

# Package ‘DCSmooth’

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**Type** Package

**Title** Nonparametric Regression and Bandwidth Selection for Spatial Models

**Version** 1.1.2

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**Description** Nonparametric smoothing techniques for data on a lattice and functional time series. Smoothing is done via kernel regression or local polynomial regression, a bandwidth selection procedure based on an iterative plug-in algorithm is implemented. This package allows for modeling a dependency structure of the error terms of the nonparametric regression model. Methods used in this paper are described in Feng/Schaefer (2021)  
<<https://ideas.repec.org/p/pdn/ciepap/144.html>>, Schaefer/Feng (2021)  
<<https://ideas.repec.org/p/pdn/ciepap/143.html>>.

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**Description**

Nonparametric smoothing techniques for data on a lattice and functional time series. Smoothing is done via kernel regression or local polynomial regression, a bandwidth selection procedure based on an iterative plug-in algorithm is implemented. This package allows for modeling a dependency structure of the error terms of the nonparametric regression model. Methods used in this paper are described in Feng/Schaefer (2021) <<https://ideas.repec.org/p/pdn/ciepap/144.html>>, Schaefer/Feng (2021) <<https://ideas.repec.org/p/pdn/ciepap/143.html>>.

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dcs

*Nonparametric Double Conditional Smoothing for 2D Surfaces***Description**

dcs provides a double conditional nonparametric smoothing of the expectation surface of a functional time series or a random field on a lattice. Bandwidth selection is done via an iterative plug-in method.

**Usage**

```
dcs(Y, dcs_options = set.options(), h = "auto", parallel = FALSE, ...)
```

**Arguments**

Y	A numeric matrix that contains the observations of the random field or functional time-series.
dcs_options	An object of class "dcs_options", specifying the parameters for the smoothing and bandwidth selection procedure.
h	Bandwidth for smoothing the observations in Y. Can be a two-valued numerical vector with bandwidths in row- and column-direction. If the value is "auto" (the default), bandwidth selection will be carried out by the iterative plug-in algorithm.
parallel	A logical value indicating if parallel computing should be used for faster computation. Default value is parallel = FALSE. Parallelization seems to be efficient at above 400,000 observations.
...	Additional arguments passed to dcs. Currently supported are numerical vectors X and/or T containing the exogenous covariates with respect to the rows and columns.

**Value**

dcs returns an object of class "dcs", including

Y	matrix of original observations.
X, T	vectors of covariates over rows (X) and columns (T).
M	resulting matrix of smoothed values.
R	matrix of residuals of estimation, $Y - M$ .
h	optimized or given bandwidths.
c_f	estimated variance coefficient.
var_est	estimated variance model. If the variance function is modeled by an SARMA/SFARIMA, var_est is an object of class "var_est".
dcs_options	an object of class dcs_options containing the initial options of the dcs procedure.
iterations	number of iterations of the IPI-procedure.
time_used	time spend searching for optimal bandwidths (not overall runtime of the function).

## Details

See the vignette for a more detailed description of the function.

## References

Schäfer, B. and Feng, Y. (2021). Fast Computation and Bandwidth Selection Algorithms for Smoothing Functional Time Series. Working Papers CIE 143, Paderborn University.

## See Also

[set.options](#)

## Examples

```
# See vignette("DCSmooth") for examples and explanation

y <- y.norm1 + matrix(rnorm(101^2), nrow = 101, ncol = 101)
dcs(y)
```

---

kernel.assign

*Assign a Kernel Function*

---

## Description

Assign a Kernel Function

## Usage

```
kernel.assign(kernel_id)
```

## Arguments

kernel\_id      a string specifying the kernel identifier as given in the details.

## Value

kernel.assign returns an object of class "function". This function takes two arguments, a numeric vector in the first argument and a single number in the second. The function itself will return a matrix with one column and the same number of rows as the input vector.

## Details

kernel.assign sets a pointer to a specified kernel function available in the DCSmooth package. The kernels are boundary kernels of the form  $K(u, q)$ , where  $u \in [-1, q]$  and  $q \in [0, 1]$   $q = [0, 1]$ . Kernels are of the Müller-Wang type ("MW"), Müller type ("M") or truncated kernels ("TR").

