Package ‘NPCirc’

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Type Package

Title Nonparametric Circular Methods

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Author María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez-Casal

Maintainer María Oliveira <maria.oliveira@usc.es>

Depends R(>= 2.15.0), circular

Imports misc3d, movMF, plotrix, rgl, shape

Description This package implements nonparametric smoothing methods for circular data.

License GPL-2

LazyLoad yes

Repository CRAN

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`NPCirc-package` *Nonparametric circular methods.*

Description

This package implements nonparametric kernel methods for density and regression estimation for circular data.

Details

Package:	NPCirc
Type:	Package
Version:	2.0.0
Date:	2013-10-18
License:	GPL-2
LazyLoad:	yes

This package incorporates the function `kern.den.circ` which computes the circular kernel density estimator. For choosing the smoothing parameter different functions are available: `bw.rt`, `bw.CV`, `bw.pi`, and `bw.boot`. For regression involving circular variables, the package includes the functions: `kern.reg.circ.lin` for a circular covariate and linear response; `kern.reg.circ.circ` for a circular covariate and a circular response; `kern.reg.lin.circ` for a linear covariate and a circular response. The three functions compute Nadaraya-Watson and Local-Linear smoothers. The functions `bw.reg.circ.lin`, `bw.reg.circ.circ` and `bw.reg.circ.lin` implement cross–validation rules for selecting the smoothing parameter. Functions `circsizer.density` and `circsizer.regression` provides CircSiZer maps for kernel density estimation and regression estimation, respectively. Functions `dcircmix` and `rcircmix` compute the density function and generate random samples of a circular distribution or a mixture of circular distributions, allowing for different components such as the circular uniform, von Mises, cardioid, wrapped Cauchy, wrapped normal and wrapped skew-normal. Finally, some data sets are provided. Missing data are allowed. Registries with missing data are simply removed.

For a complete list of functions, use `library(help="NPCirc")`.

Acknowledgements

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Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

Maintainer: María Oliveira <maria.oliveira@usc.es>

References

Oliveira, M., Crujeiras, R.M. and Rodríguez–Casal, A. (2012) A plug–in rule for bandwidth selection in circular density. *Computational Statistics and Data Analysis*, **56**, 3898–3908.

Oliveira, M., Crujeiras R.M. and Rodríguez–Casal, A. (2013) Nonparametric circular methods for exploring environmental data. *Environmental and Ecological Statistics*, **20**, 1–17.

Oliveira, M., Crujeiras, R.M. and Rodríguez–Casal (2013) CircSiZer: an exploratory tool for circular data. *Environmental and Ecological Statistics*, DOI: 10.1007/s10651-013-0249-0..

`bw.boot` *Bootstrap method*

Description

This function implements the bootstrap procedure proposed by Di Marzio et al. (2011) for selecting the smoothing parameter for density estimation taking the von Mises density as kernel.

Usage

```
bw.boot(x, lower=0, upper=100, np=500, tol=0.1)
```

Arguments

`x`	Data from which the smoothing parameter is to be computed. The object is coerced to class `circular`.
`lower, upper`	`lower` and `upper` boundary of the interval to be used in the search for the value of the smoothing parameter. Default `lower=0` and `upper=100`.
`np`	Number of points where to evaluate the estimator for numerical integration. Default `np=500`.
`tol`	Convergence tolerance for `optimize`.

Details

This method is based on the proposal of Taylor (1989) for linear data. See also Oliveira et al. (2012). The NAs will be automatically removed.

Value

Value of the smoothing parameter.

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

References

Di Marzio, M., Panzera A. and Taylor, C.C. (2011) Kernel density estimation on the torus. *Journal of Statistical Planning and Inference*, **141**, 2156–2173.

Oliveira, M., Crujeiras, R.M. and Rodríguez–Casal, A. (2012) A plug–in rule for bandwidth selection in circular density. *Computational Statistics and Data Analysis*, **56**, 3898–3908.

Taylor, C.C. (1989) Bootstrap choice of the smoothing parameter in kernel density estimation. *Biometrika*, **76**, 705–712.

See Also

kern.den.circ, bw.rt, bw.CV, bw.pi

Examples

```
set.seed(2012)
n <- 100
x <- rcircmix(n, model=17)
bw.boot(x, lower=0, upper=20)
```

---

bw.CV *Cross-validation for density estimation*

Description

This function provides a least squares cross-validation smoothing parameter or a likelihood cross-validation smoothing parameter for density estimation.

Usage

```
bw.CV(x, method="LCV", lower=0, upper=50, tol=1e-2, np=500)
```

Arguments

x	Data from which the smoothing parameter is to be computed. The object is coerced to class `circular`.
method	Character string giving the cross-validation rule to be used. This must be one of `"LCV"` or `"LSCV"`. Default `method="LCV"`.
lower, upper	`lower` and `upper` boundary of the interval to be used in the search for the value of the smoothing parameter. Default `lower=0` and `upper=50`.
tol	Convergence tolerance for `optimize`. Default `tol=1e-2`.
np	Number of points where to evaluate the estimator for numerical integration when `method="LSCV"`. Default `np=500`.

Details

The LCV smoothing parameter is obtained as the value of ν that maximizes the logarithm of the likelihood cross-validation function (8) in Oliveira et al. (2013). The LSCV smoothing parameter is obtained as the value of ν that minimizes expression (7) in Oliveira et al. (2013). See also Hall et al. (1987) and Oliveira et al. (2012). The NAs will be automatically removed.

Value

Value of the smoothing parameter.

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

References

Hall, P., Watson, G.S. and Cabrera, J. (1987) Kernel density estimation with spherical data, *Biometrika*, **74**, 751–762.

Oliveira, M., Crujeiras, R.M. and Rodríguez–Casal, A. (2012) A plug–in rule for bandwidth selection in circular density. *Computational Statistics and Data Analysis*, **56**, 3898–3908.

Oliveira, M., Crujeiras R.M. and Rodríguez–Casal, A. (2013) Nonparametric circular methods for exploring environmental data. *Environmental and Ecological Statistics*, **20**, 1–17.

See Also

`kern.den.circ`, `bw.rt`, `bw.pi`, `bw.boot`

Examples

```
set.seed(2012)
n <- 100
x <- rcircmix(n, model=11)
bw.CV(x, method="LCV", lower=0, upper=20)
bw.CV(x, method="LSCV", lower=0, upper=20)
```

`bw.pi` *Plug–in rule*

Description

This function implements the von Mises scale plug-in rule for the smoothing parameter for density estimation when the number of components in the mixture is selected by Akaike Information Criterion (AIC) which selects the best model between a mixture of 2-5 von Mises distributions.

