

Package ‘spacetime’

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Title Classes and Methods for Spatio-Temporal Data

Depends R (>= 3.0.0)

Imports graphics, utils, stats, methods, lattice, sp (>= 1.1-0), zoo
(>= 1.7-9), xts (>= 0.8-8), intervals

Suggests adehabitatLT, cshapes (>= 2.0), foreign, googleVis, gstat (>= 1.0-16), maps, mapdata, plm, raster, RColorBrewer, rmarkdown, RPostgreSQL, knitr, ISOcodes, markdown, sf, sftime, spdep

LazyData no

Description Classes and methods for spatio-temporal data, including space-time regular lattices, sparse lattices, irregular data, and trajectories; utility functions for plotting data as map sequences (lattice or animation) or multiple time series; methods for spatial and temporal selection and subsetting, as well as for spatial/temporal/spatio-temporal matching or aggregation, retrieving coordinates, print, summary, etc.

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URL <https://github.com/edzer/spacetime>

BugReports <https://github.com/edzer/spacetime/issues>

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VignetteBuilder knitr

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apply.R coerce.R stconstruct.R plot.R stplot.R timematch.R
over.R aggregate.R eof.R mnf.R bind.R na.R raster.R tgrass.R
stinteraction.R

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air	<i>Air quality data, rural background PM10 in Germany, daily averages 1998-2009</i>
-----	---

Description

Air quality data obtained from the airBase European air quality data base. Daily averages for rural background stations in Germany, 1998-2009. In addition, NUTS1 regions (states, or Bundeslaender) for Germany to illustrate spatial aggregation over irregular regions.

Usage

```
data(air)
```

Note

see vignette on overlay and spatio-temporal aggregation in this package; the vignette on using google charts shows where the ISO_3166_2_DE table comes from.

Author(s)

air quality data compiled for R by Benedict Graeler; NUTS1 level data obtained from <https://www.gadm.org/>

.

References

<https://www.eionet.europa.eu/etcs/etc-acm/databases/airbase>

Examples

```
data(air)
rural = STFDF(stations, dates, data.frame(PM10 = as.vector(air)))
# how DE was created from DE_NUTS1:
#if (require(rgeos))
# DE = gUnionCascaded(DE_NUTS1)
#
```

delta

find default time interval end points when intervals are regular

Description

find default time interval end points when intervals are regular

Usage

```
delta(x)
```

Arguments

x object of class xts, or of another class that can be coerced into POSIXct
;

Details

to find the interval size for the last observation (which has no next observation), x needs to be at least of length 2.

Value

sequence of POSIXct time stamps, indicating the end of the time interval, given by the next observation in x. The last interval gets the same width of the one-but-last interval.

Author(s)

Edzer Pebesma

References

<https://www.jstatsoft.org/v51/i07/>

Examples

```
x = as.POSIXct("2000-01-01") + (0:9) * 3600
delta(x)
```

EOF

Compute spatial or temporal empirical orthogonal function (EOF)

Description

Compute spatial or temporal empirical orthogonal function (EOF)

Usage

```
eof(x, how = c("spatial", "temporal"), returnEOFs = TRUE, ...)
EOF(x, how = c("spatial", "temporal"), returnPredictions = TRUE, ...)
```

Arguments

<code>x</code>	object of class STFDF
<code>how</code>	character; choose "spatial" or "temporal" mode
<code>returnEOFs</code>	logical; if TRUE, the eigenvectors (EOFs) are returned in the form of a Spatial or xts object; if FALSE, the object returned by prcomp is returned, which can be printed, or from which a summary can be computed; see examples.
<code>returnPredictions</code>	logical; if TRUE, the functions are returned (i.e., predicted principle components, or PC scores); if FALSE, the object returned by prcomp is returned, which can be printed, or from which a summary can be computed; see examples (deprecated, see below).
<code>...</code>	arguments passed on to function prcomp ; note that <code>scale.=TRUE</code> needs to be specified to obtain EOFs based on correlation (default: covariance)

Value

In spatial mode, the appropriate `Spatial*` object. In temporal mode, an object of class `xts`.

Note

EOF is deprecated: it mixes up spatial and temporal EOFs, and returns projections (PC scores) instead of EOFs (eigenvectors); to compute EOFs, use `eof`.

Examples

```

if (require(gstat)) {
  data(wind)
  library(sp)
  wind.loc$y = as.numeric(char2dms(as.character(wind.loc[["Latitude"]]])))
  wind.loc$x = as.numeric(char2dms(as.character(wind.loc[["Longitude"]]])))
  coordinates(wind.loc) = ~x+y
  proj4string(wind.loc) = "+proj=longlat +datum=WGS84"

  # match station order to names in wide table:
  stations = 4:15
  wind.loc = wind.loc[match(names(wind[stations]), wind.loc$Code),]
  row.names(wind.loc) = wind.loc$Station
  wind$time = ISOdate(wind$year+1900, wind$month, wind$day, 0)
  space = list(values = names(wind)[stations])
  wind.st = stConstruct(wind[stations], space, wind$time, SpatialObj = wind.loc)
  # select first 500 time steps, to limit run time:
  wind.st = wind.st[,1:500]
  wind.eof.1 = eof(wind.st)
  wind.eof.2 = eof(wind.st, "temporal")
  wind.eof.1.PCs = eof(wind.st, returnEOFs = FALSE)
  eof(wind.st, "temporal", returnEOFs = FALSE)
  summary(eof(wind.st, returnEOFs = FALSE))
  summary(eof(wind.st, "temporal", returnEOFs = FALSE))
  plot(eof(wind.st, "temporal", returnEOFs = FALSE))
}

```

fires

Northern Los Angeles County Fires

Description

Wildfire occurrences in Northern Los Angeles County, California between 1976 and 2000. The spatial units are in scaled feet, taken from the NAD 83 state-plane coordinate system. One unit is equivalent to 100,000 feet or 18.9 miles. The times for the points were produced by the date package and represent the number of days since January 1, 1960.

Usage

```
data(fires)
```

Format

A data frame with 313 observations with day of occurrence, x and y coordinates.

Author(s)

Roger Peng, taken from (non-CRAN) package ptproc,
<https://www.biostat.jhsph.edu/~rpeng/software/index.html>;
 example code by Roger Bivand.