## References

- Müller, H.-G. and Wang, J.-L. (1994). Hazard rate estimation under random censoring with varying kernels and bandwidths. *Biometrics*, 50:61-76.
- Müller, H.-G. (1991). Smooth optimum kernel estimators near endpoints. *Biometrika*, 78:521-530.
- Feng, Y. and Schäfer B. (2021). Boundary Modification in Local Regression. Working Papers CIE 144, Paderborn University.

## See Also

[kernel.list](#)

## Examples

```
# See vignette("DCSmooth") for further examples and explanation

u <- seq(from = -1, to = 0.5, length.out = 151)
kern_MW220 <- kernel.assign("MW_220")
k <- kern_MW220(u, 0.5)
plot(u, k, type = "l")
```

---

kernel.list

*Print a list of available kernels in the DCSmooth package*

---

## Description

Print a list of available kernels in the DCSmooth package

## Usage

```
kernel.list(print = TRUE)
```

## Arguments

print	Logical value. Should the list be printed to the console? If TRUE (the default), the list is printed to the console, if FALSE the list of identifiers is returned from the function as (surprise!) a list.
-------	--

## Value

If print = FALSE, a list is returned containing the kernel identifiers

## Details

kernel.list is used to get a list of available kernels in the DCSmooth package.

kernel.list prints a list of identifiers kernel\_id of available kernels in the DCSmooth package. The available kernel types are "T": truncated, "MW": Müller-Wang boundary correction, "M": Müller boundary correction.

**References**

- Müller, H.-G. and Wang, J.-L. (1994). Hazard rate estimation under random censoring with varying kernels and bandwidths. *Biometrics*, 50:61-76.
- Müller, H.-G. (1991). Smooth optimum kernel estimators near endpoints. *Biometrika*, 78:521-530.
- Feng, Y. and Schäfer B. (2021). Boundary Modification in Local Regression. Working Papers CIE 144, Paderborn University.

**See Also**

[kernel.assign](#)

**Examples**

```
# See vignette("DCSmooth") for further examples and explanation

kernel.list()
```

---

plot.dcs

*Contour Plot for the Double Conditional Smoothing*

---

**Description**

plot method for class "dcs"

**Usage**

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

**Arguments**

x an object of class "dcs\_options", usually, a result of a call to [set.options](#).

... Additional arguments passed to `print.dcs_options`. The argument `plot_choice` overrides the prompt to specify a plot, can be `c(1, 2, 3)`.

**Value**

No return value.

**Details**

`plot.dcs` provides a contour plot of either the original data (1), smoothed surface (2) or residuals (3).

**See Also**

[surface.dcs](#) to plot the surface.

## Examples

```
## Contour plot of smoothed surface
y <- y.norm1 + matrix(rnorm(101^2), nrow = 101, ncol = 101)
dcs_object <- dcs(y)
plot(dcs_object, plot_choice = 2)
```

---

print.dcs

*Summarize Results from Double Conditional Smoothing*

---

## Description

print method for class "dcs"

## Usage

```
## S3 method for class 'dcs'
print(x, ...)
```

## Arguments

x                    an object of class "dcs", usually, a result of a call to [dcs](#).  
...                   Additional arguments passed to `print.dcs`.

## Value

No return value.

## Details

`print.dcs` prints a short summary of an object of class `dcs`, only including bandwidths and the estimated variance coefficient (only if automatic bandwidth selection is used).

## See Also

[plot.dcs](#), [print.dcs\\_options](#)

## Examples

```
y <- y.norm1 + matrix(rnorm(101^2), nrow = 101, ncol = 101)
dcs_object <- dcs(y)
print(dcs_object)
dcs_object
```



---

print.dcs\_options      *Print and Summarize Options for Double Conditional Smoothing*

---

## Description

print method for class "dcs\_options"

## Usage

```
## S3 method for class 'dcs_options'  
print(x, ...)
```

## Arguments

x                    an object of class "dcs\_options", usually, a result of a call to [set.options](#).  
...                   Additional arguments passed to `print.dcs_options`.

