

Package ‘npsp’

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Type Package

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Description Multidimensional nonparametric spatio-temporal (geo)statistics.
S3 classes and methods for multidimensional: linear binning,
local polynomial kernel regression, density and variogram estimation.
Nonparametric methods for simultaneous inference on both spatial trend
and variogram functions (for spatial processes).
Nonparametric residual kriging (spatial prediction).

License GPL (>= 2)

URL <http://github.com/rubenfcasal/npsp>

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R topics documented:

npsp-package	3
aquifer	4
as.sp	5
bin.den	6
binning	7
coords	8
coordvalues	9
covar	10
cpu.time	10
data.grid	11
disc.sb	13
earthquakes	14
fitsvar.sb.iso	15
grid.par	17
h.cv	18
interp	21
kappasb	22
locpol	23
mask	26
np.den	27
np.fitgeo	29
np.geo	31
np.kriging	31
np.svar	32
npsp-geoR	35
npsp-gstat	36
npsp.tolerance	37
plot.fitgeo	37
precipitation	38
rgraphics	39
rule	40
scattersplot	41
simage	42
spersp	45
splot	48
spoints	51
sv	54
svar.bin	55
svar.grid	56
svar.plot	57
svarmod	58
varcov	59

Description

This package implements nonparametric methods for inference on multidimensional spatial (or spatio-temporal) processes, which may be (especially) useful in (automatic) geostatistical modeling and interpolation.

Main functions

Nonparametric methods for inference on both spatial trend and variogram functions:

`np.fitgeo` (automatically) fits an isotropic nonparametric geostatistical model by estimating the trend and the variogram (using a bias-corrected estimator) iteratively (by calling `h.cv`, `locpol`, `np.svariso.corr` and `fitsvar.sb.iso` at each iteration).

`locpol`, `np.den` and `np.svar` use local polynomial kernel methods to compute nonparametric estimates of a multidimensional regression function, a probability density function or a semivariogram (or their first derivatives), respectively. Estimates of these functions can be constructed for any dimension (the amount of available memory is the only limitation). To speed up computations, linear binning is used to discretize the data. A full bandwidth matrix and a multiplicative triweight kernel is used to compute the weights. Main calculations are performed in FORTRAN using the LAPACK library.

`np.svariso.corr` computes a bias-corrected nonparametric semivariogram estimate using an iterative algorithm similar to that described in Fernandez-Casal and Francisco-Fernandez (2014). This procedure tries to correct the bias due to the direct use of residuals, obtained from a nonparametric estimation of the trend function, in semivariogram estimation.

`fitsvar.sb.iso` fits a ‘nonparametric’ isotropic Shapiro-Botha variogram model by WLS. Currently, only isotropic semivariogram estimation is supported.

Nonparametric residual kriging (sometimes called external drift kriging):

`np.kriging` computes residual kriging predictions (and the corresponding simple kriging standard errors).

`kriging.simple` computes simple kriging predictions, standard errors

Currently, only global simple kriging is implemented in this package. Users are encouraged to use `krige` (or `krige.cv`) utilities in `gstat` package together with `as.vgm` for local kriging.

Other functions

Among the other functions intended for direct access by the user, the following (methods for multidimensional linear binning, local polynomial kernel regression, density or variogram estimation) could be emphasized: `binning`, `bin.den`, `svar.bin`, `h.cv` and `interp`.

There are functions for plotting data joint with a legend representing a continuous color scale. `splot` allows to combine a standard R plot with a legend. `spoints`, `simage` and `spersp` draw the corresponding high-level plot with a legend strip for the color scale. These functions are based on `image.plot` of package `fields`.

There are also some functions which can be used to interact with other packages. For instance, `as.variogram` (**geoR**) or `as.vgm` (**gstat**).

Acknowledgments

Important suggestions and contributions to some techniques included here were made by Sergio Castillo-Paez (Universidad de las Fuerzas Armadas ESPE, Ecuador) and Tomas Cotos-Yañez (Dep. Statistics, University of Vigo, Spain).

Author(s)

Ruben Fernandez-Casal (Dep. Mathematics, University of A Coruña, Spain). Please send comments, error reports or suggestions to <rubencasal@gmail.com>.

References

- Fernandez-Casal R., Castillo-Paez S. and Francisco-Fernandez M. (2018) Nonparametric geostatistical risk mapping, *Stoch. Environ. Res. Ris. Assess.*, <https://doi.org/10.1007/s00477-017-1407-y>.
- Fernandez-Casal R., Castillo-Paez S. and Garcia-Soidan P. (2017) Nonparametric estimation of the small-scale variability of heteroscedastic spatial processes, *Spa. Sta.*, **22**, 358-370, <https://doi.org/10.1016/j.spasta.2017.04.001>.
- Fernandez-Casal R. and Francisco-Fernandez M. (2014) Nonparametric bias-corrected variogram estimation under non-constant trend, *Stoch. Environ. Res. Ris. Assess.*, **28**, 1247-1259.
- Fernandez-Casal R., Gonzalez-Manteiga W. and Febrero-Bande M. (2003) Flexible Spatio-Temporal Stationary Variogram Models, *Statistics and Computing*, **13**, 127-136.
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- Wand M.P. and Jones M.C. (1995) *Kernel Smoothing*. Chapman and Hall, London.

aquifer

Wolfcamp aquifer data

Description

The Deaf Smith County (Texas, bordering New Mexico) was selected as an alternate site for a possible nuclear waste disposal repository in the 1980s. This site was later dropped on grounds of contamination of the aquifer, the source of much of the water supply for west Texas. In a study conducted by the U.S. Department of Energy, piezometric-head data were obtained at 85 locations (irregularly scattered over the Texas panhandle) by drilling a narrow pipe through the aquifer.

This data set has been used in numerous papers. For instance, Cressie (1989) lists the data and uses it to illustrate kriging, and Cressie (1993, section 4.1) gives a detailed description of the data and results of different geostatistical analyses.

Format

A data frame with 85 observations on the following 3 variables:

lon relative longitude position (miles).

lat relative latitude position (miles).

head piezometric-head levels (feet above sea level).

Source

Harper, W.V. and Furr, J.M. (1986) Geostatistical analysis of potentiometric data in the Wolfcamp Aquifer of the Palo Duro Basin, Texas. *Technical Report BMI/ONWI-587*, Bettelle Memorial Institute, Columbus, OH.

References

Cressie, N. (1989) Geostatistics. *The American Statistician*, **43**, 197-202.

Cressie, N. (1993) *Statistics for Spatial Data*. New York. Wiley.

Examples

```
str(aquifer)
summary(aquifer)
with(aquifer, spoints(lon, lat, head, main = "Wolfcamp aquifer"))
```

as.sp	<i>Convert npsp object to sp object</i>
-------	---

Description

Converts a npsp object to a [sp](#) object.

Usage

```
as.sp(obj, ...)

## S3 method for class 'grid.par'
as.sp(obj, ...)

## S3 method for class 'data.grid'
as.sp(obj, data.ind = NULL,
      proj4string = CRS(as.character(NA)), ...)
```

Arguments

obj	a npsp object.
...	further arguments passed to or from other methods.
data.ind	integer or character; vector with indexes or names of the data components.
proj4string	a CRS-class object.

See Also

[as.data.frame.data.grid](#)

bin.den	<i>Linear binning for density estimation</i>
---------	--

Description

Creates a `bin.den-class` (gridded binned density) object with linear binning counts.

Usage

```
bin.den(x, nbin = NULL)

as.bin.den(object, ...)

## S3 method for class 'data.grid'
as.bin.den(object, weights.ind = 1, ...)

## S3 method for class 'bin.den'
as.bin.den(object, ...)
```

Arguments

<code>x</code>	vector or matrix of covariates (e.g. spatial coordinates). Columns correspond with dimensions and rows with observations.
<code>nbin</code>	vector with the number of bins on each dimension.
<code>object</code>	(gridded data) used to select a method.
<code>...</code>	further arguments passed to or from other methods.
<code>weights.ind</code>	integer or character with the index or name of the component containing the bin counts/weights.

Details

If parameter `nbin` is not specified is set to `pmax(25, rule.binning(x))`.

Value

Returns an S3 object of `class bin.den` (extends `data.grid`). A list with the following 3 components:

<code>binw</code>	vector or array (dimension <code>nbin</code>) with the bin counts (weights).
<code>grid</code>	a <code>grid.par-class</code> object with the grid parameters.
<code>data</code>	a list with a component <code>\$x</code> with argument <code>x</code> .

See Also

[np.den](#), [bin.data](#), [bin.data](#), [locpol](#), [rule.binning](#).

binning

*Linear binning***Description**

Discretizes the data into a regular grid (computes a binned approximation) using the multivariate linear binning technique described in Wand (1994).

Usage

```
binning(x, y = NULL, nbin = NULL, set.NA = FALSE)
```

```
as.bin.data(object, ...)
```

```
## S3 method for class 'data.grid'
as.bin.data(object, data.ind = 1,
            weights.ind = NULL, ...)
```

```
## S3 method for class 'bin.data'
as.bin.data(object, ...)
```

```
## S3 method for class 'SpatialGridDataFrame'
as.bin.data(object, data.ind = 1,
            weights.ind = NULL, ...)
```

Arguments

<code>x</code>	vector or matrix of covariates (e.g. spatial coordinates). Columns correspond with covariates (coordinate dimension) and rows with data.
<code>y</code>	vector of data (response variable).
<code>nbin</code>	vector with the number of bins on each dimension.
<code>set.NA</code>	logical. If TRUE, sets the bin averages corresponding to cells without data to NA.
<code>object</code>	(gridded data) used to select a method.
<code>...</code>	further arguments passed to or from other methods.
<code>data.ind</code>	integer (or character) with the index (or name) of the component containing the bin averages.
<code>weights.ind</code>	integer (or character) with the index (or name) of the component containing the bin counts/weights (if not specified, they are set to <code>as.numeric(is.finite(object[[data.ind]]))</code>).

Details

If parameter `nbin` is not specified is set to `pmax(25, rule.binning(x))`.

Setting `set.NA = TRUE` (equivalent to `biny[binw == 0] <- NA`) may be useful for plotting the binned averages `$biny` (the hat matrix should be handled with care when using [locpol](#)).

Value

If `y != NULL`, an S3 object of class `bin.data` (gridded binned data; extends `bin.den`) is returned. A `data.grid` object with the following 4 components:

<code>biny</code>	vector or array (dimension <code>nbin</code>) with the bin averages.
<code>binw</code>	vector or array (dimension <code>nbin</code>) with the bin counts (weights).
<code>grid</code>	a <code>grid.par-class</code> object with the grid parameters.
<code>data</code>	a list with 3 components: <ul style="list-style-type: none"> • <code>x</code> argument <code>x</code>. • <code>y</code> argument <code>y</code>. • <code>med</code> (weighted) mean of the (binned) data.

If `y == NULL`, `bin.den` is called and a `bin.den-class` object is returned.

References

Wand M.P. (1994) Fast Computation of Multivariate Kernel Estimators. *Journal of Computational and Graphical Statistics*, **3**, 433-445.

See Also

[data.grid](#), [locpol](#), [bin.den](#), [h.cv](#).

Examples

```
with(earthquakes, spoints(lon, lat, mag, main = "Earthquake data"))

bin <- binning(earthquakes[, c("lon", "lat")], earthquakes$mag, nbin = c(30,30), set.NA = TRUE)

simage(bin, main = "Binning averages")
with(earthquakes, points(lon, lat, pch = 20))
```

<code>coords</code>	<i>(spatial) coordinates</i>
---------------------	------------------------------

Description

Retrieves the (spatial) coordinates of the object.

Usage

```
coords(x, ...)

## S3 method for class 'grid.par'
coords(x, ...)

## S3 method for class 'data.grid'
coords(x, masked = FALSE, ...)
```


Arguments

x	a (spatial) object used to select a method.
...	further arguments passed to or from other methods.
masked	logical; If TRUE, only the coordinates corresponding to unmasked cells are returned (see mask).

Value

A matrix of coordinates (columns correspond with dimensions and rows with data).

See Also

[coordvalues](#).

coordvalues

Coordinate values

Description

Returns the coordinate values in each dimension.

Usage

```
coordvalues(x, ...)
```

```
## S3 method for class 'grid.par'
```

```
coordvalues(x, ...)
```

```
## S3 method for class 'data.grid'
```

```
coordvalues(x, ...)
```

Arguments

x	a (spatial) object used to select a method.
...	further arguments passed to or from other methods.

Value

A list with the (unique) coordinates along each axis.

See Also

[coords](#).

covar	<i>Covariance values</i>
-------	--------------------------

Description

Computes covariance values (or pseudo-covariances) given a variogram model or covariance estimates given a semivariogram estimate.

Usage

```

covar(x, h, ...)

## S3 method for class 'svarmod'
covar(x, h, sill = x$sill, discretize = FALSE, ...)

## S3 method for class 'np.svar'
covar(x, h, sill = NULL, ...)