Usage

```
bw.pi(x, M=NULL, lower=0, upper=100, np=500, tol=0.1, outM=FALSE)
```

Arguments

`x`	Data from which the smoothing parameter is to be computed. The object is coerced to class `circular`.
`M`	Integer indicating the number of components in the mixture. If `M=1`, the rule of thumb is carried out with κ estimated by maximum likelihood. If `M=NULL`, AIC will be used.
`lower, upper`	`lower` and `upper` boundary of the interval to be used in the search for the value of the smoothing parameter. Default `lower=0` and `upper=100`.
`np`	Number of points where to evaluate the estimator for numerical integration. Default `np=500`.
`tol`	Convergence tolerance for `optimize`. Default `tol=0.1`.
`outM`	Logical; if `TRUE` the function also returns the number of components in the mixture. Default, `outM=FALSE`.

Details

The value of the smoothing parameter is chosen by minimizing the asymptotic mean integrated squared error (AMISE) derived by Di Marzio et al. (2009) assuming that the data follow a mixture of von Mises distributions. The number of components in the mixture can be fixed by the user, by specifying the argument `M` or selected by using AIC (default option) as described in Oliveira et al. (2012). The NAs will be automatically removed.

Value

Vector with the value of the smoothing parameter and the number of components in the mixture (if specified).

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

References

Oliveira, M., Crujeiras, R.M. and Rodríguez–Casal, A. (2012) A plug–in rule for bandwidth selection in circular density. *Computational Statistics and Data Analysis*, **56**, 3898–3908.

See Also

kern.den.circ, bw.rt, bw.CV, bw.boot

Examples

```
set.seed(2012)
n <- 100
x <- rcircmix(n,model=18)
bw.pi(x, M=3)
bw.pi(x, outM=TRUE)  # Using AIC
```

---

bw.reg.circ.lin *Cross-validation rule for circular regression estimation*

Description

Function `bw.reg.circ.lin` provides the least squares cross-validation smoothing parameter for the Nadaraya-Watson and Local-Linear estimators when the covariate is circular and the response variable is linear.

Function `bw.reg.circ.circ` provides the least squares cross-validation smoothing parameter for the Nadaraya-Watson and Local-Linear estimators when the covariate and the response variable are circular.

Function `bw.reg.lin.circ` provides the least squares cross-validation smoothing parameter for the Nadaraya-Watson and Local-Linear estimators when the covariate is linear and the response variable is circular.

Usage

```
bw.reg.circ.lin(x, y, method="LL", lower=0, upper=50, tol=1e-2)
bw.reg.circ.circ(x, y, method="LL", option=1, lower=0, upper=50, tol=1e-2)
bw.reg.lin.circ(x, y, method="LL", option=1, lower=0, upper=50, tol=1e-2)
```

Arguments

x	Vector of data for the independent variable. The object is coerced to class `circular` when using functions `bw.reg.circ.lin` and `bw.reg.circ.circ`.
y	Vector of data for the dependent variable. This must be same length as `x`. The object is coerced to class `circular` when using functions `bw.reg.circ.circ` and `bw.reg.lin.circ`.
method	Character string giving the estimator to be used. This must be one of `"LL"` or `"NW"`. Default `method="LL"`.

`option`	Cross–validation rule. Default `option=1`. See details.
`lower, upper`	`lower` and `upper` boundary of the interval to be used in the search for the value of the smoothing parameter. Default `lower=0` and `upper=50`.
`tol`	Convergence tolerance for `optimize`. Default `tol=1e-2`.

Details

For nonparmetric regression with circular response, given (X_i, Y_i), $i = 1, \ldots, n$: If `option=1`, the cross–validation smoothing parameter is computed as the value that minimizes $\sum_{i=1}^{n}(-\cos(Y_i - \hat{f}^{-i}(X_i))$, where $\hat{f}^{-i}$ denotes the estimator computed with all the observations except (X_i, Y_i).

If `option=2`, the cross–validation smoothing parameter is computed as the value that minimizes $n^{-1}\sum_{i=1}^{n}(d(Y_i, \hat{f}^{-i}(X_i))^2$ where $d(Y_i, \hat{f}^{-i}(X_i) = \min(|Y_i - \hat{f}^{-i}(X_i)|, 2\pi - |Y_i - \hat{f}^{-i}(X_i)|)$.

The NAs will be automatically removed.

Value

Value of the smoothing parameter.

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

References

Oliveira, M., Crujeiras R.M. and Rodríguez–Casal, A. (2013) Nonparametric circular methods for exploring environmental data. *Environmental and Ecological Statistics*, **20**, 1–17.

Di Marzio, M., Panzera A. and Taylor, C. C. (2012) Non–parametric regression for circular responses. *Scandinavian Journal of Statistics*, **40**, 228–255.

See Also

`kern.reg.circ.lin`, `kern.reg.circ.circ`, `kern.reg.lin.circ`

Examples

```
set.seed(2012)
n <- 100
x <- seq(0,2*pi,length=n)
y <- sin(x)+0.2*rnorm(n)
bw.reg.circ.lin(circular(x), y, method="LL", lower=1, upper=20)
bw.reg.circ.lin(circular(x), y, method="NW", lower=1, upper=20)
```

bw.rt *Rule of thumb*

Description

This function implements the selector proposed by Taylor (2008) for density estimation, based on an estimation of the concentration parameter of a von Mises distribution. The concentration parameter can be estimated by maximum likelihood or by a robustified procedure as described in Oliveira et al. (2013).

Usage

```
bw.rt(x, robust=FALSE, alpha=0.5)
```

Arguments

`x`	Data from which the smoothing parameter is to be computed. The object is coerced to class `circular`.
`robust`	Logical, if `robust=FALSE` the parameter κ is estimated by maximum likelihood, if `TRUE` it is estimated as described in Oliveira et al. (2012b). Default `robust=FALSE`.
`alpha`	Arc probability when `robust=TRUE`. Default is `alpha=0.5`. See Details.

Details

When `robust=TRUE`, the parameter κ is estimated as follows:

1. Select $\alpha \in (0,1)$ and find the shortest arc containing $\alpha \cdot 100\%$ of the sample data.

2. Obtain the estimated $\hat{\kappa}$ in such way that the probability of a von Mises centered in the midpoint of the arc is `alpha`.

The NAs will be automatically removed.

See also Oliveira et al. (2012).

Value

Value of the smoothing parameter.

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

References

Oliveira, M., Crujeiras, R.M. and Rodríguez–Casal, A. (2012) A plug–in rule for bandwidth selection in circular density. *Computational Statistics and Data Analysis*, **56**, 3898–3908.

