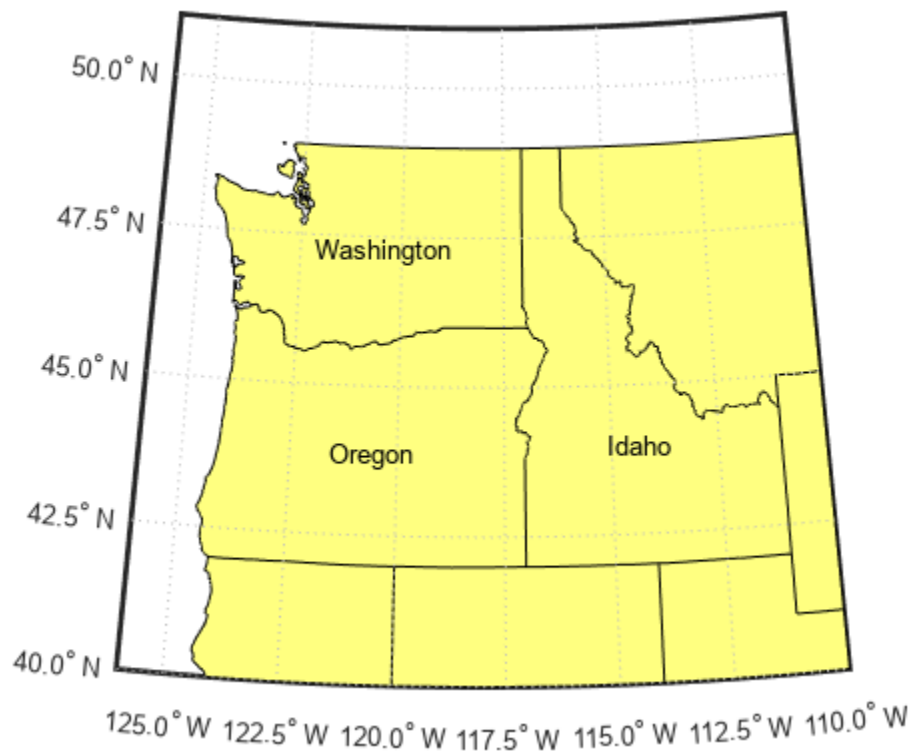
Modify Existing Text

Import a shapefile containing USA state polygons into the workspace as a geospatial table. Create a map of Oregon, Idaho, and Washington.

```
GT = readgeotable("usastatehi.shp");  
usamap(["OR" "ID" "WA"])  
geoshow(GT)
```

Label the states by adding text. Return the text objects in t.

```
lat = [43.86 44.01 47.25];  
lon = [-121.56 -115.12 -122.15];  
txt = ["Oregon" "Idaho" "Washington"];  
t = textm(lat,lon,txt)
```

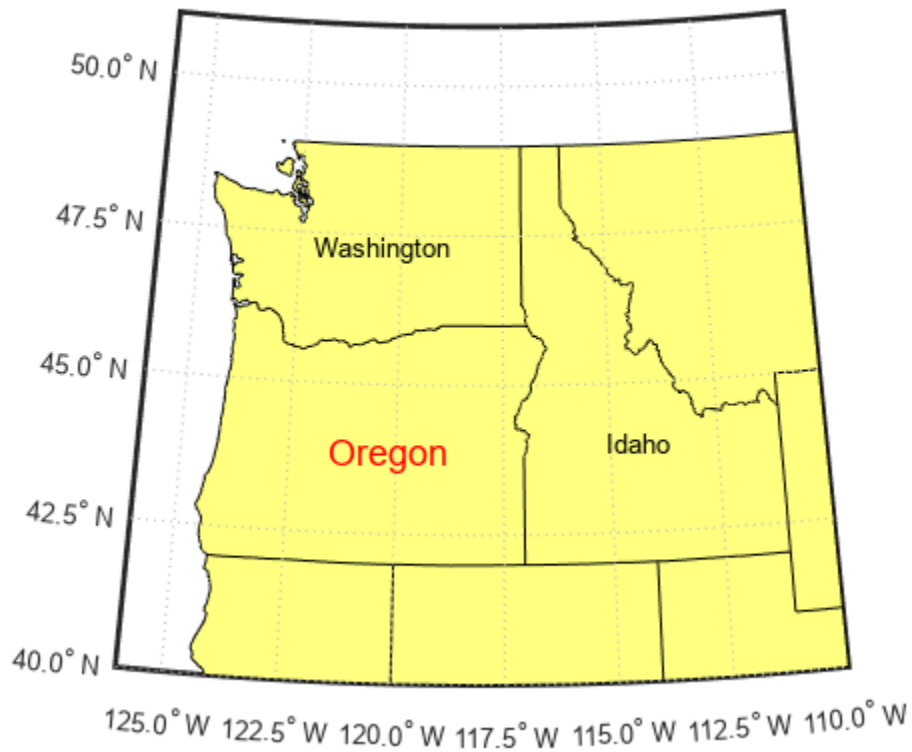


```
t =  
3x1 Text array:  
  
Text (Oregon)  
Text (Idaho)  
Text (Washington)
```

The `textm` function creates one text object for each text description. Thus, `t` contains three text objects.

Change the color and font size for the first text object using `t(1)`.

```
t(1).Color = "red";  
t(1).FontSize = 14;
```

Input Arguments

lat — Latitude coordinates

numeric scalar | numeric vector

Latitude coordinates, specified in one of these forms:

- Numeric scalar — Add text to a single point.
- Numeric vector — Add text to multiple points.

The units of `lat` must match the `AngleUnits` property of the axesm-based map. The sizes of `lat` and `lon` must match.

To control the placement of the text with relation to the specified point, use the `HorizontalAlignment`, `VerticalAlignment`, and `Extent` properties of the `Text` object.

Data Types: `single` | `double`

lon — Longitude coordinates

numeric scalar | numeric vector

Longitude coordinates, specified in one of these forms:

- Numeric scalar — Add text to a single point.

- Numeric vector — Add text to multiple points.

The units of `lon` must match the `AngleUnits` property of the axesm-based map. The sizes of `lat` and `lon` must match.

To control the placement of the text with relation to the specified point, use the `HorizontalAlignment`, `VerticalAlignment`, and `Extent` properties of the `Text` object.

Data Types: `single` | `double`

z — Altitudes

0 (default) | numeric scalar | numeric vector

Altitudes, specified in one of these forms:

- Numeric scalar — Add text to a single point.
- Numeric vector — Add text to multiple points.

When the `MapProjection` property of the axesm-based map is `'globe'`, `z` is referenced to the ellipsoid.

The sizes of `lat`, `lon`, and `z` must match.

To control the placement of the text with relation to the specified point, use the `HorizontalAlignment`, `VerticalAlignment`, and `Extent` properties of the `Text` object.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `categorical` | `datetime` | `duration`

txt — Text to display

character vector | string scalar | string array | cell array of character vectors

Text to display, specified as a character vector, string scalar, string array, or cell array of character vectors.

Text for Single Data Point

To add one line of text to a single point, specify `txt` as a character vector or string scalar. For example, `textm(0.5,0.5,'my text')`.

For multiline text:

- Use a cell array, where each cell contains a line of text. For example, `textm(0.5,0.5,{'first','second'})`.
- Use a string array, where each element is a line of text. For example, `textm(0.5,0.5,["first","second"])`.
- Use `sprintf` to create a new line character. For example, `textm(0.5,0.5,sprintf('first\nsecond'))`.

Text for Multiple Data Points

To display different text at each location, use a cell array. For example, `textm([0 1],[0 1],{'first','second'})`.

For multiline text, use nested cell arrays. For example, `textm([0 3],[0 3],{'first','new line'},'second')`.

Greek Letters, Special Characters, and Numeric Variables

To include special characters, such as superscripts, subscripts, Greek letters, or mathematical symbols, use TeX markup. For a list of supported markup, see the `Interpreter` property of the `Text` object.

To include numeric variables in the text, use the `num2str` function.

```
v = 42;
txt = ['The value is ', num2str(v)];
```

Data Types: char | string | cell

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `textm(0.5,0.5,"my text","FontSize",14,"Color","red")` displays my text with a font size of 14 and a font color of red.

Note Use name-value arguments to specify values for the properties of the `Text` objects created by this function. The properties listed here are only a subset. For a full list, see `Text`.

FontSize — Font size

scalar value greater than zero

Font size, specified as a scalar value greater than zero in point units. The default font size depends on the specific operating system and locale. One point equals 1/72 inch. To change the font units, use the `FontUnits` property.

Example: 12

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64

FontWeight — Character thickness

'normal' (default) | 'bold'

Character thickness, specified as 'normal' or 'bold'.

MATLAB uses the `FontWeight` property to select a font from those available on your system. Not all fonts have a bold weight. Therefore, specifying a bold font weight can still result in the normal font weight.

FontName — Font name

supported font name | 'FixedWidth'

Font name, specified as a supported font name or 'FixedWidth'. To display and print text properly, you must choose a font that your system supports. The default font depends on your operating system and locale.

To use a fixed-width font that looks good in any locale, use 'FixedWidth'. The fixed-width font relies on the root FixedWidthFontName property. Setting the root FixedWidthFontName property causes an immediate update of the display to use the new font.

Color — Text color

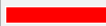


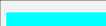
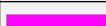
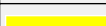


[0 0 0] (default) | RGB triplet | hexadecimal color code | 'r' | 'g' | 'b' | ...

Text color, specified as an RGB triplet, a hexadecimal color code, a color name, or a short name. The default value of [0 0 0] corresponds to black.

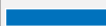





For a custom color, specify an RGB triplet or a hexadecimal color code.


- An RGB triplet is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1], for example, [0.4 0.6 0.7].
- A hexadecimal color code is a string scalar or character vector that starts with a hash symbol (#) followed by three or six hexadecimal digits, which can range from 0 to F. The values are not case sensitive. Therefore, the color codes "#FF8800", "#ff8800", "#F80", and "#f80" are equivalent.

Alternatively, you can specify some common colors by name. This table lists the named color options, the equivalent RGB triplets, and hexadecimal color codes.

Color Name	Short Name	RGB Triplet	Hexadecimal Color Code	Appearance
"red"	"r"	[1 0 0]	"#FF0000"	
"green"	"g"	[0 1 0]	"#00FF00"	
"blue"	"b"	[0 0 1]	"#0000FF"	
"cyan"	"c"	[0 1 1]	"#00FFFF"	
"magenta"	"m"	[1 0 1]	"#FF00FF"	
"yellow"	"y"	[1 1 0]	"#FFFF00"	
"black"	"k"	[0 0 0]	"#000000"	
"white"	"w"	[1 1 1]	"#FFFFFF"	
"none"	Not applicable	Not applicable	Not applicable	No color

Here are the RGB triplets and hexadecimal color codes for the default colors MATLAB uses in many types of plots.

RGB Triplet	Hexadecimal Color Code	Appearance
[0 0.4470 0.7410]	"#0072BD"	
[0.8500 0.3250 0.0980]	"#D95319"	
[0.9290 0.6940 0.1250]	"#EDB120"	
[0.4940 0.1840 0.5560]	"#7E2F8E"	
[0.4660 0.6740 0.1880]	"#77AC30"	
[0.3010 0.7450 0.9330]	"#4DBEEE"	

RGB Triplet	Hexadecimal Color Code	Appearance
[0.6350 0.0780 0.1840]	"#A2142F"	

Example: 'blue'

Example: [0 0 1]

Example: '#0000FF'

Output Arguments

t – Text objects

Text objects

Text objects. Use the elements of `t` to modify a specific Text object after creation. For a list of properties, see Text Properties.

To change the position of a Text object by specifying geographic coordinates, use the `setm` function.

Tips

The words "default", "remove", and "factory" are reserved words in MATLAB. To create text using one of these words, append a backslash (\) before the word. For example, `textm(0.5,0.5,"\default")`.

Version History

Introduced before R2006a

See Also

Functions

`axesm` | `text`

Properties

Text Properties

Topics

"Greek Letters and Special Characters in Chart Text"

tightmap

Remove white space around axesm-based map

Syntax

```
tightmap
```

Description

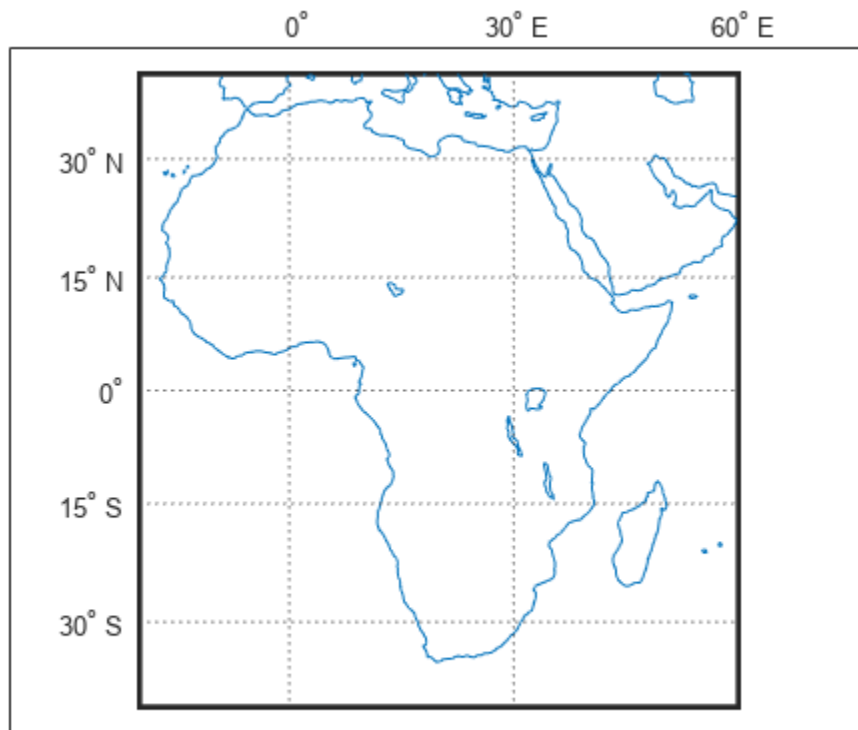
`tightmap` sets the axis limits to be tight around the map in the current axes. This eliminates or reduces the white border between the map frame and the axes box. Use `axis auto` to undo `tightmap`.

Examples

Display Map of Africa With and Without Surrounding White Space

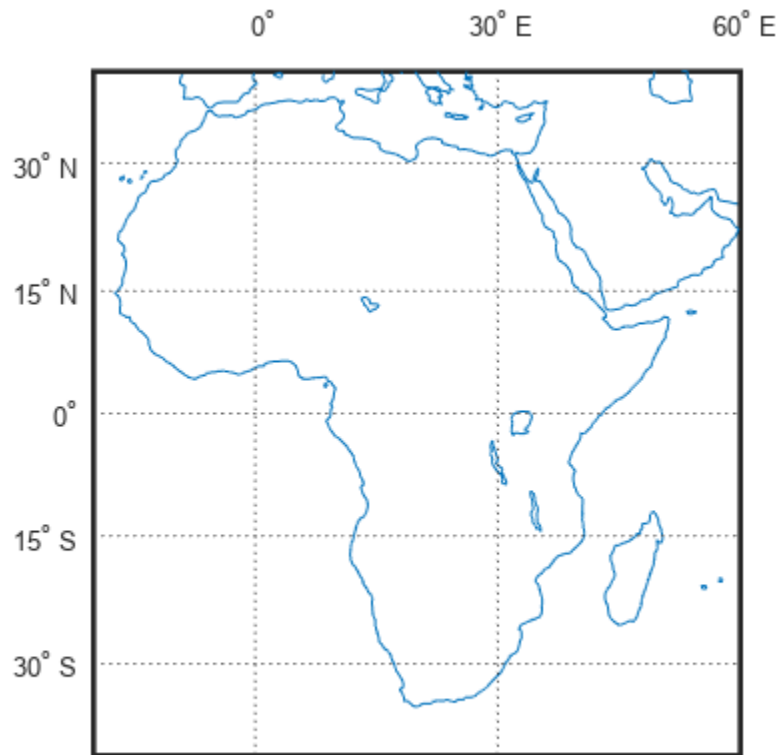
Display a map of Africa. Notice the white space between the map frame and the edge of the axes box.

```
axesm('miller','maplatlim',[-40 40],'maplonlim',[-20 60])  
framem;  
gridm;  
mlabel;  
plabel  
load coastlines  
plotm(coastlat,coastlon)
```



Now remove white space around the map.

tightmap



Tips

The axis limits are fixed. If a change in the projection parameters changes the size or position of the map display within the projected coordinate system, execute `tightmap` again. Also note that `tightmap` needs to be re-applied following any call to `setm` that causes projected map objects to be re-projected.

The `tightmap` function performs no action on a 'globe' axesm-based map.

Version History

Introduced before R2006a

See Also

`zoom` | `paperscale` | `axesscale` | `previewmap`

timezone

Time zone based on longitude

Syntax

```
[zd,zltr,zone] = timezone(lon)
[zd,zltr,zone] = timezone(lon,units)
```

Description

`[zd,zltr,zone] = timezone(lon)` returns the integer zone description `zd`, the alphabetical zone indicator `zltr`, and the complete zone description and alphabetical zone indicator `zone` that correspond to the input longitude `lon`.

`[zd,zltr,zone] = timezone(lon,units)` specifies the angle units `units` for the longitude.

Examples

Find Time Zones Based on Longitude

Display the zone description and alphabetical zone indicator for each time zone, excluding +12 Y.

```
lon = 0:15:360;
[zd,zltr,zone] = timezone(lon);
zone
```

zone = 25x5 char array

```
' 0 Z'
'-1 A'
'-2 B'
'-3 C'
'-4 D'
'-5 E'
'-6 F'
'-7 G'
'-8 H'
'-9 I'
'-10 K'
'-11 L'
'-12 M'
'+11 X'
'+10 W'
'+9 V'
'+8 U'
'+7 T'
'+6 S'
'+5 R'
'+4 Q'
'+3 P'
'+2 O'
'+1 N'
```

' 0 Z'

Input Arguments

lon — Longitude

numeric scalar | numeric array

Longitude, specified as a numeric scalar or a numeric array.

units — Angle unit for longitude

"degrees" (default) | "radians"

Angle unit for the longitude, specified as one of these options:

- "degrees" — Degrees
- "radians" — Radians

Data Types: char | string

Output Arguments

zd — Zone description

character vector | character array

Zone description, returned as a character vector or a character array.

zltr — Alphabetical zone indicator

character vector | character array

Alphabetical zone indicator, returned as a character vector or a character array.

zone — Complete zone description and alphabetical zone indicator

character vector | character array

Complete zone description and alphabetical zone indicator, returned as a character vector or a character array.

Limitations

National and local governments set their own time zone boundaries for political or geographic convenience. The `timezone` function does not account for deviations from the meridian-based system.

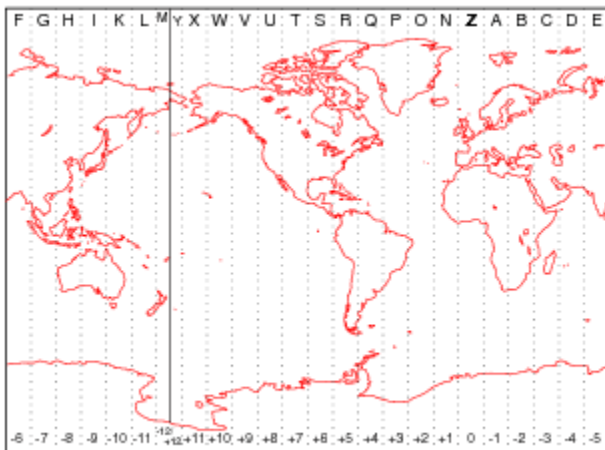
More About

Time Zones

The position of the sun relative to the prime meridian (the zero longitude line through Greenwich, England) determines the time. When the prime meridian lies directly below the sun, the time is noon Coordinate Universal Time (UTC).

For local times elsewhere, the Earth is divided into 15° longitude bands (or zones), each centered on a central meridian. When a central meridian lies directly below the sun, Local Mean Time (LMT) in that zone is noon.

The zone description is the result of subtracting LMT from UTC. For notational convenience, each zone also has an alphabetical zone indicator.



The zone centered on the International Date Line (180° E/W) is split into two zones: +12 Y and -12 M.

Version History

Introduced before R2006a

See Also

Functions

`timezones` | `tzoffset`

tissot

Project Tissot indicatrices on axesm-based map

Syntax

```
h = tissot
h = tissot(spec)
h = tissot(spec,linetype)
h = tissot(linestyle)
h = tissot(spec,PropertyName,PropertyValue,...)
h = tissot(linetype,PropertyName,PropertyValue,...)
```

Description

`h = tissot` plots the default Tissot diagram, as described above, on the current axesm-based map and returns handles for the displayed indicatrices.

`h = tissot(spec)` allows you to specify plotting parameters of the displayed Tissot diagram as described above.

`h = tissot(spec,linetype)` and `h = tissot(linestyle)` specifies the line style and color on page 1-1728.

`h = tissot(spec,PropertyName,PropertyValue,...)` and `h = tissot(linetype,PropertyName,PropertyValue,...)` allow the specification of any property and value recognized by the `line` function.

Background

Tissot indicatrices are plotting symbols that are useful for understanding the various distortions of a given map projection. The indicatrices are circles of identical true radius on the Earth's surface. When plotted on a map projection, they indicate whether the projection has certain features. If the plotted indicatrices all enclose the same area, the projection is equal area (for example, a Sinusoidal projection would have this feature). If they all remain circular, then conformality is indicated (a Mercator projection has this property). Distortions in meridional or parallel distance are exhibited by flattened or stretched indicatrices. Many projections will show very even, circular indicatrices in some regions, often near the center, and wildly distorted indicatrices in others, such as near the edges. The Tissot diagram is therefore very useful in analyzing the appropriateness of a projection to a given purpose or region.

The general layout of the Tissot diagram is defined by the specification vector `spec`.

```
spec = [Radius]
spec = [Latint,Longint]
spec = [Latint,Longint,Radius]
spec = [Latint,Longint,Radius,Points]
```

`Radius` is the small circle radius of each indicatrix circle. If entered, it should be in the same units as the axesm-based map `Geoid`. The default radius is 1/10th the radius of the sphere.

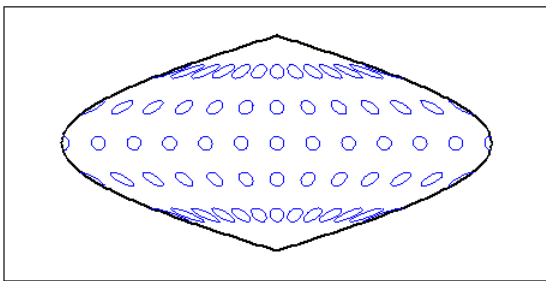
Latint is the latitude interval between indicatrix circle centers. If entered it should be in the axes-based map `AngleUnits`. The default value is one circle every 30° of latitude (that is, 0° , $\pm 30^\circ$, etc.).

Longint is the longitude interval between indicatrix circle centers. If entered it should be in the axes-based map `AngleUnits`. The default value is one circle every 30° of longitude (that is, 0° , $\pm 30^\circ$, etc.).

Points is the number of plotting points per circle. The default is 100 points.

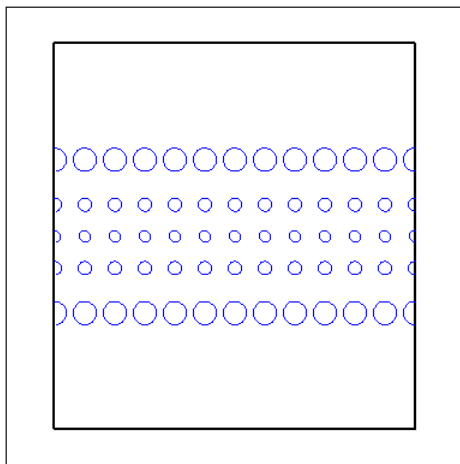
Examples

```
axesm sinusoid; framem
tissot
```



The Sinusoidal projection is equal area.

```
setm(gca, 'MapProjection', 'Mercator')
```


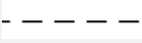

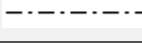










The Mercator projection is conformal.

More About

Line Style and Color

Specify the line style and color as a character vector or string containing symbols. The symbols can appear in any order. You do not need to specify a color. For example, specify a red dashed line using 'r--'.

Line Style	Description	Resulting Line
'_'	Solid line	
'--'	Dashed line	
':'	Dotted line	
'-.'	Dash-dotted line	

Color Name	Short Name	Appearance
'red'	'r'	
'green'	'g'	
'blue'	'b'	
'cyan'	'c'	
'magenta'	'm'	
'yellow'	'y'	
'black'	'k'	
'white'	'w'	

Version History

Introduced before R2006a

See Also

mdistort | distortcalc

toDegrees

Convert angles to degrees

Syntax

```
[D1,...,Dn] = toDegrees(fromUnits,A1,...,An)
```

Description

[D1,...,Dn] = toDegrees(fromUnits,A1,...,An) converts the angles specified by A1,...,An from the units specified by fromUnits to degrees. This function is useful for getting angles in degrees when you do not know the input units until run-time.

Examples

Convert to Degrees from Radians

Convert several values to degrees from radians.

```
[D1,D2,D3,D4] = toDegrees("radians",pi/2,pi,3*pi/2,2*pi)
```

```
D1 = 90
```

```
D2 = 180
```

```
D3 = 270
```

```
D4 = 360
```

Convert the same values to degrees by specifying an array.

```
A = [pi/2 pi 3*pi/2 2*pi];
D = toDegrees("radians",A)
```

```
D = 1×4
```

```
    90    180    270    360
```

Input Arguments

fromUnits — Input unit

"degrees" | "radians"

Input unit, specified as "degrees" or "radians". You can also specify abbreviations such as "deg" and "rad".

Data Types: char | string

A1,...,An — Angles in degrees or radians

numeric array

Angles in degrees or radians, specified as one or more numeric arrays.

Output Arguments

D1, . . . , Dn — Angles in degrees

numeric array

Angles in degrees, returned as the same number of numeric arrays as in A_1, \dots, A_n . The size of each output array matches the size of the corresponding input array.

Version History

Introduced in R2007b

See Also

Functions

`fromDegrees` | `fromRadians` | `rad2deg` | `toRadians`

toRadians

Convert angles to radians

Syntax

```
[R1,...,Rn] = toRadians(fromUnits,A1,...,An)
```

Description

[R1,...,Rn] = toRadians(fromUnits,A1,...,An) converts the angles specified by A1,...,An from the units specified by fromUnits to radians. This function is useful for getting angles in radians when you do not know the input units until run-time.

Examples

Convert to Radians from Degrees

Convert several values to radians from degrees.

```
[R1,R2,R3,R4] = toRadians("degrees",45,90,135,180)
```

```
R1 = 0.7854
```

```
R2 = 1.5708
```

```
R3 = 2.3562
```

```
R4 = 3.1416
```

Convert the same values to radians by specifying an array.

```
A = [45 90 135 180];
R = toRadians("degrees",A)
```

```
R = 1×4
```

```
    0.7854    1.5708    2.3562    3.1416
```

Input Arguments

fromUnits — Input unit

"degrees" | "radians"

Input unit, specified as "degrees" or "radians". You can also specify abbreviations such as "deg" and "rad".

Data Types: char | string

A1,...,An — Angles in degrees or radians

numeric array

Angles in degrees or radians, specified as one or more numeric arrays.

Output Arguments

R1, . . . , Rn — Angles in radians

numeric array

Angles in radians, returned as the same number of numeric arrays as in A_1, \dots, A_n . The size of each output array matches the size of the corresponding input array.

Version History

Introduced in R2007b

See Also

Functions

fromDegrees | fromRadians | rad2deg | toDegrees

track

Geographic track points from waypoints

Syntax

```
[latrk,lonrk] = track(waypts)
[latrk,lonrk] = track(lat,lon)
[latrk,lonrk] = track( ____,units)

[latrk,lonrk] = track(lat,lon,ellipsoid)
[latrk,lonrk] = track(lat,lon,ellipsoid,units,npts)

[latrk,lonrk] = track(method, ____)
mat = track( ____)
```

Description

Track Points Along Unit Sphere

`[latrk,lonrk] = track(waypts)` finds the latitude and longitude coordinates of track points between the waypoints specified by `waypts`. This syntax references the coordinates to a unit sphere and calculates track points using rhumb lines.

`[latrk,lonrk] = track(lat,lon)` finds the coordinates of track points between the waypoints with coordinates `lat` and `lon`. This syntax is equivalent to `track(waypts)`, where `waypts = [lat lon]`.

`[latrk,lonrk] = track(____,units)` specifies the angle units `units` for the inputs and outputs.

Track Points Along Ellipsoid

`[latrk,lonrk] = track(lat,lon,ellipsoid)` specifies a reference ellipsoid for the coordinates.

`[latrk,lonrk] = track(lat,lon,ellipsoid,units,npts)` specifies the number of points to calculate between each waypoint.

Additional Options

`[latrk,lonrk] = track(method, ____,)`, where `method` is "gc", finds track points along great circles (for a sphere) or geodesics (for an ellipsoid). The default for `method` is "rh", which finds track points using rhumb lines.

`mat = track(____,)` returns the latitude and longitude coordinates of the track points in the matrix `mat`.

Examples

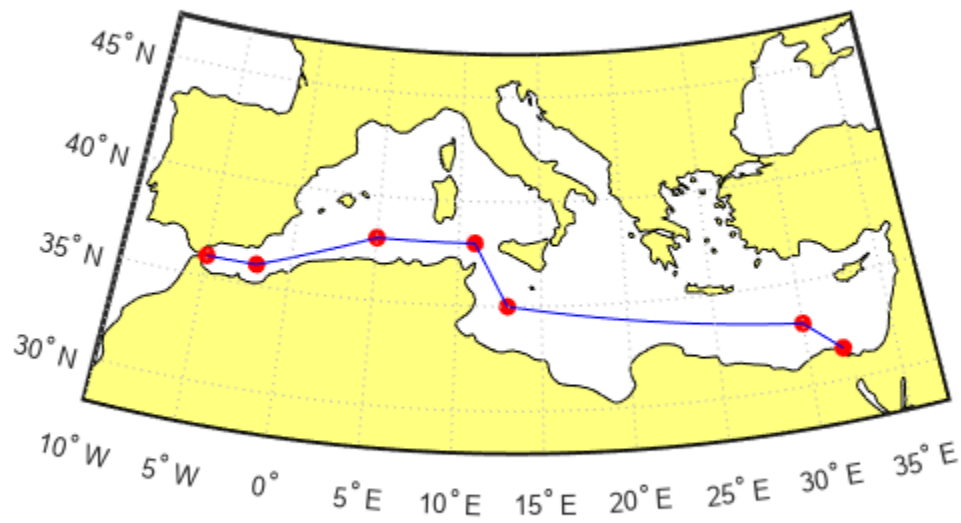
Find Track Points Between Waypoints

Specify the coordinates of several waypoints in the Mediterranean Sea. Then, find the coordinates of track points between the waypoints.

```
lat = [36 36 38 38 35 33 31.5];
lon = [-5 -2 5 11 13 30 32];
[latrk,lontrk] = track(lat,lon);
```

Create a map of the area. Display the waypoints using red circle markers and the track points using a blue line.

```
GT = readgeotable("landareas.shp");
worldmap([28 47],[-10 37])
geoshow(GT)
geoshow(lat,lon,"DisplayType","point","Marker","o","MarkerFaceColor","r")
geoshow(latrk,lontrk,"DisplayType","line","Color","b")
```



Find Track Points Along Ellipsoid

Import a shapefile containing worldwide land areas into the workspace as a geospatial table. Extract the reference ellipsoid for the land areas from the table.

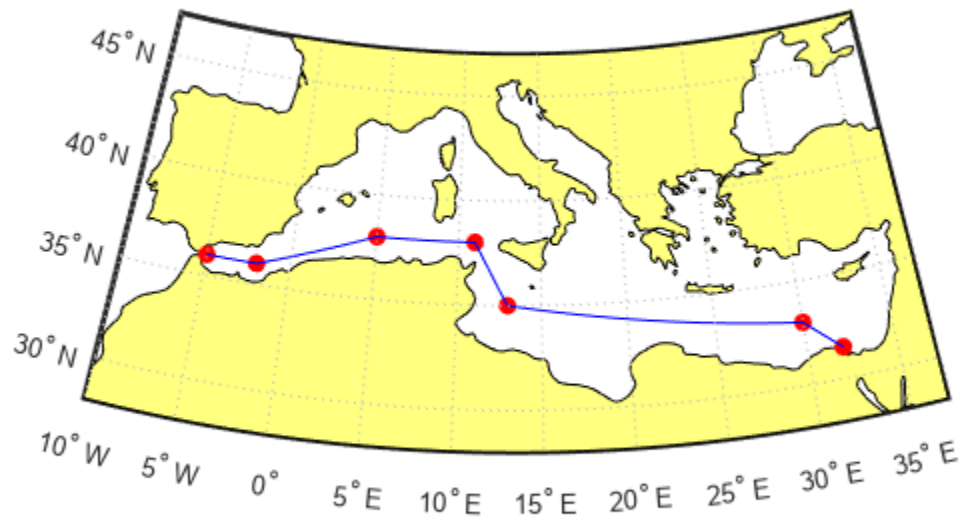
```
GT = readgeotable("landareas.shp");
ellipsoid = GT.Shape.GeographicCRS.Spheroid;
```

Specify the coordinates of several waypoints in an area surrounding the Mediterranean Sea. Then, reference the coordinates to the ellipsoid and find the coordinates of track points between the waypoints.

```
lat = [36 36 38 38 35 33 31.5];
lon = [-5 -2 5 11 13 30 32];
[lattrk,lontrk] = track(lat,lon,ellipsoid);
```

Create a map of the area. Display the waypoints using red circle markers and the track points using a blue line.

```
worldmap([28 47],[-10 37])
geoshow(GT)
geoshow(lat,lon,"DisplayType","point","Marker","o","MarkerFaceColor","r")
geoshow(lattrk,lontrk,"DisplayType","line","Color","b")
```



Input Arguments

waypts — Latitude and longitude coordinates of waypoints

two-column matrix

Latitude and longitude coordinates of the waypoints, specified as a two-column matrix. The first column of the matrix contains the latitude coordinates and the second column of the matrix contains the longitude coordinates.

Data Types: single | double

lat — Latitude coordinates of waypoints

vector

Latitude coordinates of the waypoints, specified as a vector.

The size of `lat` must match the size of `lon`.

Data Types: `single` | `double`

lon — Longitude coordinates of waypoints

vector

Longitude coordinates of the waypoints, specified as a vector.

The size of `lat` must match the size of `lon`.

Data Types: `single` | `double`

units — Angle unit`"degrees" (default) | "radians"`

Angle unit, specified as one of these options:

- `"degrees"` — Degrees
- `"radians"` — Radians

Data Types: `char` | `string`

ellipsoid — Reference ellipsoid`[1 0]` (default) | `referenceSphere` object | `referenceEllipsoid` object | `oblateSpheroid` object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element vector of the form `[semimajor_axis eccentricity]`, where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of `[1 0]` represents the unit sphere.

npts — Number of track points`30` (default) | positive integer

Number of track points to include between each waypoint, specified as a positive integer.

Data Types: `double`

method — Track method`"rh" (default) | "gc"`

Track method, specified as one of these options:

- `"rh"` — Find track points along rhumb line paths.
- `"gc"` — For spheres, find track points along great circle paths. For ellipsoids, find track points along geodesic paths.

For more information about rhumb lines and great circles, see “Comparison of Rhumb Lines and Great Circles”.

Data Types: char | string

Output Arguments

latrk – Latitude coordinates of track points

column vector

Latitude coordinates of the track points, returned as a column vector.

The `track` function separates the track points that connect each pair of waypoints by using NaN values. As a result, there is a NaN value every `npts` elements (excluding the last element).

lontrk – Longitude coordinates of track points

column vector

Longitude coordinates of the track points, returned as a column vector.

The `track` function separates the track points that connect each pair of waypoints by using NaN values. As a result, there is a NaN value every `npts` elements (excluding the last element).

mat – Latitude and longitude coordinates of track points

two-column matrix

Latitude and longitude coordinates of the track points, returned as a two-column matrix equivalent to `[latrk lontrk]`.

Version History

Introduced before R2006a

See Also

Functions

`track1` | `track2` | `gcwaypts`

Topics

“Comparison of Rhumb Lines and Great Circles”

track1

Geographic track points from starting point, azimuth, and range

Syntax

```
[latrk,lonrk] = track1(lat0,lon0,az)
[latrk,lonrk] = track1(lat0,lon0,az,arclen)
[latrk,lonrk] = track1(lat0,lon0,az,units)
[latrk,lonrk] = track1(lat0,lon0,az,arclen,units)

[latrk,lonrk] = track1(lat0,lon0,az,arclen,ellipsoid)
[latrk,lonrk] = track1(lat0,lon0,az,arclen,ellipsoid,units)
[latrk,lonrk] = track1(lat0,lon0,az,arclen,ellipsoid,units,npts)

[latrk,lonrk] = track1(method, ___ )
mat = track1( ___ )
```

Description

Track Points Along Unit Sphere

[latrk,lonrk] = track1(lat0,lon0,az) finds the latitude and longitude coordinates of track points along the great circle azimuth az starting at the point with coordinates lat0 and lon0. This syntax references the coordinates to a unit sphere and assumes that all input arguments are in degrees.

[latrk,lonrk] = track1(lat0,lon0,az,arclen) specifies the length of the track as the spherical distance arclen.

[latrk,lonrk] = track1(lat0,lon0,az,units) specifies the angle units units for the inputs and outputs.

[latrk,lonrk] = track1(lat0,lon0,az,arclen,units) specifies both the length of the track and the angle units.

Track Points Along Ellipsoid

[latrk,lonrk] = track1(lat0,lon0,az,arclen,ellipsoid) finds track points along a geodesic on the reference ellipsoid ellipsoid. In most cases, this syntax assumes that arclen is a linear distance in the units of the semimajor axis of the reference ellipsoid.

[latrk,lonrk] = track1(lat0,lon0,az,arclen,ellipsoid,units) additionally specifies the units for the azimuth and coordinates.

[latrk,lonrk] = track1(lat0,lon0,az,arclen,ellipsoid,units,npts) additionally specifies the number of track points to find.

Additional Options

[latrk,lonrk] = track1(method, ___), where method is "rh", calculates track points along rhumb lines. The default for method is "gc", which calculates track points along great circles (for spheres) or geodesics (for ellipsoids).

`mat = track1(___)` returns the latitude and longitude coordinates of the track points in the matrix `mat`.

Examples

Find Track Points Given Azimuth and Range

Find points along a great circle track from London to the point 600 nautical miles northwest of London. A northwest direction has an azimuth of 315 degrees. Convert 600 nautical miles to a spherical distance in degrees by using the `nm2deg` function.

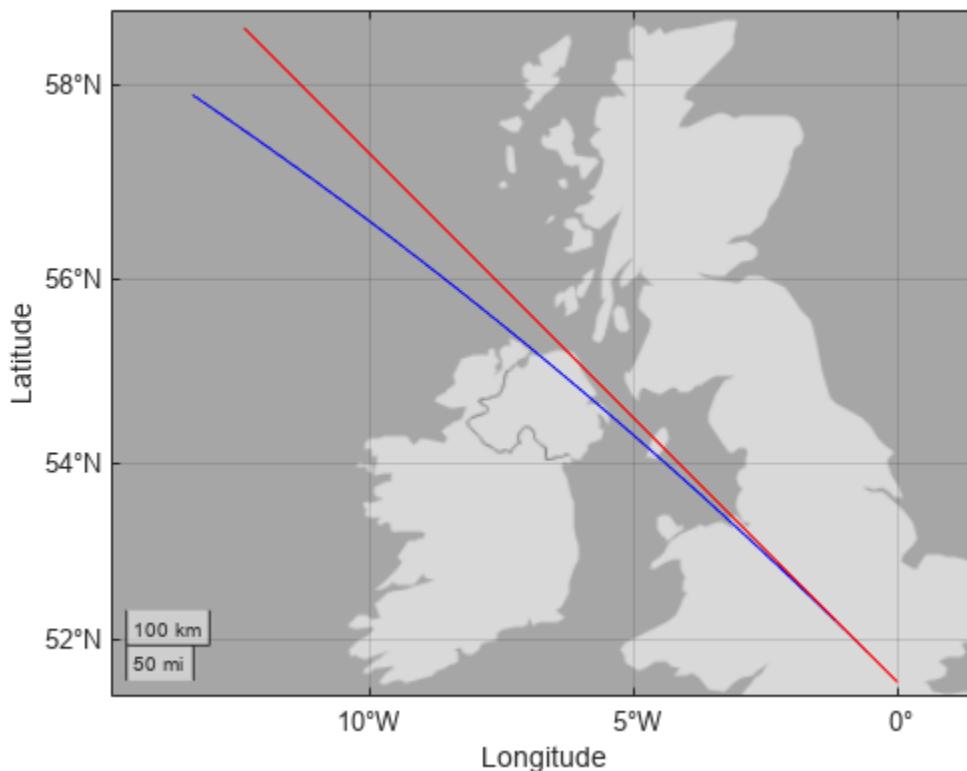
```
az = 315;
arclen = nm2deg(600);
[latgc, longc] = track1(51.5, 0, az, arclen);
```

Find points along a rhumb line track from London to the same point.

```
[latrh, lonrh] = track1("rh", 51.5, 0, az, arclen);
```

Compare the great circle and rhumb line tracks by displaying the track points on a map. Use a blue line for the great circle track and a red line for the rhumb line track.

```
geoplot(latgc, longc, "b")
hold on
geoplot(latrh, lonrh, "r")
geobasemap darkwater
```



Find Track Points Along Ellipsoid

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of nautical miles.

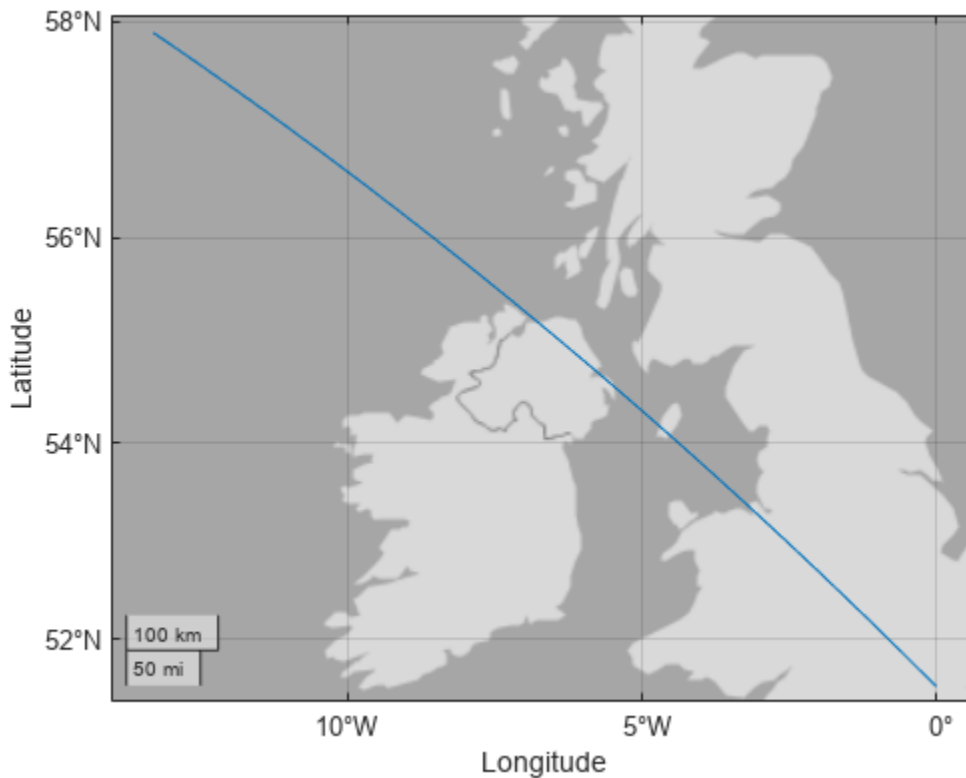
```
wgs84 = wgs84Ellipsoid("nm");
```

Find points along a geodesic track from London to the point 600 nautical miles northwest of London. When you specify a reference ellipsoid as input to the `track1` function, specify the arc length as a linear distance. A northwest direction has an azimuth of 315 degrees.

```
arclen = 600;  
az = 315;  
[latrkr,lontrkr] = track1(51.5,0,az,arclen,wgs84);
```

Display the track points on a map.

```
geoplot(latrkr,lontrkr)  
geobasemap darkwater
```



Input Arguments

lat0 — Latitude of input point

scalar | column vector

Latitude of the input point, specified as a scalar or column vector.

The sizes of `lat0` and `lon0` must match.

To find multiple tracks from a single starting point, specify `lat0` and `lon0` as scalars, `az` as a column vector, and `arclen` as a column vector or a two-column matrix.

Data Types: `single` | `double`

lon0 — Longitude of input point

scalar | column vector

Longitude of the input point, specified as a scalar or column vector.

The sizes of `lat0` and `lon0` must match.

To find multiple tracks from a single starting point, specify `lat0` and `lon0` as scalars, `az` as a column vector, and `arclen` as a column vector or a two-column matrix.

Data Types: `single` | `double`

az — Azimuth

scalar | column vector

Azimuth measured clockwise from north, specified as a scalar or column vector.

To find multiple tracks from a single starting point, specify `lat0` and `lon0` as scalars, `az` as a column vector, and `arclen` as a column vector or a two-column matrix.

Data Types: `single` | `double`

arclen — Length of track

[] (default) | scalar | column vector | two-column matrix

Length of the track, specified as a scalar, column vector, or two-column matrix.

The units of `arclen` depend on whether you specify the `ellipsoid` argument.

- When you do not specify a reference ellipsoid as input, specify `arclen` as a spherical distance in degrees. You can specify a spherical distance in radians by additionally using the `units` argument.
- In most cases, when you specify a reference ellipsoid as input, specify `arclen` as a linear distance in the units of the semimajor axis of the ellipsoid.

To find track points in a range, specify `arclen` as a two-column matrix. The `track1` function calculates track points between the distance in the first column and the distance in the second column from the starting point.

To find multiple tracks from a single starting point, specify `lat0` and `lon0` as scalars, `az` as a column vector, and `arclen` as a column vector or a two-column matrix.

The default for `arclen` is [], which finds points for the full track.

Data Types: `single` | `double`

units — Angle unit

`"degrees"` (default) | `"radians"`

Angle unit, specified as one of these options:

- `"degrees"` — Degrees
- `"radians"` — Radians

Data Types: `char` | `string`

ellipsoid — Reference ellipsoid

`[1 0]` (default) | `referenceSphere` object | `referenceEllipsoid` object | `oblateSpheroid` object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element vector of the form `[semimajor_axis eccentricity]`, where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of `[1 0]` represents the unit sphere.

In most cases, when you specify the `ellipsoid` argument, the `track1` function assumes that `arclen` is a linear distance in the units of the semimajor axis of the reference ellipsoid. The exceptions are when `ellipsoid` is `[]` or when the semimajor axis is `0`, in which case the `track1` function assumes `arclen` is a spherical distance.

method — Track method

`"gc"` (default) | `"rh"`

Track method, specified as one of these options:

- `"gc"` — `az` is a great circle azimuth (for spheres) or a geodesic azimuth (for ellipsoids).
- `"rh"` — `az` is a rhumb line azimuth.

For more information about rhumb lines and great circles, see “Comparison of Rhumb Lines and Great Circles”.

Data Types: `char` | `string`

npts — Number of track points

`100` (default) | scalar

Number of track points to include in `lattrk` and `lontrk`, specified as a scalar.

Data Types: `double`

Output Arguments**lattrk — Latitude coordinates of track points**

column vector | matrix

Latitude coordinates of the track points, returned as a column vector with `npts` elements or a matrix of size `npts-by-length(lat0)`. The function returns `latrk` as a column vector if `lat0` and `lon0` are scalars, and as a matrix if `lat0` and `lon0` are column vectors.

lonrk — Longitude coordinates of track points

column vector | matrix

Longitude coordinates of the track points, returned as a column vector with `npts` elements or a matrix of size `npts-by-length(lon0)`. The function returns `lonrk` as a column vector if `lat0` and `lon0` are scalars, and as a matrix if `lat0` and `lon0` are column vectors.

mat — Latitude and longitude coordinates of track points

matrix

Latitude and longitude coordinates of the track points, returned as a matrix equivalent to `[latrk lonrk]`.

Version History

Introduced before R2006a

See Also

Functions

`distance` | `track` | `track2` | `scircle1` | `scircle2`

Topics

“Comparison of Rhumb Lines and Great Circles”

track2

Geographic track points from starting and ending points

Syntax

```
[latrk,lonrk] = track2(lat1,lon1,lat2,lon2)
[latrk,lonrk] = track2(lat1,lon1,lat2,lon2,units)

[latrk,lonrk] = track2(lat1,lon1,lat2,lon2,ellipsoid)
[latrk,lonrk] = track2(lat1,lon1,lat2,lon2,ellipsoid,units)
[latrk,lonrk] = track2(lat1,lon1,lat2,lon2,ellipsoid,units,npts)

[latrk,lonrk] = track2(method, ___)
mat = track2(___)
```

Description

Track Points Along Unit Sphere

`[latrk,lonrk] = track2(lat1,lon1,lat2,lon2)` finds the latitude and longitude coordinates of points along a great circle track from the starting point with coordinates `lat1` and `lon1` to the ending point with coordinates `lat2` and `lon2`. This syntax references the coordinates to a unit sphere and assumes that all input arguments are in degrees.

`[latrk,lonrk] = track2(lat1,lon1,lat2,lon2,units)` specifies the angle units `units` for the inputs and outputs.

Track Points Along Ellipsoid

`[latrk,lonrk] = track2(lat1,lon1,lat2,lon2,ellipsoid)` finds track points along a geodesic on the reference ellipsoid `ellipsoid`.

`[latrk,lonrk] = track2(lat1,lon1,lat2,lon2,ellipsoid,units)` specifies both the reference ellipsoid and the units for the coordinates.

`[latrk,lonrk] = track2(lat1,lon1,lat2,lon2,ellipsoid,units,npts)` specifies the number of track points to find.

Additional Options

`[latrk,lonrk] = track2(method, ___)`, where `method` is "rh", calculates track points along rhumb lines. The default for `method` is "gc", which calculates track points along great circles (for spheres) or geodesics (for ellipsoids).

`mat = track2(___)` returns the latitude and longitude coordinates of the track points in the matrix `mat`.

Examples

Find Track Points Between Starting and Ending Points

Find points along a great circle track from New York City to Paris.

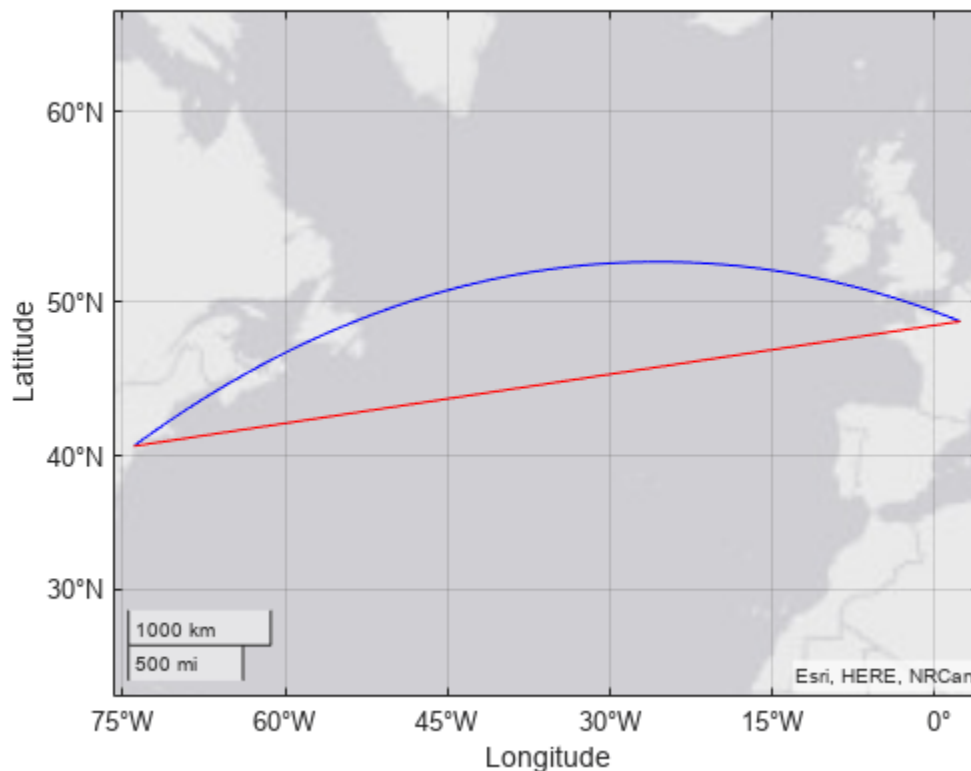
```
[latgc, longc] = track2(40.71, -74.01, 48.86, 2.35);
```

Find points along a rhumb line track between the same cities.

```
[latrh, lonrh] = track2("rh", 40.71, -74.01, 48.86, 2.35);
```

Compare the great circle and rhumb line tracks by displaying the track points on a map. Use a blue line for the great circle track and a red line for the rhumb line track.

```
geoplot(latgc, longc, "b")
hold on
geoplot(latrh, lonrh, "r")
```



Find Track Points Along Ellipsoid

Create a World Geodetic System of 1984 (WGS84) reference ellipsoid with a length unit of nautical miles.

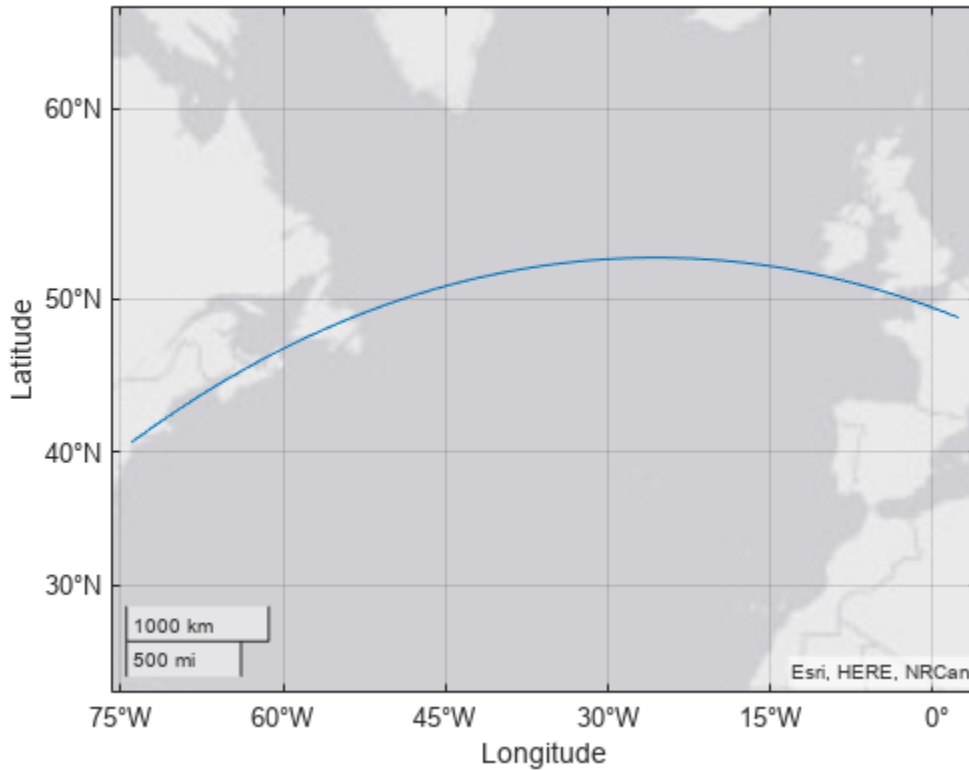
```
wgs84 = wgs84Ellipsoid("nm");
```

Find points along a geodesic track from New York City to Paris.

```
[latrk,lonrk] = track2(40.71,-74.01,48.86,2.35,wgs84);
```

Display the track on a map.

```
geoplot(latrk,lonrk)
```



Input Arguments

lat1 — Latitude of starting point

scalar | column vector

Latitude of the starting point, specified as a scalar or column vector.

The sizes of `lat1` and `lon1` must match.

To find multiple tracks from a single starting point, specify `lat1` and `lon1` as scalars and `lat2` and `lon2` as column vectors.

Data Types: `single` | `double`

lon1 — Longitude of starting point

scalar | column vector

Longitude of the starting point, specified as a scalar or column vector.

The sizes of `lat1` and `lon1` must match.

To find multiple tracks from a single starting point, specify `lat1` and `lon1` as scalars and `lat2` and `lon2` as column vectors.

Data Types: `single` | `double`

lat2 — Latitude of ending point

scalar | column vector

Latitude of the ending point, specified as a scalar or column vector.

The sizes of `lat2` and `lon2` must match.

To find multiple tracks from a single starting point, specify `lat1` and `lon1` as scalars and `lat2` and `lon2` as column vectors.

Data Types: `single` | `double`

lon2 — Longitude of ending point

scalar | column vector

Longitude of the ending point, specified as a scalar or column vector.

The sizes of `lat2` and `lon2` must match.

To find multiple tracks from a single starting point, specify `lat1` and `lon1` as scalars and `lat2` and `lon2` as column vectors.

Data Types: `single` | `double`

units — Angle unit

"degrees" (default) | "radians"

Angle unit, specified as one of these options:

- "degrees" — Degrees
- "radians" — Radians

Data Types: `char` | `string`

ellipsoid — Reference ellipsoid

[1 0] (default) | `referenceSphere` object | `referenceEllipsoid` object | `oblateSpheroid` object | two-element numeric vector

Reference ellipsoid, specified as a `referenceSphere` object, a `referenceEllipsoid` object, an `oblateSpheroid` object, or a two-element vector of the form [`semimajor_axis` `eccentricity`], where `semimajor_axis` is the length of the semimajor axis and `eccentricity` is the eccentricity. The values `semimajor_axis` and `eccentricity` must be of data type `double`.

The default value of [1 0] represents the unit sphere.

method — Track method

"gc" (default) | "rh"

Track method, specified as one of these options:

- "gc" — Find track points along a great circle path (for spheres) or a geodesic path (for ellipsoids).

- "rh" — Find track points along a rhumb line path.

For more information about rhumb lines and great circles, see “Comparison of Rhumb Lines and Great Circles”.

Data Types: `char` | `string`

npts — Number of track points

100 (default) | positive integer

Number of track points to include in `lattrk` and `lontrk`, specified as a positive integer.

Data Types: `double`

Output Arguments

lattrk — Latitude coordinates of track points

column vector | matrix

Latitude coordinates of the track points, returned as a column vector with `npts` elements or a matrix of size `npts-by-length(lat2)`. The function returns `lattrk` as a column vector if `lat2` and `lon2` are scalars, and as a matrix if `lat2` and `lon2` are column vectors.

lontrk — Longitude coordinates of track points

column vector | matrix

Longitude coordinates of the track points, returned as a column vector with `npts` elements or a matrix of size `npts-by-length(lon2)`. The function returns `lattrk` as a column vector if `lat2` and `lon2` are scalars, and as a matrix if `lat2` and `lon2` are column vectors.

mat — Latitude and longitude coordinates of track points

matrix

Latitude and longitude coordinates of the track points, returned as a matrix equivalent to `[lattrk lontrk]`.

Version History

Introduced before R2006a

See Also

Functions

`distance` | `track1` | `scircle1` | `scircle2`

Topics

“Comparison of Rhumb Lines and Great Circles”

trackg

Display great circle or rhumb line on axesm-based map using mouse

Syntax

```
h = trackg(ntrax)
h = trackg(ntrax,npts)
h = trackg(ntrax,LineStyle)
h = trackg(ntrax,PropertyName,PropertyValue,...)
[lat,lon] = trackg(ntrax,npts,...)
h = trackg(track,ntrax,...)
```

Description

`h = trackg(ntrax)` brings forward the current axesm-based map and waits for the user to make (2 x `ntrax`) mouse clicks. The output `h` is a vector of handles for the `ntrax` track segments, which are then displayed.

`h = trackg(ntrax,npts)` specifies the number of plotting points to be used for each track segment. `npts` is 100 by default.

`h = trackg(ntrax,LineStyle)` specifies the line style, marker, and color on page 1-1749.

`h = trackg(ntrax,PropertyName,PropertyValue,...)` allows property name/property value pairs to be set, where *PropertyName* and *PropertyValue* are recognized by the `line` function.

`[lat,lon] = trackg(ntrax,npts,...)` returns the coordinates of the plotted points rather than the handles of the track segments. Successive segments are stored in separate columns of `lat` and `lon`.


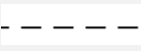

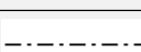
`h = trackg(track,ntrax,...)` specifies the logic with which tracks are calculated. If *track* is 'gc' (the default), a great circle path is used. If *track* is 'rh', rhumb line logic is used.
















This function is used to define great circles or rhumb lines for display using mouse clicks. For each track, two clicks are required, one for each endpoint of the desired track segment. You can modify the track after creation by **Shift**+clicking it. The track is then in edit mode, during which you can change the length and position by dragging control points, or by entering values into a control panel. **Shift**+clicking again exits edit mode.





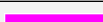
More About




Line Style, Marker, and Color

Specify the line style, marker, and color as a character vector or string containing symbols. The symbols can appear in any order. You do not need to specify all three characteristics (line style, marker, and color). For example, specify a red dashed line using ' - - r '.

Line Style	Description	Resulting Line
"_"	Solid line	
"--"	Dashed line	
":"	Dotted line	
"-."	Dash-dotted line	

Marker	Description	Resulting Marker
"o"	Circle	
"+"	Plus sign	
"*"	Asterisk	
"."	Point	
"x"	Cross	
"_"	Horizontal line	
" "	Vertical line	
"square"	Square	
"diamond"	Diamond	
"^"	Upward-pointing triangle	
"v"	Downward-pointing triangle	
">"	Right-pointing triangle	
"<"	Left-pointing triangle	
"pentagram"	Pentagram	
"hexagram"	Hexagram	

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	

Color Name	Short Name	RGB Triplet	Appearance
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Version History

Introduced before R2006a

See Also

[track1](#) | [track2](#) | [scircleg](#)

trimcart

Trim graphic objects to frame of axesm-based map

Syntax

```
trimcart(h)
```

Description

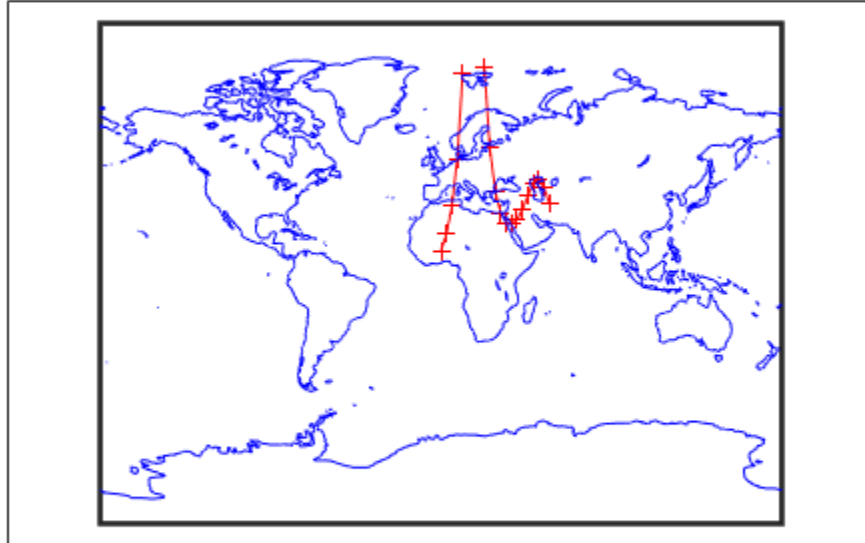
`trimcart(h)` clips the graphic objects to the map frame. `h` can be a handle or a vector of handles to graphics objects. `h` can also be any object name recognized by `handlem`. `trimcart` clips lines, surfaces, and text objects.

Examples

Trim Graphic Objects to Map Frame

Trim graphic objects to map frame.

```
figure;  
axesm('miller')  
framem  
[x, y] = humps(0:.05:1);  
h = plot(x, y/25, 'r+-');  
load coastlines  
geoshow(coastlat,coastlon)  
trimcart(h)
```



Limitations

trimcart does not trim patch objects.

Version History

Introduced before R2006a

See Also

handlem

trimdata

Trim map data exceeding projection limits

Syntax

```
[ymat,xmat,trimpts] = trimdata(ymat,ylim,xmat,xlim,object)
```

Description

`[ymat,xmat,trimpts] = trimdata(ymat,ylim,xmat,xlim,object)` identifies points in map data that exceed projection limits. The projection limits are defined by the lower and upper inputs. The particular object to be trimmed is identified by the `object` input.

Allowable objects are

- 'surface' for trimming graticules
- 'light' for trimming lights,
- 'line' for trimming lines
- 'patch' for trimming patches
- 'text' for trimming text object location points
- 'none' to skip all trimming operations

Version History

Introduced before R2006a

See Also

`clipdata` | `undotrim` | `undoclip`

undoclip

Remove object clips introduced by `clipdata`

Syntax

```
[lat,long] = undoclip(lat,long,clippts,'object')
```

Description

`[lat,long] = undoclip(lat,long,clippts,'object')` removes the object clips introduced by `clipdata`. This function is necessary to properly invert projected data from the Cartesian space to the original latitude and longitude data points.

The input variable, `clippts`, must be constructed by the function `clipdata`.

Allowable objects are

- 'surface' for trimming graticules
- 'light' for trimming lights
- 'line' for trimming lines
- 'patch' for trimming patches
- 'text' for trimming text object location points
- 'none' to skip all trimming operations

Version History

Introduced before R2006a

See Also

`clipdata` | `trimdata` | `undotrim`

undotrim

Remove object trims introduced by `trimdata`

Syntax

```
[ymat,xmat] = undotrim(ymat,xmat,trimpts,object)
```

Description

`[ymat,xmat] = undotrim(ymat,xmat,trimpts,object)` removes the object trims introduced by `trimdata`. This function is necessary to properly invert projected data from the Cartesian space to the original latitude and longitude data points.

The input variable, `trimpts`, must be constructed by the function `trimdata`.

Allowable objects are

- 'surface' for trimming graticules
- 'light' for trimming lights
- 'line' for trimming lines
- 'patch' for trimming patches
- 'text' for trimming text object location points
- 'none' to skip all trimming operations

Version History

Introduced before R2006a

See Also

`clipdata` | `trimdata` | `undoclip`

unitsratio

Conversion factor between units

Syntax

```
C = unitsratio(targetUnit,originalUnit)
```

Description

`C = unitsratio(targetUnit,originalUnit)` returns the conversion factor `C` between units so that a value in the original unit `originalUnit` multiplied by `C` provides the equivalent value in the target unit `targetUnit`.

