

# Package ‘W2CWM2C’

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**Version** 2.2

**Date** 2021-01-07

**Title** A Graphical Tool for Wavelet (Cross) Correlation and Wavelet Multiple (Cross) Correlation Analysis

**Description** Set of functions that improves the graphical presentations of the functions: `wave.correlation` and `spin.correlation` (`waveslim` package, Whitcher 2012) and the `wave.multiple.correlation` and `wave.multiple.cross.correlation` (`wavemulcor` package, Fernandez-Macho 2012b). The plot outputs (heatmaps) can be displayed in the screen or can be saved as PNG or JPG images or as PDF or EPS formats. The `W2CWM2C` package also helps to handle the (input data) multivariate time series easily as a list of  $N$  elements (times series) and provides a multivariate data set (`dataexample`) to exemplify its use. A description of the package was published in a scientific paper: Polanco-Martinez and Fernandez-Macho (2014), <[doi:10.1109/MCSE.2014.96](https://doi.org/10.1109/MCSE.2014.96)>.

**Depends** R (>= 2.14.1), `waveslim`, `wavemulcor`, `colorspace`

**URL** <https://github.com/jomopo/W2CWM2C>

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**License** GPL (>= 2)

**Repository** CRAN

**LazyLoad** yes

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W2CWM2C-package	<i>W2CWM2C: a graphical tool for wavelet (cross) correlation and wavelet multiple (cross) correlation analysis</i>
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**Description**

The W2CWM2C package is a set of functions that improves the graphical presentations of the functions 'wave.correlation' and 'spin.correlation' (wavelet cross correlation) (*waveslim* package, Whitcher 2012) and the 'wave.multiple.correlation' and 'wave.multiple.cross.correlation' (*wavemulcor* package, Fernandez-Macho 2012b). The plot outputs (heatmaps) can be displayed in the screen or can be saved as PNG or JPG images or as PDF or EPS formats. The W2CWM2C package also helps to handle the (input data) multivariate time series easily as a list of N elements (times series) and provides a multivariate data set (dataexample) to exemplify its use. A description of the package was published by **Polanco-Martinez** and Fernandez-Macho (2014), <doi:10.1109/MCSE.2014.96>.

**Details**

Package:	W2CWM2C
Type:	Package
Version:	2.2
Date:	2021-01-07
License:	GPL (>= 2)
LazyLoad:	yes

The W2CWM2C package contains four functions: (1) **WC** that performs and plots the wavelet correlation for the bivariate case, (2) **WCC** that performs and plots the wavelet cross correlation for the bivariate case, (3) **WMC** that performs and plots the wavelet multiple correlation for the multivariate case, and 4) **WMCC** that performs and plots the wavelet multiple cross correlation for the multivariate case.

**Note**

Dependencies: *waveslim*, *wavemulcor* and *colorspace*.

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I am thankful to Jan de Leeuw and Achim Zeileis for suggesting the use of the R package *colorspace*. I am also thanks to Debojyoti Das, John Garrigan, Peterson Owusu Junior, Rim Ibrahim, and Ato Wilberforce for reporting some bugs found in my W2CWM2C package. The author acknowledges to the SEPE (Spanish Public Service of Employment) for its funding support.

## References

Fernandez-Macho, J. (2012a). Wavelet multiple correlation and cross-correlation: A multiscale analysis of Euro zone stock markets. *Physica A: Statistical Mechanics and its Applications*, **391**(4):1097–1104. doi: [10.1016/j.physa.2011.11.002](https://doi.org/10.1016/j.physa.2011.11.002).

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**Polanco-Martinez, J.** and J. Fernandez-Macho (2014). The package 'W2CWM2C': description, features and applications. *Computing in Science & Engineering*, **16**(6):68–78. doi: [10.1109/MCSE.2014.96](https://doi.org/10.1109/MCSE.2014.96).

**Polanco-Martinez, J. M.** and Abadie, L. M. (2016). Analyzing crude oil spot price dynamics versus long term future prices: A wavelet analysis approach. *Energies*, **9**(12), 1089. doi: [10.3390/en9121089](https://doi.org/10.3390/en9121089).