Oliveira, M., Crujeiras R.M. and Rodríguez–Casal, A. (2013) Nonparametric circular methods for exploring environmental data. *Environmental and Ecological Statistics*, **20**, 1–17.

Taylor, C.C. (2008) Automatic bandwidth selection for circular density estimation. *Computational Statistics and Data Analysis*, **52**, 3493–3500.

See Also

`kern.den.circ`, `bw.CV`, `bw.pi`, `bw.boot`

Examples

```
set.seed(2012)
n <- 100
x <- rcircmix(n,model=7)
bw.rt(x)
bw.rt(x, robust=TRUE)
```

---

circsizer.density *CircSiZer map for density*

Description

This function plots the CircSiZer map for circular density estimation based on circular kernel methods, as described in Oliveira et al. (2013). The CircSiZer is an extension of SiZer proposed by Chaudhuri and Marron (1999) to circular data.

Usage

```
circsizer.density(x, bws, ngrid=250, alpha=0.05, B=500, log.scale=TRUE,
display=TRUE)
## S3 method for class 'circsizer'
print(x, digits=NULL, ...)
```

Arguments

`x`	Data from which the estimate is to be computed. The object is coerced to class `circular`.
`bws`	Vector of smoothing parameters. Values of `bws` must be positive. `bws` will be coerced to be equally spaced. Length of vector `bws` must be at least 2.
`ngrid`	Integer indicating the number of equally spaced angles between 0 and 2π where the estimator is evaluated. Default `ngrid=250`.
`alpha`	Significance level for the CircSiZer map. Default `alpha=0.05`.

`B`	Integer indicating the number of bootstrap samples to estimate the standard deviation of the derivative estimator. Default `B=500`.
`log.scale`	Logical, if `TRUE`, the CircSiZer map is plotted in the scale $-\log_{10}$(`bws`). Default is `TRUE`. See Details.
`display`	Logical, if `TRUE`, the CircSiZer map is plotted. Default is `TRUE`.
`digits`	Integer indicating the precision to be used.
`...`	further arguments

Details

With CircSiZer, significance features (peaks and valleys) in the data are seeked via the construction of confidence intervals for the scale-space version of the smoothed derivative curve, as it is described in Oliveira et al. (2013). Thus, for a given point and a given value of the smoothing parameter, the curve is significantly increasing (decreasing) if the confidence interval is above (below) 0 and if the confidence interval contains 0, the curve for that value of the smoothing parameter and at that point does not have a statistically significant slope. If `display=TRUE`, this information is displayed in a circular color map, the CircSiZer map, in such a way that, at a given point, the performance of the estimated curve is represented by a color ring with radius proportional to the value of the smoothing parameter.

Differents colors allow to indentify peaks and valleys. Blue color indicates locations where the curve is significantly increasing; red color shows where it is significantly decreasing and purple indicates where it is not significantly different from zero. Gray color corresponds to those regions where there is not enough data to make statements about significance. Thus, at a given bandwidth, a significant peak can be identified when a region of significant positive gradient is followed by a region of significant negative gradient (i.e. blue-red pattern), and a significant trough by the reverse (red-blue pattern), taking clockwise as the positive sense of rotation.

If `log.scale=TRUE` then, the values of the considered smoothing parameters `bws` are transformed to $-\log_{10}$ scale, i.e, a sequence of equally spaced smoothing parameters according to the parameters `-log10(max(bws))`, `-log10(min(bws))` and `length(bws)` is used. Hence, small values of this parameter corresponds with larger rings and large values corresponds with smaller rings. Whereas if `log.scale=FALSE`, small values of this parameter corresponds with smaller rings and large values corresponds with larger rings.

The NAs will be automatically removed.

Value

An object with class `circsizer` whose underlying structure is a list containing the following components:

`data`	Original dataset.
`ngrid`	Number of equally spaced angles where the derivative of the circular kernel density estimator.
`bw`	Vector of smoothing parameters (given in $-\log_{10}$ scale if `log.scale=TRUE`).
`log.scale`	Logical; if `TRUE`, the $-\log_{10}$ scale is used for constructing the CircSiZer map.

`CI` List containing: a matrix with lower limits fot the confidence intervals; a matrix with the lower limits of the confidence intervals; a matrix with the Effective Sample Size. Each row corresponds to each value of the smoothing parameter and each column corresponds to an angle.

`col` Matrix containing the colors for plotting the CircSiZer map.

If `display==TRUE`, the function also returns the CircSiZer map for density.

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

References

Chaudhuri, P. and Marron, J.S. (1999). SiZer for exploration of structures in curves, *Journal of the American Statistical Association*, **94**, 807–823.

Oliveira, M., Crujeiras, R.M. and Rodríguez–Casal (2013) CircSiZer: an exploratory tool for circular data. *Environmental and Ecological Statistics*, DOI: 10.1007/s10651-013-0249-0.

See Also

`circsizer.map`

Examples

```
# set.seed(2012)
# x <- rcircmix(100,model=7)
# sizer <- circsizer.density(x, bws=seq(0,50,length=12))
# sizer
# names(sizer)
# circsizer.map(sizer,type=1,zero=pi/2,clockwise=TRUE,raw.data=TRUE)
```

`circsizer.map` *CircSiZer map*

Description

This function plots the CircSiZer map for `circsizer` objects.

Usage

```
circsizer.map(circsizer.object, type, zero, clockwise, title=NULL, labels=NULL,
label.pos=NULL, rad.pos=NULL, raw.data=FALSE)
```

Arguments

circsizer.object
: An object of class circsizer, i.e., output from functions circsizer.density or circsizer.regression.

type
: Number indicating the labels to display in the plot: 1 (directions), 2 (hours), 3 (angles in radians), 4 (angles in degrees) or 5 (months).

zero
: Where to place the starting (zero) point.

clockwise
: Whether to interpret positive positions as clockwise from the starting point.

title
: Title for the plot.

labels
: Character or expression vector of labels to be placed at the label.pos. label.pos must also be supplied.

label.pos
: Vector indicating the position (between 0 and 2π) at which the labels are to be drawn.

rad.pos
: Vector (between 0 and 2π) with the drawing position for the radius.

raw.data
: Logical, if TRUE, points indicated by x are stacked on the perimeter of the circle. Default is FALSE.

Value

CircSiZer map.

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

See Also

circsizer.density, circsizer.regression

---

circsizer.regression *CircSiZer map for regression*

Description

This function plots the CircSiZer map for circular regression estimation based on circular kernel methods, as described in Oliveira et al. (2013). The CircSiZer is an extension of SiZer proposed by Chaudhuri and Marron (1999) to circular data.