Examples

```
data(fires)
fires$X <- fires$X*100000
fires$Y <- fires$Y*100000
library(sp)
coordinates(fires) <- c("X", "Y")
proj4string(fires) <- CRS("+init=epsg:2229 +ellps=GRS80")
dates <- as.Date("1960-01-01")+(fires$Time-1)
Fires <- STIDF(as(fires, "SpatialPoints"), dates, data.frame(time=fires$Time))
library(mapdata)
if (require(sf)) {
  m <- map("county", "california", xlim=c(-119.1, -117.5),
    ylim=c(33.7, 35.0), plot=FALSE, fill=TRUE)
  m.sf <- st_transform(st_as_sf(m), "EPSG:2229")
  cc <- as(m.sf, "Spatial")
  plot(cc, xlim=c(6300000, 6670000), ylim=c(1740000, 2120000))
  plot(slot(Fires, "sp"), pch=3, add=TRUE)
  stplot(Fires, sp.layout=list("sp.lines", cc))
}
```

mnf

Generic mnf method

Description

Compute mnf from spatial, temporal, or spatio-temporal data

Usage

```
mnf(x, ...)
## S3 method for class 'matrix'
mnf(x, ..., Sigma.Noise, use = "complete.obs")
## S3 method for class 'mts'
mnf(x, ..., use = "complete.obs")
## S3 method for class 'zoo'
mnf(x, ..., use = "complete.obs")
## S3 method for class 'SpatialPixelsDataFrame'
mnf(x, ..., use = "complete.obs")
## S3 method for class 'SpatialGridDataFrame'
mnf(x, ..., Sigma.Noise, use = "complete.obs")
## S3 method for class 'RasterStack'
mnf(x, ..., use = "complete.obs")
## S3 method for class 'RasterBrick'
mnf(x, ..., use = "complete.obs")
## S3 method for class 'STSDf'
mnf(x, ..., use = "complete.obs", mode = "temporal")
## S3 method for class 'STFDF'
mnf(x, ..., use = "complete.obs", mode = "temporal")
```

Arguments

<code>x</code>	object for which an mnf method is available
<code>...</code>	ignored
<code>Sigma.Noise</code>	Noise covariance matrix; when missing, estimated from the data by using the covariance of lag-one spatial or temporal differences (MAF)
<code>use</code>	method to deal with missing values when computing covariances; see cov
<code>mode</code>	for ST objects: if "temporal", compute covariances in time dimension, if "spatial", compute them in spatial dimension.

Details

Uses MAF (Min/max Autocorrelation Factors) to estimate the noise covariance. This implementation estimates the noise covariance by $0.5\text{Cov}(Z(s) - Z(s + \Delta))$, so that eigenvalues can be directly interpreted as approximate estimates of the noise covariance.

Value

object of class `(c("mnf", "prcomp"))`; see [prcomp](#). Additional elements are values, containing the eigenvalues.

See Also

<https://r-spatial.org/r/2016/03/09/MNF-PCA-EOF.html>

Examples

```
# temporal data:
set.seed(13531) # make reproducible
s1 = arima.sim(list(ma = rep(1,20)), 500)
s2 = arima.sim(list(ma = rep(1,20)), 500)
s3 = arima.sim(list(ma = rep(1,20)), 500)
s3 = s3 + rnorm(500, sd = 10)
d = cbind(s1,s2,s3)
plot(d)
m = mnf(d)
m
summary(m)
plot(predict(m))

# spatial example:
## Not run:
library(sp)
grd = SpatialPoints(expand.grid(x=1:100, y=1:100))
gridded(grd) = TRUE
fullgrid(grd) = TRUE
pts = spsample(grd, 50, "random")
pts$z = rnorm(50)
library(gstat)
v = vgm(1, "Sph", 90)
out = krige(z~1, pts, grd, v, nmax = 20, nsim = 4)
```

```

out[[3]] = 0.5 * out[[3]] + 0.5 * rnorm(1e4)
out[[4]] = rnorm(1e4)
spplot(out, as.table = TRUE)
m = mnf(out)
m
summary(m)

## End(Not run)
if (require(gstat)) {
  data(wind)
  library(sp)
  wind.loc$y = as.numeric(char2dms(as.character(wind.loc[["Latitude"]]))))
  wind.loc$x = as.numeric(char2dms(as.character(wind.loc[["Longitude"]]))))
  coordinates(wind.loc) = ~x+y
  proj4string(wind.loc) = "+proj=longlat +datum=WGS84"

  # match station order to names in wide table:
  stations = 4:15
  wind.loc = wind.loc[match(names(wind[stations]), wind.loc$Code),]
  row.names(wind.loc) = wind.loc$Station
  wind$time = ISOdate(wind$year+1900, wind$month, wind$day, 0)
  space = list(values = names(wind)[stations])
  wind.st = stConstruct(wind[stations], space, wind$time, SpatialObj = wind.loc, interval = TRUE)
  m = mnf(wind.st)
  m
  plot(m)
  stplot(predict(m), mode = "tp")
}

```

na.locf

replace NA attribute values; disaggregation time series

Description

replace NA attribute values in time series, using last or next observation, or using (temporal) interpolation, and disaggregation

Usage

```

## S3 method for class 'STFDF'
na.locf(object, na.rm = FALSE, ...)
## S3 method for class 'STFDF'
na.approx(object, x = time(object), xout, ..., na.rm = TRUE)
## S3 method for class 'STFDF'
na.spline(object, x = time(object), xout, ..., na.rm = TRUE)

```

Arguments

object	object of class STFDF, with potentially NA values
na.rm	logical; need non-replaced NA values be removed?
x	times at which observations are taken; should not be modified
xout	if present, new times at which the time series should be approximated (disaggregated)
...	passed on to underlying zoo functions; see details

Details

details are found in [na.locf](#), [na.approx](#), [na.spline](#).

Value

object of class STFDF, with NA values replaced.