Examples

Conversion Factor Between Units

Find the conversion factor for international feet to meters.

```
mPerFoot = unitsratio("meter", "feet")
```

```
mPerFoot = 0.3048
```

Convert 100 international feet to meters.

```
m = mPerFoot*100
```

```
m = 30.4800
```

Find the inverse conversion factor and multiply it by the `mPerFoot` conversion factor.

```
unitsratio("feet", "meter")*mPerFoot
```

```
ans = 1.0000
```

Input Arguments

originalUnit — Original unit of measure

"kilometer" | "kilometers" | "km" | "degree" | "degrees" | "deg" | ...

Original unit of measure, specified as one of these options:

- These angular units.

Value	Unit Name
"degree", "degrees", "deg"	Degrees
"radian", "radians", "rad"	Radians

- Any length unit supported by the `validateLengthUnit` function.

Value	Unit Name
"m", "meter", "meters", "metre", "metres"	Meters
"cm", "centimeter", "centimeters", "centimetre", "centimetres"	Centimeters
"mm", "millimeter", "millimeters", "millimetre", "millimetres"	Millimeters
"micron", "microns"	Microns
"km", "kilometer", "kilometers", "kilometre", "kilometers"	Kilometers
"nm", "naut mi", "nautical mile", "nautical miles"	Nautical miles
"ft", "international ft", "foot", "international foot", "feet", "international feet"	Feet
"in", "inch", "inches"	Inches
"yd", "yds", "yard", "yards"	Yards
"mi", "mile", "miles", "international mile", "international miles"	Miles
"sf", "survey ft", "US survey ft", "U.S. survey ft", "survey foot", "US survey foot", "U.S. survey foot", "survey feet", "US survey feet", "U.S. survey feet"	U.S. survey feet
"sm", "survey mile", "survey miles", "statute mile", "statute miles", "US survey mile", "US survey miles", "U.S. survey mile(s)", "U.S. survey miles"	U.S. survey miles (statute miles)
"Clarke's foot", "Clarkes foot"	Clarke's feet
"German legal metre", "German legal meter"	German legal metres
"Indian foot"	Indian feet

This argument is case insensitive.

Data Types: `char` | `string`

targetUnit – Target unit of measure

"kilometer" | "kilometers" | "km" | "degree" | "degrees" | "deg" | ...

Target unit of measure, specified as one of these options:

- These angular units.

Value	Unit Name
"degree", "degrees", "deg"	Degrees
"radian", "radians", "rad"	Radians

- Any length unit supported by the validateLengthUnit function.

Value	Unit Name
"m", "meter", "meters", "metre", "metres"	Meters
"cm", "centimeter", "centimeters", "centimetre", "centimetres"	Centimeters
"mm", "millimeter", "millimeters", "millimetre", "millimetres"	Millimeters
"micron", "microns"	Microns
"km", "kilometer", "kilometers", "kilometre", "kilometers"	Kilometers
"nm", "naut mi", "nautical mile", "nautical miles"	Nautical miles
"ft", "international ft", "foot", "international foot", "feet", "international feet"	Feet
"in", "inch", "inches"	Inches
"yd", "yds", "yard", "yards"	Yards
"mi", "mile", "miles", "international mile", "international miles"	Miles
"sf", "survey ft", "US survey ft", "U.S. survey ft", "survey foot", "US survey foot", "U.S. survey foot", "survey feet", "US survey feet", "U.S. survey feet"	U.S. survey feet
"sm", "survey mile", "survey miles", "statute mile", "statute miles", "US survey mile", "US survey miles", "U.S. survey mile(s)", "U.S. survey miles"	U.S. survey miles (statute miles)
"Clarke's foot", "Clarkes foot"	Clarke's feet
"German legal metre", "German legal meter"	German legal metres
"Indian foot"	Indian feet

This argument is case insensitive.

Data Types: char | string

Version History

Introduced before R2006a

See Also

Functions

`validateLengthUnit`

unwrapMultipart

Unwrap angles with parts separated by NaN values

Syntax

```
Q = unwrapMultipart(P)
Q = unwrapMultipart(P,angleUnit)
```

Description

`Q = unwrapMultipart(P)` unwraps the azimuths, longitudes, or phase angles in vector `P`. This syntax assumes the angle units are in radians. Whenever the jump between consecutive angles is greater than or equal to π radians, the function shifts the angles by adding multiples of $\pm 2\pi$ until the jump is less than π . When `P` includes multiple parts separated by NaN values, the function unwraps each part independently. When `P` has only one part, the result is equivalent to `unwrap(P)`.

`Q = unwrapMultipart(P,angleUnit)` specifies the angle units `angleUnit` of the angles in `P`. When `P` contains angles in degrees, specify `angleUnit` as "degrees". Whenever the jump between consecutive angles is greater than or equal to 180 degrees, this syntax shifts the angles by adding multiples of ± 360 until the jump is less than 180. The default for `angleUnit` is "radians", which specifies the units as radians.

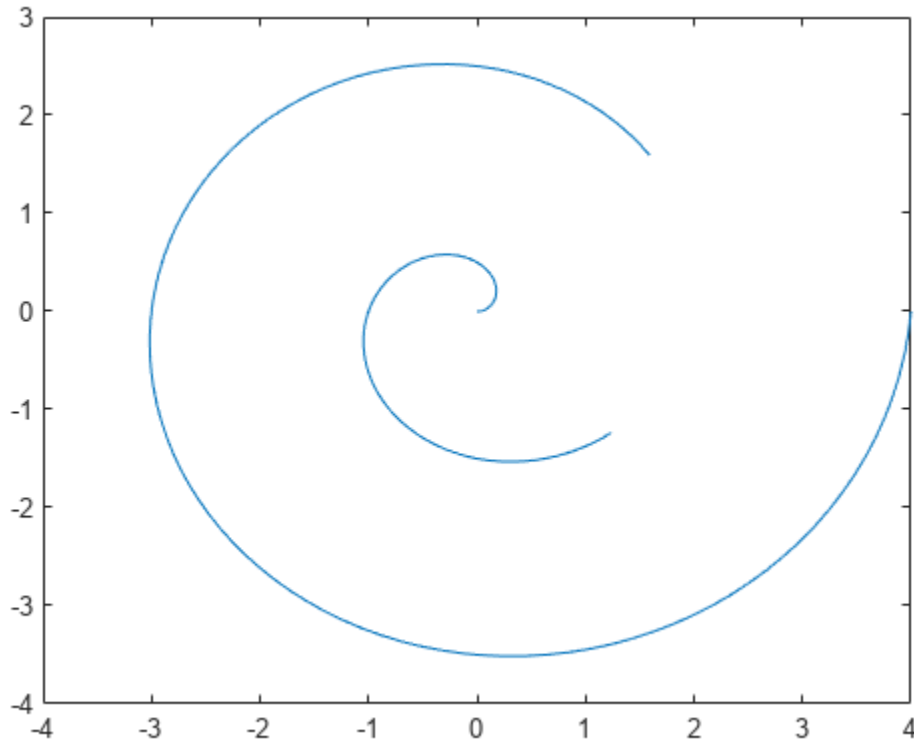
Examples

Unwrap Phase Angles Separated by NaN Values

Create a vector of phase angles from 0 to 4π that is separated into two parts by a NaN value. Use the phase angles to define the xy -coordinates of a spiral.

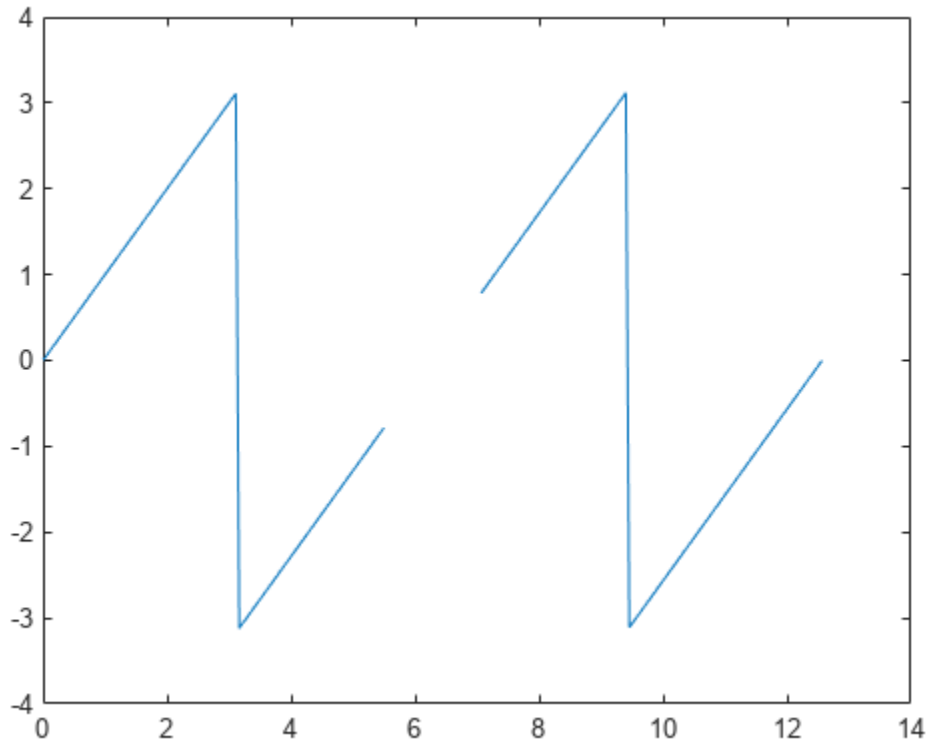
```
t1 = linspace(0,1.75*pi);
t2 = linspace(2.25*pi,4*pi);
t = [t1 NaN t2];

x = t/pi.*cos(t);
y = t/pi.*sin(t);
plot(x,y)
```



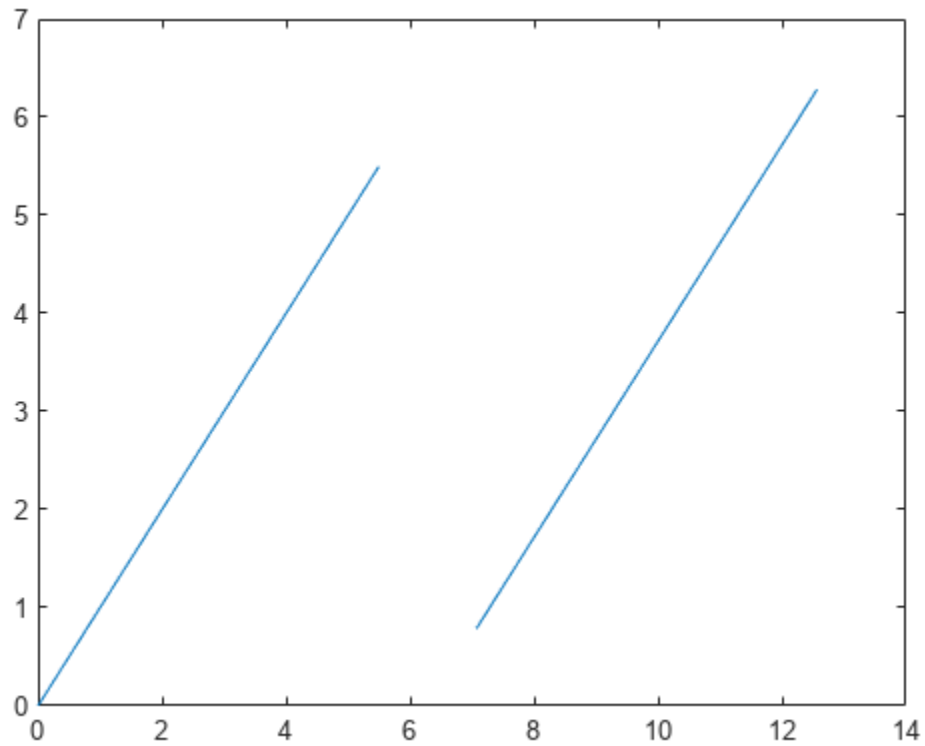
Find the phase angle of the spiral from the xy -coordinates by using the `atan2` function. The `atan2` function returns the angle values within the closed interval from $-\pi$ to π .

```
P = atan2(y,x);  
plot(t,P)
```

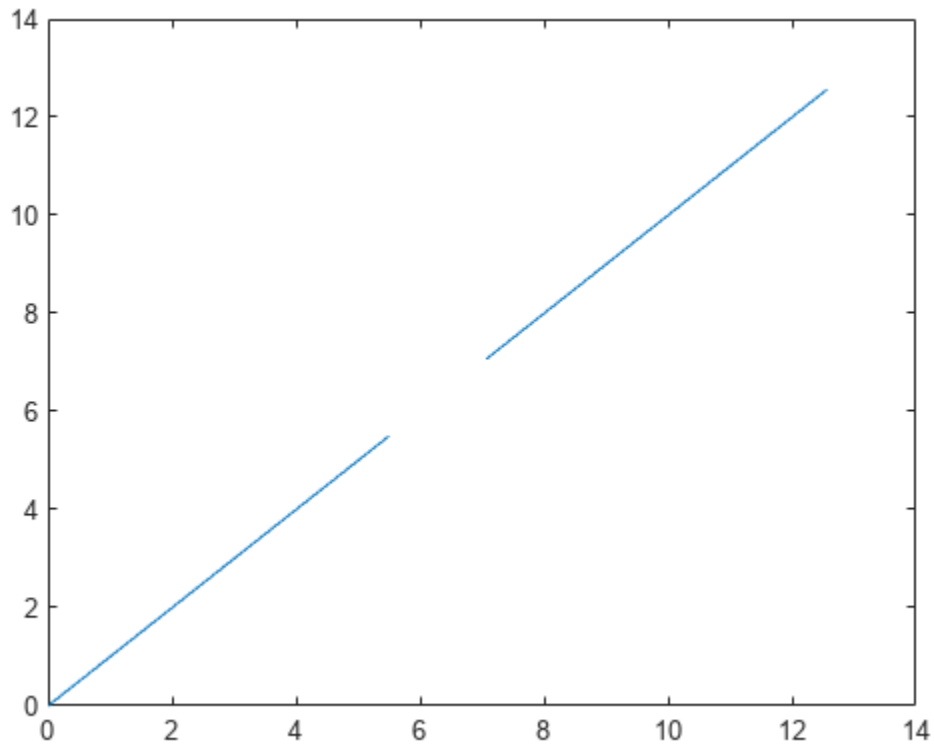
Note that the plot has discontinuities. Eliminate the discontinuities by using the `unwrapMultipart` function. The `unwrapMultipart` function independently unwraps the NaN-separated parts of the vector.

```
Q1 = unwrapMultipart(P);  
plot(t,Q1)
```



Compare the result with the `unwrap` function, which does not independently unwrap NaN-separated parts.

```
Q2 = unwrap(P);  
plot(t,Q2)
```



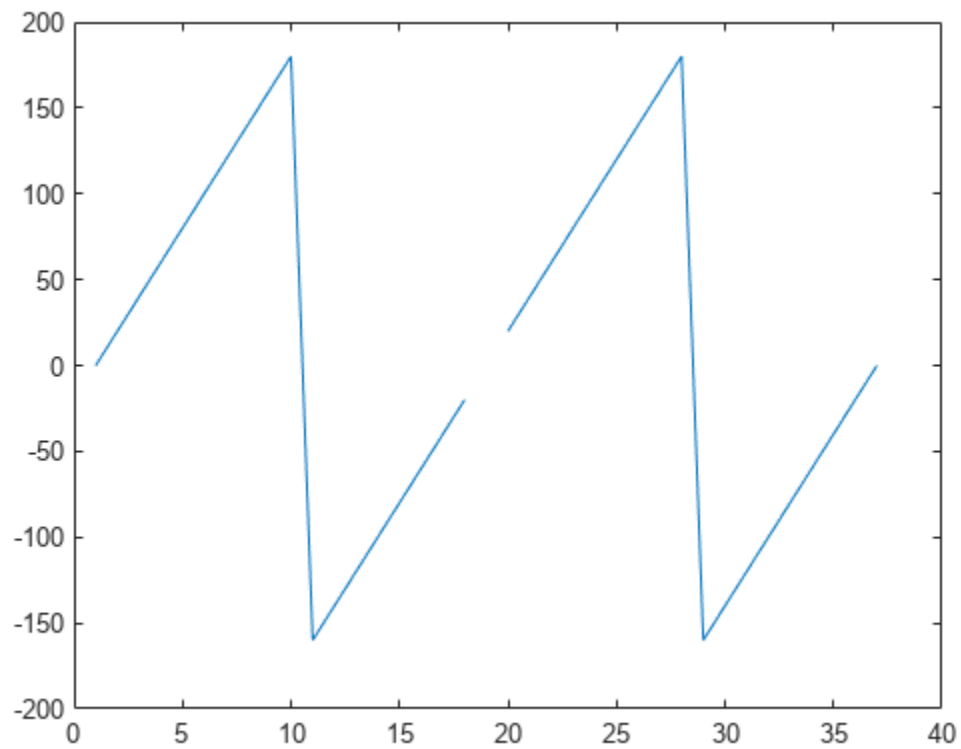
Unwrap Longitudes in Degrees

Create a vector of longitudes from 0 to 720 degrees that is separated into two parts by a NaN value.

```
lon = [0:20:340 NaN 380:20:720];
```

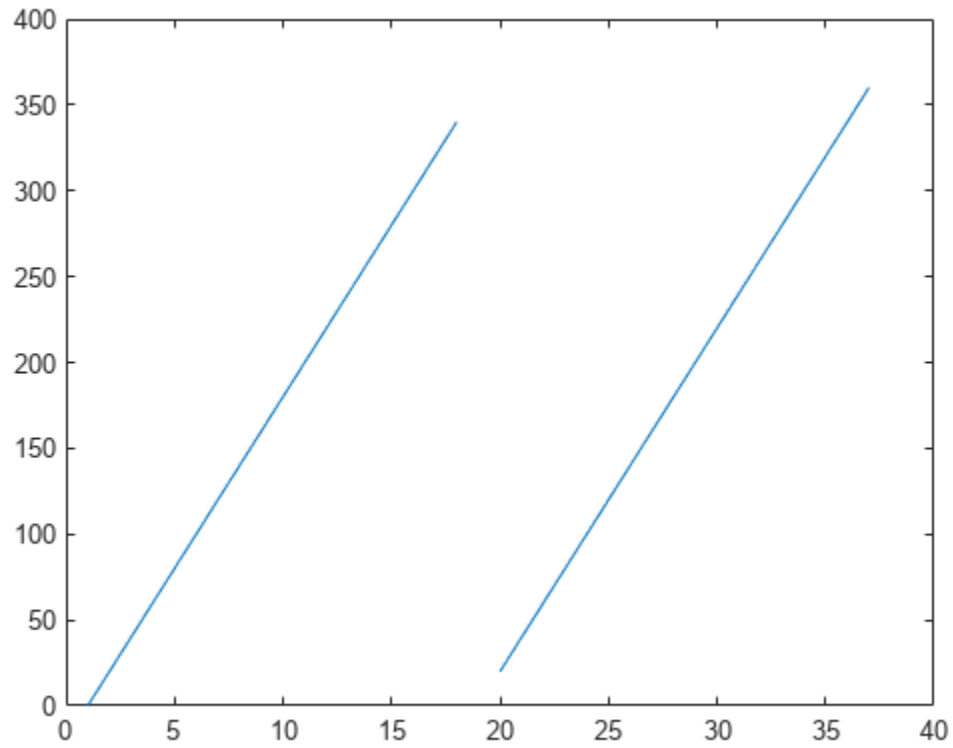
Wrap the longitudes to the closed interval from -180 to 180 degrees by using the `wrapTo180` function.

```
P = wrapTo180(lon);  
plot(P)
```



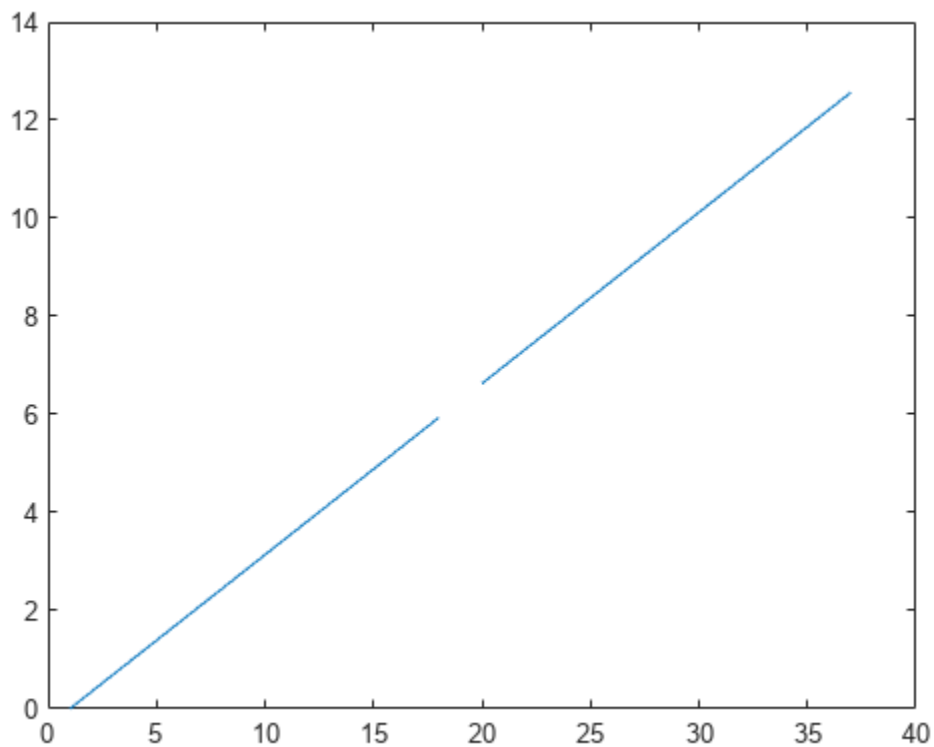
Unwrap the longitude angles by using the `unwrapMultiPart` function. The function independently unwraps the NaN-separated parts of the vector.

```
Q = unwrapMultiPart(P, "degrees");  
plot(Q)
```



Compare the result to the `unwrap` function, which works only in radians and does not independently unwrap NaN-separated parts.

```
rad = deg2rad(P);  
Q2 = unwrap(rad);  
plot(Q2)
```



Input Arguments

P — Input angles

vector

Input angles, specified as a row or column vector.

angleUnit — Angle unit

"radians" (default) | "degrees"

Angle unit, specified as one of these options:

- "degrees" — Degrees
- "radians" — Radians

Data Types: char | string

Output Arguments

Q — Unwrapped angles

vector

Unwrapped angles, returned as a vector of the same size as P. The NaN values in Q correspond to the NaN values in P.

Version History

Introduced in R2007b

See Also

Functions

[unwrap](#) | [wrapTo180](#) | [wrapTo360](#) | [wrapToPi](#) | [wrapTo2Pi](#)

updategeostruct

Convert line or patch display structure to geostruct

Syntax

```
geostruct = updategeostruct(displaystruct)
geostruct = updategeostruct(displaystruct, str)
[geostruct,symbolspec] = updategeostruct(displaystruct, ...)
[geostruct,symbolspec] = updategeostruct(displaystruct, ..., cmap)
```

Description

`geostruct = updategeostruct(displaystruct)` accepts a Mapping Toolbox display structure `displaystruct`. If `displaystruct` is a vector display structure for which the 'type' field has value 'line' or 'patch', `updategeostruct` restructures its elements to create a `geostruct`, `geostruct`. If `displaystruct` is a already geographic data structure, it is copied unaltered to `geostruct`. `updategeostruct` does not update display structure arrays of type 'text', 'light', 'regular', or 'surface'.

`geostruct = updategeostruct(displaystruct, str)` selects only elements whose `tag` field begins with the string scalar or character vector `str` (and whose `type` field is either 'line' or 'patch'). The selection is case insensitive.

`[geostruct,symbolspec] = updategeostruct(displaystruct, ...)` restructures a display structure and determines a `symbolspec` based on the graphic properties specified in the `otherproperty` field for each element of `displaystruct` and, if necessary, the `jet` colormap.

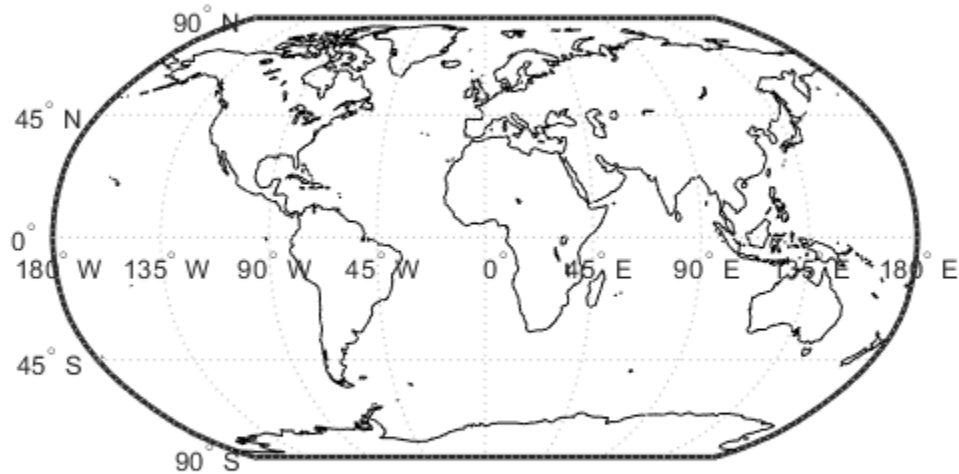
`[geostruct,symbolspec] = updategeostruct(displaystruct, ..., cmap)` specifies a colormap, `cmap`, to define the colors used in `symbolspec`.

Examples

Update and display a display structure of coastlines.

```
load coastlines
cmap = [0,0,0];
S = struct('lat',coastlat,'long',coastlon,'tag','coastlines', ...
    'type','line','altitude',[]);
[coastlines,spec] = updategeostruct(S,cmap);

figure
worldmap('world')
geoshow(coastlines,'SymbolSpec',spec)
```

Tips

There are two Mapping Toolbox encodings for vector features that use MATLAB structure arrays. In both cases there is one feature per array element, and in both cases a given array's elements all held the same type of feature. Version 1.3.1 and earlier of the Mapping Toolbox software only supported Mapping Toolbox display structures. Version 2.0 introduced a data structure for vector geodata which was less rigidly defined and more open-ended. The new structures are called `geostruct`s (if they contain geographic coordinate data) and `mapstruct`s (if they contain projected coordinate data). Over time, display structures are being phased out of the toolbox; the `updategeosruct` function is provided to help users migrate from the old display structure format to the current `geostruct`/`mapstruct` format.

A Version 1 Mapping Toolbox display structure is a MATLAB structure that can contain line, patch, text, regular data grid, geolocated data grid, and light objects. The `displaym` function does not accept `geostruct`s produced by Version 2 of the Mapping Toolbox software.

Display structures for lines and patches and `Line` and `Polygon` `geostruct`s have the following things in common:

- A field that specifies the type of feature geometry:
 - A `type` field a display structure (value: `'line'` or `'patch'`)
 - A `Geometry` field for a `geostruct` (value: `'Line'` or `'Polygon'`)
- A latitude field:

- `lat` for a display structure
- `Lat` for a geostruct
- A longitude field:
 - `long` for a display structure
 - `Lon` for a geostruct

In terms of their differences,

- A geostruct has a `BoundingBox` field; there is no display structure counterpart for this
- A geostruct typically has one or more “attribute” fields, whose values must be either scalar doubles or character vectors, with arbitrary field names. The presence or absence of a given attribute field—and its value—is dependent on the specific data set that the geostruct represents.
- A (line or patch) display structure has the following fields:
 - A `tag` field that names an individual feature or object
 - An `altitude` coordinate array that extends coordinates to 3-D
 - An `otherproperty` field in which MATLAB graphics can be specified explicitly, on a per-feature basis

Object properties used in the display are taken from the `otherproperty` field of the structure. If a line or patch object's `otherproperty` field is empty, `displaym` uses default colors. A patch is assigned an index into the current colormap based on the structure's `tag` field. Lines are assigned colors from the current color order according to their tags.

The newer geostruct representation has significant advantages:

- It can represent a much wider range of attributes (display structures essentially can represent only a feature name).
- The geostruct representation (in combination with `geoshow` and `makesymbolspec`) keeps graphics display properties separate from the intrinsic properties of the geographic features themselves.

For example, a road-class attribute can be used to display major highways with a distinctive color and greater line width than secondary roads. The same geographic data structure can be displayed in many different ways, without altering any of its contents, and shapefile data imported from external sources need not be altered to control its graphic display.

For information about the display structure format, see “Version 1 Display Structures” on page 1-319 in the reference page for `displaym`. For a discussion of the characteristics of geographic data structures, see “Geographic Data Structures”.

Version History

Introduced before R2006a

See Also

`displaym` | `geoshow` | `makesymbolspec` | `mapshow` | `shaperead`

updateLayers

Update layer properties

Syntax

```
[updatedLayer,index] = updateLayers(server,layer)
```

Description

[updatedLayer,index] = updateLayers(server,layer) returns an array of WMSLayer objects and updates the layer properties with values from the web map server, server. The WMSLayer array layer must contain only one unique ServerURL. The updateLayers function removes layers no longer available on the server. The logical array index contains true for each available layer.

Examples

Update Properties of Layer

Update the properties of a MODIS global mosaic layer obtained from the NASA Earth Observations WMS server.

Search the WMS Database for the layer.

```
neo = wmsfind("neo*nasa","SearchFields","serverurl");
modis = refine(neo,"land*day*month");
modis = modis(1);
```

Create a web map server object by specifying the server URL of the layer.

```
server = WebMapServer(modis.ServerURL);
```

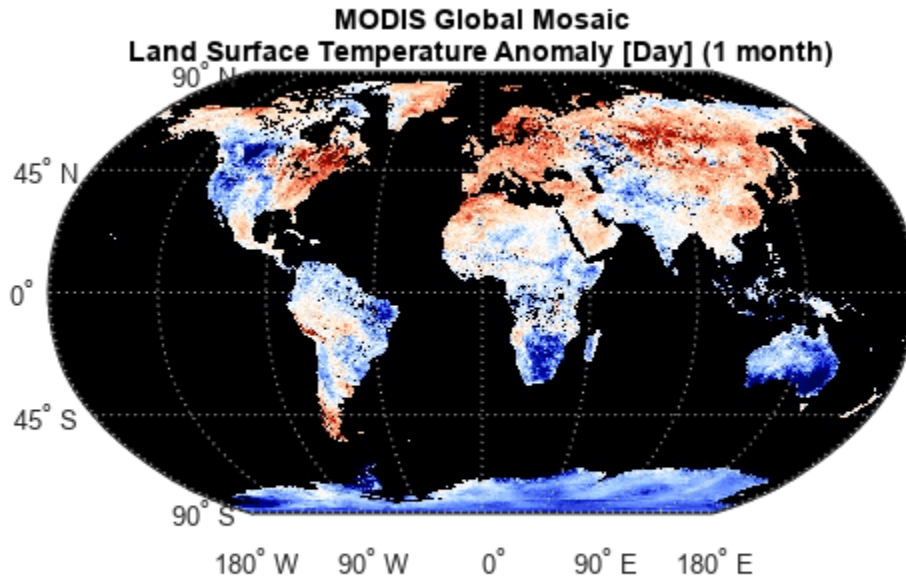
Update the properties of the layer by specifying the server and the layer.

```
updatedLayer = updateLayers(server,modis);
```

Read and display the map.

```
mapRequest = WMSMapRequest(updatedLayer,server);
A = getMap(server,mapRequest.RequestURL);
R = mapRequest.RasterReference;
```

```
figure
ax = worldmap(A,R);
geoshow(A,R)
setm(ax,"MLabelParallel",-90,"MLabelLocation",90)
title(["MODIS Global Mosaic" modis.LayerTitle])
```



The layer used in this example is courtesy of the NASA Earth Observations System.

Update Properties of Layers from Multiple Servers

Search the WMS Database for layers from USGS servers that contain the word "imagery" in the server URL.

```
usgsLayers = wmsfind('usgs*imagery', 'SearchField', 'serverurl');
```

Create an array called `updatedLayers`. Use a loop to find the layers for individual servers, update the properties of the layers, and append the updated layers to the array. Display a message to the command line if a server does not respond.

```
updatedLayers = [];
serverURLs = usgsLayers.servers;

for k=1:numel(serverURLs)
    serverLayers = refine(usgsLayers, serverURLs{k}, ...
        'SearchField', 'serverurl', 'MatchType', 'exact');
    serverURL = serverLayers(1).ServerURL;
    server = WebMapServer(serverURL);
    try
        layers = updateLayers(server, serverLayers);
        % Grow using concatenation because layers can have any
        % length ranging from 0 to numel(serverLayers).
    end
end
```

```
        updatedLayers = [updatedLayers; layers];
    catch e
        fprintf('Server %s is not responding.\n', ...
            serverURL);
        fprintf('Error message is %s\n', e.message)
    end
end
```

Input Arguments

server — Web map server

array of `WebMapServer` objects

Web map server, specified as an array of `WebMapServer` objects.

layer — Web map service layers

`WMSLayer` object

Web map service layer, specified as a `WMSLayer` object.

Output Arguments

updatedLayer — Updated web map service layers

array of `WMSLayer` objects.

Updated web map service layers, returned as an array of `WMSLayer` objects. `updatedLayers` has the same size as `layer(index)`.

index — Availability of layers

logical array

Availability of layers, returned as a logical array. `index` contains `true` for each available layer.

Tips

`updateLayers` accesses the Internet to update the properties. Occasionally, a WMS server is unavailable, or several minutes elapse before the properties are updated.

Version History

Introduced before R2006a

usamap

Create axesm-based map for United States of America

Syntax

```
usamap state
usamap(state)
usamap 'conus'
usamap('conus')
usamap
usamap(latlim,lonlim)
usamap(Z,R)
h = usamap(____)
h = usamap('all')
```

Description

`usamap state` and

`usamap(state)` create an empty axesm-based map (previously referred to as map axes) with a Lambert Conformal Conic projection and map limits covering a U.S. state or group of states specified by `state`. The axesm-based map is created in the current axes and the axis limits are set tight around the map frame.

`usamap 'conus'` and

`usamap('conus')` create an empty axesm-based map for the conterminous 48 states (that is, all states excluding Alaska and Hawaii).

`usamap` with no arguments presents a menu from which you can select a single state, the District of Columbia, the conterminous 48 states, or all states.

`usamap(latlim,lonlim)` creates an empty Lambert Conformal axesm-based map for a region of the U.S. defined by its latitude and longitude limits in degrees.

`usamap(Z,R)` derives the map limits from the extent of a regular data grid, `Z`, georeferenced by `R`.

`h = usamap(____)` returns the handle of the axesm-based map.

`h = usamap('all')` constructs three empty axesm-based maps, inset within a single figure, for the conterminous states, Alaska, and Hawaii, with a spherical Earth model and other projection parameters suggested by the U.S. Geological Survey. The maps in the three axes are shown at approximately the same scale. The handles for the three axesm-based maps are returned in `h`.

`usamap('allequal')` is the same as `usamap('all')`, but usage of `'allequal'` will be removed in a future release.

Examples

Make a Map of Alabama

Make a map of the state of Alabama only.

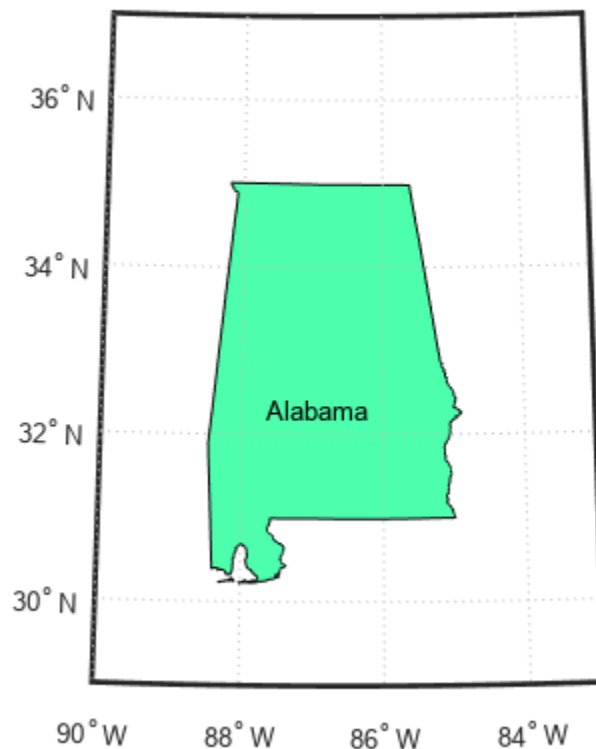
```
figure
usamap("Alabama")

states = readgeotable("usastatehi.shp");
row = states.Name == "Alabama";
alabama = states(row,:);

geoshow(alabama,"FaceColor",[0.3 1.0, 0.675])

Label the state by adding text.

textm(alabama.LabelLat,alabama.LabelLon,alabama.Name, ...
      "HorizontalAlignment","center")
```



Map a Region Extending From California to Montana

Create a map of a contiguous landmass that contains California and Montana.

```
figure
ax = usamap({'CA','MT'});
set(ax,'Visible','off')
```

```
states = readgeotable('usastatehi.shp');
geoshow(states, 'FaceColor', [0.5 0.5 1])
```

Add labels to the states that are within the map limits.

```
latlim = getm(ax, 'MapLatLimit');
lonlim = getm(ax, 'MapLonLimit');

lat = states.LabelLat;
lon = states.LabelLon;
tf = ingeoquad(lat, lon, latlim, lonlim);
textm(lat(tf), lon(tf), states.Name(tf), ...
      'HorizontalAlignment', 'center')
```



Map the Conterminous United States

Map the conterminous United States. Color each state using a random, muted color.

```
figure
usamap("conus");

states = readgeotable("usastatelo.shp");
rows = states.Name ~= "Alaska" & states.Name ~= "Hawaii";
states = states(rows,:);
```



```

h = height(states);
faceColors = makesymbolspec("Polygon",...
    {'INDEX',[1 h],'FaceColor',polcmap(h)});

geoshow(states,"DisplayType","polygon","SymbolSpec",faceColors)

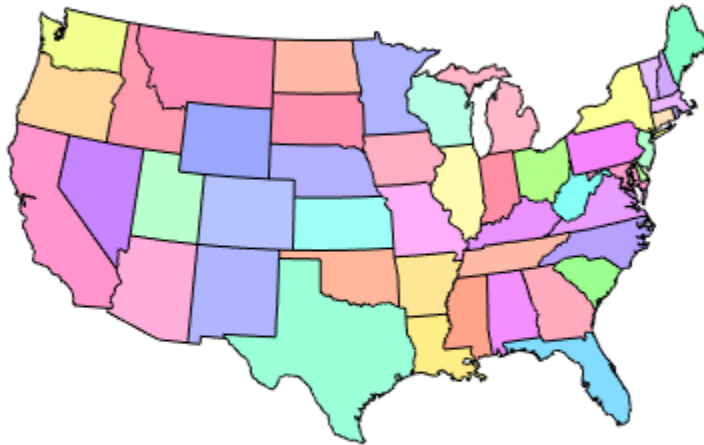
Set optional display settings.

```

```

framem off
gridm off
mlabel off
plabel off

```



Map the USA Including Alaska and Hawaii

Read a shapefile, containing polygon shapes for each of the US states and the District of Columbia, into a geospatial table. Find the table rows for the conterminous USA, Alaska, and Hawaii.

```

states = readgeotable("usastatelo.shp");
rowConus = states.Name ~= "Hawaii" & states.Name ~= "Alaska";
rowAlaska = states.Name == "Alaska";
rowHawaii = states.Name == "Hawaii";

```

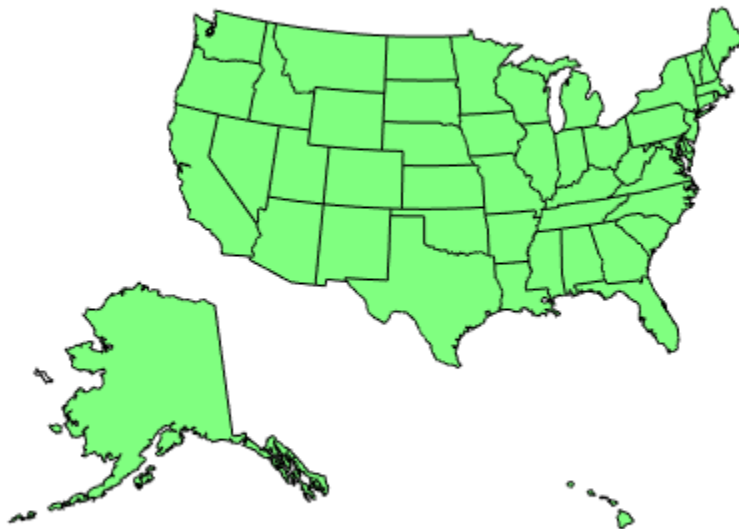
Display each of the three regions on separate axes.

```
figure
ax = usamap("all");
set(ax,"Visible","off")
stateColor = [0.5 1 0.5];

geoshow(ax(1),states(rowConus,:), "FaceColor",stateColor)
geoshow(ax(2),states(rowAlaska,:), "FaceColor",stateColor)
geoshow(ax(3),states(rowHawaii,:), "FaceColor",stateColor)
```

Hide the frame.

```
for k = 1:3
    setm(ax(k),"Frame","off","Grid","off",...
        "ParallelLabel","off","MeridianLabel","off")
end
```



Input Arguments

state — State to display

character vector | string scalar | string array | cell array of character vectors | 'District of Columbia' | 'Alabama' | 'AL' | 'Alaska' | 'AK' | ...

State to display, specified as a string scalar, string array, character vector or cell array of character vectors. Permissible values include names of states, standard two-letter U.S. Postal Service abbreviations for states, and 'District of Columbia'.

Example: `usamap({'Maine', 'Florida'})` sets the map limits to cover the region spanning from Maine to Florida.

latlim — Latitude limits

two-element vector

Latitude limits, specified as a two-element vector of the form `[southern_limit northern_limit]`.

lonlim — Longitude limits

two-element vector

Longitude limits, specified as a two-element vector of the form `[western_limit eastern_limit]`.

Z — Data grid

M-by-*N* array

Data grid, specified as an *M*-by-*N* array. *Z* is a regular data grid associated with a geographic reference *R*.

R — Geographic reference

geographic raster reference object | vector | matrix

Geographic reference, specified as one of the following.

Type	Description
Geographic raster reference object	GeographicCellsReference or GeographicPostingsReference geographic raster reference object. The RasterSize property must be consistent with the size of the data grid, <code>size(Z)</code> .
Vector	1-by-3 numeric vector with elements: <code>[cells/degree northern_latitude_limit western_longitude_limit]</code>
Matrix	3-by-2 numeric matrix that transforms raster row and column indices to or from geographic coordinates according to: $[\text{lon } \text{lat}] = [\text{row } \text{col } 1] * R$ <i>R</i> defines a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel.

For more information about referencing vectors and matrices, see “Georeferenced Raster Data”.

Output Arguments

h — Handle of the axesm-based map

handle object | array of handle objects

Handle of the axesm-based map, returned as a handle object.

If you use the syntax `h = usamap('all')`, then *h* is array of handle objects. `h(1)` is for the conterminous states, `h(2)` is for Alaska, and `h(3)` is for Hawaii.

Tips

- All axes created with `usamap` are initialized with a spherical Earth model having a radius of 6,371,000 meters.
- In some cases, `usamap` uses `tightmap` to adjust the axis limits tight around the map. If you change the projection, or just want more white space around the map frame, use `tightmap` again or `axis auto`.
- `axes(h(n))`, where `n = 1, 2, or 3`, makes the desired axes current.
- `set(h, 'Visible', 'on')` makes the axes visible.
- `axesscale(h(1))` resizes the axes containing Alaska and Hawaii to the same scale as the conterminous states.

Version History

Introduced before R2006a

See Also

`axesm` | `axesscale` | `geoshow` | `paperscale` | `plottedit` | `tightmap` | `worldmap`

usgs24kdem

(To be removed) Read USGS 7.5 minute (30 meter or 10 meter) Digital Elevation Models

Note usgs24kdem will be removed in a future release. Use `readgeoraster` instead. For more information, see “Compatibility Considerations”.

Syntax

```
[lat,lon,Z] = usgs24kdem
[lat,lon,Z] = usgs24kdem(filename)
[lat,lon,Z] = usgs24kdem(filename,samplefactor)
[lat,lon,Z] = usgs24kdem(filename,samplefactor,latlim,lonlim)
[lat,lon,Z] = usgs24kdem(filename,samplefactor,latlim,lonlim,gsize)
[lat,lon,Z,header,profile] = usgs24kdem( ___ )
```

Description

[lat,lon,Z] = usgs24kdem reads a USGS 1:24,000 digital elevation map (DEM) file in standard format. You select the file interactively. usgs24kdem reads the entire file, subsampled by a factor of 5, returning a geolocated data grid with a latitude array, `lat`, longitude array, `lon`, and an elevation array, `Z`. Horizontal units are in degrees, vertical units might vary. The 1:24,000 series of DEMs store data as a grid of elevations spaced either at 10 or 30 meters apart. The number of points in a file varies with the geographic location.

[lat,lon,Z] = usgs24kdem(filename) reads the USGS DEM specified by filename and returns the result as a geolocated data grid.

[lat,lon,Z] = usgs24kdem(filename,samplefactor) reads a subset of the DEM data from filename, where samplefactor is a scalar integer that specifies the sample frequency.

[lat,lon,Z] = usgs24kdem(filename,samplefactor,latlim,lonlim) reads the subset of the elevation data from filename specified by the two-element vectors latlim and lonlim. You specify the latitude and longitude limits in degrees. Elements in the vectors must be in ascending order. The data might extend outside the requested area.

[lat,lon,Z] = usgs24kdem(filename,samplefactor,latlim,lonlim,gsize) specifies the graticule size in gsize. gsize is a two-element vector specifying the number of rows and columns in the latitude and longitude coordinated grid.

[lat,lon,Z,header,profile] = usgs24kdem(___) also returns the contents of the header and raw profiles of the DEM file. The header structure contains descriptions of the data from the file header. The profile structure is the raw profile data from which the geolocated data grid is constructed.

Examples

Read USGS 24K DEM File

This example shows how to read a USGS 24K Digital Elevation Model file.

Unzip a USGS 24K DEM file. The toolbox includes a DEM file `sanfranciscos.dem.gz`.

```
filenames = gunzip('sanfranciscos.dem.gz',tempdir);  
demFilename = filenames{1};
```

Read every other point of the 1:24,000 DEM file.

```
[lat,lon,Z,header,profile] = usgs24kdem(demFilename,2);
```

Delete the temporary gunzipped file.

```
delete(demFilename)
```

As no negative elevations exist, move all points at sea level to -1 to color them blue.

```
Z(Z==0) = -1;
```

Compute the latitude and longitude limits for the DEM.

```
latlim = [min(lat(:)) max(lat(:))]  
lonlim = [min(lon(:)) max(lon(:))]
```

```
latlim =
```

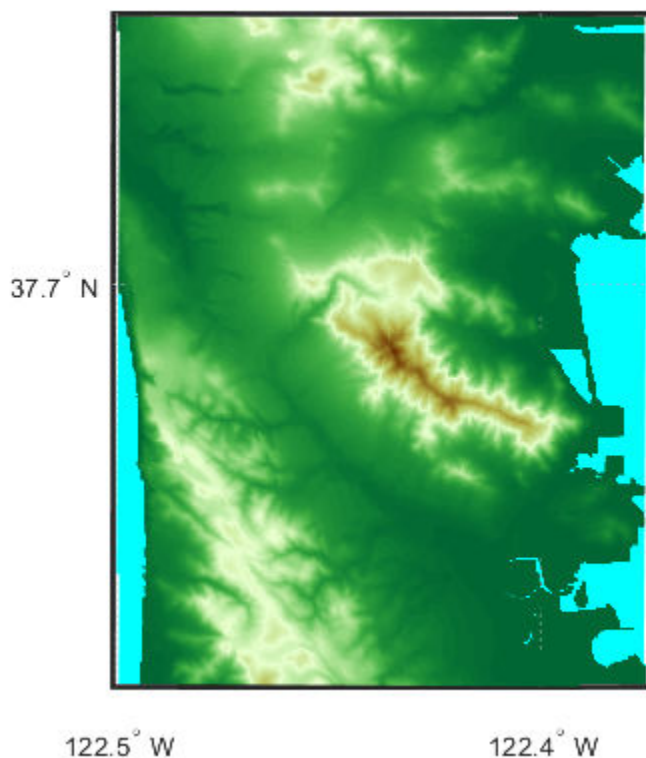
```
    37.6249    37.7504
```

```
lonlim =
```

```
   -122.5008  -122.3740
```

Display the DEM values.

```
figure  
usamap(latlim,lonlim)  
geoshow(lat,lon,Z,'DisplayType','surface')  
demcmap(Z)  
daspectm('m',1)
```



Input Arguments

filename — Name of file containing the digital elevation map

string scalar | character array

Name of file containing the digital elevation map, specified as a string scalar or character array.

Data Types: char | string

samplefactor — Data sampling factor

5 (default) | scalar integer

Data sampling factor, specified as a scalar integer. For example, if `samplefactor` is equal to 1, `usgs24kdem` reads the data at its full resolution, that is, every pixel. If you specify a `samplefactor` value `n` that is greater than 1, `usgs24kdem` reads every `n`th point.

Data Types: double

latlim — Limits of the desired data

two-element vector

Limits of the desired data, specified as a two-element vector, in degrees. The limits must be in ascending order. The data might extend outside the requested area.

Data Types: double

lonlim — Limits of desired data

two-element vector

Limits of desired data, specified as a two-element vector, in degrees.

Data Types: double

gsize — Graticule size

same size as geolocated data grid (default) | two-element vector

Graticule size, specified as a two-element vector. `gsize` specifies the number of rows and columns in the latitude and longitude coordinated grid. If omitted, `usgs24kdem` returns a graticule the same size as the geolocated data grid. To specify the coordinated grid size without specifying the geographic limits, use empty matrices for `latlim` and `lonlim`.

Data Types: double

Output Arguments**lat — Latitude array**

matrix of class double

Latitude array, returned as a matrix of class double.

lon — Longitude array

matrix of class double

Longitude array, returned as a matrix of class double.

Z — Elevation array

matrix of class double

Elevation array, returned as a matrix of class double.

header — Descriptions of the data from the file header

struct

Descriptions of the data from the file header, returned as a struct.

profile — Raw profile data from which the geolocated data grid is constructed

struct

Raw profile data from which the geolocated data grid is constructed, returned as a struct.

Tips

- The U.S. Geological Survey has created a series of digital elevation models based on their paper 1:24,000 scale maps. The grid spacing for these elevations models is either 10 meters or 30 meters on a Universal Transverse Mercator grid. Each file covers a 7.5-minute quadrangle. The map and data series are available for much of the conterminous United States, Hawaii, and Puerto Rico. The data has been released in several formats. This function reads the data in the “standard” file format.
- This function reads USGS DEM files stored in the UTM projection. The function unprojects the grid back to latitude and longitude. Use `usgsdem` for data stored in geographic grids.

- The number of points in a file varies with the geographic location. Unlike the USGS DEM products, which use an equal-angle grid, the UTM projection grid DEMs cannot simply be concatenated to cover larger areas. There can be data gaps between DEMs.
- You can obtain the data files from the U.S. Geological Survey and from commercial vendors . Other agencies have made some local area data available online. See “Find Geospatial Data Online”. The DEM files are ASCII files, and can be transferred as text. Line-ending conversion is not necessarily required.

Version History

Introduced before R2006a

R2021b: Warns

Warns starting in R2021b

Some raster reading functions that return latitude-longitude grids issue a warning that they will be removed in a future release, including `usgs24kdem`. Instead, use `readgeoraster`, which returns a map raster reference object. Reference objects have several advantages over latitude-longitude grids.

- Unlike latitude-longitude grids, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns. For more information about reference object properties, see `MapCellsReference` and `MapPostingsReference`.
- You can manipulate the limits of rasters associated with reference objects using the `mapcrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `mapresize` function.

Get metadata about files using the `georasterinfo` function.

This table shows some typical usages of `usgs24kdem` and how to update your code to use `readgeoraster`.

Will Be Removed	Recommended
<code>[latgrat, longrat, z] = usgs24kdem(filename);</code>	<code>[Z,R] = readgeoraster(filename);</code>
<code>[latgrat, longrat, z] = usgs24kdem(filename, samplefactor);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>[Z,R] = georesize(Z,R,1/samplefactor);</code>
<code>[latgrat, longrat, z] = usgs24kdem(filename, latlim, lonlim);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>[Z,R] = geocrop(Z,R,latlim,lonlim);</code> <code>[Z,R] = georesize(Z,R,1/samplefactor);</code>
<code>[latgrat, longrat, z, header, profile] = usgs24kdem(filename);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>info = georasterinfo(filename);</code>

The `readgeoraster` function returns data using the native data type embedded in the file. Return a different data type by specifying the 'OutputType' name-value pair. For example, use `[Z,R] = readgeoraster(filename, 'OutputType', 'double')`.

The `readgeoraster` function does not automatically replace missing data with NaN values. If your data set uses large negative numbers to indicate missing data, replace them with NaN values using the `standardizeMissing` function.

```
[Z,R] = readgeoraster('MtWashington-ft.grd');
info = georasterinfo('MtWashington-ft.grd');
```

```
m = info.MissingDataIndicator;  
Z = standardizeMissing(Z,m);
```

R2020a: To be removed

Not recommended starting in R2020a

The `usgs24kdem` function runs without warning but will be removed in a future release.

See Also

`usgsdems` | `readgeoraster` | `georasterinfo`

usgsdem

(To be removed) Read USGS 1-degree (3-arc-second) Digital Elevation Model

Note usgsdem will be removed in a future release. Use `readgeoraster` instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z,refvec] = usgsdem(filename,scalefactor)
[Z,refvec] = usgsdem(filename,scalefactor,latlim,lonlim)
```

Description

`[Z,refvec] = usgsdem(filename,scalefactor)` reads the specified file and returns the data in a regular data grid along with referencing vector `refvec`, a 1-by-3 vector having elements `[cells/degree north-latitude west-longitude]` with latitude and longitude limits specified in degrees. The data can be read at full resolution (`scalefactor = 1`), or can be downsampled by the `scalefactor`. A `scalefactor` of 3 returns every third point, giving 1/3 of the full resolution.

`[Z,refvec] = usgsdem(filename,scalefactor,latlim,lonlim)` reads data within the latitude and longitude limits. These limits are two-element vectors with the minimum and maximum values specified in units of degrees.

Background

The U.S. Geological Survey has made available a set of digital elevation maps of 1-degree quadrangles covering the contiguous United States, Hawaii, and limited portions of Alaska. The data is on a regular grid with a spacing of 30 arc-seconds (or about 100-meter resolution). 1-degree DEMs are also referred to as *3-arc-second* or *1:250,000 scale* DEM data.

The data is derived from the U.S. Defense Mapping Agency's DTED-1 digital elevation model, which itself was derived from cartographic and photographic sources. The cartographic sources were maps from the 7.5-minute through 1-degree series (1:24,000 scale through 1:250,000 scale).

Examples

Read every fifth point in the file containing part of Rhode Island and Cape Cod.

```
[Z,refvec] = usgsdem('providence-e',5);
```

Tips

The grid for the digital elevation maps is based on the 1984 World Geodetic System (WGS84). Older DEMs were based on WGS72. Elevations are in meters relative to National Geodetic Vertical Datum of 1929 (NGVD 29) in the continental U.S. and local mean sea level in Hawaii.

The absolute horizontal accuracy of the DEMs is 130 meters, while the absolute vertical accuracy is ± 30 meters. The relative horizontal and vertical accuracy is not specified, but is probably much better than the absolute accuracy.

These DEMs have a grid spacing of 3 arc-seconds in both the latitude and longitude directions. The exception is DEM data in Alaska, where latitudes between 50 and 70 degrees North have grid spacings of 6 arc-seconds, and latitudes greater than 70 degrees North have grid spacings of 9 arc-seconds.

Statistical data in the files is not returned.

You can obtain the data files from the U.S. Geological Survey and from commercial vendors. Other agencies have made some local area data available online.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: "Find Geospatial Data Online".

Version History

Introduced before R2006a

R2021b: Warns

Warns starting in R2021b

Raster reading functions that return referencing vectors issue a warning that they will be removed in a future release, including `usgsdem`. Instead, use `readgeoraster`, which returns a geographic raster reference object. Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see `GeographicCellsReference` and `GeographicPostingsReference`.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` function.
- Most functions that accept referencing vectors as input also accept reference objects.

This table shows some typical usages of `usgsdem` and how to update your code to use `readgeoraster` instead. The `readgeoraster` function requires you to specify a file extension.

Will Be Removed	Recommended
<code>[Z,refvec] = usgsdem(filename,scalefactor);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>[Z,R] = georesize(Z,R,1/scalefactor);</code>
<code>[Z,refvec] = usgsdem(filename,scalefactor,latlim,lonlim);</code>	<code>[Z,R] = readgeoraster(filename);</code> <code>[Z,R] = geocrop(Z,R,latlim,lonlim);</code> <code>[Z,R] = georesize(Z,R,1/scalefactor);</code>

The `readgeoraster` function returns data using the native data type embedded in the file. Return a different data type by specifying the 'OutputType' name-value pair. For example, use `[Z,R] = readgeoraster(filename,'OutputType','double')`.

The `readgeoraster` function does not automatically replace missing data with NaN values. If your data set uses large negative numbers to indicate missing data, you can replace them with NaN values using the `standardizeMissing` function.

```
[Z,R] = readgeoraster('MtWashington-ft.grd');  
info = georasterinfo('MtWashington-ft.grd');  
m = info.MissingDataIndicator;  
Z = standardizeMissing(Z,m);
```

R2020a: To be removed

Not recommended starting in R2020a

The `usgsdem` function runs without warning but will be removed in a future release.

See Also

`usgsdems` | `readgeoraster` | `georasterinfo`

usgsdems

USGS 1-degree (3-arc-sec) DEM file names for latitude-longitude quadrangle

Syntax

```
[fname, qname] = usgsdems(latlim, lonlim)
```

Description

`[fname, qname] = usgsdems(latlim, lonlim)` returns cell arrays of the DEM file names and quadrangle names covering the geographic region. The region is specified by scalar latitude and longitude points or two-element vectors of latitude and longitude limits in units of degrees.

Background

The U.S. Geological Survey has made available a set of digital elevation maps of 1-degree quadrangles covering the contiguous United States, Hawaii, and limited portions of Alaska. These are referred to as *1-degree, 3-arc second* or *1:250,000 scale* DEMs. Because the file names of these 1 degree data sets are taken from the names of cities or features in the quadrangle, determining the files needed to cover a particular region generally requires consulting an index map or other reference. This function takes the place of such a reference by returning the file names for a given geographic region.

Examples

Which files are needed to map part of New England?

```
usgsdems([41 44], [-72 -69])
```

```
ans =  
    'providence-w'  
    'providence-e'  
    'chatham-w'  
    'boston-w'  
    'boston-e'  
    'portland-w'  
    'portland-e'  
    'bath-w'
```

Tips

This function only returns file names for the contiguous United States.

Version History

Introduced before R2006a

See Also

readgeoraster

utmgeoid

Select ellipsoids for given UTM zone

Syntax

```
ellipsoid = utmgeoid  
ellipsoid = utmgeoid(zone)  
[ellipsoid,ellipsoidstr] = utmgeoid(...)
```

Description

The purpose of this function is to recommend a local ellipsoid for use with a given UTM zone, depending on the geographic location of that zone. Use it only if you are not using a global reference ellipsoid, such as the World Geodetic System (WGS) 1984 ellipsoid. In many cases, depending on your application, you should just use the output of `wgs84Ellipsoid`, or one of the other options available through `referenceEllipsoid`.

`ellipsoid = utmgeoid`, without any arguments, opens the `utmzoneui` interface for selecting a UTM zone. This zone is then used to return the recommended ellipsoid definitions for that particular zone.

`ellipsoid = utmgeoid(zone)` uses the input `zone` to return the recommended ellipsoid definitions.

`[ellipsoid,ellipsoidstr] = utmgeoid(...)` returns the short name(s) for the reference ellipsoid(s), as used by `referenceEllipsoid`, in a char array with one name in each row.

Background

The Universal Transverse Mercator (UTM) system of projections tiles the world into quadrangles called zones. Each zone has different projection parameters and commonly used ellipsoidal models of the Earth. This function returns a list of ellipsoid models commonly used in a zone.

Examples

```
zone = utmzone(0,100) % degrees  
  
zone =  
47N  
  
[ellipsoid,names] = utmgeoid(zone)  
  
ellipsoid =  
    6377.3    0.081473  
    6377.4    0.081697  
names =  
everest  
bessel
```


Version History

Introduced before R2006a

See Also

[referenceEllipsoid](#) | [wgs84Ellipsoid](#)

utmzone

UTM zone from latitude and longitude

Syntax

```
zone = utmzone
zone = utmzone(lat,lon)
[latlim,lonlim] = utmzone(queryZone)
```

Description

`zone = utmzone` opens the Pick UTM Zone dialog box, which enables you to interactively identify a Universal Transverse Mercator (UTM) zone from a world map.

`zone = utmzone(lat,lon)` identifies the UTM zone that contains the latitude-longitude coordinates specified by `lat` and `lon`. When you specify the coordinates of more than one point, the function identifies the UTM zone using the geographic mean of the points.

`[latlim,lonlim] = utmzone(queryZone)` identifies the latitude and longitude limits of the UTM zone `queryZone`.

Examples

Identify UTM Zone from Geographic Coordinates

Specify the geographic coordinates of the MathWorks Lakeside Campus in Natick, MA. Then, find the UTM zone that contains the coordinates.

```
lat = 42.3013;
lon = -71.3782;
zone = utmzone(lat,lon)
```

```
zone =
'19T'
```

Identify Geographic Limits of UTM Zone

Identify the latitude and longitude limits of UTM zone 19F, which contains the southern tip of South America. Specify the UTM zone using a zone number and latitude band letter.

```
[latlim,lonlim] = utmzone("19F")
```

```
latlim = 1×2
    -56    -48
```

```
lonlim = 1×2
```

-72 -66

Input Arguments

lat — Latitude coordinates in degrees

scalar | vector | matrix

Latitude coordinates in degrees, specified as scalar, vector, or matrix. Each latitude coordinate must be in the range [-80, 84].

- When `lat` and `lon` define a single point, the `utmzone` function finds the UTM zone containing the point.
- When `lat` and `lon` define multiple points, the `utmzone` function finds the UTM zone containing the geographic mean of the points.

The sizes of `lat` and `lon` must match.

Data Types: `single` | `double`

lon — Longitude coordinates in degrees

scalar | vector | matrix

Longitude coordinates in degrees, specified as scalar, vector, or matrix. Each longitude coordinate must be in the range [-180, 180].

- When `lat` and `lon` define a single point, the `utmzone` function finds the UTM zone containing the point.
- When `lat` and `lon` define multiple points, the `utmzone` function finds the UTM zone containing the geographic mean of the points.

The sizes of `lat` and `lon` must match.

Data Types: `single` | `double`

queryZone — UTM zone

character vector | string scalar

UTM zone, specified as a character vector or a string scalar in one of these forms:

- Zone number — An integer between 1 and 60, such as "19".
- Zone number and latitude band letter — An integer between 1 and 60 followed by a letter between C and X (excluding I and O), such as "19T". The letters are case-insensitive.

The letters N and S refer to latitude band letters, not the northern or southern hemispheres.

Data Types: `char` | `string`

Output Arguments

zone — UTM zone

character vector

UTM zone, returned as a character vector. The UTM zone returned by the `utmzone` function contains a zone number and a latitude band letter.

- When `lat` and `lon` are scalars, `zone` is the UTM zone that contains the coordinates.
- When `lat` and `lon` are vectors or matrices, `zone` is the UTM zone that contains the geographic mean of the coordinates.

The letters N and S refer to latitude band letters, not the northern or southern hemispheres.

Data Types: `char`

latlim — Latitude limits of UTM zone

two-element vector

Latitude limits of the UTM zone, returned as a two-element vector.

Data Types: `double`

lonlim — Longitude limits of UTM zone

two-element vector

Longitude limits of the UTM zone, returned as a two-element vector.

Data Types: `double`

Limitations

With the exception of a few zones in northern Europe, the UTM system of projections divides the globe into uniform zones. The `utmzone` function does not account for these exceptions.

Version History

Introduced before R2006a

R2012b: Some syntaxes of `utmzone` will be removed

Not recommended starting in R2012b

Syntaxes of the `utmzone` function that combine multiple arguments into one argument will be removed in a future release. Use a syntax that separates the argument into two arguments, instead.

This table shows the syntaxes of the `utmzone` function that will be removed and how to update your code.

Will Be Removed	Recommended
<code>mat = [lat lon]; zone = utmzone(mat);</code>	<code>zone = utmzone(lat,lon);</code>
<code>lim = utmzone(queryZone); latlim = lim(1:2); lonlim = lim(3:4);</code>	<code>[latlim,lonlim] = utmzone(queryZone);</code>

See Also

Functions

utmgeoid | utmzoneui

validateLengthUnit

Validate and standardize length unit

Syntax

```
standardName = validateLengthUnit(unit)
standardName = validateLengthUnit(unit, funcName, varName, argIndex)
```

Description

`standardName = validateLengthUnit(unit)` checks that `unit` is a valid length unit and converts it to a standard unit name. The function is case-insensitive with respect to its input. Spaces, periods, and apostrophes are ignored. Plural forms are accepted in most cases, but the result, `standardName` is always singular.

`standardName = validateLengthUnit(unit, funcName, varName, argIndex)` checks that `unit` is a valid length unit and, if it isn't, creates an error message using the optional inputs `funcName`, `varName`, and `argIndex` in error message formatting, with behavior identical to that provided by the `validateattributes` inputs of the same names.

Examples

Find Valid Length Unit Name

Find the valid length unit name for 'foot' when other valid strings for 'foot' are input.

```
validateLengthUnit('foot')
```

```
ans =
'foot'
```

```
validateLengthUnit('feet')
```

```
ans =
'foot'
```

```
validateLengthUnit('international feet')
```

```
ans =
'foot'
```

Find the valid length unit name for 'kilometer' when other valid strings for 'kilometer' are input.

```
validateLengthUnit('kilometer')
```

```
ans =
'kilometer'
```

```
validateLengthUnit('km')
```

```

ans =
'kilometer'

validateLengthUnit('kilometre')

ans =
'kilometer'

validateLengthUnit('kilometers')

ans =
'kilometer'

validateLengthUnit('kilometres')

ans =
'kilometer'

```

Find the valid length unit name when the name contains an apostrophe.

```

validateLengthUnit('Clarke's foot')

ans =
'Clarke's foot'

```

Create Custom Error Message

Create custom error messages using the `validateLengthUnit` function. An invalid input to `validateLengthUnit` results in an error message referencing a function name, 'FOO', a variable name, 'UNIT' and an argument number, 5.