Whitcher, B., P. Guttorp, and D.B (2000). Percival. Wavelet analysis of covariance with application to atmospheric time series. *Journal of Geophysical Research - Atmospheres*, **105**(D11):941–962. doi: [10.1029/2000JD900110](https://doi.org/10.1029/2000JD900110).

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Zeileis A, Hornik K, Murrell P (2009). Escaping RGBland: Selecting Colors for Statistical Graphics. *Computational Statistics & Data Analysis*, **53**, 3259–3270. doi: [10.1016/j.csda.2008.11.033](https://doi.org/10.1016/j.csda.2008.11.033).

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`dataexample`*Stock market indexes (daily closing prices).*

---

**Description**

The data set *dataexample* contains seven European stock market indexes (daily closing prices): FTSE MIB30 (Italy), IBEX35 (Spain), DAX30 (Germany), CAC40 (France), AEX25 (Netherlands), ATX20 (Austria) and NBEL20 (Belgium) spanning from January 2, 2004 to June 29, 2012. In order to cope with the different official holidays, we have adjusted the raw indices data, carrying forward the closing price from the last working day before each of these holidays.

**Usage**

```
data(dataexample)
```

**Format**

A list containing 2216 elements and 7 variables

**Source**

<https://finance.yahoo.com>

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`WC`*Wavelet correlation (bivariate case) pairwise comparisons.*

---

**Description**

The `WC` function (bivariate case) computes the wavelet correlation by means of the function *wave.-correlation* of the *waveslim* package to several time series, makes a pairwise comparisons and plot the pairwise wavelet correlations in descending order as a single heatmap using the *colorspace* package. The input data are multivariate time series and `WC` function only tackle arrays with  $N \times C$  (elements x columns, where the number of columns are between 2 and 7) dimensions.

**Usage**

```
WC(inputDATA, Wname, J, device="screen", filename,  
    Hfig, WFig, Hpdf, Wpdf)
```

### Arguments

inputDATA	An array of multivariate time series as a <i>ts</i> object (please, check the <i>ts</i> manual to get more information about the <i>ts</i> function in R).
Wname	The wavelet function or filter to use in the decomposition.
J	Specifies the depth of the decomposition.
device	The type of the output device (by default the option is “screen”, and the other options are “jpg”, “png”, “eps” and “pdf”).
filename	The output filename.
Hfig	The height of the ‘jpg’ or ‘png’ image.
WFig	The width of the ‘jpg’ or ‘png’ image.
Hpdf	The height of the ‘eps’ or ‘pdf’.
Wpdf	The width of the ‘eps’ or ‘pdf’.

### Details

The `WC` function compute the wavelet correlation among time series and plots the results in a single heatmap plot (which can be displayed in the screen or can be saved as PNG, JPG, PDF or EPS) showing the WC values as a table (please, look at Figure 3 in **Polanco-Martinez** and Fernandez-Macho 2014). The `WC` code is based on the `wave.correlation` routine from Brandon Whitcher’s `waveslim` R package Version: 1.7.1, which is based mainly on wavelet methodology developed by Whitcher, B., P. Guttorp and D.B. Percival (2000) and Gencay, Selcuk and Whitcher (2001).

### Value

Output:

Output plot: *screen or 'filename + .png, .jpg, .eps or .pdf'*.

`wavcor.modwtsDAT`: matrix with as many rows as levels in the wavelet transform object. The first column provides the point estimate for the wavelet correlation followed by the lower and upper bounds from the confidence interval.

`to3DpL`: A matrix (the matrix table added in the WC plot) with a J (number of wavelet scales) X C (the number of pairwise comparisons) dimensions, which are in descending order taking into account the sum of the wavelet correlation coefficients for all (J) wavelet scales.

### Note

Needs `waveslim` package to calculate `modwt`, `brick.wall` and the `wave.correlation` and also needs the `colorspace` package to plot the heatmaps.

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## References

Gencay, R., F. Selcuk and B. Whitcher (2001). *An Introduction to Wavelets and Other Filtering Methods in Finance and Economics*, Academic Press.

