

# **Wavelet Toolbox™ Release Notes**

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*Wavelet Toolbox™ Release Notes*

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<b>Summary by Version</b> .....	<b>1</b>
<b>Version 4.7 (R2011a) Wavelet Toolbox Software</b> .....	<b>4</b>
<b>Version 4.6 (R2010b) Wavelet Toolbox Software</b> .....	<b>6</b>
<b>Version 4.5 (R2010a) Wavelet Toolbox Software</b> .....	<b>8</b>
<b>Version 4.4.1 (R2009b) Wavelet Toolbox Software</b> .....	<b>10</b>
<b>Version 4.4 (R2009a) Wavelet Toolbox Software</b> .....	<b>11</b>
<b>Version 4.3 (R2008b) Wavelet Toolbox Software</b> .....	<b>12</b>
<b>Version 4.2 (R2008a) Wavelet Toolbox Software</b> .....	<b>13</b>
<b>Version 4.1 (R2007b) Wavelet Toolbox Software</b> .....	<b>15</b>
<b>Version 4.0 (R2007a) Wavelet Toolbox Software</b> .....	<b>16</b>
<b>Version 3.1 (R2006b) Wavelet Toolbox Software</b> .....	<b>18</b>
<b>Version 3.0.4 (R2006a) Wavelet Toolbox Software</b> .....	<b>20</b>
<b>Version 3.0.3 (R14SP3) Wavelet Toolbox Software</b> ....	<b>21</b>
<b>Version 3.0.2 (R14SP2) Wavelet Toolbox Software</b> ....	<b>22</b>
<b>Version 3.0.1 (R14SP1) Wavelet Toolbox Software</b> ....	<b>23</b>
<b>Version 3.0 (R14) Wavelet Toolbox Software</b> .....	<b>24</b>

<b>Compatibility Summary for Wavelet Toolbox</b>	
<b>Software .....</b>	<b>28</b>

## Summary by Version

This table provides quick access to what's new in each version. For clarification, see “Using 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>Latest Version V4.7 (R2011a)</b>	Yes Details	No	Bug Reports Includes fixes
V4.6 (R2010b)	Yes Details	No	Bug Reports Includes fixes
V4.5 (R2010a)	Yes Details	No	Bug Reports Includes fixes
V4.4.1 (R2009b)	No	No	Bug Reports Includes fixes
V4.4 (R2009a)	Yes Details	No	Bug Reports Includes fixes
V4.3 (R2008b)	Yes Details	No	Bug Reports Includes fixes
V4.2 (R2008a)	Yes Details	No	Bug Reports Includes fixes
V4.1 (R2007b)	Yes Details	No	Bug Reports Includes fixes
V4.0 (R2007a)	Yes Details	No	Bug Reports Includes fixes
V3.1 (R2006b)	Yes Details	No	Bug Reports Includes fixes
V3.0.4 (R2006a)	No	No	No bug fixes
V3.0.3 (R14SP3)	No	No	No bug fixes
V3.0.2 (R14SP2)	No	No	No bug fixes

Version (Release)	New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
V3.0.1 (R14SP1)	No	No	No bug fixes
V3.0 (R14)	Yes Details	Yes Summary	“Fixed Bugs” on page 27

## Using Release Notes

Use release notes when upgrading to a newer version to learn about:

- New features
- Changes
- Potential impact on your existing files and practices

Review the release notes for other MathWorks® products required for this product (for example, MATLAB® or Simulink®). Determine if enhancements, bugs, or compatibility considerations in other products impact you.

If you are upgrading from a software version other than the most recent one, review the current release notes and all interim versions. For example, when you upgrade from V1.0 to V1.2, review the release notes for V1.1 and V1.2.

## What Is in the Release Notes

### New Features and Changes

- New functionality
- Changes to existing functionality

### Version Compatibility Considerations

When a new feature or change introduces a reported incompatibility between versions, the **Compatibility Considerations** subsection explains the impact.

Compatibility issues reported after the product release appear under Bug Reports at the MathWorks Web site. Bug fixes can sometimes result in incompatibilities, so review the fixed bugs in Bug Reports for any compatibility impact.

### **Fixed Bugs and Known Problems**

MathWorks offers a user-searchable Bug Reports database so you can view Bug Reports. The development team updates this database at release time and as more information becomes available. Bug Reports include provisions for any known workarounds or file replacements. Information is available for bugs existing in or fixed in Release 14SP2 or later. Information is not available for all bugs in earlier releases.

