Package 'GRTo'

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Type Package

Title Tools for the Analysis of Gutenberg-Richter Distributions of Earthquake Magnitudes

Version 1.3

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Author Daniel Amorese, Paul A. Rydelek and Jean-Robert Grasso

Maintainer Daniel C. Amorese <amorese@ipgp.fr>

Depends R (>= 2.2.0)

Imports bootstrap, grDevices, graphics, stats, utils

Description Offers functions for the comparison of Gutenberg-Richter b-values. Several functions in GRTo are helpful for the assessment of the quality of seismicity catalogs.

License GPL

LazyLoad yes

NeedsCompilation no

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GRTo-package *Gutenberg-Richter Tools*

Description

Gutenberg-Richter Tools for the analyzis of the properties of distributions of earthquakes in magnitude. Some functions in this package are helpful for the comparison of Gutenberg-Richter b-values. The Schuster's function can be used to highlight blast contamination in earthquake catalogs.

Details

Package:	GRTo
Type:	Package
Version:	1.3
Date:	2015-09-16
License:	GPL
LazyLoad:	yes

Note

Thanks to Paul Friberg (ISTI) for telling us about the bug in the graphical part of bvmed.R. Thanks to Scott Kostyshak (Princeton University) for telling us about the extra bootstrap package dependency. GRTo version 1.2 fixes the issues reported by Paul and Scott. Thanks to Andrew Barbour (USGS) for detecting and fixing minor problems of bvmed.R of version 1.2. In version 1.3, the b-value and an optional staircase line FMD are displayed by BBootComp when a single magnitude file is processed. Version 1.3 also fixes a bug with negative magnitude values. In version 1.3, an option coded by Andrew Barbour allows the processing of data from a list. Willy Aspinall (University of Bristol) highlights bugs in the graphical parts of bvmed and BBootComp: An inappropriate magnitude shift in FMD plots is definitely fixed in version 1.3. Many thanks to Willy!

Author(s)

Daniel Amorese <amorese@ipgp.fr>, Paul A. Rydelek <prydelek@memphis.edu> and Jean-Robert Grasso <grasso@obs.ujf-grenoble.fr>

Maintainer: Daniel Amorese <amorese@ipgp.fr>

References

D. Amorese, "Applying a change-point detection method on frequency-magnitude distributions", *Bull. seism. Soc. Am.* (2007) 97, doi:10.1785\/0120060181

D. Amorese, J.-R. Grasso and P. A. Rydelek, "On varying *b*-values with depth: results from computer-intensive tests for Southern California", *Geophys. J. Int.* (2010) 180, 347-360

Rydelek, P. A. and Hass, L. (1994) On Estimating the Amount of Blasts in Seismic Catalogs with Schuster's Method *Bulletin of the Seismological Society of America*, Vol. 84, No. 4, pp. 1256-1259.

Siegel, A.F., "Robust regression using repeated medians", *Biometrika* (1982) 69, 242-244.

Zurn, W. and Rydelek, P. A. (1996) Revisiting the phasor-walkout method for detailed investigation of harmonic signals in time series *Surveys in Geophysics*, Vol. 15, No. 4, pp. 409-431.

Examples

```
# Comparison of the b-value for the IDYLLdeep data set.
    BBootComp(finame1=system.file("extdata","IDYLLdeep.data.txt",package="GRTo"),
    finame2=NULL, colid1=15, colid2=NULL,nrep=200,alter=NULL,findtm1=TRUE,
    findtm2=NULL,plot=TRUE, title="IDYLLWILD", tm1=NULL,tm2=NULL)
```

`BBootComp` *Bootstrap test for the comparison of Gutenberg-Richter b-values*

Description

This function computes Gutenberg-Richter *b*-values, as well as their uncertainties. The comparison of 2 *b*-values are performed through a bootstrap test.

Usage

```
BBootComp(finame1, finame2 = NULL, colid1 = 1, colid2 = 1, hd1 = FALSE,
hd2 = FALSE, nrep = 5000, alter = c("two.sided", "less", "greater"),
tm1 = NULL, tm2 = NULL, findtm1 = TRUE, findtm2 = TRUE, plot = FALSE,
title = "BootComp",oplt="p")
```