Ihaka, R., Murrell, P., Hornik, K., Fisher, J. C. and Zeileis, A. (2012). *colorspace: Color Space Manipulation*. R package version 1.2.0, The Comprehensive R Archive Network (CRAN), <URL: <https://cran.r-project.org/package=colorspace>>.

**Polanco-Martinez, J.** and J. Fernandez-Macho (2014). The package 'W2CWM2C': description, features and applications. *Computing in Science & Engineering*, **16**(6):68–78. doi: [10.1109/MCSE.2014.96](https://doi.org/10.1109/MCSE.2014.96).

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## Examples

```
## Figure 3 (Polanco-Martinez and Fernandez-Macho 2014).

library("colorspace")
library("waveslim")
library("W2CWM2C")
data(dataexample)

#:: Transforms to log returns using: ln(t + deltat) - ln(t).
#:: The application in this example uses stock market
#:: indexes (it is common to use log returns instead of
#:: raw data). Other kinds of pre-processing data are possible.

dataexample <- dataexample[-1] # remove dates!
dataexample <- dataexample[,1:5]
lrdatex <- apply(log(dataexample), 2, diff)
inputDATA <- ts(lrdatex, start=1, frequency=1)

#Input parameters
Wname <- "la8"
J <- 8
compWC <- WC(inputDATA, Wname, J, device="screen", NULL,
             NULL, NULL, NULL, NULL)
```

---

WCC *Wavelet cross-correlation (bivariate case).*

---

### Description

The `WCC` function (bivariate case) computes the wavelet cross correlation using the `spin.correlation` function of the `waveslim` package for two time series, and presents the result as a plot that reduce the number of plots of the classical function `spin.correlation`. The heatmap plot is built using the `colorspace` package and can be displayed in the screen or can be saved as PNG, JPG, PDF or EPS.

### Usage

```
WCC(inputDATA, Wname, J, lmax, device="screen", filename,
     Hfig, WFig, Hpdf, Wpdf)
```

### Arguments

<code>inputDATA</code>	A couple of time series as a <i>ts</i> object (please, check the <i>ts</i> manual to get more information about the <i>ts</i> function in R).
<code>Wname</code>	The wavelet function or filter to use in the decomposition.
<code>J</code>	Specifies the depth of the decomposition.
<code>lmax</code>	The maximum lag.
<code>device</code>	The type of the output device (by default the option is "screen", and the other options are "jpg", "png", "eps" and "pdf").
<code>filename</code>	The output filename.
<code>Hfig</code>	The height of the 'jpg' or 'png' image.
<code>WFig</code>	The width of the 'jpg' or 'png' image.
<code>Hpdf</code>	The height of the 'eps' or 'pdf'.
<code>Wpdf</code>	The width of the 'eps' or 'pdf'.

### Details

The `WCC` function compute the wavelet cross-correlation between two time series and plot the results in a single heatmap plot (please, look at Figure 5 in **Polanco-Martinez** and Fernandez-Macho 2014). The `WCC` code is based on the `spin.correlation` routine from Brandon Whitcher's `waveslim` R package Version: 1.7.1, which is based mainly on wavelet methodology developed by Whitcher, B., P. Guttorp and D.B. Percival (2000) and Gencay, Selcuk and Whitcher (2001).

### Value

Output:

Output plot: *screen* or *'filename + .png, .jpg, .eps or .pdf'*.

*returns.cross.cor*: a matrix with the WCC values.

**Note**

Needs *waveslim* package to calculate *modwt*, *brick.wall* and *spin.correlation* and also needs the *colorspace* package to plot the heatmaps.

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**References**

Gencay, R., F. Selcuk and B. Whitcher (2001). *An Introduction to Wavelets and Other Filtering Methods in Finance and Economics*, Academic Press.

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**Polanco-Martinez, J. M.** and Abadie, L. M. (2016). Analyzing crude oil spot price dynamics versus long term future prices: A wavelet analysis approach. *Energies*, **9**(12), 1089. doi: [10.3390/en9121089](https://doi.org/10.3390/en9121089).

Whitcher, B., P. Guttorp, and D.B. Percival (2000). Wavelet analysis of covariance with application to atmospheric time series. *Journal of Geophysical Research - Atmospheres*, **105**(D11):941–962. doi: [10.1029/2000JD900110](https://doi.org/10.1029/2000JD900110).

