

# Mapping Toolbox Release Notes

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## Summary by Version

This table provides quick access to what's new in each version. For clarification, see "About Release Notes" on page 2.

<b>Version (Release)</b>	<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>	<b>Related Documentation at Web Site</b>
<b>Latest Version V2.4 (R2006b)</b>	Yes Details	Yes Summary	Bug Reports includes fixes	Printable Release Notes: PDF  Current product documentation
V2.3 (R2006a)	Yes Details	Yes Summary	Bug Reports includes fixes	No
V2.2 (R14SP3)	Yes Details	Yes Summary	Bug Reports includes fixes	No
V2.1 (R14SP2)	Yes Details	Yes Summary	Bug Reports includes fixes	No
V2.0.3 (R14SP1)	Yes Details	Yes Summary	Fixed bugs	No
V2.0.2 (R14)	Yes Details	No	No bug fixes	No
V2.0.1 (R13SP1+)	Yes Details	No	Fixed Bugs	Version 2.0.1 product documentation
V2.0 (R13SP1+)	Yes Details	Yes Summary	Fixed Bugs	No
V1.3.1 (R13SP1)	Yes Details	No	Fixed Bugs	No

V1.3 (R13)	Yes Details	No	Fixed bugs	No
V1.2 (R12)	Yes Details	No	No bug fixes	No

## About Release Notes

Use release notes when upgrading to a newer version to learn about new features and changes, and the potential impact on your existing files and practices. Release notes are also beneficial if you use or support multiple versions.

If you are not upgrading from the most recent previous version, review release notes for all interim versions, not just for the version you are installing.

## New Features and Changes

These include

- New functionality
- Changes to existing functionality
- Changes to system requirements (complete system requirements for the current version are at the MathWorks Web site)
- Any version compatibility considerations associated with each new feature or change

## Version Compatibility Considerations

When a new feature or change introduces a known incompatibility with the previous version, its description includes a **Compatibility Considerations** subsection that details the impact. For a list of all new features and changes that have compatibility impact, see the “Compatibility Summary for Mapping Toolbox” on page 56.

Compatibility issues that become known after the product has been released are added to Bug Reports at the MathWorks Web site. Because bug fixes can sometimes result in incompatibilities, also review fixed bugs in Bug Reports for any compatibility impact.

## Fixed Bugs and Known Problems

MathWorks Bug Reports is a user-searchable database of known problems, workarounds, and fixes. The MathWorks updates the Bug Reports database as new problems and resolutions become known, so check it as needed for the latest information.

Access Bug Reports at the MathWorks Web site using your MathWorks Account. If you are not logged in to your MathWorks Account when you link to Bug Reports, you are prompted to log in or create an account. You then can view bug fixes and known problems for R14SP2 and more recent releases.

The Bug Reports database was introduced for R14SP2 and does not include information for prior releases. You can access a list of bug fixes made in prior versions via the links in the summary table.

## Related Documentation at Web Site

**Printable Release Notes (PDF).** You can print release notes from the PDF version, located at the MathWorks Web site. The PDF version does not support links to other documents or to the Web site, such as to Bug Reports. Use the browser-based version of release notes for access to all information.

**Product Documentation.** At the MathWorks Web site, you can access complete product documentation for the current version and some previous versions, as noted in the summary table.

## Version 2.4 (R2006b) Mapping Toolbox

This table summarizes what's new in Version 2.4 (R2006b):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>	<b>Related Documentation at Web Site</b>
Yes Details below	Yes— Details in <b>Changes in Behavior of mapshow and geoshow</b> below. See also Summary.	Bug reports at Web site	Printable Release Notes: PDF  Current product documentation

New features and changes introduced in this version are

- “Standard Formulations of Five Major Map Projections” on page 4
- “Two New Geodetic/Geocentric Latitude Conversion Functions” on page 5
- “Accelerated Performance for geoshow, mapshow, and bufferm” on page 5
- “Changes in Behavior of mapshow and geoshow” on page 5
- “dted Automatically Fixes Incorrectly Specified Longitude Directions in DTED Data” on page 8

### Standard Formulations of Five Major Map Projections

New formulations of five conic map projections are provided. The existing implementations remain available under their old names. The new versions use the same names as the ones they supplement, appended with “std”:

- Cassini Transverse Cylindrical (cassinistd)
- Albers Equal-Area Conic (eqaconicstd)
- Equidistant Conic (eqdconicstd)
- Lambert Conformal Conic (lambertstd)
- Polyconic (polyconstd)

Computations used for the new versions differ from the old ones only when the latitude origin (the first element of the *origin vector*) is nonzero. In this case, the old versions shift the origin off the equator through a solid body rotation of the sphere (or, for an ellipsoidal earth model, a suitable auxiliary sphere). This is technically correct, but differs from accepted industry standards for these projections. The new versions use the standard formulations and give results that are consistent with projection results from other software packages, regardless of the latitude origin. The old versions are retained in the toolbox, with no change in behavior, to ensure backward compatibility.

See the Projections Reference documentation for more information.

## Two New Geodetic/Geocentric Latitude Conversion Functions

Two new functions provide a more direct route to functionality already available via the `convertlat` function:

- `geocentric2geodeticlat` converts an array of geocentric latitude in radians to geodetic latitude in radians on a reference ellipsoid given a first eccentricity
- `geodetic2geocentriclat` converts an array of geodetic latitude in radians to geocentric latitude in radians on a reference ellipsoid given a first eccentricity.

## Accelerated Performance for `geoshow`, `mapshow`, and `bufferm`

Functions `geoshow`, `mapshow`, and `bufferm` run substantially faster in many cases, especially when vector display is being controlled via symbol specs in `mapshow` and `geoshow`.

## Changes in Behavior of `mapshow` and `geoshow`

In addition to operating faster, the `mapshow` and `geoshow` functions now behave slightly differently regarding their defaults, handles returned, warnings issued, and several other aspects:

### Default Symbols and Colors

- Point marker type changes from 'X' to '+'

- Point marker color changes from 'black' to 'red'
- Line color changes from 'black' to 'blue'
- Polygon facecolor changes from 'black' to pale yellow

Polygon edgecolor remains 'black'

### **Contour DisplayType Behavior Changes**

- The `DisplayType` option 'contour' now returns an `hggroup` handle. The children of the `hggroup` are patches. In prior versions, an array of line handles was returned.
- You can specify any `contourgroup` property as a parameter value pair. In previous versions, `mapshow` allowed you to set the `LineStyle` property, but no other contour properties.
- Both `mapshow` and `geoshow` might return a different number of contour levels by default than in previous versions, in which you could not specify contour intervals; in R2006b, you can control contour intervals and levels via the `LevelStep` or `LevelList` `contourgroup` properties, among others.
- In R2006b, when plotting contours on a regular axes (not a map axes), `geoshow` projects the contour lines using a Plate Carree projection; in previous versions it simply displayed longitudes as  $x$  and latitudes as  $y$  without doing any trimming or longitude wrapping.

### **Graphic Objects and Return Values for Vector Inputs**

- Vector coordinate array input ( $x$ - $y$  or latitude-longitude pairs) with a `DisplayType` of 'Line' or 'Point' now generates an ordinary line object instead of a map graphics line.
- For `geostruct` input, an `hggroup` object is constructed; its handle is returned instead of an array of handles to map graphic objects:
  - For polygon `geostructs`, map graphics polygon objects are still constructed, but become children of the `hggroup`.
  - For point, multipoint, and line `geostructs`, the children of the `hggroup` are ordinary line objects; map graphics objects are no longer constructed.

In both cases each child of the `hggroup`, rather than each element in an array of handles, corresponds to a distinct feature in the `geostruct`.

## Handles Returned for Graphic Objects

- Geostruct inputs result in an hggroup handle containing either line objects (for point, multipoint, and line inputs) or modified patch objects (for polygon inputs) as their children.
- Coordinate arrays ( $x,y$  pairs) displayed as lines now result in ordinary line objects.
- Geostructs containing lines result as ordinary line objects within hggroups.

## New Warnings Issued

- mapshow and geoshow now warn when given a geostruct within which the Geometry field differs from a specified 'DisplayType' parameter.
- mapshow will warn if it is given a geostruct containing Lat and Lon fields instead of X and Y fields.
- geoshow will warn if it is given a geostruct containing X and Y fields instead of Lat and Lon fields.

## geoshow Supplies Default Projection

geoshow now projects vector and raster inputs using a default projection (Plate Carree) if the parent axes is not a map axes. The axes itself is unchanged (it is not modified to become a map axes), but the scale factor of the projection is set such that latitudes and longitudes in degrees can be read directly from the axes ticks and grid lines.

## Duplicate Parameter/Value Pair Inputs Allowed

mapshow no longer errors or warns if given duplicate Parameter/Value pair inputs; in such circumstances, mapshow now uses the last value (even with SymbolSpecs)

## geoshow Supports True Surface Display

geoshow now creates a true 3-D surface if given a 'surface' DisplayType rather than setting the ZData values to 0.

## Texturemap DisplayType Behavior Changes

The 'texturemap' DisplayType now uses the pixel edges to create XData and YData grids rather than using the pixel centers, which correctly registers the

display to map coordinates. The ZData contains an array of zeros having the same dimensions as the XData and YData arrays, which exceed the input grid in size by one in both the  $x$  and  $y$  dimensions.

You should use 'texturemap' displays when the attribute being displayed is coded by color (i.e. 2-D displays); use 'surface' displays when you need to show data with relief (nonzero ZData).