Arguments

`finame1`	a character string specifying the first file to be loaded
`finame2`	an optional character string specifying the second file to be loaded. See 'Details'
`colid1`	field number for the magnitude values in `finame1`
`colid2`	an optional field number for the magnitude values in `finame2`. See 'Details'
`hd1`	logical. Whether `finame1` contains headers or not
`hd2`	logical. Whether `finame2` contains headers or not
`nrep`	number of replicates for the bootstrap
`alter`	a character string specifying the alternative hypothesis, must be one of '"two.sided"' (default), '"greater"' or '"less"'. You can specify just the initial letter
`tm1`	threshold magnitude value for the first data set. If `tm1` is NULL and `findtm1` is FALSE, the function considers that the data set has been already truncated after the threshold magnitude value (i. e. your data set shows only the linear part of the FMD)

tm2	an optional threshold magnitude value for the second data set. If tm2 is NULL and findtm2 is FALSE, the function considers that the data set has been already truncated after the threshold magnitude value (i. e. your data set shows only the linear part of the FMD)
findtm1	logical. Whether an automatic procedure is engaged to determine the threshold magnitude value tm1 or not
findtm2	logical. Whether an automatic procedure is engaged to determine the threshold magnitude value tm2 or not
plot	logical. If TRUE, a FMD plot is drawn. Default is plot equals FALSE
title	character. The title of the plot. The name for the PNG file that includes the plot begins with title
oplt	character. Option for the plot. If oplt is "p", the FMD displays points (open triangles), else it shows a staircase. This option applies only to the plot of a single FMD: When 2 FMDs are compared, they are always shown with point symbols

Details

if 'finame2' is not NULL, this function compares 2 sets of magnitude values that are contained in 2 different files. Otherwise, only the FMD for data in 'finame1' is analyzed.

Value

A list containing the following components:

val	object of class htest containing the results of the bootstrap test
b1	*b*-value for the first data set
b2	*b*-value for the second data set
sd1	standard-error of the *b*-value for the first data set
sd2	standard-error of the *b*-value for the second data set
m01	threshold magnitude for the first data set
m02	threshold magnitude for the second data set
a1	*a*-value for the first data set. This value is not corrected for time, e. g. this is not the seismic productivity per year
a2	*a*-value for the second data set. This value is not corrected for time, e. g. this is not the seismic productivity per year

Author(s)

Daniel Amorese <amorese@ipgp.fr>, Paul A. Rydelek <prydelek@memphis.edu> and Jean-Robert Grasso <grasso@obs.ujf-grenoble.fr>

Maintainer: Daniel Amorese <amorese@ipgp.fr>

References

D. Amorese, "Applying a change-point detection method on frequency-magnitude distributions", *Bull. seism. Soc. Am.* (2007) 97, doi:10.1785\/0120060181

D. Amorese, J.-R. Grasso and P. A. Rydelek, "On varying *b*-values with depth: results from computer-intensive tests for Southern California", *Geophys. J. Int.* (2010) 180, 347-360

See Also

utcomp

Examples

```
BBootComp(finame1=system.file("extdata","IDYLLshal.data.txt",package="GRTo"),
finame2=NULL, colid1=15, colid2=NULL,nrep=200,alter=NULL,findtm1=TRUE,
findtm2=NULL,plot=TRUE, title="IDYLLWILD", tm1=NULL,tm2=NULL)
```

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bvmed — *Repeated medians regression for the determination of the Gutenberg-Richter b-value*

Description

This function determines the Gutenberg-Richter *b*-value from a set of magnitude values, using the repeated medians regression method.

Usage

```
bvmed(file, lis, hd = FALSE, colid = 1, nrep = 200, tm = NULL,
findtm = TRUE, title = "bvmed")
```

Arguments

file	file to be loaded
lis	list to be loaded
hd	whether file contains header or not
colid	field number for the magnitude values in file
nrep	number of replicates for the bootstrap (calculation of the standard-error for the *b*-value)
tm	threshold magnitude value
findtm	logical. Whether an automatic procedure is engaged to determine the threshold magnitude value tm or not
title	character. The title of the plot. The name for the PNG file that includes the plot begins with title

Details

This function reads magnitude values in the field which number is indicated by `colid` in `file`. Magnitude values are read in the list `lis` if the file does not exist. This function produces a plot showing the FMD and the linear model line. The plot is stored into a file with name `file`_bvmed.png (png format file). It includes the mblm function from the version 0.11 (2007) of the mblm library by Lukasz Komsta (known e-mail address : luke@novum.am.lublin.pl).

Value

A list containing the following components:

`quantm`	the 5%, 50% and 95% quantiles of the bootstrap replicates for the threshold magnitude value
`mmed`	the median of the bootstrap replicates for the threshold magnitude value
`quantb`	the 5%, 50% and 95% quantiles of the bootstrap replicates for the *b*-value
`valid`	the number of valid replicates
`brm`	the *b*-value
`bse`	the bootstrap standard-error value for the *b*-value
`bme`	the bootstrap margin of errors value for the *b*-value

Note

Thanks to Paul Friberg for telling us about the bug in the graphical part of bvmed.R. Thanks to Scott Kostyshak for telling us about the extra bootstrap package dependency. GRTo version 1.2 fixes these issues. Thanks to Andrew Barbour (USGS) for detecting and fixing minor problems of bvmed.R of version 1.2. In version 1.3, an option coded by Andrew Barbour allows the processing of data from a list. Willy Aspinall (University of Bristol) highlights bugs in the graphical parts of bvmed: An inappropriate magnitude shift in the FMD plot is definitely fixed in version 1.3. Many thanks to Willy!