Whitcher, B. (2012). *waveslim: Basic wavelet routines for one-, two- and three-dimensional signal processing*. R package version 1.7.1, The Comprehensive R Archive Network (CRAN), <URL: <https://cran.r-project.org/package=waveslim>>.

**Examples**

```
## Figure 5 (Polanco-Martinez and Fernandez-Macho 2014)

library("colorspace")
library("waveslim")
library("W2CWM2C")
data(dataexample)

#:: Transforms to log returns using: ln(t + deltat) - ln(t).
```

```

#:: The application in this example uses stock market
#:: indexes (it is common to use log returns instead of
#:: raw data). Other kinds of pre-processing data are possible.

dataexample <- dataexample[-1] #remove the dates!
DAXCAC      <- dataexample[,c(3,4)]
lrdatex     <- apply(log(DAXCAC), 2, diff)
inputDATA   <- ts(lrdatex, start=1, frequency=1)

Wname       <- "la8"
J           <- 8
lmax        <- 30
compWCC     <- WCC(inputDATA, Wname, J, lmax, device="screen", NULL,
                  NULL, NULL, NULL, NULL)

```

---

WMC

---

*Wavelet multiple correlation (multivariate case).*


---

## Description

The `WMC` function generates a plot to the wavelet routine for multiple correlation (*wave.multiple.correlation*) from the *wavemulcor* package (Fernandez-Macho 2012b). The `WMC` plot output can be displayed in the screen (by default) or can be saved as PNG, JPG, PDF or EPS. Furthermore, it also provides a way to handle multivariate time series easily as a list of  $N$  elements (time series).

## Usage

```
WMC(inputDATA, Wname, J, device="screen", filename,
     Hfig, WFig, Hpdf, Wpdf)
```

## Arguments

<code>inputDATA</code>	A couple of time series as a <i>ts</i> object (please, check the <i>ts</i> manual to get more information about the <i>ts</i> function in R).
<code>Wname</code>	The wavelet function or filter to use in the decomposition.
<code>J</code>	Specifies the depth of the decomposition.
<code>device</code>	The type of the output device (by default the option is "screen", and the other options are "jpg", "png", "eps" and "pdf").
<code>filename</code>	The output filename.
<code>Hfig</code>	The height of the 'jpg' or 'png' image.
<code>WFig</code>	The width of the 'jpg' or 'png' image.
<code>Hpdf</code>	The height of the 'eps' or 'pdf'.
<code>Wpdf</code>	The width of the 'eps' or 'pdf'.

## Details

The `WMC` function helps to make and save easily the plot of the multiple correlation routine (`wave.multiple.correlation`) of the `wavemulcor` package (Fernandez-Macho 2012b). The `WMC` function also helps to manage easily multivariate time series to use the Wavelet multiple correlation routine.

## Value

Output:

Output plot: `screen` or `'filename + .png, .jpg, .eps or .pdf'`.

Output data: The same list of elements of the function `wave.multiple.correlation` of the `wavemulcor` package (Fernandez-Macho 2012b).

## Note

Needs `wavemulcor` (to compute the `wave.multiple.correlation`) and `waveslim` packages (to compute the `modwt` and the `brick.wall`).

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## References

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## Examples

```
# This example is the wavelet multiple correlation (WMC) version of
# the Figure 7 in Polanco-Martinez and Fernandez-Macho (2014).
```

```
library("wavemulcor")
library("W2CWM2C")
```

```

data(dataexample)

#:: Transform to log returns using: ln(t + deltat) - ln(t).
#:: The application in this example uses stock market
#:: indexes (it is common to use log returns instead of
#:: raw data). Other kinds of pre-processing data are possible.

dataexample <- dataexample[-1] #remove the dates!
dataexample <- dataexample[,1:5]
lrdatex <- apply(log(dataexample), 2, diff)
inputDATA <- ts(lrdatex, start=1, frequency=1)

#Input parameters
Wname <- "la8"
J <- 8
compWMC <- WMC(inputDATA, Wname, J, device="screen", NULL,
               NULL, NULL, NULL, NULL)