## Value

No return value.

## Details

`print.dcs_options` prints the main options and `summary.dcs_options` prints main and advanced (IPI) options used for the [dcs](#) function. Arguments should be an object of class "dcs\_options".

## See Also

[print.dcs](#), [summary.dcs\\_options](#)

## Examples

```
## Default options  
myOpt <- set.options()  
print(myOpt)  
summary(myOpt)  
  
## Use Kernel regression  
myOpt <- set.options(type = "KR")  
print(myOpt)  
summary(myOpt)
```

---

`print.summary_dcs`      *Print the Summary of a DCS estimation*

---

**Description**

print method for class "summary\_dcs"

**Usage**

```
## S3 method for class 'summary_dcs'
print(x, ...)
```

**Arguments**

`x`                    An object of class "summary\_dcs".  
`...`                Additional arguments passed to `print.summary_dcs`.

**Value**

No return value.

**See Also**

[summary.dcs](#)

---

`print.summary_sarma`      *Print the Summary of a "sarma"/"sfarima" object*

---

**Description**

print methods for class "summary\_sarma"/ "summary\_sfarima"

**Usage**

```
## S3 method for class 'summary_sarma'
print(x, ...)

## S3 method for class 'summary_sfarima'
print(x, ...)
```

**Arguments**

`x`                    An object of class "summary\_sarma" or "summary\_sfarima".  
`...`                Additional arguments passed to `print.summary_sarma/ print.summary_sfarima`.

**Value**

No return value.

**See Also**

[summary.sarma](#) [summary.sfarima](#)

---

residuals.dcs	<i>Residuals of "dcs"-object</i>
---------------	----------------------------------

---

**Description**

Returns the residuals of an object of class "dcs".

**Usage**

```
## S3 method for class 'dcs'  
residuals(x, ...)
```

**Arguments**

`x` an object of class "dcs", usually the result of a call to [dcs](#).  
`...` Additional arguments passed to `residuals.dcs`.

**Value**

Returns the  $n_x \times n_t$ -matrix of residuals.

**See Also**

[dcs](#)

**Examples**

```
y = y.norm1 + matrix(rnorm(101^2), nrow = 101, ncol = 101)  
dcs_object = dcs(y)  
residuals(dcs_object)
```

---

returns.alv	<i>Returns of Allianz SE</i>
-------------	------------------------------

---

**Description**

The (log-) returns of the shares of the German insurance company Allianz SE from 2007-01-02 to 2010-12-30 aggregated to 5-minute observations. The data is adjusted to matrix form for direct use with the DCSmooth-functions.

**Usage**

```
returns.alv
```

**Format**

A numeric matrix with 1016 rows representing the days and 101 columns representing the intraday time points.

---

sarma.est	<i>Estimation of an SARMA-process</i>
-----------	---------------------------------------

---

**Description**

Parametric Estimation of an  $SARMA(p, q)$ -process on a lattice.

**Usage**

```
sarma.est(Y, method = "HR", model_order = list(ar = c(1, 1), ma = c(1, 1)))
```

```
qarma.est(Y, model_order = list(ar = c(1, 1), ma = c(1, 1)))
```

**Arguments**

Y	A numeric matrix that contains the demeaned observations of the random field or functional time-series.
method	Method used for estimation of the parameters. One of "HR", "sep", "RSS", default value is "HR"
model_order	A list containing the orders of the SARMA model in the form <code>model_order = list(ar = c(p1, p2), ma = c(q1, q2))</code> . Default value is a $SARMA((1, 1), (1, 1))$ model.

**Value**

The function returns an object of class "sarma" including

Y	The matrix of observations, inherited from input.
innov	The estimated innovations.
model	The estimated model consisting of the coefficient matrices ar and ma and standard deviation sigma.
stnry	An logical variable indicating whether the estimated model is stationary.