Access Bug Reports using your MathWorks Account.

### **Documentation on the MathWorks Web Site**

Related documentation is available on [mathworks.com](http://mathworks.com) for the latest release and for previous releases:

- Latest product documentation
- Archived documentation

## Version 4.7 (R2011a) Wavelet Toolbox Software

This table summarizes what is new in Version 4.7 (R2011a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes	No	Bug Reports Includes fixes

New features introduced in this version:

- “Inverse Continuous Wavelet Transform” on page 4
- “FFT-based Continuous Wavelet Transform” on page 4
- “Pattern-adapted Wavelets for Signal Detection Demo” on page 4

### Inverse Continuous Wavelet Transform

In R2011a, you can compute the inverse continuous wavelet transform (CWT) using an FFT-based algorithm. The inverse CWT allows you to synthesize approximations to your 1D signal based on selected scales. The inverse CWT is only supported for coefficients obtained using the FFT-based CWT. See `icwtfft` and `cwtfft` for details.

### FFT-based Continuous Wavelet Transform

In R2011a, you can compute the continuous wavelet transform (CWT) using an FFT-based algorithm with `cwtfft`. The CWT computed using an FFT algorithm supports the computation of the inverse CWT. See `cwtfft` and `icwtfft` for details. Only select wavelets are valid for use with `cwtfft`. See `cwtfftinfo` for a list of supported wavelets.

### Pattern-adapted Wavelets for Signal Detection Demo

In R2011a there is a new demo using pattern adapted wavelets for signal detection. You can view this demo here [Pattern adapted wavelets for signal detection](#). The Wavelet Toolbox™ software enables you to design admissible wavelets based on the pattern you wish to detect. Designing a valid wavelet



based on your desired pattern allows you to exploit the optimality of matched filtering in the framework of the CWT. The demo illustrates this process on simulated data and human EEG recordings.

## Version 4.6 (R2010b) Wavelet Toolbox Software

This table summarizes what is new in Version 4.6 (R2010b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes	No	Bug Reports Includes fixes

New features introduced in this version are:

- “Cone of Influence for Continuous Wavelet Transform” on page 6
- “Wavelet Cross Spectrum and Coherence” on page 6
- “Wavelet Packet Spectrum” on page 7
- “Natural and Frequency Ordering of Wavelet Packet Terminal Nodes” on page 7
- “Image and Signal Approximation Quality Metrics” on page 7

### Cone of Influence for Continuous Wavelet Transform

In R2010b, you can compute the cone of influence (COI) for the continuous wavelet transform (CWT) of a signal. At each scale, the COI determines the set of CWT coefficients influenced by the value of the signal at a specified position. The COI provides an important visual aid in interpreting the CWT. By overlaying the cone of influence on the CWT image, you can determine which CWT coefficients each value of the signal affects at every scale. See `conofinf` for details.

### Wavelet Cross Spectrum and Coherence

In R2010b, you can estimate the wavelet cross spectrum and wavelet coherence of two time series. The wavelet cross spectrum and coherence provide wavelet-based alternatives for the Fourier-based cross spectrum and coherence. These wavelet estimators are suitable for nonstationary signals. Using a complex-valued analyzing wavelet, you can also examine intervals

in the time-scale plane where the two time series exhibit common phase behavior. See `wcoher` and the new demo `Wavelet Coherence` for details.

## **Wavelet Packet Spectrum**

In R2010b, you can compute the wavelet packet spectrum with `wpspectrum`. The wavelet packet spectrum provides a time-frequency analysis of a time series. The wavelet packet spectrum is useful as wavelet-based counterpart of the short-time Fourier transform.

## **Natural and Frequency Ordering of Wavelet Packet Terminal Nodes**

In R2010b, you can order the wavelet packet transform terminal nodes by natural (Payley) or frequency (sequency) order. See `otnodes` for details.

## **Image and Signal Approximation Quality Metrics**

In R2010b, you can measure the quality of your signal or image approximation using a number of widely-used quality metrics. These metrics include: the peak signal-to-noise ratio (PSNR), the mean square error (MSE), the maximum absolute error, and the energy ratio of the approximation to the original. See `measerr` for details.