```

Arguments

x	variogram model (svarmod object) or semivariogram estimate.
h	vector (isotropic case) or matrix of lag values.
...	further arguments passed to or from other methods.
sill	(theoretical or estimated) variance $C(0) = \sigma^2$ or pseudo-sill (unbounded variograms).
discretize	logical. If TRUE the variogram is previously discretized.

Value

A vector of (pseudo) covariance values $C(h_i) = \sigma^2 - \gamma(h_i)$ or covariance estimates.

See Also

[sv](#), [varcov](#).

cpu.time	<i>Total and partial CPU time used</i>
----------	--

Description

Returns and (optionally) prints the total and/or partial (since the last call to this function) real and CPU times.

Usage

```
cpu.time(..., reset = FALSE, total = TRUE, last = TRUE,
         flush = FALSE)
```

Arguments

...	objects (describing the last operation) to be printed (using <code>cat</code>), if <code>last == TRUE</code> .
reset	logical; if TRUE, time counters are initialized.
total	logical; if TRUE, the total time used is printed.
last	logical; if TRUE, the partial time used is printed.
flush	logical; if TRUE, <code>flush.console</code> is called.

Value

Invisibly returns a list with the following 3 components (objects of class "proc_time"):

time	user, system, and total elapsed times for the currently running R process (result of a call to <code>proc.time</code>).
last, total	differences between the corresponding <code>proc.time</code> calls.

See Also

[proc.time](#), [system.time](#), [flush.console](#).

Examples

```
## Not run:

cpu.time(reset=TRUE)
res <- median(runif(100000))
cpu.time('\nSample median of', 100000, 'values =', res)
res <- median(runif(1000))
cpu.time('\nSample median of', 1000, 'values =', res)

## End(Not run)
```

data.grid

Gridded data (S3 class "data.grid")

Description

Defines data on a full regular (spatial) grid. Constructor function of the `data.grid-class`.

Usage

```

data.grid(..., grid = NULL)

as.data.grid(object, ...)

## S3 method for class 'SpatialGridDataFrame'
as.data.grid(object, data.ind = NULL, ...)

## S3 method for class 'data.grid'
as.data.frame(x, row.names = NULL,
  optional = FALSE, data.ind = NULL, coords = FALSE, sp = FALSE,
  check.names = coords, ...)

```

Arguments

...	vectors or arrays of data with length equal to <code>prod(grid\$n)</code> .
grid	a grid.par-class object (optional).
object	(gridded data) used to select a method.
data.ind	integer or character vector with the indexes or names of the components.
x	a <code>data.grid</code> object.
row.names	NULL, column to be used as row names, or vector giving the row names for the data frame.
optional	logical; Not currently used (see as.data.frame).
coords	logical; if TRUE, the (spatial) coordinates of the object are added.
sp	logical; if TRUE, the second dimension of the data is reversed (as it is stored in sp package).
check.names	logical; if TRUE, the names of the variables in the data frame are checked and adjusted if necessary.

Details

If parameter `grid.par` is not specified it is set from first argument.

S3 "version" of the [SpatialGridDataFrame-class](#) of the **sp** package.

Value

Returns an object of [class](#) `data.grid`, a list with the arguments as components.

See Also

[grid.par](#), [binning](#), [locpol](#).

disc.sb

*Discretization nodes of a Shapiro-Botha variogram model***Description**

Computes the discretization nodes of a ‘nonparametric’ extended Shapiro-Botha variogram model, following Gorsich and Genton (2004), as the scaled roots of Bessel functions.

Usage

```
disc.sb(nx, dk = 0, rmax = 1)
```

Arguments

nx	number of discretization nodes.
dk	dimension of the kappa function (dk >= 1, see Details below).
rmax	maximum lag considered.

Details

If dk >= 1, the nodes are computed as:

$$x_i = q_i / rmax; i = 1, \dots, nx,$$

where q_i are the first n roots of $J_{(d-2)/2}$, J_p is the Bessel function of order p and $rmax$ is the maximum lag considered. The computation of the zeros of the Bessel function is done using the efficient algorithm developed by Ball (2000).

If dk == 0 (corresponding to a model valid in any spatial dimension), the nodes are computed so the gaussian variogram models involved have practical ranges:

$$r_i = 2(1 + (i - 1))rmax/nx; i = 1, \dots, nx.$$

References

Ball, J.S. (2000) Automatic computation of zeros of Bessel functions and other special functions. *SIAM Journal on Scientific Computing*, **21**, 1458-1464.

Gorsich, D.J. and Genton, M.G. (2004) On the discretization of nonparametric covariogram estimators. *Statistics and Computing*, **14**, 99-108.

See Also

[kappasb](#), [fitsvar.sb.iso](#).

Examples

```
disc.sb( 12, 1, 1.0)

nx <- 1
dk <- 0
x <- disc.sb(nx, dk, 1.0)
h <- seq(0, 1, length = 100)
plot(h, kappasb(x * h, 0), type="l", ylim = c(0, 1))
abline(h = 0.05, lty = 2)
```

earthquakes

Earthquake data

Description

The data set consists of 1859 earthquakes (with magnitude above or equal to 2.0 in Richter's scale), which occurred from 25 November 1944 to 16 October 2013 in the northwest (NW) part of the Iberian Peninsula. The area considered is limited by the coordinates 41N-44N and 6W-10W, which contains the autonomic region of Galicia (Spain) and northern Portugal.

Format

A data frame with 1859 observations on the following 6 variables:

date Date and time (POSIXct format).

time Time (years since first event).

lon Longitude.

lat Latitude.

depth Depth (km).

mag Magnitude (Richter's scale).

Source

National Geographic Institute (IGN) of Spain:

<https://www.ign.es/web/ign/portal/sis-area-sismicidad>.

References

Francisco-Fernandez M., Quintela-del-Rio A. and Fernandez-Casal R. (2012) Nonparametric methods for spatial regression. An application to seismic events, *Environmetrics*, **23**, 85-93.

Examples

```
str(earthquakes)
summary(earthquakes)
with(earthquakes, spoints(lon, lat, mag, main = "Earthquake data"))
```

fitsvar.sb.iso *Fit an isotropic Shapiro-Botha variogram model*

Description

Fits a ‘nonparametric’ isotropic Shapiro-Botha variogram model by WLS through quadratic programming. Following Gorsich and Genton (2004), the nodes are selected as the scaled roots of Bessel functions (see [disc.sb](#)).

Usage

```
fitsvar.sb.iso(esv, dk = 4 * ncol(esv$data$x), nx = NULL,
              rmax = esv$grid$max, min.contrib = 10, method = c("cressie",
              "equal", "npairs", "linear"), iter = 10,
              tol = sqrt(.Machine$double.eps))
```

Arguments

esv	pilot semivariogram estimate, a np.svar-class (or svar.bin) object. Typically an output of the function np.svariso .
dk	dimension of the kappa function ($dk == 0$ corresponds to a model valid in any dimension; if $dk > 0$, it should be greater than or equal to the dimension of the spatial process $ncol(esv\data\$x)$).
nx	number of discretization nodes. Defaults to $\min(nesv - 1, 50)$, where $nesv$ is the number of semivariogram estimates.
rmax	maximum lag considered in the discretization (range of the fitted variogram on output).
min.contrib	minimum number of (equivalent) contributing pairs (pilot estimates with a lower number are ignored, with a warning).
method	string indicating the WLS fitting method to be used (e.g. <code>method = "cressie"</code>). See "Details" below.
iter	maximum number of iterations of the WLS algorithm (used only if <code>method == "cressie"</code>).
tol	absolute convergence tolerance (used only if <code>method == "cressie"</code>).

Details

The fit is done using a (possibly iterated) weighted least squares criterion, minimizing:

$$WLS(\theta) = \sum_i w_i [(\hat{\gamma}(h_i)) - \gamma(\theta; h_i)]^2.$$

The different options for the argument `method` define the WLS algorithm used:

"cressie" The default method. The procedure is iterative, with $w_i = 1$ (OLS) used for the first step and with the weights recalculated at each iteration, following Cressie (1985), until convergence:

$$w_i = N(h_i) / \gamma(\hat{\theta}; h_i)^2,$$

where $N(h_i)$ is the (equivalent) number of contributing pairs in the estimation at lag h_i .

"equal" Ordinary least squares: $w_i = 1$.

"npairs" $w_i = N(h_i)$.

"linear" $w_i = N(h_i) / h_i^2$ (default fitting method in **gstat** package).

Function `solve.QP` of **quadprog** package is used to solve a strictly convex quadratic program. To avoid problems, the Choleski decomposition of the matrix corresponding to the original problem is computed using `chol` with `pivot = TRUE`. If this matrix is only positive semi-definite (non-strictly convex QP), the number of discretization nodes will be less than `nx`.

Value

Returns the fitted variogram model, an object of class `fitsvar`. A `svarmod` object with additional components `esv` (pilot semivariogram estimate) and `fit` containing:

<code>u</code>	vector of lags/distances.
<code>sv</code>	vector of pilot semivariogram estimates.
<code>fitted.sv</code>	vector of fitted semivariances.
<code>w</code>	vector of (least squares) weights.
<code>wls</code>	value of the objective function.
<code>method</code>	string indicating the WLS fitting method used.
<code>iter</code>	number of WLS iterations (if <code>method == "cressie"</code>).

References

- Ball, J.S. (2000) Automatic computation of zeros of Bessel functions and other special functions. *SIAM Journal on Scientific Computing*, **21**, 1458-1464.
- Cressie, N. (1985) Fitting variogram models by weighted least squares. *Mathematical Geology*, **17**, 563-586.
- Cressie, N. (1993) *Statistics for Spatial Data*. New York. Wiley.
- Fernandez Casal R., Gonzalez Manteiga W. and Febrero Bande M. (2003) Flexible Spatio-Temporal Stationary Variogram Models, *Statistics and Computing*, **13**, 127-136.
- Gorsich, D.J. and Genton, M.G. (2004) On the discretization of nonparametric covariogram estimators. *Statistics and Computing*, **14**, 99-108.
- Shapiro, A. and Botha, J.D. (1991) Variogram fitting with a general class of conditionally non-negative definite functions. *Computational Statistics and Data Analysis*, **11**, 87-96.

See Also

[svarmod.sb.iso](#), [disc.sb](#), [plot.fitsvar](#).

Examples

```

# Trend estimation
lp <- locpol(aquifer[,1:2], aquifer$head, nbin = c(41,41),
            h = diag(100, 2), hat.bin = TRUE)
            # 'np.svariso.corr()' requires a 'lp$locpol$hat' component

# Variogram estimation
esvar <- np.svariso.corr(lp, maxlag = 150, nlags = 60, h = 60, plot = FALSE)

# Variogram fitting
svm2 <- fitsvar.sb.iso(esvar) # dk = 2
svm3 <- fitsvar.sb.iso(esvar, dk = 0) # To avoid negative covariances...
svm4 <- fitsvar.sb.iso(esvar, dk = 10) # To improve fit...

plot(svm4, main = "Nonparametric bias-corrected semivariogram and fitted models", legend = FALSE)
plot(svm3, add = TRUE)
plot(svm2, add = TRUE, lty = 3)
legend("bottomright", legend = c("NP estimates", "fitted model (dk = 10)", "dk = 0", "dk = 2"),
      lty = c(NA, 1, 1, 3), pch = c(1, NA, NA, NA), lwd = c(1, 2, 1, 1))

```

grid.par

Grid parameters (S3 class "grid.par")

Description

Defines a full regular (spatial) grid. Constructor function of the `grid.par`-class.

Usage

```
grid.par(n, min, max = min + (n - 1) * lag, lag = (max - min)/(n - 1),
        dimnames = names(min))
```

Arguments

<code>n</code>	integer vector; number of nodes in each dimension.
<code>min</code>	vector; minimum coordinates values.
<code>max</code>	vector; maximum coordinates values (optional).
<code>lag</code>	vector; lag in each dimension (optional).
<code>dimnames</code>	character vector; names used to label the dimensions.

Details

All parameters must have the same length. Only one of the arguments `max` or `lag` must be specified.

S3 `version` of the [GridTopology-class](#) of the `sp` package.

Value

Returns an object of class `grid.par`, a list with the arguments as components and an additional component `$nd = length(n)`.

See Also

[data.grid](#).

Examples

```
grid.par(n = c(100, 100), min = c(-10, 42), max = c(-7.5, 44))
grid.par(n = c(100, 100), min = c(-10, 42), lag = c(0.03, 0.02))
```

h.cv

Cross-validation methods for bandwidth selection

Description

Selects the bandwidth of a local polynomial kernel (regression, density or variogram) estimator using (standart or modified) CV, GCV or MASE criteria.