**Details**

The MA- and AR-parameters of a top-left quadrant ARMA process are estimated by the specified method. The lag-orders of the  $SARMA(p, q)$  are given by  $p = (p_1, p_2)$ ,  $q = (q_1, q_2)$ , where  $p_1, q_1$  are the lags over the rows and  $p_2, q_2$  are the lags over the columns. The estimation process is based on the model

$$\phi(B_1 B_2) X_{i,j} = \theta(B_1 B_2) u_{i,j}$$

**See Also**

[sarma.sim](#), [sfarima.est](#)

**Examples**

```
# See vignette("DCSmooth") for examples and explanation

## simulation of SARMA process
ma <- matrix(c(1, 0.2, 0.4, 0.1), nrow = 2, ncol = 2)
ar <- matrix(c(1, 0.5, -0.1, 0.1), nrow = 2, ncol = 2)
sigma <- 0.5
sarma_model <- list(ar = ar, ma = ma, sigma = sigma)
sarma_simulated <- sarma.sim(100, 100, model = sarma_model)
sarma_simulated$model

## estimation of SARMA process
sarma.est(sarma_simulated$Y)$model
sarma.est(sarma_simulated$Y,
          model_order = list(ar = c(1, 1), ma = c(1, 1)))$model
```

---

sarma.sim

*Simulation of a SARMA(p, q)-process*

---

**Description**

sarma.sim simulates a specified SARMA-model on a lattice with normally distributed innovations.

**Usage**

```
sarma.sim(n_x, n_t, model)
```

```
qarma.sim(n_x, n_t, model)
```

**Arguments**

n_x	Number of simulated observation rows.
n_t	Number of simulated observation columns.
model	A list containing the coefficient matrices ar and ma of the SARMA model as well as the standard deviation of innovations sigma.

**Value**

The function returns an object of class "sarma", consisting of

Y	A $n_x \times n_t$ -matrix of simulated values of the specified SARMA process.
innov	The innovations used for simulation, iid. drawn from a normal distribution with zero mean and variance $\sigma^2$ .
model	The model used for simulation, inherited from input.
stnry	An logical variable indicating whether the simulated model is stationary.

**Details**

Simulation of a top-left dependent spatial ARMA process (SARMA). This function returns an object of class "sarma". The simulated innovations are created from a normal distribution with specified variance  $\sigma^2$ .

see the vignette for further details.

**See Also**

[sarma.est](#), [sfarima.est](#)

**Examples**

```
# See vignette("DCSmooth") for examples and explanation

ma <- matrix(c(1, 0.2, 0.4, 0.1), nrow = 2, ncol = 2)
ar <- matrix(c(1, 0.5, -0.1, 0.1), nrow = 2, ncol = 2)
sigma <- 0.5
sarma_model <- list(ar = ar, ma = ma, sigma = sigma)

sarma_sim <- sarma.sim(100, 100, model = sarma_model)
summary(sarma_sim)
```

---

set.options	<i>Set Options for the DCS procedure</i>
-------------	--

---

**Description**

Set Options for the DCS procedure

**Usage**

```
set.options(
  type = "LP",
  kerns = c("MW_220", "MW_220"),
  drv = c(0, 0),
  var_model = "iid",
  ...
)
```

**Arguments**

type	either local polynomial regression ("LP", the default) or kernel regression ("KR").
kerns	a character vector of length 2 containing the identifier for the kernels to be used in kernel regression. Weighting functions in local polynomial regression are computed according to the identifier. Default value is MW_220, the Mueller-Wang kernel of order (2, 2, 0). If only a single value is provided, it is used as kernel in both directions.
drv	A non-negative vector of length 2, containing the derivative orders to be estimated from the given data. The default is c(0, 0). For LP-regression, polynomial order is selected as $(\nu_1 + 1, \nu_2 + 1)$ . If only a single value is provided, it is used as derivative in both directions.
var_model	the method of estimating the variance coefficient $c_f$ . Currently available are var_model = c("iid", "sarma_HR", "sarma_sep", "sarma_RSS", "sfarima_RSS"). Replacing the argument var_model. For code using var_est, the argument is converted to var_model.
...	Additional arguments passed to set.options(). This includes IPI_options, a list containing further options used by the iterative plug-in algorithm. For convenience, any of the options usually included in the list IPI_options can be passed as argument directly to set.options and will be converted into the IPI_options list. Further arguments accepted are model_order controlling the order of the variance model, if either an SARMA or SFARIMA model is used. This argument is either a list of the form list(ar = c(1, 1), ma = c(1, 1)) or specifies an order selection criterion from c("aic", "bic", "gpac"). If an order selection criterion is used, the argument order_max controls the maximum order to be tested.

