Package 'ssEDA'

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Title Exploratory Data Analysis for Earthquake Data

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Description Contains functions to do epicentral plots, magnitude-time plots, b-value plots, and various other empirical summaries.

Depends ssBase, maps

Suggests rggobi, mapdata, ssNZ, ssPDE, ssSCEC

License GPL (>=2)

URL http://www.statsresearch.co.nz/software.html

R topics documented:

`bvalue.contour` *b-Value Contours at Specified Depth*

Description

This function calculates b-value contours at a pre-specified depth.

Usage

```
bvalue.contour(events, divs=c(15, 15, 15), h=c(0.5, 0.5, 15),
               threshold=30, depth=10)
```

Arguments

`events`	defines the events to be plotted. It is an object of class `"subset"`, generally created by `subsetcircle`, `subsetpolygon`, `subsetrect` or `subsetsphere`.
`divs`	a vector of length three. It specifies the grid points where b-values are calculated. The first, second and third entries of this vector correspond to the number of divisions on the longitude, latitude and depth axes respectively.
`h`	a vector of length three. This specifies the bandwidths for the kernel function (see Details).
`threshold`	the minimum number of events needed to evaluate pointwise b-values (see Details).
`depth`	specifies the longitude-latitude plane where the b-value contours are plotted.

Details

The b-values are calculated in two steps. First, they are evaluated on a 3D grid using the maximum likelihood method (Utsu, 1965). The MLE estimate at (x, y, z) (corresponds to longitude, latitude and depth respectively) only utilises data that lie in $S =$ `(x-divs[1],x+divs[1],y-divs[2],y+divs[2], z-divs[3],z+divs[3])`. However, if the number of points in S is less than that specified by the `threshold` parameter, the closest `threshold` number of points to (x, y, z) are used. The resulting b-value estimates are smoothed using local linear regression technique described in Ruppert and Wand (1994) using a standard trivariate normal kernel. The smoothness of the contours is controlled by the bandwidths of the kernel.

Value

NULL

Author(s)

Edwin Choi (ANU), 1997

References

Ruppert, D. & Wand, M.P. (1994). Multivariate locally weighted least squares regression. *Ann. Statist.* **22**, 1346–1370.

Utsu, T. (1965). A method for determining the value of b in a formula $\log n = a - bM$ showing the magnitude frequency relation for earthquakes. *Geophys. Bull. Hokkaido University* **13**, 99–103 (in Japanese).

See Also

`magnitude.contour`

Examples

```
#    This example requires the NZ catalogue

require(ssNZ)

#   Remember the parameters of the graphics device
par.reset <- par(no.readonly=TRUE)

#   Make the Wellington Catalogue
as.catalogue(subsetrect(NZ, minlat=-42.2, maxlat=-40.5,
             minlong=173.6, maxlong=176.0, minday=julian(1,1,1978)),
             catname="Wellington")

b <- subsetrect(Wellington, maxdepth=100, minmag=3,
                minlat=-42.2, maxlat=-40.5, minlong=173.6, maxlong=176.0,
                minday=julian(1,1,1980), maxday=julian(1,1,2000))

par(pty="s")
bvalue.contour(b, h=c(0.25, 0.2, 2), depth=10)
map("nz", add=TRUE, col="red")
par(par.reset)
```

Change Log — *Changes Made to the Package*

Description

This page contains a listing of recent changes made to functions, and known general problems.

Details

1. `hemisphere`: An argument has been added called `filename`, with default value `"temp.ps"`, giving the name of the postscript file. (February 2003)
2. Function `time.plot` has been renamed to `timeplot` to stop confusion with methods and generic functions. (June 2003)
3. `hemisphere`: Argument `filename` has been deleted. The plot is now written to the current device or a new window is opened. (June 2003)
4. `rotation`: Argument `psname` has been deleted. The plot is now written to the current device or a new window is opened. (June 2003)

5. epicentres: Argument mapname has been added. (July 2003)
6. epicentres.identify: Default on argument mapname has been changed to "world.lores". (July 2003)
7. epicentres.identify: Changed example in documentation. (October 2003)
8. world.lores data object renamed to worldLores and implemented as .R form in data/ directory rather than creating .rda file at install time. (October 2003)
9. world.lores map name in epicentres.identify renamed to world to match maps_2.0-2. (October 2003)
10. epicentres: default value of argument mapname changed from world2.lores to world2 to match maps_2.0-2. (November 2003)
11. epicentres.identify: default value of argument mapname changed from world to world2. (November 2003)
12. Minor documentation formatting changes, mainly to use \dQuote and \pkg. (January 2004)
13. map1: New function. (February 2004)
14. epicentres: now calls map1 to plot map. Is now plotted to the current device, not necessarily a postscript file. Colours are now not defined using the current palette, but explicitly using character strings. (February 2004)
15. worldLores, hemisphere: Examples modified to make plotting region square. (February 2004)
16. timeplot, depth.hist: ylim extended so that tallest bar doesn't touch upper box boundary. (February 2004)
17. texps1: has been deleted. (February 2004)
18. magnitude.contour, bvalue.contour: Examples added, now plotted to current device rather than a postscript file. (February 2004)
19. depth.hist, freq.cusum, magnitude.cusum, magnitude.time, multigraph, plot.subset, timeplot: The statement if(length(dev.list()) == 0) X11() has been removed, was required in S-PLUS. (February 2004)
20. epicentres: Depth ranges added as a footnote in example plots. (February 2004)
21. map1: calls the function map, whose argument color has been changed to col. (February 2004)
22. rotation: x-axis label changed to make use of degree symbol. (March 2004)
23. bvalue.contour, magnitude.contour: map added to example plot. (March 2004)
24. worldLores: quotes added around package name in code, i.e. "ssEDA". (7 May 2004)
25. epicentres: function default values in arguments magnitude and depth changed from using 1/0 to Inf. (7 May 2004)
26. threeD: a statement require(xgobi) has been added to the code. This requirement is then no longer a "package" requirement. (7 May 2004)
27. A statement require(ssNZ) has been added to the examples that use the NZ catalogue. Hence **ssNZ** is no longer a "package" requirement of **ssEDA**. (18 May 2004)
28. epicentres: code modified so that argument events can again be a catalogue. (9 Apr 2005)
29. epicentres: expression statement in examples with subtitle containing multiple inequalities changed to make syntactically compatible with recent R updates. (16 Apr 2005)
30. epicentres: Reference to postscript graphics device eliminated from manual page. (21 Apr 2005)