```

---

 WMCC

*Wavelet multiple cross-correlation (multivariate case).*


---

## Description

The **WMCC** function (multivariate case) computes the wavelet multiple cross correlation by means of the function *wave.multiple.cross.correlation* from the *wavemulcor* package (Fernandez-Macho 2012b) and present the result as a novel plot that reduce the number of plots of the classical function *wave.multiple.cross.correlation*. The **WMCC** plot output can be displayed in the screen (by default) or can be saved as PNG, JPG, PDF or EPS. The **WMCC** function also provides a way to handle multivariate time series easily as a list of N elements (time series).

## Usage

```

WMCC(inputDATA, Wname, J, lmax, device="screen", filename,
      Hfig, WFig, Hpdf, Wpdf)

```

## Arguments

<code>inputDATA</code>	An array of multivariate time series as a <i>ts</i> object (please, check the <i>ts</i> manual to get more information about the <i>ts</i> function in R).
<code>Wname</code>	The wavelet function or filter to use in the decomposition.
<code>J</code>	Specifies the depth of the decomposition.
<code>lmax</code>	The maximum lag.
<code>device</code>	The type of the output device (by default the option is "screen", and the other options are "jpg", "png", "eps" and "pdf").
<code>filename</code>	The output filename.
<code>Hfig</code>	The height of the 'jpg' or 'png' image.

WFig	The width of the 'jpg' or 'png' image.
Hpdf	The height of the eps or pdf.
Wpdf	The width of the eps or pdf.

### Details

The `WMCC` function compute the wavelet multiple cross correlation using the function `wave.multiple.cross.correlation` from the `wavemulcor` package (Fernandez-Macho 2012b), but the `WMCC` function incorporates some graphical improvements (please, look at Figure 7 in Polanco-Martinez and Fernandez-Macho 2014), such as the reduction of the number of plots to present the results of the function `wave.multiple.cross.correlation`.

### Value

Output:

Output plot: `screen` or `'filename + .png, .jpg, .eps or .pdf'`.

Output data: The same list of elements of the function `wave.multiple.cross.correlation` of the `wavemulcor` package (Fernandez-Macho 2012b).

### Note

Needs `wavemulcor` (to compute the `wave.multiple.cross.correlation`) and `waveslim` packages (to compute the `modwt` and the `brick.wall`) and also needs the `colorspace` package to plot the heatmaps.

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### References

Fernandez-Macho, J. (2012a). Wavelet multiple correlation and cross-correlation: A multiscale analysis of euro zone stock markets. *Physica A: Statistical Mechanics and its Applications*, **391**(4):1097–1104. doi: [10.1016/j.physa.2011.11.002](https://doi.org/10.1016/j.physa.2011.11.002).

Fernandez-Macho, J. (2012b). *wavemulcor: Wavelet routine for multiple correlation*. R package version 1.2, The Comprehensive R Archive Network (CRAN), <URL: <https://cran.r-project.org/package=wavemulcor>>.

Ihaka, R., Murrell, P., Hornik, K., Fisher, J. C. and Zeileis, A. (2012). *colorspace: Color Space Manipulation*. R package version 1.2.0, The Comprehensive R Archive Network (CRAN), <URL: <https://cran.r-project.org/package=colorspace>>.

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MCSE.2014.96.

### Examples

```
library("colorspace")
library("wavemulcor")
library("W2CWM2C")
data(dataexample)

#:: Figure 7 (Polanco-Martinez and Fernandez-Macho (2014)).

#:: Transform log returns using:  $\ln(t + \text{deltat}) - \ln(t)$ .
#:: The application in this example uses stock market
#:: indexes (it is common to use log returns instead of
#:: raw data). Other kinds of pre-processing data are possible.

dataexample <- dataexample[-1] #remove the dates!
lrdatex <- apply(log(dataexample), 2, diff)
inputDATA <- ts(lrdatex, start=1, frequency=1)

Wname <- "la8"
J <- 8
lmax <- 30
compWCC <- WMCC(inputDATA, Wname, J, lmax, device="screen", NULL,
                NULL, NULL, NULL, NULL)
```

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