Usage

```
h.cv(bin, ...)

## S3 method for class 'bin.data'
h.cv(bin, objective = c("CV", "GCV", "MASE"),
     h.start = NULL, h.lower = NULL, h.upper = NULL, degree = 1,
     ncv = ifelse(objective == "CV", 2, 0), cov.bin = NULL,
     DEalgorithm = FALSE, warn = TRUE, tol.mask = npsp.tolerance(2),
     ...)

## S3 method for class 'bin.den'
h.cv(bin, h.start = NULL, h.lower = NULL,
     h.upper = NULL, degree = 1, ncv = 2, DEalgorithm = FALSE, ...)

## S3 method for class 'svar.bin'
h.cv(bin, loss = c("ARSE", "ARAE", "ASE", "AAE"),
     h.start = NULL, h.lower = NULL, h.upper = NULL, degree = 1,
     ncv = 1, DEalgorithm = FALSE, warn = FALSE, ...)

hcv.data(bin, objective = c("CV", "GCV", "MASE"), h.start = NULL,
         h.lower = NULL, h.upper = NULL, degree = 1,
         ncv = ifelse(objective == "CV", 1, 0), cov.dat = NULL,
         DEalgorithm = FALSE, warn = TRUE, ...)
```

Arguments

bin	object used to select a method (binned data, binned density or binned semivariogram).
...	further arguments passed to or from other methods (e.g. parameters of the optimization routine).
objective	character; optimal criterion to be used ("CV", "GCV" or "MASE").
h.start	vector; initial values for the parameters (diagonal elements) to be optimized over. If <code>DEalgorithm == FALSE</code> (otherwise not used), defaults to $(3 + ncv) * lag$, where $lag = bin$gridlag .
h.lower	vector; lower bounds on each parameter (diagonal elements) to be optimized. Defaults to $(1.5 + ncv) * bin$gridlag .
h.upper	vector; upper bounds on each parameter (diagonal elements) to be optimized. Defaults to $1.5 * dim(bin) * bin$gridlag .
degree	degree of the local polynomial used. Defaults to 1 (local linear estimation).
ncv	integer; determines the number of cells leaved out in each dimension. (0 to GCV considering all the data, > 0 to traditional or modified cross-validation). See "Details" below.
cov.bin	(optional) covariance matrix of the binned data or semivariogram model (<code>svarmod</code> -class) of the (unbinned) data. Defaults to the identity matrix.
DEalgorithm	logical; if TRUE, the differential evolution optimization algorithm in package DEoptim is used.
warn	logical; sets the handling of warning messages (normally due to the lack of data in some neighborhoods). If FALSE all warnings are ignored.
tol.mask	tolerance used in the approximations. Defaults to <code>npsp.tolerance(2)</code> .
loss	character; CV error. See "Details" below.
cov.dat	covariance matrix of the data or semivariogram model (of class extending <code>svarmod</code>). Defaults to the identity matrix (uncorrelated data).

Details

Currently, only diagonal bandwidths are supported.

`h.cv` methods use binning approximations to the objective function values (in almost all cases, an averaged squared error). If $ncv > 0$, estimates are computed by leaving out binning cells with indexes within the intervals $[x_i - ncv + 1, x_i + ncv - 1]$, at each dimension i , where x denotes the index of the estimation location. $ncv = 1$ corresponds with traditional cross-validation and $ncv > 1$ with modified CV (it may be appropriate for dependent data; see e.g. Chu and Marron, 1991, for the one dimensional case). Setting $ncv \geq 2$ would be recommended for sparse data (as linear binning is used). For standard GCV, set $ncv = 0$ (the whole data would be used). For theoretical MASE, set `bin = binning(x, y = trend.teor)`, `cov = cov.teor` and $ncv = 0$.

If `DEalgorithm == FALSE`, the "L-BFGS-B" method in `optim` is used.

The different options for the argument `loss` in `h.cv.svar.bin()` define the CV error considered in semivariogram estimation:

"ASE" Averaged squared error

"ARSE" Averaged relative squared error

"AAE" Averaged absolute error

"ARAE" Averaged relative absolute error

`hcv.data` evaluates the objective function at the original data (combining a binning approximation to the nonparametric estimates with a linear interpolation), this can be very slow (and memory demanding; consider using `h.cv` instead). If `ncv > 1` (modified CV), a similar algorithm to that in `h.cv` is used, estimates are computed by leaving out binning cells with indexes within the intervals $[x_i - ncv + 1, x_i + ncv - 1]$.

Value

Returns a list containing the following 3 components:

<code>h</code>	the best (diagonal) bandwidth matrix found.
<code>value</code>	the value of the objective function corresponding to <code>h</code> .
<code>objective</code>	the criterion used.

References

Chu, C.K. and Marron, J.S. (1991) Comparison of Two Bandwidth Selectors with Dependent Errors. *The Annals of Statistics*, **19**, 1906-1918.

Francisco-Fernandez M. and Opsomer J.D. (2005) Smoothing parameter selection methods for non-parametric regression with spatially correlated errors. *Canadian Journal of Statistics*, **33**, 539-558.

See Also

[locpol](#), [locpolhcv](#), [binning](#), [np.svar](#).

Examples

```
bin <- binning(earthquakes[, c("lon", "lat")], earthquakes$mag)
hcv <- h.cv(bin, ncv = 2)
lp <- locpol(bin, h = hcv$h)
## Alternatively:
## lp <- locpolhcv(earthquakes[, c("lon", "lat")], earthquakes$mag, ncv = 2)

simage(lp, main = 'Smoothed magnitude')
contour(lp, add = TRUE)
with(earthquakes, points(lon, lat, pch = 20))

## Density estimation
hden <- h.cv(as.bin.den(bin))
den <- np.den(bin, h = hden$h)

plot(den, main = 'Estimated log(density)')
```

interp	<i>Fast linear interpolation of a regular grid</i>
--------	--

Description

Computes a linear interpolation of multidimensional regularly gridded data.

Usage

```
interp(object, ...)

## S3 method for class 'grid.par'
interp(object, data, newx, ...)

## S3 method for class 'data.grid'
interp(object, data.ind = 1, newx, ...)

## S3 method for class 'locpol.bin'
predict(object, newx = NULL, hat.data = FALSE,
        ...)

## S3 method for class 'np.den'
predict(object, newx = NULL, ...)
```

Arguments

object	(gridded data) object used to select a method.
...	further arguments passed to or from other methods.
data	vector or array of data values.
newx	vector or matrix with the (irregular) locations to interpolate. Columns correspond with dimensions and rows with data.
data.ind	integer (or character) with the index (or name) of the data component.
hat.data	logical; if TRUE (and possible), the hat matrix corresponding to the (original) data is returned.

Details

interp methods are interfaces to the fortran routine `interp_data_grid` (in `grid_module.f90`).
`predict.locpol.bin` is an interface to the fortran routine `predict_lp` (in `lp_module.f90`).

Value

A list with two components:

x	interpolation locations.
y	interpolated values.

If `newx == NULL`, `predict.locpol.bin` returns the estimates (and optionally the hat matrix) corresponding to the data (otherwise `interp.data.grid` is called).

Note

Linear extrapolation is performed from the end nodes of the grid.

WARNING: May fail with missing values (especially if `object$locpol$ncv > 0`).

See Also

[interp.surface](#).

kappasb

Coefficients of an extended Shapiro-Botha variogram model

Description

Computes the coefficients of an extended Shapiro-Botha variogram model.

Usage

```
kappasb(x, dk = 0)
```

Arguments

`x` numeric vector (on which the kappa function will be evaluated).
`dk` dimension of the kappa function.

Details

If `dk >= 1`, the coefficients are computed as:

$$\kappa_d(x) = (2/x)^{(d-2)/2} \Gamma(d/2) J_{(d-2)/2}(x)$$

where J_p is the Bessel function of order p .

If `dk == 0`, the coefficients are computed as:

$$\kappa_\infty(x) = e^{-x^2}$$

(corresponding to a model valid in any spatial dimension).

NOTE: some authors denote these functions as Ω_d .

Value

A vector with the coefficients of an extended Shapiro-Botha variogram model.

References

Shapiro, A. and Botha, J.D. (1991) Variogram fitting with a general class of conditionally non-negative definite functions. *Computational Statistics and Data Analysis*, **11**, 87-96.

See Also

[svarmod.sb.iso](#), [besselJ](#).

Examples

```
kappasb(seq(0, 6*pi, len = 10), 2)

curve(kappasb(x/5, 0), xlim = c(0, 6*pi), ylim = c(-1, 1), lty = 2)
for (i in 1:10) curve(kappasb(x, i), col = gray((i-1)/10), add = TRUE)
abline(h = 0, lty = 3)
```

locpol

Local polynomial estimation

Description

Estimates a multidimensional regression function (and its first derivatives) using local polynomial kernel smoothing (and linear binning).

Usage

```
locpol(x, ...)

## Default S3 method:
locpol(x, y, h = NULL, nbin = NULL, degree = 1 +
  as.numeric(drv), drv = FALSE, hat.bin = FALSE, ncv = 0,
  set.NA = FALSE, ...)

## S3 method for class 'bin.data'
locpol(x, h = NULL, degree = 1 + as.numeric(drv),
  drv = FALSE, hat.bin = FALSE, ncv = 0, ...)

## S3 method for class 'svar.bin'
locpol(x, h = NULL, degree = 1, drv = FALSE,
  hat.bin = TRUE, ncv = 0, ...)

## S3 method for class 'bin.den'
locpol(x, h = NULL, degree = 1 + as.numeric(drv),
  drv = FALSE, ncv = 0, ...)

locpolhcv(x, y, nbin = NULL, objective = c("CV", "GCV", "MASE"),
  degree = 1 + as.numeric(drv), drv = FALSE, hat.bin = FALSE,
```

```
set.NA = FALSE, ncv = ifelse(objective == "CV", 2, 0),
cov.dat = NULL, ...)
```

Arguments

x	a (data) object used to select a method.
...	further arguments passed to or from other methods (e.g. to hcv.data).
y	vector of data (response variable).
h	(full) bandwidth matrix (controls the degree of smoothing; only the upper triangular part of h is used).
nbin	vector with the number of bins on each dimension.
degree	degree of the local polynomial used. Defaults to 1 (local linear estimation).
drv	logical; if TRUE, the matrix of estimated first derivatives is returned.
hat.bin	logical; if TRUE, the hat matrix of the binned data is returned.
ncv	integer; determines the number of cells leaved out in each dimension. Defaults to 0 (the full data is used) and it is not normally changed by the user in this setting. See "Details" below.
set.NA	logical. If TRUE, sets the bin averages corresponding to cells without data to NA.
objective	character; optimal criterion to be used ("CV", "GCV" or "MASE").
cov.dat	covariance matrix of the data or semivariogram model (of class extending svarmod). Defaults to the identity matrix (uncorrelated data).

Details

Standard generic function with a default method (interface to the fortran routine `lp_raw`), in which argument `x` is a vector or matrix of covariates (e.g. spatial coordinates).

If parameter `nbin` is not specified is set to `pmax(25, rule.binning(x))`.

A multiplicative triweight kernel is used to compute the weights.

If `ncv > 0`, estimates are computed by leaving out cells with indexes within the intervals $[x_i - ncv + 1, x_i + ncv - 1]$, at each dimension `i`, where x denotes the index of the estimation position. `ncv = 1` corresponds with traditional cross-validation and `ncv > 1` with modified CV (see e.g. Chu and Marron, 1991, for the one dimensional case).

Setting `set.NA = TRUE` (equivalent to `biny[binw == 0] <- NA`) may be useful for plotting the binned averages `$biny` (the hat matrix should be handled with care).

`locpolhcv` calls [hcv.data](#) to obtain an "optimal" bandwidth (additional arguments `...` are passed to this function). Argument `ncv` is only used here at the bandwidth selection stage (estimation is done with all the data).

Value

Returns an S3 object of class `locpol.bin` (`locpol` + bin data + grid par.). A [bin.data](#) object with the additional (some optional) 3 components:

`est` vector or array (dimension `nbin`) with the local polynomial estimates.

locpol a list with 7 components:

- degree degree of the polynomial.
- h bandwidth matrix.
- rm residual mean.
- rss sum of squared residuals.
- ncv number of cells ignored in each direction.
- hat (if requested) hat matrix of the binned data.
- nr10 (if appropriate) number of cells with data ($\text{binw} > 0$) and missing estimate ($\text{est} == \text{NA}$).

deriv (if requested) matrix of first derivatives.

locpol.svar.bin returns an S3 object of class `np.svar` (locpol semivar + bin semivar + grid par.).

locpol.bin.den returns an S3 object of class `np.den` (locpol den + bin den + grid par.).

References

Chu, C.K. and Marron, J.S. (1991) Comparison of Two Bandwidth Selectors with Dependent Errors. *The Annals of Statistics*, **19**, 1906-1918.

Rupert D. and Wand M.P. (1994) Multivariate locally weighted least squares regression. *The Annals of Statistics*, **22**, 1346-1370.

See Also

[binning](#), [data.grid](#), [np.svariso](#), [svar.bin](#), [np.den](#), [bin.den](#), [hcv.data](#), [rule.binning](#).

Examples

```
lp <- locpol(earthquakes[, c("lon", "lat")], earthquakes$mag, h = diag(2, 2), nbin = c(41,41))
simage(lp, main = "Smoothed magnitude")
contour(lp, add = TRUE)

bin <- binning(earthquakes[, c("lon", "lat")], earthquakes$mag, nbin = c(41,41))
lp2 <- locpol(bin, h = diag(2, 2))
all.equal(lp, lp2)

## Alternatively:
## lp <- locpolhcv(earthquakes[, c("lon", "lat")], earthquakes$mag, ncv = 4)

den <- locpol(as.bin.den(bin), h = diag(1, 2))
plot(den, log = FALSE, main = 'Estimated density')
```

mask

*Mask methods***Description**

Filters the data that satisfy a condition.