```
validateLengthUnit(17, 'FOO', 'UNIT', 5)
```

```
Error using FOO
Expected input number 5, UNIT, to be one of these types:
```

```
char, string
```

```
Instead its type was double.
```

```
Error in validateLengthUnit (line 87)
validateattributes(unit,{'char','string'},{'nonempty','scalartext'},varargin{:})
```

Input Arguments

unit – Length unit

character vector | string scalar

Length unit, specified as any of the following:

Value	Unit Name
"m", "meter", "meters", "metre", "metres"	Meters

Value	Unit Name
"cm", "centimeter", "centimeters", "centimetre", "centimetres"	Centimeters
"mm", "millimeter", "millimeters", "millimetre", "millimetres"	Millimeters
"micron", "microns"	Microns
"km", "kilometer", "kilometers", "kilometre", "kilometers"	Kilometers
"nm", "naut mi", "nautical mile", "nautical miles"	Nautical miles
"ft", "international ft", "foot", "international foot", "feet", "international feet"	Feet
"in", "inch", "inches"	Inches
"yd", "yds", "yard", "yards"	Yards
"mi", "mile", "miles", "international mile", "international miles"	Miles
"sf", "survey ft", "US survey ft", "U.S. survey ft", "survey foot", "US survey foot", "U.S. survey foot", "survey feet", "US survey feet", "U.S. survey feet"	U.S. survey feet
"sm", "survey mile", "survey miles", "statute mile", "statute miles", "US survey mile", "US survey miles", "U.S. survey mile(s)", "U.S. survey miles"	U.S. survey miles (statute miles)
"Clarke's foot", "Clarkes foot"	Clarke's feet
"German legal metre", "German legal meter"	German legal metres
"Indian foot"	Indian feet

Example: `validateLengthUnit("feet")`

Data Types: `char` | `string`

funcName — Name of the function whose input you are validating

`character vector` | `string scalar`

Name of the function whose input you are validating, specified as a string scalar or character vector. If you specify an empty string or character vector (''), the `validateLengthUnit` function ignores the `funcName` value.

Example: `validateLengthUnit(17, 'F00', 'UNIT', 5)`

Data Types: `char` | `string`

varName — Name of input variable

`character vector` | `string scalar`

Name of input variable, specified as a string scalar or character vector. If you specify an empty string or character vector (' '), the `validateLengthUnit` function ignores the `varName` value.

Example: `validateLengthUnit(17, 'F00', 'UNIT', 5)`

Data Types: `char` | `string`

argIndex — Position of the input argument

positive integer

Position of the input argument, specified as a positive integer.

Example: `validateLengthUnit(17, 'F00', 'UNIT', 5)`

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

Output Arguments

standardName — Standard length unit name

character vector

Standard length unit name, returned as a character vector.

Version History

Introduced before R2006a

See Also

`unitsratio`

vec2mtx

Convert latitudes and longitudes to raster data grid

Syntax

```
[Z,R] = vec2mtx(lat,lon,cellsPerDegree)
[Z,R] = vec2mtx(lat,lon,cellsPerDegree,latlim,lonlim)
[Z,R] = vec2mtx(lat,lon,cellsPerDegree,Zin,Rin)
[Z,R] = vec2mtx( ____, "filled")
```

Description

`[Z,R] = vec2mtx(lat,lon,cellsPerDegree)` creates a regular raster data grid `Z` and geographic raster reference object `R` from the latitudes and longitudes in `lat` and `lon`, respectively. When a grid cell in `Z` corresponds to a location specified by `lat` and `lon`, the function sets the grid cell to 1. Otherwise, the function sets the grid cell to 0. Specify the number of grid cells per degree of latitude and longitude using `cellsPerDegree`.

This function is useful for creating raster data from vector data.

`[Z,R] = vec2mtx(lat,lon,cellsPerDegree,latlim,lonlim)` specifies the latitude limits `latlim` and longitude limits `lonlim` of the grid.

`[Z,R] = vec2mtx(lat,lon,cellsPerDegree,Zin,Rin)` specifies the geographic limits and the number of grid cells per degree using the regular raster data grid `Zin` and geographic raster reference object `Rin`.

`[Z,R] = vec2mtx(____, "filled")` where `lat` and `lon` define one or more closed polygons, differentiates between cells inside the polygon boundary and outside the polygon boundary. When a grid cell is inside a polygon boundary, the function sets the grid cell to 0. When a grid cell is on a polygon boundary, the function sets the grid cell to 1. When a grid cell is outside all the polygon boundaries, the function sets the grid cell to 2.

Examples

Convert Latitudes and Longitudes to Raster Data Grid

Load a MAT file containing global coastline coordinates into the workspace. The variables within the MAT file, `coastlat` and `coastlon`, specify numeric latitude and longitude coordinates, respectively.

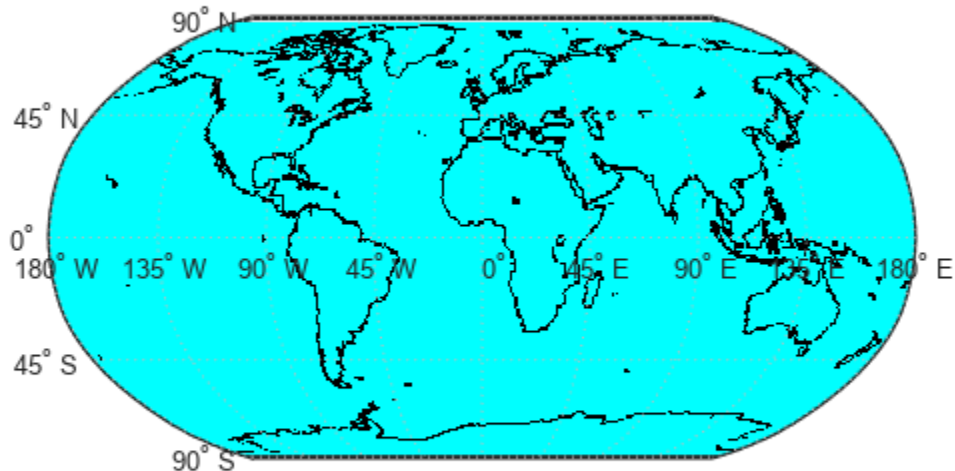
```
load coastlines
```

Convert the coordinates to a regular raster data grid and a geographic raster reference object. Specify 1 grid cell per degree of latitude and longitude. The `vec2mtx` function indicates that a grid cell corresponds to a coastline coordinate using 1 and uses 0 otherwise.

```
[Z,R] = vec2mtx(coastlat,coastlon,1);
```

Display the raster data on a map. Use black for the coastlines (`Z == 1`) and cyan for the other regions (`Z == 0`).

```
figure
worldmap world
geoshow(Z,R,"DisplayType","texturemap")
colormap([0 1 1; 0 0 0])
```



Convert Polygons to Raster Data Grid

Read a shapefile containing US state polygons into the workspace as a geospatial table. Extract the coordinates of the polygons by converting the geospatial table to a table.

```
states = readgeotable("usastatelo.shp");
T = geotable2table(states,["Latitude" "Longitude"]);
[lat,lon] = polyjoin(T.Latitude',T.Longitude');
```

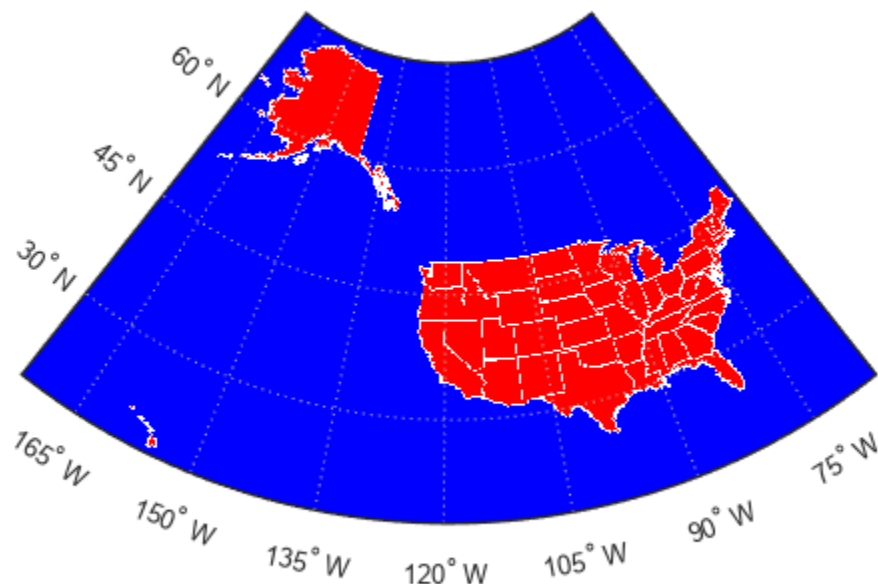
Convert the coordinates to a regular raster data grid and a geographic raster reference object. Specify 5 grid cells per degree of latitude and longitude. When you specify the "filled" option, the `vec2mtx` function indicates that a grid cell is inside a polygon using 0, on a polygon boundary using 1, and outside all the polygons using 2.

```
[Z,R] = vec2mtx(lat,lon,5,"filled");
```

Display the raster data on a map. Use red for regions inside a polygon ($Z == 0$), white for regions on a boundary ($Z == 1$), and blue for regions outside all the polygons ($Z == 2$).

```
figure
usamap(Z,R)
```

```
geoshow(Z,R,"DisplayType","texturemap")
colormap([1 0 0; 1 1 1; 0 0 1])
```



Convert to Raster Data Grid Using Reference Object

Read a shapefile containing US state polygons into the workspace as a geospatial table. Extract the coordinates of the state boundaries by converting the geospatial table to a table.

```
states = readgeotable("usastatelo.shp");
T = geotable2table(states,["Latitude" "Longitude"]);
[lat,lon] = polyjoin(T.Latitude',T.Longitude');
```

Create a reference object by using the `georefcells` function and specifying the geographic limits and extent of each cell (the inverse of the number of cells per degree). For this example, choose limits that include the conterminous US.

```
latlim = [22 52];
lonlim = [-130 -65];
cellsPerDegree = 5;
R = georefcells(latlim,lonlim,1/cellsPerDegree,1/cellsPerDegree);
```

Create a raster of zeros with a size that is consistent with R.

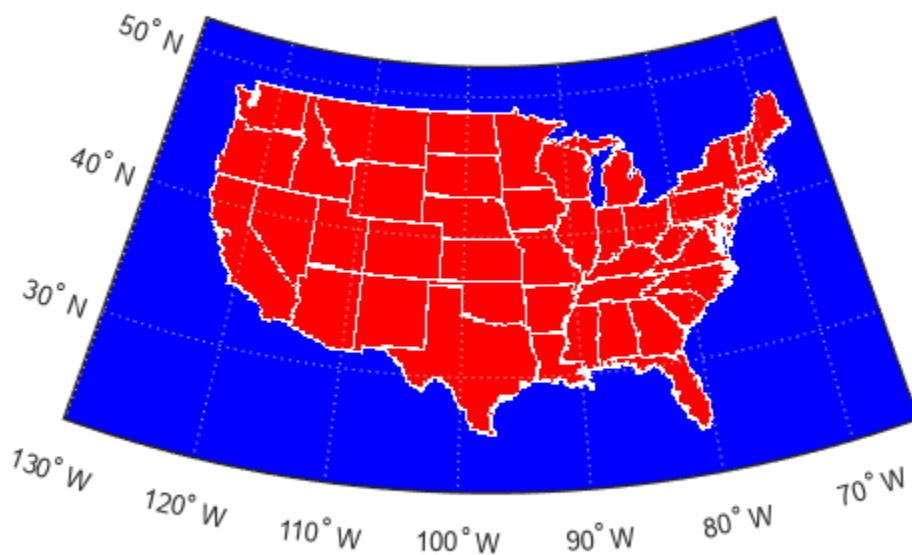
```
Z = zeros(R.RasterSize);
```

Overwrite Z and R with a new raster data grid that includes the state boundaries and interiors.

```
[Z,R] = vec2mtx(lat,lon,Z,R,"filled");
```

Plot the result on a map. Use red for the interior regions, white for the boundaries, and blue for the exterior regions.

```
figure
usamap(Z,R)
geoshow(Z,R,"DisplayType","texturemap")
colormap([1 0 0; 1 1 1; 0 0 1])
```



Create Raster Grid Containing Four Classification Values

The `vec2mtx` function enables you to create raster data grids with two classification values (when `lat` and `lon` represent lines) or three classification values (when `lat` and `lon` represent polygons). To create a raster data grid with additional classification values, you can use `vec2mtx` multiple times and combine the output grids.

Read two files into the workspace:

- A MAT file containing global coastline coordinates. The variables within the MAT file, `coastlat` and `coastlon`, specify numeric latitude and longitude coordinates, respectively.

- A shapefile containing lines that represent world rivers. Extract the latitude and longitude coordinates of the lines.

```
load coastlines
rivers = readgeotable("worldrivers.shp");
T = geotable2table(rivers,["Latitude" "Longitude"]);
[latRiver,lonRiver] = polyjoin(T.Latitude',T.Longitude');
```

Convert the coastline coordinates to a regular raster data grid and a geographic raster reference object. Specify 1 cell per degree of latitude and longitude. When you specify the "filled" option, the `vec2mtx` function creates the grid using these rules:

- When a grid cell corresponds to an area inside a coastline, use 0. These grid cells are land areas.
- When a grid cell corresponds to an area on a coastline, use 1.
- When a grid cell corresponds to an area around outside a coastline, use 2. These grid cells are ocean areas.

```
[Z,R] = vec2mtx(coastlat,coastlon,1,"filled");
```

Convert the world river coordinates to a regular raster data grid and a geographic raster reference object. When you specify a raster data grid and a reference object as input, the `vec2mtx` function creates the new grid and reference object using the same latitude limits and number of cells per degree as the input reference object. The function creates the grid using these rules:

- When a grid cell does not correspond to a river coordinate, use 0.
- When a grid cell corresponds to a river coordinate, use 1.

```
[riverZ,riverR] = vec2mtx(latRiver,lonRiver,Z,R);
```

Verify that the reference objects are the same.

```
isequal(R,riverR)
```

```
ans = logical
     1
```

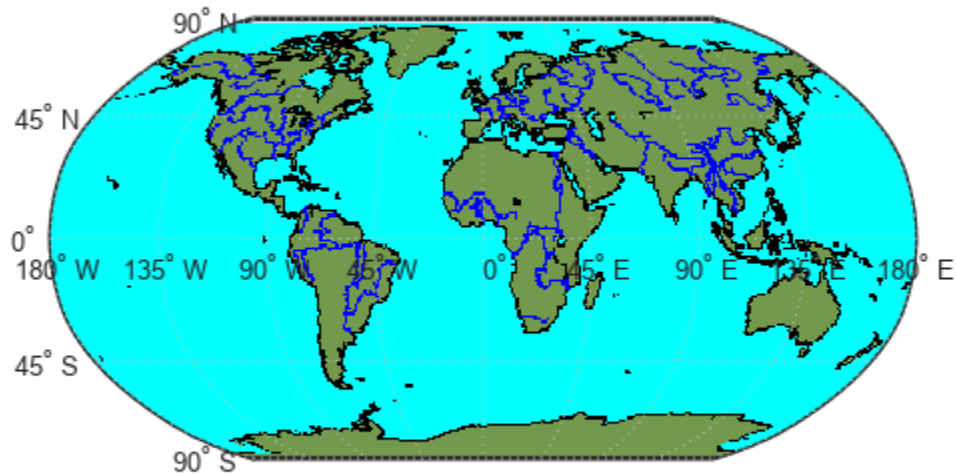
Find the indices of the river grid that correspond to river coordinates. Then, replace those elements of the coastline grid with the value 3. As a result, each element of the coastline grid is one of four values (0, 1, 2, or 3).

```
idx = riverZ == 1;
Z(idx) = 3;
```

Display the grid on a map. Use green for the land areas, black for the coastlines, cyan for the ocean areas, and blue for the rivers.

```
figure
worldmap world
geoshow(Z,R,"DisplayType","texturemap")

landColor = [0.45 0.60 0.30];
coastColor = [0 0 0];
oceanColor = [0 1 1];
riverColor = [0 0 1];
colormap([landColor; coastColor; oceanColor; riverColor])
```



Input Arguments

lat — Latitude values

vector

Latitude values, in degrees, specified as a vector.

To specify polygons, separate the vertices of each polygon using NaN values, such as [37 46 31 20 37 NaN 45 49 35 32 45 NaN 35 40 42 35]. The NaN values in `lat` must correspond to the NaN values in `lon`.

The size of `lat` must match the size of `lon`.

Data Types: `single` | `double`

lon — Longitude values

vector

Longitude values, in degrees, specified as a vector.

To specify polygons, separate the vertices of each polygon using NaN values, such as [69 90 105 79 69 NaN 6 52 43 14 6 NaN 18 32 22 18]. The NaN values in `lon` must correspond to the NaN values in `lat`.

The size of `lon` must match the size of `lat`.

Data Types: `single` | `double`

cellsPerDegree — Number of grid cells per degree of latitude and longitude

scalar

Number of grid cells per degree of latitude and longitude, specified as a scalar.

Data Types: `double`

latlim — Latitude limits

two-element vector

Latitude limits, in degrees, specified as a two-element vector.

Data Types: `double`

lonlim — Longitude limits

two-element vector

Longitude limits, in degrees, specified as a two-element vector.

Data Types: `double`

Zin — Input raster data grid

numeric array

Input raster data grid, specified as a numeric array.

The size of `Zin` must be consistent with the `RasterSize` property of `Rin`.

Rin — Input geographic raster reference object

`GeographicCellsReference` object

Input geographic raster reference object, specified as a `GeographicCellsReference` object.

The `RasterSize` property of `Rin` must be consistent with the size of `Zin`.

When you specify `Rin`, the output argument `R` is equal to `Rin`.

Output Arguments

Z — Raster data grid

numeric array

Raster data grid, returned as a numeric array.

R — Geographic raster reference object

`GeographicCellsReference` object

Geographic raster reference object, returned as a `GeographicCellsReference` object.

Tips

- When possible, the `vec2mtx` function includes a buffer of two grid cells on each of the four sides of the grid. The function can include fewer buffer cells to ensure that the latitude limits are in the range of `[-90, 90]` degrees, and that the difference in longitude limits is less than 360 degrees.

Version History

Introduced before R2006a

R2022b: vec2mtx will not accept referencing vectors or referencing matrices as input

Not recommended starting in R2022b

The `vec2mtx` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.
- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

R2021a: vec2mtx returns reference objects instead of referencing vectors

Behavior changed in R2021a

Most syntaxes of the `vec2mtx` function return a raster reference object instead of a referencing vector. This change is unlikely to affect your existing code because most Mapping Toolbox functions that accept referencing vectors as input also accept raster reference objects.

If you specify a referencing vector or matrix as input, then the `vec2mtx` function still returns a referencing vector or matrix.

See Also

Functions

`imbedm`

Objects

`GeographicCellsReference`

vertcat

Vertically concatenate geographic or planar vectors

Syntax

```
v = vertcat(v1,v2,...)
```

Description

`v = vertcat(v1,v2,...)` vertically concatenates the geographic or planar vectors `v1`, `v2`, and so on. If the class type of any property is a cell array, then the resultant field in the output `v` is also a cell array.

Examples

Vertically Concatenate Mapshape Vectors

Create three mapshape vectors. The second vector has two features and is size 2x1.

```
ms1 = mapshape(42, -110, 'Temperature', 65, 'Name', 'point1');  
ms2 = mapshape({50, 50.1}, {-101 -101.4}, 'Temperature', {73.2 77}, ...  
    'Name', {'point2','point3'});  
ms3 = mapshape(42.1, -110.4, 'Temperature', 65.5, 'Name', 'point4');
```

Vertically concatenate the vectors into a single mapshape vector.

```
ms = vertcat(ms1, ms2, ms3)
```

```
ms =  
4x1 mapshape vector with properties:  
  
Collection properties:  
    Geometry: 'line'  
    Metadata: [1x1 struct]  
Vertex properties:  
    (4 features concatenated with 3 delimiters)  
        X: [42 NaN 50 NaN 50.1000 NaN 42.1000]  
        Y: [-110 NaN -101 NaN -101.4000 NaN -110.4000]  
        Temperature: [65 NaN 73.2000 NaN 77 NaN 65.5000]  
Feature properties:  
    Name: {'point1' 'point2' 'point3' 'point4'}
```

The concatenated mapshape vector `ms` is size 4x1 and has four features. Note that the property 'Temperature' is a Vertex property in `ms` because it is a Vertex property in `ms2`, even though it is a Feature property in `ms1` and `ms3`.

Input Arguments

v_1, v_2, \dots — Geographic or planar vectors to be concatenated

geopoint, geoshape, mappoint, or mapshape objects

Geographic or planar vectors to be concatenated, specified as one or many geopoint, geoshape, mappoint, or mapshape objects. All of v_1, v_2, \dots are the same type of object.

Output Arguments

v — Concatenated geographic or planar vector

geopoint, geoshape, mappoint, or mapshape object

Concatenated geographic or planar vector, returned as a geopoint, geoshape, mappoint, or mapshape object. The object type of v matches the object type of v_1, v_2, \dots .

Version History

Introduced in R2012a

See Also

cat

vfwdtran

Transform azimuth on ellipsoid to direction on map

Syntax

```
th = vfwdtran(lat,lon,az)
th = vfwdtran(mstruct,lat,lon,az)
[th,len] = vfwdtran(...)
```

Description

`th = vfwdtran(lat,lon,az)` transforms the azimuth angle at specified latitude and longitude points on the sphere into the projection space. The map projection currently displayed is used to define the projection space. The input angles must be in the same units as specified by the current map projection. The inputs can be scalars or matrices of the equal size. The angle in the projection space is defined as positive counterclockwise from the x -axis.

`th = vfwdtran(mstruct,lat,lon,az)` uses the map projection defined by the input `mstruct` to compute the map projection.

`[th,len] = vfwdtran(...)` also returns the vector length in the projected coordinate system. A value of 1 indicates no scale distortion.

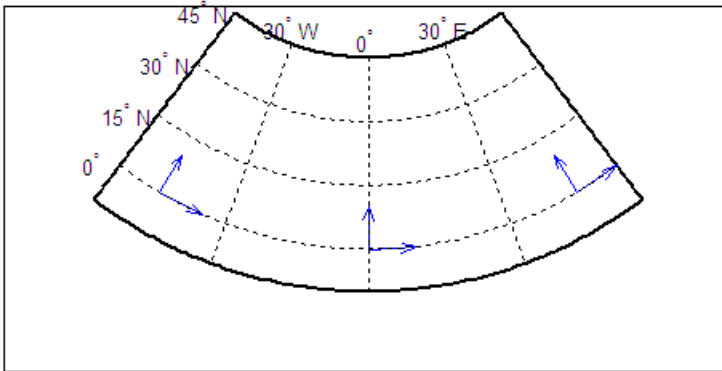
Background

The direction of north is easy to define on the three-dimensional sphere, but more difficult on a two-dimensional map. For cylindrical projections in the normal aspect, north is always in the positive y -direction. For conic projections, north can be to the left or right of the y -axis. This function transforms any azimuth angle on the sphere to the corresponding angle in the projected paper coordinates.

Examples

Sample calculations:

```
axesm('eqdconic','maplatlim',[-10 45],'maplonlim',[-55 55])
gridm; framem; mlabel; plabel
quiverm([0 0 0],[-45 0 45],[0 0 0],[10 10 10],0)
quiverm([0 0 0],[-45 0 45],[10 10 10],[0 0 0],0)
```



```
vfdtran([0 0 0],[-45 0 45],[0 0 0])
```

```
ans =
    59.614         90    120.39
```

```
vfdtran([0 0 0],[-45 0 45],[90 90 90])
```

```
ans =
   -30.385    0.0001931    30.386
```

Limitations

This transformation is limited to the region specified by the frame limits in the current map definition.

Tips

The geographic azimuth angle is measured clockwise from north. The projection space angle is measured counterclockwise from the x-axis.

This function uses a finite difference technique. The geographic coordinates are perturbed slightly in different directions and projected. A small amount of error is introduced by numerical computation of derivatives and the variation of map distortion parameters.

Version History

Introduced before R2006a

See Also

[vinvtran](#) | [projinv](#) | [projfwd](#) | [defaultm](#)

viewshed

Visible area from point on or above terrain

Syntax

```
[vis,visR] = viewshed(Z,R,latObs,lonObs)
[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs)
[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs,hTarget)
[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs,hTarget,hObsRef)
[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs,hTarget,hObsRef,hTargetRef)
```

```
[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs,hTarget,hObsRef,hTargetRef,rad)
[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs,hTarget,hObsRef,hTargetRef,rad,
effectiveRad)
```

Description

Specify Coordinates and Heights

`[vis,visR] = viewshed(Z,R,latObs,lonObs)` calculates the visible area (the viewshed) for the point specified by `latObs` and `lonObs`. Specify spatially referenced terrain data, in meters, using `Z` and `R`. This function assumes that the Earth is a sphere.

`[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs)` specifies the height, in meters, of the observer.

`[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs,hTarget)` specifies the height, in meters, of the target points. The target points are all the points specified by the spatial reference.

`[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs,hTarget,hObsRef)` references the height of the observer to either the terrain (ground level) or the sphere (mean sea level).

`[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs,hTarget,hObsRef,hTargetRef)` references the height of the target points to either the terrain (ground level) or the sphere (mean sea level).

Specify Reference Sphere

`[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs,hTarget,hObsRef,hTargetRef,rad)` specifies the radius in meters of the reference sphere. This syntax is useful for finding line-of-sight visibility for planetary bodies other than Earth.

`[vis,visR] = viewshed(Z,R,latObs,lonObs,hObs,hTarget,hObsRef,hTargetRef,rad, effectiveRad)` specifies a larger radius for the propagation of line-of-sight paths. You can use this syntax to account for the curvature of signal paths due to refraction in the atmosphere.

Examples

Display Viewshed for Point on Terrain

Create sample terrain data by using the `peaks` and `georefcells` functions.

```
Z = 500*peaks(100);
R = georefcells([-0.1 0],[0 0.1],size(Z));
```

Calculate the viewshed for a sample point that is 200 meters above the terrain.

```
latObs = -0.027;
lonObs = 0.05;
[vis,visR] = viewshed(Z,R,latObs,lonObs);
```

Display the viewshed as a surface on an axesm-based map. Plot the sample point so that it appears above the terrain.

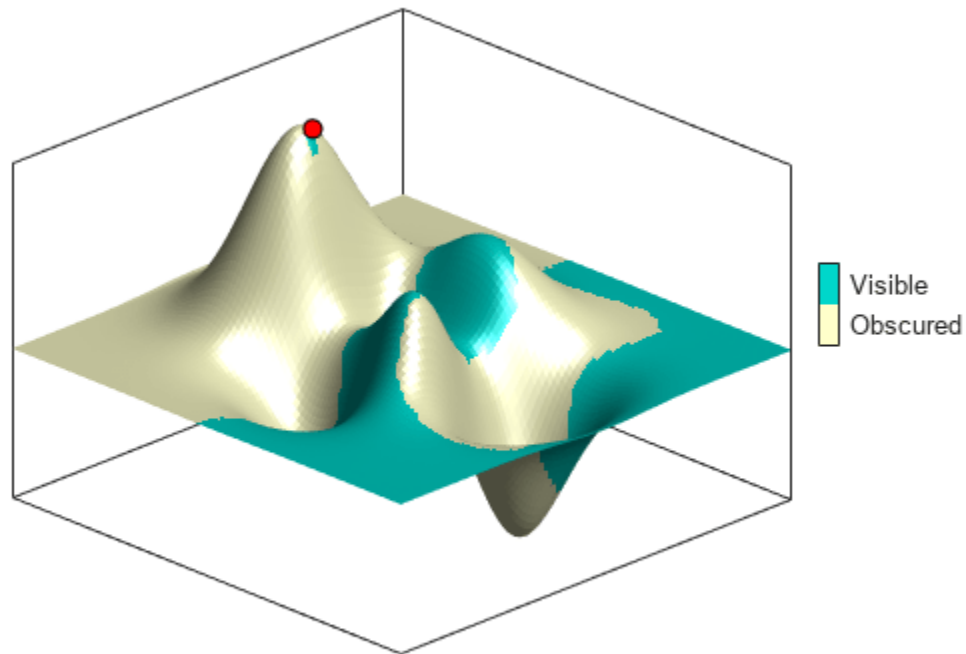
```
figure
axesm("globe","geoid",earthRadius)
meshm(vis,visR,size(Z),Z)
axis tight
camposm(-10,-10,1e6)
camupm(0,0)

[row,col] = geographicToDiscrete(R,latObs,lonObs);
h = Z(row,col);
plot3m(latObs,lonObs,h+200,"ko","MarkerSize",7,"MarkerFaceColor","r")
```

Adjust the colormap and lighting. Add a colorbar.

```
colormap(flipud(summer(2)))
brighten(0.75)
shading interp
camlight

cb = lcolorbar(["Obscured" "Visible"]);
cb.Position = [0.85 0.5 0.02 0.1];
```



Display Viewshed for Point Above Terrain

Display the area that is visible by radar for an aircraft flying above the terrain. You can use the `viewshed` function to model radio wave propagation in the atmosphere as straight lines on a sphere.

Load terrain elevation data for an area around the Korean peninsula. To make the water areas appear consistent on the plot, set all elevations below sea level (`korea5c<0`) to the same value.

```
load korea5c
korea5c(korea5c<0) = -1;
```

Specify the location of the aircraft. Then, calculate visible areas for the aircraft, at 3000 meters above mean sea level, of the surface. Model radio propagation in the atmosphere by specifying an effective radius for the reference sphere.

```
latObs = 34.0931;
lonObs = 125.6578;
hObs = 3000;
hTarget = 0;
rad = earthRadius;
[vis1,vis1R] = viewshed(korea5c,korea5cR,latObs,lonObs,hObs,hTarget,"MSL","AGL",rad,4/3*rad);
```

Set up a relief map for the area by adjusting the data aspect ratio, the plot box aspect ratio, and the lighting.


```

figure
worldmap(korea5c,korea5cR)
setm(gca,"geoid",[1 0])

da = daspect;
pba = pbaspect;
da(3) = 7.5*pba(3)/da(3);
daspect(da);

camlight(90,5)
camlight(0,5)
material([0.25 0.8 0])

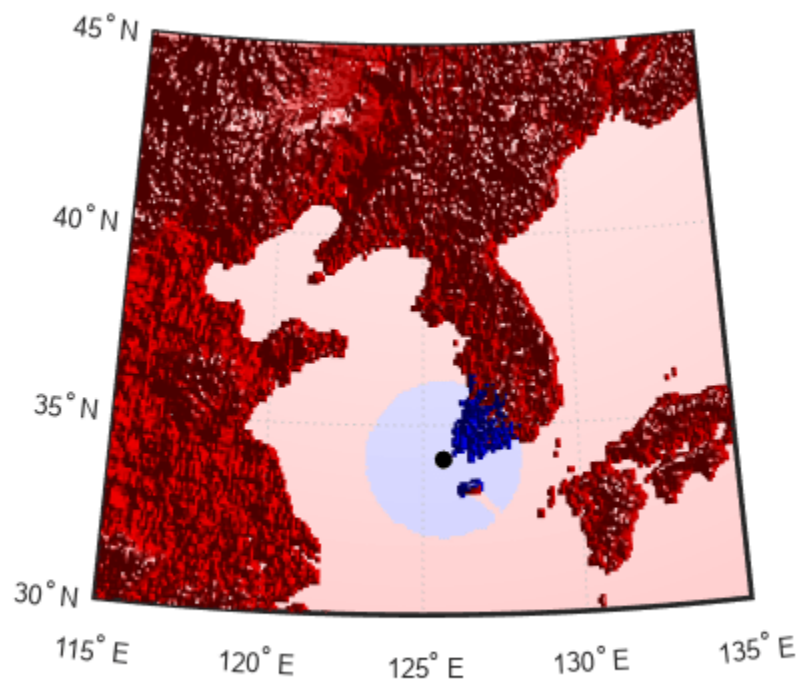
```

Display the terrain data, the viewshed, and the aircraft on the map. Adjust the colormap so that the visible areas appear in blue and the obscured areas appear in red. Note that some ocean areas are obscured by an island.

```

meshm(vis1,vis1R,size(korea5c),korea5c)
plotm(lat0bs,lon0bs,"ko","MarkerFaceColor","k")
colormap([1 0 0; 0 0 1])

```



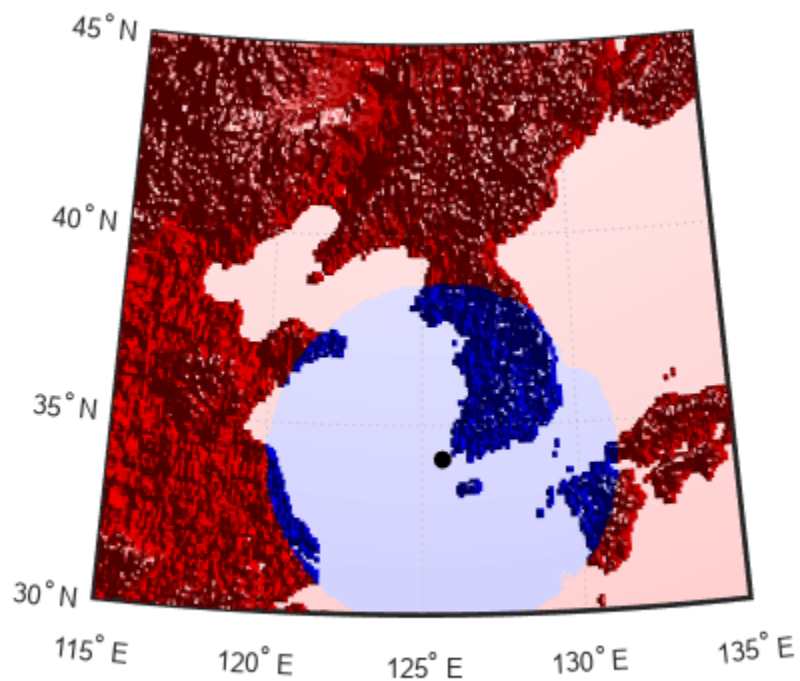
Calculate the viewshed again, this time calculating visible areas for the aircraft at 3000 meters of other aircraft flying above it at 5000 meters. The visible area is larger, with some of the area obscured by the island and mountains.

```

hTarget = 5000;
[vis2,vis2R] = viewshed(korea5c,korea5cR,lat0bs,lon0bs,h0bs,hTarget,"MSL","MSL",rad,4/3*rad);

```

```
clmo surface  
meshm(vis2,vis2R,size(korea5c),korea5c)
```



Input Arguments

Z — Elevation data grid

m-by-n array

Elevation data grid, in meters, specified as an *m-by-n* array.

Data Types: `single` | `double`

R — Spatial reference for Z

`GeographicCellsReference` object | `GeographicPostingsReference` object

Spatial reference for Z, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object. The `RasterSize` property of R must be consistent with `size(Z)`.

latObs — Latitude of observer

scalar

Latitude of the observer, in degrees, specified as a scalar.

If the latitude is outside the latitude limits of R, then the `viewshed` function issues a warning and sets all elements of `vis` to 0. You can find the latitude limits of R by querying its `LatitudeLimits` property.

Data Types: `single` | `double`

lonObs — Longitude of observer

scalar

Longitude of the observer, in degrees, specified as a scalar.

If the longitude is outside the latitude limits of R, then the `viewshed` function issues a warning and sets all elements of `vis` to 0. You can find the longitude limits of R by querying its `LongitudeLimits` property.

Data Types: `single` | `double`

hObs — Height of observer

0 (default) | scalar

Height of the observer, in meters, specified as a scalar.

Data Types: `single` | `double`

hTarget — Height of target points

0 (default) | scalar

Height of the target points, in meters, specified as a scalar.

Data Types: `single` | `double`

hObsRef — Height reference for observer

"AGL" (default) | "MSL"

Height reference for the observer, specified as one of these options:

- "AGL" — Reference `hObs` to the terrain (ground level).
- "MSL" — Reference `hObs` to the sphere (mean sea level).

Data Types: `char` | `string`

hTargetRef — Height reference for target points

"AGL" (default) | "MSL"

Height reference for the target points, specified as one of these options:

- "AGL" — Reference the target points to the terrain (ground level).
- "MSL" — Reference the target points to the sphere (mean sea level).

Data Types: `char` | `string`

rad — Radius of reference sphere in meters

6371000 (default) | positive scalar

Radius of the reference sphere in meters, specified as a positive scalar.

Data Types: `single` | `double`

effectiveRad — Effective radius of reference sphere in meters

positive scalar

Effective radius of the reference sphere in meters, specified as a positive scalar.

This argument enables you to account for the curvature of signal paths due to refraction in the atmosphere. For example, you can treat radio propagation in the atmosphere as straight-line propagation on a sphere with $4/3$ the radius of the Earth by specifying `rad` as `6371000` and `effectiveRad` as `4/3*6371000`.

To calculate line-of-sight visibility for a flat Earth, specify this argument as `Inf`.

If you do not specify this argument, then the function uses the value of `rad`.

Data Types: `single` | `double`

Output Arguments

vis — Visibility indicator*m-by-n* array containing 0 and 1 values

Visibility indicator, returned as an *m-by-n* array containing 0 and 1 values. The size of `vis` matches the size of `Z`.

- A value of 1 indicates that the observer has line-of-sight visibility with the target point.
- A value of 0 indicates that the line of sight between the observer and the target point is obscured by terrain.

visR — Spatial reference for vis

GeographicCellsReference object | GeographicPostingsReference object

Spatial reference for `vis`, returned as a `GeographicCellsReference` or `GeographicPostingsReference` object.

The output `visR` is equivalent to the input `R`.

Version History

Introduced before R2006a**R2022b: viewshed will not accept referencing vectors or referencing matrices as input***Not recommended starting in R2022b*

The `viewshed` function will not accept referencing vectors or referencing matrices as input in a future release. Use a geographic raster reference object, specified as a `GeographicCellsReference` or `GeographicPostingsReference` object, as input instead. Reference objects have several advantages over referencing vectors and referencing matrices.

- Unlike referencing vectors and referencing matrices, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns.
- You can manipulate the limits of geographic rasters associated with reference objects using the `geocrop` function.

- You can manipulate the size and resolution of geographic rasters associated with reference objects using the `georesize` function.

To update your code, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing vector to a geographic reference object by using the `refvecToGeoRasterReference` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing vector or referencing matrix in your code with the reference object.

See Also

Functions

`los2`

Topics

“Visualize Viewsheds and Coverage Maps Using Terrain”

vinvtran

Transform direction on map to azimuth on ellipsoid

Syntax

```
az = vinvtran(x,y,th)
az = vinvtran(mstruct,x,y,th)
[az,len] = vinvtran(...)
```

Description

`az = vinvtran(x,y,th)` transforms an angle in the projection space at the point specified by `x` and `y` into an azimuth angle in geographic coordinates. The map projection currently displayed is used to define the projection space. The input angles must be in the same units as specified by the current map projection. The inputs can be scalars or matrices of equal size. The angle in the projection space `th` is defined as positive counterclockwise from the x-axis.

`az = vinvtran(mstruct,x,y,th)` uses the map projection defined by the input `mstruct` to compute the map projection.

`[az,len] = vinvtran(...)` also returns the vector length in the geographic coordinate system. A value of 1 indicates no scale distortion for that angle.

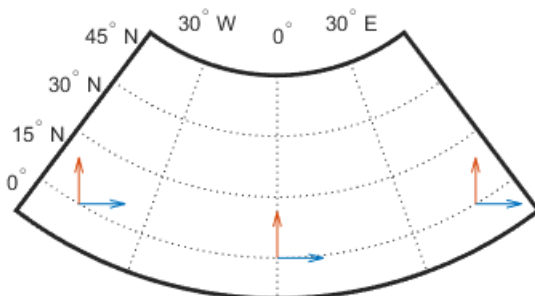
Background

While vectors along the y-axis always point to north in a cylindrical projection in the normal aspect, they can point east or west of north on conic, azimuthal, and other projections. This function computes the geographic azimuth for angles in the projected space.

Examples

Sample calculations:

```
axesm('eqdconicstd','maplatlim',[-10 45],'maplonlim',[-55 55])
gridm; framem; mlabel; plabel; axis off
mstruct = gcm;
[x,y] = projfwd(mstruct,[0 0 0],[-45 0 45]);
quiver(x,y,[0.2 0.2 0.2],[0 0 0],0)
quiver(x,y,[0 0 0],[0.2 0.2 0.2],0)
```



```
vinvtran(x,y,[0 0 0])
ans =
    56.1765    90.0000   123.8235
vinvtran(x,y,[90 90 90])
ans =
   332.8360    0.0000    27.1640
```

Limitations

This transformation is limited to the region specified by the frame limits in the current map definition.

Tips

The geographic azimuth angle is measured clockwise from north. The projection space angle is measured counterclockwise from the x-axis.

This function uses a finite difference technique. The geographic coordinates are perturbed slightly in different directions and projected. A small amount of error is introduced by numerical computation of derivatives and the variation of map distortion parameters.

Version History

Introduced before R2006a

See Also

[vfwdtran](#) | [projinv](#) | [projfwd](#) | [defaultm](#)

vmap0data

Read selected data from Vector Map Level 0

Syntax

```
struct = vmap0data(library,latlim,lonlim,theme,topolevel)
struct = vmap0data(devicename,library, ...)
[struct1,struct2,...] = vmap0data(...,{topolevel1,topolevel2,...})
```

Description

`struct = vmap0data(library,latlim,lonlim,theme,topolevel)` reads the data for the specified theme and topology level directly from the VMAP0 CD-ROM. There are four CDs, one for each of the libraries: 'NOAMER' (North America), 'SASAU' (Southern Asia and Australia), 'EURNASIA' (Europe and Northern Asia), and 'SOAMAFR' (South America and Africa). The desired theme is specified by a two-letter code. A list of valid codes is displayed when an invalid code, such as '?', is entered. `topolevel` defines the type of data returned: 'patch', 'line', 'point', or 'text'. The region of interest can be given as a point latitude and longitude or as a region with two-element vectors of latitude and longitude limits. The units of latitude and longitude are degrees. The data covering the requested region is returned, but will include data extending to the edges of the tiles. The result is returned as a Mapping Toolbox Version 1 display structure.

`struct = vmap0data(devicename,library, ...)` specifies the logical device name of the CD-ROM for computers that do not automatically name the mounted disk.

`[struct1,struct2,...] = vmap0data(...,{topolevel1,topolevel2,...})` reads several topology levels. The levels must be specified as a cell array with the entries 'patch', 'line', 'point', or 'text'. Entering {'all'} for the topology level argument is equivalent to {'patch', 'line', 'point', 'text'}. Upon output, the data structures are returned in the output arguments by topology level in the same order as they were requested.

Background

The Vector Map (VMAP) Level 0 database represents the third edition of the *Digital Chart of the World*. The second edition was a limited release item published in 1995. The product is dual named to show its lineage to the original DCW, published in 1992, while positioning the revised product within a broader emerging family of VMAP products. VMAP Level 0 is a comprehensive 1:1,000,000 scale vector base map of the world. It consists of cartographic, attribute, and textual data stored on compact disc read-only memory (CD-ROM). The primary source for the database is the Operational Navigation Chart (ONC) series of the U. S. National Geospatial Intelligence Agency (NGA), formerly the National Imagery and Mapping Agency (NIMA), and before that, the Defense Mapping Agency (DMA). This is the largest scale unclassified map series in existence that provides consistent, continuous global coverage of essential base map features. The database contains more than 1,900 MB of vector data and is organized into 10 thematic layers. The data includes major road and rail networks, major hydrologic drainage systems, major utility networks (cross-country pipelines and communication lines), all major airports, elevation contours (1000 foot (ft), with 500 ft and 250 ft supplemental contours), coastlines, international boundaries, and populated places. The database can be accessed directly from the four optical CD-ROMs that store the database or can be transferred to magnetic media.

Examples

The *devicename* is platform dependent. On an MS-DOS based operating system it would be something like 'd:', depending on the logical device code assigned to the CD-ROM drive. On a UNIX operating system, the CD-ROM might be mounted as '\cdrom', '\CDROM', '\cdrom1', or something similar. Check your computer's documentation for the right *devicename*.

To view a list of valid themes, call `vmap0data` and specify an invalid theme, for example '?'. MATLAB errors and displays a list of valid themes.

```
s = vmap0data(devicename,'NOAMER',41,-69,'?','patch');
```

```
??? Error using ==> vmap0data
Theme not present in library NOAMER
```

Valid theme identifiers are:

```
libref : Library Reference
tileref: Tile Reference
bnd    : Boundaries
dq     : Data Quality
elev   : Elevation
hydro  : Hydrography
ind    : Industry
phys   : Physiography
pop    : Population
trans  : Transportation
util   : Utilities
veg    : Vegetation
```

```
BNDpatch = vmap0data(devicename,'NOAMER',...
                    [41 44],[-72 -69],'bnd','patch')
```

```
BNDpatch =
1x169 struct array with fields:
    type
    otherproperty
    altitude
    lat
    long
    tag
```

Here are some examples that specify valid themes:

```
[TRtext,TRline] = vmap0data(devicename,'SASAUS',...
                            [-48 -34],[164 180],'trans',{'text','line'});
```

```
[BNDpatch,BNDline,BNDpoint,BNDtext] = vmap0data(devicename,...
                                                'EURNASIA',-48 ,164,'bnd',{'all'});
```

Tips

Data are returned as Mapping Toolbox display structures, which you can then update to geographic data structures. For information about display structure format, see “Version 1 Display Structures” on page 1-319 in the reference page for `displaym`. The `updategeoststruct` function performs such conversions.

Latitudes and longitudes use WGS84 as a horizontal datum. Elevations and depths are in meters above mean sea level.

Some VMAP0 themes do not contain all topology levels. In those cases, empty matrices are returned.

Patches are broken at the tile boundaries. Setting the `EdgeColor` to 'none' and plotting the lines gives the map a normal appearance.

The major differences between VMAP0 and the DCW are the elimination of the gazette layer, addition of bathymetric data, and updated political boundaries.

Vector Map Level 0, created in the 1990s, is still probably the most detailed global database of vector map data available to the public. VMAP0 CD-ROMs are available from through the U.S. Geological Survey (USGS):

USGS Information Services (Map and Book Sales)
Box 25286
Denver Federal Center
Denver, CO 80225
Telephone: (303) 202-4700
Fax: (303) 202-4693

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: "Find Geospatial Data Online".

Version History

Introduced before R2006a

See Also

`vmap0read` | `vmap0rhead` | `geoshow` | `updategeostruct`

vmap0read

Read Vector Map Level 0 file

Syntax

```
vmap0read
vmap0read(filepath, filename)
vmap0read(filepath, filename, recordIDs)
vmap0read(filepath, filename, recordIDs, field, varlen)
struc = vmap0read(...)
[struc, field] = vmap0read(...)
[struc, field, varlen] = vmap0read(...)
[struc, field, varlen, description] = vmap0read(...)
[struc, field, varlen, description, narrativefield] = vmap0read(...)
```

Description

`vmap0read` reads a VMAP0 file. The user selects the file interactively.

`vmap0read(filepath, filename)` reads the specified file. The combination [`filepath filename`] must form a valid complete file name.

`vmap0read(filepath, filename, recordIDs)` reads selected records or fields from the file. If `recordIDs` is a scalar or a vector of integers, the function returns the selected records. If `recordIDs` is a cell array of integers, all records of the associated fields are returned.

`vmap0read(filepath, filename, recordIDs, field, varlen)` uses previously read field and variable-length record information to skip parsing the file header (see below).

`struc = vmap0read(...)` returns the file contents in a structure.

`[struc, field] = vmap0read(...)` returns the file contents and a structure describing the format of the file.

`[struc, field, varlen] = vmap0read(...)` also returns a vector describing which fields have variable-length records.

`[struc, field, varlen, description] = vmap0read(...)` also returns `description`, a character vector that describes the contents of the file.

`[struc, field, varlen, description, narrativefield] = vmap0read(...)` also returns the name of the narrative file for the current file.

Background

The Vector Map Level 0 (VMAP0) uses binary files in a variety of formats. This function determines the format of the file and returns the contents in a structure. The field names of this structure are the same as the field names in the VMAP0 file.

Examples

The following examples use the UNIX directory system and file separators for the path name:

```
s = vmap0read('VMAP/VMAPLV0/NOAMER/', 'GRT')

s =
      id: 1
    data_type: 'GEO'
      units: 'M'
  ellipsoid_name: 'WGS 84'
ellipsoid_detail: 'A=6378137 B=6356752 Meters'
  vert_datum_name: 'MEAN SEA LEVEL'
  vert_datum_code: '015'
  sound_datum_name: 'N/A'
  sound_datum_code: 'N/A'
    geo_datum_name: 'WGS 84'
    geo_datum_code: 'WGE'
  projection_name: 'Dec. Deg. (unproj.)'

s = vmap0read('VMAP/VMAPLV0/NOAMER/TRANS/', 'INT.VDT')

s =
34x1 struct array with fields:
  id
  table
  attribute
  value
  description

s(1)

ans =
      id: 1
    table: 'aerofacp.pft'
  attribute: 'use'
    value: 8
  description: 'Military'
s = vmap0read('VMAP/VMAPLV0/NOAMER/TRANS/', 'AEROFACP.PFT', 1)

s =
      id: 1
    f_code: 'GB005'
      iko: 'BGTL'
      nam: 'THULE AIR BASE'
    na3: 'GL52085'
      use: 8
    zv3: 77
  tile_id: 10
  end_id: 1

s = vmap0read('VMAP/VMAPLV0/NOAMER/TRANS/', 'AEROFACP.PFT', {1,2})

s =
1x4424 struct array with fields:
  id
  f_code
```

Tips

This function reads all VMAP0 files except index files (files with names ending in 'X'), thematic index files (files with names ending in 'TI'), and spatial index files (files with names ending in 'SI').

File separators are platform dependent. The *filepath* input must use appropriate file separators, which you can determine using the MATLAB `filesep` function.

Version History

Introduced before R2006a

See Also

vmap0data | vmap0rhead

vmap0rhead

Read Vector Map Level 0 file headers

Syntax

```
vmap0rhead
vmap0rhead(filepath, filename)
vmap0rhead(filepath, filename, fid)
vmap0rhead(...),
str = vmap0rhead(...)
```

Description

vmap0rhead allows the user to select the header file interactively.

vmap0rhead(filepath, filename) reads from the specified file. The combination [filepath filename] must form a valid complete file name.

vmap0rhead(filepath, filename, fid) reads from the already open file associated with fid.

vmap0rhead(...), with no output arguments, displays the formatted header information on the screen.

str = vmap0rhead(...) returns a character vector containing the VMAP0 header.

Background

The Vector Map Level 0 (VMAP0) uses the header in most files to document the contents and format of that file. This function reads the header and displays a formatted version in the Command Window, or returns it as a character vector.

Examples

The following example uses UNIX file separators and path name:

```
s = vmap0rhead('VMAP/VMAPLV0/NOAMER/', 'GRT')
s =
L;Geographic Reference Table;-;id=I,1,P,Row
Identifier,-,-,-,:data_type=T,3,N,Data
Type,-,-,-,:units=T,3,N,Units of Measure Code for
Library,-,-,-,:ellipsoid_name=T,15,N,Ellipsoid,-,-,-,:ellipsoid
_detail=T,50,N,Ellipsoid
Details,-,-,-,:vert_datum_name=T,15,N,Datum Vertical
Reference,-,-,-,:vert_datum_code=T,3,N,Vertical Datum
Code,-,-,-,:sound_datum_name=T,15,N,Sounding
Datum,-,-,-,:sound_datum_code=T,3,N,Sounding Datum
Code,-,-,-,:geo_datum_name=T,15,N,Datum Geodetic
Name,-,-,-,:geo_datum_code=T,3,N,Datum Geodetic
Code,-,-,-,:projection_name=T,20,N,Projection Name,-,-,-,;
```

```
vmap0rhead('VMAP/VMAPLV0/NOAMER/TRANS/', 'AEROFACP.PFT')
L
Airport Point Feature Table
aerofacp.doc
id=I,1,P,Row Identifier,-,-,-,
f_code=T,5,N,FACC Feature Code,char.vdt,-,-,
iko=T,4,N,ICAO Designator,char.vdt,-,-,
nam=T,*N,Name,char.vdt,-,-,
na3=T,*N,Name,char.vdt,-,-,
use=S,1,N,Usage,int.vdt,-,-,
zv3=S,1,N,Airfield/Aerodrome Elevation (meters),int.vdt,-,-,
tile_id=S,1,N,Tile Reference ID,-,tile1_id.pti,-,
end_id=I,1,N,Entity Node Primitive ID,-,end1_id.pti,-,
```

Tips

This function reads all VMAP0 files except index files (files with names ending in 'X'), thematic index files (files with names ending in 'TI') and spatial index files (files with names ending in 'SI').

File separators are platform dependent. The *filepath* input must use appropriate file separators, which you can determine using the MATLAB `filesep` function.

Version History

Introduced before R2006a

See Also

vmap0data | vmap0read

webmap

Open web map

Syntax

```
webmap
webmap(baseLayer)
webmap(wmsLayer)
webmap(customBasemap)
webmap( ____, 'WrapAround', tf)
wm = webmap( ____ )
webmap(wm)
```

Description

`webmap` opens a new web map, with its center at the latitude, longitude point [0 0]. By default, `webmap` sets the base layer to World Street Map at the maximum spatial extent available. After the web map opens, you can select a different base layer using the Layer Manager available on the right side of the web map. Named base layers are tiled at discrete zoom resolutions.

Note The `webmap` function requires an Internet connection. MathWorks cannot guarantee the stability and accuracy of web maps, as the servers are on the Internet and are independent from MathWorks. Occasionally, maps may be slow to display, display partially, or fail to display, because web map servers can become unavailable for short periods of time.

`webmap(baseLayer)` opens a new web map with `baseLayer` as the default base layer. See `baseLayer` for a list of the available maps.

`webmap(wmsLayer)` Opens a new web map with `wmsLayer` as the default base layer. `wmsLayer` is a `WMSLayer` array. The `LayerTitle` property of each `wmsLayer` is set as an item in the Layer Manager.

`webmap` displays WMS layers in the "Web Mercator" map coordinate reference system, if that projection is available for all layers in the array. Otherwise, `webmap` displays the layers in the EPSG:4326 geographic coordinate reference system. When using EPSG:4326, `webmap` does not include the default base layers in the Layer Manager since they are in a different coordinate reference system. These projections include a geographic quadrangle bounded north/south by parallels and east/west by meridians. Parallels map to horizontal lines. Meridians map to vertical lines.

`webmap(customBasemap)` opens a new web map using the custom basemap specified by the `addCustomBasemap` function. `customBasemap` is a string scalar or character vector specifying the display name of the custom basemap, if provided, or the basemap name.

`webmap(____, 'WrapAround', tf)`, where `tf` is specified as the logical value `false` or 0, opens a new web map with the display clipped to the west at -180 degrees and to the east at +180 degrees. The default for `tf` is `true` or 1, which opens a map that supports continuous pan and zoom across the

180-degree meridian. The webmap function constrains zoom to show less than 180 degrees of longitude at a time.

`wm = webmap(___)` returns a handle to a web map, `wm`.

`webmap(wm)` makes the web map specified by `wm` the current web map.

Examples

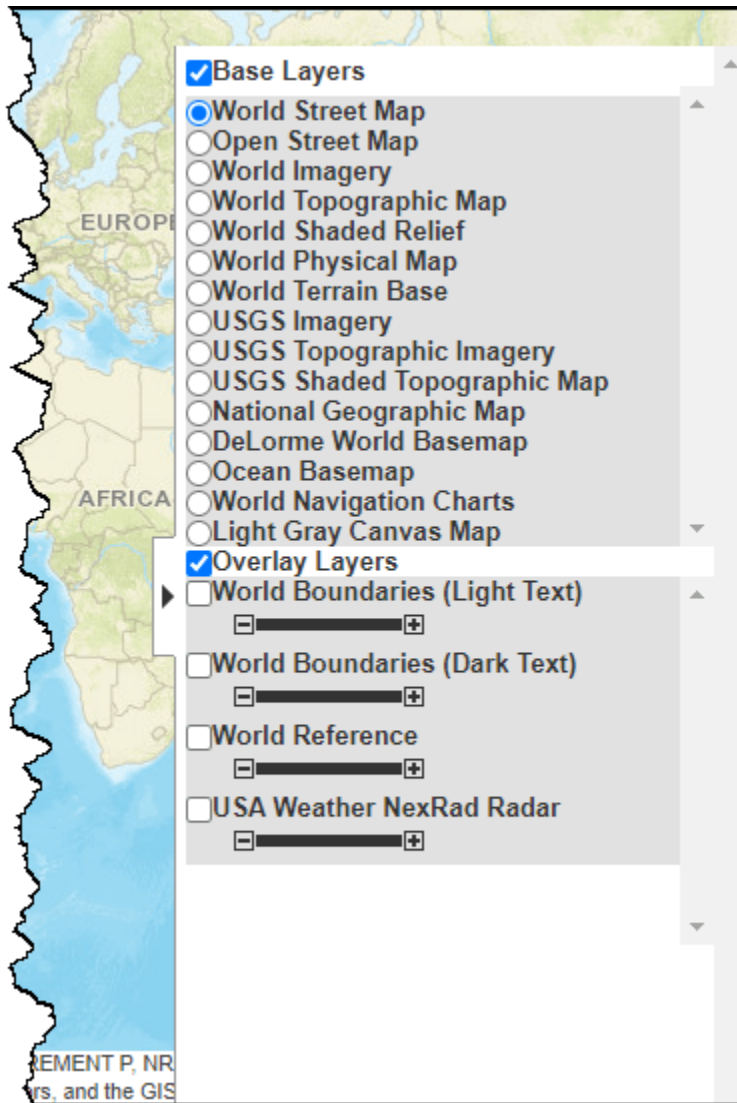
Display Web Map

Open a web map centered at [0 0].

`webmap`



View the list of available base layers (basemaps) by clicking the expander arrow ◀ on the right side of the map.



Display Web Map Specifying Base Layer

Open a web map specifying the base layer and show the full extent of the world.

```
webmap('Light Gray Canvas Map', 'WrapAround', false)
```



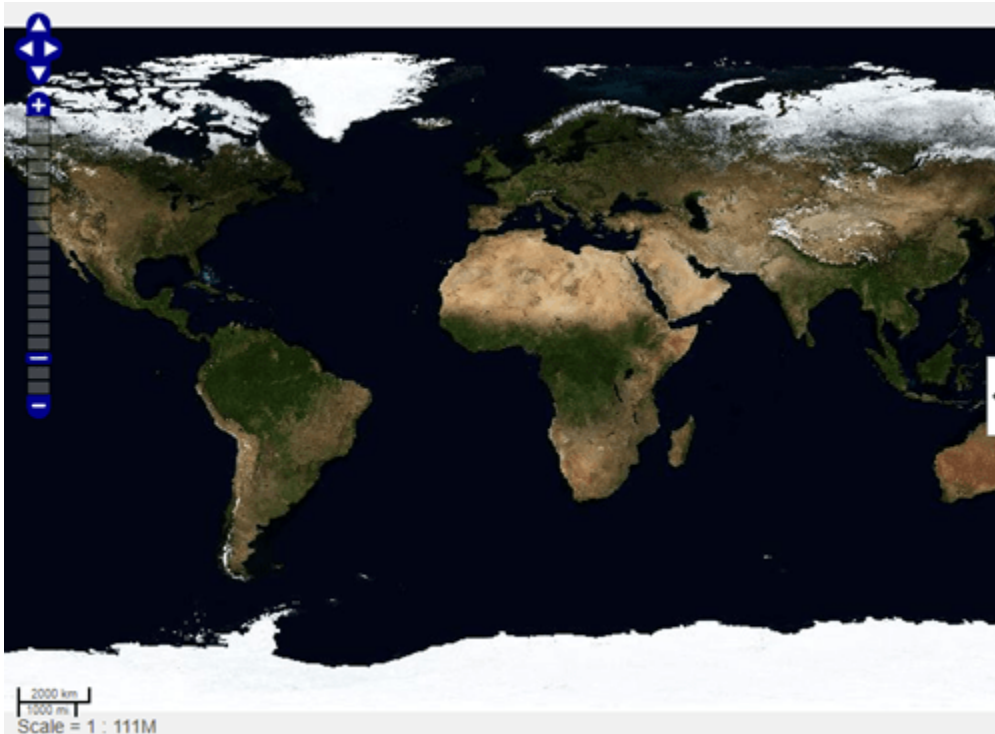
Display Web Map with WMS Layer as Base Layer

Read the Blue Marble WMS layer from the Atmospheric Composition Portal (ACP) Data from NASA Goddard Earth Sciences Data and Information Services Center (GES DISC).

```
baselayer = wmsfind('blue*marble');  
baselayer = refine(baselayer, "eosdis.nasa.gov", "SearchFields", "serverurl");  
baselayer = wmsupdate(baselayer(1));
```

Display a web map with the Blue Marble WMS layer as the base layer.

```
webmap(baselayer)
```



Display Web Map Using Custom Base Layer

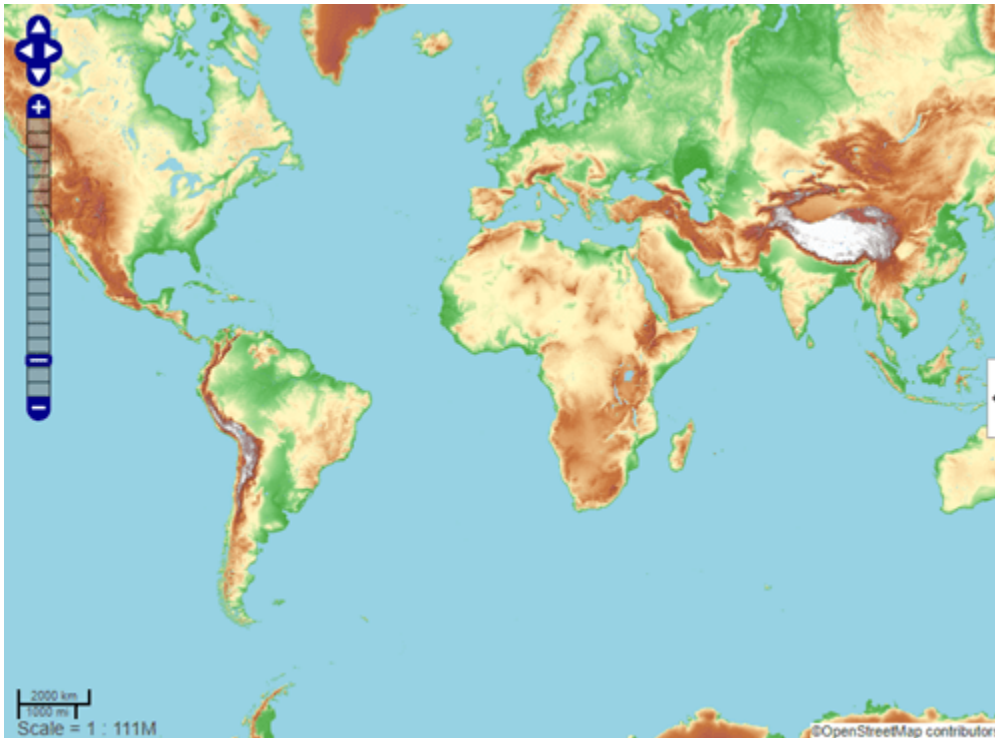
Add a basemap from OpenTopoMap as a custom base layer. Specify values for these arguments:

- A name that identifies the custom basemap.
- The URL of the map tiles. For load balancing, this provider has three servers you can use (a, b, and c).
- An attribution that gives credit to the provider of the map tiles. When you plot data, this attribution appears at the bottom of the map. Map tile providers can define specific requirements for the attribution.
- The name that appears in the Layer Manager tab of the web map.

```
basemapName = "opentopomap";  
url = "a.tile.opentopomap.org/{z}/{x}/{y}.png";  
attribution = "©OpenStreetMap contributors";  
displayName = "Open Topo Map";  
addCustomBasemap(basemapName,url,"Attribution",attribution, ...  
    "DisplayName",displayName)
```

Create a web map that uses the custom basemap.