Author(s)

Edzer Pebesma

References

<https://www.jstatsoft.org/v51/i07/>

Examples

```
# toy example:
library(sp)
pts = SpatialPoints(cbind(c(0,1),c(0,1)))
Sys.setenv(TZ="GMT")
tm = seq(as.POSIXct("2012-11-25"), as.POSIXct("2012-11-30"), "1 day")
df = data.frame(a = c(NA,NA,2,3,NA,NA,NA,2,NA,NA,4,NA), b = c(NA,2,3,4,5,1,2,NA,NA,NA,NA,3))
x = STFDF(pts, tm, df)
as(x, "xts")
as(na.locf(x), "xts")
as(na.locf(x, fromLast = TRUE), "xts")
as(na.locf(na.locf(x), fromLast = TRUE), "xts")
# drops first record:
as(na.approx(x[,1]), "xts")
# keep it:
cbind(as(na.approx(x[,1], na.rm=FALSE), "xts"),
as(na.approx(x[,2]), "xts"))
cbind(as(na.spline(x[,1]), "xts"),
as(na.spline(x[,2]), "xts"))
#disaggregate:
xout = seq(start(x), end(x), "6 hours")
as(na.approx(x[,1], xout = xout), "xts")
as(na.spline(x[,1], xout = xout), "xts")
as(na.spline(x[,2], xout = xout), "xts")
```

```
# larger/real data:
data(air)
rural = STFDF(stations, dates, data.frame(PM10 = as.vector(air)))
# fill NA's with last non-NA
r = na.locf(rural)
# sample (NOT aggregate) to monthly:
m = seq(start(rural), end(rural), "1 month")
stplot(na.approx(rural[1:20,"2003::2005"], xout = m), mode = 'ts')
```

nbMult

convert a spatial nb object to a matching STF object

Description

convert a spatial nb object to a matching STF object

Usage

```
nbMult(nb, st, addT = TRUE, addST = FALSE)
```

Arguments

nb	object of class nb (see package spdep), which is valid for the spatial slot of object st: length(nb) should equal length(st@sp)
st	object of class STF
addT	logical; should temporal neighbours be added?
addST	logical; should spatio-temporal neighbours be added?

Details

if both addT and addST are false, only spatial neighbours are added for each time replicate.

details are found in

Giovana M. de Espindola, Edzer Pebesma, Gilberto Câmara, 2011. Spatio-temporal regression models for deforestation in the Brazilian Amazon. STDM 2011, The International Symposium on Spatial-Temporal Analysis and Data Mining, University College London - 18th-20th July 2011.

Value

object of class nb

Author(s)

Edzer Pebesma

Description

consistent spatio-temporal overlay for STF, STS and STI objects, as well as their *DF counterpart: retrieves the indexes or attributes from one geometry at the spatio-temporal points of another

Usage

```
## S4 method for signature 'STF,STF'
over(x, y, returnList = FALSE, fn = NULL, ...)
## S4 method for signature 'xts,xts'
over(x, y, returnList = FALSE, fn = NULL, ...)
## S4 method for signature 'ST'
aggregate(x, by, FUN, ..., simplify = TRUE)
```

Arguments

x	geometry (S/T locations) of the queries
y	layer from which the geometries or attributes are queried
returnList	logical; determines whether a list is returned, or an index vector
fn	(optional) a function; see value
by	geometry over which attributes in x are aggregated (this can be a Spatial* geometry, or a ST* geometry), or temporal aggregation, such as "month", "10 minutes", or a function such as as.yearmon ; see aggregate.zoo . In case x is of class STFDF , argument by may be "time" or "space", in which cases aggregation over all time or all space is carried out.
FUN	aggregation function
simplify	boolean; if TRUE, and space or time dimensions can be dropped, the simpler (Spatial or xts) object will be returned
...	arguments passed on to function fn or FUN

Value

an object of length `length(x)`, or a data.frame with number of rows equal to `length(x)`. If `returnList` is FALSE, a vector with indices of y for each geometry (point, grid cell centre, polygon or lines x time point) in x. if `returnList` is TRUE, a list of length `length(x)`, with list element i the vector of indices of the geometries in y that correspond to the *i*-th geometry in x.

The aggregate method for ST objects aggregates the attribute values of x over the geometry (space, time, or space-time) of by, using aggregation function FUN.

For the matching of time intervals, see [timeMatch](#).

For setting, or retrieving whether time represents intervals, see [timeIsInterval](#).

Methods

`x = "STF", y = "STF"`

`x = "xts", y = "xts"` finds the row index of the instance or interval of time instances of `x` matching to `y`. Only if `timeIsInterval(x) == TRUE`, intervals are sought. In that case, time intervals start at the time instance of a record, and end at the next. The last time interval length is set to the interval length of the one-but-last (non-zero) interval. In case of a single time instance for `y`, its interval is right-open.

Note

See also [over](#); methods intersecting `SpatialLines` with anything else, or `SpatialPolygons` with `SpatialPolygons`, need `geos` to be loaded first.

Author(s)

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

References

<https://www.jstatsoft.org/article/view/v051i07>

See Also

[over](#); [vignette\('sto'\)](#), [vignette\('over'\)](#), [timeMatch](#), [timeIsInterval](#)

read.tgrass

read or write tgrass (time-enabled grass) files

Description

read or write tgrass (time-enabled grass) files

Usage

```
read.tgrass(fname, localName = TRUE, useTempDir = TRUE, isGeoTiff = TRUE)
write.tgrass(obj, fname, ...)
```

Arguments

<code>fname</code>	file name to read from, or write to
<code>localName</code>	logical; if TRUE, <code>fname</code> is a local file, else it is a the full path name to the file
<code>useTempDir</code>	logical: use a temporary directory for extraction?
<code>isGeoTiff</code>	logical: are the files in the tar.gz file GeoTIFFs?
<code>obj</code>	object to export, of class <code>STFDF</code> or <code>RasterStack</code>
<code>...</code>	arguments passed on to writeRaster

Details

The tgrass format is a gzip'ed tar file (.tar.gz) that has geotiff files (with suffix .tif), and three files (list.txt, proj.txt and init.txt) describing the file names and time slices, coordinate reference system, and dimensions

Value

read.tgrass returns an object of class RasterStack, writetgrass returns nothing

Author(s)

Edzer Pebesma; time-enabled grass by Soeren Gebbert

References

<https://dx.doi.org/10.1016/j.envsoft.2013.11.001>

Examples

```
## Not run:
library(spacetime)
r = read.tgrass("precipitation_1950_2011_yearly.tar.gz", useTempDir = FALSE)
write.tgrass(r, "myfile.tar.gz")

## End(Not run)
```