Usage

```
mask(x, ...)

## Default S3 method:
mask(x, tol.mask = 0, ...)

## S3 method for class 'bin.den'
mask(x, mask = mask.default(x$binw, npsp.tolerance(2)),
     warn = TRUE, ...)

## S3 method for class 'bin.data'
mask(x, mask = mask.default(x$binw,
     npsp.tolerance(2)), set.NA = TRUE, warn = TRUE, filter.lp = set.NA,
     ...)

## S3 method for class 'locpol.bin'
mask(x, mask = mask.default(x$binw,
     npsp.tolerance(2)), set.NA = TRUE, warn = TRUE, filter.lp = set.NA,
     ...)
```

Arguments

<code>x</code>	object used to select a method (binned data, ...).
<code>...</code>	further arguments passed to or from other methods
<code>tol.mask</code>	tolerance.
<code>mask</code>	logical; vector indicating the selected values (not masked).
<code>warn</code>	logical; If TRUE a warning message is generated when original data is masked.
<code>set.NA</code>	logical; If TRUE, the values corresponding to masked cells are set to NA.
<code>filter.lp</code>	logical; If TRUE, masked nodes will be leaved out in local polynomial estimation.

Value

`mask.default` returns the logical vector $x > \text{tol.mask}$.

`mask.bin.den`, `mask.bin.data` and `mask.locpol.bin` return an object of the same class as `x` with the additional component `$mask`.

See Also

[locpol](#), [locpolhcv](#), [binning](#), [np.svar](#), [npsp.tolerance](#).

Examples

```
mask(1:10, 5)
bin <- binning(aquifer[,1:2], aquifer$head, nbin = c(41,41), set.NA = TRUE)
str(mask(bin, mask(bin$binw), warn = TRUE))
str(mask(bin, mask(bin$binw, 1)))
```

 np.den

Local polynomial density estimation

Description

Estimates a multidimensional probability density function (and its first derivatives) using local polynomial kernel smoothing of linearly binned data.

Usage

```
np.den(x, ...)

## Default S3 method:
np.den(x, nbin = NULL, h = NULL, degree = 1 +
  as.numeric(drv), drv = FALSE, ncv = 0, ...)

## S3 method for class 'bin.den'
np.den(x, h = NULL, degree = 1 + as.numeric(drv),
  drv = FALSE, ncv = 0, ...)

## S3 method for class 'bin.data'
np.den(x, h = NULL, degree = 1 + as.numeric(drv),
  drv = FALSE, ncv = 0, ...)

## S3 method for class 'svar.bin'
np.den(x, h = NULL, degree = 1 + as.numeric(drv),
  drv = FALSE, ncv = 0, ...)
```

Arguments

x	a (data) object used to select a method.
...	further arguments passed to or from other methods.
nbin	vector with the number of bins on each dimension.
h	(full) bandwidth matrix (controls the degree of smoothing; only the upper triangular part of h is used).
degree	degree of the local polynomial used. Defaults to 1 (local linear estimation).

drv	logical; if TRUE, the matrix of estimated first derivatives is returned.
ncv	integer; determines the number of cells leaved out in each dimension. Defaults to 0 (the full data is used) and it is not normally changed by the user in this setting. See "Details" below.

Details

Standard generic function with a default method (interface to the fortran routine `lp_data_grid`), in which argument `x` is a vector or matrix of covariates (e.g. spatial coordinates). In this case, the data are binned (calls `bin.den`) and the local fitting procedure is applied to the scaled bin counts (calls `np.den.bin.den`).

If parameter `nbim` is not specified is set to `rep(25, ncol(x))`.

A multiplicative triweight kernel is used to compute the weights.

If `ncv > 1`, estimates are computed by leaving out cells with indexes within the intervals $[x_i - ncv + 1, x_i + ncv - 1]$, at each dimension `i`, where `x` denotes the index of the estimation position.

Value

Returns an S3 object of class `np.den` (`locpol den + bin den + grid par.`). A `bin.den` object with the additional (some optional) 3 components:

est	vector or array (dimension <code>nbin</code>) with the local polynomial density estimates.
locpol	a list with 6 components: <ul style="list-style-type: none"> • degree degree of the polinomial. • h bandwidth matrix. • rm residual mean (of the escaled bin counts). • rss sum of squared residuals (of the escaled bin counts). • ncv number of cells ignored (in each dimension).
deriv	(if requested) matrix of first derivatives.

References

Wand, M.P. and Jones, M.C. (1995) *Kernel Smoothing*. Chapman and Hall, London.

See Also

[bin.den](#), [binning](#), [data.grid](#).

Examples

```
bin <- binning(earthquakes[, c("lon", "lat")], earthquakes$mag, nbin = c(30,30))
hden <- h.cv(as.bin.den(bin))
den <- np.den(bin, h = hden$h)
## Equivalent to:
## den <- np.den(earthquakes[, c("lon", "lat")], h = hden$h, nbin = c(30,30))

plot(den, main = 'Estimated log(density)')
```

np.fitgeo

*Fit a nonparametric geostatistical model***Description**

Fits a nonparametric (isotropic) geostatistical model (jointly estimates the trend and the variogram) by calling `locpol`, `np.svariso.corr` (or `np.svariso`) and `fitsvar.sb.iso` iteratively. At each iteration, the trend estimation bandwidth is updated by a call to `h.cv`.

Usage

```
np.fitgeo(x, ...)

## Default S3 method:
np.fitgeo(x, y, nbin = NULL, iter = 2, h = NULL,
  tol = 0.05, set.NA = FALSE, h.svar = NULL, corr.svar = TRUE,
  maxlag = NULL, nlags = NULL, dk = 0, svm.resid = FALSE,
  hat.bin = corr.svar, warn = FALSE, plot = FALSE, ...)

## S3 method for class 'locpol.bin'
np.fitgeo(x, svm, iter = 1, tol = 0.05,
  h.svar = svm$esv$locpol$h, dk = 0, corr.svar = TRUE,
  svm.resid = FALSE, hat.bin = corr.svar, warn = FALSE,
  plot = FALSE, ...)

## S3 method for class 'fitgeo'
np.fitgeo(x, iter = 1, tol = 0.05,
  h.svar = x$svm$esv$locpol$h, dk = x$svm$par$dk, corr.svar = TRUE,
  svm.resid = FALSE, hat.bin = corr.svar, warn = FALSE,
  plot = FALSE, ...)
```

Arguments

<code>x</code>	a (data) object used to select a method.
<code>...</code>	further arguments passed to <code>h.cv</code> (trend bandwidth selection parameters).
<code>y</code>	vector of data (response variable).
<code>nbin</code>	vector with the number of bins on each dimension.
<code>iter</code>	maximum number of iterations (of the whole algorithm).
<code>h</code>	initial bandwidth matrix for trend estimation (final bandwidth if <code>iter = 1</code>).
<code>tol</code>	relative convergence tolerance (semivariogram).
<code>set.NA</code>	logical. If TRUE, sets the bin averages corresponding to cells without data to NA.
<code>h.svar</code>	bandwidth matrix for variogram estimation.
<code>corr.svar</code>	logical; if TRUE (default), a bias-corrected semivariogram estimate is computed (see <code>np.svariso.corr</code>). If code FALSE the (uncorrected) residual variogram is computed (the traditional approach in geostatistics).

maxlag	maximum lag. Defaults to 55% of largest lag.
nlags	number of lags. Defaults to 101.
dk	dimension of the Shapiro-Botha variogram model (see fitsvar.sb.iso).
svm.resid	logical; if TRUE, the fitted (uncorrected) residual semivariogram model is computed and returned (this parameter has no effect when <code>corr.svar = FALSE</code>).
hat.bin	logical; if TRUE, the hat matrix of the binned data is returned.
warn	logical; sets the handling of warning messages in bandwidth selection (h.cv).
plot	logical; if TRUE, semivariogram estimates obtained at each iteration are plotted.
svm	(fitted) variogram model (object of class fitsvar or svarmod).

Details

Currently, only isotropic semivariogram estimation is supported.

If parameter `h` is not specified, [h.cv](#) is called with the default values (modified CV) to set it. If parameter `h.svar` is not specified, is set to `1.5*h.cv.svar.bin()$h`.

Setting `corr.svar = TRUE` may be very slow (and memory demanding) when the number of data is large (note also that the bias in the residual variogram decreases when the sample size increases).

Value

Returns an object of class [fitgeo](#) (extends [np.geo](#)). A [locpol.bin](#) object with the additional (some optional) 3 components:

svm	fitted variogram model (object of class fitsvar).
svm0	(if requested) fitted residual variogram model (object of class fitsvar).
residuals	model residuals.

See Also

[locpol](#), [fitsvar.sb.iso](#), [np.svar](#), [np.svariso.corr](#), [np.geo](#).

Examples

```
geomod <- np.fitgeo(aquifer[,1:2], aquifer$head, svm.resid = TRUE)
plot(geomod)

# Uncorrected variogram estimator
geomod0 <- np.fitgeo(aquifer[,1:2], aquifer$head, iter = 1, corr.svar = FALSE)
plot(geomod0)

# Additional iteration with bias-corrected variogram estimator
geomod1 <- np.fitgeo(geomod0, corr.svar = TRUE, svm.resid = TRUE)
plot(geomod1)
```

np.geo	<i>Nonparametric geostatistical model (S3 class "np.geo")</i>
--------	---

Description

Defines a nonparametric geostatistical model (not intended to be used regularly; see [np.fitgeo](#)). Constructor function of the `np.geo` and `fitgeo` S3 [classes](#).

Usage

```
np.geo(lp, svm, svm0 = NULL, nbin = lp$grid$n)
```

Arguments

<code>lp</code>	local polynomial estimate of the trend function (object of class locpol.bin).
<code>svm</code>	(fitted) variogram model (object of class fitsvar or svarmod).
<code>svm0</code>	(fitted) residual variogram model (object of class fitsvar or svarmod).
<code>nbin</code>	number of bins on each dimension.

Value

Returns an object of [class](#) `np.geo` (extends [locpol.bin](#)), the `lp` argument with the others and the vector of residuals as additional components.

See Also

[np.fitgeo](#), [locpol](#), [fitsvar.sb.iso](#).

np.kriging	<i>Nonparametric (residual) kriging</i>
------------	---

Description

Compute simple kriging or residual kriging predictions (and also the corresponding simple kriging standard errors). Currently, only global (residual) simple kriging is implemented.

Usage

```
np.kriging(object, ...)

## Default S3 method:
np.kriging(object, svm, lp.resid = NULL,
  ngrid = object$grid$n, ...)

## S3 method for class 'np.geo'
```

```
np.kriging(object, ngrid = object$grid$n, ...)
```

```
kriging.simple(x, y, newx, svm)
```

```
kriging.simple.solve(x, newx, svm)
```

Arguments

object	object used to select a method: local polynomial estimate of the trend (class locpol.bin) or nonparametric geostatistical model (class extending np.geo).
...	further arguments passed to or from other methods.
svm	semivariogram model (of class extending svarmod).
lp.resid	residuals (defaults to <code>residuals(object)</code>).
ngrid	number of grid nodes in each dimension.
x	a (data) object used to select a method.
y	vector of data (response variable).
newx	vector/matrix with the (irregular) locations to predict (columns correspond with dimensions and rows with locations) or an object extending grid.par-class (data.grid).

See Also

[np.fitgeo](#), [locpol](#), [np.svar](#).

np.svar

Local polynomial estimation of the semivariogram

Description

Estimates a multidimensional semivariogram (and its first derivatives) using local polynomial kernel smoothing of linearly binned semivariances.