Author(s)

Daniel Amorese <amorese@ipgp.fr>, Paul A. Rydelek <prydelek@memphis.edu> and Jean-Robert Grasso <grasso@obs.ujf-grenoble.fr>

Maintainer: Daniel Amorese <amorese@ipgp.fr>

References

D. Amorese, J.-R. Grasso and P. A. Rydelek, "On varying *b*-values with depth: results from computer-intensive tests for Southern California", *Geophys. J. Int.* (2010) 180, 347-360

Siegel, A.F., "Robust regression using repeated medians", *Biometrika* (1982) 69, 242-244.

Examples

```
bvmed(file=system.file("extdata","IDYLLdeep.data.txt",package="GRTo"), colid = 15, nrep = 150,
tm = NULL, findtm = TRUE, title = "IDYLLWILD")
```

fmddisc *Analysis of Discontinuities in Frequency Magnitude Distributions*

Description

This function finds significant discontinuities in Frequency Magnitude Distributions (FMD).

Usage

```
fmddisc(file, header = FALSE, colid = 1, nrep = 200, title = "fmddisc")
```

Arguments

file	filename of the file to be loaded
header	whether file contains headers or not
colid	field number for the magnitude values in file
nrep	number of replicates for the bootstrap
title	main title for the plot

Details

This function reads magnitude values in the field which number is indicated by colid in file. The function returns values of significant magnitude discontinuities (e. g. deviations from linearity) in the FMD. A bootstrap procedure is used to obtain the 90% confidence interval for magnitude discontinuities. We assumed the distribution of the nrep bootstrap replicates is not skewed. Therefore, the 90% confidence interval is simply formed by taking 5% and 95% quantiles of the bootstrap replicates as the lower and upper bound of the interval respectively. These values and the 50% quantile (median) are returned in a list by the function. The function also returns bootstrap mean and bootstrap standard-error (standard deviation of bootstrap replicate estimates). The bootstrap margin of errors at the 90% normal confidence level is returned as the result of 1.645 * bootstrap standard-error. The function produces a plot showing the FMD and histograms of magnitude values for the significant discontinuities in the FMD. The plot is stored into a file with name file_disc.png (png format file). Values of counts in histograms are controlled by the number of replicates nrep that are used.

Value

This function returns a list containing the following components:

quant1	the 5%, 50% and 95% quantiles of the bootstrap replicates for the main discontinuity
valid	the numbers of valid replicates
bmean	the bootstrap mean values
bse	the bootstrap standard-error values
bme	the bootstrap margin of errors values
quant2	the 5%, 50% and 95% quantiles of the bootstrap replicates for the auxiliary discontinuity

Note

Thanks to Scott Kostyshak for telling us about the extra bootstrap package dependency. GRTo version 1.2 fixes this issue.

Author(s)

Daniel Amorese

References

D. Amorese, "Applying a change-point detection method on frequency-magnitude distributions", *Bull. seism. Soc. Am.* (2007) 97, doi:10.1785\/0120060181

Examples

```
fmddisc(file=system.file("extdata","IDYLLdeep.data.txt",package="GRTo"),
header=FALSE,colid=15,nrep=200,"FMD mag discontinuities")
```

`schuster` *Plot of a phasor walkout for the Schuster's test*

Description

This function plots a phasor walkout for the Schuster's test.

Usage

```
schuster(finame, title = "Schuster's diagram", color = c("black","red","orange",
"green","cyan","navy"), hd = FALSE, colidye = NULL, colidmo = NULL, colidda = NULL,
colidho = 1, colidmi = 2, colidma = 3, colidz = NULL, utccor = 0, dayt1 = NULL,
dayt2 = NULL, ysel1 = NULL, ysel2 = NULL, mosel1 = NULL, mosel2 = NULL,
dasel1 = NULL, dasel2 = NULL, magsel1 = NULL, magsel2 = NULL, zsel1 = NULL,
zsel2 = NULL, weekday1 = c("mo","tu","we","th","fr","sa","su"),
weekday2 = c("mo","tu","we","th","fr","sa","su"))
```

