

Package ‘mvcwt’

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Type Package

Title Wavelet analysis of multiple time series

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Imports foreach, RColorBrewer, grDevices

Description This package computes the continuous wavelet transform of irregularly sampled time series.

License GPL

URL <https://bitbucket.org/tkeitt/mvcwt/overview>, <http://www.keittlab.org>

NeedsCompilation no

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R topics documented:

mvcwt-package	2
contour.mvcwt	3
get.nscale	4
image.mvcwt	5
lrlake	6
Morlet	6
mvcwt	7
plot.mvcwt	8
wmr	9
wmr.boot	10
Index	12

Description

Computes continuous wavelet transform of multiple irregularly sampled time series.

Details

Package: mvcwt
Type: Package
Version: 1.3
Date: 2013-10-27
License: GPL

The main functions are `mvcwt`, which computes the wavelet transform of multiple time series, and `wmr`, which computes the wavelet modulus ratio, a measure of time series coherence.

Note that this is a complete rewrite of the code used in the reference below, and as such it is not well tested. It may give different or inaccurate results. I recommend you run tests on known data.

The most recent development version of this package can be found at <https://bitbucket.org/tkeitt/mvcwt/overview>.

Author(s)

Timothy H. Keitt (<http://www.keittlab.org>)

Tim Keitt <tkeitt@gmail.com>

References

Keitt, T. H. 2008. Coherent ecological dynamics induced by large-scale disturbance. *Nature* 454:331-4. doi:10.1038/nature06935.

Examples

```
## Not run:
x = seq(-pi, pi, len = 200)
y1 = sin(8 * x) + sin(32 * x)
y2 = sin(8 * (x + pi/8)) + sin(32 * x)
matplot(x, cbind(y1, y2), type = "l", lty = 1)
w = mvcwt(x, cbind(y1, y2))
plot(w, var = 1:2, scale = 2^seq(log2(min(w$y)), log2(max(w$y)), len = 5))
mr = wmr(w, smoothing = 2)
image(mr, reset.par = FALSE)
contour(mr, levels = c(0.01, 0.05, 0.1, 0.25, 0.5, 0.75, 0.9, 0.95, 0.99), add = TRUE)
## End(Not run)
```

contour.mvcwt *Make contour plot of a `mvcwt` object*

Description

Draws a contour plot

Usage

```
## S3 method for class 'mvcwt'  
contour(x, z.fun = "Re", bound = 1, reset.par = TRUE, ...)
```

Arguments

<code>x</code>	an object produced by <code>mvcwt</code> or <code>wmr</code>
<code>z.fun</code>	a function to apply to the data prior to plotting
<code>bound</code>	if finite, draw boundary lines <code>bound * scale</code> from plot boundaries
<code>reset.par</code>	if true, reset the graphical parameters on exit
<code>...</code>	passed to the <code>contour</code> function

Details

Draws a contour plot. If you want to add more plotting elements, set `reset.pars` to false.

Value

The object `x` is returned invisibly.

Author(s)

Timothy H. Keitt

See Also

[mvcwt](#), [wmr](#)

Examples

```
## Not run:  
data(lrlake)  
x = subset(lrlake, Basin == "Treatment", LRL.Day) / 365.25  
y = subset(lrlake, Basin == "Treatment", -(1:8))  
w = mvcwt(x, y, min.scale = 0.25, max.scale = 4)  
mr = wmr(w)  
contour(mr)  
## End(Not run)
```

`get.nscale`*Utility functions*

Description

Functions for calculating scales and locations to analyze

Usage

```
get.nscale(x)
```

```
get.min.scale(x)
```

```
get.max.scale(x)
```

```
log2Bins(min, max, nbins)
```

```
regularize(x, nsteps = length(as.vector(unlist(x))))
```

Arguments

<code>x</code>	a vector of values
<code>min</code>	smallest value in sequence
<code>max</code>	largest value in sequence
<code>nbins</code>	how many intervals
<code>nsteps</code>	length of returned sequence

Value

`get.nscale`: length of `x` [unlisted](#) and [as.vectorized](#).