Usage

```
np.svar(x, ...)
```

```
## Default S3 method:
```

```
np.svar(x, y, h = NULL, maxlag = NULL,
        nlags = NULL, minlag = maxlag/nlags, degree = 1, drv = FALSE,
        hat.bin = TRUE, ncv = 0, ...)
```

```
## S3 method for class 'svar.bin'
```

```
np.svar(x, h = NULL, degree = 1, drv = FALSE,
        hat.bin = TRUE, ncv = 0, ...)
```



```

np.svariso(x, y, h = NULL, maxlag = NULL, nlags = NULL,
  minlag = maxlag/nlags, degree = 1, drv = FALSE, hat.bin = TRUE,
  ncv = 0, ...)

np.svariso.hcv(x, y, maxlag = NULL, nlags = NULL,
  minlag = maxlag/nlags, degree = 1, drv = FALSE, hat.bin = TRUE,
  loss = c("ARSE", "ARAE", "ASE", "AAE"), ncv = 1, warn = FALSE, ...)

np.svariso.corr(lp, x = lp$data$x, h = NULL, maxlag = NULL,
  nlags = NULL, minlag = maxlag/nlags, degree = 1, drv = FALSE,
  hat.bin = TRUE, tol = 0.05, max.iter = 10, plot = FALSE,
  ylim = c(0, 2 * max(svar$biny, na.rm = TRUE)))

```

Arguments

x	object used to select a method. Usually a matrix with the coordinates of the data locations (columns correspond with dimensions and rows with data).
...	further arguments passed to or from other methods.
y	vector of data (response variable).
h	(full) bandwidth matrix (controls the degree of smoothing; only the upper triangular part of h is used).
maxlag	maximum lag. Defaults to 55% of largest lag.
nlags	number of lags. Defaults to 101.
minlag	minimum lag.
degree	degree of the local polynomial used. Defaults to 1 (local linear estimation).
drv	logical; if TRUE, the matrix of estimated first derivatives is returned.
hat.bin	logical; if TRUE, the hat matrix of the binned semivariances is returned.
ncv	integer; determines the number of cells leaved out in each dimension. Defaults to 0 (the full data is used) and it is not normally changed by the user in this setting. See "Details" below.
loss	character; CV error. See "Details" below.
warn	logical; sets the handling of warning messages (normally due to the lack of data in some neighborhoods). If FALSE all warnings are ignored.
lp	local polynomial estimate of the trend function (object of class <code>locpol.bin</code>).
tol	convergence tolerance. The algorithm stops if the average of the relative squared differences is less than tol. Defaults to 0.04.
max.iter	maximum number of iterations. Defaults to 10.
plot	logical; if TRUE, the estimates obtained at each iteration are plotted.
ylim	y-limits of the plot (if plot == TRUE).

Details

Currently, only isotropic semivariogram estimation is supported.

If parameter `nlags` is not specified is set to 101.

The computation of the hat matrix of the binned semivariances (`hat.bin = TRUE`) allows for the computation of approximated estimation variances (e.g. in `fitsvar.sb.iso`).

A multiplicative triweight kernel is used to compute the weights.

`np.svar.iso.hcv` calls `h.cv` to obtain an "optimal" bandwidth (additional arguments `...` are passed to this function). Argument `ncv` is only used here at the bandwidth selection stage (estimation is done with all the data).

`np.svar.iso.corr` computes a bias-corrected nonparametric semivariogram estimate using an iterative algorithm similar to that described in Fernandez-Casal and Francisco-Fernandez (2014). This procedure tries to correct the bias due to the direct use of residuals (obtained in this case from a nonparametric estimation of the trend function) in semivariogram estimation.

Value

Returns an S3 object of class `np.svar` (localpol svar + binned svar + grid par.), extends `svar.bin`, with the additional (some optional) 3 components:

<code>est</code>	vector or array with the local polynomial semivariogram estimates.
<code>localpol</code>	a list of 6 components: <ul style="list-style-type: none"> • <code>degree</code> degree of the local polinomial used. • <code>h</code> smoothing matrix. • <code>rm</code> mean of residual semivariances. • <code>rss</code> sum of squared residual semivariances. • <code>ncv</code> number of cells ignored in each direction. • <code>hat</code> (if requested) hat matrix of the binned semivariances. • <code>nr10</code> (if appropriate) number of cells with <code>binw > 0</code> and <code>est == NA</code>.
<code>deriv</code>	(if requested) matrix of estimated first semivariogram derivatives.

References

Fernandez Casal R., Gonzalez Manteiga W. and Febrero Bande M. (2003) Space-time dependency modeling using general classes of flexible stationary variogram models, *J. Geophys. Res.*, **108**, 8779, doi:10.1029/2002JD002909.

Garcia-Soidan P.H., Gonzalez-Manteiga W. and Febrero-Bande M. (2003) Local linear regression estimation of the variogram, *Stat. Prob. Lett.*, **64**, 169-179.

Fernandez-Casal R. and Francisco-Fernandez M. (2014) Nonparametric bias-corrected variogram estimation under non-constant trend, *Stoch. Environ. Res. Ris. Assess*, **28**, 1247-1259.

See Also

[svar.bin](#), [data.grid](#), [localpol](#).

npsp-geoR

Interface to package "geoR"

Description

Utilities to interact with the **geoR** package.

Usage

```
as.variogram(x, ...)  
  
## S3 method for class 'svar.bin'  
as.variogram(x, ...)  
  
## S3 method for class 'np.svar'  
as.variogram(x, ...)  
  
as.variomodel(m, ...)  
  
## S3 method for class 'svarmod'  
as.variomodel(m, ...)
```

Arguments

x	semivariogram estimate (e.g. svar.bin or np.svar object).
...	further arguments passed to or from other methods.
m	variogram model (e.g. svarmod object).

Details

`as.variogram` tries to convert a semivariogram estimate $\hat{\gamma}(h_i)$ to an object of the (not fully documented) **geoR**-class `variogram` (see e.g. [variog](#)).

`as.variomodel` tries to convert a semivariogram model $\gamma(pars; h)$ to an object of the **geoR**-class `variomodel` (see e.g. [variofit](#)).

See Also

[variog](#), [variofit](#), [variomodel](#), [svar.bin](#), [np.svar](#).

npssp-gstat

*Interface to package "gstat"***Description**

Utilities to interact with the **gstat** package.

Usage

```
as.vgm(x, ...)

## S3 method for class 'variomodel'
as.vgm(x, ...)

## S3 method for class 'svarmod'
as.vgm(x, ...)

vgm.tab.svarmod(x, h = seq(0, x$range, length = 1000), sill = x$sill,
  ...)

## S3 method for class 'sb.iso'
as.vgm(x, h = seq(0, x$range, length = 1000),
  sill = x$sill, ...)
```

Arguments

x	variogram model object (used to select a method).
...	further arguments passed to or from other methods.
h	vector of lags at which the covariogram is evaluated.
sill	sill of the covariogram (or pseudo-sill).

Details

Tries to convert a variogram object to **vgm** (variogramModel-class of **gstat** package). S3 generic function.

as.vgm.variomodel tries to convert an object of class variomodel defined in **geoR** (interface to **as.vgm.variomodel** defined in **gstat**).

vgm.tab.svarmod converts a svarmod object to a variogramModel-class object of type "Tab" (one-dimensional covariance table).

as.vgm.sb.iso is an alias of vgm.tab.svarmod.

See Also

[vgm](#), [svarmod](#).

npsp.tolerance	<i>npsp Tolerances</i>
----------------	------------------------

Description

Returns a (convergence, taper, approximation,...) tolerance. Defaults to `.Machine$double.eps^(1/level)`, typically about $1e-8$.

Usage

```
npsp.tolerance(level = 2, warn = TRUE)
```

Arguments

level	numerical,
warn	logical; If TRUE (the default) a warning message is issued when level < 1.

Value

Returns `.Machine$double.eps^(1/level)` if level ≥ 1 , in other case `1 - .Machine$double.eps`.

See Also

[.Machine](#)

Examples

```
curve(npsp.tolerance, 1, 1000)
abline(h = npsp.tolerance(0, FALSE), lty = 2)
```

plot.fitgeo	<i>Plot a nonparametric geostatistical model</i>
-------------	--

Description

Plots the trend estimates and the fitted variogram model.

Usage

```
## S3 method for class 'fitgeo'
plot(x, y = NULL, main.trend = "Trend estimates",
     main.svar = NULL, ...)
```

Arguments

<code>x</code>	a nonparametric geostatistical model object. Typically an output of <code>np.fitgeo</code> .
<code>y</code>	ignored argument.
<code>main.trend</code>	title for the trend plot.
<code>main.svar</code>	title for the semivariogram plot.
<code>...</code>	additional graphical parameters (to be passed to <code>simage</code> for trend plotting).

```
precipitation      Precipitation data
```

Description

The data set consists of total precipitations during March 2016 recorded over 1053 locations on the continental part of USA.

Format

A `SpatialPointsDataFrame` with 1053 observations on the following 6 variables:

y total precipitations (square-root of rainfall inches),

WBAN five-digit Weather station identifier,

state factor containing the U.S. state,

and the following `attributes`:

labels list with data and variable labels,

border `SpatialPolygons` with the boundary of the continental part of USA,

interior `SpatialPolygons` with the U.S. state boundaries.

Source

National Climatic Data Center:

<https://www.ncdc.noaa.gov/cdo-web/datasets>.

References

Fernandez-Casal R., Castillo-Paez S. and Francisco-Fernandez M. (2017) Nonparametric geostatistical risk mapping, *Stoch. Environ. Res. Ris. Assess.*, <https://doi.org/10.1007/s00477-017-1407-y>.

Fernandez-Casal R., Castillo-Paez S. and Garcia-Soidan P. (2017) Nonparametric estimation of the small-scale variability of heteroscedastic spatial processes, *Spa. Sta.*, <https://doi.org/10.1016/j.spasta.2017.04.001>.

Examples

```
str(precipitation)
summary(precipitation)
scattersplot(precipitation)
```

Description

Draw an image, perspective, contour or filled contour plot for data on a bidimensional regular grid (S3 methods for class "[data.grid](#)").

Usage

```
## S3 method for class 'data.grid'
image(x, data.ind = 1, xlab = NULL, ylab = NULL,
      ...)

## S3 method for class 'data.grid'
persp(x, data.ind = 1, xlab = NULL, ylab = NULL,
      zlab = NULL, ...)

## S3 method for class 'data.grid'
contour(x, data.ind = 1, filled = FALSE,
        xlab = NULL, ylab = NULL, ...)
```

Arguments

<code>x</code>	a " data.grid "-class object.
<code>data.ind</code>	integer (or character) with the index (or name) of the component containing the values to be used for coloring the rectangles.
<code>xlab</code>	label for the x axis, defaults to <code>dimnames(x)[1]</code> .
<code>ylab</code>	label for the y axis, defaults to <code>dimnames(x)[2]</code> .
<code>...</code>	additional graphical parameters (to be passed to main plot function).
<code>zlab</code>	label for the z axis, defaults to <code>names(x)[data.ind]</code> .
<code>filled</code>	logical; if FALSE (default), function contour is called, otherwise filled.contour .

See Also

[image](#), [persp](#), [contour](#), [filled.contour](#), [data.grid](#).

Examples

```
# Regularly spaced 2D data
grid <- grid.par(n = c(50, 50), min = c(-1, -1), max = c(1, 1))

f2d <- function(x) x[1]^2 - x[2]^2
trend <- apply(coords(grid), 1, f2d)
set.seed(1)
y <- trend + rnorm(prod(dim(grid)), 0, 0.1)
```

```

gdata <- data.grid(trend = trend, y = y, grid = grid)

# perspective plot
persp(gdata, main = 'Trend', theta = 40, phi = 20, ticktype = "detailed")

# filled contour plot
contour(gdata, main = 'Trend', filled = TRUE, color.palette = jet.colors)

# Multiple plots with a common legend:
scale.range <- c(-1.2, 1.2)
scale.color <- jet.colors(64)
# 1x2 plot with some room for the legend...
old.par <- par(mfrow = c(1,2), omd = c(0.05, 0.85, 0.05, 0.95))
image(gdata, zlim = scale.range, main = 'Trend', col = scale.color)
contour(gdata, add = TRUE)
image(gdata, 'y', zlim = scale.range, main = 'Data', col = scale.color)
contour(gdata, 'y', add = TRUE)
par(old.par)
# the legend can be added to any plot...
plot(slim = scale.range, col = scale.color, add = TRUE)

```

rule

npsp Rules

Description

Compute the number of classes for a histogram, the number of nodes of a binning grid, etc.

Usage

```

rule(x, d = 1, rule = c("Rice", "Sturges", "scott", "FD"), ...)

rule.binning(x, ...)

## Default S3 method:
rule.binning(x, d = ncol(x), a = 2, b = d + 1, ...)

rule.svar(x, ...)

## Default S3 method:
rule.svar(x, d = ncol(x), a = 2, b = d + 1, ...)

## S3 method for class 'bin.den'
rule.svar(x, ...)

```

Arguments

x data vector or object used to select a method.
d (spatial) dimension.

rule character; rule to be used.
 ... further arguments passed to or from other methods.
 a scale values.
 b exponent values.

Details

The Rice Rule, $m = \lceil 2n^{1/3} \rceil$, is a simple alternative to Sturges's rule ([nclass.Sturges](#)).

Value

The rule values (vector or scalar).

`rule.binning` returns a vector with the suggested number of bins on each dimension.

`rule.binning.default` returns `rep(ceiling(a * nrow(x) ^ (1 / b)), d)`.

`rule.svar` returns the suggested number of bins for variogram estimation.

`rule.svar.default` returns `ceiling(a * (nrow(x)^2 / 4) ^ (1 / b))`.

See Also

[hist](#), [nclass.Sturges](#), [nclass.scott](#), [nclass.FD](#), [binning](#), [np.den](#), [bin.den](#).

scattersplot *Exploratory scatter plots*

Description

Draws (in a 2 by 2 layout) the following plots: a scatter plot with a color scale, the scatter plots of the response against the (first two) coordinates and the histogram of the response values.