31. worldLores: now implemented directly as a data() call, rather than via delay(), which has been deprecated. (9 Jun 2005)
32. freq.cusum: replace seq(begin, finish + 1) - 1900 with formatC((seq(begin, finish + 1))%%100, width=2, flag="0"). (22 Dec 2005)
33. magnitude.cusum: replace at.breaks - 1900 with formatC(at.breaks%%100, width=2, flag="0"). (22 Dec 2005)
34. Package vignettes added. (22 Dec 2005)
35. Fix error in package vignettes. (04 May 2006)
36. depth.hist, timeplot, freq.magnitude: removed redundant arguments in call to hist when plot==FALSE. Caused warning messages. (30 Jan 2007)
37. major: new page containing a listing of major earthquake events. (14 May 2007)
38. The if require(catalogue) syntax in all examples has been changed to require(catalogue). (15 May 2007)
39. The DESCRIPTION file has the following added: Suggests: xgobi, mapdata, ssNZ, ssPDE, ssSCEC. (05 Jul 2007)
40. All occurences of subset.circle, subset.polygon, subset.rect, subset.sphere in the Examples have been changed to subsetcircle, subsetpolygon, subsetrect, subsetsphere. See Changes in **ssBase**. (8 Nov 2007)
41. threeD: modified to use the ggobi utility. See topic threeD for installation notes for ggobi. (21 Nov 2007)
42. Removal of LaTeX markups from DESCRIPTION file. (31 May 2009)
43. timeplot: complete rewrite of function. (11 Oct 2009)
44. timeplot and depth.hist: argument added to specify the colour of the bars. (13 Nov 2009)

---

depth.hist *Depth Histogram*

Description

Plots a histogram of the depth of selected events.

Usage

```
depth.hist(events, cumulative=FALSE, delta=NA, col="grey80")
```

Arguments

events	defines the events to be plotted. It is an object of class "subset", generally created by subsetcircle, subsetpolygon, subsetrect or subsetsphere.
cumulative	boolean value. If TRUE, the plot is a cumulative histogram. Default if FALSE.
delta	numeric, the bar width used in the histogram. By default, if the depth range is greater than 110 km, delta=10, else delta=1.
col	colour of the bars, default is "grey80".

See Also

freq.cusum, freq.magnitude, magnitude.cusum, magnitude.time, epicentres, threeD, timeplot, multigraph

Examples

```
data(NZ55)

depth.hist(subsetrect(NZ55, minmag=5.5))
```

---

dkagan *Kagan Distribution*

Description

Density, cumulative probability, quantiles and random generation for the Kagan distribution.

Usage

```
dkagan(M, alpha=1, beta=0, gamma=7, M0=4, mag=TRUE, theta=0.75, phi=2.4)
pkagan(M, alpha=1, beta=0, gamma=7, M0=4, mag=TRUE, theta=0.75, phi=2.4)
qkagan(p, alpha=1, beta=0, gamma=7, M0=4, mag=TRUE, theta=0.75, phi=2.4)
rkagan(n, alpha=1, beta=0, gamma=7, M0=4, mag=TRUE, theta=0.75, phi=2.4)
```

Arguments

p	Vector of probabilities.
n	Non-negative sample size. If length(n) is greater than 1, then length(n) random variables are returned.
M	Vector of quantiles.
alpha	Parameter of Kagan distribution. Index of the power law.
beta	Parameter of Kagan distribution. Controls the lower end of the distribution.
gamma	Parameter of Kagan distribution. Controls the upper end of the distribution.
M0	Lowest magnitude under consideration.
mag	Flag indicating whether stress or magnitudes are to be used. Default is true where stresses are used.
theta	Parameter of magnitude.convert.
phi	Parameter of magnitude.convert.

Details

Elements of p or M that are missing will cause the corresponding elements of the result to be missing.

The variables in this basic form of the distribution correspond physically to moments (stress, benioff strain relief). The alternative form allows the parameters and variable to be specified in terms of magnitudes. Once the appropriate values are calculated, if need be, they can be transformed to magnitudes using the magnitude.convert function.

Value

Density (`dkagan`), probability (`pkagan`), quantile (`qkagan`) or random sample (`rkagan`) for the Kagan distribution. The cumulative density function is given by:

$$F(x) = 1 - \left\{ \left(1 + \frac{x}{\beta}\right)^{-\alpha} \exp\left(\frac{-x}{\delta}\right) \right\}$$

where x, `beta` (β) and `delta` (δ) are to be interpreted as stresses according to the relation:

$$S(M) = 10^{\phi + \theta M}.$$

Warning

The function `qkagan` uses a approximate numerical method (Newton-Raphson) to evaluate the quantile.

References

Vere-Jones, D.; Robinson, R. & Yang, W. (2001). Remarks on the accelerated moment release model: problems of model formulation, simulation and estimation. *Geophysical Journal International* **144**, 517–531.

Kagan, Y.Y. (1997). Seismic moment-frequency relation for shallow earthquakes: Regional comparison. *Journal of Geophysical Research* **102**, 2835–2852.

See Also

`magnitude.convert`

Examples

```
#  Examine the Gutenberg-Richter Law:
#  Use default parameters

x <- seq(0, 10, length=1000)
plot(log(x), log(1-pkagan(x)), type="l")
```

---

epicentres *Epicentral Plot of Selected Events*

Description

Plots earthquake epicentres selected from a given catalogue. The colour and size of each point can be made to represent the depth and the magnitude of the event, respectively.