```
webmap opentopomap
```



Input Arguments

baseLayer — Map displayed in web map

character vector | string scalar

Map displayed in the web map, specified as a string scalar or character vector, listed in the following table. If specified as string scalar or character vector, the value is case insensitive and spaces are optional.

Name	Description
'World Street Map'	Worldwide street map provided by Esri. For information about the Esri ArcGIS Online layers, visit https://www.arcgis.com/home/gallery.html#c=esri&f=basemaps&t=maps .
'Open Street Map'	Street map from openstreetmap.org . For more information, visit https://www.openstreetmap.org .
'World Imagery'	Worldwide imagery provided by Esri.
'World Topographic Map'	Topographic map for the world from Esri.
'World Shaded Relief'	Surface elevation as shaded relief provided by Esri
'World Physical Map'	Natural Earth map of the world provided by Esri
'World Terrain Base'	Shaded relief and bathymetry provided by Esri
'USGS Imagery'	Composite of Blue Marble, NAIP, and Landsat provided by the USGS.
'USGS Topographic Imagery'	Topographic map with imagery provided by the USGS.

Name	Description
'USGS Shaded Topographic Map'	Composite of contours, shaded relief, and vector layers provided by the USGS.
'National Geographic Map'	General reference map provided by Esri
'DeLorme World Basemap'	Topographic map provided by Esri
'Ocean Basemap'	Bathymetry, marine features, depth in meter provided by Esri
'World Navigation Charts'	Topographic data with nautical information provided by Esri
'Light Gray Canvas Map'	Neutral background map with minimal colors provided by Esri

Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

Data Types: `char` | `string`

wmsLayer — Web map service layer

WMSLayer array

Web map service layer, specified as a WMSLayer array.

Web maps do not support layers from `wms.mathworks.com`.

customBasemap — Name of custom basemap

character vector | string

Name of custom basemap, specified as a string scalar or character vector. The value is case-insensitive and spaces are optional. Create a custom basemap by using the `addCustomBasemap` function.

Web maps do not support custom basemaps created from MBTiles files or custom basemaps hosted by Esri.

Data Types: `char` | `string`

wm — Web map

web map handle

Web map, specified as a web map handle, returned by the `webmap` function.

Output Arguments

wm — Web map

web map handle

Web map, returned as a web map handle.

Limitations

In MATLAB Online, if you refresh the URL, then the window containing the web map closes. In addition, if you returned a handle to the web map, then it is deleted.

More About

Web Map

An interactive map accessed through a web page. In a web map, you can select different map layers to view and navigate around the map using interactive tools, such as zooming. The web map is a window that displays map base layers obtained from web servers on the Internet. You can also display overlay layers that contain custom point and line vector data.

Tips

Particular maps may not support every available zoom level. If your map displays as white, try another zoom level. The map you are displaying might not support the zoom level you have currently selected. You can also select another base layer, which might support the specified zoom level.

Version History

Introduced in R2013b

R2022a: USGS Shaded Relief base layer has been removed

Errors starting in R2022a

Starting in R2022a, the webmap function issues an error when you specify the base layer as "USGS Shaded Relief". In previous releases, the web map window shows red tiles. Update your code by specifying a different base layer, such as "World Shaded Relief".

Has Been Removed	Recommended
<code>webmap("USGS Shaded Relief")</code>	<code>webmap("World Shaded Relief")</code>

R2021a: Web maps appear in multiple windows and have a default size

Behavior changed in R2021a

Starting in R2021a, web maps created using the webmap function have these differences from previous releases:

- Each web map appears in a separate window. In previous releases, each web map appeared as a tab in a single window.
- Web maps have a default size of 750-by-550 pixels. In previous releases, each new web map matched the size of the previous web map.
- You cannot dock a web map.

R2020a: Compiling web maps using Linux requires files in directory of application

Behavior changed in R2020a

Starting in R2020a, to compile web maps using MATLAB Compiler on Linux, you must copy these files to the application directory and distribute them with the application.

- `icudtl.dat`
- `natives_blob.bin`
- `snapshot_blob.bin`

You can find the path to these files using the command `fullfile(matlabroot, 'bin', 'glnxa64')`.

See Also

`wmclose` | `wmcenter` | `wmline` | `wmlimits` | `wmprint` | `wmmarker` | `wmremove` | `wmzoom` | `addCustomBasemap`

WebMapServer

Web map server

Description

A `WebMapServer` object represents a Web Map Service (WMS) and acts as a proxy to a WMS server.

The `WebMapServer` object resides physically on the client side. The object can access the capabilities document on the WMS server and perform requests to obtain maps. It supports multiple WMS versions and negotiates with the server automatically to use the highest known version that the server can support.

Creation

Syntax

```
server = WebMapServer(serverURL)
```

Description

`server = WebMapServer(serverURL)` creates a `WebMapServer` object, setting the `ServerURL` property.

Properties

Timeout — Number of milliseconds before a server times out

0 (default) | nonnegative integer

Number of milliseconds before a server times out, specified as a nonnegative integer. When `Timeout` has a value of 0, the `WebMapServer` object ignores the timeout mechanism.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

EnableCache — Flag enabling cache

1 (default) | logical scalar

Flag enabling cache, specified as a logical scalar. When `EnableCache` is `True`, the `WebMapServer` object caches the `WMSCapabilities` object, which is returned when you use the `getCapabilities` method. The cache expires if the `AccessDate` property of the cached `WMSCapabilities` object is not the current day.

Data Types: `logical`

ServerURL — URL of the server

character vector

URL of the server, specified as a character vector. The URL must include the protocol '`http://`' or '`https://`'. The URL can contain additional WMS keywords.

Data Types: char

RequestURL — URL of the last request to the server

character vector

URL of the last request to the server, specified as a character vector. RequestURL specifies a request for either the XML capabilities document or a map. You can insert the requested URL into a browser.

Data Types: char

Object Functions

getCapabilities Get capabilities document from server
getMap Get raster map from server
updateLayers Update layer properties

Examples

Get Capabilities Document from Web Map Server

Construct a WebMapServer object that communicates with one of the Environmental Research Division's Data Access Program (ERDDAP) WMS servers hosted by NOAA. Obtain the capabilities document from the server.

```
layers = wmsfind('jplglsst','SearchField','serverurl');  
serverURL = layers(1).ServerURL;  
server = WebMapServer(serverURL);  
capabilities = getCapabilities(server);  
layers = capabilities.Layer;
```

Search for a server that shows nation boundaries (`nations`). Search for a server that provides daily, global sea surface temperature (`sst`) data produced by the Jet Propulsion Laboratory's Regional Ocean Modeling System (JPL ROMS) group.

```
nations = refine(layers,'nations');  
nations = nations(1);  
sst = refine(layers,'sst');  
sst = sst(1);  
layer = [sst nations];
```

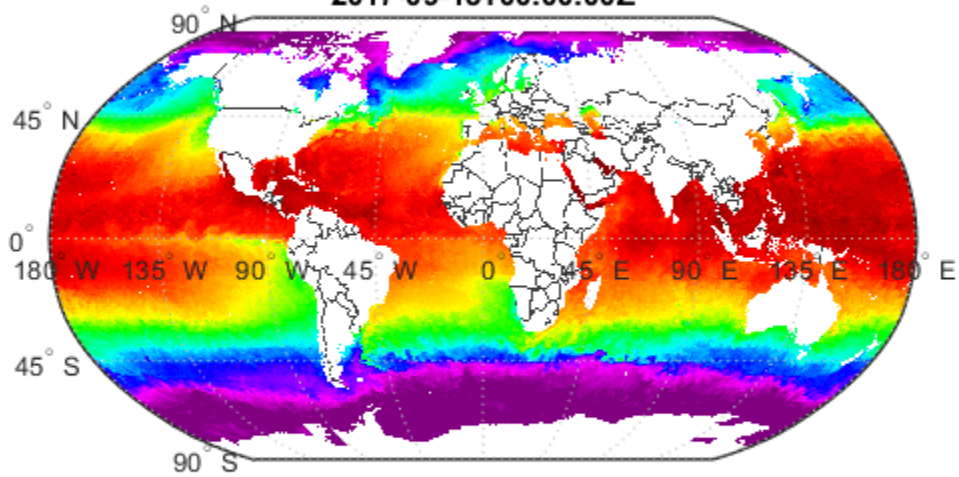
Obtain data from the servers.

```
request = WMSMapRequest(layer,server);  
A = getMap(server,request.RequestURL);  
R = request.RasterReference;
```

Display data from the servers.

```
figure  
worldmap(A,R)  
geoshow(A,R)  
title({sst.LayerTitle(1:51),sst.LayerTitle(52:end), ...  
      sst.Details.Dimension.Default})
```

**GHRSSST Global 1-km Sea Surface Temperature (G1SST),
Global, 0.01 Degree, 2010-2017, Daily - SST
2017-09-13T00:00:00Z**



Version History

Introduced before R2006a

See Also

Functions

[wmsfind](#) | [wmsinfo](#) | [wmsread](#) | [wmsupdate](#)

Objects

[WMSLayer](#) | [WMSCapabilities](#) | [WMSMapRequest](#)

wgs84Ellipsoid

Reference ellipsoid for World Geodetic System of 1984

Syntax

```
E = wgs84Ellipsoid
E = wgs84Ellipsoid(lengthUnit)
```

Description

`E = wgs84Ellipsoid` creates a `referenceEllipsoid` object for the World Geodetic System of 1984 (WGS84) reference ellipsoid. By default, the lengths of the semimajor axis and semiminor axis are in meters.

`E = wgs84Ellipsoid(lengthUnit)` creates a WGS84 reference ellipsoid with the length unit specified by `lengthUnit`.

Examples

Create WGS84 Reference Ellipsoid

Create a WGS84 reference ellipsoid. By default, the semimajor and semiminor axes are in meters.

```
wgs84 = wgs84Ellipsoid
```

```
wgs84 =
referenceEllipsoid with defining properties:
```

```
Code: 7030
Name: 'WGS 84'
LengthUnit: 'meter'
SemimajorAxis: 6378137
SemiminorAxis: 6356752.31424518
InverseFlattening: 298.257223563
Eccentricity: 0.0818191908426215
```

```
and additional properties:
```

```
Flattening
ThirdFlattening
MeanRadius
SurfaceArea
Volume
```

Display the surface area in square meters.

```
wgs84.SurfaceArea
```

```
ans = 5.1007e+14
```

Create WGS84 Reference Ellipsoid with Specified Units

Create a WGS84 reference ellipsoid with a length unit of kilometers.

```
wgs84km = wgs84Ellipsoid("kilometer")
```

```
wgs84km =  
referenceEllipsoid with defining properties:
```

```
        Code: 7030  
        Name: 'WGS 84'  
        LengthUnit: 'kilometer'  
        SemimajorAxis: 6378.137  
        SemiminorAxis: 6356.75231424518  
        InverseFlattening: 298.257223563  
        Eccentricity: 0.0818191908426215
```

```
and additional properties:
```

```
    Flattening  
    ThirdFlattening  
    MeanRadius  
    SurfaceArea  
    Volume
```

Display the surface area in square kilometers.

```
wgs84km.SurfaceArea
```

```
ans = 5.1007e+08
```

Input Arguments

LengthUnit — Length unit of measure

'meter' (default) | string scalar | character vector

Length unit of measure, specified as a string scalar or character vector. You can specify any length unit accepted by the `validateLengthUnit` function.

Value	Unit Name
"m", "meter", "meters", "metre", "metres"	Meters
"cm", "centimeter", "centimeters", "centimetre", "centimetres"	Centimeters
"mm", "millimeter", "millimeters", "millimetre", "millimetres"	Millimeters
"micron", "microns"	Microns
"km", "kilometer", "kilometers", "kilometre", "kilometres"	Kilometers

Value	Unit Name
"nm", "naut mi", "nautical mile", "nautical miles"	Nautical miles
"ft", "international ft", "foot", "international foot", "feet", "international feet"	Feet
"in", "inch", "inches"	Inches
"yd", "yds", "yard", "yards"	Yards
"mi", "mile", "miles", "international mile", "international miles"	Miles
"sf", "survey ft", "US survey ft", "U.S. survey ft", "survey foot", "US survey foot", "U.S. survey foot", "survey feet", "US survey feet", "U.S. survey feet"	U.S. survey feet
"sm", "survey mile", "survey miles", "statute mile", "statute miles", "US survey mile", "US survey miles", "U.S. survey mile(s)", "U.S. survey miles"	U.S. survey miles (statute miles)
"Clarke's foot", "Clarkes foot"	Clarke's feet
"German legal metre", "German legal meter"	German legal metres
"Indian foot"	Indian feet

Data Types: char | string

Version History

Introduced in R2012a

R2021a: Generate C and C++ code using MATLAB Coder

The wgs84Ellipsoid function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

Usage notes and limitations:

- Setting the length unit of measure is not supported.

See Also

Functions

validateLengthUnit

Objects

referenceEllipsoid

wktstring

Well-known text string

Syntax

```
str = wktstring(crs)
str = wktstring(crs,Name,Value)
```

Description

`str = wktstring(crs)` returns the well-known text (WKT) string representation of the specified projected or geographic coordinate reference system. By default, `wktstring` uses the WKT 2 standard and does not apply formatting.

`str = wktstring(crs,Name,Value)` specifies version and formatting options using one or more `Name,Value` pair arguments. For example, `'Format'`, `'formatted'` includes line breaks and indentations in the WKT string.

Examples

Get WKT of Projected CRS

Return information about projected data as a `RasterInfo` object. Find the projected CRS for the data by accessing its `CoordinateReferenceSystem` property.

```
info = georasterinfo('MtWashington-ft.grd');
p = info.CoordinateReferenceSystem;
```

Return the WKT as a string.

```
str = wktstring(p)
```

```
str =
```

```
"PROJCRS["UTM Zone 19, Northern Hemisphere",BASEGEOGCRS["NAD27",DATUM["North American Datum 1927
```

Get WKT of Geographic CRS

Return information about geographic data as a `RasterInfo` object. Find the geographic CRS for the data by accessing its `CoordinateReferenceSystem` property.

```
[Z,R] = readgeoraster('n39_w106_3arc_v2.dt1');
g = R.GeographicCRS;
```

Return the WKT as a string.

```
wkt = wktstring(g)
```

```
wkt =
```

```
"GEOGCRS["WGS 84",DATUM["World Geodetic System 1984",ELLIPSOID["WGS 84",6378137,298.257223563,LE
```


Change Default Formatting

Return information about a data set as a `RasterInfo` object. Find the projected CRS for the data by accessing the `CoordinateReferenceSystem` property.

```
info = georasterinfo('MtWashington-ft.grd');
p = info.CoordinateReferenceSystem;
```

Return the WKT as a formatted string by using the 'Format' name-value pair.

```
str = wktstring(p, 'Format', 'formatted')

str =
    "PROJCRS["UTM Zone 19, Northern Hemisphere",
      BASEGEOGCRS["NAD27",
        DATUM["North American Datum 1927",
          ELLIPSOID["Clarke_1866",6378206.4,294.978698213898,
            LENGTHUNIT["metre",1]],
          ID["EPSG",6267]],
        PRIMEM["Greenwich",0,
          ANGLEUNIT["Degree",0.0174532925199433]]],
      CONVERSION["UTM zone 19N",
        METHOD["Transverse Mercator",
          ID["EPSG",9807]],
        PARAMETER["Latitude of natural origin",0,
          ANGLEUNIT["Degree",0.0174532925199433],
          ID["EPSG",8801]],
        PARAMETER["Longitude of natural origin",-69,
          ANGLEUNIT["Degree",0.0174532925199433],
          ID["EPSG",8802]],
        PARAMETER["Scale factor at natural origin",0.9996,
          SCALEUNIT["unity",1],
          ID["EPSG",8805]],
        PARAMETER["False easting",500000,
          LENGTHUNIT["Meter",1],
          ID["EPSG",8806]],
        PARAMETER["False northing",0,
          LENGTHUNIT["Meter",1],
          ID["EPSG",8807]],
        ID["EPSG",16019]],
      CS[Cartesian,2],
      AXIS["easting",east,
        ORDER[1],
        LENGTHUNIT["Meter",1]],
      AXIS["northing",north,
        ORDER[2],
        LENGTHUNIT["Meter",1]]]"
```

Export WKT as Projection File

Return information about a data set as a `RasterInfo` object. Find the projected CRS for the data by accessing the `CoordinateReferenceSystem` property. Return the WKT as a string using the WKT 1 standard.

```
info = georasterinfo('MtWashington-ft.grd');  
p = info.CoordinateReferenceSystem;  
str = wktstring(p, 'Version', 'wkt1');
```

Export the WKT as a projection file called `mtwash.prj`.

```
writematrix(str, 'mtwash.prj', 'FileType', 'text', 'QuoteStrings', false)
```

Input Arguments

crs — Coordinate reference system

`projcrs` object | `geocrs` object

Coordinate reference system, specified as a `projcrs` object or `geocrs` object.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `'Version', 'wkt1'` specifies the WKT 1 standard for the output well-known text string.

Format — Format of WKT

`'compact'` (default) | `'formatted'`

Format of the WKT string, specified as the comma-separated pair consisting of `'Format'` and one of these values:

- `'compact'` - Do not include formatting.
- `'formatted'` - Include line breaks and indentations.

Example: `'Format', 'formatted'`

Data Types: `char` | `string`

Version — WKT version

`'wkt2'` (default) | `'wkt1'`

WKT version, specified as the comma-separated pair consisting of `'Version'` and one of these values:

- `'wkt2'` - Use the WKT 2 standard. For more information about this standard, see Geographic Information - Well-known text representation of coordinate reference systems.
- `'wkt1'` - Use the WKT 1 standard. For more information about this standard, see Coordinate Transformation Service.

Example: 'Version', 'wkt1'

Data Types: char | string

Tips

The WKT strings for two equivalent `projcrs` or `geocrs` objects may not be equivalent. Compare `projcrs` or `geocrs` objects by using the `isequal` function instead of by comparing WKT strings.

Version History

Introduced in R2020b

See Also

Objects

`projcrs` | `geocrs`

wmclose

Close web map

Syntax

```
wmclose  
wmclose(wm)  
wmclose all
```

Description

wmclose closes the current web map.

wmclose(wm) closes the web map specified by wm.

wmclose all closes all web maps.

Examples

Close Current Web Map

Open a web map, pause one second, and then close the web map.

```
webmap  
pause(1)  
wmclose
```

Close Specified Web Map

Open two web maps, pause for one second, and then close one of the web maps.

```
h1 = webmap;  
h2 = webmap('ocean basemap');  
pause(1)  
wmclose(h1)
```

Close All Web Maps

Open two web maps, pause for one second, and then close all the web maps.

```
h1 = webmap;  
h2 = webmap('ocean basemap');
```

pause(1)
wmclose **all**

Input Arguments

wm — Web map
web map handle

Web map, specified as a web map handle.⁹ You use the `webmap` function to get a web map handle when you create a web map.

Version History

Introduced in R2013b

See Also

[webmap](#) | [wmcenter](#) | [wmline](#) | [wmlimits](#) | [wmprint](#) | [wmmarker](#) | [wmremove](#) | [wmzoom](#)

⁹ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

wmprint

Print web map

Syntax

```
wmprint()  
wmprint(wm)
```

Description

`wmprint()` prints the contents of the current web map to a printer.

`wmprint(wm)` prints the contents of the web map specified by `wm`.

Examples

Print Web Map

Create a web map, specifying a base layer.

```
webmap('OpenStreetMap')
```

Position the web map.

```
wmcenter(51.487, 0, 15)
```

Print the contents of the web map.

```
wmprint()
```

Input Arguments

wm — Web map

scalar web map handle

Web map, specified as a scalar web map handle.¹⁰

Limitations

MATLAB Online does not support the `wmprint` function.

Version History

Introduced in R2013b

¹⁰ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

See Also

wmclose | wmcenter | wmline | wmlimits | webmap | wmmarker | wmremove | wmzoom

wmmarker

Display geographic marker on web map

Syntax

```
wmmarker(lat, lon)
wmmarker(P)
wmmarker(wm, ___)
wmmarker(__, Name, Value)
h = wmmarker( ___ )
```

Description

`wmmarker(lat, lon)` displays a marker overlay at the points specified by `lat` and `lon` on the current web map. If there is no current web map, `wmmarker` creates one. `wmmarker` centers the map so that all vector overlays on the web map are visible. A marker is also called a map pin.

`wmmarker(P)` displays a marker overlay based on the vector geographic features stored in `P`. Each element of `P` defines one marker overlay.

`wmmarker(wm, ___)` displays the overlay in the web map specified by the web map handle, `wm`.

`wmmarker(__, Name, Value)` specifies name-value pairs that set additional display properties. Parameter names can be abbreviated and are case-insensitive.

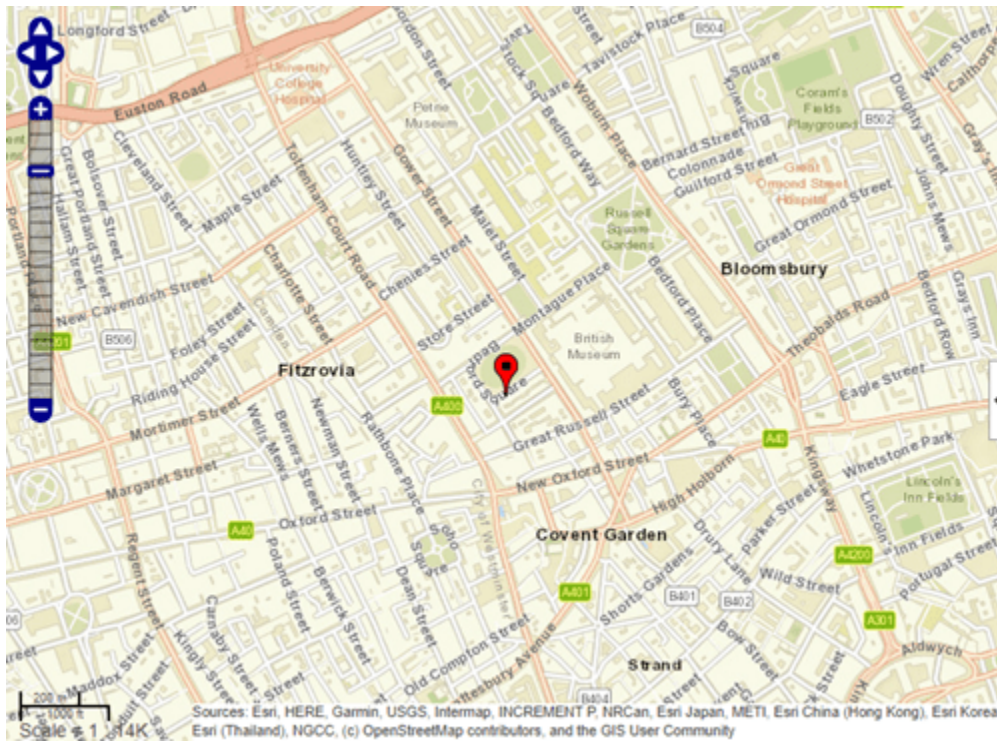
`h = wmmarker(___)` returns a handle to the overlay.

Examples

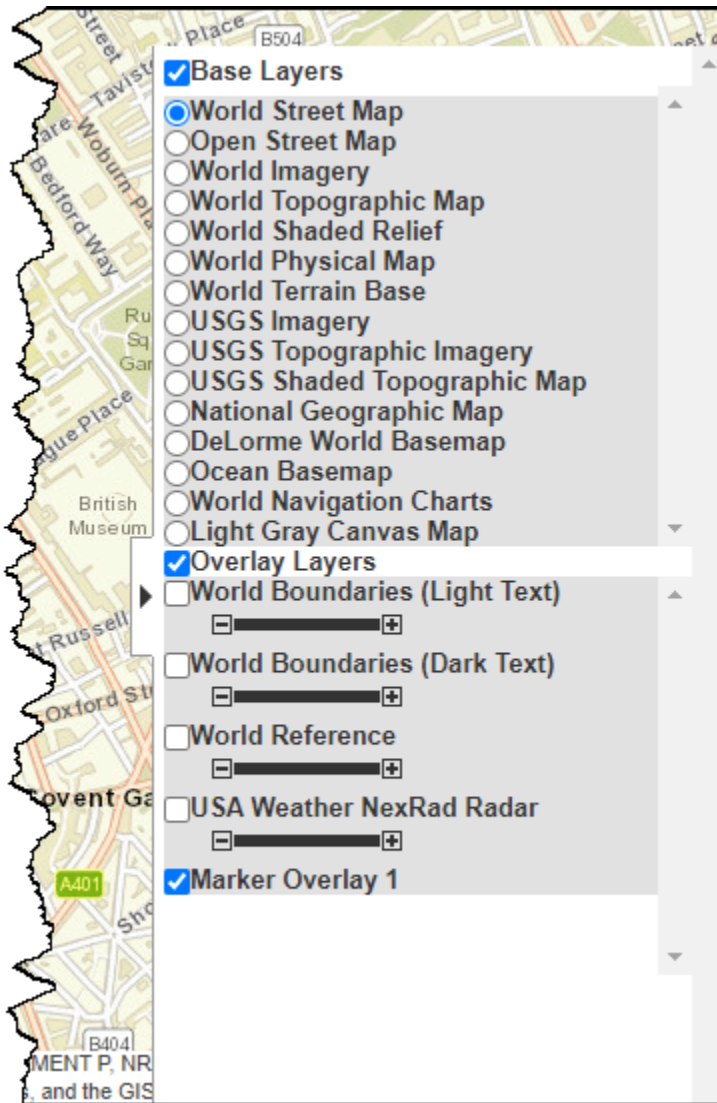
Display Marker on Web Map

Display a marker at the location of London, England. There is no current web map, so the `wmmarker` function creates one.

```
lat = 51.5187666404504;
lon = -0.130003487285315;
wmmarker(lat, lon)
```

wmmarker adds the marker name to the list of overlays in the Layer Manager. The default name is **Marker Overlay 1**.



Display Information About Markers

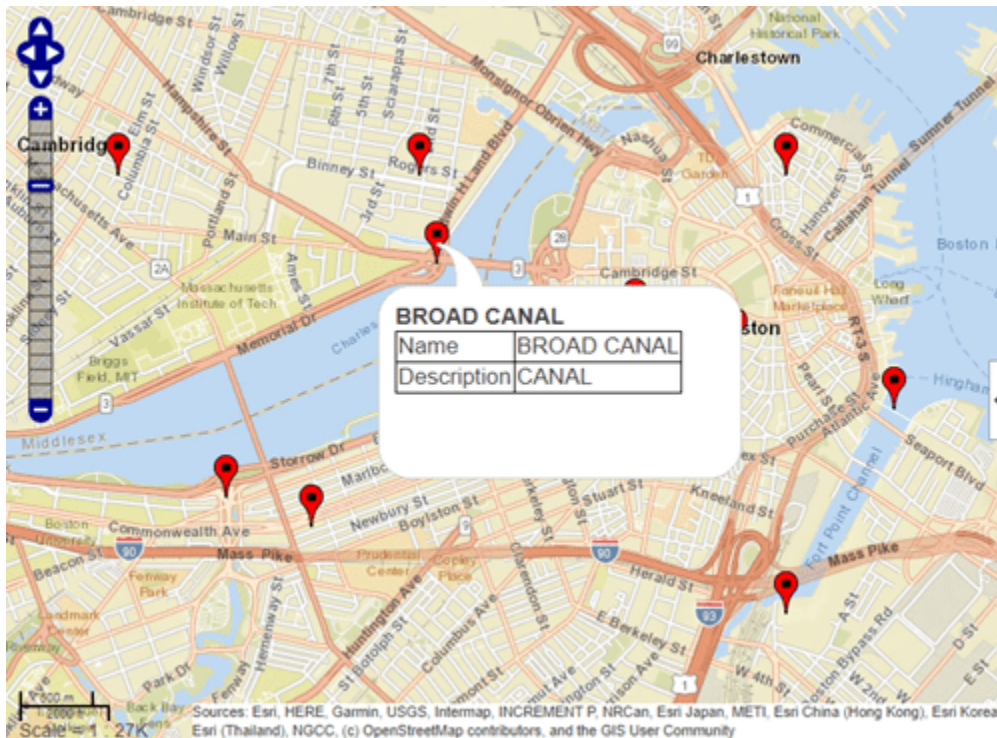
Read the coordinates and names of locations in Boston, MA, as a geospatial table.

```
P = readgeotable("boston_placenames.gpx");
```

Display the data as markers on a web map. Specify the feature names and overlay names using name-value arguments. The `wmmarker` function creates a new web map when there is no current web map.

```
wmmarker(P, "FeatureName", P.Name, "OverlayName", "Boston Placenames")
```

Click on a marker to see information about the feature, including its name.



Display Marker Using Custom Icon and Description Data

Define a location. For this example, specify the coordinates of MathWorks®.

```
lat = 42.299827;
lon = -71.350273;
```

Specify a name and text to display in the description balloon. This code makes the MathWorks URL a link.

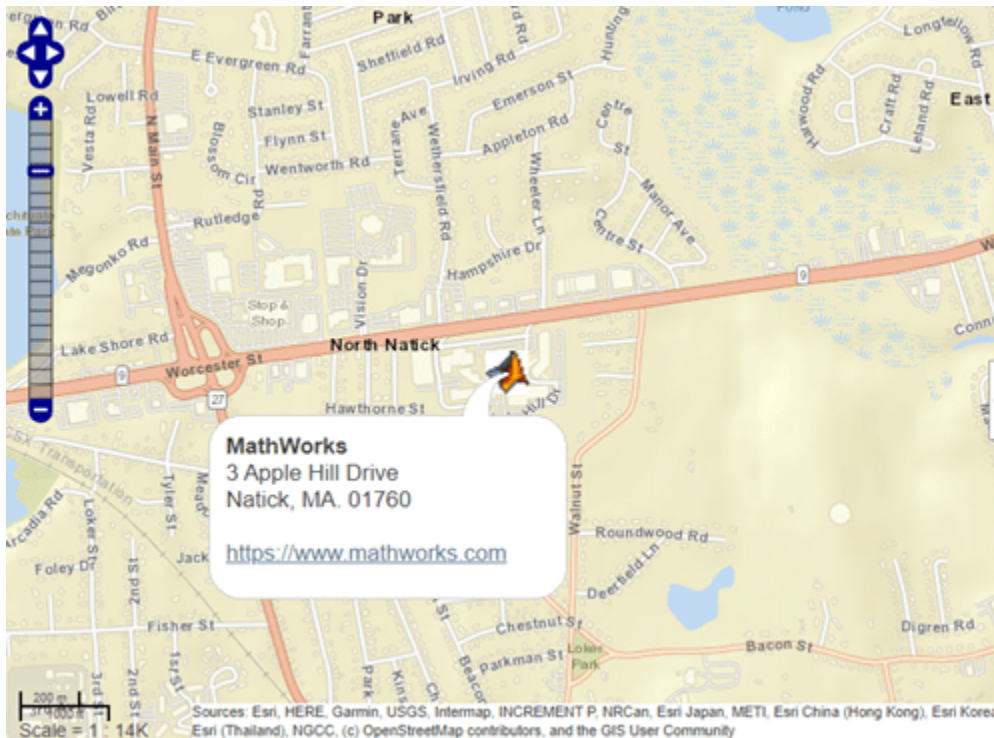
```
name = 'MathWorks';
description = sprintf(...
    '%s<br>%s</br><br>%s</br>',...
    '3 Apple Hill Drive', 'Natick, MA. 01760', ...
    '<a href="https://www.mathworks.com" target="_blank">https://www.mathworks.com</a>');
```

Specify a custom icon for the marker.

```
iconDir = fullfile(matlabroot,'toolbox','matlab','icons');
iconFilename = fullfile(iconDir,'matlabicon.gif');
```

Display the marker on the web map by using `wmmarker`. Specify the `Description`, `FeatureName`, `Icon`, and `OverlayName` name-value pairs. Note the custom icon. Display the text you included by clicking on the marker. Note the HTML formatting in the description.

```
wmmarker(lat,lon,'Description',description, ...
    'FeatureName',name, ...
    'Icon',iconFilename, ...
    'OverlayName',name)
```



Display Marker Overlay Using Attribute Specification

Import a shapefile representing tsunami events reported over several decades, tagged geographically by source location.

```
GT = readgeotable("tsunamis.shp", "CoordinateSystemType", "geographic");
```

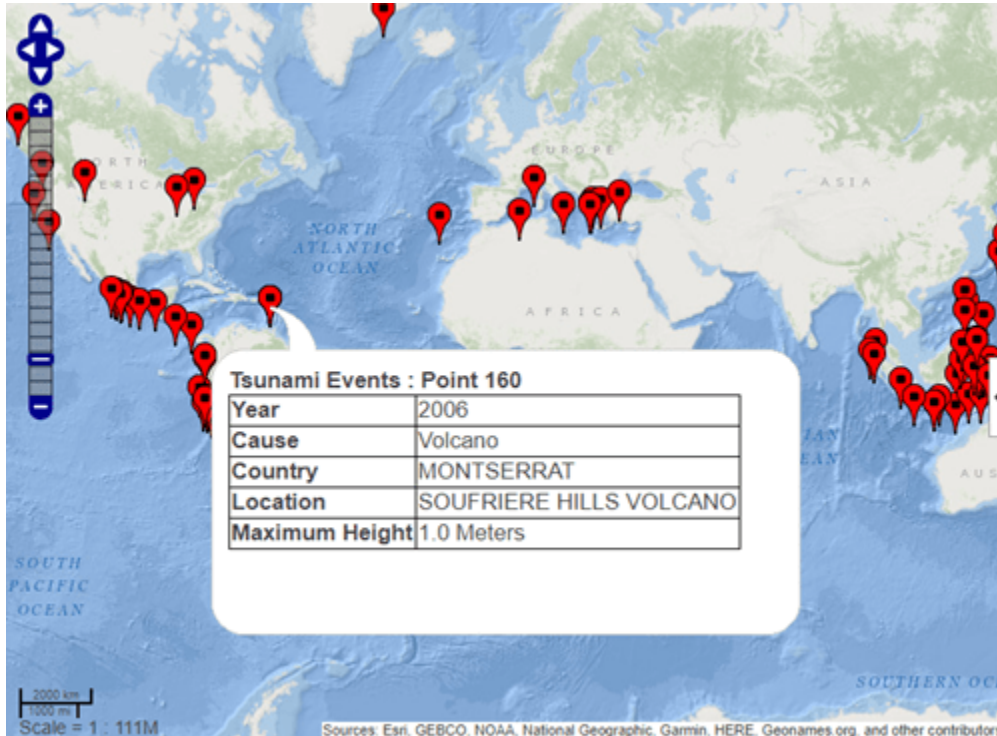
Create an attribute specification for use in the feature balloons. Modify the specification so that it defines a table of values, including year, cause, country, location, and maximum height. The attribute specification defines the format of the expected value for each field.

```
attribspec = makeattribspec(GT);
```

```
desiredAttributes = ...
    {'Max_Height', 'Cause', 'Year', 'Location', 'Country'};
allAttributes = fieldnames(attribspec);
attributes = setdiff(allAttributes, desiredAttributes);
attribspec = rmfield(attribspec, attributes);
attribspec.Max_Height.AttributeLabel = "<b>Maximum Height</b>";
attribspec.Max_Height.Format = "%.1f Meters";
attribspec.Cause.AttributeLabel = "<b>Cause</b>";
attribspec.Year.AttributeLabel = "<b>Year</b>";
attribspec.Year.Format = "%.0f";
attribspec.Location.AttributeLabel = "<b>Location</b>";
attribspec.Country.AttributeLabel = "<b>Country</b>";
```

Create a web map with a base layer containing ocean details. Add the marker overlay. Display the table data you specified in the attribute specification by selecting a marker.


```
webmap("ocean basemap");
wmmarker(GT,"Description",attribspec,...
         "OverlayName","Tsunami Events")
wmzoom(2)
```



Input Arguments

lat — Latitudes of points

matrix

Latitudes of points, specified as a matrix.

Data Types: single | double

lon — Longitudes of points

matrix

Longitudes of points, specified as a matrix.

Data Types: single | double

P — Geographic features

geospatial table | geopoint vector

Geographic features, specified as one of the following:

- A geospatial table containing `geopointshape` objects. For more information about geospatial tables, see “Create Geospatial Tables”.
- A `geopoint` vector.

wm — Web map

web map handle

Web map, specified as a web map handle.¹¹

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `wmmarker(lat,lon,'Autofit',true)`

Autofit — Overlay visibility

true (default) | false

Overlay visibility, specified as the comma-separated pair consisting of 'Autofit' and the logical flag `true` or `false`, or the numeric value 1 or 0. If `true` or 1, `wmmarker` adjusts the spatial extent of the map to ensure that all the vector overlays on the map are visible. If `false`, `wmmarker` does not adjust the spatial extent when the overlay is added to the map.

Overlay visibility, specified as a scalar logical or numeric value `true` (1) or `false` (0).

- If `true`, `wmmarker` adjusts the spatial extent of the map to ensure that all the vector overlays on the map are visible.
- If `false`, `wmmarker` does not adjust the spatial extent when the overlay is added to the map.

Data Types: `double` | `logical`

Description — Description of feature

empty character vector (' ') (default) | character vector | cell array of character vectors | scalar structure

Description of feature, specified as the comma-separated pair consisting of 'Description' and a character vector, cell array of character vectors, or scalar structure. The description defines the content that `wmmarker` displays in the feature's description balloon which appears when a user clicks on the feature in the web map. Description elements can be either plain text or HTML markup. When you specify an attribute spec, the display in the balloon for the attribute fields of `P` are modified according to the specification. The default value is an empty character vector (' '). If the value is a structure, the attribute spec is applied to the attributes of each feature of `P` and ignored with `lat` and `lon` input.

- If the value is a cell array it is either scalar or the same length as `P`, or `lat` and `lon`, and specifies the description for each marker.
- If the value is a structure, the attribute spec is applied to the attributes of each feature of `P` and ignored with `lat` and `lon` input.

Data Types: `char` | `struct` | `cell`

OverlayName — Name of overlay layer

'Marker Overlay N', (default) | character vector

¹¹ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

Name of overlay layer, specified as the comma-separated pair consisting of 'OverlayName' and a character vector. `wmmarker` inserts the name in the Layer Manager under the Overlays item. The Layer Manager is the tool that appears on the right side of the web map frame. The default name is 'Marker Overlay *N*' where *N* is the number assigned to this overlay.

Data Types: char

FeatureName — Name of feature

'OverlayName: Point *K*' (default) | character vector | cell array of character vectors

Name of feature, specified as the comma-separated pair consisting of 'FeatureName' and a character vector or cell array of character vectors. The name appears in the feature's balloon when a user clicks on the feature in the web map. The default value is 'OverlayName : Point *K*', where *OverlayName* is the name of the overlay and *K* is the number assigned to a particular point. If the value is a character vector, `wmmarker` applies it to all features. If the value is a cell array, it must be a scalar or an array with the same length as `P` or `lat` and `lon`.

Data Types: char | cell

Icon — File name of custom icon for a marker

character vector | cell array of character vectors

File name of custom icon for a marker, specified as the comma-separated pair consisting of 'Icon' and a character vector or cell array of character vectors. If the icon file name is not in the current folder, or in a folder on the MATLAB path, specify a full or relative path name. If you specify an Internet URL it must include the protocol type. If the icon file name is not specified, the default icon is displayed. For best results when you want to view a non-default icon, specify a PNG file containing image data with an alpha mask.

- If the value is a character vector, `wmmarker` applies the value to all markers.
- If you specify a cell array, it must be the same length as `P`, or `lat` and `lon`, and specifies the icon for each marker.

Data Types: char | cell

IconScale — Scaling factor for icon

1 (default) | positive numeric scalar or vector.

Scaling factor for icon, specified as the comma-separated pair consisting of 'IconScale' and a positive numeric scalar or vector.

- If the value is a scalar, the value is applied to all icons.
- If the value is a vector, it must specify a value for each icon, and it must be the same length as `lat` and `lon` or `P`.

Data Types: double

Color — Icon color

'red' (default) | color name | RGB triplet | cell array of color names | string vector of color names | matrix of RGB triplets

Icon color, specified as the comma-separated pair consisting of 'Color' and one of these options.

- A color name such as 'red' or a short name such as 'r'.







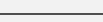

- An RGB triplet, which is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range $[0, 1]$; for example, $[0.4 \ 0.6 \ 0.7]$.
- A cell array of color names such as `{'red', 'green', 'blue'}` or `{'r', 'g', 'b'}`.
- A string vector of color names such as `["red" "green" "blue"]` or `["r" "g" "b"]`.
- A matrix of RGB triplets, which is a three-column matrix in which each row is an RGB triplet.

The way you specify the color depends on the desired color scheme.

- To apply the same color to all icons, specify a single color name or RGB triplet.
- To apply a different color to each icon, specify a cell array of color names, a string vector of color names, or a matrix of RGB triplets. The number of colors and RGB triplets must match the length of `lat` and `lon` or `P`.

If you specify a custom icon file, then the `wmmarker` function ignores this argument.

This table contains the color names and equivalent RGB triplets for some common colors.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Data Types: `char` | `string` | `cell` | `double`

Alpha — Transparency of marker

1 (default) | numeric scalar or vector

Transparency of marker, specified as the comma-separated pair consisting of 'Alpha' and a numeric scalar or vector. If you specify a vector, it must include a value for each marker, that is, the vector must be the same length as `P`. The default value, 1, means that the marker is fully opaque.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

Output Arguments

h — Marker overlay

handle to a marker overlay object

Marker overlay, returned as a handle to a marker overlay object.

Version History

Introduced in R2013b

R2021b: Display data from geospatial tables

The `wmmarker` function accepts geospatial tables as input.

See Also

`wmclose` | `wmpolygon` | `wmcenter` | `wmline` | `wmlimits` | `wmprint` | `webmap` | `wmremove` | `wmzoom`

wmline

Display geographic line on web map

Syntax

```
wmline(lat,lon)
wmline(P)
wmline(wm, ___ )
wmline( ___,Name,Value)
h = wmline( ___ )
```

Description

`wmline(lat,lon)` displays a line overlay defined by the vertices in `lat,lon` on the current web map. If there is no current web map, `wmline` creates one. `wmline` centers the map so that all vector overlays displayed on the web map are visible.

`wmline(P)` displays a line overlay based on the vector geographic features stored in `P`.

`wmline(wm, ___)` displays the line overlay on the web map specified by the web map handle, `wm`.

`wmline(___,Name,Value)` specifies name-value pairs that set additional display properties.

`h = wmline(___)` returns a handle to line overlay.

Examples

Display Line on Web Map

Import a shapefile containing the coordinates of world cities as a geospatial table. Create a subtable containing the rows for London and Paris.

```
cities = readgeotable("worldcities.shp");
rows = cities.Name == "London" | cities.Name == "Paris";
londonParis = cities(rows,:);
```

Display a line from London to Paris on a web map.

```
wmline(londonParis)
```



Display Reduced Line on Web Map

Large data sets can sometimes be slow to display, making the web map appear to hang. To work around this issue, reduce the size of the data set using the `reducem` function before calling `wmline`.

Load vector data representing the coordinates of coastlines.

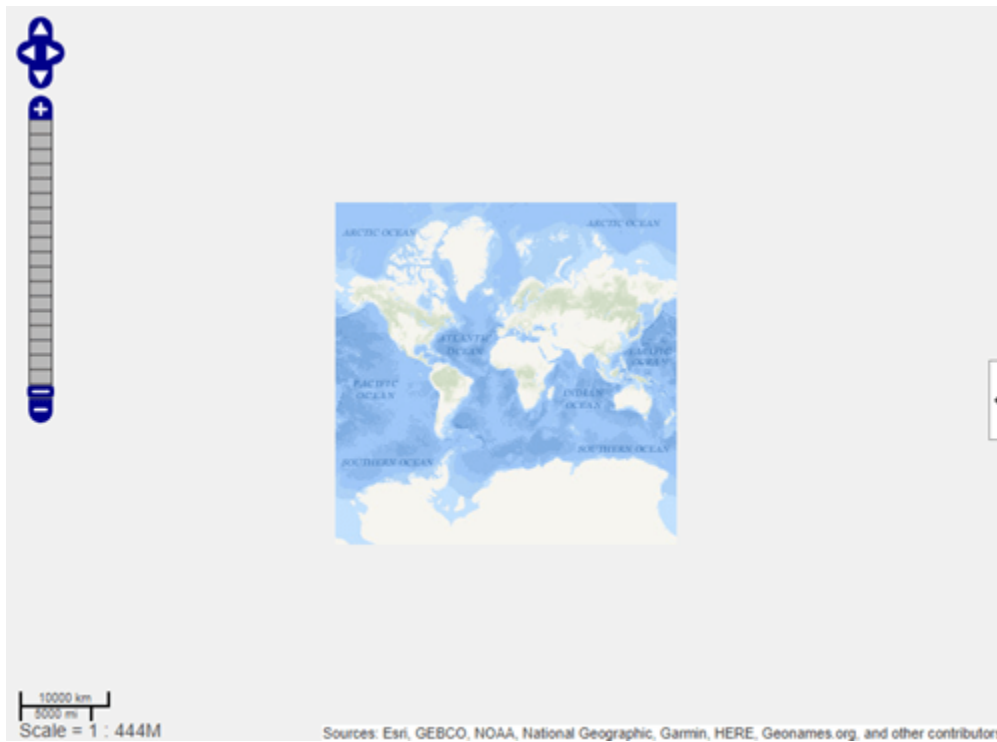
```
load coastlines
```

Reduce the number of points in the latitude and longitude vectors using the `reducem` function.

```
[lat,lon] = reducem(coastlat,coastlon);
```

Create a web map that does not wrap because the data is of global extent.

```
webmap('ocean basemap', 'WrapAround', false)
```



Display the coastlines on the web map. The figure shows the description balloon that appears when you click on the line. Name the feature using the 'FeatureName' name-value pair.

```
wmline(lat,lon,'LineWidth',3,'FeatureName','coastline')  
wmzoom(3)
```



Display Circles on Web Map

Define the latitude and longitude of the feature. This example shows how to display lines on a web map that represent range data for an airport approach pattern.

```
lat0 = 51.50487;
lon0 = 0.05235;
```

Create a web map and specify a base layer.

```
webmap('OpenStreetMap')
```

Compute a small circle with a 1000 meter radius. Setting the az parameter to an empty matrix causes `scircle1` to compute a complete circle.

```
radius = 1000;
az = [];
e = wgs84Ellipsoid;
[lat,lon] = scircle1(lat0,lon0,radius,az,e);
```

Display a red circle with 1000 meter radius, using the latitude and longitude values returned by `scircle1` in the previous step.

```
wmline(lat,lon,'Color','red','OverlayName','1000 Meters')
```

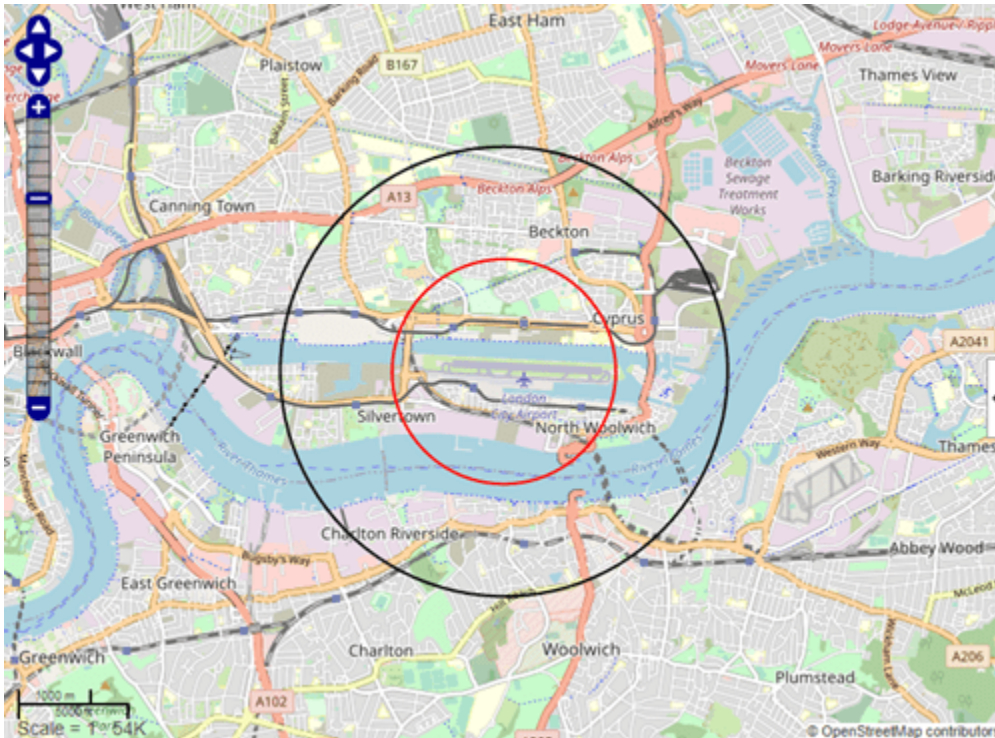


Compute another small circle, this time with a 2000 meter radius.

```
radius = 2000;  
[lat,lon] = scircle1(lat0,lon0,radius,az,e);
```

Draw the 2000 meter radius circle on the web map, setting the color to black.

```
wmline(lat,lon,'Color','k','OverlayName','2000 Meters')
```

Input Arguments

lat – Latitudes of vertices

matrix

Latitudes of vertices, specified as a matrix.

Data Types: single | double

lon – Longitudes of vertices

matrix

Longitudes of vertices, specified as a matrix.

Data Types: single | double

P – Geographic features

geospatial table | geopoint vector | geoshape vector

Geographic features, specified as one of the following:

- A geospatial table containing `geopointshape`, `geolineshape`, or `geopolyshape` objects. The `wmline` function does not support geospatial tables containing more than one type of shape object. For more information about geospatial tables, see “Create Geospatial Tables”.
- A `geopoint` vector.
- A `geoshape` vector.

If `P` is a geospatial table containing `geopointshape` objects or a `geopoint` vector, then the overlay contains a single line connecting the vertices.

If *P* is a geospatial table containing `geolineshape` or `geopolysshape` objects, or a `geoshape` vector, then the overlay contains one line feature for each feature of *P*.

wm — Web map

web map handle

Web map, specified as a web map handle.¹²

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `wmline(lat,lon,'OverlayName','Shortest Route');`

Autofit — Overlay visibility

true (default) | false

Overlay visibility, specified as the comma-separated pair consisting of 'Autofit' and the scalar logical or numeric value `true` (1) or `false` (0).

- If `true`, `wmline` adjusts the spatial extent of the map to ensure that all the vector overlays on the map are visible.
- If `false`, `wmline` does not adjust the spatial extent when this vector layer is added to the map.

Data Types: `double` | `logical`

Description — Description of feature

empty character vector (' ') (default) | character vector | cell array of character vectors | scalar structure

Description of feature, specified as the comma-separated pair consisting of 'Description' and a character vector, cell array of character vectors, or a scalar structure. The description defines the content of the description balloon displayed when you click the feature in a web map. Description elements can be either plain text or HTML markup. When an attribute spec is provided, the display in the balloon for the attribute fields of *P* are modified according to the specification.

- If you specify a scalar cell array, `wmline` applies the value to all line features.
- If you specify a nonscalar cell array, the cell array must contain a value for each feature, that is, the cell array must be the same length as *P*.
- If the value is a structure, `wmline` applies the attribute specification to each line.

Data Types: `char` | `struct` | `cell`

OverlayName — Name of overlay layer

'Line Overlay N', (default) | character vector

Name of overlay layer, specified as the comma-separated pair consisting of 'OverlayName' and a character vector. `wmline` inserts the name in the Layer Manager under the "Overlays" item. The

¹² Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

Layer Manager is the tool that appears on the right side of the web map. The default name is 'Line Overlay N ' where N is the number assigned to this overlay.

Data Types: char

FeatureName — Name of feature

'OverlayName: Line K ' (default) | character vector | cell array of character vectors

Name of feature, specified as the comma-separated pair consisting of 'FeatureName' and character vector or cell array of character vectors. The name appears in the balloon that displays when you click the feature in the web map. The default value is 'OverlayName : Line K ', where *OverlayName* is the name of the overlay and K is the number assigned to the particular line.

- If the value is a character vector, it applies to all features.
- If the value is a cell array of character vectors, it must be either a scalar or the same length as P .

Data Types: char | cell

Color — Line color

'black' (default) | color name | RGB triplet | cell array of color names | string vector of color names | matrix of RGB triplets

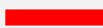






Line color, specified as the comma-separated pair consisting of 'Color' and one of these options.

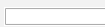
- A color name such as 'red' or a short name such as 'r'.
- An RGB triplet, which is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range $[0, 1]$; for example, $[0.4 \ 0.6 \ 0.7]$.
- A cell array of color names such as {'red', 'green', 'blue'} or {'r', 'g', 'b'}.
- A string vector of color names such as ["red" "green" "blue"] or ["r" "g" "b"].
- A matrix of RGB triplets, which is a three-column matrix in which each row is an RGB triplet.

The way you specify the color depends on the desired color scheme.

- To apply the same color to all lines in P , specify a single color name or RGB triplet.
- To apply a different color to each line in P , specify a cell array of color names, a string vector of color names, or a matrix of RGB triplets. The number of colors and RGB triplets must match the length of P .

This table contains the color names and equivalent RGB triplets for some common colors.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	

Color Name	Short Name	RGB Triplet	Appearance
"white"	"w"	[1 1 1]	

Data Types: char | string | cell | double

LineWidth — Width of line in pixels

1 (default) | positive numeric scalar or vector

Width of line in pixels, specified as the comma-separated pair consisting of LineWidth and a positive numeric scalar or vector. If you specify a vector, it must include a value for each line, that is, the vector must be the same length as P.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64

Alpha — Transparency of line

1 (default) | numeric scalar or vector

Transparency of line, specified as the comma-separated pair consisting of 'Alpha' and a numeric scalar or vector. If you specify a vector, it must include a value for each line, that is, the vector must be the same length as P. The default value, 1, means that the line is fully opaque.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64

Output Arguments

h — Overlay layer

handle to line overlay

Overlay layer, returned as a handle to a line overlay.

Tips

- Under certain conditions, when you zoom in on a line overlay in a web map, parts of the line may become invisible. This can occur if the data is one long line segment that is composed of many parts. To workaround this issue, break the long line into a series of line segments by inserting NaNs in the line data.

Version History

Introduced in R2013b

R2021b: Display data from geospatial tables

The `wmline` function accepts geospatial tables as input.

See Also

`wmclose` | `wmpolygon` | `wmcenter` | `webmap` | `wmlimits` | `wmprint` | `wmmarker` | `wmremove` | `wmzoom`

wmpolygon

Display geographic polygon on web map

Syntax

```
wmpolygon(lat,lon)
wmpolygon(P)
wmpolygon(wm, ___)
wmpolygon( ___,Name,Value)
h = wmpolygon( ___)
```

Description

`wmpolygon(lat,lon)` displays the polygon overlay defined by the vertices in `lat` and `lon` on the current web map. If there is no current web map, `wmpolygon` creates one. `wmpolygon` centers and scales the map so that all the vector overlays displayed in the web map are visible.

`wmpolygon(P)` displays a polygon overlay based on the vector geographic features stored in `P`. The overlay contains one polygon feature for each element of `P`.

`wmpolygon(wm, ___)` displays the overlay in the web map specified by the web map handle, `wm`.

`wmpolygon(___,Name,Value)` specifies name-value pairs that set additional display properties.

`h = wmpolygon(___)` returns a handle to the overlay.

Examples

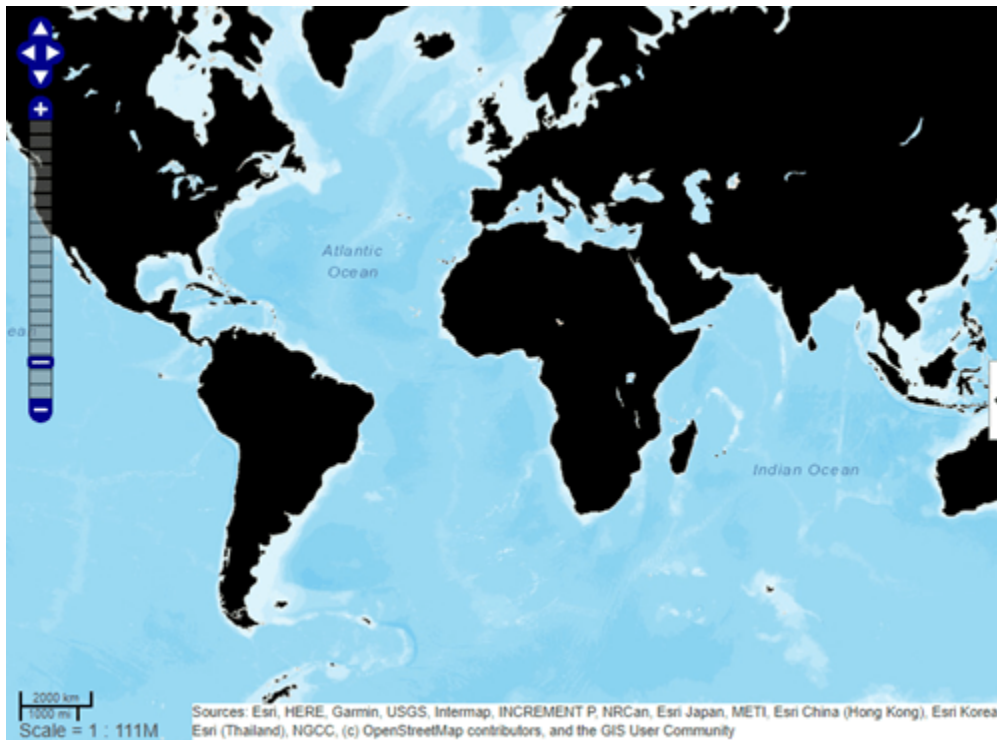
Display Coastlines as Polygon

Load coastline data from a MAT-file.

```
load coastlines
```

Display the coastlines as a polygon overlay layer.

```
wmpolygon(coastlat,coastlon,'OverlayName','Polygon coastlines')
```



Display Polygon with Inner Ring

Define coordinates of rings. For this example, the coordinates define a location centered on the Eiffel Tower.

```
lat0 = 48.858288;  
lon0 = 2.294548;  
outerRadius = .01;  
innerRadius = .005;  
[lat1,lon1] = scircle1(lat0,lon0,outerRadius);  
[lat2,lon2] = scircle1(lat0,lon0,innerRadius);  
lat2 = flipud(lat2);  
lon2 = flipud(lon2);  
lat = [lat1; NaN; lat2];  
lon = [lon1; NaN; lon2];
```

Display on a web map.

```
webmap('worldimagery')  
wmpolygon(lat,lon,'EdgeColor','g','FaceColor','c','FaceAlpha',.5)
```



Display USA State Boundaries Using Political Colormap

Import a shapefile containing state boundary data as a geospatial table.

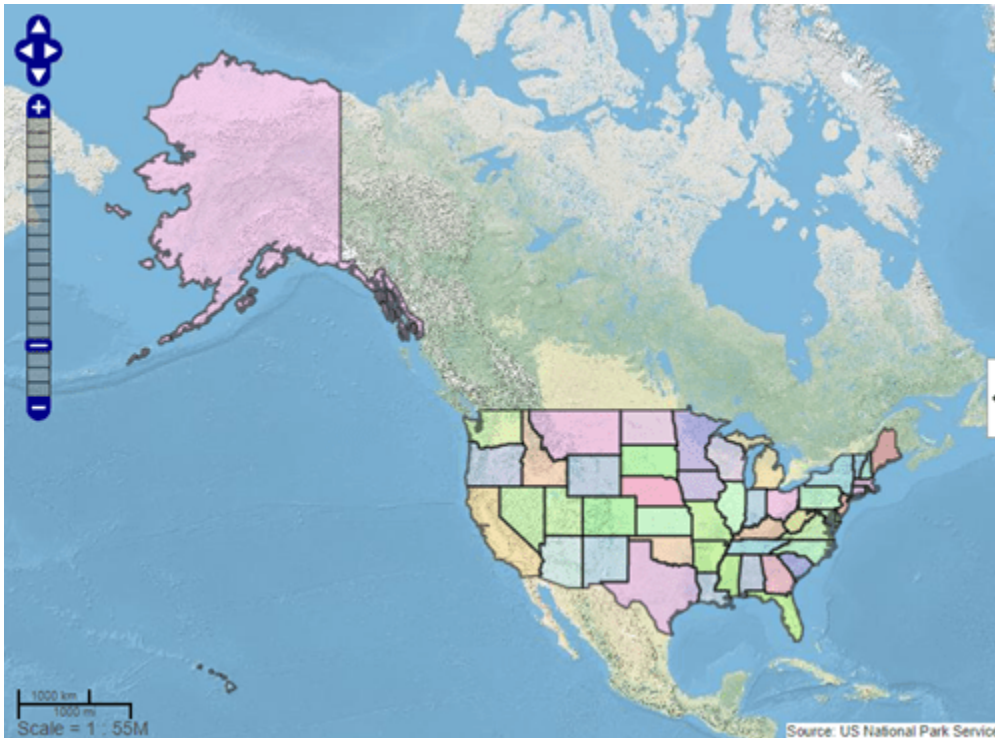
```
GT = readgeotable("usastatelo.shp");
```

Create a colormap from random, muted colors.

```
colors = polcmap(height(GT));
```

Display the polygons as an overlay on a web map. Make the polygons semitransparent by using the FaceAlpha name-value argument.

```
webmap("worldphysicalmap")  
wmpolygon(GT, "FaceColor", colors, "FaceAlpha", 0.5, "EdgeColor", "k", ...  
          "EdgeAlpha", 0.5, "OverlayName", "USA Boundary", "FeatureName", GT.Name)
```



Display Reduced High Resolution Polygon Data on Web Map

Large data sets can sometimes be slow to display, making the web map appear to hang. This example shows how to reduce the size of a data set using `reducem` before calling `wmpolygon`.

First, load high-resolution vector data into the workspace.

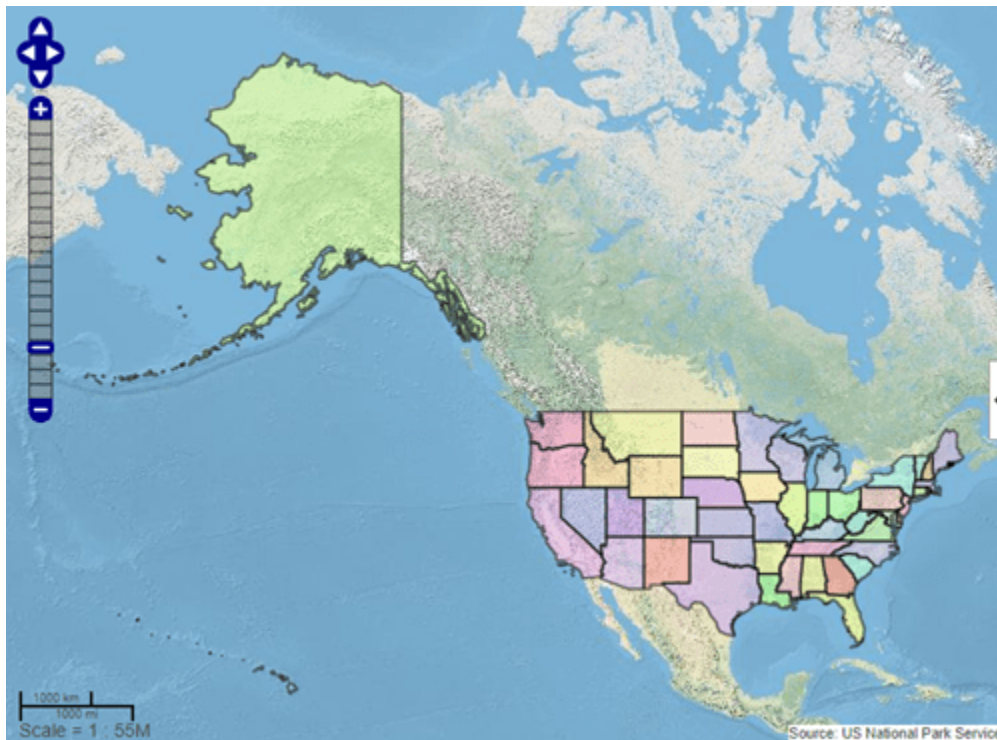
```
states = shaperead('usastatehi.shp','UseGeoCoords',true);
states = geoshape(states);
```

Then, reduce the number of points in the latitude and longitude vectors using the `reducem` function.

```
for k = 1:length(states)
    [states(k).Latitude, states(k).Longitude] = reducem( ...
        states(k).Latitude', states(k).Longitude');
end
```

Display state boundaries on the web map. Note that the borders of the reduced polygons may not meet if you zoom in on them.

```
colors = polcmap(length(states));
webmap('worldphysicalmap')
wmpolygon(states,'FaceColor',colors,'FaceAlpha',.5,'EdgeColor','k', ...
    'EdgeAlpha',.5,'OverlayName','USA Boundary','FeatureName',states.Name)
```

Input Arguments

lat — Latitude vertices

matrix in the range [-90, 90]

Latitude vertices, specified as matrix in the range [-90, 90].

Data Types: single | double

lon — Longitude vertices

matrix

Longitude of vertices, specified as a matrix.

Data Types: single | double

P — Geographic features

geospatial table | geoshape vector

Geographic features, specified as one of the following:

- A geospatial table containing `geopolyshape` objects. For more information about geospatial tables, see “Create Geospatial Tables”.
- A `geoshape` vector with polygon geometry.

wm — Web map

handle to a web map

Web map, specified as a handle to a web map.¹³

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `wmpolygon(lat,lon,'Autofit',true)`

Autofit — Overlay visibility

true (default) | false

Overlay visibility, specified as the comma-separated pair consisting of 'Autofit' and the scalar logical or numeric value true (1) or false (0).

- If true, `wmpolygon` adjusts the spatial extent of the map to ensure that all the vector overlays on the map are visible.
- If false, `wmpolygon` does not adjust the spatial extent of the map when this vector layer is added to the map.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64 | logical

Description — Description of feature

empty character vector (default) | character vector | cell array of character vectors | scalar structure

Description of feature, specified as the comma-separated pair consisting of 'Description' and a character vector, cell array of character vectors, or a scalar structure.

- If you specify a character vector, the text defines the content displayed in the description balloon, which appears when you click the feature in the web map. Description elements can be either plain text or marked up with HTML markup.
- If you specify a cell array, it must be either a scalar or the same length as `P`, and specifies the description for each polygon.
- If the value is a structure (attribute specification), `wmpolygon` displays the attribute fields of `P` in the balloon, modified according to the specification.

Data Types: char | struct | cell

OverlayName — Name of overlay layer

'Polygon Overlay N', (default) | character vector

Name of overlay layer, specified as the comma-separated pair consisting of 'OverlayName' and a character vector. `wmpolygon` inserts the name in the Layer Manager under the "Overlays" item. The Layer Manager is the tool that appears on the right side of the web map. The default name is 'Polygon Overlay N' where `N` is the number assigned to this overlay.

Data Types: char

FeatureName — Name of feature

'OverlayName: Line K' (default) | character vector | cell array of character vectors

13 Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

Name of feature, specified as the comma-separated pair consisting of 'FeatureName' and character vector or cell array of character vectors. The name appears in the balloon when you click the feature in the web map. The default value is '*OverlayName*: Polygon *K*', where *OverlayName* is the name of the overlay and *K* is the number assigned to the particular polygon.

- If the value is a character vector, it applies to all features.
- If the value is a cell array of character vectors, it must be either a scalar or the same length as P.

Data Types: char | cell

FaceColor — Color of polygon faces

'black' (default) | color name | RGB triplet | cell array of color names | string vector of color names | matrix of RGB triplets | 'none'









Color of polygon faces, specified as the comma-separated pair consisting of 'FaceColor' and one of these options.

- A color name such as 'red' or a short name such as 'r'.
- An RGB triplet, which is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1]; for example, [0.4 0.6 0.7].
- A cell array of color names such as {'red', 'green', 'blue'} or {'r', 'g', 'b'}.
- A string vector of color names such as ["red" "green" "blue"] or ["r" "g" "b"].
- A matrix of RGB triplets, which is a three-column matrix in which each row is an RGB triplet.

The way you specify the color depends on the desired color scheme.

- To apply the same face color to all polygons in P, specify a single color name or RGB triplet.
- To apply a different color to each polygon in P, specify a cell array of color names, a string vector of color names, or a matrix of RGB triplets. The number of colors and RGB triplets must match the length of P.
- To create polygons with no fill, specify 'none'.

This table contains the color names and equivalent RGB triplets for some common colors.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Data Types: char | string | cell | double

FaceAlpha — Transparency of polygon faces

1 (default) | numeric scalar or vector in the range [0, 1]

Transparency of polygon faces, specified as the comma-separated pair consisting of 'FaceAlpha' and a numeric scalar or vector in the range [0, 1]. The default value, 1, means that the polygon is fully opaque.

- If the value is a scalar, it applies to all polygon faces.
- If the value is a vector, it must be the same length as P.

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64

EdgeColor — Color of polygon edges

'none' (default) | color name | RGB triplet | cell array of color names | string vector of color names | matrix of RGB triplets | 'none'

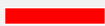







Color of polygon edges, specified as the comma-separated pair consisting of 'EdgeColor' and one of these options.

- A color name such as 'red' or a short name such as 'r'.
- An RGB triplet, which is a three-element row vector whose elements specify the intensities of the red, green, and blue components of the color. The intensities must be in the range [0, 1]; for example, [0.4 0.6 0.7].
- A cell array of color names such as {'red', 'green', 'blue'} or {'r', 'g', 'b'}.
- A string vector of color names such as ["red" "green" "blue"] or ["r" "g" "b"].
- A matrix of RGB triplets, which is a three-column matrix in which each row is an RGB triplet.

The way you specify the color depends on the desired color scheme.

- To apply the same edge color to all polygons in P, specify a single color name or RGB triplet.
- To apply a different edge color to each polygon in P, specify a cell array of color names, a string vector of color names, or a matrix of RGB triplets. The number of colors and RGB triplets must match the length of P.
- To create polygons with no edge color, specify 'none'.

This table contains the color names and equivalent RGB triplets for some common colors.

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Data Types: char | string | cell | double

EdgeAlpha — Transparency of polygon edges

1 (default) | numeric scalar or vector in the range [0, 1]

Transparency of polygon edges, specified the comma-separated pair consisting of 'EdgeAlpha' and as a numeric scalar or vector in the range [0, 1].

- If the value is a scalar, it applies to all polygon faces.
- If the value is a vector, it must be the same length as P.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

LineWidth — Width of polygon edges

1 (default) | positive numeric scalar or vector

Width of polygon edges, specified as the comma-separated pair consisting of 'LineWidth' and a positive numeric scalar or vector.

- If the value is a scalar, it applies to all polygon faces.
- If the value is a vector, it must be the same length as P.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

Output Arguments

h — Polygon overlay

handle to polygon overlay

Polygon overlay, returned as a handle to the polygon overlay.

Tips

- When you move the cursor over the polygons you define on an image and click, `wmpolygon` displays a description balloon and disables panning. If you move the cursor off the polygon, you can still click and pan the image. You can also use the arrow keys to pan the image.

Version History

Introduced in R2016a

R2021b: Display data from geospatial tables

The `wmpolygon` function accepts geospatial tables as input.

See Also

Functions

`wmclose` | `wmcenter` | `webmap` | `wmlimits` | `wmline` | `wmprint` | `wmmarker` | `wmremove` | `wmzoom`

Objects

`geoshape`

Topics

“Create and Display Polygons”

wmremove

Remove overlay on web map

Syntax

```
wmremove()  
wmremove(h)
```

Description

`wmremove()` removes the overlay most recently inserted into the current web map.¹⁴

`wmremove(h)` removes the overlay or overlays specified by the scalar overlay handle or vector of overlay handles, `h`.

Examples

Remove a Marker Overlay

Draw a marker on a web map. `wmmarker` creates the web map. Pause, and then remove the marker overlay.