**Value**

An object of class "dcs\_options".

**Details**

This function is used to set the options for bandwidth selection in the `dcf` function. Detailed information can be found in the vignette.

**See Also**

[dcf](#)

**Examples**

```
# See vignette("DCSmooth") for examples and explanation

set.options()

myOpt <- set.options(type = "KR", var_model = "iid")
y <- y.norm1 + matrix(rnorm(101^2), nrow = 101, ncol = 101)
dcf(y, dcf_options = myOpt)
```

---

sfarima.est

*Estimation of a SFARIMA-process*


---

**Description**

Parametric Estimation of a  $SFARIMA(p, q, d)$ -process on a lattice.

**Usage**

```
sfarima.est(Y, model_order = list(ar = c(1, 1), ma = c(1, 1)))
```

**Arguments**

<code>Y</code>	A numeric matrix that contains the demeaned observations of the random field or functional time-series.
<code>model_order</code>	A list containing the orders of the SFARIMA model in the form <code>model_order = list(ar = c(p1, p2), ma = c(q1, q2))</code> . Default value is a $SFARIMA((1, 1), (1, 1), d)$ model.

**Value**

The function returns an object of class "sfarima" including

<code>Y</code>	The matrix of observations, inherited from input.
<code>innov</code>	The estimated innovations.
<code>model</code>	The estimated model consisting of the coefficient matrices <code>ar</code> and <code>ma</code> , the estimated long memory parameter <code>d</code> .
<code>stnry</code>	An logical variable indicating whether the estimated model is stationary.



**Details**

The MA- and AR-parameters as well as the long-memory parameters

$$d$$

of a SFARIMA process are estimated by minimization of the residual sum of squares RSS. Lag-orders of  $SFARIMA(p, q, d)$  are given by  $p = (p_1, p_2), q = (q_1, q_2)$ , where  $p_1, q_1$  are the lags over the rows and  $p_2, q_2$  are the lags over the columns. The estimated process is based on the (separable) model

$$\varepsilon_{ij} = \Psi_1(B)\Psi_2(B)\eta_{ij}$$

, where

$$\Psi_i = (1 - B_i)^{-d_i} \phi_i^{-1}(B_i) \psi_i(B_i), i = 1, 2$$

**See Also**

[sarma.est](#), [sfarima.sim](#)

**Examples**

```
# See vignette("DCSmooth") for examples and explanation

## simulation of SFARIMA process
ma <- matrix(c(1, 0.2, 0.4, 0.1), nrow = 2, ncol = 2)
ar <- matrix(c(1, 0.5, -0.1, 0.1), nrow = 2, ncol = 2)
d <- c(0.1, 0.1)
sigma <- 0.5
sfarima_model <- list(ar = ar, ma = ma, d = d, sigma = sigma)
sfarima_sim <- sfarima.sim(50, 50, model = sfarima_model)

## estimation of SFARIMA process
sfarima.est(sfarima_sim$Y)$model
sfarima.est(sfarima_sim$Y,
            model_order = list(ar = c(1, 1), ma = c(0, 0)))$model
```

---

sfarima.sim

*Simulation of a SFARIMA(p, q, d)-process*

---

**Description**

`sfarima.sim` simulates a specified SFARIMA-model on a lattice with normally distributed innovations.

**Usage**

```
sfarima.sim(n_x, n_t, model)
```

**Arguments**

n_x	Number of simulated observation rows.
n_t	Number of simulated observation columns.
model	A list containing the coefficient matrices ar and ma of the QARMA model, the long memory parameter vector d as well as the standard deviation of innovations sigma.

**Value**

The function returns an object of class "sfarima", consisting of

Y	A $n_x \times n_t$ -matrix of simulated values of the specified SFARIMA process.
innov	The innovations used for simulation, iid. drawn from a normal distribution with zero mean and variance $\sigma^2$ .
model	The model used for simulation, inherited from input.
stnry	An logical variable indicating whether the simulated model is stationary.