Usage

```
circsizer.regression(x, y, bws=NULL, adjust=2, ngrid=150, alpha=0.05, B=500,
B2=250, log.scale=TRUE, display=TRUE)
```

Arguments

- `x` Vector of data for the independent variable. The object is coerced to class `circular`.
- `y` Vector of data for the dependent variable. This must be same length as `x`.
- `bws` Vector of smoothing parameters. Values of `bws` must be positive. `bws` will be coerced to be equally spaced. Length of vector `bws` must be at least 2.
- `adjust` If `bws=NULL`, the smoothing parameters used are `adjust/bw` and `adjust*bw`, where `bw` is the smoothing parameter obtained by using the cross–validation rule.
- `ngrid` Integer indicating the number of equally spaced angles between 0 and 2π where the estimator is evaluated. Default `ngrid=150`.
- `alpha` Significance level for the CircSiZer map. Default `alpha=0.05`.
- `B` Integer indicating the number of bootstrap samples to estimate the standard deviation of the derivative estimator. Default `B=500`.
- `B2` Integer indicating the number of bootstrap samples to compute the denominator in Step 2 of algorithm described in Oliveira et al. (2013). Default `B=250`.
- `log.scale` Logical, if `TRUE`, the CircSiZer map is plotted in the scale $-\log_{10}($`bws`$)$. Default is `TRUE`.
- `display` Logical, if `TRUE`, the CircSiZer map is plotted. Default is `TRUE`.

Details

See Details Section of `circsizer.density`. The NAs will be automatically removed.

Value

An object with class `circsizer` whose underlying structure is a list containing the following components.

- `data` Original dataset.
- `ngrid` Number of equally spaced angles where the derivative of the regression estimator is evaluated.
- `bw` Vector of smoothing parameters (given in $-\log_{10}$ scale if `log.scale=TRUE`).
- `log.scale` Logical; if `TRUE`, the $-\log_{10}$ scale is used for constructing the CircSiZer map.
- `CI` List containing: a matrix with lower limits fot the confidence intervals; a matrix with the lower limits of the confidence intervals; a matrix with the Effective Sample Size. Each row corresponds to each value of the smoothing parameter and each column corresponds to an angle.
- `col` Matrix containing the colors for plotting the CircSiZer map.

If `display==TRUE`, the function also returns the CircSiZer map for regression.

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

References

Chaudhuri, P. and Marron, J.S. (1999). SiZer for exploration of structures in curves, *Journal of the American Statistical Association*, **94**, 807–823.

Oliveira, M., Crujeiras, R.M. and Rodríguez–Casal (2013) CircSiZer: an exploratory tool for circular data. *Environmental and Ecological Statistics*, DOI: 10.1007/s10651-013-0249-0.

See Also

circsizer.map

Examples

```
# Not run: the code works but it is slow
# set.seed(2012)
# n <- 100
# x <- seq(0,2*pi,length=n)
# y <- sin(x)+sqrt(0.5)*rnorm(n)
# circsizer.regression(circular(x), y, bws=seq(10,60,by=5))
```

---

cross.beds1 *Cross-beds azimuths (I)*

Description

This dataset corresponds to azimuths of cross-beds in the Kamthi river (India). Originally analized by SenGupta and Rao (1966) and included in Table 1.5 in Mardia (1972), the dataset collects 580 azimuths of layers lying oblique to principal accumulation surface along the river, being these layers known as cross-beds.

Usage

```
data(cross.beds1)
```

Format

A single-column data frame with 580 observations in radians.

Details

Data were originally recorded in degrees.

Source

Mardia, K.V. (1972) *Statistics of Directional Data*. Academic Press, New York.

SenGupta, S. and Rao, J.S. (1966) Statistical analysis of cross–bedding azimuths from the Kamthi formation around Bheemaram, Pranhita: Godavari Valley. *Sankhya: The Indian Journal of Statistics, Series B*, **28**, 165–174.

Examples

```
data(cross.beds1)
```

---

cross.beds2 *Cross-beds (II)*

Description

A dataset of cross-beds measurements from Himalayan molasse in Pakistan presented in Fisher (1993). This dataset collects 104 measurements of Chaudan Zam large bedforms.

Usage

```
data(cross.beds2)
```

Format

A single-column data frame with 104 observations in radians.

Details

Data were originally recorded in degrees.

Source

Fisher, N.I. (1993) *Statistical Analysis of Circular Data*. Cambridge University Press, Cambridge, U.K.

Examples

```
data(cross.beds2)
```

---

cycle.changes *Cycle changes*

Description

The data consists on the changes in cycles of temperatures at ground level in periglacial Monte Alvear (Argentina). The dataset includes 350 observations which correspond to the hours where the temperature changes from positive to negative and viceversa from February 2008 to December 2009.

Usage

```
data(cycle.changes)
```

Format

A data frame with 350 observations on two variables: change, which indicates if the temperature changed from positive to negative (-1) or viceversa (1) and hour, which indicates the hour (in radians) when the cycle change occured.

Details

Analysis of cycle changes in temperatures for another locations can be seen in Oliveira et al. (2013).

Source

The authors want to acknowledge Prof. Augusto Pérez–Alberti for providing the data, collected within the Project POL2006-09071 from the Spanish Ministry of Education and Science.

References

Oliveira, M., Crujeiras R.M. and Rodríguez–Casal, A. (2013) Nonparametric circular methods for exploring environmental data. *Environmental and Ecological Statistics*, **20**, 1–17.

Examples

```
data(cycle.changes)
thaw <- (cycle.changes[,1]==1)
frosting <- (cycle.changes[,1]==-1)
plot(circular(cycle.changes[frosting,2],template="clock24"), shrink=1.08, col=4,
stack=TRUE, main="Frosting")
plot(circular(cycle.changes[thaw,2],template="clock24"), shrink=1.08, col=2,
stack=TRUE, main="Thaw")
```

---

dcircmix *Mixtures of circular distributions*

Description

Density and random generation functions for a circular distribution or a mixture of circular distributions allowing the following components: circular uniform, von Mises, cardioid, wrapped Cauchy, wrapped normal, wrapped skew-normal.

Usage

```
dcircmix(x, model=NULL, dist=NULL, param=NULL)
rcircmix(n, model=NULL, dist=NULL, param=NULL)
```

Arguments

x	Vector of angles where the density is evaluated. The object is coerced to class `circular`.
n	Number of observations to generate.
model	Number between 1 and 20, corresponding with a model defined in Oliveira et al. (2012). See Details.
dist	Vector of strings with the distributions that participate in the mixture: `"unif"`, `"vm"`, `"car"`, `"wc"`, `"wn"`, `"wsn"`.
param	List with three or four objects. The first object will be a vector containing the proportion of each distribution in the mixture, the second object will be a vector containg the location parameters and the third object will be a vector containing the concentration parameters. If the wrapped skew-normal distribution participates in the mixture, a fourth object will be introduced in the list, a vector containing the skewness parameter. In this case, the values of the skewness parameter for the rest of distributions in the mixture will be zero. The length of each object in the list must be equal to the length of argument `dist`. See Details and Examples.