```
wmmarker(42, -73);  
pause(1);  
wmremove()
```

Remove Multiple Overlays

Draw several marker overlays on a web map. `wmmarker` creates the web map. Pause, and then remove the marker overlays, specifying a vector of overlay handles.

```
h1 = wmmarker(42, -80);  
h2 = wmmarker(42, -78);  
pause(1);  
wmremove([h1 h2])
```

Remove Line Overlay

Create a web map.

```
wm = webmap();
```

Load coastline data and display it as an overlay on the web map.

¹⁴ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

```
load coastlines
h = wmline(coastlat, coastlon);
```

Remove the overlay specified by h.

```
wmremove(h)
```

Input Arguments

h — Web map overlay

scale overlay handle or vector of overlay handles

Web map overlay, specified as a scalar overlay handle or a vector of overlay handles.

Version History

Introduced in R2013b

See Also

wmclose | wmcenter | wmline | wmlimits | wmprint | wmmarker | webmap | wmzoom

wmcenter

Set or obtain web map center point

Syntax

```
wmcenter(centerLatitude,centerLongitude)
wmcenter(wm,centerLatitude,centerLongitude)
wmcenter( ____,zoomLevel)
[lat,lon] = wmcenter()
[lat,lon] = wmcenter(wm)
```

Description

`wmcenter(centerLatitude,centerLongitude)` centers the current web map at the specified latitude and longitude. If there is no current web map, `wmcenter` creates a new web map.

`wmcenter(wm,centerLatitude,centerLongitude)` centers the web map, specified by the handle `wm`, at the specified latitude and longitude.

`wmcenter(____,zoomLevel)` centers and zooms the web map to the specified zoom level.

`[lat,lon] = wmcenter()` returns the latitude and longitude of the center point of the current web map.

`[lat,lon] = wmcenter(wm)` returns the latitude and longitude of the center point of the web map specified by the handle `wm`.

Examples

Center a Web Map

Display a web map and find its center point. There is no current web map, so `wmcenter` creates one.

```
[centerLatitude,centerLongitude] = wmcenter()
centerLatitude = 51.5200
centerLongitude = 0
```



Center the map at a specified center point.

wmcenter(51.52,0)



Specify Center and Zoom Level for Multiple Web Maps

Create two web maps.

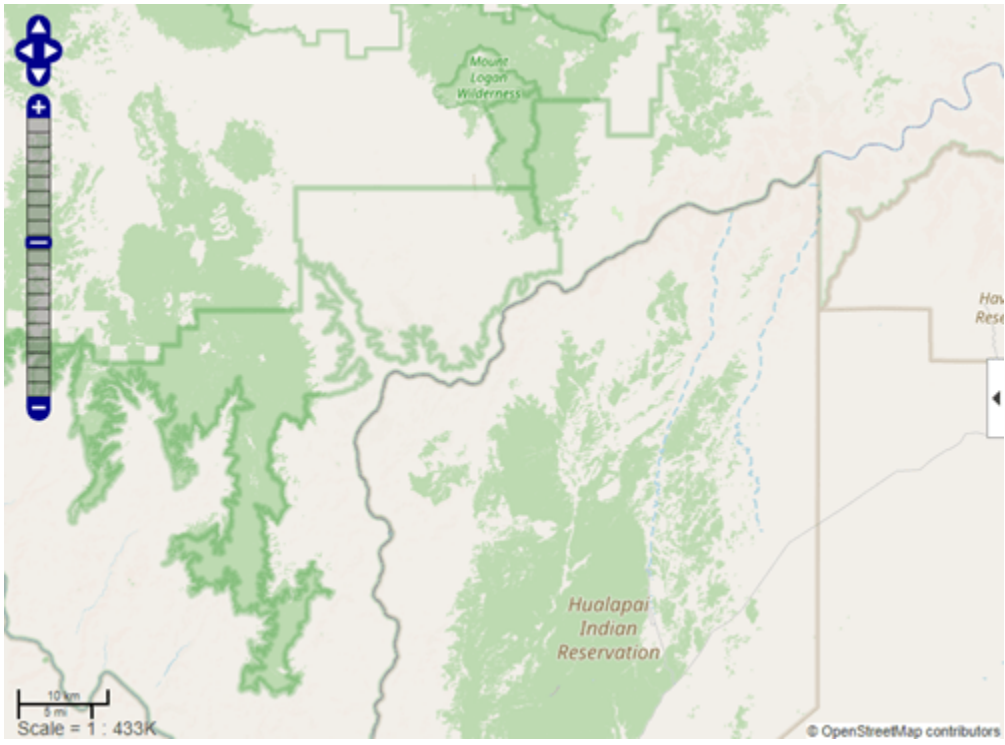
```
wm1 = webmap('OpenStreetMap');  
wm2 = webmap('USGSImagery');
```





Specify the latitude and longitude for the web map center, as well as a zoom level. Then, center the web maps.

```
centerLatitude = 36.1;  
centerLongitude = -113.2;  
zoomLevel = 10;  
wmcenter(wm1,centerLatitude,centerLongitude,zoomLevel)  
wmcenter(wm2,centerLatitude,centerLongitude,zoomLevel)
```



Input Arguments

centerLatitude — Latitude of center point

scalar in the range [-90 90] of type single or double

Latitude of center point, specified as a scalar in the range [-90 90] of type single or double.

Data Types: single | double

centerLongitude — Longitude of center point

scalar in the range [-180 180] of type single or double

Longitude of center point, specified as a scalar in the range [-180 180] of type single or double.

Data Types: single | double

wm — Web map

web map handle

Web map, specified as a web map handle.¹⁵

zoomLevel — Zoom level

scalar numeric integer in the range [0 18] of type single or double

Zoom level, specified as a scalar numeric integer in the range [0 18] of type single or double.

Data Types: single | double

Output Arguments

lat — Latitude of center point

scalar in the range [-90 90] of type single or double

Latitude of center point, returned as a scalar in the range [-90 90] of type single or double.

Data Types: single | double

lon — Longitude of center point

scalar in the range [-180 180] of type single or double

Longitude of center point, returned as a scalar in the range [-180 180] of type single or double.

Data Types: single | double

Tips

- Particular maps may not support every available zoom level. If your map displays as completely white, try another zoom level. The map you are displaying may not support the zoom level you have currently selected. You can also select another base layer, which might support the specified zoom level.

¹⁵ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

Version History

Introduced in R2013b

See Also

[wmclose](#) | [webmap](#) | [wmline](#) | [wmlimits](#) | [wmprint](#) | [wmmarker](#) | [wmremove](#) | [wmzoom](#)

wmzoom

Set or obtain zoom level of web map

Syntax

```
wmzoom(zoomLevel)
wmzoom(wm, zoomLevel)
zoomLevelOut = wmzoom()
zoomLevelOut = wmzoom(wm)
```

Description

`wmzoom(zoomLevel)` specifies the zoom level of the current web map, `zoomLevel`. If there is no current web map, `wmzoom` creates a new web map.

`wmzoom(wm, zoomLevel)` specifies the zoom level of the web map, specified by the handle `wm`.

`zoomLevelOut = wmzoom()` returns the zoom level of the current web map.

`zoomLevelOut = wmzoom(wm)` returns the zoom level of the web map specified by the handle `wm`.

Examples

Get Zoom Level of Current Web Map and Specify New Zoom Level

Create a web map at default zoom level.

```
zoomLevel = wmzoom()
zoomLevel =
    0
```

Zoom in and center the web map at the specified latitude and longitude (London).

```
wmzoom(10)
wmcenter(51.52, 0)
```

Specify Zoom Level of Several Web Maps

Create two web maps.

```
wm1 = webmap;
wm2 = webmap('worldtopographic');
```

Zoom in and center both maps at a specified latitude and longitude (Paris).

```
lat = 48.821;
lon = 1.9391;
```

```
zoomLevel = 10;  
  
wmzoom(wm1, zoomLevel)  
wmcenter(wm1, lat, lon)  
wmzoom(wm2, zoomLevel)  
wmcenter(wm2, lat, lon)
```

Input Arguments

zoomLevel — Zoom level

scalar numeric integer in the range [0 18]

Zoom level, specified as a scalar numeric integer in the range [0 18].

Data Types: `single` | `double`

wm — Web map

web map handle

Web map, specified as a web map handle.¹⁶

Output Arguments

zoomLevelOut — Zoom level of the current web map

scalar numeric integer in the range [0 18]

Zoom level of the current web map, returned as a scalar numeric integer in the range [0 18].

Data Types: `single` | `double`

Tips

- Particular maps may not support every available zoom level. If your map displays as completely white, try another zoom level. The map you are displaying may not support the zoom level you have currently selected. You can also select another base layer, which might support the specified zoom level.

Version History

Introduced in R2013b

See Also

`wmclose` | `wmcenter` | `wmline` | `wmlimits` | `wmprint` | `wmmarker` | `wmremove` | `webmap`

¹⁶ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

wmlimits

Set or obtain web map limits

Syntax

```
wmlimits(latitudeLimits,longitudeLimits)
wmlimits(wm,latitudeLimits,longitudeLimits)
[latlim,lonlim] = wmlimits()
[latlim,lonlim] = wmlimits(wm)
```

Description

`wmlimits(latitudeLimits,longitudeLimits)` center the current web map within the specified latitude limits and the longitude limits. If there is no current web map, `wmlimits` creates one.

Note The resulting limits often do not match the specified limits because the zoom level is quantized to discrete integer values and the longitude limits may be constrained if the map was constructed with the `WrapAround` property equal to `false`.

`wmlimits(wm,latitudeLimits,longitudeLimits)` centers the web map specified by the web map handle `wm` within the specified latitude limits and longitude limits.

`[latlim,lonlim] = wmlimits()` returns the latitude and longitude limits of the current web map.

`[latlim,lonlim] = wmlimits(wm)` returns the latitude and longitude limits of the web map specified by `wm`.

Examples

Specify Limits for Web Map

Specify latitude and longitude limits. `wmlimits` creates the web map.

```
wmlimits([37 42],[-108.9 -100.7])
```



Get the latitude and longitude limits of the current web map.

```
[latitudeLimits,longitudeLimits] = wmlimits()
```

```
latitudeLimits = 1x2
```

```
    34.7311    44.0468
```

```
longitudeLimits = 1x2
```

```
   -113.0397   -96.5603
```

Specify Limits for Multiple Web Maps

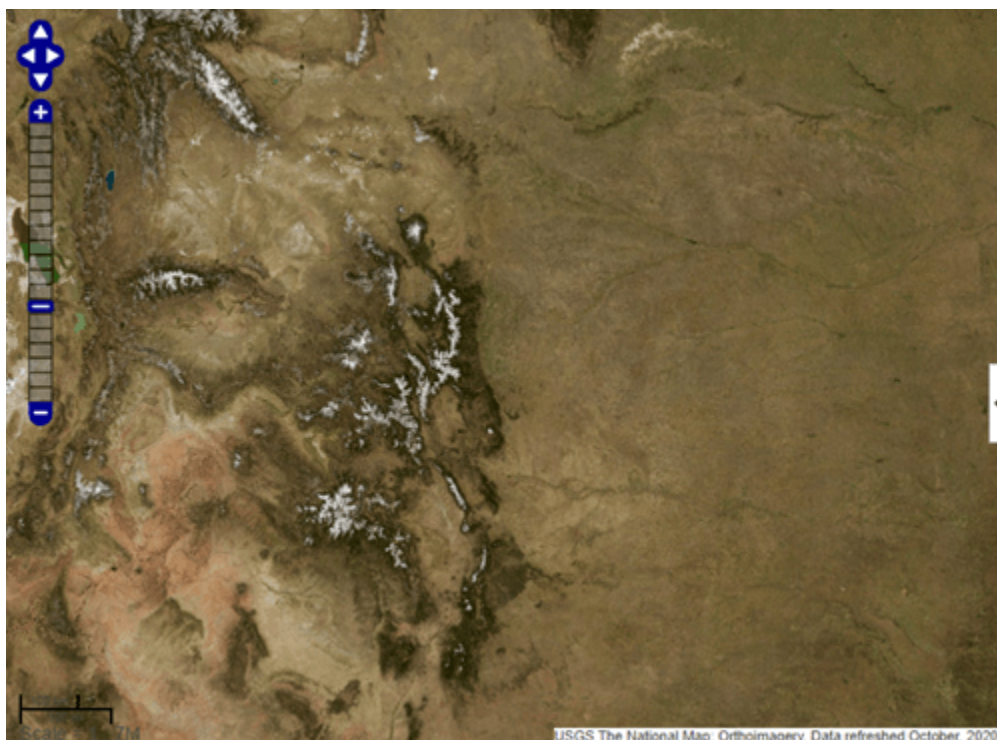
Create two web maps, specifying different base layers.

```
wm1 = webmap('OpenStreetMap');  
wm2 = webmap('USGSImagery');
```




Specify latitude and longitude limits and apply to both maps to get two different views of the same region.

```
latitudeLimits = [37, 42];  
longitudeLimits = [-108.9, -100.7];  
wmlimits(wm1, latitudeLimits, longitudeLimits)  
wmlimits(wm2, latitudeLimits, longitudeLimits)
```



Input Arguments

latitudeLimits — Latitude limits in degrees

1-by-2 row vector of type `double`

Latitude limits in degrees, specified as a 1-by-2 row vector of type `double` of the form `[southern-limit northern-limit]`.

Example: `[37, 42]`

Data Types: `double`

longitudeLimits — Longitude limits in degrees

1-by-2 row vector of type `double`

Longitude limits in degrees, specified as a 1-by-2 row vector of type `double` of the form `[western-limit eastern-limit]`.

Example: `[-108.9, -100.7]`

Data Types: `double`

wm — Web map

scalar web map handle

Web map, specified as a scalar web map handle.¹⁷

Output Arguments

latLim — Latitude limits in degrees

1-by-2 row vector of type `double`

Latitude limits in degrees, returned as a 1-by-2 row vector of type `double`.

Example: `[37, 42]`

Data Types: `double`

lonLim — Longitude limits in degrees

1-by-2 row vector of type `double`

Longitude limits in degrees, returned as a 1-by-2 row vector of type `double`.

Example: `[-108.9, -100.7]`

Data Types: `double`

Version History

Introduced in R2013b

¹⁷ Alignment of boundaries and region labels are a presentation of the feature provided by the data vendors and do not imply endorsement by MathWorks.

See Also

wmclose | wmcenter | wmline | webmap | wmprint | wmmarker | wmremove | wmzoom

WMSCapabilities

Web Map Service capabilities document

Description

A `WMSCapabilities` object represents a Web Map Service (WMS) capabilities document obtained from a WMS server. A capabilities document is an XML document that contains metadata describing the geographic content offered by the server.

Creation

You can create a `WMSCapabilities` object using the `WMSCapabilities` function described here, or using the `wmsinfo` function to specify a timeout. A `WMSCapabilities` is also returned from the `getCapabilities` function when you have a `WebMapServer` object.

Syntax

```
capabilities = WMSCapabilities(serverURL,capabilitiesResponse)
```

Description

`capabilities = WMSCapabilities(serverURL,capabilitiesResponse)` creates a `WMSCapabilities` object, sets the `ServerURL` property, and defines the capabilities of the server using the XML elements in `capabilitiesResponse`.

Input Arguments

serverURL — URL of WMS server

character vector | string scalar

URL of WMS server, specified as a character vector or a string scalar. The server URL must include the protocol 'http://' or 'https://'.

Data Types: char | string

capabilitiesResponse — XML elements that describe the capabilities of the WMS server

character vector | string scalar

XML elements that describe the capabilities of the WMS server, specified as a character vector or a string scalar.

Data Types: char | string

Properties

ServerTitle — Title of WMS server

character vector

This property is read-only.

Title of WMS server, returned as a character vector.

Data Types: char

ServerURL — URL of WMS server

character vector

This property is read-only.

URL of WMS server, returned as a character vector. The server URL must include the protocol 'http://' or 'https://'.

Data Types: char

ServiceName — Name of Web map service

character vector

This property is read-only.

Name of Web map service, returned as a character vector.

Data Types: char

Version — WMS version specification

character vector

This property is read-only.

WMS version specification, returned as a character vector.

Data Types: char

Abstract — Information about server

character vector

This property is read-only.

Information about server, returned as a character vector.

Data Types: char

OnlineResource — Online information about server

character vector

This property is read-only.

Online information about server, returned as a character vector.

Data Types: char

ContactInformation — Contact information for an individual or an organization

structure

This property is read-only.

Contact information for an individual or an organization, returned as a `ContactInformation` structure, containing the following fields:

Field Name	Data Type	Field Content
Person	Character vector	Name of individual
Organization	Character vector	Name of organization
Email	Character vector	Email address

Data Types: struct

AccessConstraints – Constraints inherent in accessing the server

character vector

This property is read-only.

Constraints inherent in accessing the server, such as server load limits, returned as a character vector.

Data Types: char

Fees – Types of fees associated with accessing server

character vector

This property is read-only.

Types of fees associated with accessing server, returned as a character vector.

Data Types: char

KeywordList – Descriptive keywords of the server

cell array of character vectors

This property is read-only.

Descriptive keywords of the server, returned as a cell array of character vectors.

Data Types: char

ImageFormats – Image formats supported by server

cell array of character vectors

This property is read-only.

Image formats supported by server, returned as a cell array of character vectors.

Data Types: char

LayerNames – Layer names provided by server

cell array of character vectors

This property is read-only.

Layer names provided by server, returned as a cell array of character vectors.

Data Types: cell

Layer – Information about layers on WMS server

WMSLayer array

This property is read-only.

Information about layers on WMS server, returned as an array of `WMSLayer` objects.

AccessDate — Date of request to server

character vector

This property is read-only.

Date of request to server, returned as a character vector.

Data Types: `char`

Object Functions

`disp` Display properties of WMS layers or capabilities

Examples**Create WMS Capabilities Object**

Create a `WMSCapabilities` object from the content of a downloaded capabilities file from the NASA SVS Image Server.

```
nasa = wmsfind('NASA SVS Image', 'SearchField', 'servertitle');
serverURL = nasa(1).ServerURL;
server = WebMapServer(serverURL);
capabilities = server.getCapabilities;
filename = 'capabilities.xml';
websave(filename, server.RequestURL);

fid = fopen(filename, 'r');
capabilitiesResponse = fread(fid, 'uint8=>char');
fclose(fid);
capabilities = WMSCapabilities(serverURL, capabilitiesResponse);
```

Version History

Introduced in R2009b

See Also

`WMSLayer` | `WebMapServer` | `wmsinfo` | `websave`

Topics

“Explore Layers on Same Server”

wmsfind

Search local database for Web map servers and layers

Syntax

```
layers = wmsfind(querystr)
layers = wmsfind(querystr,Name,Value)
```

Description

`layers = wmsfind(querystr)` searches the fields of the installed “WMS Database” on page 1-1912 for partial matches of `querystr`, which is a string, string array, character vector, or cell array of character vectors. By default, `wmsfind` searches the `Layer` or `LayerName` properties but you can include other fields in the search using the `SearchFields` parameter.

`wmsfind` returns `layers`, an array of `WMSLayer` objects containing one object for each layer whose name or title partially matches `querystr`. WMS servers produce maps of spatially referenced raster data, such as temperature or elevation, that are known as layers.

`layers = wmsfind(querystr,Name,Value)` modifies the search of the WMS Database based on the values of the parameters. You can abbreviate parameter names and case does not matter.

Examples

Find Temperature Data in the WMS Database

Search the WMS Database for temperature data.

```
layers = wmsfind('temperature');
```

The `wmsfind` function searches both the `LayerName` and `LayerTitle` fields of the WMS Database for partial matches. The function returns an array of `WMSLayer` objects, which contains one object for each layer whose name or title partially matches 'temperature'.

Refine the search to include temperature data from NOAA. Display information about the first layer.

```
layersNOAA = refine(layers,'noaa');
layersNOAA(1)
```

```
ans =
```

```
WMSLayer
```

```
Properties:
```

```
    Index: 1
  ServerTitle: 'WMS for SST and SST Anomaly, NOAA Global Coral Bleaching Monitoring, 5km, V.3
  ServerURL: 'https://coastwatch.pfeg.noaa.gov/erddap/wms/NOAA_DHW_monthly/request?'
  LayerTitle: 'SST and SST Anomaly, NOAA Global Coral Bleaching Monitoring, 5km, V.3.1, Mont
  LayerName: 'NOAA_DHW_monthly:sea_surface_temperature'
    Latlim: [-89.9750 89.9750]
    Lonlim: [-179.9750 179.9750]
```

Methods

A `WMSLayer` object contains three properties that do not appear in the WMS Database: `Abstract`, `CoordRefSysCodes`, and `Details`. Populate these properties by using the `wmsupdate` function.

```
updatedLayers = wmsupdate(layersNOAA(1));
updatedLayers(1)
```

```
ans =
```

```
WMSLayer
```

```
Properties:
```

```
    Index: 1
  ServerTitle: 'WMS for SST and SST Anomaly, NOAA Global Coral Bleaching Monitoring, 5km, V.3
  ServerURL: 'https://coastwatch.pfeg.noaa.gov/erddap/wms/NOAA_DHW_monthly/request?'
  LayerTitle: 'SST and SST Anomaly, NOAA Global Coral Bleaching Monitoring, 5km, V.3.1, Mont
  LayerName: 'NOAA_DHW_monthly:sea_surface_temperature'
    Latlim: [-89.9750 89.9750]
    Lonlim: [-179.9750 179.9750]
  Abstract: ''
CoordRefSysCodes: {'EPSG:4326'}
  Details: [1x1 struct]
```

Methods

Your results might be different because the WMS Database changes each release.

Search the WMS Database for Layers

Search the Entire WMS Database

Search the WMS database for layers that contain the word "temperature". The `wmsfind` function returns an array of `WMSLayer` objects.

```
layers = wmsfind('temperature');
```

Find layers that contain global temperature data. The query includes the asterisk wildcard character `*`.

```
layers = wmsfind('global*temperature');
```

Search Specific Fields in the WMS Database

Search the `LayerTitle` field for all layers that contain an exact match for the term 'Rivers'. You must use the `MatchType` parameter to specify an exact match.

```
layers = wmsfind('Rivers','MatchType','exact', ...
                'IgnoreCase',false,'SearchFields','layertitle');
```

Search the `LayerName` field for all layers that contain a partial match for 'elevation'. By default, `wmsfind` searches for partial matches.

```
layers = wmsfind('elevation','SearchFields','layername');
```

Search the LayerName field for all unique servers that contain 'BlueMarbleNG'.

```
layers = wmsfind('BlueMarbleNG','SearchFields','layername', ...
                'MatchType','exact');
urls = servers(layers);
```

Limit Your Search to Specific Geographic Regions

Find layers that contain elevation data for Colorado. Use the Latlim and Lonlim parameters to specify the location.

```
latlim = [35 43];
lonlim = [-111 -101];
layers = wmsfind('elevation','Latlim',latlim,'Lonlim',lonlim);
```

Find all layers that contain temperature data for a point in Perth, Australia. Use the Latlim and Lonlim parameters to specify the location.

```
lat = -31.9452;
lon = 115.8323;
layers = wmsfind('temperature','Latlim',lat,'Lonlim',lon);
```

Find all the unique URLs of all government servers.

```
layers = wmsfind('*.gov*','SearchFields','serverurl');
urls = servers(layers);
```

Search Multiple Fields at the Same Time and Refine Your Search

Search both the LayerTitle and the LayerName fields for all the layers that contain the word "temperature".

```
fields = [string('layertitle') string('layername')];
temperature = wmsfind('temperature','SearchFields',fields);
```

Refine the results of your temperature search to find only those layers that deal with sea surface temperatures. Use the WMSLayer object refine method.

```
sst = refine(temperature,'sea surface');
```

Refine your sea surface temperature search further to find only those layers that deal with global sea surface temperatures.

```
global_sst = refine(sst,'global');
```

Search the Entire WMS Database and Progressively Refine Your Search

Note that finding all the layers from the WMS database may take several seconds to execute and require a substantial amount of memory. The database contains more than 100,000 layers.

Find all the layers in the WMS database and sort them into a set that comprises only the unique layer titles.

```
layers = wmsfind('*');
layerTitles = sort(unique({layers.LayerTitle}));
```

Refine your original search, layers, to include only those layers with global coverage. Use the WMSLayer object refineLimits method.

```
global_layers = refineLimits(layers, ...  
                             'Latlim', [-90 90], 'Lonlim', [-180 180]);
```

Refine the results of your global layers search to contain only layers with global extent that include the word "topography". Use the `WMSLayer` object `refine` method.

```
global_topography_layers = refine(global_layers, 'topography');
```

Refine your original search, `layers`, to contain only layers that have some combination of the terms "oil" and "gas" in the `LayerTitle` field.

```
oil_gas_layers = refine(layers, 'oil*gas', 'SearchFields', 'layertitle');
```

Search Online Version of WMS Database

Search the WMS database for layers containing the word "elevation". Search the online version of the database by specifying the `Version` name-value pair argument as `'online'`. If you do not specify the version, then `wmsfind` reads from the installed database.

```
elevation = wmsfind('elevation', 'Version', 'online');
```

Input Arguments

querystr — Characters to search for in WMS Database fields

string scalar | string array | character vector | cell array of character vectors

Characters to search for in WMS Database fields, specified as a string scalar, string array, character vector, or cell array of character vectors. `querystr` can contain the asterisk wildcard character (*).

Data Types: `char` | `string`

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `[A,R] = wmsfind('elevation', 'SearchFields', 'layername');`

IgnoreCase — Ignore case when comparing field values to querystr

true (default) | false

Ignore case when comparing field values to `querystr`, specified as the logical value `true` or `false`.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

Latlim — Latitudinal limits of the search

two-element numeric vector | numeric scalar

Latitudinal limits of the search, specified as a two-element vector of the form `[southern_limit northern_limit]` or a scalar value representing the latitude of a single point. Values are in the

range [-90, 90]. All angles are in units of degrees. If provided and not empty, a given layer appears in the results only if its limits fully contain the specified 'Latlim' limits. Partial overlap does not result in a match.

Data Types: double | int16 | int32 | int64 | int8 | single | uint8 | uint16 | uint32 | uint64

Lonlim — Longitudinal limits of the search

two-element numeric vector | numeric scalar

Longitudinal limits of the search, specified as a two-element vector of the form [western_limit eastern_limit] or scalar value representing the longitude of a single point. All angles are in units of degrees. If provided and not empty, a given layer appears in the results only if its limits fully contain the specified 'Lonlim' limits. Partial overlap does not result in a match.

Data Types: double | int16 | int32 | int64 | int8 | single | uint8 | uint16 | uint32 | uint64

MatchType — Strictness of match

'partial' (default) | 'exact'

Strictness of match, specified as the character vector or string 'partial' or 'exact'. If 'MatchType' is 'exact' and querystr is '*', a match occurs when the search field matches the character '*'.

Data Types: char | string

SearchFields — Fields to search in the WMS Database

'layer' (default) | 'server' | 'layertitle' | 'layername' | 'servertitle' | 'serverurl' | 'any'

Fields to search in the WMS Database, specified as a character vector, cell array of character vectors, string, or array of strings. The function searches the values of the specified fields in the WMS Database for a partial or exact match with querystr. The following table lists valid values.

Field	Behavior
'layername'	Search the LayerName field in the WMS Database. The layer name is an abbreviated form of the LayerTitle field and is the keyword the server uses to retrieve the layer.
'layertitle'	Search the LayerTitle field in the WMS Database. The layer title includes descriptive information about a layer and facilitates understanding the meaning of the raster values of the layer.
'layer'	Search both the LayerTitle and the LayerName fields.
'servertitle'	Search the ServerTitle field in the WMS Database. A server title includes descriptive information about the server.
'serverurl'	Search the ServerURL field in the WMS Database. The server URL and layer information facilitate the reading of raster layers by the function wmsread.
'server'	Search both the ServerTitle and the ServerURL fields.
'any'	Search all fields.

Data Types: char | cell | string

Version — Version of the WMS Database to read

'installed' (default) | 'online' | 'custom'

Version of the WMS Database to read, specified as one of the following values.

Value	Description
'installed'	Read from the installed database. This is the default. The information found in the installed database is static and is not automatically updated—it was validated at the time of the software release.
'online'	Read from the version of the database hosted on the MathWorks website. This version of the database contains more up-to-date information about servers because it is updated regularly. Note, however, that searching this online database requires a connection to the Internet. If your network uses a firewall or another method of protection that restricts Internet access, you can provide information about your proxy server to MATLAB. For more information, see “Proxy Server Authentication”.
'custom'	Read from the <code>wmsdatabase.mat</code> file on the MATLAB path, such as from a previous release.

Data Types: `char` | `string`

Output Arguments

Layers — Layers that match search criteria

`WMSLayer` objects

Layers that match search criteria, returned as an array of `WMSLayer` objects, one for each layer found.

More About

WMS Database

Mapping Toolbox contains a database of over 1000 stored WMS servers and over 100,000 layers. MathWorks creates this database, called the WMS Database, by conducting a series of Internet searches and qualifying the search results.

Note MathWorks does not guarantee the stability or accuracy of WMS data. The servers listed in the WMS Database are located on the Internet and are independent from MathWorks. Occasionally, you might receive error messages from servers experiencing difficulties. Servers might go down or become unavailable.

The `wmsfind` function is the only function that accesses the stored WMS Database. By default, the `wmsfind` function searches the WMS Database that is installed with the product. You can search a version of the WMS Database hosted on the MathWorks website or a WMS Database from a previous release by using the `Version` name-value argument. The information in the WMS Database installed with the product is static. The web-hosted database is updated regularly.

The WMS Database contains these fields:

Field Name	Data Type	Field Content
ServerTitle	Character vector	Title of the WMS server, descriptive information about the server
ServerURL	Character vector	URL of the WMS server
LayerTitle	Character vector	Title of the layer, descriptive information about the layer
LayerName	Character vector	Name of the layer, keyword the server uses to retrieve the layer
Latlim	Two-element vector	Southern and northern latitude limits of the layer
Lonlim	Two-element vector	Western and eastern longitude limits of the layer

The `LayerTitle` and `LayerName` fields sometimes have the same values. The `LayerName` field indicates a code used by the servers, such as '29:2', while the `LayerTitle` field provides more descriptive information. For example, 'Elevation and Rivers with Backdrop' might be an entry in the `LayerTitle` field.

Tips

- The `WMSLayer` objects returned by `wmsfind` contain properties with the same names as the field names of the WMS Database, along with three additional properties: 'Abstract', 'CoordRefSysCodes', and 'Details'. The WMS Database does not contain information about these properties. To get this information about a server, you must use the `wmsupdate` function which updates these properties of the `WMSLayer` object by downloading information from the server. To view these properties, use the `WMSLayer.disp` method, specifying the 'Properties' parameter value 'all'. If you want to know more about a WMS server, use the `wmsinfo` function with the specific server URL.

Version History

Introduced in R2009b

See Also

`wmsupdate` | `wmsinfo` | `wmsread` | `WebMapServer` | `WMSLayer`

Topics

"Basic Workflow for Creating WMS Maps"

wmsinfo

Read capabilities document from WMS server

Syntax

```
capabilities = wmsinfo(url)
[capabilities,infoRequestURL] = wmsinfo(url)
[ ___ ] = wmsinfo(url,"TimeoutInSeconds",sec)
```

Description

`capabilities = wmsinfo(url)` reads the capabilities document `capabilities` from the Web Map Service (WMS) server URL or information request URL specified by `url`. A capabilities document is an XML document that describes the geographic content the server offers.

The `wmsinfo` function requires an internet connection. WMS servers can periodically be unavailable. Reading the capabilities document can take several minutes.

`[capabilities,infoRequestURL] = wmsinfo(url)` additionally returns the information request URL `infoRequestURL`.

`[___] = wmsinfo(url,"TimeoutInSeconds",sec)` specifies the number of seconds to wait before timing out.

Examples

Read Capabilities Document from WMS Server

Read the capabilities document and information request URL from the NASA Goddard Space Flight Center WMS server.

```
url = "https://svs.gsfc.nasa.gov/cgi-bin/wms?";
[capabilities,infoRequestURL] = wmsinfo(url);
```

View the information request URL, which is the server URL with additional WMS parameters.

```
infoRequestURL
```

```
infoRequestURL =
'https://svs.gsfc.nasa.gov/cgi-bin/wms?REQUEST=GetCapabilities&VERSION=1.3.0&SERVICE=WMS'
```

Display information about the first layer in the capabilities document.

```
layers = capabilities.Layer;
layers(1)
```

```
ans =
    WMSLayer

    Properties:
        Index: 1
```



```

ServerTitle: 'NASA SVS Image Server'
ServerURL: 'https://svs.gsfc.nasa.gov/cgi-bin/wms?'
LayerTitle: 'African Fires During 2002 (1024x1024 Animation)'
LayerName: '2890_17402'
  Latlim: [-39.0000 41.0000]
  Lonlim: [-22.0000 58.0000]
Abstract: 'This animation shows fire activity in Africa from January 1, 2002 to December

```

Additional Credit:

```
B>Please give credit for this item to:</b><br />
```

```
CoordRefSysCodes: {'CRS:84'}
```

```
Details: [1x1 struct]
```

Methods

Refine the layers in the capabilities document to include only layers with the term "glacier retreat" in the title.

```
glaciers = refine(layers, "glacier retreat", "SearchFields", "LayerTitle");
```

Display the title of the first refined layer.

```
glaciers(1).LayerTitle
```

```
ans =
```

```
'Jakobshavn Glacier Retreat (2048x512 Animation)'
```

Input Arguments

url — WMS server URL or information request URL

string scalar | character vector

WMS server URL or information request URL, specified as a string scalar or a character vector.

- A WMS server URL contains the protocol "http://" or "https://" and WMS access keywords.
- An information request URL contains the WMS server URL and additional WMS parameters, such as the request type and version. An information request URL is also known as a get capabilities request URL.

Example: "http://svs.gsfc.nasa.gov/cgi-bin/wms?" is a server URL.

Example: "http://svs.gsfc.nasa.gov/cgi-bin/wms?REQUEST=GetCapabilities&VERSION=1.3.0&SERVICE=WMS" is an information request URL.

Data Types: char | string

sec — Time out connection duration

60 (default) | nonnegative integer

Time out connection duration in seconds, specified as a nonnegative integer. The value is the number of seconds to wait to receive a response from the server. To deactivate the time out mechanism, specify this argument as 0.

Data Types: double

Output Arguments

capabilities — Capabilities document

WMSCapabilities object

Capabilities document, returned as a WMSCapabilities object.

infoRequestURL — Information request URL

character vector

Information request URL, returned as a character vector. This argument contains the WMS server URL and additional WMS parameters, such as the request type and version. This argument can contain different WMS parameters than you specify in `url`.

View the capabilities document as an XML document by opening the returned URL in a browser. Alternatively, view the XML document in MATLAB by passing this argument to the `webread` function.

Algorithms

The `wmsinfo` function communicates with the WMS server by using a `WebMapServer` object that represents an implementation of a WMS specification. The object acts as a proxy to the WMS server, resides physically on the client side, accesses the capabilities document for the server, and uses the highest known WMS version that the server supports.

Version History

Introduced in R2009b

R2021a: Read WMS capabilities documents from additional servers, get additional keywords, get additional layer information

There are several improvements to reading Web Map Service (WMS) capabilities documents.

- Read capabilities documents from servers that are not supported in earlier releases, such as capabilities documents from the Lunaserv Global Explorer.
- The `KeywordList` property of the `WMSCapabilities` object returned by the `wmsinfo` function can contain additional keywords.
- The `Layer` property of the `WMSCapabilities` object returned by the `wmsinfo` function can contain additional details about layer styles and legend graphics.
- The `Layer` property of the `WMSCapabilities` object returned by the `wmsinfo` function excludes coordinate reference system codes if the codes do not have a corresponding bounding box.

See Also

Functions

`wmsfind` | `wmsupdate` | `wmsread`

Objects

`WebMapServer` | `WMSLayer`

Topics

“Basic Workflow for Creating WMS Maps”

“Proxy Server Authentication”

WMSLayer

Web Map Service layer

Description

A `WMSLayer` object describes a Web Map Service (WMS) layer or layers.

Creation

You can create a `WMSLayer` object using any of the following methods:

- `wmsfind` — Returns a `WMSLayer` array.
- `wmsinfo` — Returns a `WMSCapabilities` object, which contains an array of `WMSLayer` objects in its `Layer` property.
- The `WMSLayer` object creation function, described here.

Syntax

```
layers = WMSLayer(Name,Value)
```

Description

`layers = WMSLayer(Name,Value)` constructs a `WMSLayer` object, where `Name` is the name of any property of the `WMSLayer` and `Value` is the value that you want to assign to the property. You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. The size of the output `layers` is scalar unless all inputs are cell arrays, in which case, the size of `layers` matches the size of the cell arrays.

Properties

ServerTitle — Descriptive information about the server

empty character vector (' ') (default) | character vector

This property is read-only.

Descriptive information about the server, returned as a character vector.

Data Types: char

ServerURL — URL of WMS Server

empty character vector (' ') (default) | character vector

This property is read-only.

URL of WMS Server, returned as a character vector.

Data Types: char

LayerTitle — Descriptive information about the layer

empty character vector (' ') (default) | character vector

This property is read-only.

Descriptive information about the layer, returned as a character vector. The `LayerTitle` clarifies the meaning of the raster values of the layer.

Data Types: char

LayerName — Keyword the server uses to retrieve the layer

empty character vector (' ') (default) | character vector

This property is read-only.

Keyword the server uses to retrieve the layer, returned as a character vector.

Data Types: char

LatLim — Latitude limits of the layer in units of degrees

[] (default) | two-element numeric vector

Latitude limits of the layer in units of degrees, specified as a two-element numeric vector. The limits specify the southern and northern latitude limits and must be in units of degrees and in the range [-90, 90].

Data Types: double

LonLim — Longitude limits of the layer in units of degrees

[] (default) | two-element numeric vector

Longitude limits of the layer in units of degrees, specified as a two-element numeric vector. The limits specify the western and eastern longitude limits and must be ascending and in the range [-180, 180] or [0, 360].

Data Types: double

Abstract — Information about the layer

empty character vector (' ') (default) | character vector

This property is read-only.

Information about the layer, returned as a character vector.

Data Types: char

CoordRefSysCodes — Codes identifying available coordinate reference systems

empty cell array {} (default) | cell array of character vectors

This property is read-only.

Codes identifying available coordinate reference systems, returned as a cell array of character vectors.

Data Types: cell

Details — Detailed information about the layer

structure

This property is read-only.

Detailed information about the layer, returned as a structure containing these fields:

Field	Description
MetadataURL	URL containing metadata information about the layer, returned as a character vector.
Attributes	<p>Attributes of the layer, returned as a structure array containing these fields.</p> <ul style="list-style-type: none"> • Queryable — Logical 1 (true) when you can query the layer for feature information, and logical 0 (false) otherwise. • Cascaded — Number of times a Cascading Map server has retransmitted the layer, returned as a double value. • Opaque — Logical 1 (true) when the map data is mostly or completely opaque, and logical 0 (false) otherwise. • NoSubsets — Logical 1 (true) when the map must contain the full bounding box, and logical 0 (false) when the map can be a subset of the full bounding box. • FixedWidth — Logical 1 (true) when the map has a fixed width that the server cannot change, and logical 0 (false) when the server can resize the map to an arbitrary width. • FixedHeight — Logical 1 (true) when the map has a fixed height that the server cannot change, and logical 0 (false) when the server can resize the map to an arbitrary height.
BoundingBox	<p>Bounding box of the layer, returned as a structure array containing these fields.</p> <ul style="list-style-type: none"> • CoordRefSysCode — Code number for the coordinate reference system, returned as a character vector. • XLim — <i>x</i>-limits of the layer in units of the coordinate reference system, returned as a double array. • YLim — <i>y</i>-limits of the layer in units of the coordinate reference system, returned as a double array.

Field	Description
Dimension	<p>Dimension parameters, returned as a structure array containing these fields. Examples of dimensions include time, elevation, and temperature.</p> <ul style="list-style-type: none"> • Name — Name of the dimension, returned as a character vector. • Units — Measurement unit for the dimension, returned as a character vector. • UnitSymbol — Symbol for the measurement unit, returned as a character vector. • Extent — Dimension values, returned as a character vector in one of these forms. <ul style="list-style-type: none"> • 'v' — A single value, for example <code>'2002-01-01'</code>. • 'v1,v2,...,vN' — A list of values, for example <code>'2002-01-01,2002-02-01,2002-03-01'</code>. • 'min/max/res' — An interval defined by the minimum and maximum bounds <code>min</code> and <code>max</code>, respectively, and the resolution <code>res</code>, for example <code>'2002-01-01/2002-12-31/P1D'</code>. • 'min1/max1/res1,min2/max2/res2,...,minN/maxN/resN' — A list of intervals, for example <code>'2002-01-01/2002-12-31/P1D,2003-01-01/2003-12-31/P1D,2004-01-01/2004-12-31/P1D'</code>. • Default — Default dimension value for the <code>wmsread</code> function to use, returned as a character vector. For example, when the value of <code>Name</code> is <code>'time'</code>, by default, the <code>wmsread</code> function reads data from the layer using the time contained in this field. To read data from the layer using a different time, use <code>wmsread</code> and specify the <code>Time</code> name-value argument. • MultipleValues — Logical <code>1</code> (<code>true</code>) if you can request dimension values, and logical <code>0</code> (<code>false</code>) if you can request only one value. • NearestValue — Logical <code>1</code> (<code>true</code>) if the server returns the nearest dimension value in response to a request for a nearby value, and logical <code>0</code> (<code>false</code>) if the value must match a value in the <code>Extent</code> field.

Field	Description
	<ul style="list-style-type: none"> • Current — Logical 1 (true) if the temporal data is kept current, and logical 0 (false) otherwise. This field is valid for temporal extents only.
ImageFormats	Image formats supported by the server, returned as a cell array of character vectors.
ScaleLimits	<p>Scale limits of the layer, returned as a structure containing these fields.</p> <ul style="list-style-type: none"> • ScaleHint — Minimum and maximum values that are appropriate for displaying the layer, returned as a double array. These values express the scale as ground distance, in meters, represented by the diagonal of the central pixel in the image. • MinScaleDenominator — Minimum scale denominator of maps for which a layer is appropriate, returned as a double value. • MaxScaleDenominator — Maximum scale denominator of maps for which a layer is appropriate, returned as a double value.
Style	<p>Style parameters that determine layer rendering, returned as a structure array containing these fields.</p> <ul style="list-style-type: none"> • Title — Descriptive title of the style, returned as a character vector. • Name — Name of the style, returned as a character vector. • Abstract — Information about the style, returned as a character vector. • LegendURL — Information about the legend graphics, returned as a structure containing these fields. <ul style="list-style-type: none"> • OnlineResource — URL of the legend graphics, returned as a character vector. • Format — Format of the legend graphics, returned as a character vector. • Height — Height of the legend graphics, returned as a double value. • Width — Width of the legend graphics, returned as a double value.
Version	WMS version specification, returned as a character vector.

Data Types: struct

Object Functions

disp	Display properties of WMS layers or capabilities
refine	Refine search of WMS layers
refineLimits	Refine search of WMS layers based on geographic limits
servers	Return URLs of unique WMS servers
serverTitles	Return titles of unique WMS servers

Examples

Construct WMSLayer Object from WMS GetMap Request URL

Specify the server URL. These values are typically found during an Internet search. The WMSLayer ServerURL value is obtained from the host and path of the request URL. The WMSLayer LayerName value is obtained from the LAYERS value in the query part of the URL.

```
host = 'www.mrlc.gov';
path = '/geoserver/NLCD_Land_Cover/wms?';
serverURL = ['https://' host path];
requestURL = [serverURL 'SERVICE=WMS&FORMAT=image/jpeg&REQUEST=GetMap&' ...
  'STYLES=&SRS=EPSG:4326&VERSION=1.1.1&LAYERS=mrlc_display:NLCD_2016_Land_Cover_L48&' , ...
  'WIDTH=1024&HEIGHT=470&BBOX=-128,23,-65,51'];
layerName = 'mrlc_display:NLCD_2016_Land_Cover_L48';
```

Construct the WMSLayer object by using the serverURL variable and the value of the WMS LAYERS parameter.

```
layer = WMSLayer('ServerURL',serverURL,'LayerName',layerName);
```

Use the wmsupdate function to get the other properties of the WMSLayer array from the server.

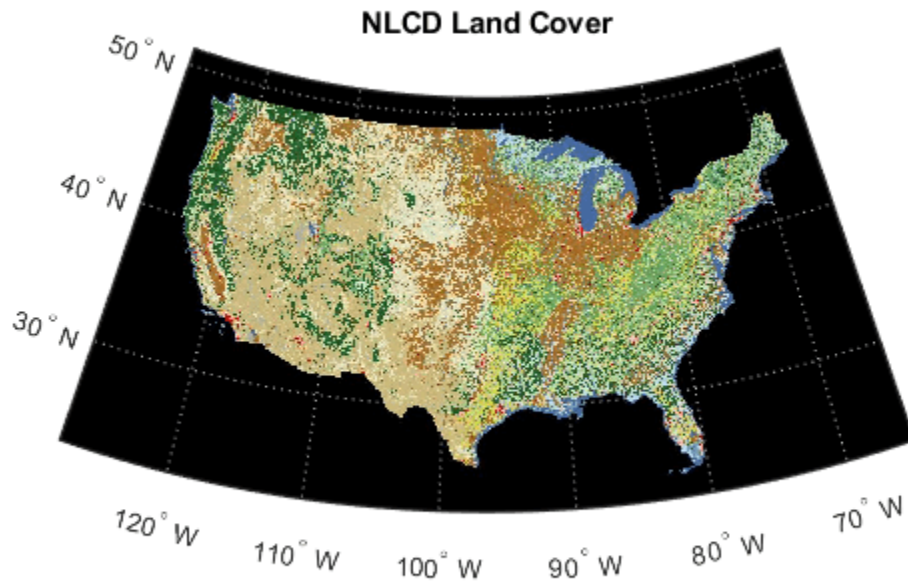
```
layer = wmsupdate(layer);
layer.Lonlim = [-180 180];
```

Retrieve an image from the WMS server using layer and parameter values from the WMS GetMap request URL. Set latitude and longitude limits from the BBOX request value. Set image height and width values from the WIDTH and HEIGHT request values.

```
lonlim = [-128 -65];
latlim = [23 51];
height = 470;
width = 1024;
[A,R] = wmsread(layer,'Latlim',latlim,'Lonlim',lonlim, ...
  'ImageHeight',height,'ImageWidth',width);
```

Display the image from the server.

```
figure
usamap(A,R)
geoshow(A,R)
title('NLCD Land Cover')
```



This image can also be retrieved using the WMS requestURL.

```
[A,R] = wmsread(requestURL);
```

Version History

Introduced in R2009b

See Also

Functions

wmsfind | wmsinfo | wmsread | wmsupdate

Objects

WebMapServer | WMSCapabilities | WMSMapRequest

WMSMapRequest

Web Map Service map request

Description

A `WMSMapRequest` object contains a request to a WMS server to obtain a map, which represents geographic information. The WMS server renders the map as a color or grayscale image. The object contains properties that you can set to control the geographic extent, rendering, or size of the requested map.

Creation

Syntax

```
mapRequest = WMSMapRequest(layer)
mapRequest = WMSMapRequest(layer, server)
```

Description

`mapRequest = WMSMapRequest(layer)` creates a `WMSMapRequest` object, setting the `Layer` property. The `WMSMapRequest` object updates the properties of `Layer`, if necessary.

`mapRequest = WMSMapRequest(layer, server)` creates a `WMSMapRequest` object, setting the `Layer` and `Server` properties. The `ServerURL` property of `layer` must match the `ServerURL` property of `server`. The `Server` object updates `Layer` properties.

Properties

Server — Web map server

scalar `WebMapServer` object

Web map server, specified as a scalar `WebMapServer` object. If a server is not supplied as an argument when creating the `WMSMapRequest`, the value of `Server` is set to the `ServerURL` of `Layer`.

Layer — Web Map Service layers

array of `WMSLayer` objects

Web Map Service layers, specified as an array of `WMSLayer` objects.

`Layer` contains one unique `ServerURL`, which must match the `ServerURL` property of `Server`. The `Server` property updates the properties of `Layer` when the property is set.

CoordRefSysCode — Coordinate reference system code

'CRS:84' | 'EPSG:4326'

Coordinate reference system code, specified as the character vector 'CRS:84' for WMS version 1.3.x, and 'EPSG:4326' for all other versions.

- If 'EPSG:4326' is not found in `Layer.CoordRefSysCodes`, then the `CoordRefSysCode` value is set from the first `CoordRefSysCode` found in the `Layer.Details.BoundingBox` structure array.
- When `CoordRefSysCode` is set to 'EPSG:4326' or 'CRS:84', the `XLim` and `YLim` properties are set to [] and the `LatLim` and `LonLim` properties are set to the geographic extent defined by the `Layer` array.
- When `CoordRefSysCode` is set to a value other than 'EPSG:4326' or 'CRS:84', then the `XLim` and `YLim` properties are set from the values found in the `Layer.Details.BoundingBox` structure and the `LatLim` and `LonLim` properties are set to [].
- Automatic projections are not supported. (Automatic projections begin with 'AUTO'.)

Data Types: char

RasterReference — Map or geographic raster reference

`MapCellsReference` or `GeographicCellsReference`

Map or geographic raster reference, specified as a `MapCellsReference` or `GeographicCellsReference` object. `RasterReference` references the raster map to an intrinsic coordinate system

LatLim — Latitude limits

two-element vector

Latitude limits, specified as a two-element vector. `LatLim` contains the southern and northern latitudinal limits of the request in units of degrees. The limits must be ascending. By default, the latitude limits span all latitudinal limits found in the `Layer.LatLim` property.

LonLim — Longitude limits

two-element vector

Longitude limits, specified as a two-element vector. `LonLim` contains the western and eastern longitudinal limits of the request in units of degrees. The limits must be ascending and in the range [-180, 180] or [0, 360]. By default, the longitude limits span all longitudinal limits found in the `Layer.LonLim` property.

XLim — Western and eastern limits in the units of the coordinate reference system

[] (default) | two-element vector

Western and eastern limits of the requested map in the units of the coordinate reference system, specified as a two-element vector. The limits must be ascending. You can set `XLim` only if you set `CoordRefSysCode` to a value other than `EPSG:4326`.

YLim — Southern and northern in the units of the coordinate reference system

[] (default) | two-element vector

Southern and northern limits of the requested map in the units of the coordinate reference system, specified as a two-element vector. The limits must be ascending. You can set `YLim` only if you set `CoordRefSysCode` to a value other than `EPSG:4326`.

ImageHeight — Height in pixels for the requested raster map

positive integer

Height in pixels for the requested raster map, specified as a positive integer. The property `MaximumHeight` defines the maximum value for `ImageHeight`. The `WMSMapRequest` object

initializes the `ImageHeight` property to either 512 or to an integer value that best preserves the aspect ratio of the coordinate limits, without changing the coordinate limits.

ImageWidth — Width in pixels for the requested raster map

positive integer

Width in pixels for the requested raster map, specified as a positive integer. The property `MaximumWidth` defines the maximum value for `ImageWidth`. The `WMSMapRequest` object initializes the `ImageWidth` property to either 512 or to an integer value that best preserves the aspect ratio of the coordinate limits, without changing the coordinate limits.

MaximumHeight — Maximum height in pixels of requested map

8192

This property is read-only.

Maximum height in pixels for the requested map, specified as the number 8192.

Data Types: `double`

MaximumWidth — Maximum width in pixels of requested map

8192

This property is read-only.

Maximum width in pixels for the requested map, specified as the number 8192.

Data Types: `double`

Elevation — Elevation extent of requested map

' ' (default) | character vector

Elevation extent of the requested map, specified as a character vector. When you set the property, `'elevation'` must be the value of the `Layer.Details.Dimension.Name` field.

Time — Time extent of requested map

' ' (default) | numeric scalar | string scalar | character vector

Time extent of the requested map, specified as a numeric scalar, a string scalar, or a character vector. This property stores time using the ISO[®] 8601:1988(E) extended format.

- When you specify a numeric scalar, the `Time` property interprets the input as a serial date number, which represents the whole and fractional number of days from January 0, 0000. For example, to set the time extent of a WMS map request object, `mapRequest`, as 731885.75 days after January 0, 0000, use `mapRequest.Time = 731885.75`. MATLAB stores numeric scalar input in `Time` using a character vector in `'yyyy-mm-dd'` format.
- When you specify a string scalar or character vector, the `Time` property interprets the input as a date and time. For example, to set the time extent of a WMS map request object, `mapRequest`, to March 17, 2022, you can use `mapRequest.Time = "03/17/22"`. Express hours, minutes, and seconds in Coordinated Universal Time (UTC).

This table shows the string scalar and character vector inputs you can use to set the `Time` property and how the `Time` property stores the inputs.

Input Format	Input Format Example	Stored Format	Stored Format Example
"mm-dd-yyyy HH:MM:SS"	"17-03-2022 14:45:02"	'yyyy-mm-ddTHH:MM:SSZ'	'2022-03-17T14:45:02Z'
"mm-dd-yyyy"	"17-03-2022"	'yyyy-mm-dd'	'2022-03-17'
"mm/dd/yy"	"03/17/22"	'yyyy-mm-dd'	'2022-03-17'
"mm/dd"	"03/17"	'yyyy-mm-dd' yyyy is the current year	'2022-03-17'
"yyyy"	"2022"	'yyyy'	'2022'
"HH:MM:SS"	"14:45:02"	'yyyy-mm-ddTHH:MM:SSZ' yyyy, mm, and dd are the current year, month, and day, respectively	'2022-02-07T14:45:02Z'
"HH:MM:SS PM"	"02:45:02 PM"	'yyyy-mm-ddTHH:MM:SSZ' yyyy, mm, and dd are the current year, month, and day, respectively	'2022-02-07T14:45:02Z'
"HH:MM"	"02:45"	'yyyy-mm-ddTHH:MM:00Z' yyyy, mm, and dd are the current year, month, and day, respectively	'2022-02-07T02:45:00Z'
"HH:MM PM"	"02:45 PM"	'yyyy-mm-ddTHH:MM:00Z' yyyy, mm, and dd are the current year, month, and day, respectively	'2022-02-07T14:45:00Z'
"mmm.dd,yyyy HH:MM:SS"	"Mar.07,2022 02:45:02"	'mmm.dd,yyyy HH:MM:SSZ'	'Mar.07,2022 02:45:02Z'
"mmm.dd,yyyy"	"Mar.07,2022"	'mmm.dd,yyyy'	'Mar.07,2022'
"mm/dd/yyyy "	"03/17/2022"	'yyyy-mm-dd'	'2022-03-17'
"yyyy/mm/dd"	"2022/03/17"	'yyyy-mm-dd'	'2022-03-17'
"yyyy-mm-dd"	"2022-03-17"	'yyyy-mm-dd'	'2022-03-17'
"yyyymmddTHHMSS"	"20220317T144502"	'yyyy-mm-ddTHH:MM:SSZ'	'2022-03-17T14:45:02Z'
"yyyy-mm-dd HH:MM:SS"	"2022-03-17 14:45:02"	'yyyy-mm-ddTHH:MM:SSZ'	'2022-03-17T14:45:02Z'

Input Format	Input Format Example	Stored Format	Stored Format Example
"current" indicates the most current data available on the server. Not all servers support this input.	"current"	'current'	'current'
"Byyyy" indicates a year BCE	"B1000" indicates 1000 BCE	'Byyyy'	'B1000'
"Kx" indicates x thousand years in the distant past	"K10" indicates 10,000 years in the past	'Kx'	'K10'
"Mx" indicates x million years in the distant past	"M9" indicates 9 million years in the past	'Mx'	'M9'
"Gx" indicates x billion years in the distant past	"G3" indicates 3 billion years in the past	'Gx'	'G3'

To use this property, the dimension name of the layer must be 'time'. You can query the dimension name of a layer by accessing the structure array in its `Details` property, specifying the `Dimension` field, and, within the `Dimension` structure array, specifying the `Name` field. For example, given a layer `layer`, specify `layer.Details.Dimension.Name`.

Data Types: `double` | `char` | `string`

SampleDimension — Name and value of a sample dimension

two-element cell array of character vectors

Name and value of a sample dimension, specified as a two-element cell array of character vectors. The name cannot be 'time' or 'elevation'. `SampleDimension{1}` must be the value of the `Layer.Details.Dimension.Name` field.

Transparent — Flag indicating transparency of map background

false (default) | logical scalar

Flag indicating transparency of map background, specified as a logical scalar. When you set `Transparent` to `true`, the server sets all pixels not representing features or data values in that layer to a transparent value, producing a composite map. When you set `Transparent` to `false`, the server sets all non-data pixels to the value of the background color.

Data Types: `logical`

BackgroundColor — Color of the background (non-data) pixels of the map

three-element numeric vector

Color of the background (non-data) pixels of the map, specified as a three-element numeric vector. The values range from 0 to 255. The default value, `[255, 255, 255]`, specifies the background color as white. You can set `BackgroundColor` using non-`uint8` numeric values, but they are cast and stored as `uint8`.

Data Types: `uint8`

StyleName — Style to use when rendering the image

{ } (default) | character vector or cell array of character vectors

Style to use when rendering the image, specified as a character vector or cell array of character vectors. The `StyleName` must be a valid entry in the `Layer.Details.Style.Name` field. The cell array of character vectors contains the same number of elements as does `Layer`.

ImageFormat — Desired image format used to render the map as an image

character vector

Desired image format used to render the map as an image, specified as a character vector. If set, the format must match an entry in the `Layer.Details.ImageFormats` cell array and an entry in the `ImageRenderFormats` property. If not set, the format defaults to a value in the `ImageRenderFormats` property.

ImageRenderFormats — Preferred image rendering formats when Transparent is set to false

cell array

This property is read-only.

Preferred image rendering formats when `Transparent` is set to `false`, specified as a cell array. The first entry is the most preferred image format. If the preferred format is not stored in the `Layer` property, then the next format from the list is selected, until a format is found. The `ImageRenderFormats` array is not used if the `ImageFormat` property is set.

ImageTransparentFormats — Preferred image rendering formats when Transparent is set to true

cell array

This property is read-only.

Preferred image rendering formats when `Transparent` is set to `true`, specified as a cell array. The first entry is the most preferred image format. If the preferred format is not stored in the `Layer` property, then the next format from the list is selected, until a format is found. If a transparent image format is not found in the list, or if the `ImageFormat` property is set to a non-default value, then `ImageFormat` is unchanged.

ServerURL — Server URL for the WMS GetMap request

character vector

Server URL for the WMS GetMap request, specified as a character vector. In general, `ServerURL` matches the `ServerURL` of the `Layer`. However, some WMS servers, such as the Microsoft® TerraServer, require a different URL for GetMap requests than for WMS GetCapabilities requests. By default, `ServerURL` is `Layer(1).ServerURL`.

Data Types: `char`

RequestURL — Full URL for the WMS GetMap request

character vector

This property is read-only.

Full URL for the WMS GetMap request, specified as a character vector. It is composed of the `ServerURL` with additional WMS parameter/value pairs.

Object Functions

`boundImageSize` Bound size of raster map

Examples

Read and Display Terrain Elevation Data

Create a web map server object that communicates with the WMS server provided by MathWorks®. Get the terrain elevation layer from the capabilities document.

```
serverURL = "https://wms.mathworks.com";
server = WebMapServer(serverURL);
info = getCapabilities(server);
elevation = refine(info.Layer,"elevation");
```

Create a map request object for the layer.

- Specify latitude and longitude limits for an area surrounding the Gulf of Maine.
- Specify the sampling interval as 30 arc-seconds.
- Calculate the image height and width by using the latitude limits, the longitude limits, and the sampling interval.
- Request quantitative elevation data (rather than an image) by specifying the image format as BIL.

```
mapRequest = WMSMapRequest(elevation);
mapRequest.Latlim = [40 46];
mapRequest.Lonlim = [-71 -65];
samplingInterval = dms2degrees([0 0 30]);
mapRequest.ImageHeight = round(abs(diff(mapRequest.Latlim))/samplingInterval);
mapRequest.ImageWidth = round(abs(diff(mapRequest.Lonlim))/samplingInterval);
mapRequest.ImageFormat = "image/bil";
```

Read the terrain data from the server into the workspace as an array and a geographic raster reference object. Prepare the data for plotting by converting the data type to `double`. To make the water areas appear blue on the plot, set elevations at sea level ($Z == 0$) to a value below sea level.

```
Z = getMap(server,mapRequest.RequestURL);
R = mapRequest.RasterReference;
Z = double(Z);
Z(Z == 0) = -1;
```

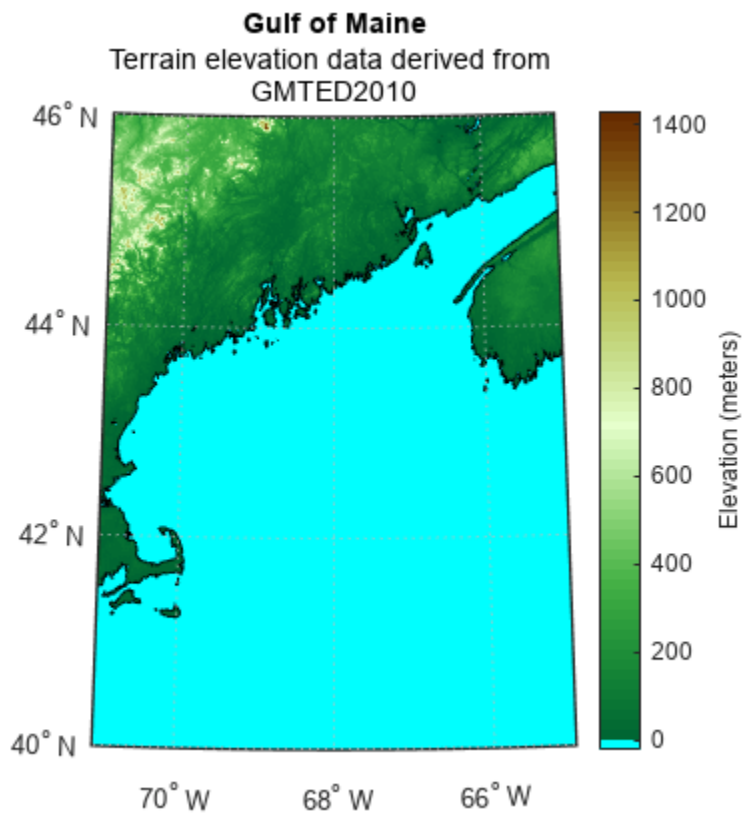
Display the elevation data on a map and plot contour lines at sea level.

```
figure
worldmap(Z,R)
geoshow(Z,R,"DisplayType","texturemap")
contourm(Z,R,[0,0],"Color","k")
```

Customize the map by adding a title and subtitle, a colormap appropriate for elevation data, and a labeled color bar.