Usage

```
epicentres(events, usr=NA, magnitude=c(-Inf, Inf), cex=NA,
           criteria = TRUE, depth=c(0, Inf),
           colours=c("red2", "yellow2", "green2", "cyan2", "blue2"),
           mapname="world2")
```

Arguments

events	defines the events to be plotted. It is an object of class "subset", "catalogue", or "matrix". If of class "subset", it will generally be created by subsetcircle, subsetpolygon, subsetrect or subsetsphere. If of class "matrix", it must contain the named columns: longitude, latitude, depth, and magnitude.
usr	a vector of length 4 than defines boundary positions of the axes, i.e. c(xmin, xmax, ymin, ymax). The default is selected so that the extreme events are just included.
magnitude	vector of magnitudes, where magnitude[i] is less than or equal to magnitude[i+1]. If length(magnitude)==2, then events with magnitude greater than or equal to magnitude[1] and less than magnitude[2] are selected and events are plotted as points. If length(magnitude) is greater than 2, magnitude defines a sequence of intervals, for which events are plotted as circles of increasing size by for increasing magnitude. The size of the circles is determined by the cex parameter. Default is c(-Inf, Inf).
cex	vector containing the sizes of the plotted points or circles. The length of the vector should correspond to the number of magnitude intervals defined by the magnitude vector. If length(magnitude)==2, then events will be plotted as points and cex will be a scalar denoting the size of the points. If length(magnitude) is greater than 2, then the events are plotted as circles of increasing radius for increasing magnitude. The circle radii are proportional to the values specified in the cex vector. Default values of cex are seq(0.2, length(magnitude)-1, 0.5). These values are appropriate for plots with the order of a thousand points, but may be too small for 100 or less.
criteria	logical variable. If TRUE (default) the subsetting parameters are printed below the graph.
depth	vector of depths, where depth[i] is less than or equal to depth[i+1]. If length(depth)==2, then events with depth greater than or equal to depth[1] and less than depth[2] are selected. If length(depth) is greater than 2, depth defines a sequence of intervals, for which events are plotted in the colours specified by the parameter colours. Default is c(0, Inf).
colours	vector of colours for the different depth intervals.
mapname	character string giving the map name. Low resolution maps contained in package **maps** are "nz" and "world2" (default). High resolution maps contained in the package **mapdata** are "nzHires", "world2Hires" and "chinaHires". The "2" on "world2" denotes the version where the longitudes are all positive.

Details

The plot is placed into the current graphics device. If a graphics device is not open, one of the default type is opened.

The plot uses a rectangular projection. The aspect of the plot (y/x ratio) is calculated within the function, and is set so that the use of the available area within the graphics device is maximised. The graphics device remains open at the end of the function execution so that additional annotation and points can be added to the plot, if required. The margins and aspect ratio will also remain in effect at the end of the execution of the function, and should be reset if multiple plots are to be written to the same output file; see "Examples" below.

See Also

depth.hist, freq.cusum, freq.magnitude, magnitude.cusum, magnitude.time, threeD, timeplot, multigraph

Examples

```
#   Remember the parameters of the graphics device

par.reset <- par(no.readonly=TRUE)

#-----------------------------------------------------------------

#    Here the data are contained in a matrix

data <- cbind(latitude=c( -41.70, -39.30, -40.50, -30.62, -28.42, -32.31),
              longitude=c(172.20,  177.00, 175.50, 178.42, 179.97, 181.21),
              depth=c(20, 30, 45, 12, 300, 339),
              magnitude=c(7.8, 7.8, 7.6, 7.4, 7.4, 7.9))

epicentres(data, usr=c(172, 182, -42, -28), cex=2, mapname="nz")
par(par.reset)

#-----------------------------------------------------------------

#    Here the data are contained in a catalogue

data(NZ55)

epicentres(NZ55, mapname="nz")
title(main="Some Large NZ Events")
par(par.reset)

#-----------------------------------------------------------------

#    Requires the NZ Catalogue
require(ssNZ)

#   Make the Wellington Catalogue
as.catalogue(subsetrect(NZ, minlat=-42.2, maxlat=-40.5,
             minlong=173.6, maxlong=176.0, minday=julian(1,1,1978)),
             catname="Wellington")

b <- subsetrect(Wellington, minlong=173.6, maxlong=176.0, minlat=-42.1,
                maxlat=-40.5, mindepth=36, minday=julian(1,1,1988),
                maxday=julian(1,1,1993))

#   Note that usr specifies the area in the plot
epicentres(b, usr=c(b$minlong-0.01, b$maxlong+0.01,
                    b$minlat-0.005, b$maxlat+0.005),
           depth=c(36, 50, 70, 100, 150, Inf), criteria=FALSE,
           magnitude=c(2, 3, 4, 5, 6, Inf), mapname="nz")
title(sub=expression(paste("Depth (km):  ", 36 <= {red < {50 <=
      {yellow < {70 <= {green < {100 <= {cyan < {150 <= {blue <
      infinity}}}}}}}}})), line=3)
title(main="Wellington Catalogue:  Deep Events")
par(par.reset)
```

```
#-----------------------------------------------------------------

#    Requires the NZ Catalogue
require(ssNZ)

b <- subsetrect(Wellington, minlong=173.6, maxlong=176.0, minlat=-42.1,
                maxlat=-40.5, maxdepth=35.99, minday=julian(1,1,1988),
                maxday=julian(1,1,1993))

#   Note that usr specifies the area in the plot
epicentres(b, usr=c(b$minlong-0.01, b$maxlong+0.01,
                    b$minlat-0.005, b$maxlat+0.005),
           depth=c(0, 10, 15, 20, 25, 36), criteria=FALSE,
           magnitude=c(2, 3, 4, 5, 6, Inf), mapname="nz")
title(sub=expression(paste("Depth (km):  ", 0 <= {red < {10 <=
      {yellow < {15 <= {green < {20 <= {cyan < {25 <= {blue < 36}}}}}}}}})),
      line=3)
title(main="Wellington Catalogue:  Shallow Events")
par(par.reset)

#-----------------------------------------------------------------

#    Requires the NZ Catalogue
require(ssNZ)

b <- subsetrect(NZ, minlong=166, maxlong=180, minlat=-48,
                maxlat=-34, minmag=3, minday=julian(1,1,1970),
                maxday=julian(1,1,1993), mindepth=36)

epicentres(b, depth=c(36, 70, 100, 140, 200, Inf), criteria=FALSE,
           usr=c(b$minlong, b$maxlong, b$minlat, b$maxlat), mapname="nz")
title(sub=expression(paste("Depth (km):  ", 36 <= {red < {70 <=
      {yellow < {100 <= {green < {140 <= {cyan < {200 <= {blue <
      infinity}}}}}}}}})), line=3, cex.sub=0.95)
title(main="NZ Catalogue:  Deep Events")
par(par.reset)

#-----------------------------------------------------------------

#    Requires the NZ Catalogue
require(ssNZ)

b <- subsetcircle(NZ, centrelong=176.8, centrelat=-37.8,
                  minmag=3, minday=julian(1,1,1987),
                  maxday=julian(1,1,1988), maxradius=100)

epicentres(b, cex=1.3, mapname="nz")
title(main="Edgecumbe Earthquake")
par(par.reset)

#-----------------------------------------------------------------

#    Requires the NZ Catalogue
require(ssNZ)

b <- subsetcircle(NZ, centrelong=177.5, centrelat=-37,
```

```
                    minmag=3, minday=julian(1,1,1984),
                    maxday=julian(1,1,1986), maxradius=100)

epicentres(b, cex=1.5, mapname="nz")
title(main="Bay of Plenty Swarm")
par(par.reset)

#-----------------------------------------------------------------------

#    Requires the NZ Catalogue
require(ssNZ)

b <- subsetcircle(NZ, centrelong=176.4, centrelat=-40.4,
                    minmag=3, minday=julian(1,1,1990),
                    maxday=julian(1,1,1991), maxradius=50)

epicentres(b, cex=1.5, mapname="nz")
title(main="Weber (Dannevirke) Earthquake")
par(par.reset)
```