Details

Models from Oliveira et al. (2012) are described below:

M1: Circular uniform.

M2: von Mises: $vM(\pi, 1)$.

M3: Wrapped normal: $WN(\pi, 0.9)$.

M4: cardioid: $C(\pi, 0.5)$.

M5: Wrapped Cauchy: $WC(\pi, 0.8)$.

M6: Wrapped skew–normal: $WSN(\pi, 1, 20)$.

M7: Mixture of two von Mises $1/2vM(0, 4) + 1/2vM(\pi, 4)$.

M8: Mixture of two von Mises $1/2vM(2, 5) + 1/2vM(4, 5)$.

M9: Mixture of two von Mises $1/4vM(0, 2) + 3/4vM(\pi/\sqrt{3}, 2)$.

M10: Mixture of von Mises and wrapped Cauchy $4/5vM(\pi, 5) + 1/5WC(4\pi/3, 0.9)$.

M11: Mixture of three von Mises $1/3vM(\pi/3, 6) + 1/3vM(\pi, 6) + 1/3vM(5\pi/3, 6)$.

M12: Mixture of three von Mises $2/5vM(\pi/2, 4) + 1/5vM(\pi, 5) + 2/5vM(3\pi/2, 4)$.

M13: Mixture of three von Mises $2/5vM(0.5, 6) + 2/5vM(3, 6) + 1/5vM(5, 24)$.

M14: Mixture of four von Mises $1/4vM(0, 12)+1/4vM(\pi/2, 12)+1/4vM(\pi, 12)+1/4vM(3\pi/2, 12)$.

M15: Mixture of wrapped Cauchy, wrapped normal, von Mises and wrapped skew-normal $3/10WC(\pi-1, 0.6) + 1/4WN(\pi + 0.5, 0.9) + 1/4vM(\pi + 2, 3) + 1/5WSN(6, 1, 3)$.

M16: Mixture of five von Mises $1/5vM(\pi/5, 18)+1/5vM(3\pi/5, 18)+1/5vM(\pi, 18)+1/5vM(7\pi/5, 18)+1/5vM(9\pi/5, 18)$.

M17: Mixture of cardioid and wrapped Cauchy $2/3C(\pi, 0.5) + 1/3WC(\pi, 0.9)$.

M18: Mixture of four von Mises $1/2vM(\pi,1)+1/6vM(\pi-0.8,30)+1/6vM(\pi,30)+1/vM(\pi+0.8,30)$.

M19: Mixture of five von Mises $4/9vM(2,3)+5/36vM(4,3)+5/36vM(3.5,50)+5/36vM(4,50)+5/36vM(4.5,50)$.

M20: Mixture of two wrapped skew-normal and two wrapped Cauchy $1/3WSN(0,0.7,20)+1/3WSN(\pi,0.7,20)+1/6WC(3\pi/4,0.9)+1/6WC(7\pi/4,0.9)$.

When the wrapped skew-normal distribution participates in the mixture, the argument `param` for function `dcircmix` can be a list with fifth objects. The fifth object would be the number of terms to be used in approximating the density function of the wrapped skew normal distribution. By default the number of terms used is 20.

Value

`dcircmix` gives the density and `rcircmix` generates random deviates.

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

References

Oliveira, M., Crujeiras, R.M. and Rodríguez–Casal, A. (2012) A plug–in rule for bandwidth selection in circular density. *Computational Statistics and Data Analysis*, **56**, 3898–3908.

Examples

```
set.seed(2012)
# Circular representation of models M1-M20, each one in a separate window
for (i in 1:20){
dev.new()
f <- function(x) dcircmix(x, model=i)
curve.circular(f, n=500, join=TRUE, shrink=1.9, main=i)
}

# Random generation from model M1 (uniform model)
data1 <- rcircmix(50, model=1)
plot(data1)

# Density function and random generation from a mixture of a von Mises and
# a wrapped skew-normal
f <- function(x) dcircmix(x, model=NULL, dist=c("vm","wsn"),
param=list(p=c(0.5,0.5), mu=c(0,pi), con=c(1,1), sk=c(0,10)))
curve.circular(f, n=500, shrink=1.2)
data <- rcircmix(100, model=NULL, dist=c("vm","wsn"),
param=list(p=c(0.5,0.5), mu=c(0,pi), con=c(1,1), sk=c(0,10)))
points(data)

# Density function and random generation from a mixture of two von Mises and
# two wrapped Cauchy
f <- function(x) dcircmix(x, model=NULL, dist=c("vm","vm","wc","wc"),
```

```
param=list(p=c(0.3,0.3,0.2,0.2), mu=c(0,pi,pi/2,3*pi/2), con=c(5,5,0.9,0.9)))
curve.circular(f, n=1000, xlim=c(-1.65,1.65))
data <- rcircmix(100, model=NULL, dist=c("vm","vm","wc","wc"),
param=list(p=c(0.3,0.3,0.2,0.2), mu=c(0,pi,pi/2,3*pi/2), con=c(5,5,0.9,0.9)))
points(data)
```

`dragonfly` *Orientations of dragonflies*

Description

The data, presented in Batschelet (1981), consists on the orientation of 214 dragonflies with respect to the sun's azimuth.

Usage

```
data(dragonfly)
```

Format

A single-column data frame with 214 observations in radians.

Details

Data were originally recorded in degrees.

Source

Batschelet, E. (1981) *Circular Statistics in Biology.* Academic Press, New York.

Examples

```
data(dragonfly)
x <- circular(dragonfly$orientation)
dens <- kern.den.circ(x)
plot(dens, shrink=1.3)
```

`dwsn` *Wrapped skew-Normal density function*

Description

Density function and random generation for the wrapped skew-Normal distribution introduced by Pewsey (2000).

Usage

```
dwsn(x,xi,eta,lambda,K=NULL,min.k=20)
rwsn(n,xi,eta,lambda)
```

Arguments

`x`	Vector of angles where the density is evaluated . The object is coerced to class `circular`.
`n`	Number of observations.
`xi`	Location parameter. The object is coerced to class `circular`.
`eta`	Scale parameter.
`lambda`	Skewness parameter.
`K`	Number of terms to be used in approximating the density. Default `K=NULL`.
`min.k`	Minimum number of terms used in approximating the density.

Details

The NAs will be automatically removed.