**Details**

Simulation of a separable spatial fractionally ARIMA process (SFARIMA). This function returns an object of class "sfarima". The simulated innovations are created from a normal distribution with specified variance  $\sigma^2$ .

see the vignette for further details.

**See Also**

[qarma.est](#)

**Examples**

```
# See vignette("DCSmooth") for examples and explanation

ma <- matrix(c(1, 0.2, 0.4, 0.1), nrow = 2, ncol = 2)
ar <- matrix(c(1, 0.5, -0.1, 0.1), nrow = 2, ncol = 2)
d <- c(0.1, 0.1)
sigma <- 0.5
sfarima_model <- list(ar = ar, ma = ma, d = d, sigma = sigma)

sfarima_sim <- sfarima.sim(100, 100, model = sfarima_model)
surface.dcs(sfarima_sim$Y)
```

**Description**

summary method for class "dcs"

**Usage**

```
## S3 method for class 'dcs'
summary(object, ...)
```

**Arguments**

`object` an object of class "dcs", usually, a result of a call to `dcs`.  
`...` Additional arguments passed to the `summary.dcs` function.

**Value**

The function `summary.dcs` returns an object of class `summary_dcs` including

<code>h_opt</code>	estimated optimal bandwidth from the IPI-procedure.
<code>c_f</code>	estimated variance factor.
<code>iterations</code>	number of iterations of the IPI-procedure.
<code>time_used</code>	time spend searching for optimal bandwidths (not overall runtime of the function).
<code>var_est</code>	estimated variance model. Has class "sarima" if an SARMA model is used and class "sfarima" if an SFARIMA model is used.
<code>var_model_id</code>	identifier for the variance model estimated.
<code>var_model_order</code>	order of the estimated variance model, if either SARMA or SFARIMA is used.
<code>dcs_options</code>	an object of class <code>dcs_options</code> containing the initial options of the <code>dcs</code> procedure.

**Details**

`summary.dcs` strips an object of class "dcs" from all large matrices (Y, X, T, M, R), allowing for easier handling of meta-statistics of the bandwidth selection procedure.

`print.summary_dcs` returns a list of summary statistics from the `dcs` procedure. The output depends on the use of the `dcs`- function. If automatic bandwidth selection is chosen, `summary.dcs` prints detailed statistics of the type of regression, the estimated bandwidths `h_x`, `h_t`, the variance coefficient `c_f` and performance statistics such as the number of iterations of the IPI-algorithm and the time used for bandwidth selection.

The method used for estimation of the variance coefficient is printed and the results of an SARMA/SFARIMA-estimation, if available.

If bandwidths are supplied to `dcs`, `summary.dcs` only prints the given bandwidths.

**Examples**

```
y <- y.norm1 + matrix(rnorm(101^2), nrow = 101, ncol = 101)
dcs_object <- dcs(y)
summary(dcs_object)
```

---

summary.dcs\_options     *Print and Summarize Options for Double Conditional Smoothing*

---

### Description

summary method for class "dcs\_options"

### Usage

```
## S3 method for class 'dcs_options'  
summary(object, ...)
```

### Arguments

object            an object of class "dcs\_options", usually, a result of a call to [set.options](#).  
...                Additional arguments passed to `summary.dcs_options`.

### Value

No return value.

### Details

`print.dcs_options` prints the main options and `summary.dcs_options` prints main and advanced (IPI) options used for the [dcs](#) function. Arguments should be an object of class "dcs\_options".

### See Also

[print.dcs](#), [print.dcs\\_options](#)

### Examples

```
## Default options  
myOpt <- set.options()  
print(myOpt)  
summary(myOpt)  
  
## Use Kernel regression  
myOpt <- set.options(type = "KR")  
print(myOpt)  
summary(myOpt)
```

summary.sarma

*Summarizing SARMA/SFARIMA Estimation or Simulation***Description**

summary method for class "sarma" or "sfarima"

**Usage**

```
## S3 method for class 'sarma'
summary(object, ...)
```

```
## S3 method for class 'sfarima'
summary(object, ...)
```

**Arguments**

**object** an object of class "sarma" or "sfarima", usually a result of a call to the estimation functions [sarma.est](#), [sfarima.est](#) or to the corresponding simulation functions [sarma.sim](#) and [sfarima.sim](#).