ST-class

Class "ST"

Description

An abstract class from which useful spatio-temporal classes are derived

Usage

```
ST(sp, time, endTime)
```

Arguments

sp	an object deriving from class Spatial , such as a SpatialPoints or SpatialPolygons
time	an object of class xts, or a time vector (currently: Date, POSIXct, timeDate, yearmon and yearqtr; are supported; see xts); in the latter case, it should be in time order
endTime	vector of class POSIXct holding end points of time intervals

Objects from the Class

Objects of this class are not meant to be useful; only derived classes can be meaningful

Slots

sp: Object deriving from class "Spatial"

time: Object of class "xts"

Methods

`[[ signature(obj = "ST")`: retrieves the attribute element

`$ signature(obj = "ST")`: retrieves the attribute element

`[[<- signature(obj = "ST")`: sets or replaces the attribute element

`$<- signature(obj = "ST")`: sets or replaces the attribute element

Note

argument (and object slot) sp can be pure geometry, or geometry with attributes. In the latter case, the geometries are kept with the sp slot, and only replicated (when needed) on coercion to the long format, with `as.data.frame`.

Slot time needs to be of class xts; if a time or date vector is passed as argument to SP, it will be converted into an xts object.

When endTime is missing, an error is thrown.

ST is meant as a super-class, and is not to be used for representing data, similar to Spatial in the sp package.

Author(s)

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

References

<https://www.jstatsoft.org/v51/i07/>

Examples

```
time = as.Date('2008-01-01')+1:2
library(sp)
sp = SpatialPoints(cbind(c(0,1),c(0,1)))
ST(sp, time, delta(time))
```

stbox	<i>obtain ranges of space and time coordinates</i>
-------	--

Description

obtain ranges of space and time coordinates

Usage

```
stbox(obj)
bbox(obj)
```

Arguments

obj object of a class deriving from ST

Value

stbox returns a `data.frame`, with three columns representing x-, y- and time-coordinates, and two rows containing min and max values. bbox gives a matrix with coordinate min/max values, compatible to [bbox](#)

Methods

stbox signature(x = "ST"): obtain st range from object

stConstruct	<i>create ST* objects from long or wide tables</i>
-------------	--

Description

create ST* objects from long or wide tables

Usage

```
stConstruct(x, space, time, SpatialObj = NULL, TimeObj = NULL,
  crs = CRS(as.character(NA)), interval, endTime)
```

Arguments

<code>x</code>	object of class <code>matrix</code> or <code>data.frame</code> , holding the long, space-wide or time-wide table; see details.
<code>space</code>	in case <code>x</code> is a long table, character or integer holding the column index in <code>x</code> where the spatial coordinates are (if <code>length(space)==2</code>) or where the ID of the spatial location is (if <code>length(space)==1</code>). If <code>x</code> is a space-wide table, a list with each (named) list element a set of columns that together form a variable
<code>time</code>	in case <code>x</code> is a long table, character or integer indicating the column in <code>x</code> with times;
<code>SpatialObj</code>	object of class Spatial-class , containing the locations of a time-wide table, or the locations of a long table
<code>TimeObj</code>	in case of space-wide table, object of class xts , containing the times for each of the columns in a list element of <code>space</code>
<code>crs</code>	object of class CRS-class ; only used when coordinates are in <code>x</code> and no CRS can be taken from <code>SpatialObj</code>
<code>interval</code>	logical; specifies whether time should reflect time instance (FALSE) or time intervals (TRUE). If omitted, defaults values depend on the class
<code>endTime</code>	vector of <code>POSIXct</code> , specifying (if present) the end points of observation time intervals

Details

For examples, see below.

A long table is a `data.frame` with each row holding a single observation in space-time, and particular columns in this table indicate the space (location or location ID) and time.

A space-wide table is a table in which different columns refer to different locations, and each row reflects a particular observation time.

A time-wide table is a table where different times of a particular characteristic are represented as different columns; rows in the table represent particular locations or location IDs.

Value

Depending on the arguments, an object of class `STIDF` or `STFDF`.

References

<https://www.jstatsoft.org/v51/i07/>

Examples

```
# stConstruct multivariable, time-wide
if (require(maps) && require(plm) && require(sf)) {
  library(sp)

  states.m <- map('state', plot=FALSE, fill=TRUE)
  IDs <- sapply(strsplit(states.m$names, ":"), function(x) x[1])
```

```

sf = st_as_sf(states.m, IDs=IDs)
row.names(sf) = sf$ID # not needed if sf >= 1.0-13
states <- as(sf, "Spatial")
states=geometry(states)

yrs = 1970:1986
time = as.POSIXct(paste(yrs, "-01-01", sep=""), tz = "GMT")
data("Produc")
# deselect District of Columbia, polygon 8, which is not present in Produc:
Produc.st <- STFDF(states[-8], time, Produc[order(Produc[,2], Produc[,1]),])
# stplot(Produc.st[,,"unemp"], yrs, col.regions = brewer.pal(9, "YlOrRd"),cuts=9)

# example 1: st from long table, with states as Spatial object:
# use Date format for time:
Produc$time = as.Date(paste(yrs, "01", "01", sep = "-"))
# take centroids of states:
xy = coordinates(states[-8])
Produc$x = xy[,1]
Produc$y = xy[,2]
#using stConstruct, use polygon centroids for location:
x = stConstruct(Produc, c("x", "y"), "time", interval = TRUE)
class(x)
stplot(x[,,"unemp"])

# alternatively, pass states as SpatialObj:
Produc$state = gsub("TENNESSE", "TENNESSEE", Produc$state)
Produc$State = gsub("_", " ", tolower(Produc$state))
x = stConstruct(Produc, "State", "time", states)
class(x)
all.equal(x, Produc.st, check.attributes = FALSE)
}

if (require(sf)) {
  fname = system.file("shape/nc.shp", package="sf")[1]
  nc = as(st_read(fname), "Spatial")
  timesList = list(
    BIR=c("BIR74", "BIR79"), # sets of variables that belong together
    NWBIR=c("NWBIR74", "NWBIR79"), # only separated by space
    SID=c("SID74", "SID79")
  )
  t = as.Date(c("1974-01-01", "1979-01-01"))
  nc.st = stConstruct(as(nc, "data.frame"), geometry(nc), timesList,
    TimeObj = t, interval = TRUE)
}

# stConstruct multivariable, space-wide
if (require(gstat)) {
  data(wind)
  wind.loc$y = as.numeric(char2dms(as.character(wind.loc[["Latitude"]]))))
  wind.loc$x = as.numeric(char2dms(as.character(wind.loc[["Longitude"]]))))
  coordinates(wind.loc) = ~x+y
  proj4string(wind.loc) = "+proj=longlat +datum=WGS84"
}