Value

`dwsn` gives the density and `rwsn` generates random deviates.

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

References

Pewsey, A. (2000) The wrapped skew–Normal distribution on the circle. *Communications in Statistics - Theory and Methods*, **29**, 2459–2472.

Examples

```
set.seed(2012)
# Density function of a wrapped skew-normal distribution WSN(pi,1,20)
wsn <- function(x) dwsn(x, xi=circular(pi), eta=1, lambda=20)
curve.circular(wsn,n=500,xlim=c(-1.65,1.65),main=expression(WSN(pi,1,20)))
# Random generation
data<-rwsn(50,xi=circular(pi),eta=1,lambda=20)
points(data)
```

---

kern.den.circ — *Nonparametric circular kernel density estimation*

Description

This function computes circular kernel density estimates with the given bandwidth, taking the von Mises distribution as circular kernel.

Usage

```
kern.den.circ(x, t=NULL, bw=NULL, from=circular(0), to=circular(2*pi), len=250)
```

Arguments

`x`	Data from which the estimate is to be computed. The object is coerced to class `circular`.
`t`	Points where the density is estimated. If `NULL` equally spaced points are used according to the parameters `from`, `to` and `len`.
`bw`	Smoothing parameter to be used. The value of the smoothing parameter can be chosen by using the functions `bw.rt`, `bw.CV`, `bw.pi` and `bw.boot`.
`from, to`	Left and right-most points of the grid at which the density is to be estimated. The objects are coerced to class `circular`.
`len`	Number of equally spaced points at which the density is to be estimated.

Details

The NAs will be automatically removed.

Value

An object with class `density.circular` whose underlying structure is a list containing the following components:

`data`	Original dataset.
`x`	The points where the density is estimated.
`y`	The estimated density values.
`bw`	The smoothing parameter used.

N	The sample size after elimination of missing values.
call	The call which produced the result.
data.name	The deparsed name of the x argument.
has.na	Logical, for compatibility (always FALSE).

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

References

Oliveira, M., Crujeiras, R.M. and Rodríguez–Casal, A. (2012) A plug–in rule for bandwidth selection in circular density. *Computational Statistics and Data Analysis*, **56**, 3898–3908.

Taylor, C.C. (2008) Automatic bandwidth selection for circular density estimation. *Computational Statistics and Data Analysis*, **52**, 3493–3500.

See Also

bw.rt, bw.CV, bw.pi, bw.boot, plot.density.circular, lines.density.circular

Examples

```
set.seed(2012)
n <- 100
x <- rcircmix(n, model=14)
est1 <- kern.den.circ(x, t=NULL, bw=NULL)
plot(est1, plot.type="circle", points.plot=TRUE, shrink=1.2, main="Circular plot")
est2 <- kern.den.circ(x, t=NULL, bw=20)
lines(est2, plot.type="circle",shrink=1.2,col=2)
plot(est1, plot.type="line", main="Linear plot")
lines(est2, plot.type="line", col=2)
```

---

kern.reg.circ.lin *Nonparametric regression estimation for circular data*

Description

Function kern.reg.circ.lin implements the Nadaraya-Watson estimator and the Local-Linear estimator for circular-linear data (circular covariate and linear response), as described in Di Marzio et al. (2009) and Oliveira et al. (2013), taking the von Mises distribution as kernel.

Function kern.reg.circ.circ implements the Nadaraya-Watson estimator and the Local-Linear estimator for circular-circular data (circular covariate and circular response), as described in Di Marzio et al. (2012), taking the von Mises distribution as kernel.

Function kern.reg.lin.circ implements the Nadaraya-Watson estimator and the Local-Linear estimator for linear-circular data (linear covariate and circular response), as described in Di Marzio et al. (2012), taking the Normal distribution as kernel.

Usage

```
kern.reg.circ.lin(x, y, t=NULL, bw, method="LL", from=circular(0),
to=circular(2*pi), len=250, tol=300)
kern.reg.circ.circ(x, y, t=NULL, bw, method="LL", from=circular(0),
to=circular(2*pi), len=250)
kern.reg.lin.circ(x, y, t=NULL, bw, method="LL", len=250)
## S3 method for class 'regression.circular'
print(x, digits=NULL, ...)
```

Arguments

`x`	Vector of data for the independent variable. The object is coerced to class `circular` when using functions `kern.reg.circ.lin` and `kern.reg.circ.circ`.
`y`	Vector of data for the dependent variable. This must be same length as `x`. The object is coerced to class `circular` when using functions `kern.reg.circ.circ` and `kern.reg.lin.circ`.
`t`	Points where the regression function is estimated. If `NULL` equally spaced points are used according to the parameters `from`, `to` and `len`.
`bw`	Smoothing parameter to be used. The value of the smoothing parameter can be chosen by using the function `bw.reg.circ.lin`, `bw.reg.circ.circ` and `bw.reg.lin.circ`.
`method`	Character string giving the estimator to be used. This must be one of `"LL"` for Local-Linear estimator or `"NW"` for Nadaraya-Watson estimator. Default `method="LL"`.
`from, to`	Left and right-most points of the grid at which the density is to be estimated. The objects are coerced to class `circular`.
`len`	Number of equally spaced points at which the density is to be estimated.
`tol`	Tolerance parameter to avoid overflow when `bw` is larger than `tol`. Default is `tol=300`.
`digits`	Integer indicating the precision to be used.
`...`	further arguments

Details

See Di Marzio et al. (2012). See Section 3 in Oliveira et al. (2013). See Di Marzio et al. (2009). The NAs will be automatically removed.

Value

An object with class "regression.circular" whose underlying structure is a list containing the following components:

`data`	Original dataset.
`x`	The n coordinates of the points where the regression is estimated.
`y`	The estimated values.

bw	The smoothing parameter used.
N	The sample size after elimination of missing values.
call	The call which produced the result.
data.name	The deparsed name of the x argument.
has.na	Logical, for compatibility (always FALSE).

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

References

Di Marzio, M., Panzera A. and Taylor, C. C. (2009) Local polynomial regression for circular predictors. *Statistics and Probability Letters*, **79**, 2066–2075.

Di Marzio, M., Panzera A. and Taylor, C. C. (2012) Non–parametric regression for circular responses. *Scandinavian Journal of Statistics*, **40**, 228–255.

Oliveira, M., Crujeiras R.M. and Rodríguez–Casal, A. (2013) Nonparametric circular methods for exploring environmental data. *Environmental and Ecological Statistics*, **20**, 1–17.