### **More General Support for Graphics Properties**

All Handle Graphics<sup>®</sup> patch properties are now supported for polygon inputs.

All Handle Graphics line properties are now supported for point and line inputs, except that 'linestyle' is ignored for point inputs.

### **Limitations on Referencing Matrices for Geoshow Removed**

geoshow is now capable of accepting any referencing matrix. Previously it could only accept those referencing matrices that were convertible to referencing vectors.

### **mapshow and geoshow Ignore Empty Inputs Rather than Erroring**

In previous versions, mapshow and geoshow would throw errors when provided with empty ([]) arrays. This behavior could be inconvenient when running these functions via scripts. The new behavior is also more consistent with that of MATLAB plotting functions such as plot, surf, mesh, and contour.

### **dted Automatically Fixes Incorrectly Specified Longitude Directions in DTED Data**

Some DTED level 0 files available via the National Geospatial-Intelligence Agency's (NGA) web interface may have minor errors. Specifically, Level 0 data for cells just to the east of the prime meridian may have longitude coordinate strings with 'W' substituted for 'E'. The dted function now detects and automatically corrects this data error.



## Version 2.3 (R2006a) Mapping Toolbox

This table summarizes what's new in Version 2.3 (R2006a):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>	<b>Related Documentation at Web Site</b>
Yes Details below	Yes— Details in <b>GeoTIFF Compatibility Considerations</b> below. See also Summary.	Bug reports at Web site	Printable Release Notes: PDF  Current product documentation

New features and changes introduced in this version are

- Full Support for 64-Bit Windows
- Third-Party Library and Code Upgrades
- Support for 32-Bit Floating-Point GeoTIFF Images
- Utility Functions for NaN-Separated Polygons and Lines
- Standardized Vector Topology in coast.mat
- Three New Demos

### Full Support for 64-Bit Windows

Version 2.3 adds support for the mex- and library-based functions `geotiffinfo`, `geotiffread`, `sdtsinfo`, and `sdtsdemread` on this new MATLAB<sup>®</sup> platform via library upgrades (described below) and a custom port of STDS++.

### Third-Party Library and Code Upgrades

Third-party libraries and software packages have been upgraded to their current versions to ensure best performance and compatibility with external geospatial data sources and applications software:

- General Polygon Clipper (GPC) upgraded to Version 2.32

- PROJ.4 library upgraded to Version 4.4.9
- SDTS++ library upgraded to Version 1.5.1
- GeoTIFF library upgraded to Version 1.2.2

## Support for 32-Bit Floating-Point GeoTIFF Images

The MATLAB function `imread` can now import TIFF images containing 32-bit floating-point data. As a result, `geotiffread` now reads the corresponding variety of GeoTIFF.

## GeoTIFF Compatibility Considerations

The structure returned by `geotiffinfo` in V. 2.3 has changed. The following table describes the differences between the current and previous versions:

Version 2.3	Previous Versions
The <code>TiePoints</code> structure contains two substructures, <code>ImagePoints</code> and <code>WorldPoints</code> . <code>ImagePoints</code> contains [1-by-N] arrays <code>Row</code> and <code>Col</code> ; <code>WorldPoints</code> contains [1-by-N] arrays <code>X</code> and <code>Y</code> .	The <code>TiePoints</code> structure contained two [3-by-1] arrays, <code>ImagePoints</code> and <code>WorldPoints</code> .
The <code>CornerCoords</code> structure contains six [1-by-4] row vectors, respectively, <code>X</code> , <code>Y</code> , <code>Col</code> , <code>Row</code> , <code>Lat</code> , and <code>Lon</code> .	The <code>CornerCoords</code> structure contained six [4-by-1] column vectors: <code>PCSX</code> , <code>PCSY</code> , <code>X</code> , <code>Y</code> , <code>LAT</code> , and <code>LON</code> .
The <code>Zone</code> field contains [] if the UTM zone is not applicable or was missing from the metadata.	The <code>Zone</code> field contained 32767 if the UTM zone was not applicable or was missing from the metadata.

## Utility Functions for NaN-Separated Polygons and Lines

### `closePolygonParts`

Closes all rings in a multipart polygon to ensure proper analysis and rendering.

### **isShapeMultipart**

Boolean-valued function that returns true if a polygon or line has multiple parts.

### **removeExtraNaNSeparators**

Eliminates redundant NaN separators that might exist in polygons and lines.

## **Standardized Vector Topology in coast.mat**

Polygons in the low-resolution coastline sample data file `coast.mat` now follow the convention used by `geoshow`, `mapshow`, and `mapview` to display polygons with “holes” (inner rings representing lakes, inland seas, and islands within them). Outer contours now always run clockwise and inner contours run counterclockwise. These edits, which reversed the order of vertices in some rings, enable the display functions to fill outer rings properly while leaving inner rings blank.

## **Three New Demos**

If you are viewing these release notes using the Help browser, clicking any of the demo links below will open the demo in a browser window. Click the links at the top of that window to view or run the M-code for the demo.

### **Converting Coastline Data (GSHHS) to Shapefile Format**

Shows how to extract coastlines from the Global Self-consistent Hierarchical High-resolution Shorelines (GSHHS) data set, manipulate the polygon features, and save the result to a polygon shapefile.

### **Plotting a 3-D Dome as a Mesh Over a Globe**

Illustrates how to construct a 3-D feature in a system of local vertical coordinates, then transform and combine it with a globe display in Earth-Centered, Earth-Fixed (ECEF) coordinates.

### **Unprojecting a Digital Elevation Model (DEM)**

Shows how to unproject a georeferenced terrain elevation grid from Universal Transverse Mercator (UTM) into a regular latitude-longitude grid having comparable spatial resolution.

## Version 2.2 (R14SP3) Mapping Toolbox

This table summarizes what's new in Version 2.2 (R14SP3):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>	<b>Related Documentation at Web Site</b>
Yes Details below	Yes— Details in <b>“Compatibility Considerations”</b> below. See also Summary.	Bug reports at Web site	Current product documentation

New features and changes introduced in this version are

- “Geodetic-Geocentric Coordinate Conversion Functions” on page 12
- “Additional User Control Over Shapefile Content” on page 12
- “Shapefile Read/Write Efficiency Enhanced” on page 13
- “Improved Rendering of Polygons with Inner Rings” on page 13
- “Map Viewer Now Georeferences Images It Saves” on page 13
- “TIGER/Line File Support Upgraded” on page 14

### Geodetic-Geocentric Coordinate Conversion Functions

New three-dimensional coordinate conversion functions (`geodetic2ecef`, `ecef2geodetic`, `ecef2lv`, `lv2ecef`) transform 3-D point locations between geodetic (latitude, longitude, height), geocentric Cartesian (Earth Centered, Earth Fixed), and local vertical Cartesian coordinate systems.

### Additional User Control Over Shapefile Content

Function `shapewrite` now allows user control over field names, lengths, and decimal precision when writing feature attributes to the DBF file, via a “DBF specification.” The new function `makedbfspec` constructs a default DBF

specification from a geographic data structure (`geostruct2`) array. Users can customize the output and pass it to `shapewrite`.

## Shapefile Read/Write Efficiency Enhanced

Improved implementations of functions `shaperead` and `shapewrite` process data substantially faster (about four times faster for a 10-MB shapefile of major roads in Massachusetts).

## Improved Rendering of Polygons with Inner Rings

The Map Viewer (function `mapview`) and functions `mapshow` and `geoshow` now properly render polygons containing inner rings (e.g., lakes and inland seas within a continent, islands within a pond). Features in underlying layers “show through” inner rings because they are not obscured by the patch faces used to render the polygons.

## Compatibility Considerations

**Polygon Vertex Ordering Is Now Significant for Properly Rendering Filled Polygons.** The map display functions `geoshow`, `mapshow`, and `mapview` now require that coordinate vectors representing polygons have consistent directionality, such that

- Vertices defining outer rings (to be filled) be encoded in a *clockwise* direction.
- Vertices defining inner rings (often termed “lakes” or “islands,” to be rendered as transparent holes) be encoded in a *counterclockwise* direction.

If you have vector map data sets that violate these conditions, the map display functions `geoshow`, `mapshow`, and `mapview` might not be capable of rendering them as filled polygons. To determine the directionality of polygon vertices, use the logical function `ispolycw`, which returns a separate result for each NaN-delimited polygon in an array of vertices. If you find inner rings which are clockwise or outer rings which are counterclockwise, use the utility functions `poly2ccw` or `poly2cw`, respectively, to reverse the direction of those rings.

## Map Viewer Now Georeferences Images It Saves

When the Map Viewer saves the visible or selected area as a raster map (an image file), it now also writes a worldfile to georeference the image.

## **TIGER/Line File Support Upgraded**

Function `tgrLine` now supports the most recent (2003/2004) TIGER/Line data sets from the U.S. Bureau of the Census.