## Version 4.5 (R2010a) Wavelet Toolbox Software

This table summarizes what is new in Version 4.5 (R2010a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes	No	Bug Reports Includes fixes

New features and changes introduced in this version are

- “3-D Discrete Wavelet Transform” on page 8
- “Nondecimated Wavelet Transform” on page 8
- “New Denoising Function” on page 8

### 3-D Discrete Wavelet Transform

This release adds new functions and a GUI to support the 3-D discrete wavelet transform. This new functionality lets you decompose, analyze, and display a 3-D object using a different wavelet for each dimension. The new functions are: `dwt3`, `idwt3`, `wavedec3`, and `waverec3`. A demo (`wavelet3demo`) is also included.

### Nondecimated Wavelet Transform

New nondecimated wavelet transform functions support signals of arbitrary size and different extension modes. Previous functionality had two limitations: signal length had to equal a power of 2 and the only allowable extension mode was periodized. The new functions are: `ndwt`, `indwt`, `ndwt2`, and `indwt2`. A demo (`ndwtdemo`) is also included.

### New Denoising Function

The new `cmddenoise` function uses interval-dependent denoising to compute the denoised signal and coefficients. This allows you to apply different denoising thresholds to different portions of the signal, which is typically

nonuniform. You can also export thresholds from the GUI and use them in the `cmddenoise` function. The toolbox includes a denoising demo (`cmddenoise`).

## Version 4.4.1 (R2009b) Wavelet Toolbox Software

This table summarizes what is new in Version 4.4.1 (R2009b):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>
No	No	Bug Reports Includes fixes

## Version 4.4 (R2009a) Wavelet Toolbox Software

This table summarizes what is new in Version 4.4 (R2009a):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>
Yes Details below	No	Bug Reports Includes fixes

New features introduced in this version are three new demos.

### **New Demos**

The toolbox now includes three new demos:

Adding a New Wavelet

Wavelet Interval-dependant Denoising

Wavelet Scalograms

## Version 4.3 (R2008b) Wavelet Toolbox Software

This table summarizes what is new in Version 4.3 (R2008b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are

- “True Image Compression Support” on page 12
- “New Demo” on page 12

### True Image Compression Support

The new `wcompress` functions lets you compress 2-D image data. You can also interactively compress images using the new Two-Dimensional Images Compression GUI.

### New Demo

The toolbox now includes a new codepad demo on image compression.



## Version 4.2 (R2008a) Wavelet Toolbox Software

This table summarizes what's new in Version 4.2 (R2008a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes	No	Bug Reports Includes fixes

New features and changes introduced in this version are

- “True Color Images Support” on page 13
- “New Extension Modes for Continuous Wavelets” on page 13
- “New Norms Calculation” on page 13
- “Wavelet Families Display” on page 14
- “Single Data Type Support” on page 14
- “New Demos” on page 14

### True Color Images Support

The toolbox can now process true color images. All major toolbox GUIs and all of the 2-D-oriented command line functions have been also updated and support true color images.

### New Extension Modes for Continuous Wavelets

The new `cwtext` function lets you calculate 1-D continuous wavelet parameters using extension parameters.

### New Norms Calculation

The Multisignal 1-D GUI and other related GUIs now include 1-norm, 2-norm, and inf-norm calculations.

## **Wavelet Families Display**

A new function, `waveletfamilies`, displays all the available wavelet families and their properties.

## **Single Data Type Support**

The `swt2` and `iswt2` functions now support single data types.

## **New Demos**

The toolbox now includes the following new codepad demos:

- Multiscale Principal Component Analysis
- Multivariate Denoising

## Version 4.1 (R2007b) Wavelet Toolbox Software

This table summarizes what's new in Version 4.1 (R2007b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are

- “Importing and Exporting between GUIs and Workspace” on page 15
- “Scalograms for Continuous Wavelet Transforms” on page 15
- “Constructing Clusters from Hierarchical Cluster Trees” on page 15

### Importing and Exporting between GUIs and Workspace

You can now import data from the workspace to all toolbox GUIs and export data from all toolbox GUIs to the workspace. Use **Import from Workspace** and **Export to Workspace**, respectively, on the GUI's **File** menu.

### Scalograms for Continuous Wavelet Transforms

The ability to compute scalograms of the wavelet coefficients in continuous wavelet analysis has been added as an option to the `cwt` function. You can also pass the structure produced by `cwt` directly to the new `wscalogram` function. Scalograms show the percentage of energy in each wavelet coefficient.

### Constructing Clusters from Hierarchical Cluster Trees

You can now construct clusters from hierarchical cluster trees in multisignal analysis using the new `mdwtcluster` function.