```
title("Gulf of Maine")
st = textwrap(string(mapRequest.Layer.LayerTitle),40);
subtitle(st)
demcmap(Z)
```

```
c = colorbar;  
c.Label.String = "Elevation (meters)";
```



Version History

Introduced in R2009b

See Also

Functions

wmsread | wmsinfo | wmsfind

Objects

WebMapServer | WMSCapabilities | WMSLayer

Topics

“Modify Your Map Request”

wmsread

Retrieve WMS map from server

Syntax

```
[A,R] = wmsread(layer)
[A,R] = wmsread(layer,Name,Value,...)
[A,R] = wmsread(mapRequestURL)
[A,R,mapRequestURL] = wmsread(...)
```

Description

`[A,R] = wmsread(layer)` accesses the Internet to render and retrieve a raster map from a Web Map Service (WMS) server. The `ServerURL` property of the `WMSLayer` object, `layer`, specifies the server. If `layer` has more than one element, then the server overlays each subsequent layer on top of the base (first) layer, forming a single image. The server renders multiple layers only if all layers share the same `ServerURL` value.

The WMS server returns a raster map, either a color or grayscale image, in the output `A`. The second output, `R`, is a raster reference object that ties `A` to the EPSG:4326 geographic coordinate system on page 1-1942. The rows of `A` are aligned with parallels, with even sampling in longitude. Likewise, the columns of `A` are aligned with meridians, with even sampling in latitude.

The geographic limits of `A` span the full latitude and longitude extent of `layer`. The `wmsread` function chooses the larger spatial size of `A` to match its larger geographic dimension. The larger spatial size is fixed at the value 512. In other words, assuming RGB output, `A` is 512-by-`N`-by-3 if the latitude extent exceeds longitude extent and `N`-by-512-by-3 otherwise. In both cases `N` ≤ 512. The `wmsread` function sets `N` to the integer value that provides the closest possible approximation to equal cell sizes in latitude and longitude. The map spans the full extent supported for the `layer`.

`[A,R] = wmsread(layer,Name,Value,...)` specifies parameter-value pairs that modify the request to the server. You can abbreviate parameter names, which are case-insensitive.

`[A,R] = wmsread(mapRequestURL)` uses the input argument `mapRequestURL` to define the request to the server. The `mapRequestURL` contains a WMS serverURL with additional WMS parameters. These WMS parameters include `BBOX`, `GetMap` and the EPSG:4326 or CRS:84 keyword. Obtain a `mapRequestURL` from the output of `wmsread`, the `RequestURL` property of a `WMSMapRequest` object, or an Internet search.

`[A,R,mapRequestURL] = wmsread(...)` returns a WMS `GetMap` request URL in the character vector `mapRequestURL`. You can insert the `mapRequestURL` into a browser to make a request to a server, which then returns the raster map. The browser opens the returned map if its mime type is understood, or saves the raster map to disk.

Examples

Read and Display Layer from NASA

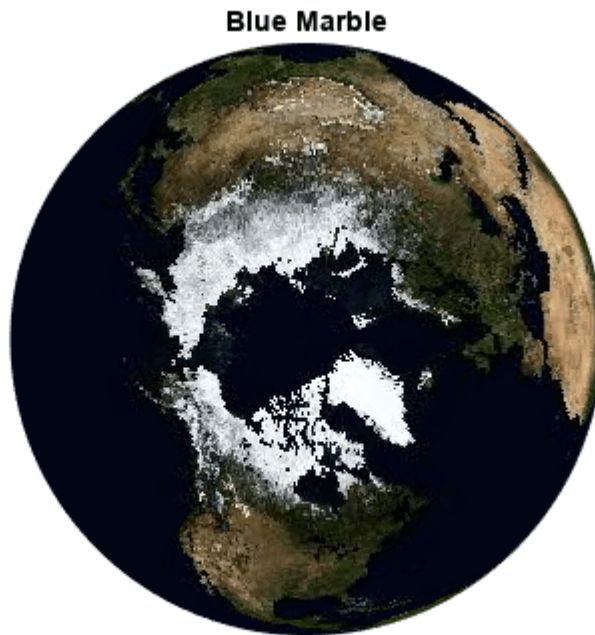
Search the WMS Database for layers containing the string "bluemarble". Extract the first layer.

```
layers = wmsfind("bluemarble");  
layer = layers(1);
```

Read the layer and display it on a map.

```
[A,R] = wmsread(layer);
```

```
axesm globe  
axis off  
geoshow(A,R)  
title("Blue Marble")
```



Read and Display Orthoimage

Read and display an orthoimage of the northern section of the Golden Gate Bridge in San Francisco, California, using the USGS National Map Seamless server.

First, specify the latitude and longitude limits of the Golden Gate Bridge.

```
latlim = [37.78 37.84];  
lonlim = [-122.53 -122.40];
```

Then, find the USGS high-resolution orthoimagery layer by reading the capabilities document from the server. The server may be busy, so try to connect multiple times.

```
numberOfAttempts = 5;  
attempt = 0;  
info = [];  
serverURL = 'http://basemap.nationalmap.gov/ArcGIS/services/USGSImageryOnly/MapServer/WMSServer?'
```

```
while isempty(info)
    try
        info = wmsinfo(serverURL);
        orthoLayer = info.Layer(1);
    catch e

        attempt = attempt + 1;
        if attempt > numberOfAttempts
            throw(e);
        else
            fprintf('Attempting to connect to server:\n"%s"\n', serverURL)
        end
    end
end
```

Retrieve the map from the server and display it in a UTM projection.

```
imageLength = 1024;
[A,R] = wmsread(orthoLayer, 'Latlim', latlim, ...
                'Lonlim', lonlim, ...
                'ImageHeight', imageLength, ...
                'ImageWidth', imageLength);

axesm('utm', ...
      'Zone', utmzone(latlim, lonlim), ...
      'MapLatlimit', latlim, ...
      'MapLonlimit', lonlim, ...
      'Geoid', wgs84Ellipsoid)
geoshow(A,R)
axis off
title({'San Francisco', 'Northern Section of Golden Gate Bridge'})
```

San Francisco Northern Section of Golden Gate Bridge



Read and Display Composite of Sea Surface Temperature

Read and display a global monthly composite of sea surface temperature based on data from the AMSR-E sensor on board the Aqua satellite.

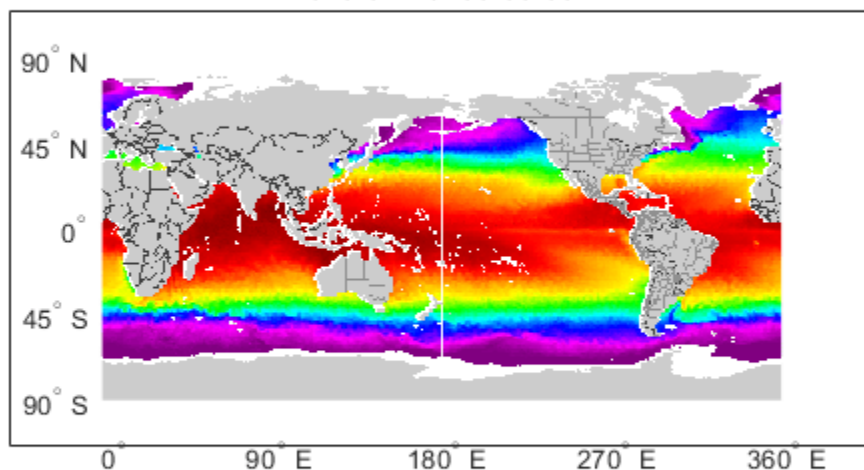
First, search the WMS database for layers containing the word "coastwatch". Refine the search to find layers from the AMSR-E sensor.

```
coastwatch = wmsfind('coastwatch', 'SearchField', 'serverurl');  
layers = refine(coastwatch, 'erdAAsstamday', 'Searchfield', 'serverurl');
```

Read and display the composite of sea surface temperature for April 16, 2010. Include the coastline, landmask, and nation layers.

```
time = '2010-04-16T00:00:00Z';  
[A,R] = wmsread(layers(end:-1:1), 'Time', time);  
  
axesm('pcarree', 'Maplonlimit', [0, 360], ...  
      'PLabelLocation', 45, ...  
      'MLabelLocation', 90, ...  
      'MLabelParallel', -90, ...  
      'MeridianLabel', 'on', ...  
      'ParallelLabel', 'on');  
  
geoshow(A,R);  
title({layers(end).LayerTitle, time})
```

**Aqua AMSR-E, Near Real Time, Global, 2005-2011 (Monthly Composite), Lon+/-1
2010-04-16T00:00:00Z**



Customize Map Appearance

The `wmsread` function enables you to set optional parameters such as the image height, image width, and background color. For this example, customize the map by specifying an image resolution and background color.

Search the WMS Database for a layer containing terrain elevation data from the WMS server hosted by MathWorks®. The default background color defines the ocean and is white.

```
layers = wmsfind("mathworks", "SearchField", "serverurl");
elevation = refine(layers, "elevation");
```

Define a background color by specifying the red, green, and blue levels. Specify the cell size as 0.5 degrees.

```
oceanColor = [0 170 255];
cellSize = 0.5;
```

Read an image from the layer as an array and a geographic cells reference object. Specify the background color and resolution using name-value arguments.

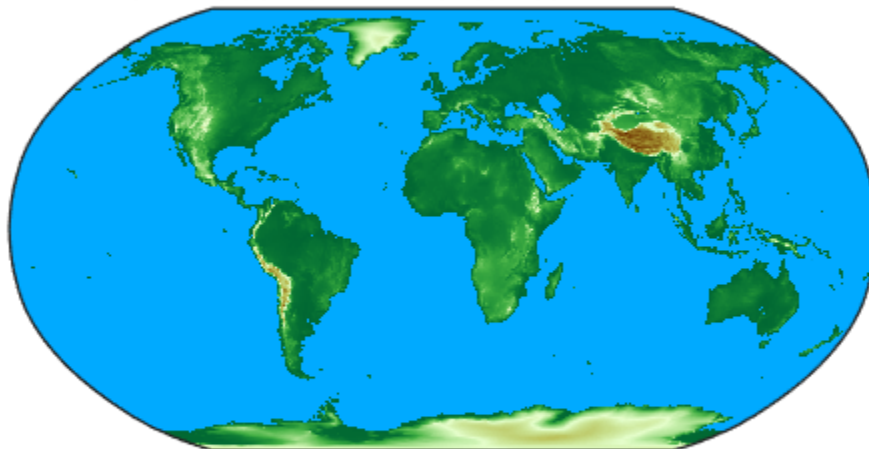
```
[A,R] = wmsread(elevation, "BackgroundColor", oceanColor, ...
    "CellSize", cellSize);
```

Display the image on a map and add a title. Remove the labels and the graticule lines.

```
worldmap world
geoshow(A,R)
title(elevation.LayerTitle)

gridm off
mlabel off
plabel off
```

Terrain elevation data derived from GMTED2010



Input Arguments

layer — Information about the layer you are retrieving

WMSLayer object

Information about the layer you are retrieving, specified as a WMSLayer object.

Example: [A,R] = wmsread(layers(1));

mapRequestURL — WMS GetMap request URL

character vector

WMS GetMap request URL, specified as a character vector.

Example: [A,R] = wmsread(mapURL);

Data Types: char

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, . . . , NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `[A,R] = wmsread(layers(1),'latlim',[40 50]);`

latlim — Latitude limits of the output image in degrees

`[]` (default) | two-element vector

Latitude limits of the output image in degrees, specified as a two-element vector of the form `[southern_limit northern_limit]`. The limit values must be ascending. By default, 'Latlim' is empty, and `wmsread` uses the full extent in latitude of `layer`. If `Layer.Details.Attributes.NoSubsets` is true, 'Latlim' may not be modified.

Example: `[A,R] = wmsread(layers(1),'latlim',[40 50]);`

Data Types: double

lonlim — Longitude limits of the output image in degrees

`[]` (default) | two-element vector

Longitude limits of the output image in degrees, specified as a two-element vector in the form `[western_limit eastern_limit]`. The limit values must be ascending. By default, 'Lonlim' is empty and the full extent in longitude of `layer` is used. If `Layer.Details.Attributes.NoSubsets` is true, you cannot modify 'Lonlim'

Example: `[A,R] = wmsread(layers(1),'lonlim',[40 50]);`

Data Types: double

ImageHeight — Desired height of the raster map in pixels

scalar, positive, integer-valued number

Desired height of the raster map in pixels, specified as a scalar, positive, integer-valued number. `ImageHeight` cannot exceed 8192. If `layer.Details.Attributes.FixedHeight` contains a positive number, you cannot modify 'ImageHeight'.

Example: `[A,R] = wmsread(layers(1),'ImageHeight',40);`

Data Types: double

ImageWidth — Desired width of the raster map in pixels

scalar, positive, integer-valued number

Desired width of the raster map in pixels, specified as a scalar, positive, integer-valued number. `ImageWidth` cannot exceed 8192. If `Layer.Details.Attributes.FixedWidth` contains a positive number, you cannot modify 'ImageWidth'.

Example: `[A,R] = wmsread(layers(1),'ImageWidth',100);`

Data Types: double

CellSize — Target size of the output pixels (raster cells) in degrees

scalar or two-element vector

Target size of the output pixels (raster cells) in degrees, specified as a scalar or two-element vector. If you specify a scalar, the value applies to both height and width dimensions. If you specify a vector, use the form [height width]. The wmsread function issues an error if you specify both CellSize and ImageHeight or ImageWidth. The output raster map must not exceed a size of [8192,8192].

Example: [A,R] = wmsread(layers(1),'Cellsize',5);

Data Types: double

RelTolCellSize – Relative tolerance for 'CellSize'

.001 (default) | scalar or two-element vector

Relative tolerance for 'CellSize', specified as a scalar or two-element vector. If you specify a scalar, the value applies to both height and width dimensions. If you specify a vector, the tolerances appear in the order [height width].

Example: [A,R] = wmsread(layers(1),'RelTolCellsize',[4 5]);

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64

ImageFormat – Desired format to use in rendering the map as an image

first available format in the Layer.Details.ImageFormats cell array (default) | character vector

Desired format to use in rendering the map as an image, specified as one of the following character vectors. If specified, the format must match an entry in the Layer.Details.ImageFormats cell array. If not specified, the format defaults to the first available format in the supported format list. .

Value	Description
'image/jpeg'	JPEG
'image/gif'	GIF
'image/png'	PNG
'image/tiff'	TIFF
'image/geotiff'	GeoTIFF
'image/geotiff8'	GeoTIFF8
'image/tiff8'	TIFF8
'image/png8'	PNG8
'image/bil'	Band Interleaved by Line (BIL) format. When you specify the 'image/bil' format, wmsread returns A as a two-dimensional array with a class type of int16 or int32.

Example: [A,R] = wmsread(layers(1),'ImageFormat','image/png');

Data Types: char

StyleName – Style to use when rendering the image

' ' (default) | character vector | cell array of character vectors

Style to use when rendering the image, specified as a character vector or cell array of character vectors. The StyleName must be a valid entry in the Layer.Details.Style.Name field. If you request multiple layers, each with a different style, then StyleName must be a cell array of character vectors.

Example: [A,R] = wmsread(layer(1),'StyleName','style');

Data Types: char | cell

Transparent — Pixel transparency

false (default) | true

Pixel transparency, specified as a logical value, true or false. When you set Transparent to true, pixel transparency is enabled, meaning all pixels not representing features or data values are set to a transparent value. When you set Transparent to false, non-data pixels are set to the value of the background color.

Example: `[A,R] = wmsread(layers(1), 'Transparent', true);`

Data Types: logical

BackgroundColor — Color used for background (nondata) pixels of the map

[255,255,255] (default) | three-element vector

Color used for background (nondata) pixels of the map, specified as a three-element vector.

Example: `[A,R] = wmsread(layers(1), 'BackgroundColor', [0,0,255]);`

Data Types: single | double | int8 | int16 | int32 | int64 | uint8 | uint16 | uint32 | uint64

Elevation — Desired elevation extent of the requested map

character vector

Desired elevation extent of the requested map, specified as a character vector. The layer must contain elevation data, which is indicated by the 'Name' field of the `Layer.Details.Dimension` structure. The 'Name' field must contain the value 'elevation'. The 'Extent' field of the `Layer.Details.Dimension` structure determines the permissible range of values for the parameter.

Example: `[A,R] = wmsread(layer(1), 'Elevation', 'test');`

Data Types: char

Time — Desired time extent of the requested map

character vector | numeric date number

Desired time extent of the requested map, specified as a character vector or numeric date number. The layer must contain data with a time extent, which is indicated by the 'Name' field of the `Layer.Details.Dimension` structure. The 'Name' field must contain the value 'time'. The 'Extent' field of the `Layer.Details.Dimension` structure determines the permissible range of values for the parameter. For more information about setting this parameter, see the Time property of the `WMSMapRequest` object.

Example: `[A,R] = wmsread(layer(1), 'Time', 'June 15, 2015');`

Data Types: double | char

SampleDimension — Name of sample dimension

two-element cell array of character vectors

Name of dimension, specified as a two-element cell array of character vectors, other than 'time' or 'elevation' and its character vector value. The layer must contain data with a sample dimension extent, which is indicated by the 'Name' field of the `Layer.Details.Dimension` structure. The 'Name' field must contain the value of the first element of 'SampleDimension'. The 'Extent'

field of the `Layer.Details.Dimension` structure determines the permissible range of values for the second element of 'SampleDimension'.

Example: `[A,R] = wmsread(layer(1), 'SampleDimension', {'sample', 'test'});`

Data Types: `cell`

TimeoutInSeconds — Number of seconds to elapse before issuing a server time-out

60 (default) | scalar integer

Number of seconds to elapse before issuing a server time-out, specified as a scalar integer. If you set the value to 0, `wmsread` ignores the time-out mechanism.

Example: `[A,R] = wmsread(layers(1), 'TimeoutInSeconds', 80);`

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64`

Output Arguments

A — Color or grayscale image

real, nonsparse, 2-D matrix

Color or grayscale image, returned as a real, nonsparse, 2-D matrix.

R — Geographic raster reference object

`map.rasterref.GeographicCellsReference` object

Geographic raster reference object, returned as a `map.rasterref.GeographicCellsReference` object. A raster referencing object ties the image A to the EPSG:4326 geographic coordinate system.

mapRequestURL — WMS GetMap request URL

character vector

WMS GetMap request URL, returned as a character vector.

More About

EPSG: 4326 Coordinate Reference System

The EPSG:4326 coordinate reference system is based on the WGS84 (1984 World Geodetic System) datum. Latitude and longitude are in degrees and longitude is referenced to the Greenwich Meridian.

Tips

- Establish an Internet connection to use `wmsread`. Periodically, the WMS server is unavailable. Retrieving the map can take several minutes. `wmsread` communicates with the server using a `WebMapServer` object representing a WMS server. The object acts as a proxy to a WMS server and resides physically on the client side. The object retrieves the map from the server. The object automatically times-out after 60 seconds if a connection is not made to the server.
- To specify a proxy server to connect to the Internet, select **File > Preferences > Web** and enter your proxy information. Use this feature if you have a firewall.
- `wmsread` supports reading data in WMS versions 1.0.0, 1.1.1, and 1.3.0. For version 1.3.0 only, the WMS specification states, "EPSG:4326 refers to WGS 84 geographic latitude, then longitude. That is, in this CRS the x-axis corresponds to latitude, and the y-axis to longitude." Most servers

provide data in this manner; however, some servers conform to version 1.1.1, where the x-axis corresponds to longitude and the y-axis to latitude.

wmsread attempts to validate whether a server is conforming to the specification. It checks the EPSG:4326 bounding box, and if the XLim values exceeds the range of latitude, then the axes are swapped to conform to version 1.1.1 rather than 1.3.0. If wmsread does not detect that the XLim values exceed the range of latitude and you notice that the latitude and longitude limits are reversed, then you need to swap them. You can either modify the bbox parameters in the mapRequestURL or modify the LatLim and LonLim parameter values, if permissible.

Version History

Introduced before R2006a

See Also

wmsfind | wmsinfo | wmsupdate | WebMapServer | WMSLayer

Topics

“Basic Workflow for Creating WMS Maps”

wmsupdate

Synchronize WMSLayer object with server

Syntax

```
updatedLayers = wmsupdate(layers)
[updatedLayers,index] = wmsupdate(layers)
[ ___ ] = wmsupdate(layers,Name,Value)
```

Description

`updatedLayers = wmsupdate(layers)` synchronizes the properties of the WMSLayer objects in `layers` with values from their associated WMS server and returns the updated layers in `updatedLayers`. The function removes layers that are not available on the server. This syntax requires all specified layers to be associated with the same WMS server.

The `wmsupdate` function requires an internet connection. WMS servers can periodically be unavailable. Synchronizing layers with a server can take several minutes.

`[updatedLayers,index] = wmsupdate(layers)` additionally returns a logical array whose elements are 1 (true) when the corresponding layer in `layers` is available on the server. This syntax requires all specified layers to be associated with the same WMS server.

`[___] = wmsupdate(layers,Name,Value)` specifies options for synchronizing layers with their WMS server. For example, `"AllowMultipleServers",true` enables the function to synchronize layers that are associated with different WMS servers.

Examples

Synchronize Layers with Server

Search the WMS Database for specific layers from the NASA Goddard Space Flight Center DAAC servers. Then, synchronize the properties of the layers with values from the servers. Enable the function to synchronize layers that are associated with different servers.

```
layers = wmsfind("disc1.gsfc.nasa.gov","SearchField","serverurl");
updatedLayers = wmsupdate(layers,"AllowMultipleServers",true);
```

Synchronize Layers and Refine Search

When you synchronize WMS layers with their associated WMS server, the function populates the `Abstract`, `CoordRefSysCodes`, and `Details` properties of the WMSLayer objects. You can use the additional information to refine your search.

Find all layers in the WMS Database with the title "Global Sea Surface Temperature". Determine the number of unique servers by using the `servers` function.

```
layers = wmsfind("Global Sea Surface Temperature", "SearchField", "LayerTitle");
servers(layers)
```

```
ans = 1x1 cell array
    {'https://svs.gsfc.nasa.gov/cgi-bin/wms?'}
```

Synchronize the layers with the server. View the abstract, coordinate reference system code, and details of the first layer.

```
updatedLayers = wmsupdate(layers);
updatedLayers(1).Abstract
```

```
ans =
    'The temperature of the surface of the world's oceans provides a clear indication of the sta

    Additional Credit:
    B>Please give credit for this item to:</b><br />'
```

```
updatedLayers(1).CoordRefSysCodes
```

```
ans = 1x1 cell array
    {'CRS:84'}
```

```
updatedLayers(1).Details
```

```
ans = struct with fields:
    MetadataURL: 'http://svs.gsfc.nasa.gov/vis/a000000/a002900/a002905/a002905.fgdc'
    Attributes: [1x1 struct]
    BoundingBox: [1x1 struct]
    Dimension: [1x1 struct]
    ImageFormats: {'image/png'}
    ScaleLimits: [1x1 struct]
    Style: [1x2 struct]
    Version: '1.3.0'
```

Refine the search to include only layers with abstracts that contain "El Nino".

```
el_nino = refine(layers, "El Nino", "SearchFields", "abstract");
```

Synchronize and Display Layers

Search the WMS Database for layers from the NASA Goddard Space Flight Center SVS Image Server. Synchronize the properties of the layers with values from the server. Then, refine the search to find layers containing the term "blue marble".

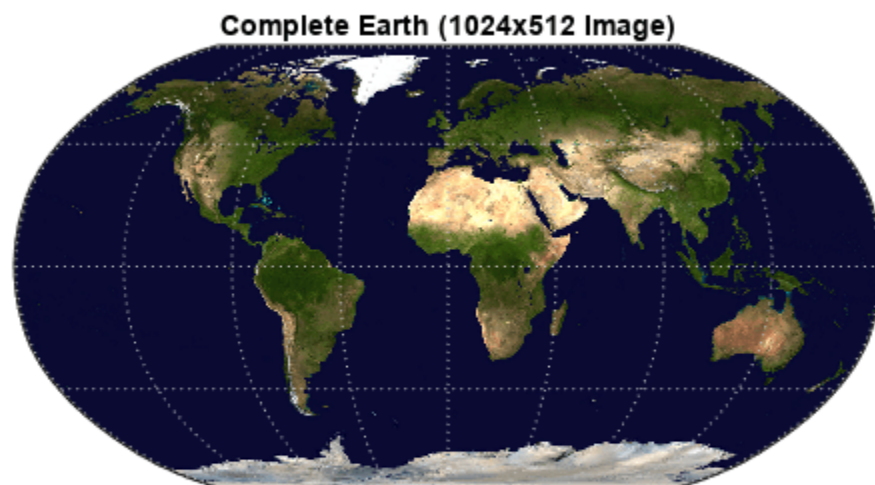
```
layers = wmsfind("svs.gsfc.nasa.gov", "SearchField", "serverurl");
updatedLayers = wmsupdate(layers);
blueMarble = refine(updatedLayers, "blue marble", "SearchField", "abstract");
```

Refine the search again to find the first layer with a title containing the term "512".

```
blueMarble512 = refine(blueMarble, "*512");
blueMarble512 = blueMarble512(1);
```

Display the layer on a world map. Remove the parallel and meridian labels.

```
[A,R] = wmsread(blueMarble512);  
worldmap world  
geoshow(A,R)  
title(blueMarble512.LayerTitle)  
plabel off  
mlabel off
```



Save Updated Layers

Synchronizing layers from multiple servers can take a long time. You can avoid synchronizing layers multiple times by saving updated layers to a MAT file.

Search the WMS Database for server URLs that contain "noaa". Refine the search to include only layers with information about oceans.

```
layers = wmsfind("noaa", "SearchFields", "ServerURL");  
layers = refine(layers, "ocean");
```

Synchronize the layers. The code might take several minutes to run because it is synchronizing layers that are associated with multiple servers.

```
updatedLayers = wmsupdate(layers, "AllowMultipleServers", true);
```


Save the layers to a MAT file called `oceanLayers`.

```
save("oceanLayers","updatedLayers")
```

Loading the MAT file enables you to refine your search and read a map without updating the layers again.

Note that servers change, so the layers contained in the MAT file might become out-of-date.

Input Arguments

layers — WMS layers

array of `WMSLayer` objects

WMS layers, specified as an array of `WMSLayer` objects.

Name-Value Pair Arguments

Specify optional pairs of arguments as `Name1=Value1, ..., NameN=ValueN`, where `Name` is the argument name and `Value` is the corresponding value. Name-value arguments must appear after other arguments, but the order of the pairs does not matter.

Before R2021a, use commas to separate each name and value, and enclose Name in quotes.

Example: `wmsupdate(layers,"AllowMultipleServers",true)` enables the function to synchronize layers that are associated with different WMS servers.

TimeoutInSeconds — Time out connection duration

60 (default) | nonnegative integer

Time out connection duration in seconds, specified as a nonnegative integer. The value is the number of seconds to wait to receive a response from the server. To deactivate the time out mechanism, specify this argument as 0.

AllowMultipleServers — Layers can be associated with multiple servers

false or 0 (default) | true or 1

Layers can be associated with multiple servers, specified as a numeric or logical 1 (`true`) or 0 (`false`).

- `false` specifies that all layers in `layers` must be from the same server.
- `true` specifies that the layers in `layers` can be associated with different servers. This option makes a request to each unique server, which can take several minutes to finish.

Output Arguments

updatedLayers — Synchronized layers

array of `WMSLayer` objects

Synchronized layers, returned as an array of `WMSLayer` objects.

In addition to synchronizing the properties of the `WMSLayer` objects with the server, the `wmsupdate` function populates the `Abstract`, `CoordRefSysCodes`, and `Details` properties of the objects.

The `wmsupdate` function removes layers that are not available on the server. Except for deleted layers, `updatedLayers` preserves the order of layers in `layers`.

The size of `updatedLayers` matches the size of `layers (index)`.

index — Indicator for available layers

logical array

Indicator for available layers, returned as a logical array. The size of `index` matches the size of `layers`.

- A logical `1 (true)` indicates that the corresponding layer is available on the server.
- A logical `0 (false)` indicates that the corresponding layer is not available on the server.

Data Types: `logical`

Version History

Introduced in R2009b

See Also

Functions

`wmsfind` | `wmsinfo` | `wmsread`

Objects

`WebMapServer`

Topics

“Basic Workflow for Creating WMS Maps”

“Proxy Server Authentication”

worldFileMatrix

Package: map.rasterref

Return world file parameters for transformation

Syntax

`W = worldFileMatrix(R)`

Description

`W = worldFileMatrix(R)` returns a 2-by-3 world file matrix from geographic or map raster R.

Examples

Create World File Matrix from a Planar Map Raster

Create a MapCellsReference raster reference object.

```
xWorldLimits = [207000 208000];
yWorldLimits = [912500 913000];
rasterSize = [10 20];
R = maprefcells(xWorldLimits,yWorldLimits,rasterSize,'ColumnsStartFrom','north')
```

R =

MapCellsReference with properties:

```

    XWorldLimits: [207000 208000]
    YWorldLimits: [912500 913000]
    RasterSize: [10 20]
    RasterInterpretation: 'cells'
    ColumnsStartFrom: 'north'
    RowsStartFrom: 'west'
    CellExtentInWorldX: 50
    CellExtentInWorldY: 50
    RasterExtentInWorldX: 1000
    RasterExtentInWorldY: 500
    XIntrinsicLimits: [0.5 20.5]
    YIntrinsicLimits: [0.5 10.5]
    TransformationType: 'rectilinear'
    CoordinateSystemType: 'planar'
    ProjectedCRS: []
```

Compute the world file matrix.

```
W = worldFileMatrix(R)
```

W = 2×3

```

    50         0    207025
```

```
0 -50 912975
```

Observe that $W(2,1)$ and $W(1,2)$ are 0. This value is expected since `R.TransformationType` is 'rectilinear'.

Input Arguments

R — Geographic or map raster

GeographicCellsReference, GeographicPostingsReference, MapCellsReference, or MapPostingsReference object

Geographic or map raster, specified as a GeographicCellsReference, GeographicPostingsReference, MapCellsReference, or MapPostingsReference object.

Output Arguments

W — World file matrix

2-by-3 numeric array

World file matrix, returned as a 2-by-3 numeric array. Each of the six elements in W matches one of the lines in a world file corresponding to the transformation defined by raster referencing object `R`.

Data Types: double

More About

World File Matrix

A world file matrix maps points in intrinsic coordinates to points in geographic or planar world coordinates.

Given a world file matrix W of the form:

$$W = \begin{bmatrix} A & B & C \\ D & E & F \end{bmatrix}$$

a point (x_i, y_i) maps to a point (x_w, y_w) in world coordinates according to:

$$\begin{aligned} x_w &= A \times (x_i - 1) + B \times (y_i - 1) + C \\ y_w &= D \times (x_i - 1) + E \times (y_i - 1) + F. \end{aligned}$$

More compactly:

$$\begin{bmatrix} x_w & y_w \end{bmatrix} = W \times \begin{bmatrix} (x_i - 1) \\ (y_i - 1) \end{bmatrix}.$$

Note Similar equations hold true for points (lat, lon) in geographic coordinates. However, the geographic coordinate ordering is switched. That is, x_w is substituted by lon , and y_w is substituted by lat .

The -1 s are needed to maintain the Mapping Toolbox convention for intrinsic coordinates, which is consistent with the 1-based indexing used throughout MATLAB.

W is stored in a world file with one term per line in column-major order: A, D, B, E, C, F . That is, a world file contains the elements of W in this order:

$W(1,1)$
 $W(2,1)$
 $W(1,2)$
 $W(2,2)$
 $W(1,3)$
 $W(2,3)$

The previous expressions hold for both affine and rectilinear transformations of rasters. The values $B, D, W(2,1)$ and $W(1,2)$ are identically 0 whenever:

- R is a geographic raster, since longitude depends only on intrinsic x and latitude depends only on intrinsic y
- R is a map raster and $R.TransformationType$ is 'rectilinear'

Version History

Introduced in R2013b

worldFileMatrixToRefmat

(To be removed) Convert world file matrix to referencing matrix

Note `worldFileMatrixToRefmat` will be removed in a future release. Use the `georasterref` or `maprasterref` function instead. For more information, see “Compatibility Considerations”.

Syntax

```
refmat = worldFileMatrixToRefmat(W)
```

Description

`refmat = worldFileMatrixToRefmat(W)` converts the 2-by-3 world file matrix `W` to a 3-by-2 referencing matrix `refmat`.

Input Arguments

W — World file matrix

2-by-3 numeric array

World file matrix, specified as a 2-by-3 numeric array. A world file matrix defines a transformation that maps intrinsic coordinates to geographic or world coordinates.

Output Arguments

refmat — Referencing matrix

3-by-2 numeric array

Referencing matrix, returned as a 3-by-2 numeric array. A referencing matrix defines a transformation that maps intrinsic coordinates to geographic or world coordinates.

- For world coordinates, the function returns `refmat` so that $[x_w \ y_w] = [x_i \ y_i \ 1] \cdot refmat$, where (x_i, y_i) is a location in intrinsic coordinates and (x_w, y_w) is the same location in world coordinates.
- For geographic coordinates, the function returns `refmat` so that $[lon \ lat] = [x \ y \ 1] \cdot refmat$, where x and y specify a location in intrinsic coordinates and lat and lon specify the same location in geographic coordinates.

Version History

Introduced in R2011a

R2022a: Warns

Warns starting in R2022a

Some functions that return referencing matrices issue a warning that they will be removed, including the `worldFileMatrixToRefmat` function. Instead of using this function, create a raster reference

object using the `georasterref` or `maprasterref` function. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `MapPostingsReference` functions.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` or `mapcrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` or `mapresize` function.
- Most functions that accept referencing matrices as inputs also accept reference objects.

To update your code, change instances of the `worldFileMatrixToReformat` function to the `georasterref` or `maprasterref` function and specify the size of the raster `A`. Use the `georasterref` function for geographic coordinates and the `maprasterref` function for planar map coordinates.

```
R = georasterref(W,size(A));
```

You can also specify the raster interpretation as `"cells"` for a raster of cells or `"postings"` for a raster of regularly posted samples. By default, the `georasterref` and `maprasterref` functions use `"cells"`.

```
R = georasterref(W,size(A),"postings");
```

R2020b: To be removed

Not recommended starting in R2020b

The `worldFileMatrixToReformat` function runs without warning but will be removed in a future release.

See Also

Functions

`reformatToWorldFileMatrix` | `georasterref` | `maprasterref`

worldfileread

Read world file and return reference object

Note Syntaxes of the `worldfileread` function that return referencing matrices will be removed in a future release. Use a syntax that returns a reference object instead. For more information, see “Compatibility Considerations”.

Syntax

```
R = worldfileread(worldFileName, coordinateSystemType, rasterSize)
```

Description

`R = worldfileread(worldFileName, coordinateSystemType, rasterSize)` reads the world file, `worldFileName`, and constructs a spatial referencing object, `R`. The argument `coordinateSystemType` specifies the type of referencing object. `rasterSize` specifies the size of the image corresponding to the world file.

Examples

Read Image Referenced to Projected Coordinate System

Read an ortho image referenced to a projected coordinate system (Massachusetts State Plane Mainland).

```
filename = 'concord_ortho_w.tif';  
[X, cmap] = imread(filename);
```

Derive world file name from image file name.

```
worldFileName = getworldfilename(filename);
```

Read the world file, returning a referencing object.

```
R = worldfileread(worldFileName, 'planar', size(X))
```

```
R =
```

```
MapCellsReference with properties:
```

```
    XWorldLimits: [207000 209000]  
    YWorldLimits: [911000 913000]  
    RasterSize: [2000 2000]  
    RasterInterpretation: 'cells'  
    ColumnsStartFrom: 'north'  
    RowsStartFrom: 'west'  
    CellExtentInWorldX: 1  
    CellExtentInWorldY: 1  
    RasterExtentInWorldX: 2000  
    RasterExtentInWorldY: 2000
```



```

XIntrinsicLimits: [0.5 2000.5]
YIntrinsicLimits: [0.5 2000.5]
TransformationType: 'rectilinear'
CoordinateSystemType: 'planar'
ProjectedCRS: []

```

Read Image Referenced to Geographic Coordinate System

Read image reference to a geographic coordinate system.

```

filename = 'boston_ovr.jpg';
RGB = imread(filename);

```

Derive world file name from image file name,

```

worldFileName = getworldfilename(filename);

```

Read world file, returning a referencing object.

```

R = worldfileread(worldFileName, 'geographic', size(RGB))

```

R =

GeographicCellsReference with properties:

```

LatitudeLimits: [42.3052018188767 42.4165064733949]
LongitudeLimits: [-71.1308390797572 -70.9898400731705]
RasterSize: [769 722]
RasterInterpretation: 'cells'
ColumnsStartFrom: 'north'
RowsStartFrom: 'west'
CellExtentInLatitude: 0.000144739472715501
CellExtentInLongitude: 0.000195289482807142
RasterExtentInLatitude: 0.11130465451822
RasterExtentInLongitude: 0.140999006586757
XIntrinsicLimits: [0.5 722.5]
YIntrinsicLimits: [0.5 769.5]
CoordinateSystemType: 'geographic'
GeographicCRS: []
AngleUnit: 'degree'

```

Input Arguments

worldFileName — Name of world file

character vector

Name of world file, specified as a character vector.

Example: worldFileName = getworldfilename(filename);

Data Types: char

coordinateSystemType — Type of referencing object

'planar' | 'geographic'

Type of referencing object, specified as one of the following:

Value	Description
'geographic'	Latitude-longitude systems
'planar'	Projected map coordinate systems

Example: `R = worldfileread(worldFileName, 'geographic', size(RGB));`

Data Types: char

rasterSize — Size of the image corresponding to the world file

two-element vector

Size of the image corresponding to the world file, specified as a two-element vector, $[m\ n]$, where m is the number of rows in the image and n is the number of columns in the image.Example: `size(I)`

Data Types: double

Output Arguments**R — Spatial referencing object**

raster reference object

Spatial referencing object, returned as a raster reference object.

Version History**Introduced before R2006a****R2022a: Syntaxes that return referencing matrices warn***Warns starting in R2022a*

Syntaxes of the `worldfileread` function that return referencing matrices issue a warning that they will be removed in a future release. Use syntaxes that return reference objects instead. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns. For more information about reference object properties, see the `GeographicCellsReference` and `MapPostingsReference` objects.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` or `mapcrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` or `mapresize` function.
- Most functions that accept referencing matrices as inputs also accept reference objects.

To update your code, specify the coordinate system type as a second argument. Use 'planar' for planar map coordinates or 'geographic' for geographic coordinates. Specify the size of the associated raster, A, as a third argument.

Will Be Removed	Recommended
<code>refmat = worldfileread(worldFileName);</code>	<code>R = worldfileread(worldFileName, ... coordinateSystemType, size(A));</code>

R2020b: Syntaxes that return referencing matrices will be removed

Not recommended starting in R2020b

Syntaxes of the `worldfileread` function that return referencing matrices will be removed in a future release.

See Also

`getworldfilename` | `worldToIntrinsic` | `worldfilewrite` | `intrinsicToWorld` | `readgeoraster`

worldfilewrite

Write world file from raster reference object

Syntax

```
worldfilewrite(R,worldfilename)
```

Description

`worldfilewrite(R,worldfilename)` calculates the world file entries corresponding to reference object `R` and writes them into the file `worldfilename`. Specify `R` as a `GeographicCellsReference`, `GeographicPostingsReference`, `MapCellsReference`, or `MapPostingsReference` object.

Examples

Write out the information from a reference object for the image file `concord_ortho_w.tif`

```
info = imfinfo('concord_ortho_w.tif');  
R = worldfileread('concord_ortho_w.tfw','planar',[info.Height info.Width])  
worldfilewrite(R,'concord_ortho_w_test.tfw');  
type concord_ortho_w_test.tfw
```

Version History

Introduced before R2006a

R2022b: worldfilewrite will not accept referencing matrices as input

Not recommended starting in R2022b

The `worldfilewrite` function will not accept referencing matrices as input in a future release. Use a geographic raster reference object (specified as a `GeographicCellsReference` or `GeographicPostingsReference` object) or a map raster reference object (specified as a `MapCellsReference` or `MapPostingsReference` object) as input instead. Reference objects have several advantages over referencing matrices.

- Unlike referencing matrices, reference objects have properties that document the size of the associated raster, its limits, and the direction of its rows and columns.
- You can manipulate the limits of rasters associated with reference objects using the `geocrop` or `mapcrop` function.
- You can manipulate the size and resolution of rasters associated with reference objects using the `georesize` or `mapresize` function.

Depending on whether the referencing matrix is in geographic or planar coordinates, there are different ways to update your code.

Geographic Coordinates

If the referencing matrix is in geographic coordinates, create a geographic reference object.

- Create a geographic reference object for a raster of cells by using the `georefcells` function.
- Create a geographic reference object for a raster of regularly posted samples by using the `georefpostings` function.
- Convert from a referencing matrix to a geographic reference object by using the `refmatToGeoRasterReference` function.

Once you have created a reference object, replace uses of the referencing matrix in your code with the reference object.

Planar Map Coordinates

If the referencing matrix is in planar map coordinates, create a map reference object.

- Create a map reference object for a raster of cells by using the `maprefcells` function.
- Create a map reference object or for a raster of regularly posted samples by using the `maprefpostings` function.
- Convert from a referencing matrix to a map reference object by using the `refmatToMapRasterReference` function.

Once you have created a reference object, replace uses of the referencing matrix in your code with the reference object.

See Also

`getworldfilename` | `intrinsicToWorld` | `worldToIntrinsic` | `worldfileread`

worldGrid

Package: map.rasterref

World coordinates of raster elements

Syntax

```
[X,Y] = worldGrid(R)
[X,Y] = worldGrid(R,gridOption)
```

Description

`[X,Y] = worldGrid(R)` returns the world coordinates of raster elements as the 2-D arrays X and Y. The coordinates of raster element (i,j) are (X(i,j),Y(i,j)).

`[X,Y] = worldGrid(R,gridOption)`, where `gridOption` is 'gridvectors', returns X and Y as row vectors. The coordinates of raster element (i,j) are (X(j),Y(i)). The default for `gridOption` is 'fullgrid', which returns X and Y as 2-D arrays.

Examples

Find Coordinates of Raster Elements

Import elevation data, find the coordinates of the imported data, then display the data as a surface.

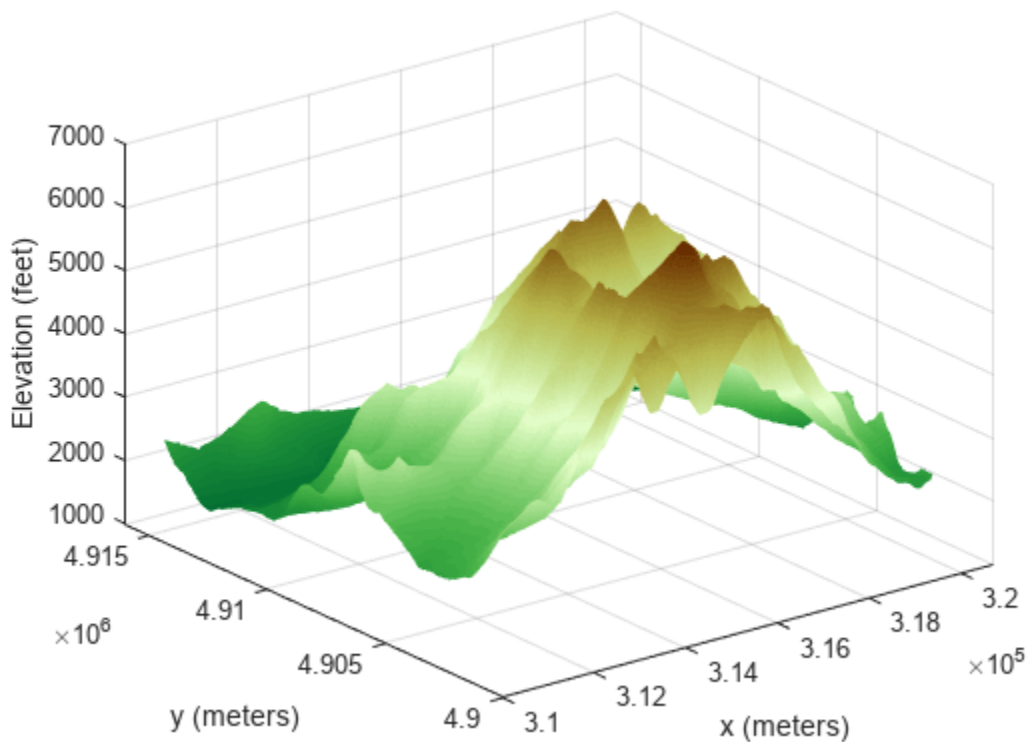
First import elevation data [1] on page 1-1961 for an area around Mount Washington as an array and a map cells reference object. Prepare the data for plotting by replacing missing data values with 0. Then, find the coordinates of each element in the array.

```
[Z,R] = readgeoraster('MtWashington-ft.grd','OutputType','double');
info = georasterinfo('MtWashington-ft.grd');
Z = standardizeMissing(Z,info.MissingDataIndicator);
```

```
[X,Y] = worldGrid(R);
```

Display the elevation data as a surface using an appropriate colormap. Set the `EdgeColor` property to 'none' to remove the mesh from the surface.

```
surf(X,Y,Z,'EdgeColor','none')
demcmap(Z)
xlabel('x (meters)')
ylabel('y (meters)')
zlabel('Elevation (feet)')
```



[1] The elevation data used in this example is courtesy of the U.S. Geological Survey.

Get Vectors Instead of Arrays

Create a map cells reference object for a 3-by-4 raster with x values in the range [7000, 7400] meters and y values in the range [2700, 3300] meters. Get the coordinates of the raster elements and return them as row vectors.

```
R = maprefcells([7000 7400],[2700 3300],[3 4]);
[X,Y] = worldGrid(R,'gridvectors')
```

```
X = 1×4
```

```
    7050    7150    7250    7350
```

```
Y = 1×3
```

```
    2800    3000    3200
```

If you do not specify the second argument as 'gridvectors', then the worldGrid function returns 2-D arrays by default.

```
[xFull,yFull] = worldGrid(R)
```

```
xFull = 3×4
```

```
    7050    7150    7250    7350
    7050    7150    7250    7350
    7050    7150    7250    7350
```

```
yFull = 3×4
```

```
    2800    2800    2800    2800
    3000    3000    3000    3000
    3200    3200    3200    3200
```

Input Arguments

R — Spatial reference

MapCellsReference object | MapPostingsReference object

Spatial reference, specified as a MapCellsReference or MapPostingsReference object.

If R is a MapCellsReference object, then X and Y are cell centers. If R is a MapPostingsReference object, then X and Y are posting points.

gridOption — Grid option

'fullgrid' (default) | 'gridvectors'

Grid option, specified as one of these values:

- 'fullgrid' — Return X and Y as 2-D arrays, where each row of X is identical and each column of Y is identical. This is the default behavior.
- 'gridvectors' — Return X and Y as row vectors. Use this option when you want to reduce memory usage and when 2-D arrays are unnecessary, such as when plotting large data sets with the surf function. You can specify gridOption as 'gridvectors' only when the TransformationType property of R has a value of 'rectilinear'.

This table shows the difference between 'fullgrid' and 'gridvectors'.

'fullgrid'	'gridvectors'
<code>R = maprefcells([7000 7400],[2700 3300],[3 4]);</code> <code>[X,Y] = worldGrid(R)</code>	<code>R = maprefcells([7000 7400],[2700 3300],[3 4]);</code> <code>[X,Y] = worldGrid(R,'gridvectors')</code>
X =	X =
7050 7150 7250	7350 7050 7150 7250 7350
7050 7150 7250	7350
7050 7150 7250	Y =
	2800 3000 3200
Y =	2800
2800 2800 2800	3000
3000 3000 3000	3200
3200 3200 3200	

Data Types: char | string

Output Arguments

X — x-coordinates

2-D array (default) | row vector

x-coordinates, returned as a 2-D array or a row vector. By default, X is a 2-D array. To return X as a row vector, specify `gridOption` as `'gridvectors'`.

By default, and when `gridOption` is `'fullgrid'`, the sizes of X and Y each equal the `RasterSize` property of R. When `gridOption` is `'gridvectors'`, the lengths of X and Y equal the second and first elements of the `RasterSize` property of R, respectively.

Y — y-coordinates

2-D array (default) | row vector

y-coordinates, returned as a 2-D array or a row vector. By default, Y is a 2-D array. To return Y as a row vector, specify `gridOption` as `'gridvectors'`.

By default, and when `gridOption` is `'fullgrid'`, the sizes of X and Y each equal the `RasterSize` property of R. When `gridOption` is `'gridvectors'`, the lengths of X and Y equal the second and first elements of the `RasterSize` property of R, respectively.

Version History

Introduced in R2021a

See Also

Functions

`ndgrid` | `meshgrid` | `intrinsicToWorld` | `geographicGrid`

Objects

`MapCellsReference` | `MapPostingsReference`

worldmap

Create axesm-based map for world region

Syntax

```
worldmap region
worldmap(region)
worldmap
worldmap(latlim,lonlim)
worldmap(Z,R)
h = worldmap( ___ )
```

Description

`worldmap region` or `worldmap(region)` sets up an empty axesm-based map (previously referred to as map axes) with projection and limits suitable to the part of the world specified in `region`.

`worldmap` with no arguments presents a menu from which you can select the name of a single continent, country, island, or region.

`worldmap(latlim,lonlim)` allows you to define a custom geographic region in terms of its latitude and longitude limits in degrees.

`worldmap(Z,R)` derives the map limits from the extent of a regular data grid, `Z`, georeferenced by `R`.

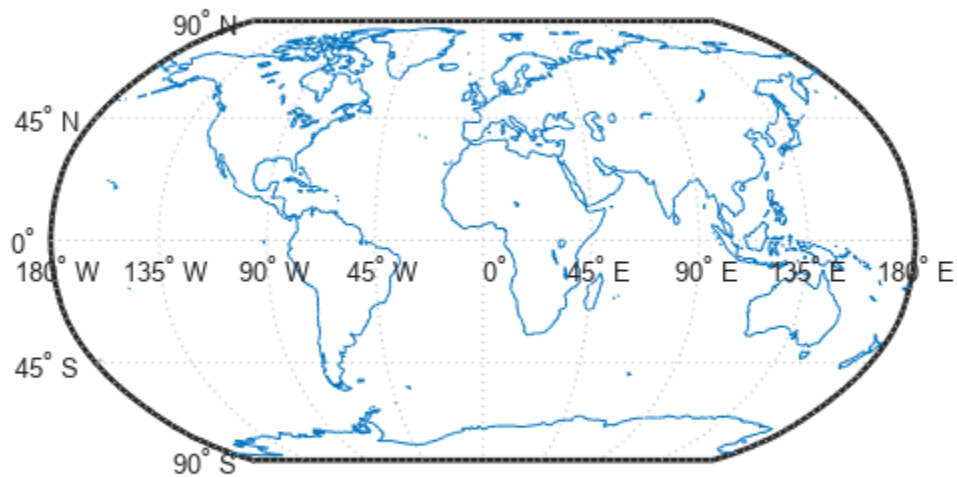
`h = worldmap(___)` returns the handle of the axesm-based map.

Examples

Set up World Map and Draw Coastlines

Set up a world map and draw coarse coastlines.

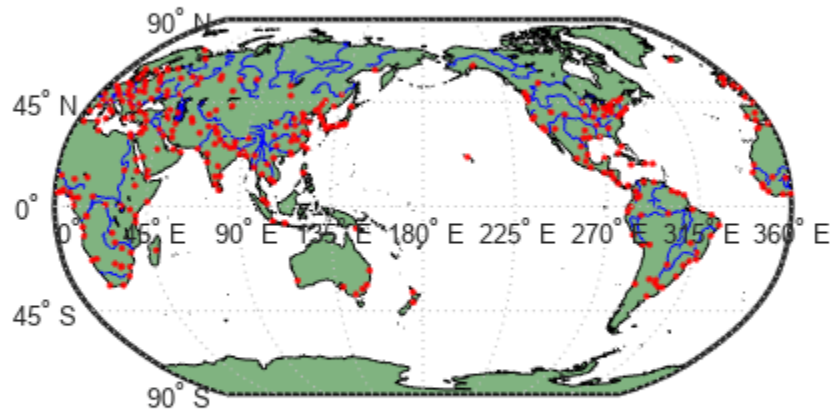
```
worldmap('World')
load coastlines
plotm(coastlat,coastlon)
```



Create World Map with Land Areas, Lakes, and Other Landmarks

Read and display land areas, major lakes and rivers, cities, and populated places on a world map.

```
ax = worldmap("World");  
setm(ax,"Origin",[0 180 0])  
  
land = readgeotable("landareas.shp");  
geoshow(ax,land,"FaceColor",[0.5 0.7 0.5])  
  
lakes = readgeotable("worldlakes.shp");  
geoshow(lakes,"FaceColor","blue")  
  
rivers = readgeotable("worldrivers.shp");  
geoshow(rivers,"Color","blue")  
  
cities = readgeotable("worldcities.shp");  
geoshow(cities,"Marker",".", "Color","red")
```



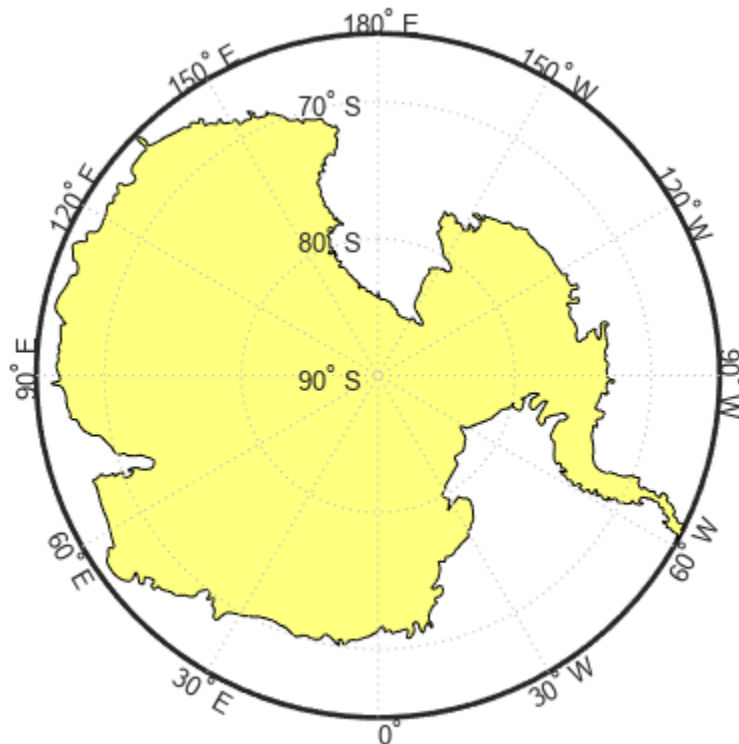
Create Map of Antarctica

Read world land areas as a geospatial table. Extract the table row containing Antarctica.

```
GT = readgeotable("landareas.shp");  
row = GT.Name == "Antarctica";  
ant = GT(row, :);
```

Display Antarctica on a map with an appropriate projection.

```
worldmap("antarctica")  
geoshow(ant)
```

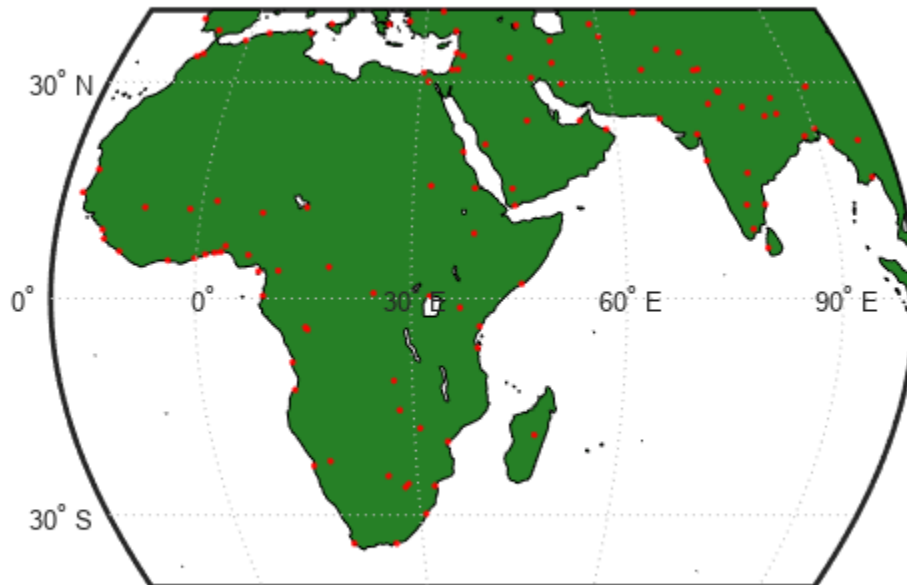


Create Map of Africa and India with Major Cities

Read world land areas and cities as geospatial tables. Create a world map appropriate for Africa and India. Then, display the land areas and cities on the map

```
land = readgeotable("landareas.shp");  
cities = readgeotable("worldcities.shp");
```

```
worldmap(["Africa" "India"])  
geoshow(land,"FaceColor",[0.15 0.5 0.15])  
geoshow(cities,"Marker",".", "Color","red")
```



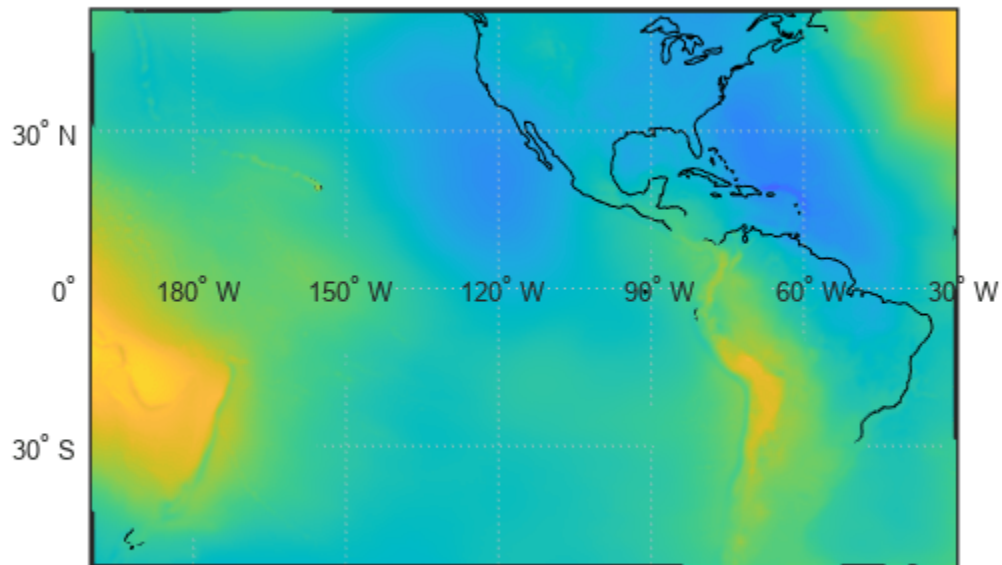
Display Geoid Heights Over South America and Central Pacific

Display geoid heights from the EGM96 geoid model over a map of South America and the central Pacific. First, get geoid heights and a geographic postings reference object. Load coastline latitude and longitude data.

```
[N,R] = egm96geoid;  
load coastlines
```

Create a world map by specifying latitude and longitude limits. Then, display the geoid heights and coastline data.

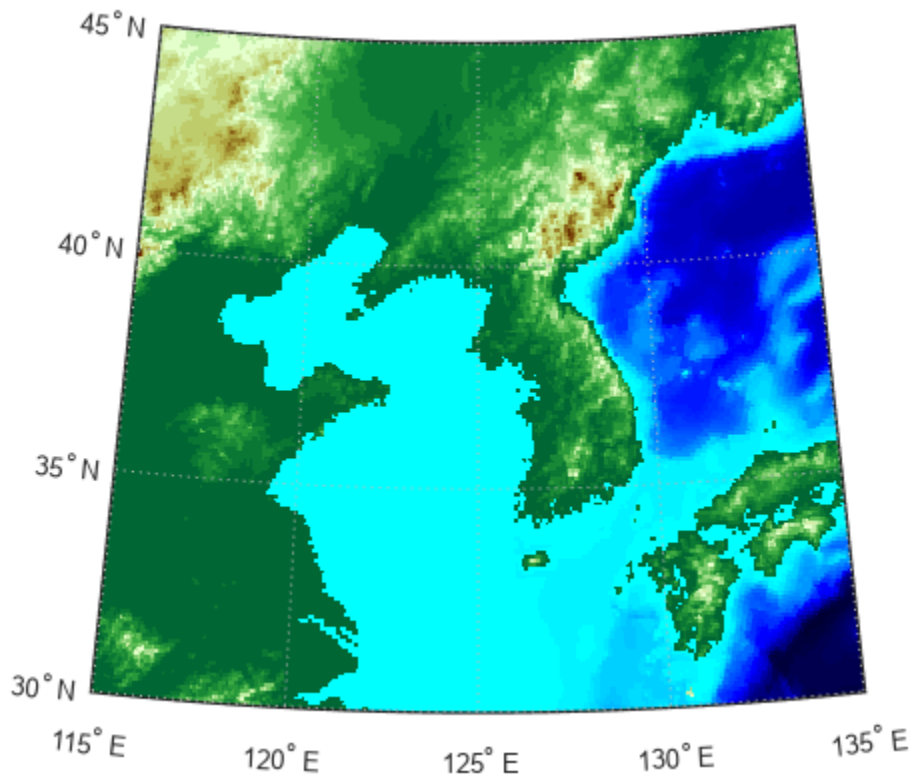
```
latlim = [-50 50];  
lonlim = [160 -30];  
worldmap(latlim,lonlim)  
  
geoshow(N,R, 'DisplayType', 'surface')  
geoshow(coastlat,coastlon, 'Color', 'k')
```



Display Map of Terrain Elevations in Korea

Load elevation data and a geographic cells reference object for the Korean peninsula. Create a world map with appropriate latitude and longitude limits. Then, display the data as a texture map using `geoshow`. Apply a colormap appropriate for elevation data using `demcmap`.

```
load korea5c
worldmap(korea5c,korea5cR);
geoshow(korea5c,korea5cR,'DisplayType','texturemap')
demcmap(korea5c)
```



Map the United States of America Coloring State Polygons

Create a map of the United States of America. Display the states using a palette of random, muted colors.

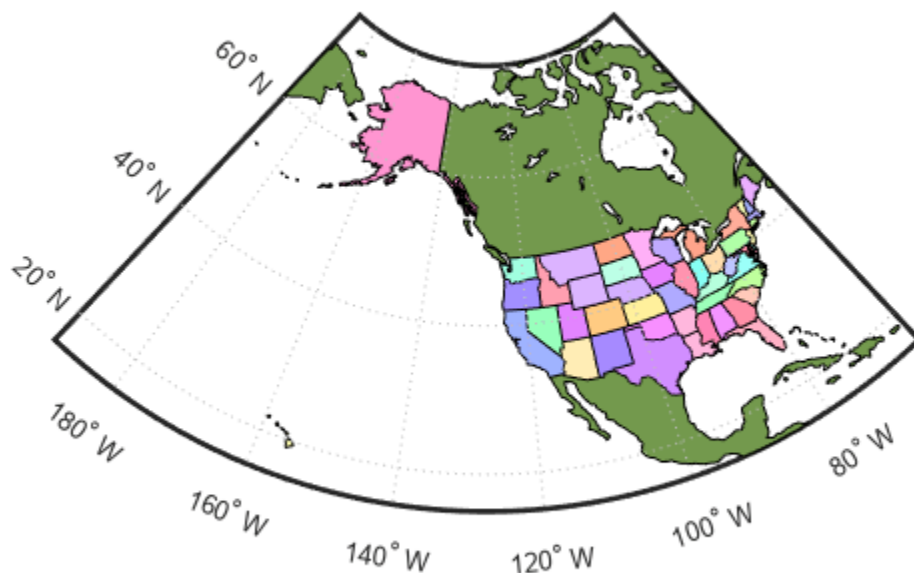
```
worldmap("USA");

load coastlines
geoshow(coastlat,coastlon, ...
        "DisplayType","polygon","FaceColor",[0.45 0.60 0.30])

states = readgeotable("usastatelo.shp");

h = height(states);
faceColors = makesymbolspec("Polygon", ...
    {'INDEX',[1 h],'FaceColor',polcmap(h)});

geoshow(states,"DisplayType","polygon", ...
        "SymbolSpec",faceColors)
```

Input Arguments

region — Region to display

'World' | 'North Pole' | 'South Pole' | 'Pacific' | character vector | string scalar | string array | cell array of character vectors

Region to display, specified as a string scalar, string array, character vector, or cell array of character vectors. Permissible values include names of continents, countries, and islands as well as 'World', 'North Pole', 'South Pole', and 'Pacific'.

Example: {'Africa', 'India'}

latlim — Latitude limits

two-element vector

Latitude limits, specified as a two-element vector of the form [southern_limit northern_limit].

lonlim — Longitude limits

two-element vector

Longitude limits, specified as a two-element vector of the form [western_limit eastern_limit].

Z — Data grid

M-by-*N* array

Data grid, specified as an M -by- N array. Z is a regular data grid associated with a geographic reference R .

R — Geographic reference

geographic raster reference object | vector | matrix

Geographic reference, specified as one of the following.

Type	Description
Geographic raster reference object	GeographicCellsReference or GeographicPostingsReference geographic raster reference object. The RasterSize property must be consistent with the size of the data grid, size(Z).
Vector	1-by-3 numeric vector with elements: [cells/degree northern_latitude_limit western_longitude_limit]
Matrix	3-by-2 numeric matrix that transforms raster row and column indices to or from geographic coordinates according to: [lon lat] = [row col 1] * R R defines a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel.

For more information about referencing vectors and matrices, see “Georeferenced Raster Data”.

Output Arguments

h — Handle of the axesm-based map

handle object

Handle of the axesm-based map, returned as a handle object.

Tips

- All axes created with worldmap are initialized with a spherical Earth model having a radius of 6,371,000 meters.
- worldmap uses tightmap to adjust the axes limits around the map. If you change the projection, or just want more white space around the map frame, use tightmap again or auto axis.

Version History

Introduced before R2006a

See Also

axesm | framem | geoshow | gridm | mlabel | plabel | tightmap | usamap

worldToDiscrete

Package: `map.rasterref`

Transform planar world to discrete coordinates

Syntax

```
[I,J] = worldToDiscrete(R,xWorld,yWorld)
```

Description

`[I,J] = worldToDiscrete(R,xWorld,yWorld)` returns the indices corresponding to world coordinates `xWorld` and `yWorld` in map raster `R`. If `R.RasterInterpretation` is:

- `'cells'`, then `I` and `J` are the row and column subscripts of the raster cells (or image pixels)
- `'postings'`, then `I` and `J` refer to the nearest sample point (posting)

Examples

Find Indices of Cell from World Coordinates

Import a GeoTIFF image [1] on page 1-1973 of Boston as an array and a `MapCellsReference` object. Find the indices of the cell containing data with world `x`- and `y`-coordinates of 776500 and 2956600 survey feet, respectively.

```
[Z,R] = readgeoraster('boston.tif');  
[I,J] = worldToDiscrete(R,776500,2956600)
```

```
I = 1212
```

```
J = 3714
```

The result means that the cell center closest to the world coordinates is in row 1212 and column 3714 of the array.

[1] The data used in this example includes material copyrighted by GeoEye, all rights reserved.

Input Arguments

R — Map raster

`MapCellsReference` or `MapPostingsReference` object

Map raster, specified as a `MapCellsReference` or `MapPostingsReference` object.

xWorld — x-coordinates in the world coordinate system

numeric array

x-coordinates in the world coordinate system, specified as a numeric array.

Data Types: `single` | `double`

yWorld — y-coordinates in the world coordinate system

numeric array

y-coordinates in the world coordinate system, specified as a numeric array. `yWorld` is the same size as `xWorld`.

Data Types: `single` | `double`

Output Arguments

I — World x-coordinate indices

array of integers

World x-coordinate indices, returned as an array of integers. `I` is the same size as `xWorld`.

For an m -by- n raster, $1 \leq I \leq m$, except for points $(xWorld(k), yWorld(k))$ that fall outside the bounds of the raster as defined by the function `contains`. In this case `I(k)` and `J(k)` are `NaN`.

Data Types: `double`

J — World y-coordinate indices

array of integers

World y-coordinate indices, returned as an array of integers. `J` is the same size as `yWorld`.

For an m -by- n raster, $1 \leq I \leq m$, except for points $(xWorld(k), yWorld(k))$ that fall outside the bounds of the raster as defined by the function `contains`. In this case `I(k)` and `J(k)` are `NaN`.

Data Types: `double`

Version History

Introduced in R2013b

See Also

`contains` | `worldToIntrinsic` | `geographicToDiscrete`

worldToIntrinsic

Package: `map.rasterref`

Transform planar world to intrinsic coordinates

Syntax

```
[xIntrinsic,yIntrinsic] = worldToIntrinsic(R,xWorld,yWorld)
```

Description

`[xIntrinsic,yIntrinsic] = worldToIntrinsic(R,xWorld,yWorld)` returns the intrinsic coordinates corresponding to planar world coordinates (`xWorld`, `yWorld`) in map raster `R`. If a point is outside the bounds of `R`, then `worldToIntrinsic` extrapolates the `xIntrinsic` and `yIntrinsic` coordinates.

Examples

Find Intrinsic Coordinates from World Coordinates

Import a GeoTIFF image [1] on page 1-1975 of Boston as an array and a `MapCellsReference` object. Find the intrinsic coordinates corresponding to the world x- and y-coordinates of 776500 and 2956600 survey feet, respectively.