## Version 2.1 (R14SP2) Mapping Toolbox

This table summarizes what's new in Version 2.1 (R14SP2):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>	<b>Related Documentation at Web Site</b>
Yes Details below	Yes— Details labeled as <b>Compatibility Considerations</b> below. See also Summary.	Bug reports at Web site	Current product documentation

New features and changes introduced in this version are

- “New Function Reads Both 5-Minute and 2-Minute ETOPO Data” on page 15
- “Function gshhs Now Returns a Version 2 Geostruc” on page -16
- “Geodata Can Now Be Exported in Shapefile Format” on page 16
- “Accessing Geodata Resources on the Internet” on page 16
- “Compatibility Considerations for Atlas Data and Associated Functions” on page 17
- “Compatibility Considerations for worldmap and usamap” on page 18
- “Data Files Added in This Release” on page 23
- “Atlas Data MAT-Files Removed in This Release” on page 24
- “Functions Deleted in This Release” on page 25
- “Functions Made Obsolete in This Release” on page 25

### **New Function Reads Both 5-Minute and 2-Minute ETOPO Data**

The new function `etopo` reads from either the 5-minute (ETOPO5) or the 2-minute (ETOPO2) global terrain data set. This function supersedes function `etopo5` and fixes several significant bugs.

## Function `gshhs` Now Returns a Version 2 `Geostruct`

Function `gshhs`, which reads the Global Self-consistent Hierarchical High-resolution Shoreline data set, has been upgraded. It now returns a Version 2 geographic data structure (`geostruct2`) array instead of a Version 1 `geostruct`. Polygons returned from `gshhs` now follow the shapefile vertex-ordering convention (supported by functions `polybool`, `shaperead`, and `shapewrite`, for example). Under this convention the coordinates of outer rings (e.g., continent outlines) are given in clockwise order, while counterclockwise ordering is used for inner rings (e.g., lakes and inland seas within a continent). Note that function `gshhs` does not yet support Version 1.3 of the data set, released on Sept. 27, 2004.

## Geodata Can Now Be Exported in Shapefile Format

The new function `shapewrite` writes a geographic data structure to a shapefile. It exports a Version 2 geographic data structure array (`geostruct2`), creating `.shp`, `.shx`, and `.dbf` files. Like `shaperead`, the function supports the `Point`, `MultiPoint`, `PolyLine`, and `Polygon` shape types. The contents of string-valued attribute fields and scalar numerical attribute fields are written to the dBase (`.dbf`) file.

## Accessing Geodata Resources on the Internet

Links and URLs to documentation and data files for various Internet sources of digital map data are now collected in the following technical note on the MathWorks Web site:

<http://www.mathworks.com/support/tech-notes/2100/2101.html>

This technical note replaces many individual links formerly scattered across the User's Guide, reference pages, and M-file help. Collecting this information on a Web page rather than on product CDs or printed documentation should substantially mitigate recurrent problems with stale links. Please report any stale links that you might find in the technical note to MathWorks Technical Support ([http://www.mathworks.com/contact\\_TS.html](http://www.mathworks.com/contact_TS.html)), so that it can be updated promptly.



## Compatibility Considerations for Atlas Data and Associated Functions

Through Version 2.0.3, the Mapping Toolbox included a set of *atlas data* with global geopolitical data embedded as MATLAB arrays in four MAT-files: `worldlo`, `worldhi`, `worldmtx`, and `worldmtxmed`. However, geopolitical data is difficult to keep current, and is subject to inaccuracies and interpretations that can cause contention. Therefore, starting with Version 2.1, the Mapping Toolbox now excludes geopolitical data that would specify national sovereignty over specific regions of the Earth. The only exceptions are the boundaries of the 50 U.S. states and the District of Columbia.

This change means that the `worldlo`, `worldhi`, `worldmtx`, and `worldmtxmed` MAT-files are no longer part of the Mapping Toolbox. However, the nonpolitical data on global coastlines, major lakes and inland seas, major rivers, and major cities and populated places that was in `worldlo.mat` has been retained in the toolbox and transformed into shapefile format. This includes the addition of name attributes for many previously unnamed features. There are four new shapefiles in this category: `landareas.shp`, `worldlakes.shp`, `worldrivers.shp`, and `worldcities.shp`.

For consistency, the atlas data for the United States that was originally stored in the `usalo` and `usahi` MAT-files has also been transformed, although none has been removed. These data sets now reside in the following shapefiles and MAT-files: `usastatelo.shp`, `usastatehi.shp`, `conus.mat`, and `greatlakes.mat`.

The Mapping Toolbox originally included four functions dedicated to extracting data from the atlas data MAT-files: `worldlo`, `worldhi`, `usalo`, and `usahi`. With the data removal/transformation described above, these functions are no longer needed and have been removed from the toolbox in Version 2.1. You can easily access the new shapefiles using the `shaperead` function, which includes powerful and flexible options for selecting features and even controlling which attributes are read. In addition, function `country2mtx`, whose sole purpose was to rasterize the country boundary polygons in `worldlo.mat`, has been removed.

Related changes extend to the `worldmap` function, which formerly combined two purposes:

- Select an appropriate map projection and parameters with which to display a given latitude-longitude area.
- Automatically display atlas data for that area.

In Version 2.1, `worldmap` supports only the first of these actions. A call to `worldmap` constructs a map axes object and can easily be followed with a variety of Mapping Toolbox commands to display the map data of your choice. Because the `usamap` function is so similar to `worldmap`, corresponding changes have been made there as well.

To help those who have relied heavily on `worldmap` and `usamap` to plot base maps with automatically selected vector map data, examples throughout the User's Guide, reference pages, and M-file Help entries have been updated to illustrate the new behavior of `worldmap` and `usamap`, and to show how to create maps including vector shapefile data layers. These examples cover a wide variety of ways to read and subset data with `shaperead` and display data with `geoshow` and other Mapping Toolbox display functions. A good place to start is with the examples for the `worldmap` and `usamap` functions. Also see example code in "Changes to `worldmap` and `usamap` Display Types" on page 19.

To help you update commands, scripts, and data for constructing and maintaining base maps, a recently published technical note on the MathWorks Web site provides links to data and documentation for many sources of vector and raster digital map data that you can access over the Internet:

<http://www.mathworks.com/support/tech-notes/2100/2101.html>

## **Compatibility Considerations for `worldmap` and `usamap`**

`worldmap` and `usamap` have been simplified to construct appropriate map axes for a given area without displaying any map data.

In all cases, map frames, latitude-longitude grid lines, meridian labels, and parallel labels are turned on. You can use the following command sequence to remove them:

```
framem off; gridm off; mlabel off; plabel off
```

Other changes include the following:

- `usamap` now accepts two-letter U.S. Postal Service abbreviations for state names (e.g., AL, AK, AR, etc.).
- The following input options are now obsolete (if used, a warning is issued):
  - A first argument equal to 'lo' or 'hi'

- The `regiononly` and `stateonly` syntax: a state or country name with the string `'only'` appended
- All type options: `'none'`, `'line'`, `'lineonly'`, `'patch'`, `'patchonly'`, `'mesh'`, `'meshonly'`, `'dem'`, `'demonly'`, `'dem3d'`, `'dem3donly'`, `'lmesh3d'`, `'lmesh3donly'`, `'ldem3d'`, and `'ldem3donly'` (the new behavior matches the `'none'` option)

### Changes to `worldmap` and `usamap` Display Types

As of this release, the `worldmap` and `usamap` functions no longer supports the `type` input argument. This argument provided an easy way to control display behavior.

The `type` option in `worldmap` was a single argument that could be one of the following strings: `'none'`, `'line'`, `'lineonly'`, `'patch'`, `'patchonly'`, `'mesh'`, `'meshonly'`, `'dem'`, `'demonly'`, `'dem3d'`, `'dem3donly'`, `'lmesh3d'`, `'lmesh3donly'`, `'ldem3d'`, and `'ldem3donly'`. In `usamap`, `type` was a subset of the above names (the 3-D options were not supported).

In the current release, the various `type` display options can be simulated by following a call to `worldmap` or `usamap` with an appropriate set of Mapping Toolbox commands. The following table specifies how you can achieve the effects of the old `worldmap type` argument using such auxiliary methods:

Mapping 1.x to 2.0.x Usage	Mapping 2.1 Usage
<pre>load topo worldmap(topo, ...          topolegend, 'dem')</pre>	<pre>load topo worldmap(topo, topolegend) meshm(topo, topolegend) demcmmap(topo) land = shaperead('landareas.shp',...          'UseGeoCoords', true); geoshow([land.Lat], [land.Lon])</pre>
<pre>load topo worldmap(topo, ...          topolegend, 'demonly')</pre>	<pre>load topo worldmap(topo, topolegend) meshm(topo, topolegend) demcmmap(topo)</pre>

<b>Mapping 1.x to 2.0.x Usage</b>	<b>Mapping 2.1 Usage</b>
<pre>load topo worldmap(topo, ...     topolegend, 'dem3d')</pre>	<pre>load topo worldmap(topo, topolegend) meshm(topo, topolegend,size(topo),topo) da = daspect; pba = pbaspect; da(3) = 7.5*pba(3)/da(3); daspect(da); demcmap(topo) land = shaperead('landareas.shp',...     'UseGeoCoords', true); geoshow([land.Lat], [land.Lon])</pre>
<pre>load topo worldmap(topo, ...     topolegend, 'dem3donly')</pre>	<pre>load topo worldmap(topo, topolegend) meshm(topo, topolegend,size(topo),topo) demcmap(topo)</pre>
<pre>load korea worldmap (map, refvec,...     'mesh')</pre>	<pre>load korea worldmap(map, refvec) meshm(map, refvec) land = shaperead('landareas.shp',...     'UseGeoCoords', true); geoshow([land.Lat], [land.Lon]) (Text North Korea and South Korea will be missing)</pre>
<pre>load korea worldmap(map, refvec,...     'meshonly')</pre>	<pre>load korea worldmap(map, refvec) meshm(map,refvec)</pre>