## Version 4.0 (R2007a) Wavelet Toolbox Software

This table summarizes what's new in Version 4.0 (R2007a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are

- “1-D Multisignal Analysis, Compression, and Denoising Added” on page 16
- “1-D Multisignal Wavelet and Clustering Added” on page 17
- “Wavelet 1-D Multisignal Analysis GUI Added” on page 17

### 1-D Multisignal Analysis, Compression, and Denoising Added

The following command-line functions for 1-D multisignal analysis, compression, and denoising have been added to the toolbox:

mswcmp	Multisignal 1-D compression using wavelets.
mswcmpscr	Multisignal 1-D wavelet compression scores.
mswcmptp	Multisignal 1-D compression thresholds and perf.
mswden	Multisignal 1-D denoising using wavelets.
mswthresh	Performs Multisignal 1-D thresholding.

## 1-D Multisignal Wavelet and Clustering Added

The following command-line functions for 1-D multisignal wavelets and clustering have been added to the toolbox:

chgwdceccfs	Change Multisignal 1-D decomposition coeffs
mdwtdec	Multisignal 1-D wavelet decomposition
mdwtrec	Multisignal 1-D wavelet reconstruction.
wdcenergy	Multisignal 1-D decomposition energy repartition

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**Note** Clustering analyses require that Statistics Toolbox is installed.

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## Wavelet 1-D Multisignal Analysis GUI Added

A graphical user interface for 1-D multisignal analysis has been added. To start this GUI, select **Multisignal Analysis 1-D** from the wavemenu dialog.

## Version 3.1 (R2006b) Wavelet Toolbox Software

This table summarizes what's new in Version 3.1 (R2006b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are

- “Multivariate De-noising Added” on page 18
- “Multiscale Principal Component Analysis Added” on page 18
- “New Demos” on page 19

### Multivariate De-noising Added

A new command-line function (`wmu1den`) and a new GUI (**Multivariate Denoising** from the `wavemenu` initial window) for de-noising a matrix of signals have been added. Both the function and GUI take into account the signals themselves and the correlations between the signals. A two-step process is used. First, a change of basis is performed to deal with noise spatial correlation de-noising in the new basis. Then, a principal component analysis is performed to take advantage of the deterministic relationships between the signals, leading to an additional de-noising effect.

### Multiscale Principal Component Analysis Added

A new command-line function (`wmspca`) and a new GUI (**Multiscale Princ. Comp. Analysis** from the `wavemenu` initial window) for simplifying a matrix of signals have been added. Both the function and GUI take into account the signals themselves and the correlations between the signals. The multiscale principal component analysis mixes wavelet decompositions and principal component analysis.

## **New Demos**

The following new demos are added:

- Continuous and Discrete Wavelet Analysis
- Detecting Discontinuities and Breakdown Points
- De-Noising Signals and Images
- Data Compression using 2D Wavelet Analysis
- Image Fusion
- Detecting Self-Similarity
- Wavelet Packets: Decomposing the Details

## Version 3.0.4 (R2006a) Wavelet Toolbox Software

This table summarizes what's new in V3.0.4 (R2006a):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>
No	No	No bug fixes



## Version 3.0.3 (R14SP3) Wavelet Toolbox Software

This table summarizes what's new in V3.0.3 (R14SP3):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>
No	No	No bug fixes

## Version 3.0.2 (R14SP2) Wavelet Toolbox Software

This table summarizes what's new in V3.0.2 (R14SP2):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>
No	No	No bug fixes

## Version 3.0.1 (R14SP1) Wavelet Toolbox Software

This table summarizes what's new in V3.0.1 (R14SP1):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>
No	No	No bug fixes

## Version 3.0 (R14) Wavelet Toolbox Software

This table summarizes what's new in V3.0 (R14):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
V3.0 (R14)	Yes—Details labeled as <b>Compatibility Considerations</b> , below. See also Summary.	“Fixed Bugs” on page 27

New features and changes introduced in this version are

### Wavelet Design for CWT Tool Added

The **New Wavelet for CWT** tool designs a new wavelet adapted to a given pattern using least squares optimization. The new wavelet can be used for accurate pattern detection using the continuous wavelet transform (cwt). This new tool is useful for creating new wavelets for accurate 1-D pattern detection. From the command line, use the `pat2cwav` function.

### Image Fusion Tool Added

The **Image Fusion** tool performs fusion of two images. Image fusion using wavelets merges the wavelet decompositions of two original images using various fusion methods applied to approximations coefficients and details coefficients. Examples of uses of this tool are creating a new image from two different images and restoring an image from two fuzzy versions of an original image. From the command line, use the `wfusing` and `wfusmat` functions to fuse two images and fuse two matrices or arrays, respectively.