Usage

```
scattersplot(x, ...)

## Default S3 method:
scattersplot(x, z, main, xlab, ylab, zlab,
  col = hot.colors(128), lowess = TRUE, density = TRUE,
  omd = c(0.05, 0.95, 0.01, 0.95), ...)

## S3 method for class 'SpatialPointsDataFrame'
scattersplot(x, data.ind = 1, main,
  xlab, ylab, zlab, col = hot.colors(128), lowess = TRUE,
  density = FALSE, omd = c(0.05, 0.95, 0.01, 0.95), ...)
```

Arguments

x	object used to select a method.
...	additional graphical parameters (to be passed to spoints).
z	vector of data (response variable).
main	an overall title for the plot.
xlab	a title for the axis corresponding to the first coordinate.
ylab	a title for the axis corresponding to the second coordinate.
zlab	a title for the axis corresponding to the response.
col	color table used to set up the color scale (see spoints).
lowess	logical. If TRUE, a lowess smooth is added to the plots of the response against the coordinates.
density	logical. If TRUE, a kernel density estimate is added to the histogram.
omd	a vector of the form c(x1, x2, y1, y2) giving the region inside outer margins in normalized device coordinates (i.e. fractions of the device region).
data.ind	integer (or character) with the index (or name) of the data component.

Details

Standard generic function with a default method, in which argument x is a matrix with the spatial coordinates (each row is a point).

`scattersplot.SpatialPointsDataFrame` sets default values for some of the arguments from attributes of the object x (if present; see e.g. `precipitation`).

See Also

[splot](#), [spoints](#), [lowess](#), [density](#)

simage

Image plot with a color scale

Description

`simage` (generic function) draws an image (a grid of colored rectangles) and (optionally) adds a legend strip with the color scale (calls [splot](#) and [image](#)).

`plot.np.den` calls `simage.data.grid` ([contour](#) and [points](#) also by default).

Usage

```

simage(x, ...)

## Default S3 method:
simage(x = seq(0, 1, len = nrow(s)), y = seq(0, 1,
  len = ncol(s)), s, slim = range(s, finite = TRUE),
  col = jet.colors(128), breaks = NULL, legend = TRUE,
  horizontal = FALSE, legend.shrink = 1, legend.width = 1.2,
  legend.mar = ifelse(horizontal, 3.1, 5.1), legend.lab = NULL,
  bigplot = NULL, smallplot = NULL, lab.breaks = NULL,
  axis.args = NULL, legend.args = NULL, graphics.reset = FALSE,
  xlab = NULL, ylab = NULL, asp = NA, ...)

## S3 method for class 'data.grid'
simage(x, data.ind = 1, xlab = NULL, ylab = NULL,
  ...)

## S3 method for class 'np.den'
plot(x, y = NULL, log = TRUE, contour = TRUE,
  points = TRUE, col = hot.colors(128), tolerance = npsp.tolerance(),
  ...)

```

Arguments

x	grid values for x coordinate. If x is a list, its components x\$x and x\$y are used for x and y, respectively. For compatibility with image , if the list has component z this is used for s.
...	additional graphical parameters (to be passed to image or <code>simage.default</code> ; e.g. <code>xlim</code> , <code>ylim</code> , ...). NOTE: graphical arguments passed here will only have impact on the main plot. To change the graphical defaults for the legend use the par function beforehand (e.g. <code>par(cex.lab = 2)</code> to increase colorbar labels).
y	grid values for y coordinate.
s	matrix containing the values to be used for coloring the rectangles (NAs are allowed). Note that x can be used instead of s for convenience.
slim	limits used to set up the color scale.
col	color table used to set up the color scale (see image for details).
breaks	(optional) numeric vector with the breakpoints for the color scale: must have one more breakpoint than col and be in increasing order.
legend	logical; if TRUE (default), the plotting region is splitted into two parts, drawing the image plot in one and the legend with the color scale in the other. If FALSE only the image plot is drawn and the arguments related to the legend are ignored (splot is not called).
horizontal	logical; if FALSE (default) legend will be a vertical strip on the right side. If TRUE the legend strip will be along the bottom.
legend.shrink	amount to shrink the size of legend relative to the full height or width of the plot.

<code>legend.width</code>	width in characters of the legend strip. Default is 1.2, a little bigger than the width of a character.
<code>legend.mar</code>	width in characters of legend margin that has the axis. Default is 5.1 for a vertical legend and 3.1 for a horizontal legend.
<code>legend.lab</code>	label for the axis of the color legend. Default is no label as this is usual evident from the plot title.
<code>bigplot</code>	plot coordinates for main plot. If not passed these will be determined within the function.
<code>smallplot</code>	plot coordinates for legend strip. If not passed these will be determined within the function.
<code>lab.breaks</code>	if breaks are supplied these are text string labels to put at each break value. This is intended to label axis on a transformed scale such as logs.
<code>axis.args</code>	additional arguments for the axis function used to create the legend axis (see image.plot for details).
<code>legend.args</code>	arguments for a complete specification of the legend label. This is in the form of list and is just passed to the <code>mtext</code> function. Usually this will not be needed (see image.plot for details).
<code>graphics.reset</code>	logical; if FALSE (default) the plotting region (<code>par("plt")</code>) will not be reset to make it possible to add more features to the plot (e.g. using functions such as <code>points</code> or <code>lines</code>). If TRUE will reset plot parameters to the values before entering the function.
<code>xlab</code>	label for the x axis, defaults to a description of x.
<code>ylab</code>	label for the y axis, defaults to a description of y.
<code>asp</code>	the y/x aspect ratio, see plot.window .
<code>data.ind</code>	integer (or character) with the index (or name) of the component containing the values to be used for coloring the rectangles.
<code>log</code>	logical; if TRUE (default), <code>log(x\$est)</code> is plotted.
<code>contour</code>	logical; if TRUE (default), contour lines are added.
<code>points</code>	logical; if TRUE (default), points at <code>x\$data\$x</code> are drawn.
<code>tolerance</code>	tolerance value (lower values are masked).

Value

Invisibly returns a list with the following 3 components:

<code>bigplot</code>	plot coordinates of the main plot. These values may be useful for drawing a plot without the legend that is the same size as the plots with legends.
<code>smallplot</code>	plot coordinates of the secondary plot (legend strip).
<code>old.par</code>	previous graphical parameters (<code>par(old.par)</code> will reset plot parameters to the values before entering the function).

Side Effects

After exiting, the plotting region may be changed (`par("plt")`) to make it possible to add more features to the plot (set `graphics.reset = FALSE` to avoid this).

Author(s)

Based on [image.plot](#) function from package **fields**: fields, Tools for spatial data. Copyright 2004-2013, Institute for Mathematics Applied Geosciences. University Corporation for Atmospheric Research.

Modified by Ruben Fernandez-Casal <rubenfcasal@gmail.com>.

See Also

[splot](#), [spoints](#), [spersp](#), [image](#), [image.plot](#), [data.grid](#).

Examples

```
#
# Regularly spaced 2D data
nx <- c(40, 40) # ndata = prod(nx)
x1 <- seq(-1, 1, length.out = nx[1])
x2 <- seq(-1, 1, length.out = nx[2])
trend <- outer(x1, x2, function(x,y) x^2 - y^2)
simage( x1, x2, trend, main = 'Trend')

#
# Multiple plots
set.seed(1)
y <- trend + rnorm(prod(nx), 0, 0.1)
x <- as.matrix(expand.grid(x1 = x1, x2 = x2)) # two-dimensional grid
# local polynomial kernel regression
lp <- locpol(x, y, nbin = nx, h = diag(c(0.3, 0.3)))
# 1x2 plot
old.par <- par(mfrow = c(1,2))
simage( x1, x2, y, main = 'Data')
simage(lp, main = 'Estimated trend')
par(old.par)
```

spersp

Perspective plot with a color scale

Description

`spersp` (generic function) draws a perspective plot of a surface over the x-y plane with the facets being filled with different colors and (optionally) adds a legend strip with the color scale (calls [splot](#) and [persp](#)).

Usage

```
spersp(x, ...)
```

```
## Default S3 method:
```

```
spersp(x = seq(0, 1, len = nrow(z)), y = seq(0, 1,
  len = ncol(z)), z, s = z, slim = range(s, finite = TRUE),
  col = jet.colors(128), breaks = NULL, legend = TRUE,
  horizontal = FALSE, legend.shrink = 0.8, legend.width = 1.2,
  legend.mar = ifelse(horizontal, 3.1, 5.1), legend.lab = NULL,
  bigplot = NULL, smallplot = NULL, lab.breaks = NULL,
  axis.args = NULL, legend.args = NULL, graphics.reset = FALSE,
  xlab = NULL, ylab = NULL, zlab = NULL, theta = 40, phi = 20,
  ticktype = "detailed", cex.axis = 0.75, ...)
```

```
## S3 method for class 'data.grid'
spersp(x, data.ind = 1, s = x[[data.ind]],
  xlab = NULL, ylab = NULL, zlab = NULL, ...)
```

Arguments

x	grid values for x coordinate. If x is a list, its components x\$x and x\$y are used for x and y, respectively. If the list has component z this is used for z.
...	additional graphical parameters (to be passed to persp or <code>spersp</code> . default; e.g. <code>xlim</code> , <code>ylim</code> , <code>zlim</code> , ...). NOTE: graphical arguments passed here will only have impact on the main plot. To change the graphical defaults for the legend use the par function beforehand (e.g. <code>par(cex.lab = 2)</code> to increase colorbar labels).
y	grid values for y coordinate.
z	matrix containing the values to be plotted (NAs are allowed). Note that x can be used instead of z for convenience.
s	matrix containing the values used for coloring the facets.
slim	limits used to set up the color scale.
col	color table used to set up the color scale (see image for details).
breaks	(optional) numeric vector with the breakpoints for the color scale: must have one more breakpoint than <code>col</code> and be in increasing order.
legend	logical; if TRUE (default), the plotting region is splitted into two parts, drawing the perspective plot in one and the legend with the color scale in the other. If FALSE only the (coloured) perspective plot is drawn and the arguments related to the legend are ignored (<code>splot</code> is not called).
horizontal	logical; if FALSE (default) legend will be a vertical strip on the right side. If TRUE the legend strip will be along the bottom.
legend.shrink	amount to shrink the size of legend relative to the full height or width of the plot.
legend.width	width in characters of the legend strip. Default is 1.2, a little bigger than the width of a character.
legend.mar	width in characters of legend margin that has the axis. Default is 5.1 for a vertical legend and 3.1 for a horizontal legend.
legend.lab	label for the axis of the color legend. Default is no label as this is usual evident from the plot title.

<code>bigplot</code>	plot coordinates for main plot. If not passed these will be determined within the function.
<code>smallplot</code>	plot coordinates for legend strip. If not passed these will be determined within the function.
<code>lab.breaks</code>	if breaks are supplied these are text string labels to put at each break value. This is intended to label axis on a transformed scale such as logs.
<code>axis.args</code>	additional arguments for the axis function used to create the legend axis (see image.plot for details).
<code>legend.args</code>	arguments for a complete specification of the legend label. This is in the form of list and is just passed to the <code>mtext</code> function. Usually this will not be needed (see image.plot for details).
<code>graphics.reset</code>	logical; if FALSE (default) the plotting region (<code>par("plt")</code>) will not be reset to make it possible to add more features to the plot (e.g. using functions such as points or lines). If TRUE will reset plot parameters to the values before entering the function.
<code>xlab</code>	label for the x axis, defaults to a description of x.
<code>ylab</code>	label for the y axis, defaults to a description of y.
<code>zlab</code>	label for the z axis, defaults to a description of z.
<code>theta</code>	x-y rotation angle for perspective (azimuthal direction).
<code>phi</code>	z-angle for perspective (colatitude).
<code>ticktype</code>	character; "simple" draws just an arrow parallel to the axis to indicate direction of increase; "detailed" draws normal ticks as per 2D plots.
<code>cex.axis</code>	magnification to be used for axis annotation (relative to the current setting of <code>par("cex")</code>).
<code>data.ind</code>	integer (or character) with the index (or name) of the component containing the z values to be plotted.

Value

Invisibly returns a list with the following 4 components:

<code>pm</code>	the viewing transformation matrix (see persp for details), a 4 x 4 matrix that can be used to superimpose additional graphical elements using the function trans3d .
<code>bigplot</code>	plot coordinates of the main plot. These values may be useful for drawing a plot without the legend that is the same size as the plots with legends.
<code>smallplot</code>	plot coordinates of the secondary plot (legend strip).
<code>old.par</code>	previous graphical parameters (<code>par(old.par)</code> will reset plot parameters to the values before entering the function).

Side Effects

After exiting, the plotting region may be changed (`par("plt")`) to make it possible to add more features to the plot (set `graphics.reset = FALSE` to avoid this).

Author(s)

Based on [image.plot](#) function from package **fields**: fields, Tools for spatial data. Copyright 2004-2013, Institute for Mathematics Applied Geosciences. University Corporation for Atmospheric Research.

Modified by Ruben Fernandez-Casal <rubenfcasal@gmail.com>.

See Also

[splot](#), [spoints](#), [simage](#), [image](#), [image.plot](#), [data.grid](#), [persp](#).