Mapping 1.x to 2.0.x Usage	Mapping 2.1 Usage
<pre>load topo worldmap(topo,... topolegend, 'mesh3d')</pre>	<pre>load topo worldmap(topo, topolegend) meshm(topo, topolegend,size(topo),topo) da = daspect; pba = pbaspect; da(3) = 7.5*pba(3)/da(3); daspect(da);</pre>
<pre>load topo worldmap... (topo,topolegend,... 'mesh3donly')</pre>	<pre>load topo worldmap(topo, topolegend) meshm(topo, topolegend,size(topo),topo)</pre>
<pre>load topo worldmap(topo,... topolegend, 'ldem3d')</pre>	<pre>load topo worldmap(topo, topolegend) meshm(topo, topolegend,size(topo),topo) da = daspect; pba = pbaspect; da(3) = 7.5*pba(3)/da(3); daspect(da); demcmap(topo) camlight(90,5); camlight(0,5); lighting phong material([0.25 0.8 0])</pre>
<pre>load topo worldmap(topo, ... topolegend,'ldem3donly')</pre>	<pre>load topo worldmap(topo, topolegend) meshm(topo, topolegend,size(topo),topo) da = daspect; pba = pbaspect; da(3) = 7.5*pba(3)/da(3); daspect(da); demcmap(topo)</pre>

Mapping 1.x to 2.0.x Usage	Mapping 2.1 Usage
<pre>load topo worldmap(topo,...     topolegend, 'lmesh3d')</pre>	<pre>load topo worldmap(topo, topolegend) meshm(topo,     topolegend,size(topo),topo) da = daspect; pba = pbaspect; da(3) = 2*pba(3)/da(3); daspect(da); camlight(90,5); camlight(0,5); lighting phong material([0.25 0.8 0])</pre>
<pre>load topo worldmap(topo,...     topolegend,...     'lmesh3donly')</pre>	<pre>load topo worldmap(topo, topolegend) meshm(topo,     topolegend,size(topo),topo) da = daspect; pba = pbaspect; da(3) = 2*pba(3)/da(3); daspect(da);</pre>
<pre>load korea worldmap(map, refvec,...     'line')</pre>	<pre>load korea worldmap(map, refvec) land = ...     shaperead('landareas.shp',...         'UseGeoCoords', true); geoshow([land.Lat], [land.Lon]) (Text North Korea and South Korea will be missing. Land area boundaries resolution is lower.)</pre>
<pre>load korea worldmap(map, refvec,...     'lineonly')</pre>	<pre>load korea worldmap(map, refvec) land = ...     shaperead('landareas.shp',...         'UseGeoCoords', true); geoshow([land.Lat], [land.Lon])</pre>

Mapping 1.x to 2.0.x Usage	Mapping 2.1 Usage
<pre>load korea worldmap(map, refvec,... 'none')</pre>	<pre>load korea worldmap(map, refvec)</pre>
<pre>load korea worldmap(map, refvec,... 'patch')</pre>	<pre>load korea worldmap(map, refvec) land = ... shaperead('landareas.shp',... 'UseGeoCoords', true); faceColors = ... makesymbolspec('Polygon',... {'INDEX', [1 numel(land)],... 'FaceColor', ... polcmap(numel(land))}); geoshow(land, 'SymbolSpec',... faceColors) (Text North Korea and South Korea will be missing. Country coloring will be missing.)</pre>
<pre>load korea worldmap(map, refvec,... 'patchonly')</pre>	<pre>load korea worldmap(map, refvec) land = ... shaperead('landareas.shp',... 'UseGeoCoords', true); faceColors =... makesymbolspec('Polygon',... {'INDEX', [1 numel(land)],... 'FaceColor', ... polcmap(numel(land))}); geoshow(land, 'SymbolSpec',... faceColors) (Country coloring will be missing.)</pre>

## Data Files Added in This Release

The following files were added to the mapdemos directory, for use in toolbox demos and examples:

- `landareas` — Polygon shapefile: global coastlines, both exterior and interior, including names for larger land masses
- `worldlakes` — Polygon shapefile: coastlines and names of major lakes and inland seas worldwide
- `worldrivers` — PolyLine shapefile: major world rivers and their names
- `worldcities` — Point shapefile: locations and names of major cities and populated places worldwide
- `usastate10` — Polygon shapefile: low-resolution outlines and names of the 50 U.S. states plus D.C.
- `usastate10` — Polygon shapefile: moderate-resolution outlines and names of the 50 U.S. states plus D.C.
- `conus` — MAT-file: Low-resolution latitudes and longitudes, in degrees, for the perimeter of the conterminous United States (CONUS), the Great Lakes, and interstate borders
- `greatlakes` — MAT-file: A Version 1 geographic data structure (`geostruct1`) with outlines and names for the Great Lakes of North America

## **Atlas Data MAT-Files Removed in This Release**

MAT-files containing Atlas Data have been removed in Version 2.1. Some of the data has been retained in a different form. The disposition of these data sets and variables is described below.

### **World MAT-File Data**

- `world10.mat`, which contained the following variables:
  - `DNline` — Data moved to `worldrivers.shp`
  - `DNpatch` — Data moved to `worldlakes.shp`
  - `POline` — Data removed from toolbox
  - `POtext` — Data removed from toolbox
  - `PPpoint` — Data moved to `worldcities.shp`
  - `PPtext` — Data moved to `worldcities.shp`
  - `gazette` — Data removed from toolbox
- `worldhi.mat` — Data removed from toolbox
- `worldmtx.mat` — Data removed from toolbox



- `worldmtxmed.mat` — Data removed from toolbox

### United States MAT-File Data

- `usalo.mat`, which contained the following variables (all retained):
  - `conus` — Data moved to `conus.mat`
  - `greatlakes` — Data moved to `greatlakes.mat`
  - `gtlakelat` — Data moved to `conus.mat`
  - `gtlakelon` — Data moved to `conus.mat`
  - `state` — Data moved to `usastatelo.shp`
  - `stateborder` — Data moved to `conus.mat`
  - `statelat` — Data moved to `conus.mat`
  - `statelon` — Data moved to `conus.mat`
  - `uslat` — Data moved to `conus.mat`
  - `uslon` — Data moved to `conus.mat`
- `usahi.mat` — Data moved to `usastatehi.shp`

### Functions Deleted in This Release

The following functions, which performed specific operations on Atlas Data sets, have been removed in Version 2.1:

- `country2mtx` — Create a raster map grid of a country from `worldlo` atlas data
- `usahi` — Return high-resolution vector atlas data for the United States
- `usalo` — Return vector atlas data for the United States
- `worldhi` — Return high-resolution vector atlas data for the world
- `worldlo` — Return vector atlas data for the world or oceans

### Functions Made Obsolete in This Release

- `etopo5` — Replaced by `etopo`. Use `etopo` instead.
- `tigerp` — Download U.S. Census cartographic boundary files in shapefile format and use `shaperead` instead.

- `tigermif` — Download U.S. Census cartographic boundary files in shapefile format and use `shaperead` instead.

## Version 2.0.3 (R14SP1) Mapping Toolbox

This table summarizes what's new in Version 2.0.3 (R14SP1):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>	<b>Related Documentation at Web Site</b>
Yes Details below	Yes Details in <b>“Compatibility Considerations”</b> below. See also Summary.	Fixed bugs	Current product documentation

The new features and changes introduced in this version are

### Polygon Vertex Ordering Functions

Four new functions have been added to Mapping 2.0.3. These are called by or can be used in conjunction with the `polybool` function (see “`polybool` Revised, Has New Helper Functions” on page 28.) Three of the functions check or change the ordering of vertices that define a polygon, and the fourth one splits polygons with holes in a consistent fashion.

These functions are

- `ispolycw` — True if vertices of polygonal contour are clockwise ordered
- `poly2cw` — Convert polygonal contour to clockwise ordering
- `poly2ccw` — Convert polygonal contour to counterclockwise ordering
- `poly2fv` — Convert polygonal region to face-vertex form for use with `patch` in order to properly render polygons containing holes

## Compatibility Considerations

### **axesm Does Not Reorder Longitude Limits**

Function `axesm` now requires that 'MapLonLimit' values have the form [west east], but east can be less than west numerically (e.g., [120 -60]). The form [east west] is no longer supported.

### **contourm Returns Contourgroup Handle**

Function `contourm` now returns a handle to a `contourgroup` object instead of an array of handles to line objects.

### **elevation Has New Azimuth Output**

Function `elevation` can now return a third output, the line-of-sight azimuth corresponding to the elevation angle (output 1) and slant range (output 2). This eliminates the need to use a geodesic or rhumb line azimuth, computed with functions `azimuth` or `distance`, as an approximate substitute.

### **gtopo30 Has New Options**

The functionality of `gtopo30` has been extended so that:

- Data can be read from a more general directory structure.
- Empty may be supplied in place of any input argument.
- Latitude and longitude limits are no longer restricted to lie within a tile. Instead, areas not covered by available data are automatically filled with NaNs.

### **inputm Has New Button Output**

`inputm` now has an optional third output argument, 'button', which functions like the third output of `ginput`.

### **polybool Revised, Has New Helper Functions**

Mapping 2.0.3 fixes major problems with the `polybool` function, which computes set operations on polygonal regions. The fixes include incompatible data structure and syntax changes.