Arguments

`finame`	name of the file to be loaded
`title`	main title that will appear in the phasor walkout plot
`color`	color of the phasor walkout (black/red/orange/green/cyan/navyblue). The first letter is enough to discriminate the color name
`hd`	logical. Whether `finame` contains headers or not
`colidye`	field number for the year values in the loaded file
`colidmo`	field number for the month values in the loaded file
`colidda`	field number for the day values in the loaded file

colidho	field number for the hour values in the loaded file
colidmi	field number for the minute values in the loaded file
colidma	field number for the magnitude values in the loaded file
colidz	field number for the depth values in the loaded file
utccor	correction for local time. This value and values of the start and end hours of nighttime are used to filter the daytime seismic noise from the walkout plot
dayt1	the start hour of nighttime in local time
dayt2	the end hour of nighttime in local time
ysel1	minimum year value for selection (Default is NULL, e. g. no selection)
ysel2	maximum year value for selection (Default is NULL, e. g. no selection)
mosel1	minimum month value for selection (Default is NULL, e. g. no selection)
mosel2	maximum month value for selection (Default is NULL, e. g. no selection)
dasel1	minimum day value for selection (Default is NULL, e. g. no selection)
dasel2	maximum day value for selection (Default is NULL, e. g. no selection)
magsel1	minimum magnitude value for selection (Default is NULL, e.g. no selection)
magsel2	maximum magnitude value for selection (Default is NULL, e.g. no selection)
zsel1	minimum depth value for selection (Default is NULL, e. g. no selection)
zsel2	maximum depth value for selection (Default is NULL, e. g. no selection)
weekday1	first day in the week for selection ("mo" for "Monday", "tu" for "Tuesday", "we" for "Wednesday", "th" for "Thursday", "fr" for "Friday", "sa" for "Saturday", "su" for "Sunday")
weekday2	last day in the week for selection ("mo" for "Monday", "tu" for "Tuesday", "we" for "Wednesday", "th" for "Thursday", "fr" for "Friday", "sa" for "Saturday", "su" for "Sunday")

Details

This function reads earthquake times (hour and minutes values are required) in an input file and plots a phasor walkout into a file with name `file\_schu.png` (png format file). Selections can be performed based on ranges in hour of the day, year, month, day, magnitude, depth and day of the week (in the same week). The correction for local time is such that GMT time + correction (e. g. `utccor`) = local time.

Author(s)

Daniel Amorese \& Paul A. Rydelek

References

Rydelek, P. A. and Hass, L. (1994) On Estimating the Amount of Blasts in Seismic Catalogs with Schuster's Method *Bulletin of the Seismological Society of America*, Vol. 84, No. 4, pp. 1256-1259.

Zurn, W. and Rydelek, P. A. (1996) Revisiting the phasor-walkout method for detailed investigation of harmonic signals in time series *Surveys in Geophysics*, Vol. 15, No. 4, pp. 409-431.

Examples

```
schuster(finame=system.file("extdata","IDYLLdeep.data.txt",package="GRTo"),
title = "Schuster's diagram", hd = FALSE, colidye = 1, color="n", colidmo = 2,
colidda = 3, colidho = 4, colidmi = 5, colidma = 15, colidz = 9, utccor = -9,
dayt1 = NULL, dayt2 = NULL, ysel1 = 1983, ysel2 = 1990, mosel1 = NULL,
mosel2 = NULL, dasel1 = NULL, dasel2 = NULL, magsel1 = NULL, magsel2 = NULL,
zsel1 = NULL, zsel2 = NULL, weekday1 = NULL, weekday2 = NULL)
```

---

utcomp *p-value for the Utsu's test*

Description

This function calculates the *p*-value for the Utsu's test from 2 values of b and 2 sample sizes.

Usage

```
utcomp(b1, n1, b2, n2)
```

Arguments

b1	*b*-value from the first sample
n1	size of the first sample (number of data above or equal to the threshold magnitude in the first data set)
b2	*b*-value from the second sample
n2	size of the second sample (number of data above or equal to the threshold magnitude in the second data set)

Details

The formula is given in Utsu's (1992, 1999).

Value

utcomp returns the *p*-value of the Utsu's test for the comparison of 2 *b*-values.

Author(s)

Daniel Amorese

References

Utsu, T. (1992) Introduction to seismicity, *Surijishingaku (Mathematical Seismology)*, Inst. Statis. Math, 34, (VII), 139-157, (in Japanese).

Utsu, T. (1999) Representation and analysis of the earthquake size distribution: a historical review and some new approaches, *Pure appl. Geophys.*, 155, 509-535

See Also

BBootComp

Examples

```
# Utsu's \emph{p}-value for the comparison of 2 \emph{b}-values in the Santa Paula area.
utcomp(0.97,366,0.77,1161)
```

Index