```

```

# match station order to names in wide table:
stations = 4:15
wind.loc = wind.loc[match(names(wind[stations]), wind.loc$Code),]
row.names(wind.loc) = wind.loc$Station
# convert to utm zone 29, to be able to do interpolation in
# proper Euclidian (projected) space:

# create time variable
wind$time = ISOdate(wind$year+1900, wind$month, wind$day, 0)

w = STFDF(wind.loc, wind$time,
data.frame(values = as.vector(t(wind[stations]))))
space = list(values = names(wind)[stations])
wind.st = stConstruct(wind[stations], space, wind$time, SpatialObj = wind.loc, interval = TRUE)
all.equal(w, wind.st)
class(wind.st)
}

```

STFDF-class

*Class "STFDF"***Description**

A class for spatio-temporal data with full space-time grid; for n spatial locations and m times, $n \times m$ observations are available

Usage

```

STF(sp, time, endTime = delta(time))
STFDF(sp, time, data, endTime = delta(time))
## S4 method for signature 'STFDF'
x[i, j, ..., drop = is(x, "STFDF")]
## S4 method for signature 'STFDF,xts'
coerce(from, to, strict=TRUE)
## S4 method for signature 'STFDF,Spatial'
coerce(from, to)

```

Arguments

sp	object of class Spatial , having n elements
time	object holding time information, of length m ; see ST for details
endTime	vector of class <code>POSIXct</code> , holding end points of time intervals; by default, time intervals equal the time step width, see delta
data	data frame with $n \times m$ rows corresponding to the observations (spatial index moving fastest)
x	an object of class <code>STFDF</code>
i	selection of spatial entities

<code>j</code>	selection of temporal entities (see syntax in package <code>xts</code>)
<code>...</code>	selection of attribute(s)
<code>drop</code>	if TRUE and a single spatial entity is selected, an object of class <code>xts</code> is returned; if TRUE and a single temporal entity is selected, and object of the appropriate <code>Spatial</code> class is returned; if FALSE, no coercion to reduced classes takes place
<code>from</code>	object of class STFDF
<code>to</code>	target class
<code>strict</code>	ignored

Value

the `as.data.frame` coercion returns the full long table, with purely spatial attributes and purely time attributes replicated appropriately.

Objects from the Class

Objects of this class represent full space/time data with a full grid (or lattice) layout

Slots

`sp`: spatial object; see [ST-class](#)

`time`: temporal object; see [ST-class](#)

`data`: Object of class `data.frame`, which holds the measured values; space index cycling first, time order preserved

Methods

[`signature(x = "STFDF")`]: selects spatial entities, temporal entities, and attributes

coerce STFDF,xts

coerce STFDF,Spatial(from) coerces to (wide form) `SpatialXxDataFrame`, where `SpatialXx` is the spatial class of `from@sp`

plot `signature(x = "STF", y = "missing")`: plots space-time layout

plot `signature(x = "STFDF", y = "missing")`: plots space-time layout, indicating full missing valued records

Author(s)

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

References

<https://www.jstatsoft.org/v51/i07/>

Examples

```

sp = cbind(x = c(0,0,1), y = c(0,1,1))
row.names(sp) = paste("point", 1:nrow(sp), sep="")
library(sp)
sp = SpatialPoints(sp)
time = as.POSIXct("2010-08-05")+3600*(10:13)
m = c(10,20,30) # means for each of the 3 point locations
mydata = rnorm(length(sp)*length(time),mean=rep(m, 4))
IDs = paste("ID",1:length(mydata))
mydata = data.frame(values = signif(mydata,3), ID=IDs)
stfdf = STIDF(sp, time, mydata)
stfdf
stfdf[1:2,]
stfdf[,1:2]
stfdf[,2]
stfdf[,,"values"]
stfdf[1,]
stfdf[,2]
as(stfdf[,1], "xts")
as(stfdf[,2], "xts")
# examples for [[, [[<-, $ and $<-
stfdf[[1]]
stfdf[["values"]]
stfdf[["newVal"]] <- rnorm(12)
stfdf$ID
stfdf$ID = paste("OldIDs", 1:12, sep="")
stfdf$NewID = paste("NewIDs", 12:1, sep="")
stfdf
x = stfdf[stfdf[1:2,],]
all.equal(x, stfdf[1:2,])
all.equal(stfdf, stfdf[stfdf,]) # converts character to factor...

```

STIDF-class

Class "STIDF"

Description

A class for unstructured spatio-temporal data; for n spatial locations and times, n observations are available

Usage

```

STI(sp, time, endTime)
STIDF(sp, time, data, endTime)
## S4 method for signature 'STIDF'
x[i, j, ..., drop = FALSE]
## S4 method for signature 'STIDF,STSDF'
coerce(from, to, strict=TRUE)

```

Arguments

<code>sp</code>	object of class Spatial
<code>time</code>	object holding time information; when STIDF is called, a non-ordered vector with times, e.g. POSIXct will also work, and rearrange the <code>sp</code> and <code>data</code> slots according to the ordering of time; for this to work no ties should exist.
<code>endTime</code>	vector of class <code>POSIXct</code> , indicating the end points of time intervals for the observations. By default, for <code>STI</code> objects <code>time</code> is taken, indicating that time intervals have zero width (time instances)
<code>data</code>	data frame with appropriate number of rows
<code>x</code>	an object of class <code>STFDF</code>
<code>i</code>	selection of record index (spatial/temporal/spatio-temporal entities)
<code>j</code>	or character string with temporal selection
<code>...</code>	first element is taken as column (variable) selector
<code>drop</code>	if <code>TRUE</code> and a single spatial entity is selected, an object of class xts is returned (NOT yet implemented); if <code>TRUE</code> and a single temporal entity is selected, and object of the appropriate <code>Spatial</code> class is returned; if <code>FALSE</code> , no coercion to reduced classes takes place
<code>from</code>	object of class <code>STFDF</code>
<code>to</code>	target class
<code>strict</code>	ignored