- The 'cutvector' option has been removed from the syntax. This option facilitated plotting of polygonal regions containing holes, but the cutvector

computation was not robust, nor was it an effective way to represent polygonal regions containing multiply nested holes and/or discontinuous regions. To replace the `cutvector` functionality, a new function, `poly2fv`, has been added. `poly2fv` converts a polygonal region, possibly including holes and discontinuous regions, into a faces and a vertices matrix that can be used with the `patch` function to display the region. The M-file help for `polybool` and `poly2fv` contain examples illustrating how to use `poly2fv`.

- The `'cell'` and `'vector'` options have been removed from the syntax. `polybool` now returns the output polygonal region using the same format as the input polygonal region. Use `polysplit` and `polyjoin` to convert from one format to the other.
- `polybool` now uses the “clockwise” rule to distinguish between external polygonal contours and internal polygonal contours. This is the same rule used by ESRI shapefiles. `polybool` assumes that a polygonal contour whose vertices are arranged in clockwise order is an external contour, and that a polygonal contour whose vertices are arranged in counterclockwise order is an internal contour. Use `ispolycw` to determine whether a polygonal contour is clockwise ordered, and use `poly2cw` and `poly2ccw` to convert polygonal contours to be clockwise or counterclockwise ordered, respectively. If a polygonal region input has no external contours according to this rule, `polybool` issues a warning message.

An input polygonal region can either take the form of a pair of NaN-separated vectors, or it can take the form of a pair of cell arrays. In the cell array format, each cell must contain the vertices of a single polygonal contour. Representing a polygonal region as a cell array whose cells can contain NaN-separated vectors is no longer supported, and an error message will be issued.

**Summary of new `polybool`-related helper functions.** You can use the helper functions that support `polybool` for your own purposes. They are

- `ispolycw` — True if vertices of polygonal contour are clockwise ordered
- `poly2cw` — Convert polygonal contour to clockwise ordering
- `poly2ccw` — Convert polygonal contour to counterclockwise ordering
- `poly2fv` — Convert polygonal region to face-vertex form for use with `patch`

**Summary of known problems addressed.** The issues solved by the new implementation of `polybool` are

- `polybool` no longer errors out or produces incorrect results for proper inputs.
- `polybool` now produces consistent output when computing intersections, with results no longer depending on the order of its inputs.
- `polybool` now operates correctly on polygons with collinear edges.

### **polymerge Output Vertex Order Changes**

Improvements in the algorithm that `polymerge` uses to chain together adjacent polygon or line segments, required to address a bug and improve efficiency, in some cases also change the ordering of the output vertices.

## Version 2.0.2 (R14) Mapping Toolbox

This table summarizes what's new in Version 2.0.2 (R14):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>	<b>Related Documentation at Web Site</b>
Yes Details below	No	No bug fixes	Current product documentation

New features and changes introduced in this version are

### Mapping Toolbox Compilability Enhanced

Almost all Mapping Toolbox command line functions can be compiled using the new MATLAB Compiler. However, large Atlas Data MAT-files need to be added explicitly to use them in applications. For details, see “Using the Compiler with the Mapping Toolbox” in the MATLAB Compiler Release Notes.

### SDTS Functions Now Available on HP-UX

The input functions `sdtinfo` and `sdtsemread` are now available on the HP-UX platform.

## Version 2.0.1 (R13SP1+) Mapping Toolbox

This table summarizes what's new in Version 2.0.1 (R13SP1+):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
Yes Details below	No	Fixed bugs, below	V2.0.1 product documentation

The new feature introduced in this version is

### **mapexreg Demo (Georeferencing an Image to an Orthotile Base Layer) Generalized and Clarified**

Calls to `imtransform` and `makereformat` are no longer hard-coded for an output pixel size of one meter. The choice of output pixel size now is explained in detail.

### **Fixed Bugs**

Version 2.0.1 contains the following bug fixes:

#### **almanac**

Function `almanac` now gives a precise inverse flattening ( $1/f$ ) value for Bessel 1841 ellipsoid. Previously, `almanac` used a truncated value (299.1528) instead of the full precision value (299.1528128).

#### **axesm**

Function `axesm` now accepts the 'meridianlabel' parameter. Previously, `axesm` would throw an error if the 'meridianlabel' parameter was specified.

#### **distance**

Function `distance` now computes correct results for rhumb line distances along a parallel (including the equator) on a (nonspherical) ellipsoid.



**distance**

Function `distance` now uses the robust “haversine formula” to compute great circle distances on a sphere. For certain inputs roundoff sensitivities in the previous implementation resulted in a small, but nonzero, distance between identical points.

**distance**

Function `distance` now correctly obtains correct results for rhumb lines that follow the equator, or any other parallel, and cross the 180-degree meridian; it gives the distance along the short arc of the parallel. Previously the length of the long arc could be returned instead.

**distance, azimuth**

Functions `distance` and `azimuth` now produce accurate results even for long geodesics on an ellipsoid, up to near-antipodal distances.

**projfwd, projinv**

Functions `projfwd` and `projinv` now use NaN separators on all platforms. Previously, under certain circumstances, `projfwd` and `projinv` returned coordinate arrays with Inf separators rather than NaNs.

**reckon**

Function `reckon` now supports geodesics on an ellipsoid, in addition to rhumb lines on an ellipsoid and both geodesics and rhumb lines on a sphere.

## Version 2.0 (R13SP1+) Mapping Toolbox

This table summarizes what's new in Version 2.0 (R13SP1+):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>	<b>Related Documentation at Web Site</b>
Yes Details below	Yes— Details in <b>“Compatibility Considerations”</b> below. See also Summary.	Fixed Bugs, below	V2.0.1 product documentation

New features and changes introduced in this version are

- “New Demos and Sample Data” on page 35
- “New Map Viewer” on page 36
- “Spatially Referenced Image Formats” on page 38
- “Working with Images Referenced to Map Coordinates” on page 39
- “SDTS Terrain Data Access” on page 40
- “Shapefiles and Vector Features” on page 40
- “Geographic Data Structure Enhancements” on page 41
- “Attribute-Driven Vector Data Symbolization” on page 42
- “Access to PROJ.4 Map Projections” on page 42
- “Minor Enhancements” on page 42
- “Summary of Functions Added in Version 2.0” on page 43
- “Compatibility Considerations” on page 45
- “Functions Obsolete in Version 2.0” on page 45
- “Functions Deleted in Version 2.0” on page 46
- “Changes in Nomenclature” on page 46

## Release Summary

Mapping Toolbox 2.0 provides a comprehensive set of functions and graphical user interfaces for building map displays and performing geospatial data analysis in MATLAB. In this major release of the toolbox, new functions and capabilities include:

- Support for standard GIS and geospatial file formats:
  - ESRI shapefile; GeoTIFF; Arc ASCII Grid; SDTS Raster Profile (read only)
  - “Worldfiles” for spatially registered images (read and write)
- New display functions for vector features, georeferenced imagery, and data grids in  $x$ - $y$  map coordinates (as well as unprojected latitude-longitude)
- New functions for vector symbolization based on feature attributes
- Transverse Mercator projection and PROJ.4 projection library support
- A new interactive Map Viewer with the following features:
  - Support for multiple raster and vector layers
  - Data import from file or workspace
  - Zooming/panning/map navigation tools
  - Cursor coordinate and map-scale readout
  - Data tip and info tools
  - Graphical overlays
  - Map exporting/printing
- A major update of the Mapping Toolbox User’s Guide, focused on clarifying concepts and terminology, explaining features and functions, adding new and enhancing existing examples, and organizing and cross-referencing material to make the documentation easier to access

## New Demos and Sample Data

The Mapping Toolbox now has six new demos, available from the **Demos** tab of the Help Browser. You can also access this demos page by typing

```
mapdemos
```

The demos consist of the following:

- `mapexenhance` — Enhancing Multispectral GeoTIFF Images

- `mapexfindcity` — Interactive Global City Finder
- `mapexgeo` — Creating Maps using `geoshow` (for latitude, longitude data)
- `mapexmap` — Creating Maps using `mapshow` (for  $x, y$  data)
- `mapexrefmat` — Creating and Using Referencing Matrices
- `mapexreg` — Georeferencing an Image to an Orthotile Base Layer
- `viewmaps` — GUI Demonstrating Map Projections (not new in 2.0)

Note that the above commands run the demo scripts to produce figures, whereas `mapdemos` describes and illustrates the demos in the Help Browser.

In addition, a number of new sample data sets containing vector features, digital elevation models, and georeferenced images have been added for use in demos and examples. The new data includes satellite images of the Boston area, topographic grids of the White Mountains in New Hampshire, and vector data for roads and hydrographic features in the Boston area. The data sets are provided in standard geospatial and GIS formats: GeoTIFF, TIFF images with worldfiles, SDTS Raster Profile, Arc ASCII Grid, and ESRI shapefiles. They are accompanied by ASCII text files (with suffix `.txt`), containing descriptive metadata.

The new data files are in addition to existing sample data sets stored in MAT-files, such as `geoid`, `russia`, and `korea`. In addition, metadata indicating the source and describing the contents of most sample data and atlas data has been added to their respective MAT-files.

To read the metadata for a Mapping Toolbox MAT-file data set, load it and inspect the source and description workspace variables.

To read brief descriptions of the demos and sample data sets, type

```
help mapdemos
```

## **New Map Viewer**

The toolbox includes a new interactive tool for displaying and examining map data, called the Map Viewer. The Map Viewer helps you work with data that is already in a projected map coordinate system, which is the case for many high-resolution satellite and aerial imagery products, as well as many vector map data sets that cover small areas of the Earth in substantial detail. The Map Viewer gives you a view (or views) of an  $x$ - $y$  map coordinate plane where, for example,  $x$  and  $y$  may correspond to the easting and northing coordinates of

a given UTM or State Plane zone. If some of your data is referenced to geographic (latitude-longitude) coordinates, you first need to use an appropriate projection to transform it to map coordinates.