`epicentres.identify`
Identify Epicentre Outliers

Description

Plots earthquake epicentres selected from a given catalogue. The points are plotted on the screen, and then may be identified.

Usage

```
epicentres.identify(events, mapname = "world2", criteria = TRUE)
```

Arguments

`events`	defines the events to be plotted. It is an object of class `"subset"`, generally created by `subsetcircle`, `subsetpolygon`, `subsetrect` or `subsetsphere`.
`mapname`	character string giving the map name. Low resolution maps contained in package **maps** are `"nz"` and `"world2"` (default). High resolution maps contained in the package **mapdata** are `"nzHires"`, `"world2Hires"` and `"china"`. The "2" on `"world2"` denotes the version where the longitudes are all positive.
`criteria`	boolean variable. If `TRUE` (default) the subsetting parameters are printed below the graph.

Details

The points are plotted on an appropriate map, and points which are considered to be outliers are highlighted with larger circles. After the points have been plotted, the `identify` command is used for the user to identify points of interest. Use the left mouse button to select points (which are then identified on the map with their sequence number within the list of points plotted). Then use the middle or right button to terminate the identification process.

Value

A vector of indices (into the original catalogue) of the points identified.

See Also

epicentres, identify

Examples

```
data(NZ55)

a <- subsetrect(NZ55, minmag=6.5)
b <- epicentres.identify(a, mapname = "nz")
if (length(b) > 0) print(NZ55[b,])
```

---

est.kagan *Estimate Parameters of Kagan Distribution*

Description

Estimate different parameter or parameters of Kagan distribution for a given data set.

Usage

```
est.kagan(Data, alpha=1, beta=0, gamma=7, theta=0.75, phi=2.4, tol=10^-3,
          Mag=TRUE, deltam=2)
```

Arguments

Data	Vector of magnitude or stress.
alpha	Parameter of Kagan distribution. Index of the power law.
beta	Parameter of Kagan distribution. Control the lower turning point of distribution.
gamma	Parameter of Kagan distribution. Control the upper turning point of the distribution.
theta	Parameter of magnitude.convert.
phi	Parameter of magnitude.convert.
tol	minimum step length of Newton-Raphson algorithm.
Mag	Flag indicating whether stress or magnitude is to be used.
deltam	Range for scanning over beta parameter.

Details

Data is given in magnitudes or stress. Under the condition of data following Kagan distribution, parameters of distribution could be estimated, Newton-Raphson algorithm and maximum likelihood method are used here.

Value

Vector of estimated (or fixed) parameters alpha (α), beta (β) and gamma (γ) of the Kagan distribution, the value of M0 (minimum magnitude) determined from the data and loglikelihood value that those parameters correspond to.

Warning

When the parameters of distribution are all unknown, the estimated results are sometimes not very accurate.

Author(s)

Wang Lifeng, 2001

References

Vere-Jones, D.; Robinson, R. & Yang, W. (2001). Remarks on the accelerated moment release model: problems of model formulation, simulation and estimation. *Geophysical Journal International* **144**, 517–531.

See Also

dkagan

Examples

```
estimate.alph <- NULL
for (i in 1:100)
{
    # follow Kagan distribution, using default parameters.
    stress <- rkagan(1000, mag = FALSE) # simulate data set of stress which
    # when alpha is unknown.
    alpha <- est.kagan(stress, alpha = NA, Mag = FALSE) # estimate alpha,
    estimate.alph <- rbind(estimate.alph, alpha)
}

# Get distribution of alpha estimated from the 100 samples.  This
# way, we could know possible distance between estimated one
# and real one.
hist(estimate.alph[, 1], xlab="Alpha", ylab="Frequency", main="")
box()
```

---

freq.cusum *Frequency Cusum Plot*

Description

Draws a cusum of event frequencies over time. The target value is the estimated mean frequency in the training period.

Usage

```
freq.cusum(events, delta=1, trainyears=7)
```

Arguments

events	defines the events to be plotted. It is an object of class "subset", generally created by subsetcircle, subsetpolygon, subsetrect or subsetsphere.
delta	number of months in each counted interval. Default is 1.
trainyears	number of years in the training period.

See Also

depth.hist, freq.magnitude, magnitude.cusum, magnitude.time, epicentres, threeD, timeplot, multigraph

Examples

```
#    This example requires the NZ catalogue

require(ssNZ)

b <- subsetrect(NZ, minday=julian(1,1,1964), maxday=julian(1,1,1994),
                 mindepth=40, maxdepth=120, minmag=4)

freq.cusum(b)
```

---

freq.magnitude *Frequency Magnitude Plot*

Description

Frequency-magnitude plot of the selected events. That is, for a given magnitude m (x axis), the log10 of the proportion of events with magnitude greater than m is given on the y axis. The slope is commonly referred to as the b-value.