Objects from the Class

Objects of this class carry full space/time grid data

Slots

`sp`: Object of class "Spatial"
`time`: Object holding time information, see [ST-class](#)
`data`: Object of class `data.frame`, which holds the measured values

Methods

[`signature(x = "STIDF")`]: selects spatial-temporal entities, and attributes

Note

arguments `sp`, `time` and `data` need to have the same number of records, and regardless of the class of time (`xts` or `POSIXct`) have to be in corresponding order: the triple `sp[i]`, `time[i]` and `data[i,]` refer to the same observation

Author(s)

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

References

<https://www.jstatsoft.org/v51/i07/>

Examples

```
sp = cbind(x = c(0,0,1), y = c(0,1,1))
row.names(sp) = paste("point", 1:nrow(sp), sep="")
library(sp)
sp = SpatialPoints(sp)
time = as.POSIXct("2010-08-05")+3600*(10:13)
m = c(10,20,30) # means for each of the 3 point locations
mydata = rnorm(length(sp)*length(time),mean=rep(m, 4))
IDs = paste("ID",1:length(mydata))
mydata = data.frame(values = signif(mydata,3), ID=IDs)
stidf = as(STFDF(sp, time, mydata), "STIDF")
stidf[1:2,]
all.equal(stidf, stidf[stidf,])
```

stInteraction

subtract marginal (spatial and temporal) means from observations

Description

subtract marginal (spatial and temporal) means from observations

Usage

```
stInteraction(x, ...)
```

Arguments

x object of class STFDF
... arguments passed to [rowMeans](#), [colMeans](#) and [mean](#), such as `na.rm=TRUE`

Value

object of class [STFDF](#) with each attribute replaced by its residual, computed by $y_{ij} = x_{ij} - m_{.j}m_{i.}/m$ with m the grand mean, $m_{.j}$ the temporal mean, $m_{i.}$ the spatial mean and m the grand mean.

Examples

```
if (require(gstat)) {
  library(sp)
  data(wind)
  wind.loc$y = as.numeric(char2dms(as.character(wind.loc[["Latitude"]])))
  wind.loc$x = as.numeric(char2dms(as.character(wind.loc[["Longitude"]])))
  coordinates(wind.loc) = ~x+y
```

```

proj4string(wind.loc) = "+proj=longlat +datum=WGS84"
# match station order to names in wide table:
stations = 4:15
wind.loc = wind.loc[match(names(wind[stations]), wind.loc$Code),]
row.names(wind.loc) = wind.loc$Station
wind$time = ISOdate(wind$year+1900, wind$month, wind$day, 0)
space = list(values = names(wind)[stations])
wind.st = stConstruct(wind[stations], space, wind$time, SpatialObj = wind.loc)

wind.sti = stInteraction(wind.st)
# temporal means for any station should be zero:
c(mean(wind.sti[3,]),
# spatial mean for each time step should be zero:
mean(wind.sti[,5][[1]]))
}

```

stplot

produce trellis plot for STxDF object

Description

create trellis plot for ST objects

Usage

```

stplot(obj, ...)
stplot.STFDF(obj, names.attr = trimDates(obj), ...,
as.table = TRUE, at, cuts = 15, scales = list(draw = FALSE),
animate = 0, mode = "xy", scaleX = 0, auto.key = list(space = key.space),
main, key.space = "right", type = "l", do.repeat = TRUE, range.expand = 0.001)
stplot.STIDF(obj, ..., names.attr = NULL, as.table = TRUE,
scales = list(draw = FALSE), xlab = NULL, ylab = NULL,
type = "p", number = 6, tcuts, sp.layout = NULL, xlim =
bbox(obj)[1, ], ylim = bbox(obj)[2, ])

```

Arguments

obj	object of a class deriving from ST
names.attr	names that will be used in the strip; trimDates(obj) trims "-01" ending(s) from printed Dates
as.table	logical; if TRUE, time will increase from top to bottom; if FALSE, time will increase from bottom to top
at	values at which colours will change; see levelplot
cuts	number of levels the range of the attribute would be divided into

<code>animate</code>	numeric; if larger than 0, the number of seconds between subsequent animated time steps (loop; press ctrl-C or Esc to stop)
<code>mode</code>	plotting mode; if "xy", maps for time steps are plotted; if "xt", a space-time plot is constructed (see argument <code>scaleX</code> , but read details below); if "ts", multiple-locations time series are plotted in a single plot, or in a separate panel for each attribute; if "tp" single- or multi-attribute time series are plotted in multiple panels, one panel per location.
<code>scaleX</code>	integer: 0, 1 or 2; when mode is "xt", used to determine whether the index of the spatial location is shown (0), the x coordinate (1) or the y coordinate (2).
<code>auto.key</code>	see the <code>auto.key</code> argument in xyplot
<code>main</code>	character; plot title, use NULL to omit title
<code>key.space</code>	character; see xyplot
<code>scales</code>	scales drawing; see <code>scales</code> argument of xyplot
<code>xlab</code>	x-axis label
<code>ylab</code>	y-axis label
<code>type</code>	character; use 'l' for lines, 'p' for symbols, 'b' for both lines and symbols
<code>do.repeat</code>	logical; repeat the animation in an infinite loop?
<code>range.expand</code>	numeric; if <code>at</code> is not specified, expand the data range with this factor to cover all values
<code>number</code>	number of time intervals, equally spaced
<code>tcuts</code>	time cuts in units of <code>index(obj)</code> ; this overrides <code>number</code>
<code>sp.layout</code>	list or NULL; see spplot
<code>...</code>	arguments passed on to spplot in case of plotting objects of class STFDF or STIDF, or to xyplot in case of <code>stplot.STIDF</code>
<code>xlim</code>	numeric, x range
<code>ylim</code>	numeric, y range

Value

In non-animation and "xy" mode, `stplot` is a wrapper around [spplot](#), that automatically plots each time stamp in a panel. The returned value is a lattice plot.