Examples

```
#
# Regularly spaced 2D data
nx <- c(40, 40) # ndata = prod(nx)
x1 <- seq(-1, 1, length.out = nx[1])
x2 <- seq(-1, 1, length.out = nx[2])
trend <- outer(x1, x2, function(x,y) x^2 - y^2)
spersp( x1, x2, trend, main = 'Trend', zlab = 'y')

#
# Multiple plots
set.seed(1)
y <- trend + rnorm(prod(nx), 0, 0.1)
x <- as.matrix(expand.grid(x1 = x1, x2 = x2)) # two-dimensional grid
# local polynomial kernel regression
lp <- locpol(x, y, nbin = nx, h = diag(c(0.3, 0.3)))
# 1x2 plot
old.par <- par(mfrow = c(1,2))
spersp( x1, x2, y, main = 'Data')
spersp(lp, main = 'Estimated trend', zlab = 'y')
par(old.par)
```

splot

Utilities for plotting with a color scale

Description

splot is designed to combine a standard R plot with a legend representing a (continuous) color scale. This is done by splitting the plotting region into two parts. Keeping one for the main chart and putting the legend in the other.

sxxxx functions ([spoints](#), [simage](#) and [spersp](#)) draw the corresponding high-level plot (xxxx) with a legend strip for the color scale.

These functions are based on function [image.plot](#) of package **fields**, see its documentation for additional information.

[jet.colors](#) and [hot.colors](#) create a color table useful for contiguous color scales and [scolor](#) assigns colors to a numerical vector.

Usage

```

splot(slim = c(0, 1), col = jet.colors(128), breaks = NULL,
      horizontal = FALSE, legend.shrink = 0.9, legend.width = 1.2,
      legend.mar = ifelse(horizontal, 3.1, 5.1), legend.lab = NULL,
      bigplot = NULL, smallplot = NULL, lab.breaks = NULL,
      axis.args = NULL, legend.args = NULL, add = FALSE)

scolor(s, col = jet.colors(128), slim = range(s, finite = TRUE))

jet.colors(n)

hot.colors(n, rev = TRUE)

```

Arguments

slim	limits used to set up the color scale.
col	color table used to set up the color scale (see image for details).
breaks	(optional) numeric vector with the breakpoints for the color scale: must have one more breakpoint than col and be in increasing order.
horizontal	logical; if FALSE (default) legend will be a vertical strip on the right side. If TRUE the legend strip will be along the bottom.
legend.shrink	amount to shrink the size of legend relative to the full height or width of the plot.
legend.width	width in characters of the legend strip. Default is 1.2, a little bigger than the width of a character.
legend.mar	width in characters of legend margin that has the axis. Default is 5.1 for a vertical legend and 3.1 for a horizontal legend.
legend.lab	label for the axis of the color legend. Default is no label as this is usual evident from the plot title.
bigplot	plot coordinates for main plot. If not passed these will be determined within the function.
smallplot	plot coordinates for legend strip. If not passed these will be determined within the function.
lab.breaks	if breaks are supplied these are text string labels to put at each break value. This is intended to label axis on a transformed scale such as logs.
axis.args	additional arguments for the axis function used to create the legend axis (see image.plot for details).
legend.args	arguments for a complete specification of the legend label. This is in the form of list and is just passed to the mtext function. Usually this will not be needed (see image.plot for details).
add	logical; if TRUE the legend strip is just added to the existing plot.
s	values to be converted to the color scale.
n	number of colors (≥ 1) to be in the palette.
rev	logical; if TRUE, the palette is reversed (decreasing overall luminosity).

Details

`scolor` converts a real valued vector to a color scale. The range `slim` is divided into `length(col) + 1` pieces of equal length. Values which fall outside the range of the scale are coded as NA.

`jet.colors` generates a rainbow style color table similar to the MATLAB (TM) jet color scheme. It may be appropriate to distinguish between values above and below a central value (e.g. between positive and negative values).

`hot.colors` generates a color table similar to the MATLAB (TM) hot color scheme (reversed by default). It may be appropriate to represent values ranging from 0 to some maximum level (e.g. density estimation). The default value `rev = TRUE` may be adequate to grayscale conversion.

Value

`splot` invisibly returns a list with the following 3 components:

<code>bigplot</code>	plot coordinates of the main plot. These values may be useful for drawing a plot without the legend that is the same size as the plots with legends.
<code>smallplot</code>	plot coordinates of the secondary plot (legend strip).
<code>old.par</code>	previous graphical parameters (<code>par(old.par)</code> will reset plot parameters to the values before entering the function).

`jet.colors` and `hot.colors` return a character vector of colors (similar to `heat.colors` or `terrain.colors`; see `rgb`).

Side Effects

After exiting, the plotting region may be changed (`par("plt")`) to make it possible to add more features to the plot.

Author(s)

Based on `image.plot` function from package **fields**: fields, Tools for spatial data. Copyright 2004-2013, Institute for Mathematics Applied Geosciences. University Corporation for Atmospheric Research.

Modified by Ruben Fernandez-Casal <rubenfcasal@gmail.com>.

See Also

`spoints`, `simage`, `spersp`, `image`, `image.plot`.

Examples

```
scale.range <- range(aquifer$head)
splot(slim = scale.range)
with( aquifer, plot(lon, lat, col = scolor(head, slim = scale.range),
  pch = 16, cex = 1.5, main = "Wolfcamp aquifer data"))
# equivalent to:
# with( aquifer, spoints(lon, lat, head, main = "Wolfcamp aquifer data"))
```

```

#
# Multiple plots with a common legend:
#
# regularly spaced 2D data...
set.seed(1)
nx <- c(40, 40) # ndata = prod(nx)
x1 <- seq(-1, 1, length.out = nx[1])
x2 <- seq(-1, 1, length.out = nx[2])
trend <- outer(x1, x2, function(x,y) x^2 - y^2)
y <- trend + rnorm(prod(nx), 0, 0.1)
scale.range <- c(-1.2, 1.2)
scale.color <- heat.colors(64)
# 1x2 plot with some room for the legend...
old.par <- par(mfrow = c(1,2), omd = c(0.05, 0.85, 0.05, 0.95))
image( x1, x2, trend, zlim = scale.range, main = 'Trend', col = scale.color)
image( x1, x2, y, zlim = scale.range, main = 'Data', col = scale.color)
par(old.par)
# the legend can be added to any plot...
splot(slim = scale.range, col = scale.color, add = TRUE)
## note that argument 'zlim' in 'image' corresponds with 'slim' in 'sxxxx' functions.

```

spoints

Scatter plot with a color scale

Description

spoints (generic function) draws a scatter plot with points filled with different colors and (optionally) adds a legend strip with the color scale (calls `splot` and `plot.default`).

Usage

```
spoints(x, ...)
```

```
## Default S3 method:
```

```
spoints(x, y = NULL, s, slim = range(s, finite =
  TRUE), col = jet.colors(128), breaks = NULL, legend = TRUE,
  horizontal = FALSE, legend.shrink = 1, legend.width = 1.2,
  legend.mar = ifelse(horizontal, 3.1, 5.1), legend.lab = NULL,
  bigplot = NULL, smallplot = NULL, lab.breaks = NULL,
  axis.args = NULL, legend.args = NULL, add = FALSE,
  graphics.reset = add, pch = 16, cex = 1.5, xlab = NULL,
  ylab = NULL, asp = NA, ...)
```

```
## S3 method for class 'data.grid'
```

```
spoints(x, s = x[[1]], xlab = NULL, ylab = NULL,
  ...)
```

```
## S3 method for class 'SpatialPointsDataFrame'
```

```
spoints(x, data.ind = 1, main, xlab,
  ylab, legend.lab, ...)
```

Arguments

<code>x</code>	object used to select a method. In the default method, it provides the x coordinates for the plot (and optionally the y coordinates; any reasonable way of defining the coordinates is acceptable, see the function <code>xy.coords</code> for details).
<code>...</code>	additional graphical parameters (to be passed to the main plot function or <code>sxxxx.default</code> ; e.g. <code>xlim</code> , <code>ylim</code> , ...). NOTE: graphical arguments passed here will only have impact on the main plot. To change the graphical defaults for the legend use the <code>par</code> function beforehand (e.g. <code>par(cex.lab = 2)</code> to increase colorbar labels).
<code>y</code>	y coordinates. Alternatively, a single argument <code>x</code> can be provided.
<code>s</code>	numerical vector containing the values used for coloring the points.
<code>slim</code>	limits used to set up the color scale.
<code>col</code>	color table used to set up the color scale (see <code>image</code> for details).
<code>breaks</code>	(optional) numeric vector with the breakpoints for the color scale: must have one more breakpoint than <code>col</code> and be in increasing order.
<code>legend</code>	logical; if TRUE (default), the plotting region is splitted into two parts, drawing the main plot in one and the legend with the color scale in the other. If FALSE only the (coloured) main plot is drawn and the arguments related to the legend are ignored (<code>splot</code> is not called).
<code>horizontal</code>	logical; if FALSE (default) legend will be a vertical strip on the right side. If TRUE the legend strip will be along the bottom.
<code>legend.shrink</code>	amount to shrink the size of legend relative to the full height or width of the plot.
<code>legend.width</code>	width in characters of the legend strip. Default is 1.2, a little bigger than the width of a character.
<code>legend.mar</code>	width in characters of legend margin that has the axis. Default is 5.1 for a vertical legend and 3.1 for a horizontal legend.
<code>legend.lab</code>	label for the axis of the color legend. Default is no label as this is usual evident from the plot title.
<code>bigplot</code>	plot coordinates for main plot. If not passed, and <code>legend</code> is TRUE, these will be determined within the function.
<code>smallplot</code>	plot coordinates for legend strip. If not passed, and <code>legend</code> is TRUE, these will be determined within the function.
<code>lab.breaks</code>	if <code>breaks</code> are supplied these are text string labels to put at each break value. This is intended to label axis on a transformed scale such as logs.
<code>axis.args</code>	additional arguments for the axis function used to create the legend axis (see <code>image.plot</code> for details).
<code>legend.args</code>	arguments for a complete specification of the legend label. This is in the form of list and is just passed to the <code>mtext</code> function. Usually this will not be needed (see <code>image.plot</code> for details).
<code>add</code>	logical; if TRUE the scatter plot is just added to the existing plot.
<code>graphics.reset</code>	logical; if FALSE (default) the plotting region (<code>par("plt")</code>) will not be reset to make it possible to add more features to the plot (e.g. using functions such as <code>points</code> or <code>lines</code>). If TRUE will reset plot parameters to the values before entering the function.

pch	vector of plotting characters or symbols: see points .
cex	numerical vector giving the amount by which plotting characters and symbols should be scaled relative to the default. This works as a multiple of <code>par("cex")</code> .
xlab	label for the x axis, defaults to a description of x.
ylab	label for the y axis, defaults to a description of y.
asp	the y/x aspect ratio, see plot.window .
data.ind	integer (or character) with the index (or name) of the data component.
main	an overall title for the plot.

Details

`spoints.SpatialPointsDataFrame` sets default values for some of the arguments from attributes of the object `x` (if present; see e.g. `precipitation`).

Value

Invisibly returns a list with the following 3 components:

bigplot	plot coordinates of the main plot. These values may be useful for drawing a plot without the legend that is the same size as the plots with legends.
smallplot	plot coordinates of the secondary plot (legend strip).
old.par	previous graphical parameters (<code>par(old.par)</code> will reset plot parameters to the values before entering the function).

Side Effects

After exiting, the plotting region may be changed (`par("plt")`) to make it possible to add more features to the plot (set `graphics.reset = FALSE` to avoid this).

Author(s)

Based on [image.plot](#) function from package **fields**: fields, Tools for spatial data. Copyright 2004-2013, Institute for Mathematics Applied Geosciences. University Corporation for Atmospheric Research.

Modified by Ruben Fernandez-Casal <rubenfcasal@gmail.com>.

See Also

[splot](#), [simage](#), [spersp](#), [image](#), [image.plot](#), [data.grid](#), [plot.default](#).

Examples

```
#
with(aquifer, spoints(lon, lat, head, main = "Wolfcamp aquifer data"))
```

`sv`*Evaluate a semivariogram model*

Description

Evaluates an `svarmod` object `x` at lags `h` (S3 generic function).

Usage

```
sv(x, h, ...)  
  
## Default S3 method:  
sv(x, h, ...)  
  
## S3 method for class 'svarmod'  
sv(x, h, ...)  
  
## S3 method for class 'svar.grid'  
sv(x, h, ...)  
  
## S3 method for class 'sb.iso'  
sv(x, h, discretize = FALSE, ...)
```

Arguments

<code>x</code>	variogram model (<code>svarmod</code> object).
<code>h</code>	vector (isotropic case) or matrix of lag values.
<code>...</code>	further arguments passed to or from other methods.
<code>discretize</code>	logical. If TRUE the variogram is previously discretized.

Value

A vector of semivariance values $\gamma(h_i)$.

See Also

[covar](#)

svar.bin	<i>Linear binning of semivariances</i>
----------	--

Description

Creates a `svar.bin` (binned semivar. + grid parameters) object with linearly binned semivariances (i.e. computes a binned sample variogram).