See Also

plot.regression.circular, lines.regression.circular

Examples

```
### circular-linear
data(speed.wind2)
dir <- speed.wind2$Direction
vel <- speed.wind2$Speed
nas <- which(is.na(vel))
dir <- circular(dir[-nas],units="degrees")
vel <- vel[-nas]
estLL <- kern.reg.circ.lin(dir, vel, method="LL")
estNW <- kern.reg.circ.lin(dir, vel, method="NW")
# Circular representation
res<-plot(estNW, plot.type="circle", points.plot=TRUE,
labels=c("N","NE","E","SE","S","SO","O","NO"),
label.pos=seq(0,7*pi/4,by=pi/4), zero=pi/2, clockwise=TRUE)
lines(estLL, plot.type="circle", plot.info=res, line.col=2)
# Linear representation
plot(estNW, plot.type="line", points.plot=TRUE, xlab="direction", ylab="speed (m/s)")
lines(estLL, plot.type="line", line.col=2)


### circular-circular
data(wind)
wind6 <- circular(wind$wind.dir[seq(7,1752,by=24)])
wind12 <- circular(wind$wind.dir[seq(13,1752,by=24)])
estNW <- kern.reg.circ.circ(wind6,wind12,t=NULL,bw=6.1,method="NW")
estLL <- kern.reg.circ.circ(wind6,wind12,t=NULL,bw=2.25,method="LL")
```

```
# Torus representation
plot(estNW, plot.type="circle", points.plot=TRUE, line.col=2, lwd=2, points.col=2,
units="degrees")
lines(estLL, plot.type="circle", line.col=3, lwd=2)
# Linear representation
plot(estNW, plot.type="line", points.plot=TRUE, xlab="Wind direction at 6 a.m.",
ylab="Wind direction at noon")
lines(estLL, plot.type="line", line.col=2)


### linear-circular
data(periwinkles)
dist <- periwinkles$distance
dir <- circular(periwinkles$direction, units="degrees")
estNW <- kern.reg.lin.circ(dist,dir,t=NULL,bw=12.7,method="NW")
estLL <- kern.reg.lin.circ(dist,dir,t=NULL,bw=200,method="LL")
# Cylinder representation
plot(estNW, plot.type="circle", points.plot=TRUE, line.col=2, lwd=2, points.col=2)
lines(estLL, plot.type="circle", line.col=3, lwd=2)
# Linear representation
plot(estNW, plot.type="line", points.plot=TRUE, units="radians", main="")
lines(estLL, plot.type="line", line.col=2, units="radians")
```

---

lines.regression.circular

Add a plot for circular regression

Description

The lines add a plot for regression.circular objects.

Usage

```
## S3 method for class 'regression.circular'
lines(x, plot.type=c("circle", "line"), points.plot=FALSE, rp.type="p", type="l",
line.col=1, points.col="grey", points.pch=1, units=NULL, zero=NULL,
clockwise=NULL, radial.lim=NULL, plot.info=NULL, ...)
```

Arguments

x	An object of class regression.circular.
plot.type	Type of the plot: "line": linear plot, "circle": circular plot.
points.plot	Logical; if TRUE original data are added to the plot.
rp.type, type	Character indicating the type of plotting.
line.col	Color code or name.
points.col	Color code or name for the original data. Used if points.plot=TRUE.
points.pch	Plotting 'character', i.e., symbol to use for the original data. Used if points.plot=TRUE.

`units`	Units measure used in the plot. If `NULL` the value is taken from the attribute of object 'x' from the argument 'x', i.e. x$x.
`zero`	Where to place the starting (zero) point, i.e., the zero of the plot. Ignored if `plot.info` is provided.
`clockwise`	Logical, indicating the sense of rotation of the plot: clockwise if `TRUE` and counterclockwise if `FALSE`. Ignored if plot.info is provided.
`radial.lim`	The range of the grid circle. Used if `plot.type="circle"`.
`plot.info`	An object from `plot.regression.circular` that contains information on the `zero`, the `clockwise` and `radial.lim`. Used if `plot.type="circle"`.
`...`	Further arguments to be passed to `lines.default` (if `plot.type="line"`) or to `radial.plot` (if `plot.type="circle"` and x is the output of `kern.reg.circ.lin`) or to `lines3d` (if `plot.type="circle"`) and x is the output of `kern.reg.circ.circ`).

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

See Also

`kern.reg.circ.lin`, `kern.reg.circ.circ`, `kern.reg.lin.circ`, `plot.regression.circular`

Examples

```
set.seed(1012)
n <- 100
x <- runif(100, 0, 2*pi)
y <- sin(x)+0.5*rnorm(n)
estNW<-kern.reg.circ.lin(circular(x),y,t=NULL,bw=10,method="NW")
estLL<-kern.reg.circ.lin(circular(x),y,t=NULL,bw=10,method="LL")
res<-plot(estNW, plot.type="circle", points.plot=TRUE)
lines(estLL, plot.type="circle",line.col=2, plot.info=res)
```

`periwinkles` *Orientations of dragonflies*

Description

These data, presented in Fisher and Lee (1992), contain distance and directions of movements from small blue periwinkles after relocation.

Usage

```
data(periwinkles)
```

Format

A two-column data frame with 73 observations. Distances are measured in centimeters and directions are measured in degrees.

Source

Fisher, N. I. and Lee, A. J. (1992) Regression models for angular responses. *Biometrics*, **48**, 665–677.

Examples

```
data(periwinkles)
```

`plot.regression.circular` *Plot circular regression*

Description

The `plot` method for `regression.circular` objects.

Usage

```
## S3 method for class 'regression.circular'
plot(x, plot.type=c("circle", "line"), points.plot=FALSE, rp.type="p", type="l",
line.col=1, points.col="grey", points.pch=1, xlim=NULL, ylim=NULL,
radial.lim=NULL, xlab=NULL, ylab=NULL, labels=NULL, label.pos=NULL, units=NULL,
zero=NULL, clockwise=NULL, main=NULL, ...)
```

Arguments

`x`	An object of class `regression.circular`.
`plot.type`	Type of the plot: "line": linear plot, "circle": circular plot.
`points.plot`	Logical; if TRUE original data are added to the plot.
`rp.type, type`	Character indicating the type of plotting. Default `type="l"` and `rp.type="p"`.
`line.col`	Color code or name.
`points.col`	Color code or name for the original data. Used if `points.plot=TRUE`.
`points.pch`	Plotting 'character', i.e., symbol to use for the original data. Used if `points.plot=TRUE`.
`xlim, ylim`	The ranges to be encompassed by the x and y axes. Used if `plot.type="line"`.
`radial.lim`	The range of the grid circle, used if `plot.type="circle"`.
`xlab, ylab`	Titles for the x axis and y axis, respectively.
`labels`	Character or expression vector of labels to be placed at the `label.pos`. `label.pos` must also be supplied.
`label.pos`	Vector indicating the position (between 0 and 2π) at which the labels are to be drawn.
`units`	Units measure used in the plot. If `NULL` the value is taken from the attribute of object 'x' from the argument 'x', i.e. x$x.