```
[Z,R] = readgeoraster('boston.tif');  
[xIntrinsic,yIntrinsic] = worldToIntrinsic(R,776500,2956600)
```

```
xIntrinsic = 3.7136e+03
```

```
yIntrinsic = 1.2119e+03
```

The result means that the world coordinates fall close to the center of the cell corresponding to column 3713 and row 1211 of the array.

You can reverse the operation by using the `intrinsicToWorld` function.

```
[xWorld,yWorld] = intrinsicToWorld(R,xIntrinsic,yIntrinsic)
```

```
xWorld = 776500
```

```
yWorld = 2956600
```

[1] The data used in this example includes material copyrighted by GeoEye, all rights reserved.

Input Arguments

R — Map raster

`MapCellsReference` or `MapPostingsReference` object

Map raster, specified as a `MapCellsReference` or `MapPostingsReference` object.

xWorld — x-coordinates in the world coordinate system

numeric array

x-coordinates in the world coordinate system, specified as a numeric array. `xWorld` coordinates can be outside the bounds of the raster `R`.

Data Types: `single` | `double`

yWorld — y-coordinates in the world coordinate system

numeric array

y-coordinates in the world coordinate system, specified as a numeric array. `yWorld` is the same size as `xWorld`. `yWorld` coordinates can be outside the bounds of the raster `R`.

Data Types: `single` | `double`

Output Arguments

xIntrinsic — x-coordinates in the intrinsic coordinate system

numeric array

x-coordinates in the intrinsic coordinate system, returned as a numeric array. `xIntrinsic` is the same size as `xWorld`.

When `xWorld(k)` is outside the bounds of raster `R`, `xIntrinsic(k)` is extrapolated in the intrinsic coordinate system.

Data Types: `double`

yIntrinsic — y-coordinates in the intrinsic coordinate system

numeric array

y-coordinates in the intrinsic coordinate system, returned as a numeric array. `yIntrinsic` is the same size as `xWorld`.

When `yWorld(k)` outside the bounds of raster `R`, `yIntrinsic(k)` is extrapolated in the intrinsic coordinate system.

Data Types: `double`

Version History

Introduced in R2013b

See Also

`intrinsicToWorld` | `worldToDiscrete` | `geographicToIntrinsic`

wrapTo180

Wrap angle in degrees to [-180 180]

Syntax

```
lonWrapped = wrapTo180(lon)
```

Description

`lonWrapped = wrapTo180(lon)` wraps angles in `lon`, in degrees, to the interval [-180, 180] such that 180 maps to 180 and -180 maps to -180. In general, odd, positive multiples of 180 map to 180 and odd, negative multiples of 180 map to -180.

Examples

Wrap Longitudes to 180 Degrees

Specify a short list of longitudes to wrap.

```
lon = [-400 -190 -180 -175 175 180 190 380];
```

Wrap the longitudes to the range [-180, 180] degrees.

```
lonWrapped = wrapTo180(lon)
```

```
lonWrapped = 1×8
```

```
-40    170   -180   -175    175    180   -170    20
```

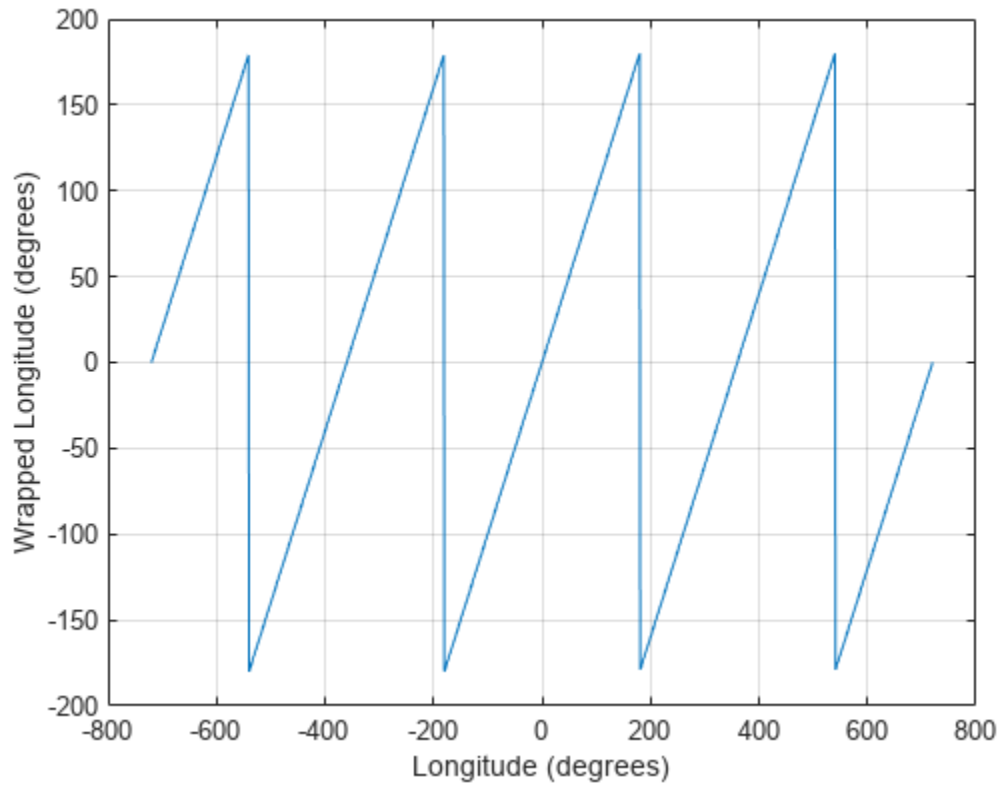
Specify a second list of longitudes that are sampled over a large range of angles. Wrap the longitudes.

```
lon2 = -720:720;
```

```
lon2Wrapped = wrapTo180(lon2);
```

Plot the wrapped longitudes. The wrapped longitudes stay in the range [-180, 180] degrees.

```
plot(lon2, lon2Wrapped)
xlabel("Longitude (degrees)")
ylabel("Wrapped Longitude (degrees)")
grid on
```



Input Arguments

lon — Angles

numeric vector

Angles, specified as a numeric vector.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

Output Arguments

lonWrapped — Wrapped angles

numeric vector

Wrapped angles, specified as a numeric vector with values in the range `[-180, 180]`.

Version History

Introduced in R2007b

R2021a: Generate C and C++ code using MATLAB Coder

The wrapTo180 function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

[wrapTo360](#) | [wrapTo2Pi](#) | [wrapToPi](#)

wrapTo360

Wrap angle in degrees to [0 360]

Syntax

```
lonWrapped = wrapTo360(lon)
```

Description

`lonWrapped = wrapTo360(lon)` wraps angles in `lon`, in degrees, to the interval [0, 360] such that 0 maps to 0 and 360 maps to 360. In general, positive multiples of 360 map to 360 and negative multiples of 360 map to zero.

Examples

Wrap Longitudes to 360 Degrees

Specify a short list of longitudes to wrap.

```
lon = [-720 -400 -360 -355 350 360 370 720];
```

Wrap the longitudes to the range [0, 360] degrees.

```
lonWrapped = wrapTo360(lon)
```

```
lonWrapped = 1×8
```

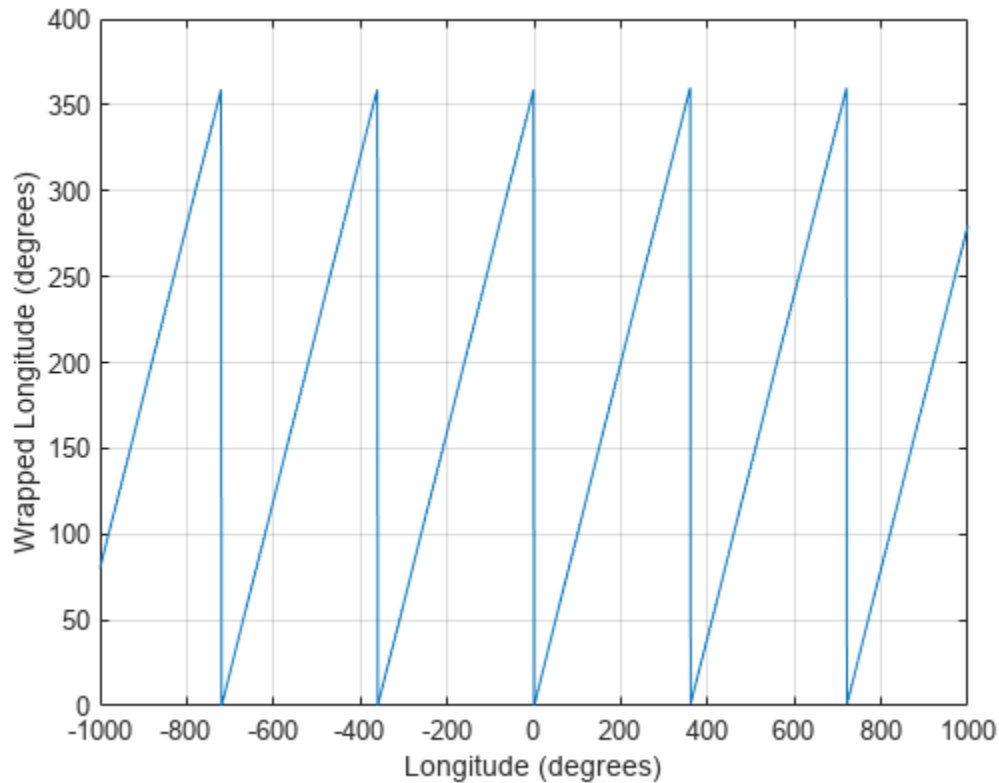
```
    0    320     0     5   350   360    10   360
```

Specify a second list of longitudes that are sampled over a large range of angles. Wrap the longitudes.

```
lon2 = -1000:1000;  
lon2Wrapped = wrapTo360(lon2);
```

Plot the wrapped longitudes. The wrapped longitudes stay in the range [0, 360] degrees.

```
plot(lon2, lon2Wrapped)  
xlabel("Longitude (degrees)")  
ylabel("Wrapped Longitude (degrees)")  
grid on
```



Input Arguments

lon – Angles

numeric vector

Angles, specified as a numeric vector.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

Output Arguments

lonWrapped – Wrapped angles

numeric vector

Wrapped angles, specified as a numeric vector with values in the range [0, 360].

Version History

Introduced in R2007b

R2021a: Generate C and C++ code using MATLAB Coder

The `wrapTo360` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`wrapTo180` | `wrapTo2Pi` | `wrapToPi`

wrapTo2Pi

Wrap angle in radians to $[0, 2\pi]$

Syntax

```
lambdaWrapped = wrapTo2Pi(lambda)
```

Description

`lambdaWrapped = wrapTo2Pi(lambda)` wraps angles in `lambda`, in radians, to the interval $[0, 2\pi]$ such that 0 maps to 0 and 2π maps to 2π . In general, positive multiples of 2π map to 2π and negative multiples of 2π map to 0.

Examples

Wrap Angles to 2Pi Radians

Specify a short list of angles to wrap.

```
lambda = [-2*pi -pi-0.1 -pi -2.8 3.1 pi pi+1 2*pi];
```

Wrap the angles to the range $[0, 2\pi]$ radians.

```
lambdaWrapped = wrapTo2Pi(lambda)
```

```
lambdaWrapped = 1×8
```

```
      0      3.0416      3.1416      3.4832      3.1000      3.1416      4.1416      6.2832
```

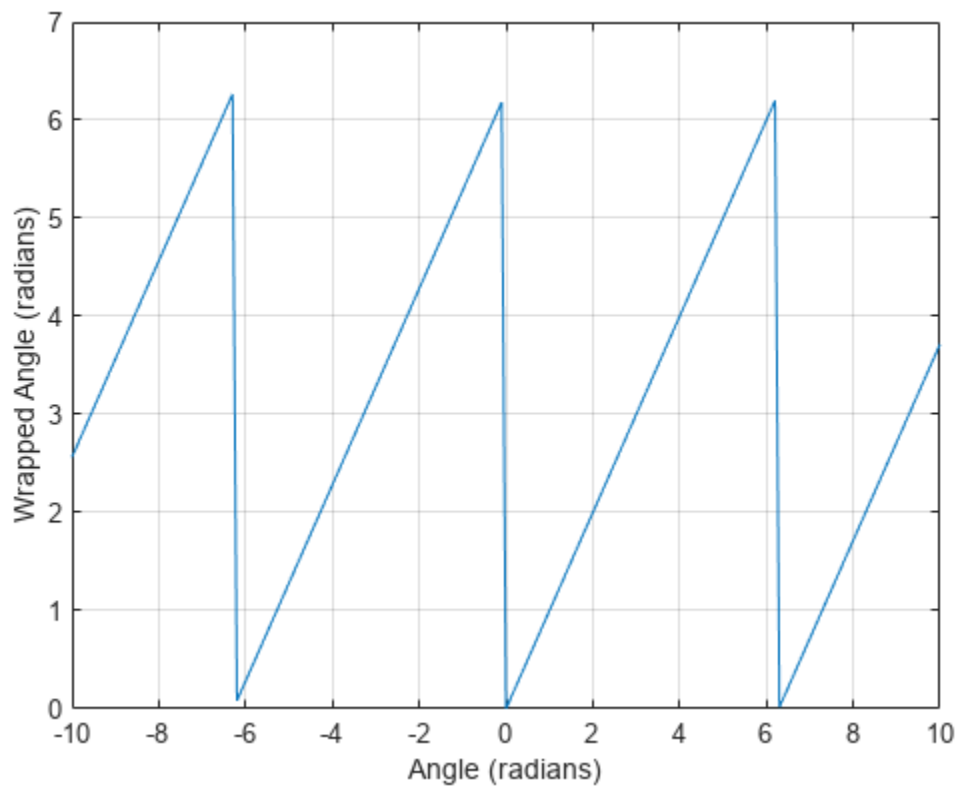
Specify a second list of angles, and wrap them.

```
lambda2 = -10:0.1:10;
```

```
lambda2Wrapped = wrapTo2Pi(lambda2);
```

Plot the wrapped angles. The wrapped angles stay in the range $[0, 2\pi]$ radians.

```
plot(lambda2, lambda2Wrapped)
xlabel("Angle (radians)")
ylabel("Wrapped Angle (radians)")
grid on
```



Input Arguments

lambda — Angles

numeric vector

Angles, specified as a numeric vector.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

Output Arguments

lambdaWrapped — Wrapped angles

numeric vector

Wrapped angles, specified as a numeric vector with values in the range $[0, 2\pi]$.

Version History

Introduced in R2007b

R2021a: Generate C and C++ code using MATLAB Coder

The wrapTo2Pi function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

[wrapTo180](#) | [wrapTo360](#) | [wrapToPi](#)

wrapToPi

Wrap angle in radians to $[-\pi, \pi]$

Syntax

```
lambdaWrapped = wrapToPi(lambda)
```

Description

`lambdaWrapped = wrapToPi(lambda)` wraps angles in `lambda`, in radians, to the interval $[-\pi, \pi]$ such that π maps to π and $-\pi$ maps to $-\pi$. In general, odd, positive multiples of π map to π and odd, negative multiples of π map to $-\pi$.

Examples

Wrap Angles to Pi Radians

Specify a short list of angles to wrap.

```
lambda = [-2*pi -pi-0.1 -pi -2.8 3.1 pi pi+1 2*pi];
```

Wrap the angles to the range $[-\pi, \pi]$ radians.

```
lambdaWrapped = wrapToPi(lambda)
```

```
lambdaWrapped = 1x8
```

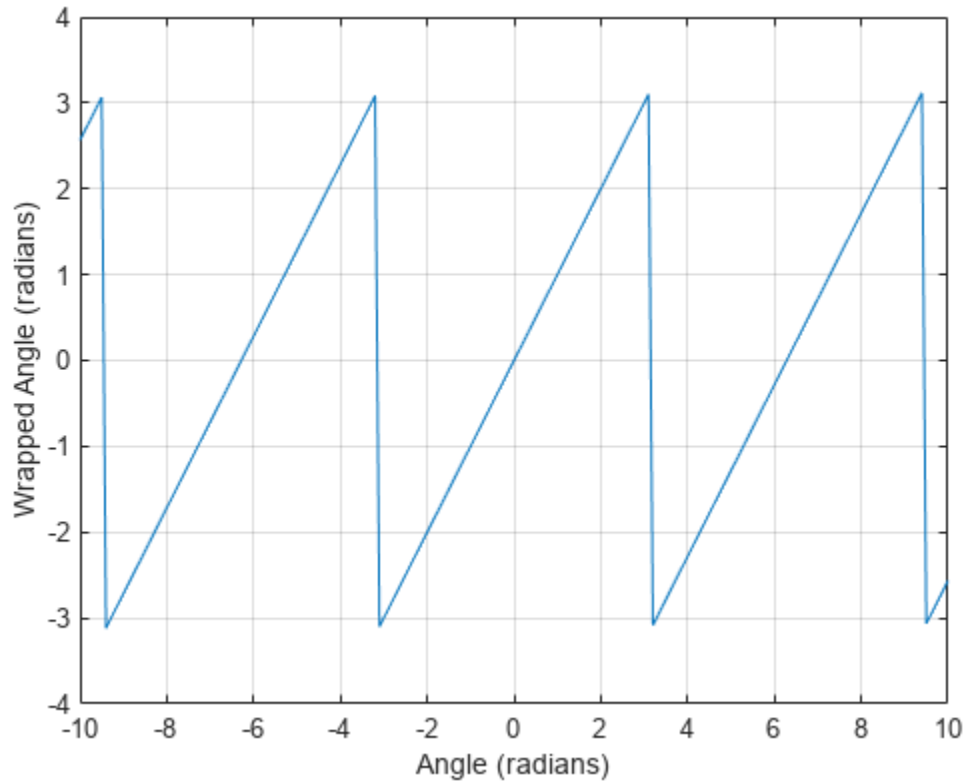
```
    0    3.0416   -3.1416   -2.8000    3.1000    3.1416   -2.1416    0
```

Specify a second list of angles, and wrap them.

```
lambda2 = -10:0.1:10;  
lambda2Wrapped = wrapToPi(lambda2);
```

Plot the wrapped angles. The wrapped angles stay in the range $[-\pi, \pi]$ radians.

```
plot(lambda2, lambda2Wrapped)  
xlabel("Angle (radians)")  
ylabel("Wrapped Angle (radians)")  
grid on
```

Input Arguments

lambda — Angles

numeric vector

Angles, specified as a numeric vector.

Data Types: `single` | `double` | `int8` | `int16` | `int32` | `int64` | `uint8` | `uint16` | `uint32` | `uint64` | `logical`

Output Arguments

lambdaWrapped — Wrapped angles

numeric vector

Wrapped angles, specified as a numeric vector with values in the range $[-\pi, \pi]$.

Version History

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R2021a: Generate C and C++ code using MATLAB Coder

The `wrapToPi` function supports code generation.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using MATLAB® Coder™.

See Also

`wrapTo180` | `wrapTo360` | `wrapTo2Pi`

zdatam

Adjust z-plane of map object on axesm-based map

Syntax

```
zdatam
zdatam(hndl)
zdatam('str')
zdatam(hndl,zdata)
zdatam('str',zdata)
```

Description

`zdatam` displays a GUI for selecting an object from the current axes and modifying its `ZData` property.

`zdatam(hndl)` and `zdatam('str')` display a GUI to modify the `ZData` of the object(s) specified by the input. `str` is any character vectors recognized by `handlem`.

`zdatam(hndl,zdata)` alters the z-plane position of displayed map objects designated by the MATLAB graphics handle `hndl`. The z-plane position may be the Z position in the case of text objects, or the `ZData` property in the case of other graphic objects. The function behaves as follows:

- If `hndl` is an `hggroup` handle, the `ZData` property of the children in the `hggroup` are altered.
- If the handle is scalar, then `ZData` can be either a scalar (z-plane definition), or a matrix of appropriate dimension for the displayed object.
- If `hndl` is a vector, then `ZData` can be a scalar or a vector of the same dimension as `hndl`.
- If `ZData` is a scalar, then all objects in `hndl` are drawn on the `ZData` z-plane.
- If `ZData` is a vector, then each object in `hndl` is drawn on the plane defined by the corresponding `ZData` element.
- If `ZData` is omitted, then a modal dialog box prompts for the `ZData` entry.

`zdatam('str',zdata)` identifies the objects by the input `str`, where `str` is any of the character vectors recognized by `handlem`, and uses `zdata` as described above to update their `ZData` property.

This function adjusts the z-plane position of selected graphics objects. It accomplishes this by setting the objects' `ZData` properties to the appropriate values.

Version History

Introduced before R2006a

See Also

`handlem` | `setm`

zero22pi

(Removed) Wrap longitudes to [0 360] degree interval

Note The `zero22pi` function has been removed. Use the `wrapTo360` or `wrapTo2Pi` function instead.

Syntax

```
newlon = zero22pi(lon)
newlon = zero22pi(lon,angleunits)
```

Description

`newlon = zero22pi(lon)` wraps the input angle `lon` in degrees to the 0 to 360 degree range.

`newlon = zero22pi(lon,angleunits)` works in the units defined by `angleunits`, which can be either 'degrees' or 'radians'. `angleunits` can be abbreviated and is case-insensitive.

Examples

```
zero22pi(567.5)
```

```
ans =
    207.5
```

```
zero22pi(-567.5)
```

```
ans =
    152.5
```

```
zero22pi(-7.5,'radian')
```

```
ans =
    5.0664
```

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `zero22pi` function has been removed. Use the `wrapTo180` or `wrapToPi` function instead.

R2022a: Warns

Warns starting in R2022a

The `zero22pi` function issues a warning that it will be removed in a future release.

R2007b: To be removed

Not recommended starting in R2007b

The `zero22pi` function runs without warning but will be removed in a future release.

See Also

`wrapTo2Pi` | `wrapTo360`

zerom

(To be removed) Construct regular data grid of 0s

Note `zerom` will be removed in a future release. Use the `georefcells` and `zeros` functions instead. For more information, see “Compatibility Considerations”.

Syntax

```
[Z,refvec] = zerom(latlim,lonlim,scale)
```

Description

`[Z,refvec] = zerom(latlim,lonlim,scale)` returns a full regular data grid consisting entirely of 0s and a three-element referencing vector for the returned `Z`. The two-element vectors `latlim` and `lonlim` define the latitude and longitude limits of the geographic region. They should be of the form `[south north]` and `[west east]`, respectively. The scalar `scale` specifies the number of rows and columns per degree of latitude and longitude.

Examples

```
[Z,refvec] = zerom([46,51],[-79,-75],1)
```

```
Z =
     0     0     0     0
     0     0     0     0
     0     0     0     0
     0     0     0     0
     0     0     0     0
refvec =
     1    51   -79
```

Version History

Introduced before R2006a

R2022a: Warns

Warns starting in R2022a

Some functions that return referencing vectors issue a warning that they will be removed in a future release, including the `zerom` function. Instead, create a geographic raster reference object using the `georefcells` function and a matrix of zeros using the `zeros` function. Reference objects have several advantages over referencing vectors.

- Unlike referencing vectors, reference objects have properties that document the size of the associated raster, its geographic limits, and the direction of its rows and columns. For examples of reference object properties, see the `GeographicPostingsReference` object.

- You can manipulate the limits of rasters associated with geographic reference objects using the `geocrop` function.
- You can manipulate the size and resolution of rasters associated with geographic reference objects using the `georesize` function.
- Most functions that accept referencing vectors as inputs also accept reference objects.

This table shows how to update your code to use the `georefcalls` and `zeros` functions instead of the `zerom` function.

Will Be Removed	Recommended
<code>[Z,refvec] = zerom(latlim,lonlim,scale);</code>	<code>R = georefcalls(latlim,lonlim,1/scale,1/scale);</code> <code>Z = zeros(R.RasterSize);</code>

R2020b: To be removed

Not recommended starting in R2020b

The `zerom` function runs without warning but will be removed in a future release.

See Also

[NaN](#) | [ones](#) | [sparse](#) | [georefcalls](#) | [zeros](#)

axesmui

Define axesm-based map and modify projection and display properties

Activation

Command Line	Map Display
axesmui	extend-click map display
c = axesmui(...)	

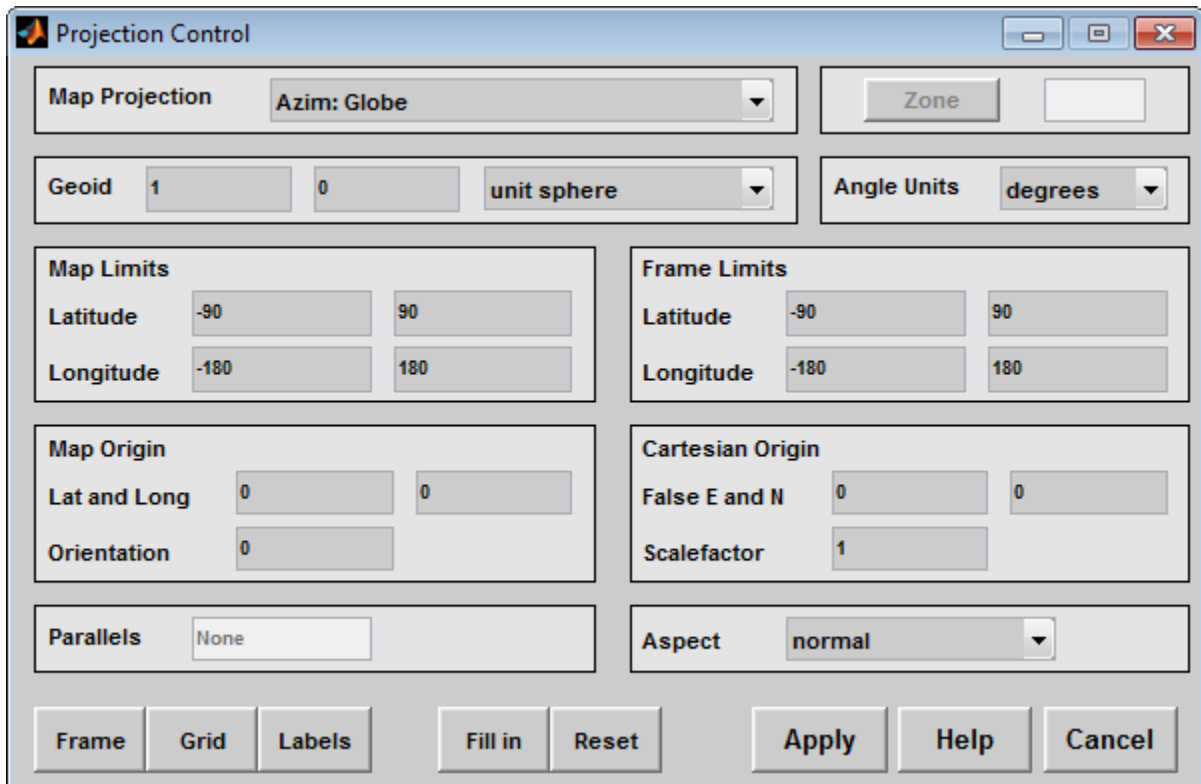
Description

axesmui activates a Projection Control dialog box for the current axesm-based map. The dialog box allows map projection definition and property modification.

c is an optional output argument that indicates whether the Projection Control dialog box was closed by the cancel button. c = 1 if the cancel button is pushed. Otherwise, c = 0.

Extend-clicking a map display brings up the Projection Control dialog box for that axesm-based map.

Controls



The **Map Projection** pull-down menu is used to select a map projection. The projections are listed by type, and each is preceded by a four-letter type indicator:

```
Cyln = Cylindrical
Pcyl = Pseudocylindrical
Coni = Conic
Poly = Polyconic
Pcon = Pseudoconic
Azim = Azimuthal
Mazi = Modified Azimuthal
Pazi = Pseudoazimuthal
```

The **Zone** button and edit box are used to specify a zone for the Universal Transverse Mercator (UTM) and Universal Polar Stereographic (UPS) projections.

Note The **Zone** button and edit box are not supported in MATLAB Online. Programmatically create an axesm-based map instead. For example, create an axesm-based map using a UTM projection by specifying the MapProjection and Zone name-value pairs:

```
ax = axesm('MapProjection','UTM','Zone','54S');
```

The **Geoid** edit boxes and pull-down menu are used to specify the geoid. Units must be in meters for the UTM and UPS projections, since this is the standard unit for the two projections. For non-UTM and UPS projections, the geoid unit can be anything, bearing in mind that the resulting projected data will be in the same units as the geoid.

The **Angle Units** pull-down menu is used to specify the angle units used on the map projection. All angle entries corresponding to the current map projection must be entered in these units. Current angle entries are automatically updated when new angle units are selected.

The **Map Limits** edit boxes are used to specify the extent of the map data in geographic coordinates. The **Latitude** edit boxes contain the southern and northern limits of the map. The **Longitude** edit boxes contain the western and eastern limits of the map. The map limits establish the extent of the meridian and parallel grid lines, regardless of the display settings (see grid settings). Map limits are always in geographic coordinates, regardless of the map origin and orientation setting. In the normal aspect, the map display is trimmed to the minimum of the map and frame limits.

The **Frame Limits** edit boxes are used to specify the location of the map frame, measured from the center of the map projection in the base coordinate system. The **Latitude** edit boxes contain the southern and northern frame edge locations. The **Longitude** edit boxes contain the western and eastern frame edge locations. Displayed map data are trimmed at the frame limits. For azimuthal map projections, the latitude limits should be set to `-inf` and the desired trim distance from the map origin. In the normal aspect, the map display is trimmed to the minimum of the map and frame limits.

The **Map Origin** edit boxes are used to specify the origin and aspect angle of the map projection. The **Lat** and **Long** boxes specify the map origin in geographic coordinates. This is the point that is placed in the center of the projection. If either box is left blank, 0 degrees is used. The **Orientation** box specifies the azimuth angle of the North Pole relative to the map origin. Azimuth is measured clockwise from the top of the projection. If the **Orientation** box is disabled, then the selected map projection requires a fixed orientation. See the *Mapping Toolbox User's Guide* for a complete description of the map origin.

The **Cartesian Origin** edit boxes are used to specify the x-y offset, along with a desired scale factor of the map projection. The **False E and N** boxes specify the false easting and northing in Cartesian

coordinates. These must be in the same units as the geoid. The **Scalefactor** box specifies the scale factor used in the map projection calculations.

The **Parallels** edit boxes specify the standard parallels of the selected map projection. A particular map projection may have one or two standard parallels. If the edit boxes are disabled, then the selected projection has no standard parallels or the standard parallels are fixed.

The **Aspect** pull-down menu is used to select a normal or transverse display aspect. When the aspect is normal, *north* (on the base projection) is up, and the map is displayed in a *portrait* setting. In a transverse aspect, north (in the base projection) is to the right, and the map is displayed in a *landscape* setting. This property does not control the map projection aspect. The projection aspect is determined by the map **Origin** property).

The **Frame** button brings up the Map Frame Properties dialog box, which allows the map frame settings to be modified.

The **Grid** button brings up the Map Grid Properties dialog box, which allows the map grid settings to be modified.

The **Labels** button brings up the Map Label Properties dialog box, which allows the parallel and meridian label settings to be modified.

The **Fill in** button is used to compute projection and display settings based on any currently specified map parameters. Only settings that are left blank are affected when this button is pushed.

The **Reset** button is used to reset the default projection properties and display settings of the current map. Default display settings include frame, grid, and label properties set to 'off'.

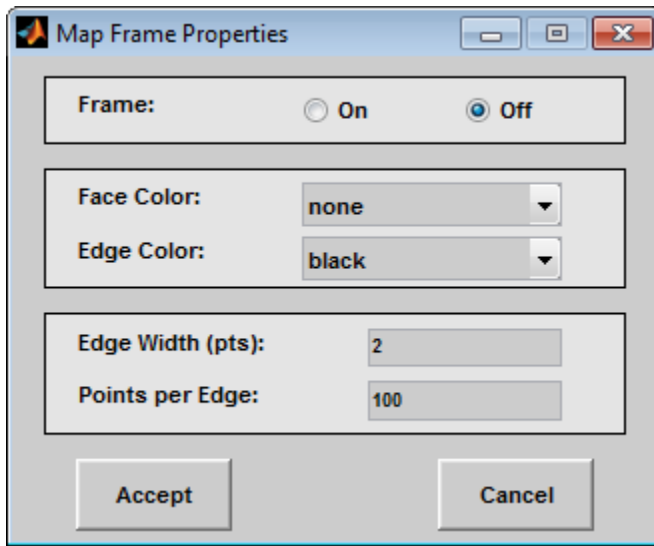
The **Apply** button is used to apply the projection and display settings to the current map, which results in the map being reprojected.

The **Help** button is used to bring up online help text for each control on the Projection Control dialog box.

The **Cancel** button disregards any modified projection or display settings and closes the Projection Control dialog box.

Map Frame Properties Dialog Box

This dialog box allows modification of the map frame settings. It is accessed via the **Frame** button on the Projection Control dialog box.



The **Frame** selection buttons determine whether the map frame is visible.

The **Face Color** pull-down menu is used to select the background color of the map frame. Selecting **none** results in a transparent frame background, i.e., the same as the axes color. Selecting **custom** allows a custom RGB triple to be defined for the background color.

The **Edge Color** pull-down menu is used to select the color of the frame edge. Selecting **none** hides the frame edge. Selecting **custom** allows a custom RGB triple to be defined for the edge color.

The **Edge Width** edit box is used to enter the line width of the frame edge, in points.

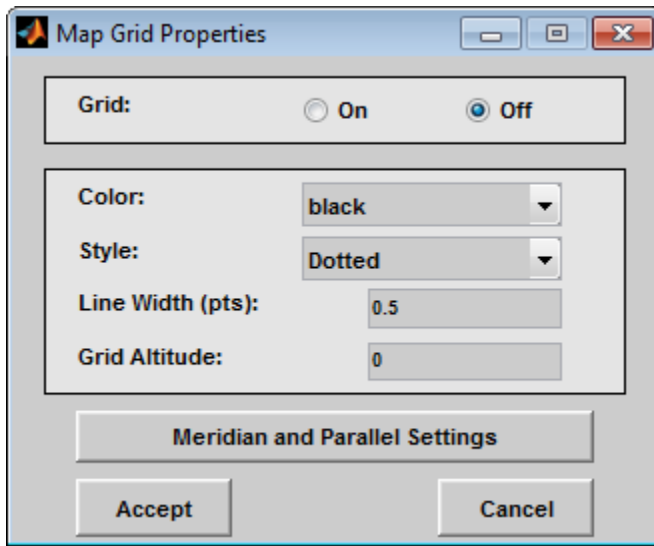
The **Points per Edge** edit box is used to enter the number of points used to display each edge of the map frame.

The **Accept** button accepts any modifications made to the map frame properties and returns to the Projection Control dialog box. Changes are applied to the current map only when the **Apply** button on the Projection Control dialog box is pushed.

The **Cancel** button disregards any modifications to the map frame properties and returns to the Projection Control dialog box.

Map Grid Properties Dialog Box

This dialog box allows modification of the map frame settings. It is accessed via the **Grid** button on the Projection Control dialog box.



The Grid selection buttons determine whether the map grid is visible.

The **Color** pull-down menu is used to select the color of the map grid lines. Selecting **custom** allows a custom RGB triple to be defined for the grid line color.

The **Style** pull-down menu is used to select the line style of the map grid lines.

The **Line Width** edit box is used to enter the width of the map grid lines, in points.

The **Grid Altitude** edit box is used to enter z-axis location of the map grid. This property can be used to place some mapped objects above or below the map grid. The default map grid altitude is `inf`, which places the grid above all other mapped objects.

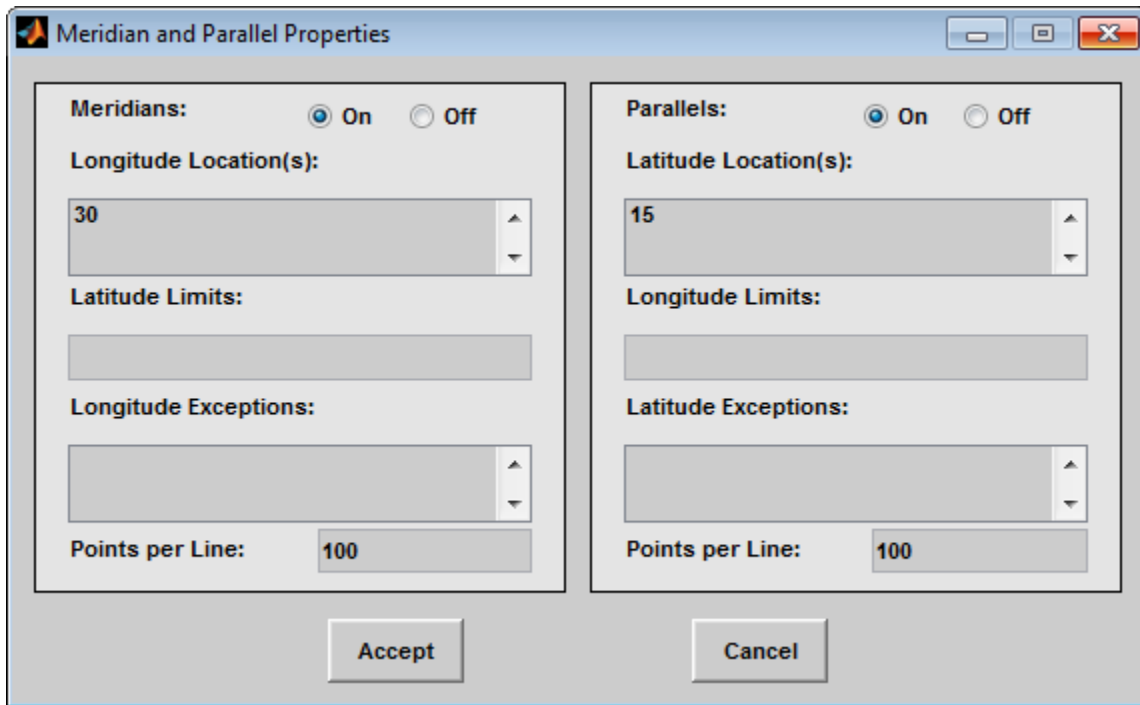
The **Meridian and Parallel Settings** button brings up the **Meridian and Parallel Properties** dialog box, which allows the properties of the meridian and parallel grid lines to be modified.

The **Accept** button accepts any modifications made to the map grid properties and returns to the Projection Control dialog box. Changes are applied to the current map only when the **Apply** button on the Projection Control dialog box is pushed.

The **Cancel** button disregards any modifications to the map grid properties and returns to the Projection Control dialog box.

Meridian and Parallel Properties Dialog Box

This dialog box is used to modify the settings for meridian and parallel grid lines. It is accessed via the **Meridian and Parallel Settings** button on the Map Grid Properties dialog box.



The **Meridians** selection buttons determine whether the meridian grid lines are visible when the map grid is turned on.

The **Longitude Location(s)** edit box is used to specify which meridians are to be displayed if the meridian lines are turned on. If a scalar interval value is entered, meridian lines are displayed at that interval, starting from the Prime Meridian and proceeding in east and west directions. If a vector of values is entered, meridian lines are displayed at locations given by each element of the vector.

The **Latitude Limits** edit box is used to specify the latitude limits beyond which meridian lines do not extend. If this property is left empty, all meridian lines extend to the map latitude limits (specified by the Latitude Map Limits entry on the **Projection Control** dialog box). This entry must be a two-element vector enclosed in brackets.

The **Longitude Exceptions** edit box is used to enter specific meridians of the displayed grid that are to extend beyond the latitude limits, to the map limits. This entry is a vector of longitude values.

The **Parallels** selection buttons determine whether the parallel grid lines are visible when the map grid is turned on.

The **Latitude Location(s)** edit box is used to specify which parallels are to be displayed if the parallel lines are turned on. If a scalar interval value is entered, parallel lines are displayed at that interval, starting from the Equator and proceeding in north and south directions. If a vector of values is entered, parallel lines are displayed at locations given by each element of the vector.

The **Longitude Limits** edit box is used to specify the longitude limits beyond which parallel lines do not extend. If this property is left empty, all parallel lines extend to the map longitude limits (specified by the Longitude Map Limits entry on the **Projection Control** dialog box). This entry must be a two-element vector enclosed in brackets.

The **Latitude Exceptions** edit box is used to enter specific parallels of the displayed grid that are to extend beyond the longitude limits, to the map limits. This entry is a vector of latitude values.

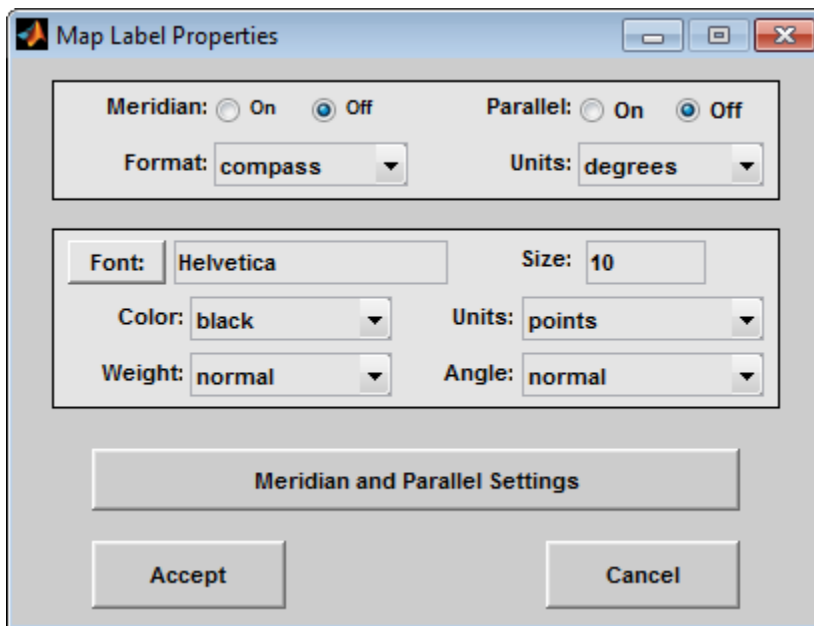
The **Points per Line** edit boxes are used to enter the number of points used to plot each meridian and each parallel grid line. The default value is 100 points.

The **Accept** button accepts any modifications that have been made to the meridian and parallel grid line properties and return to the Map Grid Properties dialog box. Changes are applied to the current map only when the **Apply** button on the Projection Control dialog box is pushed.

The **Cancel** button disregards any modifications to the meridian and parallel grid lines and returns to the Map Grid Properties dialog box.

Map Label Properties Dialog Box

This dialog box is used to modify the settings of the meridian and parallel labels. It is accessed via the **Label** button on the Projection Control dialog box.



The **Meridian** and **Parallel** selection buttons determine whether the meridian and parallel labels are visible.

The **Format** pull-down menu is used to specify the format of the grid labels. If **compass** is selected, meridian labels are appended with E for east and W for west, and parallel labels are appended with N for north and S for south. If **signed** is chosen, meridian labels are prefixed with + for east and - for west, and parallel labels are prefixed with + for north and - for south. If **none** is selected, western meridian labels and southern parallel labels are prefixed by -, but no symbol precedes eastern meridian labels and northern parallel labels.

The label **Units** pull-down menu is used to specify the angle units used to display the parallel and meridian labels. These units, used for display purposes only, need not be the same as the angle units of the map projection.

The **Font** edit box is used to specify the character font used to display the parallel and meridian labels. If the font specified does not exist on the computer, the default of Helvetica is used. Pressing the **Font** button previews the selected font.

The font **Size** edit box is used to enter an integer value that specifies the font size of the parallel and meridian labels. This value must be in the units specified by the font **Units** pull-down menu.

The font **Color** pull-down menu is used to select the color of the parallel and meridian labels. Selecting custom allows a custom RGB triple to be defined for the labels.

The font **Weight** pull-down menu is used to specify the character weight of the parallel and meridian labels.

The font **Units** pull-down menu is used to specify the units used to interpret the font size entry. When set to *normalized*, the value entered in the **Size** edit box is interpreted as a fraction of the height of the axes. For example, a normalized font size of 0.1 sets the label text to a height of one tenth of the axes height.

The font **Angle** pull-down menu is used to select the character slant of the parallel and meridian labels. *normal* specifies nonitalic font. *italic* and *oblique* specify italic font.

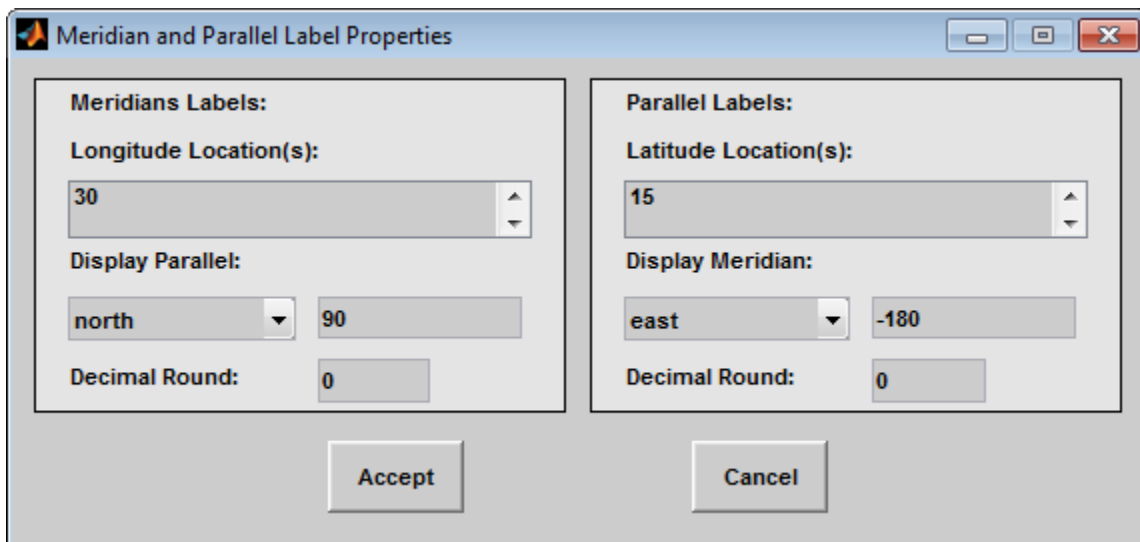
The **Meridian and Parallel Settings** button brings up the Meridian and Parallel Label Properties dialog box, which allows modification of properties specific to the meridian and parallel grid labels.

The **Accept** button accepts any modifications that have been made to the map label properties and returns to the Projection Control dialog box. Changes are applied to the current map only when the **Apply** button on the Projection Control dialog box is pushed.

The **Cancel** button disregards any modifications to the map labels and returns to the **Projection Control** dialog box.

Meridian and Parallel Label Properties Dialog Box

This dialog box is used to modify properties specific to the meridian and parallel grid labels. It is accessed via the **Meridian and Parallel Settings** button on the Map Label Properties dialog box.



The **Longitude Location(s)** edit box is used to specify which meridians are to be labeled. Meridian labels need not coincide with displayed meridian grid lines. If a scalar interval value is entered, labels are displayed at that interval, starting from the Prime Meridian and proceeding in east and west

directions. If a vector of values is entered, labels are displayed at longitude locations given by each element of the vector.

The **Display Parallel** pull-down menu and edit box are used to specify the latitude location of the meridian labels. If a scalar latitude value is provided in the edit box, the meridian labels are placed at that parallel. Alternatively, the pull-down menu can be used to select a latitude location. If **north** is chosen, meridian labels are placed at the maximum map latitude limit. If **south** is chosen, meridian labels are placed at the minimum map latitude limit.

The **Latitude Location(s)** edit box is used to specify which parallels are to be labeled. Parallel labels need not coincide with displayed parallel grid lines. If a scalar interval value is entered, labels are displayed at that interval, starting from the Equator and proceeding in north and south directions. If a vector of values is entered, labels are displayed at latitude locations given by each element of the vector.

The **Display Meridian** pull-down menu and edit box are used to specify the longitude location of the parallel labels. If a scalar longitude value is provided in the edit box, the parallel labels are placed at that meridian. Alternatively, the pull-down menu can be used to specify a longitude location. If **east** is chosen, parallel labels are placed at the maximum map longitude limit. If **west** is chosen, parallel labels are placed at the minimum map longitude limit.

The **Decimal Round** edit boxes are used to specify the power of ten to which the meridian and parallel labels are rounded. For example, a value of -1 results in labels displayed to the tenths decimal place.

The **Accept** button accepts any modifications that have been made to the meridian and parallel label properties and return to the Map Label Properties dialog box. Changes are applied to the current map only when the **Apply** button on the **Projection Control** dialog box is pushed.

The **Cancel** button disregards any modifications to the meridian and parallel labels and returns to the Map Label Properties dialog box.

The **Map Geoid** edit box is used to specify the geoid (ellipsoid) definition for the current axesm-based map. The geoid is defined by a two-element vector of the form [semimajor-axis eccentricity]. Eccentricity must be a value between 0 and 1, but not equal to 1. A nonzero eccentricity represents an ellipsoid. The default geoid is a sphere with radius 1, represented as [1 0]. If a scalar entry is provided, it is assumed to be the radius of a sphere.

The **Accept** button accepts any modifications that have been made to the map geoid and return to the Projection Control dialog box. Changes are applied to the current map only when the **Apply** button on the Projection Control dialog box is pushed.

The **Cancel** button disregards any modifications to the map geoid and returns to the Projection Control dialog box.

Version History

Introduced in R2007a

See Also

axesm

clmo-ui

GUI to clear graphics objects from axesm-based map

Activation

clmo

Description

clmo brings up a Select Object dialog box for selecting mapped objects to delete.

Controls

The scroll box is used to select the desired objects from the list of mapped objects.



Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the **OK** button deletes the selected objects from the map. Pushing the **Cancel** button aborts the operation.

Version History

Introduced in R2007a

See Also

clmo

clrmenu

(To be removed) Add colormap menu to figure window

Note The `clrmenu` function will be removed in a future release. Use the **Colormap Editor** instead.

Activation

Command Line
<code>clrmenu</code>
<code>clrmenu(h)</code>

Description

`clrmenu` adds a colormap menu to the current figure.

`clrmenu(h)` adds a colormap menu to the figure specified by the handle `h`.

Controls

The following choices are included on the colormap menu:

Parula, **Gray**, **Hsv**, **Hot**, **Pink**, **Cool**, **Bone**, **Jet**, **Copper**, **Spring**, **Summer**, **Autumn**, **Winter**, **Flag**, and **Prism** generate colormaps.

Rand is a random colormap.

Brighten increases the brightness.

Darken decreases the brightness.

Flipud inverts the order of the colormap entries.

Fliplr interchanges the red and blue components.

Permute permutes the colormap: red > blue, blue > green, green > red.

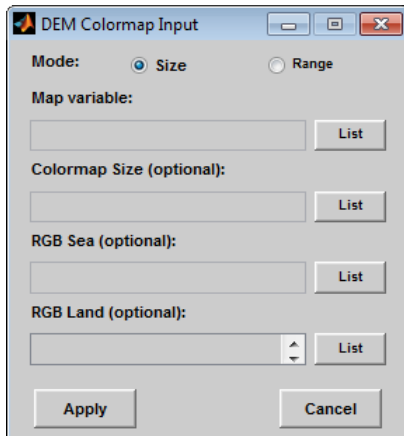
Define allows a workspace variable to be specified for the colormap.

Remember stores the current colormap.

Restore reverts to the stored colormap (initially, the stored colormap is the colormap in use when `clrmenu` is invoked).

Refresh redraws the current figure window.

Digital Elevation activates the DEM Colormap Input dialog box. Use it to specify a colormap for a digital elevation map, and then apply the colormap to the current figure. The number of land and sea colors in the colormap is appropriate for the maximum elevations and depths of the data grid. The dialog box is shown and described below:



The **Mode** selection buttons are used to specify whether the length of the colormap is specified or whether the altitude range increment assigned to each color is specified.

The **Map variable** edit box is used to specify the data grid containing the elevation data.

The **Colormap Size** edit box is used in Size mode. This entry defines the length of the colormap. If omitted, a default length of 64 is used. This entry must be a scalar value.

The **Altitude Range** edit box is used in Range mode. This entry defines the altitude range increment assigned to each color. If omitted, a default increment of 100 is used. This entry must be a scalar value.

The **RGB Sea** edit box is used to define colors for data with negative values. The actual sea colors of the generated colormap are interpolated from this matrix. This entry can be a matrix of any length (n -by-3). The colormap matrix of the current figure can be used by entering 'window' in this box. The demcmap function provides default sea colors, which are used if this entry is left blank.

The **RGB Land** edit box is used to define colors for data with positive values. The actual land colors of the generated colormap are interpolated from this matrix. This entry can be a matrix of any length (n -by-3). The colormap matrix of the current figure can be used by entering 'window' in this box. The demcmap function provides default sea colors, which are used if this entry is left blank.

Pressing the **Apply** button accepts the input data, creates the colormap, and assigns it to the current figure.

Pressing the **Cancel** button disregards any input data and closes the DEM Colormap Input dialog box.

Version History

Introduced before R2006a

R2022b: To be removed

Not recommended starting in R2022b

The `clrmnu` function runs without warning, but will be removed in a future release. Use the **Colormap Editor** instead.

See Also

`demcmap` | `colormap` | **Colormap Editor**

colorm

(Removed) Create index map colormaps

Note The `colorm` function has been removed.

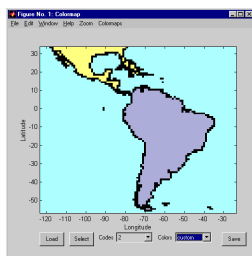
Syntax

```
colorm(datagrid,refvec)
```

Description

`colorm(datagrid,refvec)` displays the data grid in a new figure window and allows a colormap to be edited and saved to a new variable. `datagrid` and `refvec` are the data grid and the referencing vector of the surface. `map` must have positive index values into the colormap.

Controls



The `colorm` tool displays the surface map data in a new figure window with the current colormap. **Zoom** and **Colormaps** menus are activated for that figure.

The **Zoom On/Off** menu toggles interactive zoom on and off.

The **Colormaps** menu provided a variety of colormap options that can be applied to the map.

The **Load** button activates a dialog box, used to specify a colormap variable to be applied to the displayed surface map. This colormap can then be edited and saved.

The **Select** button activates the mouse cursor and allows a point on the map to be selected. The value of that point then appears in the **Codes** pull-down menu. The color of the selected point appears in the **Color** pull-down menu and can then be edited.

The **Codes** pull-down menu is used to select a particular value in the data grid. The color associated with that value then appears in the **Color** pull-down menu and can be edited.

The **Color** pull-down menu is used to select a particular color to assign to the value currently displayed in the Codes pull-down menu. A custom color can be defined by selecting the **custom** option. This brings up a custom color interface with which an RGB triple can be selected.

The **Save** button is used to save the modified colormap to the workspace. A dialog box appears in which the colormap variable name is entered.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `colorm` function has been removed.

R2022a: Warns

Warns starting in R2022a

The `colorm` function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The `colorm` function runs without warning but will be removed in a future release.

See Also

`encodem`

demdataui

(To be removed) UI for selecting digital elevation data

Note The `demdataui` function will be removed in a future release. Use the `readgeoraster` function instead.

Syntax

`demdataui`

Description

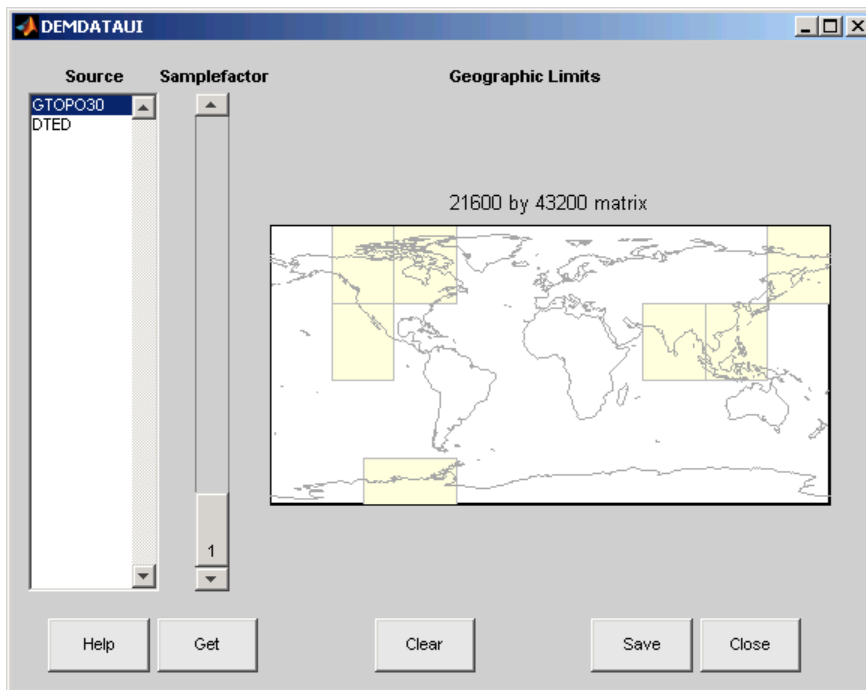
`demdataui` is a graphical user interface to extract digital elevation map data from a number of external data files. You can extract data to MAT-files or the base workspace as regular data grids with referencing vectors.

The `demdataui` panel lets you read data from a variety of high-resolution digital elevation maps (DEMs). These DEMs range in resolution from about 10 kilometers to 100 meters or less. The data files are available over the Internet at no cost, or (in some cases) on CD-ROMs for varying fees. `demdataui` reads ETOPO5, TerrainBase, GTOPO30, GLOBE, satellite bathymetry from Smith and Sandwell, and DTED data. `demdataui` looks for these geospatial data files on the MATLAB path and, for some operating systems, on CD-ROM disks.

Note When it opens, `demdataui` scans your Mapping Toolbox path for candidate data files. On PCs, it also checks the root directories of CD-ROMs and other drives, including mapped network drives. This can cause a delay before the GUI appears.

You use the list to select the source of data and the map to select the region of interest. When you click the **Get** button, data is extracted and displayed on the map. Use the **Save** button to save the data in a MAT-file or to the base workspace for later display. The **Close** button closes the window.

Controls



The Map

The map controls the geographic extent of the data to be extracted. `demdataui` extracts data for areas currently visible on the map. Use the mouse to zoom in or out to the area of interest. See `zoom` for more on zooming.

Some data sources divide the world up into tiles. When extracting, data is concatenated across all visible tiles. The map shows the tiles in light yellow with light gray edges. When data resolution is high, extracting data for large area can take much time and memory. An approximate count of the number of points is shown above the map. Use the **Samplefactor** slider to reduce the amount of data.

The List

The list controls the source of data to be extracted. Click a name to see the geographic coverage in light yellow. The sources list shows the data sources found when `demdataui` started.

`demdataui` searches for data files on the MATLAB path. On some computers, `demdataui` also checks for data files on the root level of letter drives. `demdataui` looks for the following data:

- `etopo5`: The files `new_etopo5.bin` or `etopo5.northern.bat` and `etopo5.southern.bat`.
- `tbase`: The file `tbase.bin`.
- `satbath`: The file `topo_6.2.img`.
- `gtopo30`: A folder that contains subfolders with the data files. For example, `demdataui` would detect GTOPO30 data if a folder on the path contained the folders `E060S10` and `E100S10`, each of which holds the uncompressed data files.
- `globedem`: A folder that contains data files and in the subfolder `/esri/hdr` and the `*.hdr` header files.

- `dted`: A folder that has a subfolder named DTED. The contents of the DTED folder are more subfolders organized by longitude and, below that, the DTED data files for each latitude tile.

The Samplefactor Slider

The **Sample Factor** slider allows you to reduce the density of the data. A sample factor of 2 returns every second point. The current sample factor is shown on the slider.

The Get Button

The **Get** button reads the currently selected data and displays it on the map. Press the standard interrupt key combination for your platform to interrupt the process.

The Clear Button

The **Clear** button removes any previously read data from the map.

The Save Button

The **Save** button saves the currently displayed data to a MAT-file or the base workspace. If you choose to save to a file, you will be prompted for a file name and location. If you choose to save to the base workspace, you can choose the variable name under which the data will be stored. The `demdataui` function returns one or more matrices as an array of display structures, having one element for each separate `get` you requested (assuming you did not subsequently **Clear**).

Data are returned as Mapping Toolbox Version 1 display structures. For information about display structure format, see “Version 1 Display Structures” on page 1-319 in the reference page for `displaym`.

Use `load` and `displaym` to redisplay the data from a file on an axesm-based map. To display the data in the base workspace, use `displaym`. To gain access to the data matrices, subscript into the structure (for example, `datagrid = demdata(1).map; refvec = demdata(1).maplegend`). Use `worldmap` to create easy displays of the elevation data (for example, `worldmap(datagrid, refvec)`). Use `meshm` to add regular data grids to existing displays, or `surfm` or a similar function for geolocated data grids (for example, `meshm(datagrid, refvec)` or `surfm(latgrat, longrat, z)`).

The Close Button

The **Close** button closes the `demdataui` panel.

Examples

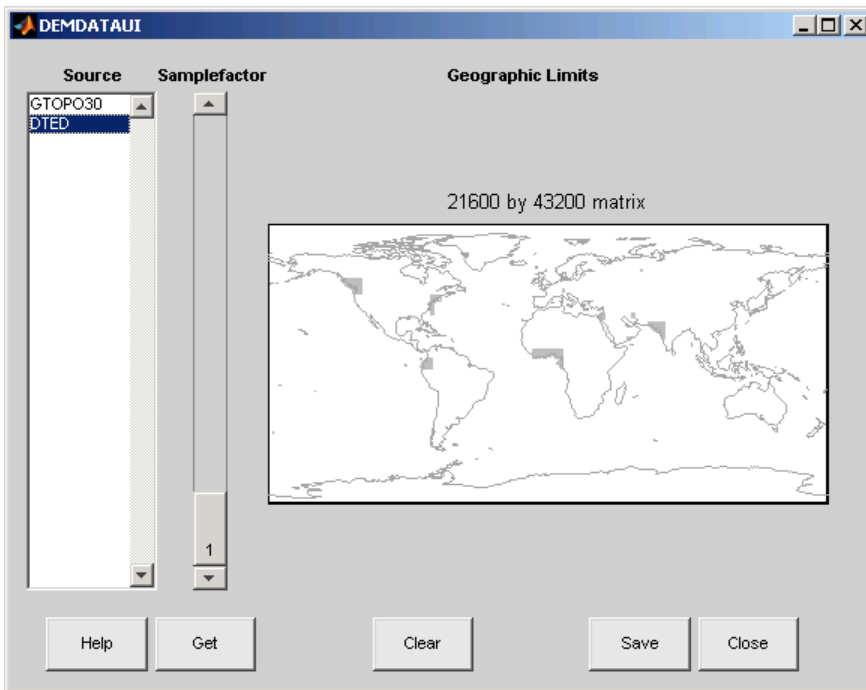
Read Elevation Data Interactively

Read from data sets that `demdataui` has located. You will not necessarily have all the DEM data sets shown in this example. For information about finding data sets over the Internet, see “Find Geospatial Raster Data”.

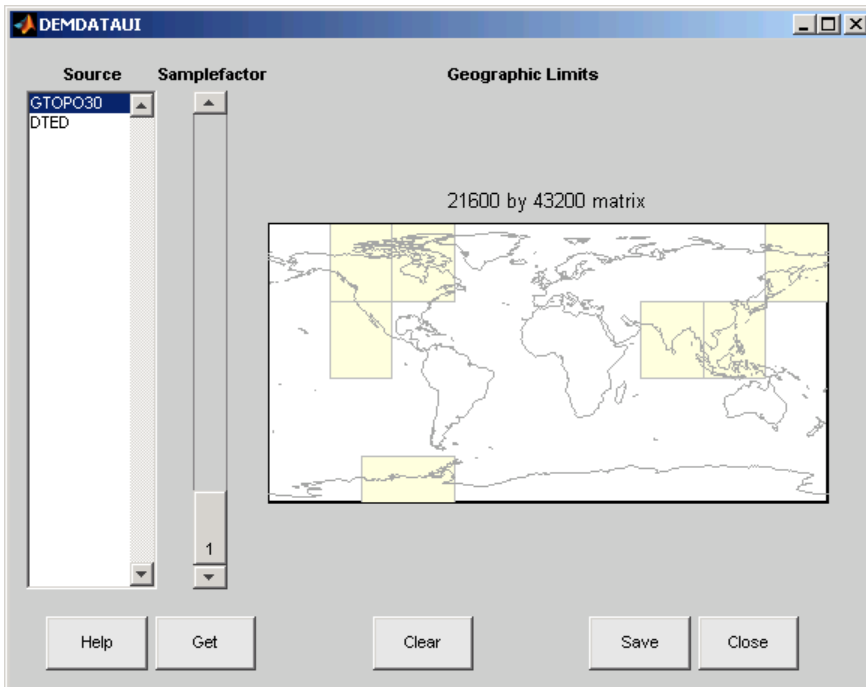
Open the `demdataui` UI. It scans the path for data before it is displayed.