Usage

```
svar.bin(x, ...)
```

Default S3 method:

```
svar.bin(x, y, maxlag = NULL, nlags = NULL,
  minlag = maxlag/nlags, estimator = c("classical", "modulus"), ...)
```

```
svariso(x, y, maxlag = NULL, nlags = NULL, minlag = maxlag/nlags,
  estimator = c("classical", "modulus"), ...)
```

Arguments

<code>x</code>	object used to select a method. Usually a matrix with the coordinates of the data locations (columns correspond with dimensions and rows with data).
<code>...</code>	further arguments passed to or from other methods.
<code>y</code>	vector of data (response variable).
<code>maxlag</code>	maximum lag. Defaults to 55% of largest lag.
<code>nlags</code>	number of lags. Defaults to <code>max(12, rule.svar(x))</code> .
<code>minlag</code>	minimum lag.
<code>estimator</code>	character, estimator name (e.g. "classical"). See "Details" below.

Details

Currently, only isotropic semivariogram estimation is supported.

If parameter `nlags` is not specified is set to `max(12, rule.svar(x))`.

Value

Returns an S3 object of class `svar.bin` (extends `bin.data`), a `data.grid` object with the following 4 components:

<code>biny</code>	array (dimension <code>nlags</code>) with the binned semivariances.
<code>binw</code>	array (dimension <code>nlags</code>) with the bin counts (weights).
<code>grid</code>	a <code>grid.par-class</code> object with the grid parameters.
<code>data</code>	a list with 3 components:

- x argument x.
- y argument y.
- med (weighted) mean of the (binned) semivariances.

svar a list of 2 components:

- type character, type of estimation (e.g. "isotropic").
- estimator character, estimator name (e.g. "classical").

See Also

[np.svariso](#), [np.svar](#), [data.grid](#), [binning](#), [locpol](#), [rule.svar](#).

svar.grid

Discretize a (semi)variogram model

Description

Discretizes a variogram model (to speed up variogram evaluation). Constructor function of the `svar.grid-class`.

Usage

```
svar.grid(svar, log = TRUE, ...)
```

```
## S3 method for class 'svarmod'
```

```
svar.grid(svar, log = TRUE, n = 256, min = 10 *  
         .Machine$double.eps, max = 1.1 * svar$range, ...)
```

Arguments

svar	(fitted) variogram model (a <code>svarmod</code> or <code>fitsvar</code> object).
log	logical. If TRUE, the variogram is discretized in (base 2) logarithmic scale.
...	further arguments passed to or from other methods.
n	number of lags. Defaults to 256.
min	minimum lag. Defaults to $10 * .Machine$double.eps$.
max	maximum lag. Defaults to $1.1 * svar$range$.

 svar.plot

Plot a semivariogram object

Description

Utilities for plotting pilot semivariograms or fitted models.

plot.fitsvar plots a fitted variogram model.

plot.svar.bin plots the binned semivariances.

plot.np.svar plots a local polynomial estimate of the semivariogram.

Usage

```
## S3 method for class 'fitsvar'
plot(x, y = NULL, legend = TRUE, xlab = "distance",
     ylab = "semivariance", ylim = c(0, 1.25 * max(x$fit$sv, na.rm =
     TRUE)), lwd = c(1, 2), add = FALSE, ...)
```

```
## S3 method for class 'svar.bin'
plot(x, y = NULL, xlab = "distance",
     ylab = "semivariance", ylim = c(0, max(x$biny, na.rm = TRUE)),
     add = FALSE, ...)
```

```
## S3 method for class 'np.svar'
plot(x, y = NULL, xlab = "distance",
     ylab = "semivariance", ylim = c(0, max(x$biny, na.rm = TRUE)),
     add = FALSE, ...)
```

Arguments

x	a variogram object. Typically an output of functions np.svariso or fitsvar.sb.iso .
y	ignored argument.
legend	logical; if TRUE (default), a legend is added to the plot.
xlab	label for the x axis (defaults to "distance").
ylab	label for the y axis (defaults to "semivariance").
ylim	y-limits.
lwd	line widths for points (estimates) and lines (fitted model) respectively.
add	logical; if TRUE the semivariogram plot is just added to the existing plot.
...	additional graphical parameters (see par).

See Also

[svariso](#), [np.svariso](#), [fitsvar.sb.iso](#).

svarmod

*Define a (semi)variogram model***Description**

Defines a variogram model specifying the parameter values. Constructor function of the `svarmod-class`.

Usage

```
svarmod(model, type = "isotropic", par, nugget = NULL, sill = NULL,
        range = NULL)
```

```
svarmod.sb.iso(dk, x, z, nu, range, sill = nu)
```

```
svarmodels(type = "isotropic")
```

Arguments

<code>model</code>	string indicating the variogram family (see Details below).
<code>type</code>	string indicating the type of variogram, e.g. "isotropic".
<code>par</code>	vector of variogram parameters.
<code>nugget</code>	nugget value c_0 .
<code>sill</code>	variance σ^2 or sill of the variogram (NA for unbounded variograms).
<code>range</code>	range (practical range or scale parameter) of the variogram (NA for unbounded variograms; maybe a vector for anisotropic variograms).
<code>dk</code>	dimension of the kappa function.
<code>x</code>	discretization nodes.
<code>z</code>	jumps (of the spectral distribution) at the discretization nodes.
<code>nu</code>	parameter ν_0 (can be thought of as the sill).

Value

`svarmod` returns an `svarmod-class` object, a list with function arguments as components.

`svarmod.sb.iso` returns an S3 object of `class` `sb.iso` (extends `svarmod`) corresponding to a 'non-parametric' isotropic Shapiro-Botha model.

`svarmodels` returns a named character vector with the available models of the corresponding type (when appropriate, component values could be used as `cov.model` argument in **geoR** routines and component names as `model` argument in **gstat** routines).

Note

`svarmod` does not check the consistency of the parameter values.

References

Shapiro, A. and Botha, J.D. (1991) Variogram fitting with a general class of conditionally non-negative definite functions. *Computational Statistics and Data Analysis*, **11**, 87-96.

See Also

[sv](#), [covar](#).

varcov	<i>Covariance matrix</i>
--------	--------------------------

Description

Computes the covariance matrix a corresponding to a set of spatial locations given a variogram model or a semivariogram estimate.

Usage

```
varcov(x, coords, ...)

## S3 method for class 'isotropic'
varcov(x, coords, sill = x$sill, range.taper,
       discretize = nrow(coords) > 256, ...)

## S3 method for class 'np.svar'
varcov(x, coords, sill = max(x$est),
       range.taper = x$grid$max, ...)
```

Arguments

x	variogram model (svarmod object) or semivariogram estimate.
coords	matrix of coordinates (columns correspond with dimensions and rows with data).
...	further arguments passed to or from other methods.
sill	(theoretical or estimated) variance $C(0) = \sigma^2$ or pseudo-sill (unbounded variograms).
range.taper	(optional) if provided, covariances corresponding to distances larger than this value are set to 0.
discretize	logical. If TRUE (default), the variogram is (previously) discretized.

Value

The covariance matrix of the data.

See Also

[sv](#), [covar](#).

Index

- *Topic **datasets**
 - aquifer, 4
 - earthquakes, 14
 - precipitation, 38
- *Topic **hplot**
 - scattersplot, 41
 - simage, 42
 - spersp, 45
 - splot, 48
 - spoints, 51
- *Topic **nonparametric**
 - npsp-package, 3
- *Topic **smooth**
 - npsp-package, 3
- .Machine, 37

- aquifer, 4
- as.bin.data (binning), 7
- as.bin.den (bin.den), 6
- as.data.frame, 12
- as.data.frame.data.grid, 6
- as.data.frame.data.grid (data.grid), 11
- as.data.grid (data.grid), 11
- as.sp, 5
- as.variogram, 4
- as.variogram (npsp-geoR), 35
- as.variomodel (npsp-geoR), 35
- as.vgm, 3, 4
- as.vgm (npsp-gstat), 36
- as.vgm.variomodel, 36
- attributes, 38

- besselJ, 23
- bin.data, 6, 24, 55
- bin.data (binning), 7
- bin.data-class (binning), 7
- bin.den, 3, 6, 8, 25, 28, 41
- bin.den-class (bin.den), 6
- binning, 3, 7, 12, 20, 25, 27, 28, 41, 56

- cat, 11
- chol, 16
- class, 6, 8, 11, 12, 15–17, 30–32, 36, 55, 56, 58
- contour, 39, 42
- contour.data.grid (rgraphics), 39
- coords, 8, 9
- coordvalues, 9, 9
- covar, 10, 54, 59
- cpu.time, 10

- data.grid, 6, 8, 11, 18, 25, 28, 32, 34, 39, 45, 48, 53, 55, 56
- data.grid-class (data.grid), 11
- density, 42
- disc.sb, 13, 15, 16

- earthquakes, 14

- filled.contour, 39
- fitgeo-class (np.geo), 31
- fitsvar, 30, 31, 56
- fitsvar (fitsvar.sb.iso), 15
- fitsvar.sb.iso, 3, 13, 15, 29–31, 34, 57
- flush.console, 11

- grid.par, 6, 8, 12, 17, 32, 55
- grid.par-class (grid.par), 17
- GridTopology, 17

- h.cv, 3, 8, 18, 29, 30, 34
- hcv.data, 24, 25
- hcv.data (h.cv), 18
- heat.colors, 50
- hist, 41
- hot.colors (splot), 48

- image, 39, 42, 43, 45, 46, 48–50, 52, 53
- image.data.grid (rgraphics), 39
- image.plot, 3, 44, 45, 47–50, 52, 53
- interp, 3, 21

- interp.surface, 22
- iso.np.svar (np.svar), 32
- iso.svar (svar.bin), 55
- jet.colors (splot), 48
- kappasb, 13, 22
- krige, 3
- krige.cv, 3
- kriging (np.kriging), 31
- locpol, 3, 6–8, 12, 20, 23, 27, 29–32, 34, 56
- locpol.bin, 30–33
- locpolhcv, 20, 27
- locpolhcv (locpol), 23
- lowess, 42
- mask, 9, 26
- mtext, 44, 47, 49, 52
- nclass.FD, 41
- nclass.scott, 41
- nclass.Sturges, 41
- np.den, 3, 6, 25, 27, 41
- np.den-class (np.den), 27
- np.den.bin.data (np.den), 27
- np.den.bin.den, 28
- np.den.bin.den (np.den), 27
- np.den.default (np.den), 27
- np.den.svar.bin (np.den), 27
- np.fitgeo, 3, 29, 31, 32, 38
- np.geo, 30, 31, 32
- np.geo-class, (np.geo), 31
- np.kriging, 31
- np.svar, 3, 15, 20, 25, 27, 30, 32, 32, 35, 56
- np.svar-class (np.svar), 32
- np.svar.default (np.svar), 32
- np.svar.svar.bin (np.svar), 32
- np.svariso, 15, 25, 29, 56, 57
- np.svariso (np.svar), 32
- np.svariso.corr, 3, 29, 30
- npsp, 5
- npsp (npsp-package), 3
- npsp-geoR, 35
- npsp-gstat, 36
- npsp-package, 3
- npsp.tolerance, 19, 27, 37
- optim, 19
- par, 43, 44, 46, 47, 50, 52, 53, 57
- persp, 39, 45–48
- persp.data.grid (rgraphics), 39
- plot.default, 51, 53
- plot.fitgeo, 37
- plot.fitsvar, 16
- plot.fitsvar (svar.plot), 57
- plot.np.den (simage), 42
- plot.np.svar (svar.plot), 57
- plot.svar.bin (svar.plot), 57
- plot.window, 44, 53
- points, 42, 53
- precipitation, 38
- predict.locpol.bin (interp), 21
- predict.np.den (interp), 21
- proc.time, 11
- rgb, 50
- rgraphics, 39
- rule, 40
- rule.binning, 6, 25
- rule.svar, 55, 56
- sb.iso-class (svarmod), 58
- scattersplot, 41
- scolor (splot), 48
- simage, 3, 38, 42, 48, 50, 53
- solve.QP, 16
- sp, 5
- SpatialGridDataFrame, 12
- SpatialPointsDataFrame, 38
- SpatialPolygons, 38
- spersp, 3, 45, 45, 48, 50, 53
- splot, 3, 42, 43, 45, 46, 48, 48, 51–53
- spoints, 3, 42, 45, 48, 50, 51
- sv, 10, 54, 59
- svar.bin, 3, 15, 25, 34, 35, 55
- svar.bin-class (svar.bin), 55
- svar.bin.default (svar.bin), 55
- svar.grid, 56
- svar.plot, 57
- svariso, 57
- svariso (svar.bin), 55
- svarmod, 10, 16, 19, 24, 30–32, 35, 36, 54, 56, 58, 59
- svarmod.sb.iso, 16, 23
- svarmodels (svarmod), 58
- system.time, 11

terrain.colors, [50](#)
trans3d, [47](#)

varcov, [10](#), [59](#)
variofit, [35](#)
variog, [35](#)
variogram (npsp-geoR), [35](#)
variomodel, [35](#)
variomodel (npsp-geoR), [35](#)
vgm, [36](#)
vgm.tab.svarmod (npsp-gstat), [36](#)

xy.coords, [52](#)