`get.min.scale`: twice the median distance between successive values of `x`

`get.max.scale`: 1/2 the maximum distance between values in `x`

`log2Bins`: a sequence of values on a log2 scale

`regularize`: a regular sequence of values

`image.mvcwt`*Draw a heatmap of a `mvcwt` object*

Description

Draws one or more heatmaps

Usage

```
## S3 method for class 'mvcwt'  
image(x, z.fun = "Re", bound = 1, reset.par = TRUE, ...)
```

Arguments

<code>x</code>	an object as returned by <code>mvcwt</code>
<code>z.fun</code>	a function applied to the data before plotting
<code>bound</code>	if finite, draw lines bound * scale units inside the plot boundaries
<code>reset.par</code>	if true, reset graphical parameters on exit
<code>...</code>	additional arguments passed to <code>image</code>

Details

This function will draw a series of heatmaps on the graphical device. If you want to add additional graphical elements, set `reset.par` to false.

Value

`x` is returned invisibly

Author(s)

Timothy H. Keitt

See Also

`mvcwt`, `wmr`

Examples

```
## Not run:  
data(lrlake)  
x = subset(lrlake, Basin == "Treatment", LRL.Day) / 365.25  
y = subset(lrlake, Basin == "Treatment", -(1:8))  
w = mvcwt(x, y, min.scale = 0.25, max.scale = 4)  
image(w, z.fun = "Mod")  
## End(Not run)
```

lrlake

Little Rock Lake zooplankton dataset

Description

Contains time series for 10 dominant crustaceous species of zooplankton sampled from Little Rock Lake, Wisconsin. Samples come from two basins: one treated to lower pH and the other an untreated reference.

Format

A data frame with 592 observations on the following 18 variables.

Source

<http://lter.limnology.wisc.edu/>

References

Keitt, T. H. 2008. Coherent ecological dynamics induced by large-scale disturbance. *Nature* 454:331-4. doi:10.1038/nature06935.

Examples

```
data(lrlake)
x = subset(lrlake, Basin == "Reference", LRL.Day)
y = subset(lrlake, Basin == "Reference", -(1:8))
matplot(x, y, type = "l", lty = 1)
```

Morlet

The Morlet function

Description

Given a sequence of lag distances, this function returns the Morlet wavelet

Usage

```
Morlet(lag)
```

Arguments

lag A sequence of lag distances, typically a matrix

Details

This version of the Morlet is scaled so that the central frequency is exactly 2π radians. This is the simple version of the Morlet, sometimes referred to as a pseudo-wavelet as it is not precisely normalized, leading to some leakage into the DC component. It is therefore unsuited to reconstruction using the inverse transform.

Value

A set of Morlet filters, typically as a matrix

Author(s)

Timothy H. Keitt

See Also

[mvcwt](#)

Examples

```
x = seq(-pi, pi, len = 256)
plot(x, Re(Morlet(x)), col = "darkblue", type = "l")
lines(x, Im(Morlet(x)), col = "darkred")
lines(range(x), rep(0, 2), lty = 2)
```

`mvcwt`

Computes the wavelet transform of a multivariate time series

Description

This function takes set a set of sequences as columns in a matrix and computes the continuous wavelet transform on each.

Usage

```
mvcwt(x, y, scale.exp = 0.5, nscales = get.nscale(x),
      min.scale = get.min.scale(x), max.scale = get.max.scale(x),
      scales = log2Bins(min.scale, max.scale, nscales), loc = regularize(x),
      wave.fun = "Morlet")
```

Arguments

<code>x</code>	sample locations
<code>y</code>	one or more columns of samples corresponding to <code>x</code>
<code>scale.exp</code>	scale output
<code>nscales</code>	number of scales to analyze
<code>min.scale</code>	minimum scale in units of <code>x</code>

max.scale	maximum scale in units of x
scales	a set of scales to analyze; overrides all other scale arguments
loc	the loci at which to evaluate the wavelet function
wave.fun	a wavelet function

plot.mvcwt	<i>Plot wavelet output</i>
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Description

Plot multivariate wavelet output across variables, scales or both.