Usage

```
freq.magnitude(events, delta=0.1, bvalue=NA, estimate="ml", plot=TRUE)
```

Arguments

events	defines the events to be plotted. It is an object of class "subset", generally created by subsetcircle, subsetpolygon, subsetrect or subsetsphere.
delta	the interval width between points on the graph. Note that the limits of magnitudes plotted (x axis) are determined by minmag and maxmag in the object events. Hence, maxmag-minmag must be a multiple of delta.
bvalue	default is NA, in which case a least squares regression line is fitted through the points. If not NA, a line with the given slope is plotted.
estimate	takes the values "ml" (default) or "ls", meaning maximum likelihood or least squares respectively. It determines the estimation method used for the b-value. In the case of least squares, the intercept parameter is estimated, whereas in the case of maximum likelihood the log of the cumulative proportion is set to zero at the minimum magnitude.
plot	logical, default is TRUE. Determines whether the frequency magnitude distribution is plotted.

Value

The estimated b-value is returned if the function call is assigned to an object, otherwise NULL.

See Also

depth.hist, freq.cusum, magnitude.cusum, magnitude.time, epicentres, threeD, timeplot, multigraph

Examples

```
#    This example requires the NZ catalogue

require(ssNZ)

b <- subsetrect(NZ, minday=julian(1,1,1964), maxday=julian(1,1,1993),
                mindepth=40, maxdepth=120, minmag=4)

freq.magnitude(b)
```

---

hemisphere *Map of the Hemisphere*

Description

Map of the hemisphere about a given point on earths surface.

Usage

```
hemisphere(longitude, latitude, plot.title="Azimuths Projection")
```

Arguments

longitude	longitude of centre point.
latitude	latitude of centre point.
plot.title	plot title. Default is "Azimuths Projection".

See Also

projection

Examples

```
#    make plotting area square shape
par.reset <- par(no.readonly=TRUE)
par(pin=rep(min(par()$pin), 2))

hemisphere(170,-42, plot.title="Hemisphere Centred on NZ")

hemisphere(350,42, plot.title="The Other Hemisphere")

par(par.reset)
```

`magnitude.contour` *Mean Magnitude Contours*

Description

This function calculates mean magnitude contours at a pre-specified depth.

Usage

```
magnitude.contour(events, h=c(0.3, 0.2, 10), depth=10)
```

Arguments

`events`	defines the events to be plotted. It is an object of class `"subset"`, generally created by `subsetcircle`, `subsetpolygon`, `subsetrect` or `subsetsphere`.
`h`	a vector of length three. It specifies the bandwidths for the kernel function (see Details).
`depth`	specifies the longitude-latitude plane where the b-value contours are plotted.

Details

The mean magnitude contours are produced using local linear regression technique described in Ruppert and Wand (1994) using a standard trivariate normal kernel. The smoothness of the contours is controlled by the bandwidths of the kernel.

Value

NULL

Author(s)

Edwin Choi (ANU), 1997

References

Ruppert, D. & Wand, M.P. (1994). Multivariate locally weighted least squares regression. *Ann. Statist.* **22**, 1346–1370.

See Also

`bvalue.contour`

Examples

```
#    This example requires the NZ catalogue

require(ssNZ)

#   Remember the parameters of the graphics device
par.reset <- par(no.readonly=TRUE)

#   Make the Wellington Catalogue
```

```
as.catalogue(subsetrect(NZ, minlat=-42.2, maxlat=-40.5,
             minlong=173.6, maxlong=176.0, minday=julian(1,1,1978)),
             catname="Wellington")

b <- subsetrect(Wellington, maxdepth=100, minmag=3,
                minlat=-42.2, maxlat=-40.5, minlong=173.6, maxlong=176.0,
                minday=julian(1,1,1980), maxday=julian(1,1,2000))

par(pty="s")
magnitude.contour(b, h=c(0.25, 0.2, 2), depth=10)
map("nz", add=TRUE, col="red")
par(par.reset)
```

`magnitude.convert` *Magnitude-Moment Conversion*

Description

Converts magnitudes to Benioff moments and vice versa.

Usage

```
magnitude.convert(m, phi=0.75, B=2.4, inverse=FALSE)
```

Arguments

`m`	A vector to which the `magnitude.convert` function is applied.
`phi`	parameter of the Benioff Moment.
`B`	parameter of the Benioff Moment.
`inverse`	logical. If `inverse` is `FALSE`, the Benioff Moment is returned. If `inverse` is `TRUE`, the magnitude is returned.

Value

The Benioff Moment is defined as:

$$S(m) = 10^{\phi m}.$$

The inverse is:

$$S(s)^{-1} = \frac{\log 10(s) - B}{\phi}.$$

Author(s)

Alistair Merrifield, 1998

References

Kagan, Y.Y. (1997). Seismic moment-frequency relation for shallow earthquakes: Regional comparison. *Journal of Geophysical Research* **102**, 2835–2852.

Kanamori, H. & Anderson, D.L. (1975). Theoretical basis of some empirical relations in seismology. *Bulletin of the Seismological Society of America* **65**(5), 1073–1095.

Vere-Jones, D.; Robinson, R. & Yang, W. (2001). Remarks on the accelerated moment release model: problems of model formulation, simulation and estimation. *Geophysical Journal International* **144**, 517–531.

See Also

pkagan, qkagan, rkagan, dkagan

Examples

```
magnitudes <- seq(0, 11, length=100)
moments <- magnitude.convert(magnitudes)
magnitudes <- magnitude.convert(moments, inverse=TRUE)
```

---

magnitude.cusum *Cusum Magnitude Plot*

Description

Draws a cusum of event magnitudes over time. The target value is the estimated mean magnitude in the training period.

Usage

```
magnitude.cusum(events, trainyears=7, at.breaks=NA)
```

Arguments

events	defines the events to be plotted. It is an object of class "subset", generally created by subsetcircle, subsetpolygon, subsetrect or subsetsphere.
trainyears	length of the training period in years.
at.breaks	positions of labelled tick marks on the third (top) axis. Default is January of each year.

See Also

depth.hist, freq.cusum, freq.magnitude, magnitude.time, epicentres, threeD, timeplot, multigraph

Examples

```
#    This example requires the NZ catalogue

require(ssNZ)

b <- subsetrect(NZ, minday=julian(1,1,1964), maxday=julian(1,1,1994),
                mindepth=40, maxdepth=120, minmag=4)

magnitude.cusum(b)
```

magnitude.time *Magnitude Time Plot*

Description

Plots event magnitudes over time.

Usage

```
magnitude.time(events)
```

Arguments

events	defines the events to be plotted. It is an object of class "subset", generally created by subsetcircle, subsetpolygon, subsetrect or subsetsphere.