**...** Additional arguments passed to the `summary.sarma/summary.sfarima` function.

**Value**

The function `summary.sarma/summary.sfarima` returns an object of class `summary_sarma` including

<code>model</code>	estimated or simulated model parameters including coefficient matrices <code>ar</code> , <code>ma</code> , the error term standard deviation
<code>model_order</code>	order of the estimated/simulated model computed from the matrices <code>ar</code> , <code>ma</code> .
<code>stnry</code>	a flag for stationarity of the short memory part.
<code>subclass</code>	a flag indicating whether the object inherits from an estimation ( <code>subclass = "est"</code> ) or simulation procedure ( <code>subclass = "sim"</code> ).

**Details**

`summary.sarma/summary.sfarima` strips an object of class "sarma"/"sfarima" from all large matrices (`Y`, `innov`), allowing for easier handling of meta-statistics of the bandwidth selection procedure.

`print.summary_sarma/print.summary_sarma` returns a list of summary statistics from the estimation or simulation procedure.

**See Also**

[sarma.est](#), [sfarima.est](#), [sarma.sim](#), [sfarima.sim](#)

**Examples**

```

# SARMA Simulation and Estimation
ma = matrix(c(1, 0.2, 0.4, 0.1), nrow = 2, ncol = 2)
ar = matrix(c(1, 0.5, -0.1, 0.1), nrow = 2, ncol = 2)
sigma = 0.5
sarma_model = list(ar = ar, ma = ma, sigma = sigma)
sarma_sim = sarma.sim(100, 100, model = sarma_model)
summary(sarma_sim)
sarma_est = sarma.est(sarma_sim$Y)
summary(sarma_est)

# SFARIMA Simulation and Estimation
ma = matrix(c(1, 0.2, 0.4, 0.1), nrow = 2, ncol = 2)
ar = matrix(c(1, 0.5, -0.1, 0.1), nrow = 2, ncol = 2)
d = c(0.1, 0.1)
sigma = 0.5
sfarima_model = list(ar = ar, ma = ma, d = d, sigma = sigma)
sfarima_sim = sfarima.sim(100, 100, model = sfarima_model)
summary(sfarima_sim)
sfarima_est = sfarima.est(sfarima_sim$Y)
summary(sfarima_est)

```

---

surface.dcs

3D Surface Plot of "dcs"-object or numeric matrix

---

**Description**

3D Surface Plot of "dcs"-object or numeric matrix

**Usage**

```
surface.dcs(Y, trim = c(0, 0), plot_choice = "choice", ...)
```

**Arguments**

Y	an object of class "dcs" or a numeric matrix that contains the values to be plotted.
trim	a numeric vector with two values specifying the percentage of trimming applied to the boundaries of the surface to plot. Useful for derivative estimation.
plot_choice	override the prompt to specify a plot, can be c(1, 2, 3).
...	optional arguments passed to the plot function.

**Value**

dcs.3d returns an object of class "plotly" and "htmlwidget".

**Details**

surface.dcs uses the plotly device to plot the 3D surface of the given "dcs"-object or matrix. If a "dcs"-object is passed to the function, it can be chosen between plots of the original data (1), smoothed surface (2) and residuals (3).

**See Also**

[plot.dcs](#)

**Examples**

```
# See vignette("DCSmooth") for examples and explanation

smth <- dcs(y.norm1 + rnorm(101^2))
surface.dcs(smth, trim = c(0.05, 0.05), plot_choice = 2)
```

---

temp.nunn

*Temperatures from Nunn, CO*


---

**Description**

This dataset contains the 5-minute observations of the 2020 temperature in Nunn, CO. The data is from the U.S. Climate Reference Network database at [www.ncdc.noaa.gov](http://www.ncdc.noaa.gov). (see Diamond et al., 2013). The observations were adjusted matrix form for direct use with the DCSmooth-functions.