### Fractional Brownian Generation 1-D Tool Added

The **Fractional Brownian Generation 1-D** tool performs the random generation of fractional Brownian motion, which is a useful model for Internet traffic and financial series. From the command line, use the `wfbm`

and `wfbmesti` functions to synthesize and perform parameter estimation of fractional Brownian motion, respectively.

## Lifting Methods Added

You can use lifting methods to design new wavelets. The new lifting methods also allow integer-to-integer wavelet transforms and transforms using different length decomposition high-pass and low-pass filters. Five groups of new lifting functions are included in Wavelet Toolbox, Version 3.0:

- Key lifting scheme structures
  - `addlift`—Add primal or dual elementary lifting steps to a lifting scheme
  - `displs`—Display a lifting scheme
  - `lsinfo`—Information about lifting schemes
- Biorthogonal quadruplets of filters
  - `bswfun`—Compute and plot biorthogonal "scaling and wavelet" functions
  - `filt2ls`—Transform a quadruplet of filters to a lifting scheme
  - `liftfilt`—Apply elementary lifting steps on quadruplet of filters
  - `ls2filt`—Transform a lifting scheme to a quadruplet of filters
- Orthogonal or biorthogonal ("true") wavelets and "lazy" wavelets.
  - `liftwave`—Provides lifting scheme associated to a wavelet
  - `wave2lp`—Provides Laurent polynomials associated to a wavelet
  - `wavenames`—Provides wavelet names available for LWT
- Direct and inverse Lifting Wavelet Transform (LWT)
  - `lwt`—1-D Lifting Wavelet Transform
  - `lwt2`—2-D Lifting Wavelet Transform
  - `lwtcoef`—Extract or reconstruct 1-D LWT wavelet coefficients
  - `lwtcoef2`—Extract or reconstruct 2-D LWT wavelet coefficients
  - `ilwt`—Inverse 1-D Lifting Wavelet Transform
  - `ilwt2`—Inverse 2-D Lifting Wavelet Transform

- Laurent polynomials and matrices (see Note below)
  - `laurmat`—Constructor for the class LM of Laurent Matrices
  - `laurpoly`—Constructor for the class LP of Laurent Polynomials

### **Compatibility Consideration**

If you saved `laurmat` or `laurpoly` objects using the names `lm` or `lp`, respectively, in the Beta release, you must rename them to `laurmat` or `laurpoly`, respectively, in this release of Wavelet Toolbox 3.0.

### **Speed Enhancements**

Many functions, including those involving decomposition and reconstruction, have been enhanced so they run more efficiently.

### **New Extension Modes for DWT**

Four new extension modes are available for `dwt`, which allows specifying half- or whole-point symmetry, or half- or whole-point anti-symmetry. See `dwtmode`. These new extension modes are supported by both `wextend` to extend or truncate signal or images, and by the corresponding GUI tools: **Signal Extension** and **Image Extension**.

### **New Supported Image Formats**

Images stored using JPEG, TIFF, PCX, and others can be directly loaded into the Wavelet Toolbox GUI.

Images stored in `uint8` format can be used in all the 2-D tools.

Images stored in True Colour mode are converted automatically in indexed mode when loaded in the 2-D tools. See the Wavelet Toolbox documentation on working with images for more information.

## **Fixed Bugs**

### **Complex Wavelets in fbsp and shan Families**

Numeric values associated with the fbsp and shan wavelet families (in particular, the shanwavf, fbspwavf, and sca12frq functions) were incorrect and have been fixed.

### **Density Estimation 1-D Normalization**

An omitted normalization step has been added in the **Density Estimation 1-D** tool.

## Compatibility Summary for Wavelet Toolbox Software

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 V4.7 (R2011a)</b>	None
V4.6 (R2010b)	None
V4.5 (R2010a)	None
V4.4.1 (R2009b)	None
V4.4 (R2009a)	None
V4.3 (R2008b)	None
V4.2 (R2008a)	None
V4.1 (R2007b)	None
V4.0 (R2007a)	None
V3.1 (R2006b)	None
V3.0.4 (R2006a)	None
V3.0.3 (R14SP3)	None
V3.0.2 (R14SP2)	None
V3.0.1 (R14SP1)	None
V3.0 (R14)	<p>See the <b>Compatibility Considerations</b> subheading for this new feature or change:</p> <ul style="list-style-type: none"> <li>• Rename laurmat or laurpoly objects</li> </ul>