See Also

depth.hist, freq.cusum, freq.magnitude, magnitude.cusum, epicentres, threeD, timeplot, multigraph

Examples

```
#    This example requires the NZ catalogue

require(ssNZ)

#   Make the Wellington Catalogue
as.catalogue(subsetrect(NZ, minlat=-42.2, maxlat=-40.5,
             minlong=173.6, maxlong=176.0, minday=julian(1,1,1978)),
             catname="Wellington")

#    Cape Palliser Earthquake Sequence
b <- subsetcircle(Wellington, centrelong=175.5, centrelat=-41.65,
                  maxradius=20, minday=julian(1,1,1990),
                  maxday=julian(1,1,1993), maxdepth=40)
magnitude.time(b)
title(main="Cape Palliser Earthquake Sequence")
```

major *Major Earthquake Events*

Description

This page contains a listing of major earthquake events. They all require certain catalogues to be installed.

Examples

```
#   Remember the parameters of the graphics device
#   Run this first, else the plots will get progressively smaller

par.reset <- par(no.readonly=TRUE)

#-----------------------------------------------------------------
event <- "Sumatra (Nias) Earthquake - 28 March 2005"

require(ssPDE)
if (require(mapdata)) mpnm <- "world2Hires" else mpnm <- "world2"

usr <- c(92, 104, -5, 7)
a <- subsetrect(PDE, minday=julian(3, 1, 2005),
                maxday=julian(8, 1, 2005), minlong=usr[1],
                maxlong=usr[2], minlat=usr[3], maxlat=usr[4],
                minmag=4)
epicentres(a, usr=usr, mapname=mpnm, magnitude=c(4, 5, 6, 7, 8),
           cex=c(0.2, 1, 2, 4), criteria=FALSE)
title(main=event)
par(par.reset)
magnitude.time(a)
title(main=event)


#-----------------------------------------------------------
event <- "Phuket Thailand Earthquake - 26 Dec 2004"

require(ssPDE)
if (require(mapdata)) mpnm <- "world2Hires" else mpnm <- "world2"

usr <- c(89, 105, 0, 16)
a <- subsetrect(PDE, minday=julian(12, 1, 2004),
                maxday=julian(3, 1, 2005), minlong=usr[1],
                maxlong=usr[2], minlat=usr[3], maxlat=usr[4],
                minmag=5)
epicentres(a, usr=usr, mapname=mpnm, magnitude=c(5, 6, 7, 8),
           cex=c(0.2, 1, 4), criteria=FALSE)
title(main=event)
par(par.reset)
magnitude.time(a)
title(main=event)


#-----------------------------------------------------------
event <- "Parkfield California Earthquake - 28 Sept 2004"

require(ssSCEC)
if (require(mapdata)) mpnm <- "world2Hires" else mpnm <- "world2"

usr <- c(238, 241, 35, 37)
a <- subsetrect(SCEC, minday=julian(9, 1, 2004),
                maxday=julian(1, 1, 2005), minlong=usr[1],
                maxlong=usr[2], minlat=usr[3], maxlat=usr[4],
                minmag=2)
epicentres(a, usr=usr, mapname=mpnm, magnitude=c(2, 3, 4, 5, 6, 7),
```

```
           cex=c(0.2, 0.5, 1, 3, 5), criteria=FALSE)
title(main=event)
par(par.reset)
magnitude.time(a)
title(main=event)


#-----------------------------------------------------------
event <- "Alaska (Denali) Earthquake - 3 November 2002"

require(ssPDE)
if (require(mapdata)) mpnm <- "world2Hires" else mpnm <- "world2"

usr <- c(200, 220, 55, 66)
a <- subsetrect(PDE, minday=julian(11, 1, 2002),
                maxday=julian(7, 1, 2003), minlong=usr[1],
                maxlong=usr[2], minlat=usr[3], maxlat=usr[4],
                minmag=4)
epicentres(a, usr=usr, mapname=mpnm, magnitude=c(4, 5, 6, 7, 8),
           cex=c(0.2, 1, 2, 4), criteria=FALSE)
title(main=event)
par(par.reset)
magnitude.time(a)
title(main=event)


#-----------------------------------------------------------
event <- "Hector Mine California Earthquake - 16 October 1999"

require(ssSCEC)
if (require(mapdata)) mpnm <- "world2Hires" else mpnm <- "world2"

usr <- c(240, 246, 32, 38)
a <- subsetrect(SCEC, minday=julian(10, 1, 1999),
                maxday=julian(7, 1, 2000), minlong=usr[1],
                maxlong=usr[2], minlat=usr[3], maxlat=usr[4],
                minmag=3)
epicentres(a, usr=usr, mapname=mpnm, magnitude=c(3, 5, 6, 7, 8),
           cex=c(0.2, 1, 2, 4), criteria=FALSE)
title(main=event)
par(par.reset)
magnitude.time(a)
title(main=event)


#-----------------------------------------------------------
event <- "Kobe Japan Earthquake - 17 January 1995"

require(ssPDE)
if (require(mapdata)) mpnm <- "world2Hires" else mpnm <- "world2"

usr <- c(133, 137, 32, 36)
a <- subsetrect(PDE, minday=julian(1, 10, 1995),
                maxday=julian(12, 31, 1995), minlong=usr[1],
                maxlong=usr[2], minlat=usr[3], maxlat=usr[4],
                minmag=4)
epicentres(a, usr=usr, mapname=mpnm, magnitude=c(4, 5, 6, 7),
```

```
           cex=c(1, 2, 3), criteria=FALSE)
title(main=event)
par(par.reset)
magnitude.time(a)
title(main=event)


#-------------------------------------------------------
event <- "Northridge California Earthquake - 17 January 1994"

require(ssSCEC)
if (require(mapdata)) mpnm <- "world2Hires" else mpnm <- "world2"

usr <- c(240, 245, 33, 36)
a <- subsetrect(SCEC, minday=julian(1, 1, 1994),
                maxday=julian(7, 1, 1994), minlong=usr[1],
                maxlong=usr[2], minlat=usr[3], maxlat=usr[4],
                minmag=3)
epicentres(a, usr=usr, mapname=mpnm, magnitude=c(3, 5, 6, 7),
           cex=c(0.2, 1, 4), criteria=FALSE)
title(main=event)
par(par.reset)
magnitude.time(a)
title(main=event)


#-------------------------------------------------------
event <- "Landers California Earthquake - 28 June 1992"

require(ssSCEC)
if (require(mapdata)) mpnm <- "world2Hires" else mpnm <- "world2"

usr <- c(240, 246, 32, 38)
a <- subsetrect(SCEC, minday=julian(6, 1, 1992),
                maxday=julian(1, 1, 1993), minlong=usr[1],
                maxlong=usr[2], minlat=usr[3], maxlat=usr[4],
                minmag=3)
epicentres(a, usr=usr, mapname=mpnm, magnitude=c(3, 5, 6, 7, 8),
           cex=c(0.2, 1, 2, 4), criteria=FALSE)
title(main=event)
par(par.reset)
magnitude.time(a)
title(main=event)


#-------------------------------------------------------
event <- "Loma Prieta Earthquake - 18 October 1989"

require(ssPDE)
if (require(mapdata)) mpnm <- "world2Hires" else mpnm <- "world2"

usr <- c(237, 239, 36.5, 38.5)
a <- subsetrect(PDE, minday=julian(10, 1, 1989),
                maxday=julian(7, 1, 1990), minlong=usr[1],
                maxlong=usr[2], minlat=usr[3], maxlat=usr[4],
                minmag=3)
epicentres(a, usr=usr, mapname=mpnm, magnitude=c(3, 5, 6, 7),
```

```
           cex=c(0.2, 1, 4), criteria=FALSE)
title(main=event)
par(par.reset)
magnitude.time(a)
title(main=event)


#-------------------------------------------------------
event <- "Edgecumbe NZ Earthquake - 2 March 1987"

require(ssNZ)
if (require(mapdata)) mpnm <- "world2Hires" else mpnm <- "world2"

usr <- c(176, 178, -38.5, -36.5)
a <- subsetrect(NZ, minday=julian(1, 1, 1987),
                maxday=julian(1, 1, 1988), minlong=usr[1],
                maxlong=usr[2], minlat=usr[3], maxlat=usr[4],
                minmag=3)
epicentres(a, usr=usr, mapname=mpnm, magnitude=c(3, 5, 6, 7),
           cex=c(0.2, 1, 4), criteria=FALSE)
title(main=event)
par(par.reset)
magnitude.time(a)
title(main=event)


#-------------------------------------------------------
event <- "Tangshan China Earthquake - 26 July 1976"

require(ssPDE)
if (require(mapdata)) mpnm <- "world2Hires" else mpnm <- "world2"

usr <- c(116, 120, 38, 41)
a <- subsetrect(PDE, minday=julian(7, 1, 1976),
                maxday=julian(1, 1, 1977), minlong=usr[1],
                maxlong=usr[2], minlat=usr[3], maxlat=usr[4],
                minmag=4)
epicentres(a, usr=usr, mapname=mpnm, magnitude=c(4, 5, 6, 7, 8),
           cex=c(0.2, 1, 2, 4), criteria=FALSE)
title(main=event)
par(par.reset)
magnitude.time(a)
title(main=event)
as.catalogue(a, catname="temp")
print(temp)
```