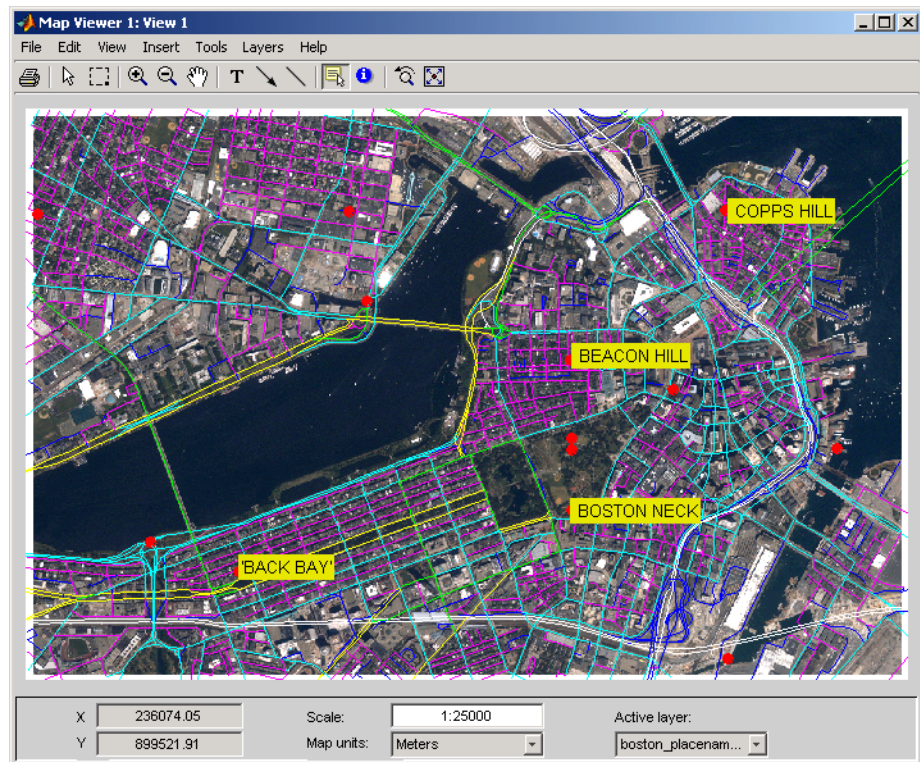
Key features of the Map Viewer include:

- A two-dimensional view of the  $x$ - $y$  map plane with interactive tools for navigating in that plane: magnification, de-magnification, panning, setting the map scale, and zooming the view to the extent of a given data set, or all data sets
- Vector and image data import from files or from the MATLAB workspace
- Management of each data set in a separate layer. You can control layer ordering and visibility to bring what you need into view.
- Multiple, simultaneous views (differing in scale or view extent) of the same data layers
- A data tip tool to identify vector shapes or query a feature attribute that you specify
- An info tool to display, in a separate window, all the attributes of a selected feature
- Tools to annotate the map with lines, arrows, and text
- Ability to export a raster snapshot of the map view

To start the Map Viewer, use the `mapview` function. Typing

```
mapview
```

will open a Map Viewer window. You can then import standard format files or load workspace data into the Map Viewer. The following figure shows the Map Viewer's main window after loading image, line, and point data sets, also illustrating user-specified symbology for streets and landmarks, and Data Tip labels for selected point features:



You can print maps as they appear in the Map Viewer window, to either a printer or a file. Either click the **Print** button on the left end of the toolbar or select **Print** in the **File** menu. A standard figure print dialog appears. You should consider selecting a driver appropriate to your printer; this may be necessary if you attempt to print in color.

## Spatially Referenced Image Formats

The toolbox adds support for several industry-standard formats for spatially referenced images and data grids: Arc ASCII Grid files, GeoTIFF files, and worldfiles. You do this by using the following new functions: `arcgridread`, `geotiffinfo`, `geotiffread`, `getworldfilename`, `worldfileread`, and `worldfilewrite`.

The grid and image file-reading functions construct referencing matrices, enabling a general and consistent approach to managing the relationship between map coordinates and pixel columns and rows (see below).

## Working with Images Referenced to Map Coordinates

The toolbox includes a family of functions supporting images and gridded data sets that are referenced to two-dimensional projected map coordinates. These functions represent the relationship between a point at position (row,col) in an image and point in map coordinates (x,y) with a *referencing matrix*. A referencing matrix is a 3-by-2 matrix, R, that represents a general affine transformation such that

$$[x \ y] = [\text{row} \ \text{col} \ 1] * R$$

Most often the image (or data grid) consists of square pixels and has edges that align with the map coordinate axes, but you are not limited to this situation.

The new function `makerefmat` provides several options for constructing referencing matrices from scratch. See its M-file help for further information. However, you can most often obtain a referencing matrix from a world file, via `worldfileread`, or from a GeoTIFF file via `geotiffread`. If you have created a new referencing matrix for an image in a generic image format such as TIFF or JPEG, you can save this information in a world file using `worldfilewrite`.

New functions `pix2map` and `map2pix` implement the basic transformation defined above, along with its inverse. With functions `mapbbox` and `mapoutline` you can calculate the image bounds or perimeter in map coordinates. You can use the function `pixcenters` to calculate the coordinates of the center of each image pixel. This is helpful if you have a data grid that you want to display using surface.

The new function `mapshow` accepts a referencing matrix in order to correctly position an image in a standard Handle Graphics<sup>®</sup> axes (i.e., not a map axes).

Because the affine transformation is extremely general, it can equally well represent the registration of an image to geographic coordinates, with longitude taking the place of map x and latitude replacing map y:

$$[\text{lon} \ \text{lat}] = [\text{row} \ \text{col} \ 1] * R$$

A referencing matrix is a more general version of the 1-by-3 map legend vector, perhaps better characterized as a *referencing vector*, that many toolbox functions already use. To convert a referencing vector to a referencing matrix, you can use function `refvec2mat`. The inverse transformation exists only for referencing matrices having a special form, but if it does you can compute it with `refmat2vec`. Functions `latlon2pix` and `pix2latlon` support transformations for referencing matrices in geographic coordinates, allowing for longitude-wrapping differences.

Use the new function `geoshow` along with map axes to display data grids referenced to latitude and longitude via either a referencing vector or a referencing matrix. Or, you can use the new function `grid2image` to quickly display an unprojected grid with latitude as the ordinate (*x*-axis) and longitude as the abscissa (*y*-coordinate).

## SDTS Terrain Data Access

The Mapping Toolbox can now import terrain grids stored in United States Spatial Data Transfer Standard (SDTS) raster profile format, giving you access to a wide selection of public domain terrain data sets, principally those prepared by the U.S. Geological Survey (USGS). USGS DEM data is no longer distributed from government Internet sites. Instead, these and other USGS files are now available from a commercial server at no charge. For further information, see <http://edc.usgs.gov/products/elevation/dem.html> and <http://edc.usgs.gov/geodata/>.

Two new Mapping Toolbox functions support SDTS data handling:

- `sdtsinfo` returns a structure containing metadata for an SDTS data set.
- `sdtsdemread` returns elevation data and a referencing matrix from an SDTS DEM data set.

For details, type `help sdtsinfo` or `help sdtsdemread` at the MATLAB prompt.

## Shapefiles and Vector Features

The toolbox now reads the shapefile format defined by Environmental Systems Research Institute (ESRI) and widely used as a data exchange format for nontopological GIS data. You can query a shapefile for its shapetype, attribute names and types, number of records, etc., using `shapeinfo`, and read 2-D shapes using `shaperead`. The `shaperead` function constructs a *geostruct2*



geographic data structure array (see “Geographic Data Structure Enhancements” on page 41 ), tailored to the contents read in from shapefiles.

The shape data is represented in MATLAB as a 1-D structure array, with one element per feature. Attribute values are stored in structure fields, or in a separate, parallel structure array. Because attributes are defined according to the needs of the shapefile author and might be unknown until the time a given shapefile is read, the new geographic data structures (described below) are necessarily more general than the geographic data structures already in use in the Mapping Toolbox.

## Geographic Data Structure Enhancements

Certain functions introduced in Version 2 of the Mapping Toolbox use an enhanced geographic data structure layout (called a *geostruct2*) to store and manipulate vector geodata. This layout has the flexibility to store any kind and number of attributes, and handles either geographic (latitude and longitude) or plane (*x* and *y*) coordinates. In contrast, a Version 1 geographic data structure (*geostruct1*) — which is still supported — is limited to a fixed set of fields and can contain geographic coordinates only.

One way to create a Version 2 geographic data structure is to input vector geodata to the workspace from a shapefile. The function `shaperead` returns a *geostruct2* that encapsulates some or all of the data stored in a shapefile and its supporting index and dBASE files. To determine what kinds of data a shapefile contains, you can use the `shapeinfo` function to query it.

The new functions `mapshow`, `geoshow`, and `mapview` each display vector data in *geostruct2* form. Use `geoshow` when `Lat` and `Lon` coordinate fields exist in the *geostruct*, and use `mapshow` or `mapview` when `X` and `Y` fields are present.