- `zero` — Where to place the starting (zero) point, i.e. the zero of the plot. If `NULL` the value is taken from the attribute of object 'x' from the argument 'x', i.e. x$x
- `clockwise` — Logical, indicating the sense of rotation of the plot: clockwise if `TRUE` and counterclockwise if `FALSE`. If `NULL` the value is taken from the attribute of object 'x' from the argument 'x', i.e. x$x
- `main` — An overall title for the plot.
- `...` — Further arguments to be passed to `plot.default` (if `plot.type="line"`) or to to `radial.plot` (if codeplot.type="circle" and `x` is the output of `kern.reg.circ.lin`) or to `lines3d` (if `plot.type="circle"`) and `x` is the output of `kern.reg.circ.circ`).

Value

If `plot.type="circle"` and `x` is the output of `kern.reg.circ.lin`), this function returns a list with information on the plot: `zero`, `clockwise` and `radial.lim`.

Author(s)

María Oliveira, Rosa M. Crujeiras and Alberto Rodríguez–Casal

See Also

`kern.reg.circ.lin`, `kern.reg.circ.circ`, `kern.reg.lin.circ`, `lines.regression.circular`

Examples

```
set.seed(1012)
n <- 100
x <- runif(100, 0, 2*pi)
y <- sin(x)+0.5*rnorm(n)
estNW<-kern.reg.circ.lin(circular(x),y,t=NULL,bw=10,method="NW")
plot(estNW, plot.type="line", points.plot=TRUE)
plot(estNW, plot.type="circle", points.plot=TRUE)
```

---

speed.wind *Wind speed and wind direction data*

Description

This dataset consists of hourly observations of wind direction and wind speed in winter season (from November to February) from 2003 until 2012 in the Atlantic coast of Galicia (NW–Spain). Data are registered by a buoy located at longitude -0.210E and latitude 43.500N in the Atlantic Ocean. The dataset `speed.wind2`, analized in Oliveira et al. (2013), is a subset of `speed.wind` which is obtained by taking the observations with a lag period of 95 hours.

Usage

```
data(speed.wind)
data(speed.wind2)
```

Format

speed.wind is a data frame with 19488 observations on six variables: day, month, year, hour, wind speed (in m/s) and wind direction (in degrees). speed.wind2 is a subset with 200 observations.

Details

Data contains NAs. There is no data in November 2005, December 2005, January 2006, February 2006, February 2007, February 2009 and November 2009. Months of November 2004, December 2004, January 2007, December 2009 are not fully observed.

Source

Data can be freely downloaded from the Spanish Portuary Authority (http://www.puertos.es).

References

Oliveira, M., Crujeiras, R.M. and Rodríguez–Casal (2013) CircSiZer: an exploratory tool for circular data. *Environmental and Ecological Statistics*, DOI: 10.1007/s10651-013-0249-0.

Examples

```
data(speed.wind2)

# Density
dir <- circular(speed.wind2$Direction, units="degrees", template="geographics")
plot(dir, stack=TRUE,  shrink= 1.1)
rose.diag(dir, bins=16, add=TRUE)
lines(kern.den.circ(dir,bw=1), lwd=2, col=2)
lines(kern.den.circ(dir,bw=10), lwd=2, col=3)
lines(kern.den.circ(dir,bw=40), lwd=2, col=4)

# Regression
vel <- speed.wind2$Speed
nas <- which(is.na(vel))
dir <- dir[-nas]
vel <- vel[-nas]
res<-plot(kern.reg.circ.lin(dir, vel, bw=1, method="LL"), plot.type="circle",
points.plot=TRUE, line.col=2, lwd=2, main="")
lines(kern.reg.circ.lin(dir, vel, bw=10, method="LL"), plot.type="circle", plot.info=res,
line.col=3, lwd=2)
lines(kern.reg.circ.lin(dir, vel, bw=40, method="LL"), plot.type="circle", plot.info=res,
line.col=4, lwd=2)
```

---

temp.wind *Temperature and wind direction data*

Description

These data, analyzed by Oliveira et al. (2013), consists of observations of temperature and wind direction during the austral summer season 2008-2009 (from November 2008 to March 2009) in Vinciguerra (Tierra del Fuego, Argentina).

Usage

```
data(temp.wind)
```

Format

A data frame with 3648 observations on four variables: `Date`, `Time`, `Temperature` (in degrees Celsius) and `Direction` (in degrees).

Details

Data contains NAs.

Source

The authors want to acknowledge Prof. Augusto Pérez–Alberti for providing the data, collected within the Project POL2006-09071 from the Spanish Ministry of Education and Science.

References

Oliveira, M., Crujeiras R.M. and Rodríguez–Casal, A. (2013) Nonparametric circular methods for exploring environmental data. *Environmental and Ecological Statistics*, **20**, 1–17.

Examples

```
data(temp.wind)
winddir <- temp.wind[,4]
temp <- temp.wind[,3]
nas <- which(is.na(winddir))
winddir <- circular(winddir[-nas], units="degrees")
temp <- temp[-nas]

est <- kern.reg.circ.lin(winddir, temp, t=NULL, bw=3.41, method="LL")
plot(est, plot.type="line", xlab="wind direction", ylab="temperature")
plot(est, plot.type="circle", points.plot=TRUE)
```

`wind` *Wind direction data*

Description

This dataset consists of hourly observations of wind direction measured at a weather station in Texas from May 20 to July 31, 2003 inclusive.

Usage

```
data(wind)
```

Format

`wind` is a data frame with observations on three variables: data, hour and wind direction (in radians).

Source

The data, which correspons to the weather station designated as C28_1, are part of a larger data set taken from the Codiac data archive, available at http://data.eol.ucar.edu/codiac/dss/id=85.034. The full data set contains hourly resolution surface meteorological data from the Texas Natural Resources Conservation Commission Air Quality Monitoring Network, from May 20 to July 31, 2003 inclusive. These data are provided by NCAR/EOL under the sponsorship of the National Science Foundation.

References

Kato, S. and Jones, M. C. (2010) A family of distributions on the circle with links to, and applications arising from, Möbius transformation. *Journal of the American Statistical Association*, **105**, 249–262.

Di Marzio, M., Panzera A. and Taylor, C. C. (2012) Non–parametric regression for circular responses. *Scandinavian Journal of Statistics*, **40**, 228–255.

Examples

```
data(wind)
```

Index