`map1` *Draw Geographical Map*

Description

Draws a geographical map with a rectangular projection. The user specifies the exact boundaries (latitude and longitude) of the map. The map is plotted to the current graphics device. If one is not open, a device of the default type will be opened.

Usage

```
map1(mapname, usr, axes = TRUE, reset = TRUE, col = "gray35")
```

Arguments

mapname	character string giving the map name. Low resolution maps contained in package **maps** are "nz" and "world2" (default). High resolution maps contained in the package **mapdata** are "nzHires", "world2Hires" and "chinaHires". The "2" on "world2" denotes the version where the longitudes are all positive.
usr	a vector of length 4 than defines boundary positions (longitudes and latitudes) of the axes, i.e. c(xmin, xmax, ymin, ymax).
axes	logical variable. If TRUE (default), axes are added to the map, FALSE otherwise.
reset	logical variable. If TRUE (default), the graphics device parameters are reset to their initial values, and FALSE will leave them the same as those used to plot the current map.
col	the colour of the map outline, specified either as a character string or the number representing the required colour in current palette.

Details

It is assumed that generally the user will want to add further features to the map. In this situation, the argument reset should be set to FALSE. In this situation the sizes of the margins and area within the axes will remain the same.

If one subsequently wants to put a different plot onto the graphics device, then the graphics parameters (par) would need to be reset. See Examples below.

Author(s)

David Harte, 2004

See Also

map, epicentres

Examples

```
par.reset <- par(no.readonly=TRUE)

map1(mapname="nz", usr=c(166, 179, -48, -34), reset=FALSE)
title(main="New Zealand")
par(par.reset)

map1(mapname="world2", usr=c(220, 320, 10, 80), reset=FALSE)
title(main="North America")
par(par.reset)

map1(mapname="world2", usr=c(90, 170, -20, 30), reset=FALSE)
title(main="South-East Asia")
par(par.reset)

map1(mapname="world", usr=c(-12, 40, 34, 65), reset=FALSE)
title(main="Europe")
```

```
par(par.reset)

map1(mapname="world", usr=c(-20, 60, -40, 45), reset=FALSE)
title(main="Africa")
par(par.reset)
```

`multigraph` *Plot Multiple Graphs*

Description

Graph of multiple plots of events satisfying selection criteria.

Usage

```
multigraph(events, plots, ncols=1, title="", criteria=TRUE)
```

Arguments

`events`	defines the events to be plotted. It is an object of class `"subset"`, generally created by `subsetcircle`, `subsetpolygon`, `subsetrect` or `subsetsphere`.
`plots`	list object of plot functions. Plot functions that can be included are those with the single events argument. Some of these are: `depth.hist`, `freq.cusum`, `freq.magnitude`, `magnitude.cusum`, `magnitude.time`, `timeplot`.
`ncols`	number of columns. Graphs are laid out in a matrix format, positions being filled row by row.
`title`	overall title for the collection of all graphs.
`criteria`	logical, default is `TRUE`. Determines whether the subsetting criteria is written at the bottom of the page.