You can transform a *geostruct1* into a *geostruct2* (but not the reverse). Use the function `updategeostruct` for this purpose. See “Mapping Toolbox Geographic Data Structures” in the Mapping Toolbox documentation for descriptions of *geostruct* formats and uses.

Another new function, `extractfield`, lets you conveniently combine all the values of a given *geostruct* field into a single array. For example, given a shapefile with a 'Name' attribute, `extractfield` can output a cell array of feature names from the *geostruct* returned by `shaperead`.

## Attribute-Driven Vector Data Symbolization

When you display shape features as points, lines, or polygons using `mapview`, `mapshow`, and `geoshow`, you can make feature attributes control how they are symbolized. This lets the data control graphic attributes such as color, line width, marker symbol, and visibility on a per-feature basis. In prior versions of the toolbox, attribute-specific symbology was difficult to accomplish, but now a general mechanism exists for this purpose. The new function `makesymbolspec` generates a structure called a *symbolspec* that maps specific attribute values (or ranges) to symbology parameters, and lets you specify default parameters for unspecified values. For example, the following `symbolspec` colors all roads of `class` 1 red, all roads of `class` 2 green, all roads of `class` 3 blue, and defaults other classes to black (where `class` is an attribute of the road layer):

```
roadColors = makesymbolspec('Line',{ 'CLASS',1, 'Color','r'},...
                             { 'CLASS',2, 'Color','g'},...
                             { 'CLASS',3, 'Color','b'},...
                             { 'Default','Color','k'});
```

To see an example of what you can do with `symbolspecs`, look at the illustration for “New Map Viewer” on page 36. For details, type `help shaperead`, `help mapshow`, `help geoshow`, `help mapview`, or `help makesymbolspec` at the MATLAB prompt.

## Access to PROJ.4 Map Projections

The Mapping Toolbox now incorporates the PROJ.4 cartographic projections library, originally written by Gerald Evenden of the USGS. Currently the toolbox uses this library primarily to support the GeoTIFF format. You can access selected PROJ.4 projections and their inverses using new functions `projfwd` and `projinv`. Use the `projlist` function to learn about which PROJ.4 projections are available. In addition to accepting GeoTIFF info structures, `projfwd` and `projinv` also work with a standard map projection structure (`mstruct`) used to define projections within map axes.

## Minor Enhancements

In addition to the major new features just described, this release includes the following enhancements and new functions, among others.

**almanac**

Now accepts 'ellipsoid' as a synonym for 'geoid' as a parameter or reftbody value.

**convertlat**

A new function that unifies the latitude conversions previously dispersed among functions `geod2aut`, `aut2geod`, etc. For a list of the files it replaces, see “Functions Obsolete in Version 2.0” on page 45.

**geoloc2grid**

New function for converting a geolocated data grid (general matrix map) to a regular gridded data set (matrix map). Easier to use for this purpose than `imbedm`, and produces a smoother output with 2-D resampling.

**grid2image**

New function to display a regular data grid, with a referencing matrix or referencing vector, as an image. The grid can contain `double`, `uint8`, or `uint16` values. `grid2image` replaces the obsoleted function `imagem`.

**tranmerc**

A new map projection, Transverse Mercator, has been added. This is a general Transverse Mercator, as opposed to the more specific Universal Transverse Mercator supported by the `utm` function.

**unitsratio**

Provides conversion factors among units of length, and between radians and degrees. Supports a wider range of length units than `distdim`.

For information on using any of these functions, type `help function` at the MATLAB prompt.

**Summary of Functions Added in Version 2.0**

Version 2.0 features many new functions, all of which are itemized below. Several existing functions have been deprecated or deleted. These are described in “Functions Obsolete in Version 2.0” on page 45 and “Functions Deleted in Version 2.0” on page 46.

## Geospatial Data Import and Access

- `arcgridread` — Read a gridded data set in Arc ASCII Grid Format.
- `geotiffinfo` — Information about a GeoTIFF file
- `geotiffread` — Read a georeferenced image from GeoTIFF file.
- `getworldfilename` — Derive a worldfile name from an image file name.
- `sdtsemread` — Read data from an SDTS raster/DEM data set.
- `sdtinfo` — Information about an SDTS data set
- `shapeinfo` — Information about a shapefile
- `shaperead` — Read vector feature coordinates and attributes from a shapefile.
- `worldfileread` — Read a worldfile and return a referencing matrix.
- `worldfilewrite` — Construct a worldfile from a referencing matrix.

## Vector Map Data and Geographic Data Structures

- `extractfield` — Extract the field values from a structure.
- `updategeostruct` — Update a geographic data structure.

## Spatial Referencing of Georeferenced Images and Data Grids

- `latlon2pix` — Convert latitude-longitude coordinates to pixel coordinates.
- `makerefmat` — Construct an affine spatial-referencing matrix.
- `map2pix` — Convert map coordinates to pixel coordinates.
- `mapbbox` — Compute bounding box of a georeferenced image or data grid.
- `mapoutline` — Compute outline of a georeferenced image or data grid.
- `pix2latlon` — Convert pixel coordinates to latitude-longitude coordinates.
- `pix2map` — Convert pixel coordinates to map coordinates.
- `pixcenters` — Compute pixel centers for georeferenced image or data grid.
- `refmat2vec` — Convert a referencing matrix to a referencing vector.
- `refvec2mat` — Convert a referencing vector to a referencing matrix.
- `geoloc2grid` — Convert a geolocated data array to a regular data grid.

## Map Projection Properties and Transformations

- `geotiff2mstruct` — Convert GeoTIFF info to a map projection structure.
- `projlist` — List map projections supported by `projfwd` and `projinv`.
- `projfwd` — Forward map projection using the PROJ.4 library
- `projinv` — Inverse map projection using the PROJ.4 library
- `tranmerc` — Transverse Mercator Projection

## Map Display and Interaction

- `geoshow` — Display map latitude and longitude data.
- `grid2image` — Display a regular data grid as an image.
- `mapshow` — Display map data.
- `mapview` — Interactive map viewer
- `makesymbolspec` — Construct a vector symbolization specification.

## Geographic Calculations

- `convertlat` — Convert between geodetic and auxiliary latitudes.

## Utilities

- `ind2rgb8` — Convert an indexed image to a uint8 RGB image.
- `unitsratio` — Unit conversion factors

## Compatibility Considerations

The following changes affect compatibility between Version 2.0 and previous versions of the Mapping Toolbox.

### Functions Obsolete in Version 2.0

The following functions are still available but should no longer be used:

- `imagem`, which displayed a regular matrix map as an image, has been replaced by `grid2image`.
- The following 12 latitude conversion functions have been replaced by a single utility function, `convertlat`:
  - `aut2geod`

- `cen2geod`
- `cnf2geod`
- `iso2geod`
- `par2geod`
- `rec2geod`
- `geod2aut`
- `geod2cen`
- `geod2cnf`
- `geod2iso`
- `geod2pa`
- `geod2rec`

This improves the stability of numerical results in certain projections.

### Functions Deleted in Version 2.0

The following functions are no longer available in the Mapping Toolbox.

- `coast` — This function simply loaded the `coast` MAT-file containing world coastlines. Instead of calling it, type  
`load coast`
- `loadmoonalb` — This function simply loaded the `moonalb` MAT-file of the Moon's albedo. Instead of calling it, type  
`load moonalb`
- `maskm` — This function, which reassigned a scalar value to an array based on a Boolean mask, has been removed. Ordinary MATLAB command syntax does the same thing.
- `movescale` — This undocumented function now is a subfunction of `scaleruler`.

### Changes in Nomenclature

To achieve greater consistency with the literature on geospatial data handling, documentation for Version 2.0 of the Mapping Toolbox has changed the usage of certain terms and names of variables provided as sample data. The primary changes are described below.

**Geoid** — Where it is used to describe the geometric shape of the Earth (an equipotential surface), this term has been retained. Where it was used as a synonym for ellipsoid, occurrences of *geoid* have been changed to *ellipsoid*. This

includes changing references to *geoid vector* to *ellipsoid vector*. You also now specify ellipsoid models for almanac data using the keyword 'ellipsoid' (however, 'geoid' still works). Note that a similar update has *not* been made for `axesm`, `getm`, or `setm`, which also 'geoid' as a keyword to identify the userdata structure (mstruct) field `geoid`.

**Map** — Where this term referred to data sets (either raster or vector), occurrences of *map* have been changed to *data grid*, *data set*, or some other appropriate term. Where it refers to a cartographic presentation of geodata, *map* has been retained.

**Map legend** — This term, which used to refer to a three-element vector that georeferenced a data grid, has been replaced with *referencing vector*. In some contexts (when more degrees of freedom are involved), the term *referencing matrix* replaces it.

Most sample data sets that contain `map` and `maplegend` as variables (data grids and referencing vectors, respectively) have been updated. For example, the `geoid` MAT-file now has variables `geoid` (the data grid), and `geoidrefvec` and `geoidlegend` (referencing vectors; the second is a copy of the first, provided to maintain compatibility). This file, along with most other sample data except for `topo` and `coast`, also now contains metadata in the form of source and description strings.

## Fixed Bugs

Mapping Toolbox Version 2.0 includes the following bug fixes:

### **size**

`size` now respects the order of its longitude limits. Now, for example, `[r,c] = size([-5 5],[170 -170],1)` sizes a 10-by-20 grid that crosses the 180-degree meridian, rather than a 10-by-340 grid that extending from -170 all the way to 170. `maptriml`, `maptrimp`, and `maptrims` now respect the order of their longitude limits as well.