In "xt" mode, a space-time plot with space on the x-axis and time on the y-axis is plotted. By default, the space ID is plotted on the x-axis, as space can be anything (points, polygons, grid cells etc). When `scaleX` is set to 1 or 2, the x- resp. y-coordinates of the spatial locations, obtained by [coordinates](#), is used instead. Beware: when the x-coordinate is plotted, and for each (x,t) element multiple y-coordinates are sent to the plot, it is not clear which (x,y,t) value becomes the plotted value, so slicing single y values is advised – no checking is done. The returned value is a lattice plot.

In animation mode (`animate > 0`), single maps are animated in an endless loop, with `animate` seconds between each. No proper value is returned: the loop needs to be interrupted by the user.

Methods

stplot signature(x = "STFDF"): plots object of class [STFDF](#)

stplot signature(x = "STSDf"): plots object of class [STSDf](#)

stplot signature(x = "STI"): plots object of class [STI](#)

stplot signature(x = "STIDf"): plots object of class [STIDf](#)

stplot signature(x = "STT"): plots object of class [STT](#)

stplot signature(x = "STTDF"): plots object of class [STTDF](#)

Note

vignette("spacetime") contains several examples

References

<https://www.jstatsoft.org/v51/i07/>

STSDf-class	<i>Class "STSDf"</i>
-------------	----------------------

Description

A class for spatio-temporal data with partial space-time grids; for n spatial locations and m times, an index table is kept for which nodes observations are available

Usage

```
STS(sp, time, index, endTime = delta(time))
STSDf(sp, time, data, index, endTime = delta(time))
## S4 method for signature 'STSDf'
x[i, j, ..., drop = is(x, "STSDf")]
## S4 method for signature 'STSDf,STFDF'
coerce(from, to, strict=TRUE)
## S4 method for signature 'STSDf,STIDf'
coerce(from, to, strict=TRUE)
```

Arguments

sp	object of class Spatial
time	object holding time information; see ST-class
data	data frame with rows corresponding to the observations (spatial index moving faster than temporal)
index	two-column matrix: rows corresponding to the nodes for which observations are available, first column giving spatial index, second column giving temporal index

<code>endTime</code>	vector of class <code>POSIXct</code> with end points of time intervals for the observations
<code>x</code>	an object of class <code>STFDF</code>
<code>i</code>	selection of spatial entities
<code>j</code>	selection of temporal entities (see syntax in package <code>xts</code>)
<code>...</code>	selection of attribute(s)
<code>drop</code>	if <code>TRUE</code> and a single spatial entity is selected, an object of class <code>xts</code> is returned; if <code>TRUE</code> and a single temporal entity is selected, an object of the appropriate <code>Spatial</code> class is returned; if <code>FALSE</code> , no coercion to reduced classes takes place
<code>from</code>	object of class <code>STFDF</code>
<code>to</code>	target class
<code>strict</code>	ignored

Objects from the Class

Objects of this class carry sparse space/time grid data

Slots

`sp`: Object of class `"Spatial"`

`time`: Object holding time information; see [ST-class](#) for permitted types

`index`: matrix of dimension $n \times 2$, where n matches the number of rows in slot data

`data`: Object of class `data.frame`, which holds the measured values

Methods

`[ signature(x = "STSDf")`: selects spatial entities, temporal entities, and attributes

plot `signature(x = "STS", y = "missing")`: plots space-time layout

plot `signature(x = "STSDf", y = "missing")`: plots space-time layout, indicating records partially NA

Author(s)

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

References

<https://www.jstatsoft.org/v51/i07/>

See Also

[delta](#)

Examples

```

sp = cbind(x = c(0,0,1), y = c(0,1,1))
row.names(sp) = paste("point", 1:nrow(sp), sep="")
library(sp)
sp = SpatialPoints(sp)
library(xts)
time = xts(1:4, as.POSIXct("2010-08-05")+3600*(10:13))
m = c(10,20,30) # means for each of the 3 point locations
mydata = rnorm(length(sp)*length(time),mean=rep(m, 4))
IDs = paste("ID",1:length(mydata))
mydata = data.frame(values = signif(mydata,3), ID=IDs)
stfdf = STTDF(sp, time, mydata)
stfdf
stsd = as(stfdf, "STSD")
stsd[1:2,]
stsd[,1:2]
stsd[,2]
stsd[, "values"]
stsd[1,]
stsd[,2]
# examples for [[, [[<-, $ and $<-
stsd[[1]]
stsd[["values"]]
stsd[["newVal"]] <- rnorm(12)
stsd$ID
stsd$ID = paste("OldIDs", 1:12, sep="")
stsd$newID = paste("NewIDs", 12:1, sep="")
stsd
x = stsd[stsd[,]]
x = stsd[stsd[1:2,],]
all.equal(x, stsd[1:2,])

```

STTDF-class

Class "STTDF"

Description

A class for spatio-temporal trajectory data

Usage

```

## S4 method for signature 'STTDF,ltraj'
coerce(from, to, strict=TRUE)
## S4 method for signature 'ltraj,STTDF'
coerce(from, to, strict=TRUE)

```

Arguments

from from object

to	target class
strict	ignored

Objects from the Class

Objects of this class carry sparse (irregular) space/time data

Slots

sp: Object of class "Spatial", containing the bounding box of all trajectories
time: Object of class "xts", containing the temporal bounding box of all trajectories
traj: Object of class list, each element holding an [STI](#) object reflecting a single trajectory;
data: Object of class data.frame, which holds the data values for each feature in each trajectory

Methods

[signature(x = "STTDF"): select trajectories, based on index, or spatial and/or temporal predicates

Note

The data.frame needs to have a column called burst which is a factor (or character) and contains the grouping of observations that come from a continuous sequence of observations. In addition, a column id is used to identify individual items.