See Also

`depth.hist`, `freq.cusum`, `freq.magnitude`, `magnitude.cusum`, `magnitude.time`, `epicentres`, `threeD`, `timeplot`

Examples

```
#    This example requires the NZ catalogue

require(ssNZ)

b <- subsetrect(NZ, minday=julian(1,1,1964), maxday=julian(1,1,1994),
                 mindepth=40, maxdepth=120, minmag=4)

multigraph(b,list(depth.hist, timeplot, magnitude.time,
                  freq.magnitude, freq.cusum, magnitude.cusum),
           ncols=3, title="Catalogue Completeness Analysis")
```

plot.subset *Method for Generic Function Plot*

Description

Plots four summary graphs for the selected subset: frequency-magnitude plot, depth histogram, counts by year, and magnitude-time plot.

Usage

```
## S3 method for class 'subset':
plot(x, ...)
```

Arguments

x	defines the events to be plotted. It is an object with class "subset" created by subsetcircle, subsetpolygon, subsetrect or subsetsphere.
...	other options for plotting "subset" objects.

Value

NULL

See Also

subsetcircle, subsetpolygon, subsetrect, subsetsphere

Examples

```
data(NZ55)
a <- subsetrect(NZ55, minday=julian(1,1,1970))
plot(a)
```

rotation *Rotates Events to View Plate Boundary*

Description

Plots a cross section of depth for the selected events. Depth is on the vertical axis, and the view is theta degrees west of north.

Usage

```
rotation(events, theta=0, km=TRUE, criteria=TRUE)
```

Arguments

events	defines the events to be plotted. It is an object of class "subset", generally created by subsetcircle, subsetpolygon, subsetrect or subsetsphere.
theta	number of degrees of the direction of view from north, positive to the west. For example, theta=0 is viewing to the north (default) and for theta=-45 one would be viewing towards the NE.
km	if TRUE units of kilometres are used on the horizontal scale, if FALSE units of degrees are used.
criteria	boolean variable. If TRUE (default) the subsetting parameters are printed below the graph.

See Also

depth.hist, epicentres, freq.cusum, freq.magnitude, magnitude.cusum, magnitude.time, threeD, timeplot, multigraph

Examples

```
#    These examples require the NZ catalogue

require(ssNZ)
b <- subsetrect(NZ, minlong=170, maxlong=180, minlat=-43,
                maxlat=-35, minmag=3, minday=julian(1,1,1970),
                maxday=julian(1,1,1993))

rotation(b, theta=-47)
title(main="NZ Plate Boundary")

#-----------------------------------------------------------------

#   Make the Wellington Catalogue
require(ssNZ)
as.catalogue(subsetrect(NZ, minlat=-42.2, maxlat=-40.5,
             minlong=173.6, maxlong=176.0, minday=julian(1,1,1978)),
             catname="Wellington")

b <- subsetrect(Wellington, minlong=173.6, maxlong=176.1, minlat=-42.0,
                maxlat=-40.3, minmag=2, minday=julian(1,1,1978),
                maxday=julian(1,1,1992), maxdepth=200)

rotation(b, theta=-40, km=FALSE)
title(main="Wellington Plate Boundary")
```

---

threeD *Dynamic 3D Plot of Earthquake Hypocentres*

Description

Dynamic three dimensional plot of earthquake hypocentres (longitude, latitude and depth) locations.

Usage

```
threeD(events)
```

Arguments

events	defines the events to be plotted. It is an object of class "subset", generally created by subsetcircle, subsetpolygon, subsetrect or subsetsphere.

Installing the rggobi Package

This function uses the ggobi R function to display the data and provide a dynamical graphics interface. The ggobi function is contained in the **rggobi** package, which is available from CRAN (http://www.r-project.org).

The **rggobi** package in turn uses the ggobi system software, which is external to R. The ggobi system software can be downloaded from http://www.ggobi.org. Installation instructions are included on that site.

One needs to install the same version of the **rggobi** package as that of the ggobi system software. Older versions of **rggobi** can be found by clicking on "Archive" at the bottom of the contributed packages page on CRAN.

See Also

rotation

Examples

```
#    This example requires the NZ catalogue

require(ssNZ)

#   Make the Wellington Catalogue
as.catalogue(subsetrect(NZ, minlat=-42.2, maxlat=-40.5,
             minlong=173.6, maxlong=176.0, minday=julian(1,1,1978)),
             catname="Wellington")

#   Cape Palliser Sequence
b <- subsetcircle(Wellington, centrelong=175.5, centrelat=-41.65,
                  maxradius=20, minday=julian(1,1,1990),
                  maxday=julian(1,1,1993), maxdepth=40)

threeD(b)
```

---

timeplot *Plots Event Frequencies by Time*

Description

Plots a histogram of the number of selected events by time interval, either months or years.

Usage

```
timeplot(events, yearly=TRUE, smoothline=FALSE, ymax=max(y)*1.05,
         col=c("grey80", "grey50"))
```

Arguments

events	defines the events to be plotted. It is an object of class "subset", generally created by subsetcircle, subsetpolygon, subsetrect or subsetsphere.
yearly	logical. Should each bar represent annual TRUE or monthly FALSE counts. Default is TRUE.
smoothline	logical. Plot a smoothed line over the counts. Default is FALSE. The smoothing is done using the function supsmu.
ymax	numeric. Sets the upper limit of the y axis for the bar plot, default is about 5% greater than the tallest bar.
col	colour of the bars. If annual, then only the first colour is used. If monthly, then each year alternates between the two colours. Default is c("grey80", "grey50").

See Also

depth.hist, freq.cusum, freq.magnitude, magnitude.cusum, magnitude.time, epicentres, threeD, rotation, multigraph

Examples

```
#    This example requires the NZ catalogue

require(ssNZ)

b <- subsetrect(NZ, minday=julian(1,1,1961), minmag=4,
                minlat=-50, maxlat=-33.5, minlong=165, maxlong=180)
timeplot(b)
title(main=expression(paste("Events in NZ With ", M[L] >= 4)))
```

---

worldLores *Low Resolution World Map*

Description

This list object has components longitude and latitude which provide a low resolution version of the world map. It is used by the function hemisphere.

Usage

```
worldLores
```

Examples

```
#    make plotting area square shape
par.reset <- par(no.readonly=TRUE)
par(pin=rep(min(par()$pin), 2))

hemisphere(longitude=0, latitude=0, plot.title="Western Hemisphere")

par(par.reset)
```

Index