### **Fixed Error in Inverse UTM Projection**

This release corrects an error in the inverse UTM projection. This error caused mislocations that ranged from negligible near the central meridian to several meters at the east-west zone boundaries.

This release also removes the rounding that decreased precision of the latitude-longitude outputs.

### **Improved Numerical Behavior of Geodetic-to-Conformal Latitude Conversion**

A new formulation, using the new `convertlat` function, fixes subtle inaccuracies near the poles that could cause unexpected, hard-to-explain behavior in the stereographic projection.

### **Line-of-Sight Computation Corrected for Observer at Zero Elevation**

A problem that caused `los2` and `viewshed` to report some visible points as invisible has been fixed.



## Version 1.3.1 (R13SP1) Mapping Toolbox

This table summarizes what's new in Version 1.3.1 (R13SP1):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
No	No	Fixed Bugs, below	No

### Fixed Bugs

Mapping Toolbox Version 1.3.1 contains the following bug fixes:

#### **almanac**

Minor typographical errors in defining the parameters for the Clarke 1866 and Clarke 1880 ellipsoids have been fixed.

#### **areaint**

Every simple polygon divides the Earth's surface into two regions. Now `areaint` consistently returns the area of the smaller region.

#### **avhrrgoode**

No longer fails due to an illegal assignment of NaN to class logical (mitigated side effect of new logical class in Release 13)

#### **axesmui**

Now updates frame limits when the projection is changed

#### **demdataui**

No longer disables zoom mode

#### **dted**

The calculation of directory names is now correct, even for longitudes between -10 and +10.

The calculation of file names for tiles close to the equator no longer includes an extra period.

`dted` now handles the case of missing tiles that result in nonrectangular tile configurations.

Transparently handles a kind of error found in some data tiles just north of the equator (affecting some tiles with file names ending in `n00.dt0`). In these files, the NW and NE corners are incorrectly designated with south instead of north latitudes.

Directory and filename calculations are more efficient.

### **`km2sm`, `nm2sm`, `sm2km`, `sm2nm`**

These functions now use precise factors for conversion to/from statute miles.

These changes also correct `distdim` results for both statute miles and feet (assuming U.S. Survey Foot).

### **`tigerp`**

Terminates file read properly when an empty data point is encountered (signaling end of data)

### **`worldmap`**

No longer generates errors when there is no data to display within the specified latitude/longitude limits; it now displays complete mesh, even for data grids (matrix maps) that span all longitudes

## Version 1.3 (R13) Mapping Toolbox

This table summarizes what's new in Version 1.3 (R13):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
Yes Details below	Yes— Details in <b>“Compatibility Considerations”</b> below. See also Summary.	Fixed Bugs	No

New features and changes introduced in this version are

- “New northarrow Annotation Function” on page 51
- “New mlabelzero22pi Axes Label Command” on page 51
- “Enhanced clegendm Contour Annotation Function” on page 52
- “New Interactive Interface” on page 52
- “Updated Atlas Data” on page 52
- “Ellipses Now Drawn More Smoothly” on page 52
- “Compatibility Considerations” on page 52

### New northarrow Annotation Function

The new northarrow function lets you add a north arrow symbol to a map, pointing to geographic north. You can reposition a north arrow by clicking and dragging it, or adjust other properties such as position, color, and size via alternate-clicking.

### New mlabelzero22pi Axes Label Command

The new mlabelzero22pi command converts meridian labels to use the range 0 to 360 degrees, instead of the default -180 to 180 degrees.

## **Enhanced `clegendm` Contour Annotation Function**

The `clegendm` function has been enhanced with a new, optional syntax that accepts a string indicating the contour line units. Alternatively, text label strings can be supplied for each and every contour level via a cell array.

## **New Interactive Interface**

The new `lightmui` function provides an interactive, graphical user interface to control the position of lights on a globe or 3-D map.

## **Updated Atlas Data**

Political boundaries and country names have been updated in both the `world10` and `worldhi` atlas files.

## **Ellipses Now Drawn More Smoothly**

The `ellipse1` function has been modified to create smoother ellipses. A weighted distribution of azimuth points is used instead of the uniform distribution between the starting and ending points. More points are added at locations near the semi-major and semi-minor axes and fewer points at the other intermediate locations.

## **Compatibility Considerations**

### **Functions `contorm` and `contor3m` Obsolete**

Functions `contorm` and `contor3m` are now obsolete. You should now use `contourm` and `contour3m` instead, which are functionally identical. The older functions still exist, but have been removed from the Mapping Toolbox documentation.

## Version 1.2 (R12) Mapping Toolbox

This table summarizes what's new in Version 1.2 (R12):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
Yes Details below	No	No	No

New features and changes introduced in this version are

- “Higher Resolution Atlas Data” on page 53
- “External Data Interface Improved” on page 53
- “New Interactive Interfaces” on page 54
- “New Analysis Functions for Geographic Data” on page 54
- “Other New Functions” on page 55

### Higher Resolution Atlas Data

There are now high-resolution country outlines and more city locations available through the `worldhi` database. The `worldmap` command automatically chooses this high-resolution data if the region's area is small enough.

The `worldlo` atlas file has been updated to make it coincide more closely with high-resolution coastlines and boundaries.

The `worldmtxmed` MAT-file provides a medium-resolution political world matrix map.

### External Data Interface Improved

Importing high-resolution atlas data is now much easier with these two visual interfaces:

- Digital Elevation Map Data user interface (invoked with the `demdataui` function)
- Vector Map Level 0 user interface (invoked with the `vmap0ui` function)

Many of the matrix map data interface functions now automatically concatenate data across separate files.

The external interface now supports the GLOBE digital elevation map data, a product similar to GTPO30. Use the `globedem` function for working with that data.

## New Interactive Interfaces

You can now adjust interactively, on a map display, geographic lines such as great circle tracks, small circles and sectors of small circles. Use the `trackg`, `scircleg`, and `sectorg` functions to make these interactive adjustments. While in an edit mode, you can drag the lines around on the map, modify the lines in a control panel, or read measurements.

There is a new visual interface to create colormaps. Use the `cmapui` function to invoke this new interface.

## New Analysis Functions for Geographic Data

You can use the new `elevation` function to find the elevation angle of a geographic point.

The new `gradientm` function performs matrix map data calculations, including gradient, slope, and aspect.

You can use the new `los2` and `viewshed` functions with terrain data to check the line of sight visibility between points or the visibility of entire regions.

Several new functions have been added to support polygon operations:

Function	Description
<code>bufferm</code>	Compute polygon buffer regions
<code>polybool</code>	Perform polygon Boolean operations
<code>polyjoin</code>	Combine polygon segments into a NaN-clipped polygon
<code>polymerge</code>	Merge polygon segments with abutting ends
<code>polysplit</code>	Separate NaN-clipped polygon segments into cell arrays
<code>polyxpoly</code>	Polygon intersections

## Other New Functions

Several new functions have been added to support polygon operations.

<b>Function</b>	<b>Description</b>
contourcmap	Contour colormap and colorbar for surfaces
driftcorr	Heading to correct for wind or current drift
driftvel	Wind or current from heading, course, and speeds
flatearthpoly	Insert points along date line to pole
lcolorbar	Labeled colorbar
mapprofile	Interpolated lines connecting waypoints on a surface
str2angle	Convert formatted DMS angle strings to numbers

## Compatibility Summary for Mapping Toolbox

This table summarizes new features and changes that might cause incompatibilities when you upgrade from an earlier version, or when you use files on multiple versions. Details are provided with the description of the new feature or change.

<b>Version (Release)</b>	<b>New Features and Changes with Version Compatibility Impact</b>
<b>Latest Version V2.4 (R2006b)</b>	See compatibility consideration <ul style="list-style-type: none"> <li>• Changes in Behavior of mapshow and geoshow</li> </ul>
Latest Version V2.3 (R2006a)	See compatibility consideration <ul style="list-style-type: none"> <li>• GeoTIFF Compatibility Considerations</li> </ul>
V2.2 (R14SP3)	See compatibility consideration <ul style="list-style-type: none"> <li>• Improved Rendering of Polygons with Inner Rings</li> </ul>
V2.1 (R14SP2)	See compatibility considerations <ul style="list-style-type: none"> <li>• Compatibility Considerations for Atlas Data and Associated Functions</li> <li>• Compatibility Considerations for worldmap and usamap</li> <li>• Functions Deleted in This Release</li> <li>• Functions Made Obsolete in This Release</li> </ul>



V2.0.3 (R14SP1)	See compatibility considerations <ul style="list-style-type: none"> <li>• axesm Does Not Reorder Longitude Limits</li> <li>• contourm Returns Contourgroup Handle</li> <li>• elevation Has New Azimuth Output</li> <li>• gtopo30 Has New Options</li> <li>• inputm Has New Button Output</li> <li>• polybool Revised, Has New Helper Functions</li> <li>• polymerge Ouput Vertex Order Changes</li> </ul>
V2.0.2 (R14)	None
V2.0.1 (R13SP1+)	None
V2.0 (R13SP1+)	See compatibility considerations <ul style="list-style-type: none"> <li>• Functions Obsolete in Version 2.0</li> <li>• Functions Deleted in Version 2.0</li> <li>• Changes in Nomenclature</li> </ul>
V1.3.1 (R13SP1+)	None
V1.3 (R13SP1)	See compatibility consideration <ul style="list-style-type: none"> <li>• Functions contorm and contor3m Obsoleted</li> </ul>
V1.2 (R12)	None