**Usage**

```
temp.nunn
```

**Format**

A numeric matrix with 366 rows and 288 columns containing the temperatures in Celsius.

---

temp.yuma

*Temperatures from Yuma, AZ*


---

**Description**

This dataset contains the 5-minute observations of the 2020 temperature in Yuma, AZ. The data is from the U.S. Climate Reference Network database at [www.ncdc.noaa.gov](http://www.ncdc.noaa.gov). (see Diamond et al., 2013). The observations were adjusted matrix form for direct use with the DCSmooth-functions.

**Usage**

```
temp.yuma
```

**Format**

A numeric matrix with 366 rows and 288 columns containing the temperatures in Celsius.

---

volumes.alv	<i>Volumes of Allianz SE</i>
-------------	------------------------------

---

**Description**

The trading volumes of the shares of the German insurance company Allianz SE from 2007-01-02 to 2010-09-30 aggregated to 5-minute observations. The data is adjusted to matrix form for direct use with the DCSmooth-functions.

**Usage**

volumes.alv

**Format**

A numeric matrix with 1016 rows representing the days and 102 columns representing the intraday time points.

---

wind.nunn	<i>Wind Speed from Nunn, CO</i>
-----------	---------------------------------

---

**Description**

This dataset contains the 5-minute observations of the 2020 wind speed in Nunn, CO. The data is from the U.S. Climate Reference Network database at [www.ncdc.noaa.gov](http://www.ncdc.noaa.gov). (see Diamond et al., 2013). The observations were adjusted matrix form for direct use with the DCSmooth-functions.

**Usage**

wind.nunn

**Format**

A numeric matrix with 366 rows and 288 columns containing the wind speed in  $m/s$ .



---

wind.yuma	<i>Wind Speed from Yuma, AZ</i>
-----------	---------------------------------

---

**Description**

This dataset contains the 5-minute observations of the 2020 wind speed in Yuma, AZ. The data is from the U.S. Climate Reference Network database at [www.ncdc.noaa.gov](http://www.ncdc.noaa.gov). (see Diamond et al., 2013). The observations were adjusted matrix form for direct use with the DCSmooth-functions.

**Usage**

wind.yuma

**Format**

A numeric matrix with 366 rows and 288 columns containing the wind speeds in *m/s*.

---

y.norm1	<i>Single Gaussian Peak</i>
---------	-----------------------------

---

**Description**

Example data for using the DCSmooth functions. Data resembles a single gaussian peak on the interval  $[0, 1] \times [0, 1]$  with maximum at  $(0.5, 0.5)$  and variance matrix  $0.1 \cdot \mathbf{I}$ , where  $\mathbf{I}$  represents the  $2 \times 2$  identity matrix.

**Usage**

y.norm1

**Format**

A numeric matrix with 101 rows and 101 columns.

---

y.norm2

*Double Gaussian Peak*

---

**Description**

Example data for using the DCSSmooth functions. Data resembles two gaussian peaks on the interval  $[0, 1] \times [0, 1]$  with maxima at  $(0.5, 0.3)$  with variance matrix  $0.1 \cdot \mathbf{I}$  and at  $(0.2, 0.8)$  with variance matrix  $0.05 \cdot \mathbf{I}$ , where  $\mathbf{I}$  represents the  $2 \times 2$  identity matrix.

**Usage**

y.norm2

**Format**

A numeric matrix with 101 rows and 101 columns.

---

y.norm3

*Double Gaussian Ridges*

---

**Description**

Example data for using the DCSSmooth functions. Data resembles two gaussian ridges on the interval  $[0, 1] \times [0, 1]$  with maxima at  $(0.25, 0.75)$  with variance matrix  $(0.01, -0.1) \cdot \mathbf{I}$  and at  $(0.75, 0.5)$  with variance matrix  $(0.01, -0.1) \cdot \mathbf{I}$ , where  $\mathbf{I}$  represents the  $2 \times 2$  identity matrix.

**Usage**

y.norm3

**Format**

A numeric matrix with 101 rows and 101 columns.

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