Usage

```
## S3 method for class 'mvcwt'
plot(x, var = 1, scale = 1, titles = TRUE, z.fun = "Re",
     ...)
```

Arguments

x	an object such as produced by mvcwt
var	which variables to plot; can be a vector
scale	which scales to plot; can be a vector; closest scale is picked
titles	plot titles on each sub-plot?
z.fun	apply function to data prior to plotting
...	additional graphical parameters passed to plot

Details

Makes one or more plots on the graphics device. Total number of plots is limited to 10.

Value

x is returned invisibly

Author(s)

Timothy H. Keitt

See Also

[mvcwt](#)

Examples

```
## Not run:
data(lrlake)
x = subset(lrlake, Basin == "Reference", LRL.Day) / 365.25
y = subset(lrlake, Basin == "Reference", -(1:8))
w = mvcwt(x, y, min.scale = 0.25, max.scale = 4)
plot(w, var = 1:10)
## End(Not run)
```

wmr

Compute the wavelet modulus ratio of multivariate data

Description

Computes the wavelet modulus ratio described in Keitt (2008). A value of one indicated perfect synchrony among time series and a value of zero, perfect compensation.

Usage

```
wmr(w, smoothing = 1)
```

Arguments

w	an object such as returned by mvcwt
smoothing	width of smoothing kernel; larger values give more smoothing

Value

an object of class "mvcwt"

Author(s)

Timothy H. Keitt

References

Keitt, T. H. 2008. Coherent ecological dynamics induced by large-scale disturbance. *Nature* 454:331-4. doi:10.1038/nature06935.

See Also

[mvcwt](#), [image.mvcwt](#)

Examples

```
## Not run:
data(lrlake)
x = subset(lrlake, Basin == "Treatment", LRL.Day) / 365.25
y = subset(lrlake, Basin == "Treatment", -(1:8))
w = mvcwt(x, y, min.scale = 0.25, max.scale = 4)
mr = wmr(w)
image(mr, reset.par = FALSE)
contour(mr, bound = NA, add = TRUE)
## End(Not run)
```

wmr.boot

Boot strap p-values for wavelet modulus ratio

Description

Performs a phase-randomization bootstrap estimate of the null hypothesis of independent time series

Usage

```
wmr.boot(w, smoothing = 1, reps = 1000, mr.func = "wmr")
```

Arguments

w	an object such as returned by mvcwt
smoothing	degree of smoothing; larger values give greater smoothing
reps	number of repetitions
mr.func	a function taking a "mvcwt" object to be applied to each trial

Details

The phases are randomized reps times for each combination of input variable and scale. This package depends heavily on the dopar function in the foreach package. If you do not have a lot of cores available to you, you may need to let this run overnight.

Value

an object of class "mvcwt" suitable for use with [contour.mvcwt](#).

Author(s)

Timothy H. Keitt

References

Keitt, T. H. 2008. Coherent ecological dynamics induced by large-scale disturbance. Nature 454:331-4. doi:10.1038/nature06935.

wmr.boot

11

See Also

[mvcwt](#), [wmr](#)

Index

- *Topic **datasets**
 - lrlake, 6
- *Topic **graphics**
 - contour.mvcwt, 3
 - image.mvcwt, 5
 - plot.mvcwt, 8
- *Topic **package**
 - mvcwt-package, 2
- *Topic **statistics**
 - wmr.boot, 10
- *Topic **wavelets**
 - Morlet, 6
 - wmr, 9

as.vector, 4

contour, 3

contour.mvcwt, 3, 10

get.max.scale (get.nscale), 4

get.min.scale (get.nscale), 4

get.nscale, 4

image, 5

image.mvcwt, 5, 9

log2Bins (get.nscale), 4

lrlake, 6

Morlet, 6

mvcwt, 2, 3, 5, 7, 7, 8–11

mvcwt-package, 2

plot, 8

plot.mvcwt, 8

print.mvcwt (mvcwt), 7

regularize (get.nscale), 4

unlist, 4

wmr, 2, 3, 5, 9, 11

wmr.boot, 10