```
demdataui
```

The **Source** list shows the data sets that were found. Here, the source is selected to present all DTED files available to a user.

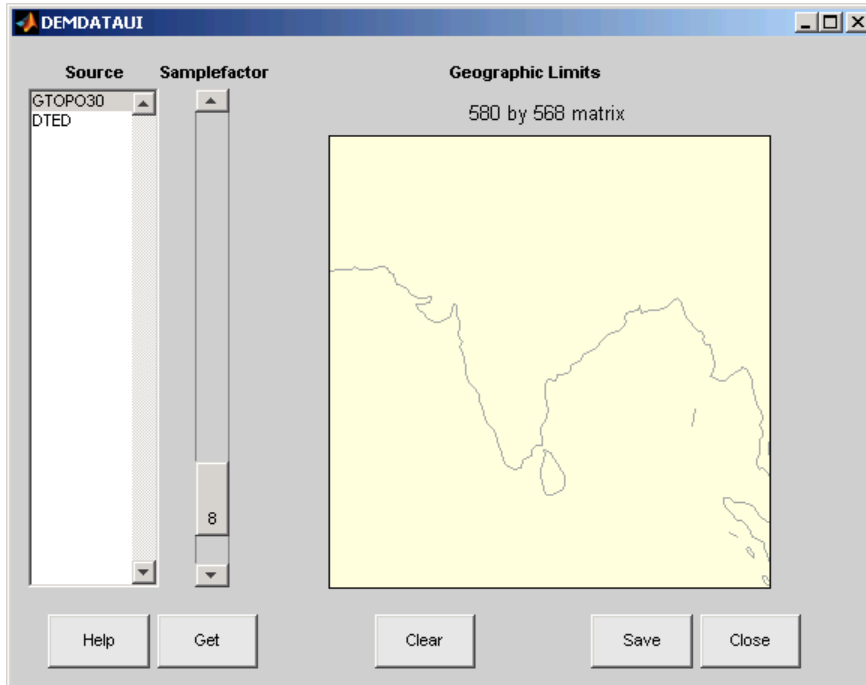


Click **GTOPO30**. In this example, there are available GTOPO30 tiles. The coverage of each data set is indicated by a yellow tint on the map with gray borders around each tile of data.

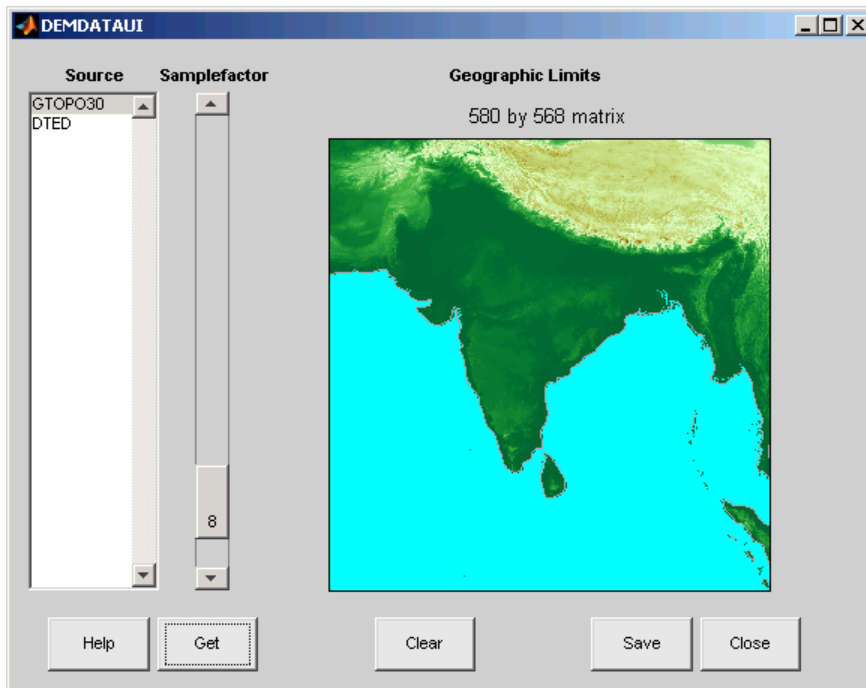


Use the map in the UI to specify the location and density of data to extract. To interactively set a region of interest, click in the map to zoom by a factor of two centered on the cursor, or click and drag across the map to define a rectangular region. The size of the matrix of the area currently displayed is printed above the map. To reduce the amount of data, you can continue to zoom in, or you can raise the **Samplefactor** slider. A sample factor of 1 reads every point, 2 reads every other point, 3 reads every third point, etc. The matrix size is updated when you move the **Samplefactor** slider.

Here is the UI panel after selecting GTOPO30 data and zooming in on the Indian subcontinent.



To see the terrain you have windowed at the sample factor you specified, click the **Get** button. This causes the GUI map pane to repaint to display the terrain grid with the demcmap colormap. In this example, the data grid contains 580-by-568 data values, as shown below.



If you are not satisfied with the result, click the **Clear** button to remove all data previously read in via **Get** and make new selections. You might need to close and reopen `demdatui` in order to select a new region of interest.

When you are ready to import DEM data to the workspace or save it as a MAT-file, click the **Save** button.

Tips

- If `demdatui` does not recognize data you think it should find, check your path and click **Help** to read about how files are identified.
- You can add the data grids to an `axesm`-based map by using the `geoshow` function.
- Updating the data returned by `demdatui` to geographic data structures (`geost structs`) using the `updategeost ruct` function is not supported because they are of type `surface`.

Version History

Introduced before R2006a

R2022b: To be removed

Not recommended starting in R2022b

The `demdatui` function runs without warning, but will be removed in a future release. Use the `readgeoraster` function instead.

See Also

`readgeoraster` | `vmap@read`

handlem-ui

GUI for selecting objects on axesm-based map

Activation

Command Line
<code>h = handlem</code>
<code>h = handlem('prompt')</code>

Description

`h = handlem` brings up a Select Object dialog box, which lists all currently displayed objects. Returns the selected objects.

`h = handlem('prompt')` brings up a Specify Object dialog box, which allows greater control of object selection.

Controls

Select Object Dialog Box



The scroll box is used to select the desired objects from the list of mapped objects. Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the **OK** button returns the object in the variable `h`. Pushing the **Cancel** button aborts the operation.

Specify Object Dialog Box



The **Object** Controls are used to select an object type or tag. The **Name** pull-down menu is used to select from a list of predefined objects. The **Other Tag** edit box is used to specify an object tag not listed in the **Name** pull-down menu. Pushing the **Select** button brings up the Select Object dialog box, which shows only the currently displayed objects for selection.

The **Match** Controls are used when a graphics object type (image, line, surface, patch, or text) is specified. The **Untagged Objects** selection button is used to return only those objects with empty tag properties. The **All Objects** selection button is used to return all objects of the specified type, regardless of whether they are tagged.

Pushing the **Apply** button returns the specified objects. Pushing the **Cancel** button aborts the operation.

Version History

Introduced in R2007a

See Also

handel

hidem-ui

GUI to hide objects on axesm-based map

Activation

hidem

Description

hidem brings up a Select Object dialog box for selecting mapped objects to hide (`Visible` property set to 'off').

Controls



The scroll box is used to select the desired objects from the list of mapped objects. Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the **OK** button changes the `Visible` property of the selected objects to 'off'. Pushing the **Cancel** button aborts the operation without changing any properties of the selected objects.

Version History

Introduced in R2007a

See Also

hidem

maptool

(To be removed) Add menu tools to figure containing axesm-based map

Note The `maptool` function will be removed in a future release. Select a replacement function based on the desired menu item. For more information about replacement functionality, see “Compatibility Considerations”.

Activation

Command Line

```
maptool(PropertyName,PropertyValue)
maptool(ProjectionFile,...)
h = maptool(...)
```

Description

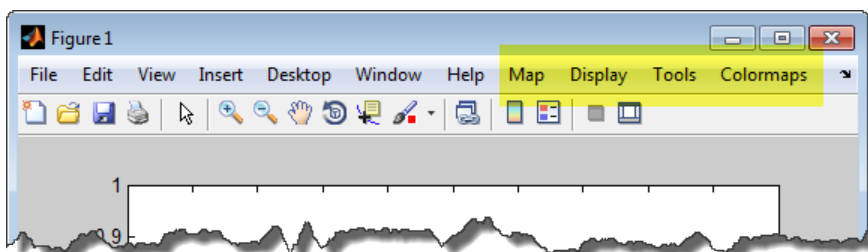
`maptool` adds several items to the menu in the current figure window with an axesm-based map and opens the Projection Control dialog box for defining map projection and display properties. The figure window features a special menu bar that provides access to most of Mapping Toolbox capabilities.

`maptool(PropertyName,PropertyValue,...)` creates a figure window with an axesm-based map defined by the supplied map properties. The `MapProjection` property must be the first input pair. `maptool` supports the same map properties as `axesm`.

`maptool(ProjectionFile,PropertyName, PropertyValue,...)` allows for the omission of the `MapProjection` property name. *ProjectionFile* must be the identifier of an available map projection.

`h = maptool(...)` returns a two-element vector containing the handle of the `maptool` figure window and the handle of the axesm-based map.

Controls



Map Menu

The **Lines** option activates the Line Map Input dialog box for projecting two- and three-dimensional line objects onto the axesm-based map.

The **Patches** option activates the Patch Map Input dialog box for projecting patch objects onto the axesm-based map.

The **Regular Surfaces** option activates the Mesh Map Input dialog box for projecting a regular data grid onto a graticule projected onto the axesm-based map.

The **General Surfaces** option activates the Surface Map Input dialog box for projecting a geolocated data grid onto the axesm-based map.

The **Contours** option activates the Contour Map Input dialog box for projecting a two- or three-dimensional contour plot onto the axesm-based map.

The **Quiver 2D** option activates the Quiver Map Input dialog box for projecting a two-dimensional quiver plot onto the axesm-based map.

The **Quiver 3D** option activates the Quiver3 Map Input dialog box for projecting a three-dimensional quiver plot onto the axesm-based map.

The **Stem** option activates the Stem Map Input dialog box for projecting a stem plot onto the axesm-based map.

The **Scatter** option activates the Scatter Map Input dialog box for projecting a scatter plot onto the axesm-based map.

The **Text** option activates the Text Map Input dialog box for projecting text objects onto the axesm-based map.

Display Menu

The **Projection** option activates the Projection Control dialog box for editing map projection properties and map display settings.

The **Graticule** option is used to view and edit the graticule size for surface maps.

The **Legend** option is used to display a contour map legend.

The **Frame** option is used to toggle the map frame on and off.

The **Grid** option is used to toggle the map grid on and off.

The **Meridian Labels** option is used to toggle the meridian grid labels on and off.

The **Parallel Labels** option is used to toggle the parallel grid labels on and off.

The **Tracks** option activates the Define Tracks input box for calculating and displaying Great Circle and Rhumb Line tracks on the axesm-based map.

The **Small Circles** option activates the Define Small Circles input box for calculating and displaying small circles on the axesm-based map.

The **Surface Distances** option activates the Surface Distance dialog box for distance, azimuth, and reckoning calculations.

Tools Menu

The **Hide** option is used to hide the mouse tool buttons.

The **Off** option is used to turn off the current mouse tool.

The **Set Limits** option is used to define the zoom out limits to the current settings on the axes.

The **Full View** option is used to zoom out to the current axes limit settings.

The **Origin** option is used to toggle Origin mode on and off. Origin mode is used to interactively modify the map origin.

The **2D View** option is used to set the default two-dimensional view (azimuth=0, elevation=90).

The **Edit** option activates the **Property Inspector** to manipulate properties of a plotted object. Choose the **Current Object** option to edit the currently selected object or choose the **Select Object** option to open the Select Object dialog box and choose the object you want to edit.

The **Show** option is used to set the **Visible** property of mapped objects to 'on'. The **All** option shows all currently mapped objects. The **Object** option activates the Select Object dialog box.

The **Hide** option is used to set the **Visible** property of mapped objects to 'off'. Choose from the **All** or **Map** options, or choose the **Object** option to activate the Select Object dialog box.

The **Delete** option is used to clear the selected objects. The **All** option clears the current map, frame, and grid lines. The map definition is left in the axes definition. The **Map** option clears the current map, deleting objects plotted on the map but leaving the frame and grid lines displayed. The **Object** option activates the Select Object dialog box.

The **Axes** option is used to manipulate the MATLAB Cartesian axes. The **Show** option shows this axes, the **Hide** option hides this axes, and the **Color** option allows for custom color selection for this axes.

Colormaps Menu

The **Colormaps** menu allows for manipulation of the colormap for the current figure.

Version History

Introduced before R2006a

R2022b: To be removed

Not recommended starting in R2022b

The `maptool` function runs without warning, but will be removed in a future release. Select a replacement function based on the desired menu item. These tables shows the recommended replacement functions for each menu item.

Map Menu

To Be Removed	Recommended
Lines	linem
Patches	patchesm
Regular Surfaces	meshm
General Surfaces	surfacem
Regular Shaded Relief	meshlsrm
General Shaded Relief	surflsrm
Contour Lines	contourm
Filled Contours	clabelm
Quiver 2D	quiverm
Quiver 3D	quiver3m
Stem	stem3m
Scatter	scatterm
Text	textm

Display Menu

To Be Removed	Recommended
Projection	axesmui
Graticule	Set the MeshGrat property of axesm-based map using setm
Legend	legend
Frame	framem
Grid	gridm
Meridian Labels	mlabel
Parallel Labels	plabel
Tracks	trackg
Small Circles	scircleg
Surface Distances	distance
Map Distortion	mdistort
Scale Ruler	scaleruler
Print Preview	previewmap

Tools Menu

To Be Removed	Recommended
Hide	Set the Visible property of the axes using dot notation
Origin	Set the Origin property of the axesm-based map using setm

To Be Removed	Recommended
Parallel	Set the MapParallels property of the axesm-based map using setm
Set Limits	zoom
Full View	zoom
2D View	view
Tight Map	tightmap
Loose Map	axis
Fill Figure	Set the Units property of the axes using dot notation
Default Size	Set the Units property of the axes using dot notation
Edit	Property Inspector
Show	showm
Hide	hidem
Delete	clma or clmo
Axes	showaxes, showm, or hidem

Colormaps Menu

To Be Removed	Recommended
Colormaps	colormap

See Also

axesm

maptrim

(To be removed) Interactively trim vector data on axesm-based map and convert to raster format

Note The `maptrim` function will be removed in a future release. Use the `geocrop` or `geoclip` function instead.

Syntax

```
maptrim(lat,lon,LineStyle)
maptrim(datagrid,refvec)
maptrim(datagrid,refvec,PropertyName,PropertyValue)
```

Description

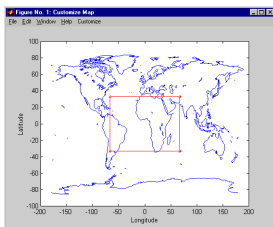
`maptrim(lat,lon)` displays the supplied map data in a new figure window and allows a region of the map to be selected and saved in the workspace. `lat` and `lon` must be vector map data. The output can be line, patch, or regular surface (matrix) data. If patch map output is selected, the inputs `lat` and `lon` must originally be patch map data.

`maptrim(lat,lon,LineStyle)` displays the supplied map using the specified line style, marker, and color on page 1-2024.

`maptrim(datagrid,refvec)` displays data grid data in a new figure window and allows a subset of this map to be selected and saved. The output is regular surface data.

`maptrim(datagrid,refvec,PropertyName,PropertyValue)` displays the data grid using the surface properties provided. The object `Tag`, `EdgeColor`, and `UserData` properties cannot be set.

Controls

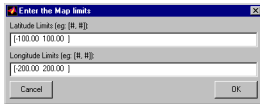


The `maptrim` tool displays the supplied map data in a new figure window and activates a **Customize** menu for that figure. The **Customize** menu has three menu options: **Zoom On/Off**, **Limits**, and **Save As**.

The **Zoom On/Off** menu toggles interactive zoom on and off.

The **Limits** menu option activates the Enter Map Limits dialog box, which is used to enter the latitude and longitude limits of the desired map subset. These entries are two-element vectors,

enclosed in brackets. Pressing the **OK** button zooms in to the new limits. Pressing the **Cancel** button disregards the new limits and returns to the map display.



The **Save As** menu option is used to specify the variable names in which to save the map data subset. To save line and patch data, enter the new latitude and longitude variable names, along with the map resolution. For surface data, enter the new map and referencing vector variable names, along with the scale of the map. Latitude and longitude limits are optional.






More About

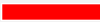







Line Style, Marker, and Color

Specify the line style, marker, and color as a character vector or string containing symbols. The symbols can appear in any order. You do not need to specify all three characteristics (line style, marker, and color). For example, specify a red dashed line using `'--r'`.

Line Style	Description	Resulting Line
"_"	Solid line	
"_ _"	Dashed line	
":"	Dotted line	
"_ ."	Dash-dotted line	

Marker	Description	Resulting Marker
"o"	Circle	
"+"	Plus sign	
"*"	Asterisk	
"."	Point	
"x"	Cross	
"_ "	Horizontal line	
" "	Vertical line	
"square"	Square	
"diamond"	Diamond	
"^"	Upward-pointing triangle	

Marker	Description	Resulting Marker
"v"	Downward-pointing triangle	
">"	Right-pointing triangle	
"<"	Left-pointing triangle	
"pentagram"	Pentagram	
"hexagram"	Hexagram	

Color Name	Short Name	RGB Triplet	Appearance
"red"	"r"	[1 0 0]	
"green"	"g"	[0 1 0]	
"blue"	"b"	[0 0 1]	
"cyan"	"c"	[0 1 1]	
"magenta"	"m"	[1 0 1]	
"yellow"	"y"	[1 1 0]	
"black"	"k"	[0 0 0]	
"white"	"w"	[1 1 1]	

Version History

Introduced before R2006a

R2022b: To be removed

Not recommended starting in R2022b

The `maptrim` function runs without warning, but will be removed in a future release. Use the `geocrop` or `geoclip` function instead.

See Also

`mapclip` | `geoclip` | `maptriml` | `maptrimp` | `geocrop`

mobjects

(Removed) Manipulate object sets displayed on axesm-based map

Note The `mobjects` function has been removed.

Activation

`mobjects`

`mobjects(h)`

Description

An object set is defined as all objects with identical tags. If no tags are supplied, object sets are defined by object type.

`mobjects` allows manipulation of the object sets on the current axesm-based map.

`mobjects(h)` allows manipulation of the objects set on the axesm-based map specified by the handle `h`.

Controls



The scrollable list box displays all of the object sets associated with the axesm-based map. An asterisk next to an object set name indicates that the object set is currently visible. An `h` next to an object set name indicates an object set that is plotted, but currently hidden. The order shown in the list indicates the stacking order of objects within the same plane.

The **Hide/Show** button toggles the `Visible` property of the selected object set to `'off'` and `'on'`, respectively, depending on the current `Visible` status.

The **Zdata** button activates the Specify Zdata dialog box, which is used to enter the workspace variable containing the ZData. The ZData property is used to specify the plane in which the selected object set is drawn. Pressing the **List** button produces a list of all current workspace variables, from which the ZData variable can be selected. Alternatively, a scalar value can be entered instead of a variable.



The **Highlight** button highlights all objects belonging to the selected object set.

The **Tag** button brings up an Edit Tag dialog box, which allows the tag of all members of the selected object set to be modified.

The **Delete** button clears all objects belonging to the selected object set from the map. The cleared object set remains associated with the axesm-based map.



The **Property** button activates the Define Object Properties dialog box, which is used to specify additional properties of all objects in the selected object set. Character vector entries must be enclosed in single quotes.



The **Update** button updates the list box display with current objects sets.

The **Stacking Order** buttons are used to modify the drawing order of the selected object set in relation to other plotted object sets in the same plane. Objects drawn first appear at the bottom of the stack, and objects drawn last appear at the top of the stack. The **Top** button places the selected object set above all other object sets in its plane. The **Up** and **Dwn** buttons move the selected object set up and down one place in the stacking order, respectively. The **Btm** button places the selected object set below all other object sets in its plane. Note that the ZData property overrides stacking order, i.e., if an object is at the top of the stacking order for its plane, it can still be covered by an object drawn in a higher plane.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The `mobjects` function has been removed.

R2022a: Warns

Warns starting in R2022a

The `mobjects` function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The `objects` function runs without warning but will be removed in a future release.

originui

(To be removed) Interactively change origin on axesm-based map

Note The `originui` function will be removed in a future release. Instead, set the `Origin` property of the axesm-based map by using the `setm` function.

Activation

`originui`

`originui on`

`originui off`

Description

`originui` provides a tool to modify the origin of a displayed map projection. A marker (dot) is displayed where the origin is currently located. This dot can be moved and the map reprojected with the identified point as the new origin.

`originui` automatically toggles the current axes into a mode where only actions recognized by `originui` are executed. Upon exit of this mode, all prior `ButtonDown` functions are restored to the current axes and its children.

`originui on` activates origin tool. `originui off` e-activates the tool. `originui` will toggle between these two states.

Controls

Keystrokes

`originui` recognizes the following keystrokes. **Enter** (or **Return**) will reproject the map with the identified origin and remain in the `originui` mode. **Delete** and **Escape** will exit the origin mode (same as `originui off`). **N,S,E,W** keys move the marker North, South, East or West by 10.0 degrees for each keystroke. **n,s,e,w** keys move the marker in the respective directions by 1 degree per keystroke.

Mouse Actions

`originui` recognizes the following mouse actions when the cursor is on the origin marker.

- Single-click and hold moves the origin marker. Double-click the marker reprojects the map with the specified map origin and remains in the origin mode (same as `originui Return`).
- Extended-click moves the marker along the Cartesian X or Y direction only (depending on the direction of greatest movement).

- Alternate-click exits the origin tool (same as `originui off`).

Macintosh Key Mapping

- Extend-click: **Shift**+click mouse button
- Alternate-click: **Option**+click mouse button

Microsoft Windows Key Mapping

- Extend-click: **Shift**+click left button or both buttons
- Alternate-click: **Ctrl**+click left button or right button

X-Windows Key Mapping

- Extend-click: **Shift**+click left button or middle button
- Alternate-click: **Ctrl**+click left button or right button

Version History

Introduced before R2006a

R2022b: To be removed

Not recommended starting in R2022b

The `originui` function runs without warning, but will be removed in a future release. Instead, set the `Origin` property of the `axesm`-based map by using the `setm` function.

See Also

`axesm` | `setm`

panzoom

(Removed) Zoom settings on 2-D map

Note The panzoom function has been removed. Use the zoom function instead.

Syntax

```
panzoom
panzoom on
panzoom off
panzoom setlimits
panzoom out
panzoom fullview
```

Description

panzoom toggles the pan and zoom tool on and off.

panzoom on is equivalent to zoom on.

panzoom off is equivalent to zoom off.

panzoom setlimits is equivalent to zoom reset.

panzoom out is equivalent to zoom out.

panzoom fullview sets the axes limit modes to 'auto' and resets zoom to the resulting limits.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The panzoom function has been removed. Use the zoom function instead.

R2022a: Warns

Warns starting in R2022a

The panzoom function issues a warning that it will be removed in a future release.

R2014a: To be removed

Not recommended starting in R2014a

The panzoom function runs without warning but will be removed in a future release.

See Also

zoom

parallelui

(To be removed) Interactively change parallels on axesm-based map

Note The `parallelui` function will be removed in a future release. Instead, set the `MapParallels` property of the axesm-based map by using the `setm` function.

Activation

`parallelui`

`parallelui on`

`parallelui off`

Description

`parallelui` toggles the parallel tool on and off.

`parallelui on` activates the parallel tool

`parallelui off` deactivates the parallel tool

The `parallelui` GUI provides a tool to modify the standard parallels of a displayed map projection. One or two red lines are displayed where the standard parallels are currently located. The parallel lines can be dragged to new locations, and the map reprojected with the locations of the parallel lines as the new standard parallels.

Controls

Mouse Interaction

A single-click-and-drag moves the parallel lines. A double-click on one of the standard parallels reprojects the map using the new parallel locations.

Version History

Introduced before R2006a

R2022b: To be removed

Not recommended starting in R2022b

The `parallelui` function runs without warning, but will be removed in a future release. Instead, set the `MapParallels` property of the axesm-based map by using the `setm` function.

See Also
axesm | setm

property editors

GUIs to edit properties of objects on axesm-based map

Activation

Alternate-click mapped object (for Click-and-Drag Property Editor)

In plot edit mode, double-click mapped object (to obtain MATLAB Property Editor; click the **More Properties...** button to open the Property Inspector)

Description

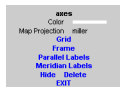
Alternate (e.g., **Ctrl**+clicking a mapped object activates a property editor, which allows modification of some basic properties of the object through simple mouse clicks and drags. The objects supported by this editor are axesm-based maps, lines, text, patches, and surfaces, and the properties supported for each object type are shown below.

In plot edit mode, double-clicking a mapped object activates the MATLAB Property Editor for that object. From the Property Editor you can launch the Property Inspector, a GUI that lists the properties and values of the selected object and allows you to modify them.

Controls

Click-and-Drag Property Editor

The Click-and-Drag editor lists object properties and values. The object tag appears at the top of the editor. Property names and values that appear in blue are toggles. For example, clicking **Frame** in the axes editor toggles the value of the Frame property between 'on' and 'off'.



Click-and-Drag Editor for an axesm-based map

Property values that appear on the right side of the editor box are modified by clicking and dragging. For example, to change the **MarkerColor** property of a line object, click and hold the dot next to **MarkerColor**, and drag the cursor until the dot appears in the desired color.



Click-and-Drag Editor for a line object

The **Drag** control in the text editor is used to reposition the text character vector. In drag mode, use the mouse to move the text to a new location, and click to reposition the text. The **Edit** control in the text editor activates a **Text Edit** window, which is used to modify text.



Click-and-Drag Editor for a text object

The **Marker** property name in the patch editor is used to toggle the marker on and off. The property value to the right of **Marker** can be modified by clicking and dragging until the desired marker symbol appears.



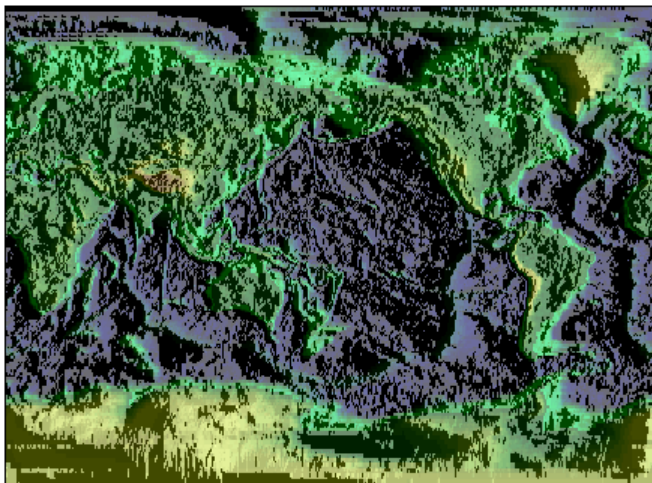
Click-and-Drag Editor for a patch object

The **Graticule** control on the surface editor activates a Graticule Mesh dialog box, which is used to alter the size of the graticule.

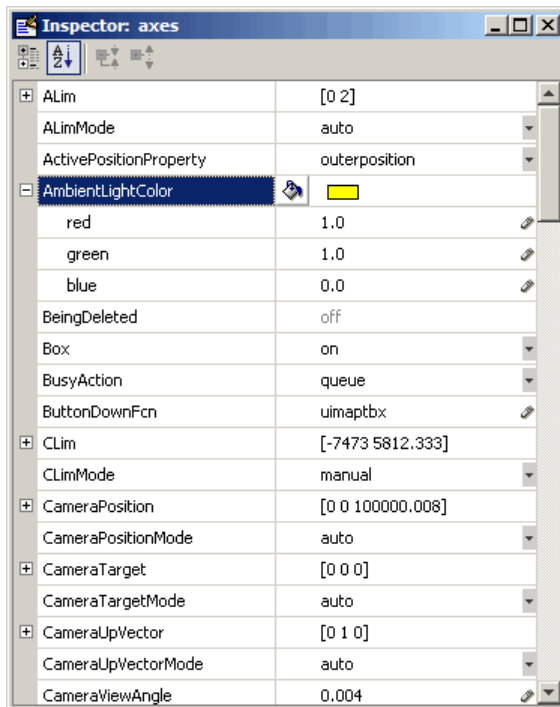
To move the property editor around the figure window, hold down the **Shift** key while dragging the editor box. Alternate-clicking the background of the property editor closes the **Click-and-Drag** editing session.

Guide Property Editor

The MATLAB **Property Inspector** allows you to view and modify property values for most properties of the selected object. Use it to expand and collapse the hierarchy of objects, showing an object's parents and children. A plus sign (+) before a property indicates that it can be expanded to show its components, for example the axes `AmbientLightColor` applied to the surface object displayed below. A minus sign (-) before an object indicates an object can be collapsed to hide its components. To activate the Object Browser, check the **Show Object Browser** check box. The **Property List** shows all the property names of the selected object and their current values. To activate the **Property List**, check the **Show Property List** check box. To change a property value, use the edit boxes above the Property List. Pressing the **Close** button closes the Guide Property Editor and applies the property modifications to the object.



A lit surface object in an axesm-based map



Property Inspector view of axes object

Version History

Introduced before R2006a

See Also

propedit | **Property Inspector** | uimaptbx

qrydata

(Removed) Create queries associated with axesm-based map

Note The `qrydata` function has been removed.

Activation

Command Line

```
qrydata(cellarray)
qrydata(titlestr,cellarray)
qrydata(h,cellarray)
qrydata(h,titlestr,cellarray)
qrydata(...,cellarray1,cellarray2,...)
```

Description

A data query is used to obtain the data corresponding to a particular (x,y) or (lat,lon) point on a standard or axesm-based map.

`qrydata(cellarray)` activates a data query dialog box for interactive queries of the data set specified by `cellarray` (described below). `qrydata` can be used on a standard axes or an axesm-based map. (x,y) or (lat,lon) coordinates are entered in the dialog box, and the data corresponding to these coordinates is then displayed.

`qrydata(titlestr,cellarray)` uses `titlestr` as the title of the query dialog box.

`qrydata(h,cellarray)` and `qrydata(h,titlestr,cellarray)` associate the data queries with the axes specified by the handle `h`, which in turn allows the input coordinates to be specified by clicking the axes.

The input `cellarray` is used to define the data set and the query. The first cell must contain a character vector that is the label of the data display line. The second cell must contain a character vector that specifies the type of query operation. The operation can be either a predefined operation or a valid user-defined function name. The predefined query operations are 'matrix', 'vector', 'mapmatrix', and 'mapvector'.

The 'matrix' query uses the MATLAB `interp2` function to find the value of the matrix `Z` at the input (x,y) point. The format of the `cellarray` input for this query is: {'label', 'matrix', X, Y, Z, method}. `X` and `Y` are matrices specifying the points at which the data `Z` is given. The rows and columns of `X` and `Y` must be monotonic. `method` is an optional argument that specifies the interpolation method. Possible `method` values are 'nearest', 'linear', or 'cubic'. The default is 'nearest'.

The 'vector' query uses the `interp2` function to find the value of the matrix `Z` at the input (x,y) point, then uses that value as an index to a data vector. The value of the data vector at that index is

returned by the query. The format of `cellarray` for this type of query is: `{'label', 'vector', X, Y, Z, vector}`. `X` and `Y` are matrices specifying the points at which the data `Z` is given. The rows and columns of `X` and `Y` must be monotonic. `vector` is the data vector.

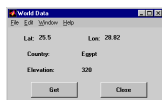
The `'mapmatrix'` query interpolates to find the value of the map at the input `(lat, lon)` point. The format of `cellarray` for this query is: `{'label', 'mapmatrix', datagrid, refvec, method}`. `datagrid` and `refvec` are the data grid and the corresponding referencing vector. `method` is an optional argument that specifies the interpolation method. Possible `method` values are `'nearest'`, `'linear'`, or `'cubic'`. The default is `'nearest'`.

The `'mapvector'` query interpolates to find the value of the map at the input `(lat, lon)` point, then uses that value as an index to a data vector. The value of the vector at that index is returned by the query. The format of `cellarray` for this type of query is `{'label', 'mapvector', datagrid, refvec, vector}`. `datagrid` and `refvec` are the data grid and the corresponding referencing vector. `vector` is the data vector.

User-defined query operations allow for functional operations using the input `(x, y)` or `(lat, lon)` coordinates. The format of `cellarray` for this type of query is `{'label', function, other arguments...}` where the other arguments are the remaining elements of `cellarray` as in the four predefined operations above. `function` is a user-created function and must refer to a MATLAB function with the signature `z = fcn(x, y, other_arguments...)`.

`qrydata(..., cellarray1, cellarray2, ...)` is used to input multiple cell arrays. This allows more than one data query to be performed on a given point.

Controls



Sample data query dialog box

If an axes handle `h` is not provided, or if the axes specified by `h` is not an `axesm`-based map, the currently selected point is labeled as **Xloc** and **Yloc** at the top of the query dialog box. If `h` is an `axesm`-based map, the current point is labeled as **Lat** and **Lon**. Displayed below the current point are the results from the queries, each labeled as specified by the `'label'` input arguments.

The **Get** button appears if an axes handle `h` is provided. Pressing this button activates a mouse cursor, which is used to select the desired point by clicking the axes. Once a point is selected, the queries are performed and the results are displayed.

The **Process** button appears if the handle `h` is not provided. In this case, the `(x, y)` coordinates of the desired point are entered into the edit boxes. Pressing the **Process** button performs the data queries and displays the results.

Pressing the **Close** button closes the query dialog box.

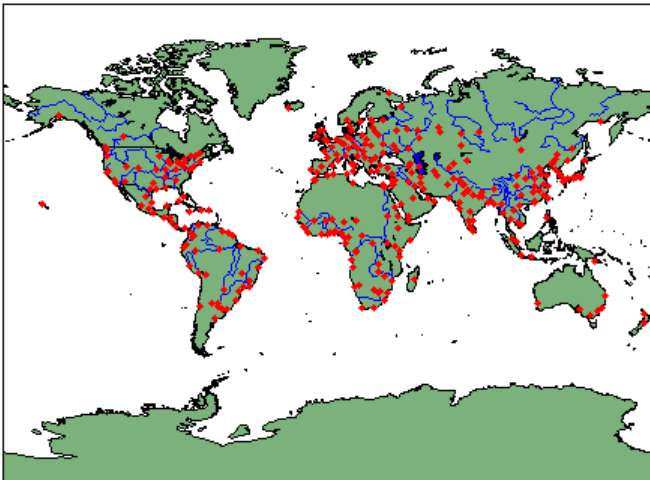
Examples

This example illustrates use of a user-defined query to display city names for map points specified by a mouse click. The query is evaluated by a user-supplied file called `qrytest.m`, described below:

```
axesm miller
land = shaperead('landareas', 'UseGeoCoords', true);
geoshow(land, 'FaceColor', [0.5 0.7 0.5])
lakes = shaperead('worldlakes', 'UseGeoCoords', true);
geoshow(lakes, 'FaceColor', 'blue')
rivers = shaperead('worldrivers', 'UseGeoCoords', true);
geoshow(rivers, 'Color', 'blue')
cities = shaperead('worldcities', 'UseGeoCoords', true);
geoshow(cities, 'Marker', '.', 'Color', 'red')
tightmap
lat = [cities.Lat]';
lon = [cities.Lon]';
mat = char(cities.Name);
qrydata(gca, 'City Data', {'City', 'qrytest', lat, lon, mat})
```

Create the file `qrytest.m` on your path, and in it put the following code:

```
function cityname = qrytest(lt, lg, lat, lon, mat)
% function QRYTEST returns city name for mouse click
% QRYTEST will find the closest city (min radius) from
% the mouse click, within an angle of 5 degrees.
%
latdiff = lt-lat;
londiff = lg-lon;
rad = sqrt(latdiff.^2+londiff.^2);
[minrad,index] = min(rad);
if minrad > 5
    index = [];
end
switch length(index)
    case 0, cityname = 'No city located near click';
    case 1, cityname = mat(index,:);
end
```



Clicking the mouse over a city marker displays the name of the selected city. Clicking the mouse in an area away from any city markers displays 'No city located near click'.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The qrydata function has been removed.

R2022a: Warns

Warns starting in R2022a

The qrydata function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The qrydata function runs without warning but will be removed in a future release.

See Also

interp2

scirclui

(To be removed) GUI to display small circles on axesm-based map

Note The `scirclui` function will be removed in a future release. Use the `scircleg` function instead.

Activation

`scirclui`

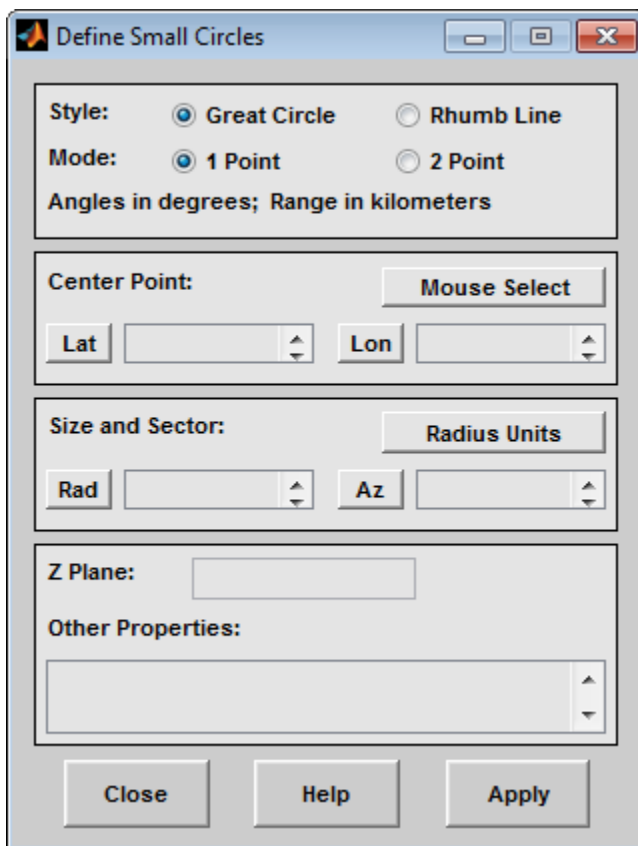
`scirclui(h)`

Description

`scirclui` activates the Define Small Circles dialog box for adding small circles to the current axesm-based map.

`scirclui(h)` activates the Define Small Circles dialog box for adding small circles to the axesm-based map specified by the axes handle `h`.

Controls



Define Small Circles dialog box for one-point mode

The **Style** selection buttons are used to specify whether the circle radius is a constant great circle distance or a constant rhumb line distance.

The **Mode** selection buttons are used to specify whether one point or two points are to be used in defining the small circle. If one-point mode is selected, a center point, radius, and azimuth are the required inputs. If two-point mode is selected, a center point, and perimeter point on the circle are the required inputs.

The **Center Point** controls are used in both one-point and two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of the center point of the small circle to be displayed. These values must be in degrees. To display more than one small circle, a vector of values can be entered, enclosed in brackets in each edit box. Pushing the **Lat** or **Lon** button brings up an expanded edit box for easier entry of long vectors. The **Mouse Select** button is used to select a center point by clicking the displayed map. The coordinates of the selected point then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection.

The **Circle Point** controls are used only in two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of a point on the perimeter of the small circle to be displayed. These values must be in degrees. To display more than one small circle, a vector of values can be entered, enclosed in brackets in each edit box. Pushing the **Lat** or **Lon** button brings up an expanded edit box

for easier entry of long vectors. The **Mouse Select** button is used to select a perimeter point by clicking the displayed map. The coordinates of the selected point then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection.

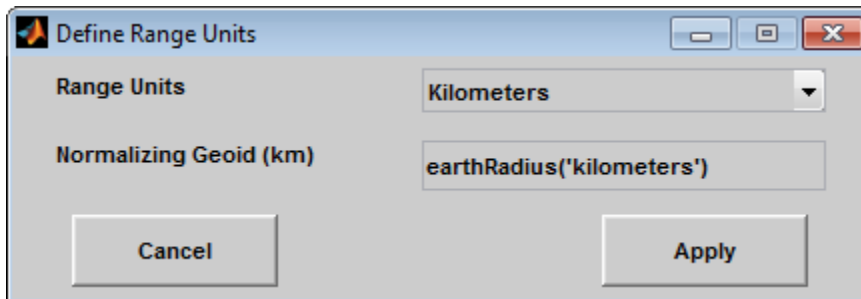
The **Size and Sector** controls are used only in one-point mode. The **Radius Units** button brings up a Define Range Units dialog box, which allows for modification of the small circle radius units and the normalizing geoid. The **Rad** edit box is used to enter the radius of the small circle in the proper units. The **Arc** edit box is used to specify the sector azimuth, measured in degrees, clockwise from due north. If the entry is omitted, a complete small circle is drawn. When entering radius and arc data for more than one small circle, vectors of values, enclosed in brackets, are entered in each edit box. Pushing the **Rad** or **Arc** button brings up an expanded edit box for that entry, which is useful for entering long vectors.

The **Z Plane** edit box is used to enter a scalar value that specifies the plane in which to display the small circles.

The **Other Properties** edit box is used to specify additional properties of the small circles to be projected, such as 'Color', 'b'. Character vector entries must be enclosed in quotes.

Pressing the **Apply** button accepts the input data and displays the small circles on the current axesm-based map.

Pressing the **Cancel** button disregards any input data and closes the Define Small Circles dialog box.



This dialog box, available only in one-point mode, allows for modification of the small circle radius units and the normalizing geoid.

The **Radius Units** pull-down menu is used to select the units of the small circle radius. The unit selected is displayed near the top of the Define Small Circles dialog box, and all latitude and longitude entries must be entered in these units. Users must also be sure to specify the normalizing geoid in the same units. If radians are selected, it is assumed the radius entry is a multiple of the radius used to display the current map, as defined by the map geoid property.

The **Normalizing Geoid** edit box is used to modify the radius used to normalize the small circle radius to a radian value, which is necessary for proper calculations and map display. This entry must be in the same units as the small circle radius. If the small circle radius units are in radians, then the normalizing geoid must be the same as the geoid used for the current axesm-based map.

Pressing the **Cancel** button disregards any modifications and closes the Define Radius Units dialog box.

Pressing the **Apply** button accepts any modifications and returns to the Define Small Circles dialog box.

Version History

Introduced before R2006a

R2022b: To be removed

Not recommended starting in R2022b

The `scirclui` function runs without warning, but will be removed in a future release. Use the `scircleg` function instead.

See Also

`scircleg` | `scircle1` | `scircle2`

seedm

(Removed) GUI to fill data grids with seeded values

Note The `seedm` function has been removed.

Activation

Command Line

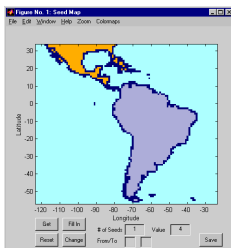
```
seedm(datagrid, refvec)
```

Description

Encoding is the process of filling in specific values in regions of a data grid up to specified boundaries, which are indicated by entries of 1 in the variable `map`. Encoding entire regions at one time allows indexed maps to be created quickly.

`seedm(datagrid, refvec)` displays the surface map in a new figure window and allows for seeds to be specified and the encoded map generated. The encoded map can then be saved to the workspace. `map` is the data grid and must consist of positive integer index values. `refvec` is the referencing vector of the surface.

Controls



The **Zoom On/Off** menu toggles the zoom box on and off. The box can be moved by clicking the new location or by dragging the box to the new location. The box size can be increased or decreased by dragging a corner of the box. Pressing the **Return** key or double-clicking in the center of the box zooms in to the box limits.

The **Colormaps** menu provides a variety of colormap options that can be applied to the map.

The **Get** button allows mouse selection of points on the map to which seeds are assigned. The number of points to be selected is entered in the **# of Seeds** edit box. The value of the seed is entered in the **Value** edit box. This seed value is assigned to each point selected with the mouse. The **Get** button is pressed to begin mouse selection. After all the points have been selected, the **Fill In** button is pressed to perform the encoding operation. The region containing the seed point is filled in with the seed value. The **Reset** button is used to disregard all points selected with the mouse before the **Fill In** button is pressed.

Alternatively, specific map values can be globally replaced by using the **From/To** edit boxes. The value to be replaced is entered in the first edit box, and the new value is entered in the second edit box. Pressing the **Change** button replaces all instances of the **From** value to the **To** value in the map.

Note Values of 1 represent boundaries and should not be changed.

The **Save** button is used to save the encoded map to the workspace. A dialog box appears in which the map variable name is entered.

Version History

Introduced before R2006a

R2023a: Removed

Errors starting in R2023a

The seedm function has been removed.

R2022a: Warns

Warns starting in R2022a

The seedm function issues a warning that it will be removed in a future release.

R2013b: To be removed

Not recommended starting in R2013b

The seedm function runs without warning but will be removed in a future release.

See Also

encodem

showm-ui

GUI to show objects on axesm-based map

Activation

showm

Description

showm brings up a Select Object dialog box for selecting mapped objects to show (Visible property set to 'on').

Controls



The scroll box is used to select the desired objects from the list of mapped objects. Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the **OK** button changes the Visible property of the selected objects to 'on'. Pushing the **Cancel** button aborts the operation without changing any properties of the selected objects.

Version History

Introduced in R2007a

See Also

showm

surfdist

(To be removed) Distance, azimuth, and reckoning on axesm-based map using mouse

Note The `surfdist` function will be removed in a future release. Use the `distance` function instead.

Activation

`surfdist`

`surfdist(h)`

`surfdist([])`

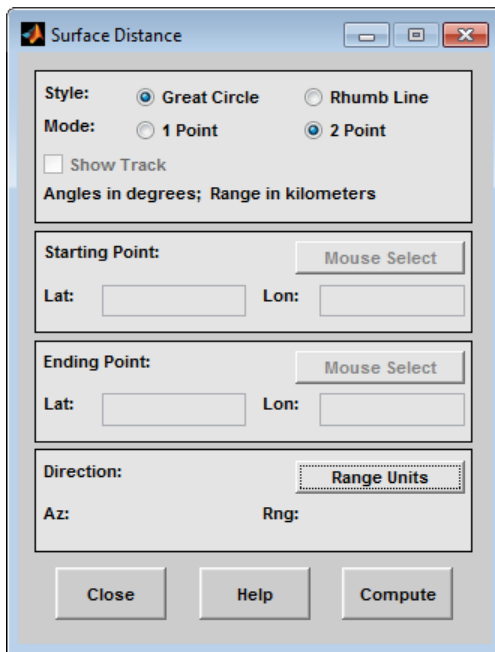
Description

`surfdist` activates the Surface Distance dialog box for the current axes only if the axes has a proper map definition. Otherwise, the Surface Distance dialog box is activated, but is not associated with any axes.

`surfdist(h)` activates the Surface Distance dialog box for the axesm-based map specified by the handle `h`.

`surfdist([])` activates the Surface Distance dialog box and does not associate it with any axes, regardless of whether the current axes has a valid map definition.

Controls



The **Style** selection buttons are used to specify whether a great circle or rhumb line is used to calculate the surface distance. When all other entries are provided, selecting a style updates the surface distance calculation.

The **Mode** selection buttons are used to specify whether one point or two points are to be used in defining the track distance. If one-point mode is selected, a starting point, azimuth, and range are the required inputs, and the ending point is computed. If two-point mode is selected, starting and ending points of the track are required, and the azimuth and distance along this track are then computed.

The **Show Track** check box is used to indicate whether the track is shown on the associated map display. The track is deleted when the Surface Distance dialog box is closed, or when the **Show Track** check box is unchecked and the surface distance calculations are recomputed.

The **Starting Point** controls are used for both one-point and two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of the starting point of the track. These values must be in degrees. Only one starting point can be entered. The **Mouse Select** button is used to select a starting point by clicking the displayed map. The coordinates of the selected point then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection.

The **Ending Point** controls are enabled only for two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of the ending point of the track. These values must be in degrees. Only one ending point can be entered. The **Mouse Select** button is used to select an ending point by clicking the displayed map. The coordinates of the selected point then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection. During one-point mode, the Ending Point controls are disabled, but the ending point that results from the surface distance calculation is displayed.

The **Direction** controls are enabled only for one-point mode. The **Range Units** button brings up a Define Range Units dialog box which allows for modification of the range units and the normalizing

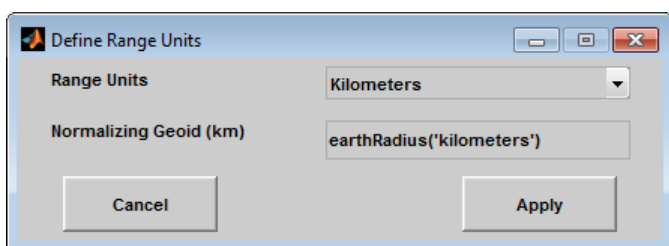
geoid. The **Az** edit box is used to enter the azimuth, which sets the initial direction of the track from the starting point. Azimuth is measured in degrees clockwise from due north. The **Rng** edit box is used to specify the reckoning range of the track, in the proper units. The azimuth and reckoning range, along with the starting point, are used to compute the ending point of the track in one-point mode. During two-point mode, the **Direction** controls are disabled, but the azimuth and range values resulting from the surface distance calculation are displayed.

Pressing the **Close** button disregards any input data, deletes any surface distance tracks that have been plotted, and closes the Surface Distance dialog box.

Pressing the **Compute** button accepts the input data and computes the specified distances.

Define Range Units Dialog Box

This dialog box, available only for one-point mode, allows for modification of the range units and the normalizing geoid.



The **Range Units** pull-down menu is used to select the units of the reckoning range. The unit selected is displayed near the top of the Surface Distance dialog box, and all latitude and longitude entries must be entered in these units. Users must also be sure to specify the normalizing geoid in the same units. If radians are selected, it is assumed the range entry is a multiple of the radius of the normalizing geoid. In this case, the normalizing geoid must be the same as the geoid used to display the current map.

The **Normalizing Geoid** edit box is used to modify the radius used to normalize range entries to radian values, which is necessary for proper calculations and map display. This entry must be in the same units as the range units. If the range units are in radians, then the normalizing geoid must be the same as the geoid used for the current axesm-based map.

Pressing the **Cancel** button disregards any modifications and closes the Define Range Units dialog box.

Pressing the **Apply** button accepts any modifications and returns to the Surface Distance dialog box.

Version History

Introduced before R2006a

R2022b: To be removed

Not recommended starting in R2022b

The `surfdist` function runs without warning, but will be removed in a future release. Use the `distance` function instead.

See Also

Functions
distance

tagm-ui

GUI to set Tag property of objects on axesm-based map

Activation

Command Line
tagm
tagm(h)

Description

tagm brings up a Select Object dialog box for selecting mapped objects and changing their Tag property. Upon selecting the objects, the Edit Tag dialog box is activated, in which the new tag is entered.

tagm(h) activates the Edit Tag dialog box for the objects specified by the handle h.

Controls



Select Object Dialog Box

The scroll box is used to select the desired objects from the list of mapped objects. Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the **Ok** button activates the Edit Tag dialog box. Pushing the **Cancel** button aborts the operation without changing any properties of the selected objects.



Edit Tag Dialog Box

Enter the new tag character vector in the edit box. Pressing the **Apply** button changes the Tag property of all selected objects to the new tag character vector. Pressing the **Cancel** button closes the Edit Tag dialog box without changing the Tag property of the selected objects.

Version History

Introduced in R2007a

See Also
tagm

trackui

(To be removed) GUI to display great circles and rhumb lines on axesm-based map

Note The `trackui` function will be removed in a future release. Use the `trackg` function instead.

Activation

`trackui`

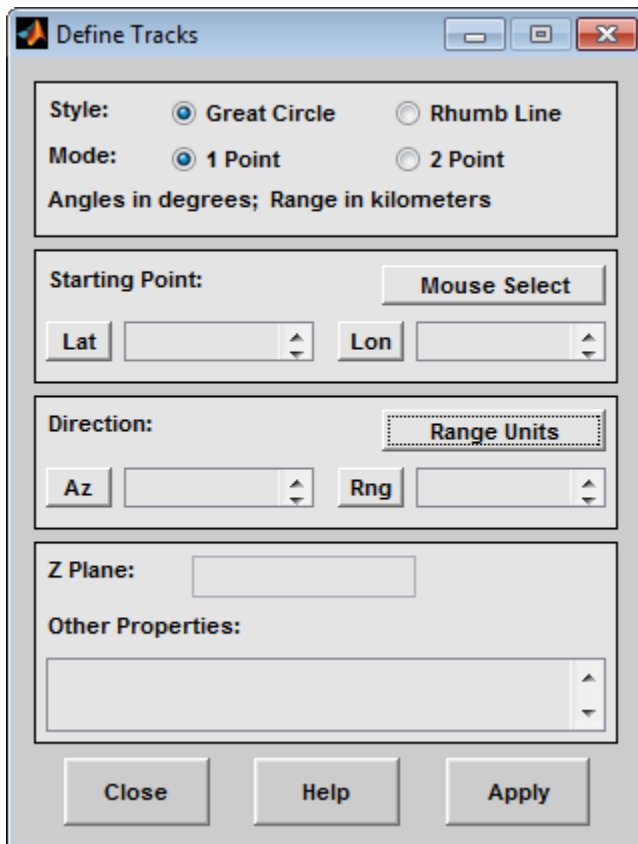
`trackui(h)`

Description

`trackui` activates the Define Tracks dialog box for adding great circle or rhumb line tracks to the current axesm-based map.

`trackui(h)` activates the Define Tracks dialog box for adding great circle or rhumb line tracks to the axesm-based map specified by the axes handle `h`.

Controls



Define Tracks dialog box for two-point mode

The **Style** selection buttons are used to specify whether a great circle or rhumb line track is displayed.

The **Mode** selection buttons are used to specify whether one point or two points are to be used in defining the track. If one-point mode is selected, a starting point, azimuth, and range are the required inputs. If two-point mode is selected, starting and ending points are required.

The **Starting Point** controls are used for both one-point and two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of the starting point of the track to be displayed. These values must be in degrees. To display more than one track, a vector of values can be entered, enclosed in brackets in each edit box. Pushing the **Lat** or **Lon** button brings up an expanded edit box for easier entry of long vectors. The **Mouse Select** button is used to select a starting point by clicking the displayed map. The coordinates of the selected point then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection.

The **Ending Point** controls are used only for two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of the ending point of the track to be displayed. These values must be in degrees. To display more than one track, a vector of values can be entered, enclosed in brackets, in each edit box. Pushing the **Lat** or **Lon** button brings up an expanded edit box for easier entry of long vectors. The **Mouse Select** button is used to select an ending point by clicking the displayed map.

The coordinates of the selected point then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection.

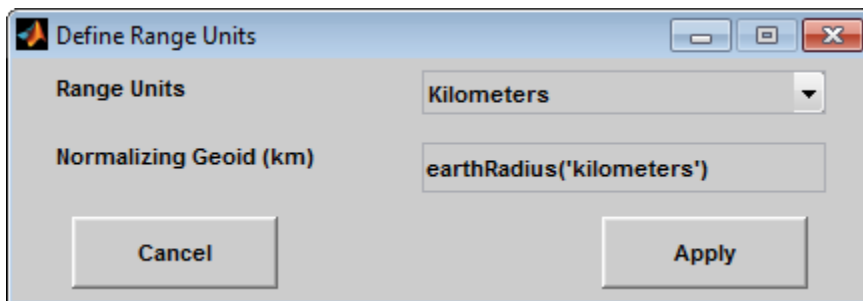
The **Direction** controls are used only for one-point mode. The **Range Units** button brings up a Define Range Units dialog box, which allows for modification of the range units and the normalizing geoid. The **Az** edit box is used to enter the azimuth, which sets the initial direction of the track from the starting point. Azimuth is measured in degrees clockwise from due north. The **Rng** edit box is used to specify the range of the track, in the proper units. If the range entry is omitted, a complete track is drawn. When inputting azimuth and range data for more than one track, vectors of values, enclosed in brackets, are entered in each edit box. Pushing the **Az** or **Rng** button brings up an expanded edit box for that entry, which is useful for entering long vectors.

The **Z Plane** edit box is used to enter a scalar value that specifies the plane in which to display the tracks.

The **Other Properties** edit box is used to specify additional properties of the tracks to be projected, such as 'Color', 'b'. Character vector entries must be enclosed in quotes.

Pressing the **Apply** button accepts the input data and displays the tracks on the current axesm-based map.

Pressing the **Cancel** button disregards any input data and closes the Define Tracks dialog box.



Define Range Units Dialog Box

This dialog box, available only for one-point mode, allows for modification of the range units and the normalizing geoid.

The **Range Units** pull-down menu is used to select the units of the track range. The unit selected is displayed near the top of the Define Tracks dialog box, and all latitude and longitude entries must be entered in these units. Users must also be sure to specify the normalizing geoid in the same units. If radians are selected, it is assumed the range entry is a multiple of the radius used to display the current map.

The **Normalizing Geoid** edit box is used to modify the radius used to normalize range entries to radian values, which is necessary for proper calculations and map display. This entry must be in the same units as the range units. If the range units are in radians, then the normalizing geoid must be the same as the geoid used for the current axesm-based map.

Pressing the **Cancel** button disregards any modifications and closes the Define Range Units dialog box.

Pressing the **Apply** button accepts any modifications and returns to the Define Tracks dialog box.

Version History

Introduced before R2006a

R2022b: To be removed

Not recommended starting in R2022b

The `trackui` function runs without warning, but will be removed in a future release. Use the `trackg` function instead.

See Also

`trackg` | `track1` | `track2`

uimaptbx

Handle buttondown callbacks for objects on axesm-based map

Activation

set the ButtonDownFcn property to 'uimaptbx'

Description

uimaptbx processes mouse events for mapped objects. uimaptbx can be assigned to an object by setting the ButtonDownFcn to 'uimaptbx'. This is the default setting for all objects created with Mapping Toolbox functions.

If uimaptbx is assigned to an object, the following mouse events are recognized: A single-click and hold on an object displays the object tag. If no tag is assigned, the object type is displayed. A double-click on an object activates the **Property Inspector**. An extend-click on an object activates the Projection Control dialog box, which allows the map projection and display properties to be edited. An alternate-click on an object allows basic properties to be edited using simple mouse clicks and drags.

Definitions of extend-click and alternate-click on various platforms are as follows:

For MS-Windows:	Extend-click - Shift +click left button or both buttons
	Alternate-click - Ctrl +click left button or right button
For X-Windows:	Extend-click - Shift +click left button or middle button
	Alternate-click - Ctrl + click left button or right button

Version History

Introduced before R2006a

See Also

axesm | axesmui | property editors

utmzoneui

Choose or identify UTM zone by clicking map

Activation

Command Line

```
utmzoneui
```

```
utmzoneui(InitZone)
```

Description

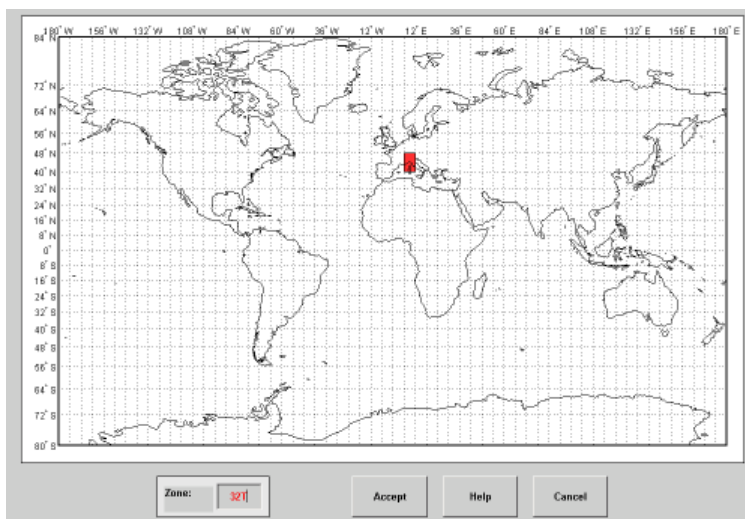
`zone = utmzoneui` opens a graphical user interface for choosing a UTM zone on a world display map. You select a zone by clicking an area for its appropriate zone, or entering a valid zone to identify the zone on the map.

`zone = utmzoneui(InitZone)` initialize the map displayed to the zone character vector specified in `InitZone`.

To interactively pick a UTM zone, activate the interface, and then click any rectangular zone on the world map to display its UTM zone. The selected zone is highlighted in red and its designation is displayed in the **Zone** edit field. Alternatively, type a valid UTM designation in the **Zone** edit field to select and see the location of a zone. Valid zone designations consist of an integer from 1 to 60 followed by a letter from C to X.

Typing only the numeric portion of a zone designation will highlight a column of cells. Clicking **Accept** returns a that UTM column designation. You cannot return a letter (row designation) in such a manner, however.

Controls



Tips

The syntax of `utmzoneui` is similar to that of `utmzone`. If `utmzone` is called with no arguments, the `utmzoneui` interface is displayed for you to select a zone. Note that `utmzone` can return latitude-longitude coordinates of a specified zone, but that `utmzoneui` only returns zone names.

Version History

Introduced before R2006a

See Also

`utmgeoid` | `utmzone`

Topics

`ups`
`utm`

vmap0ui

(To be removed) UI for selecting data from Vector Map Level 0

Note The vmap0ui function will be removed in a future release. Use the vmap0read function instead.

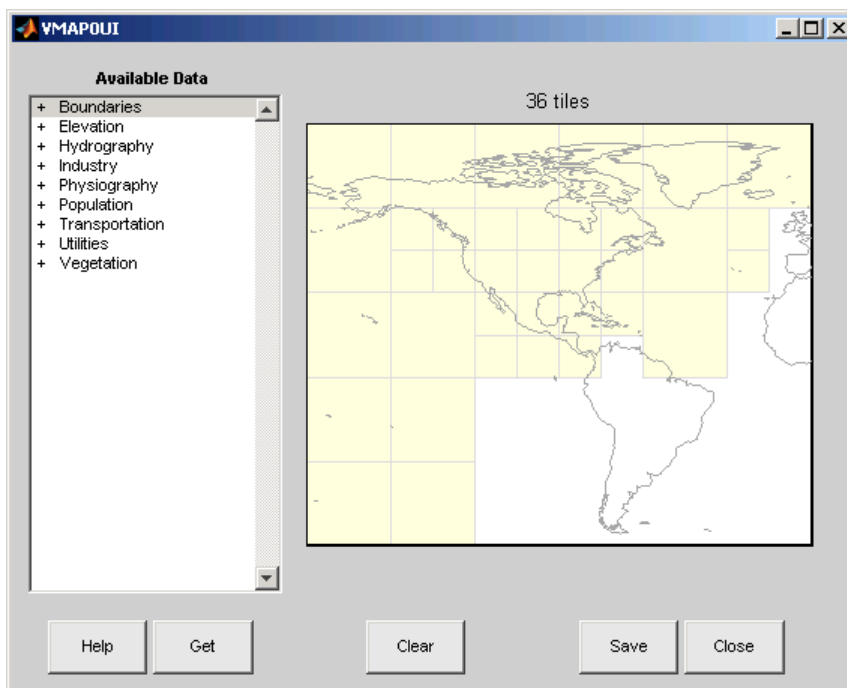
Description

vmap0ui(dirname) launches a graphical user interface for interactively selecting and importing data from a Vector Map Level 0 (VMAP0) data base. dirname is a character vector that specifies the folder containing the data base. For more on using vmap0ui, click the **Help** button after the interface appears.

vmap0ui(devicename) or vmap0ui devicename uses the logical device (volume) name specified in the character vector devicename to locate CD-ROM drive containing the VMAP0 CD-ROM. Under the Windows operating system it could be 'F:', 'G:', or some other letter. Under Macintosh OS X it should be '/Volumes/VMAP'. Under other UNIX systems it could be '/cdrom/'.

vmap0ui can be used on Windows without any arguments. In this case it attempts to automatically detect a drive containing a VMAP0 CD-ROM. If vmap0ui fails to locate the CD-ROM device, then specify it explicitly.

Controls



The `vmap0ui` screen lets you read data from the Vector Map Level 0 (VMAPO). The VMAPO is the most detailed world map database available to the public.

You use the list to select the type of data and the map to select the region of interest. When you click the **Get** button, data is extracted and displayed on the map. Use the **Save** button to save the data in a MAT-file or to the base workspace for later display. The **Close** button closes the window.

The Map

The **Map** controls the geographic extent of the data to be extracted. `vmap0ui` extracts data for areas currently visible on the map. Use the mouse to zoom in or out to the area of interest. Type `help zoom` for more on zooming.

The VMAPO divides the world into tiles of about 5-by-5 degrees. When extracting, data is returned for all visible tiles, including those parts of the tile that are outside the current view. The map shows the VMAPO tiles in light yellow with light gray edges. The data density is high, so extracting data for a large number of tiles can take much time and memory. A count of the number of visible tiles is above the map.

The List

The **List** controls the type of data to be extracted. The tree structure of the list reflects the structure of the VMAPO database. Upon starting `vmap0ui`, the list shows the major categories of VMAP data, called themes. Themes are subdivided into features, which consist of data of common graphic types (patch, line, point, or text) or cultural types (airport, roads, railroads). Double-click a theme to see the associated features. Features can have properties and values, for example, a railroad tracks property, with values single or multiple. Double-click a feature to see the associated properties and values. Double-clicking an open theme or feature closes it. When a theme is selected, `vmap0ui` gets all the associated features. When a feature is selected, `vmap0ui` gets all of that feature's data. When properties and values are selected, `vmap0ui` gets the data for any of the properties and values that match (that is, the union operation).

The Get Button

The **Get** button reads the currently selected VMAPO data and displays it on the map. Use the **Cancel** button on the progress bar to interrupt the process. For a quicker response, press the standard interrupt key combination for your platform.

The Clear Button

The **Clear** button removes any previously read data from the map.

The Save Button

The **Save** button saves the currently displayed VMAPO data to a MAT-file or the base workspace. If you choose to save to a file, you are prompted for a file name and location. If you choose to save to the base workspace, you are notified of the variable names that will be overwritten.

Data are returned as Mapping Toolbox display structures with variable names based on theme and feature names. You can update vector display structures to geographic data structures. For information about display structure format, see "Version 1 Display Structures" on page 1-319 in the reference page for `displaym`. The `updategeostruc` function performs such conversions.

Use `load` and `displaym` to redisplay the data from a file on an `axesm`-based map. To display the data in the base workspace, use `displaym`.

The Close Button

The **Close** button closes the `vmap0ui` panel.

Examples

- 1 Launch `vmap0ui` and automatically detect a CD-ROM on Microsoft Windows:

```
vmap0ui
```

- 2 Launch `vmap0ui` on Macintosh OS X (need to specify volume name):

```
vmap0ui('Volumes/VMAP')
```

Version History

Introduced before R2006a

R2022b: To be removed

Not recommended starting in R2022b

The `vmap0ui` function runs without warning, but will be removed in a future release. Use the `vmap0read` function instead.

See Also

`vmap0read` | `displaym` | `vmap0data`

zdatam-ui

GUI to adjust z-plane of mapped objects on axesm-based map

Activation

Command Line

```
zdatam
zdatam(h)
zdatam(str)
```

Description

`zdatam` brings up a Select Object dialog box for selecting mapped objects and adjusting their `ZData` property. Upon selecting the objects, the Specify Zdata dialog box is activated, in which the new `ZData` variable is entered. Note that not all mapped objects have the `ZData` property (for example text objects).

`zdatam(h)` activates the Specify Zdata dialog box for the objects specified by the handle `h`.

`zdatam(str)` activates the Specify Zdata dialog box for the objects identified by `str`, where `str` is any of the character vectors recognized by `handlem`.

Controls



Select Object Dialog Box

The scroll box is used to select the desired objects from the list of mapped objects. Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the **OK** button activates another Specify Zdata dialog box. Pushing the **Cancel** button aborts the operation without changing any properties of the selected objects.



Specify ZData Dialog Box

The **Zdata Variable** edit box is used to specify the name of the `ZData` variable. Pressing the **List** button produces a list of all current workspace variables, from which the `ZData` variable can be selected. A scalar value or a valid MATLAB expression can also be entered. Pressing the **Apply** button changes the `ZData` property of all selected objects to the new values. Pressing the **Cancel** button closes the Specify ZData dialog box without changing the `ZData` property of the selected objects.

Version History

Introduced in R2007a

See Also

zdatam