Author(s)

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

References

<https://www.jstatsoft.org/v51/i07/>

Examples

```
library(sp)
m = 3# nr of trajectories
n = 100 # length of each
l = vector("list", m)
t0 = as.POSIXct("2013-05-05", tz="GMT")
set.seed(1331) # fix randomness
for (i in 1:m) {
  x = cumsum(rnorm(n))
  y = cumsum(rnorm(n))
  sp = SpatialPoints(cbind(x,y))
  #t = t0 + (0:(n-1) + (i-1)*n) * 60
  t = t0 + (0:(n-1) + (i-1)*n/2) * 60
  l[[i]] = STI(sp, t)
}
stt= STT(l)
```

```

sttdf = STTDF(stt, data.frame(attr = rnorm(n*m), id = paste("ID", rep(1:m, each=n))))
x = as(stt, "STI")
stplot(sttdf, col=1:m, scales=list(draw=TRUE))
stplot(sttdf, by = "id")
stplot(sttdf[1])
stplot(sttdf[1])

# select a trajectory that intersect with a polygon
p = Polygon(cbind(x=c(-20,-15,-15,-20,-20),y=c(10,10,15,15,10)))
pol=SpatialPolygons(list(Polygons(list(p), "ID")))
#if (require(rgeos)) {
#  stplot(sttdf[pol])
#  names(sttdf[pol]@traj)
#  stplot(sttdf[1:2],col=1:2)
#  stplot(sttdf[,t0])
#  stplot(sttdf[, "2013"])
#  stplot(sttdf[pol, "2013"])
#  is.null(sttdf[pol,t0])
#}

```

timeIsInterval	<i>retrieve, or set, information whether time reflects instance (FALSE) or intervals (TRUE)</i>
----------------	---

Description

retrieve, or set, information whether time reflects instance (FALSE) or intervals (TRUE)

Usage

```

timeIsInterval(x, ...)
timeIsInterval(x) <- value

```

Arguments

x	object, of any class
...	ignored
value	logical; sets the timeIsInterval value

Value

logical; this function sets or retrieves the attribute timeIsInterval of x, UNLESS x is of class ST, in which case it sets or retrieves this attribute for the time slot of the object, i.e. timeIsInterval(x@time) <- value

Note

From spacetime 0.8-0 on, timeIsInterval is dropped in favour of a more generic time intervals by specifying endTime of each observation

See Also

[over](#), [timeIsInterval](#)

timeMatch	<i>match two (time) sequences</i>
-----------	-----------------------------------

Description

match two (time) sequences, where each can be intervals or instances.

Usage

```
timeMatch(x, y, returnList = FALSE, ...)
```

Arguments

x	ordered sequence, e.g. of time stamps
y	ordered sequence, e.g. of time stamps
returnList	boolean; should a list be returned with all matches (TRUE), or a vector with single matches (FALSE)?
...	end.x and end.y can be specified for xts and POSIXct methods

Details

When x and y are of class xts or POSIXct, end.x and end.y need to specify endpoint of intervals.

In case x and y are both not intervals, matching is done on equality of values, using [match](#).

If x represents intervals, then the first interval is from x[1] to x[2], with x[1] included but x[2] not (left-closed, right-open). In case of zero-width intervals (e.g. x[1]==x[2]), nothing will match and a warning is raised. Package intervals is used to check overlap of intervals, using, [interval_overlap](#).

Value

if returnList = FALSE: integer vector of length length(x) with indexes of y matching to each of the elements of x, or NA if there is no match. See section details for definition of match.

if returnList = TRUE: list of length length(x), with each list element an integer vector with all the indexes of y matching to that element of x.

Author(s)

Edzer Pebesma

References

<https://www.jstatsoft.org/v51/i07/>

See Also

[over](#), [timeIsInterval](#), [interval_overlap](#)

Examples

```
t0 = as.POSIXct("1999-10-10")
x = t0 + c(0.5+c(2,2.1,4),5)*3600
y = t0 + 1:5 * 3600
x
y
#timeIsInterval(x) = FALSE
#timeIsInterval(y) = FALSE
timeMatch(x,y, returnList = FALSE)
timeMatch(x,y, returnList = TRUE)
#timeIsInterval(y) = TRUE
timeMatch(x,y, returnList = FALSE, end.y = delta(y))
timeMatch(x,y, returnList = TRUE, end.y = delta(y))
#timeIsInterval(x) = TRUE
timeMatch(x,y, returnList = FALSE, end.x = delta(x), end.y = delta(y))
timeMatch(x,y, returnList = TRUE, end.x = delta(x), end.y = delta(y))
#timeIsInterval(y) = FALSE
timeMatch(x,y, returnList = FALSE, end.x = delta(x))
timeMatch(x,y, returnList = TRUE, end.x = delta(x))

x = as.POSIXct("2000-01-01") + (0:9) * 3600
y = x + 1
y[1] = y[2]
x
y
TI = function(x, ti) {
  timeIsInterval(x) = ti
  x
}
#timeMatch(TI(y,FALSE),TI(y,FALSE))
#timeMatch(TI(y,TRUE), TI(y,TRUE))
#
#timeMatch(TI(x,FALSE),TI(y,FALSE))
#timeMatch(TI(x,FALSE),TI(y,TRUE))
#timeMatch(TI(x,TRUE), TI(y,FALSE))
#timeMatch(TI(x,TRUE), TI(y,TRUE))
#
#timeMatch(TI(x,FALSE),TI(y,FALSE), returnList = TRUE)
#timeMatch(TI(x,FALSE),TI(y,TRUE), returnList = TRUE)
#timeMatch(TI(x,TRUE), TI(y,FALSE), returnList = TRUE)
#timeMatch(TI(x,TRUE), TI(y,TRUE), returnList = TRUE)
```

Description

create table forms of STFDF objects

Usage

```
## S3 method for class 'STFDF'
unstack(x, form, which = 1, ...)
## S3 method for class 'STFDF'
as.data.frame(x, row.names, ...)
```

Arguments

<code>x</code>	object of class STFDF
<code>form</code>	formula; can be omitted
<code>which</code>	column name or number to have unstacked
<code>row.names</code>	row.names for the data.frame returned
<code>...</code>	arguments passed on to the functions unstack or as.data.frame

Value

`unstack` returns the data in wide format, with each row representing a spatial entity and each column a time; see [unstack](#) for details and default behaviour.

`as.data.frame` returns the data.frame in long format, where the coordinates of the spatial locations (or line starting coordinates, or polygon center points) and time stamps are recycled accordingly.

Examples

```
sp = cbind(x = c(0,0,1), y = c(0,1,1))
row.names(sp) = paste("point", 1:nrow(sp), sep="")
library(sp)
sp = SpatialPoints(sp)
library(xts)
time = xts(1:4, as.POSIXct("2010-08-05")+3600*(10:13))
m = c(10,20,30) # means for each of the 3 point locations
mydata = rnorm(length(sp)*length(time),mean=rep(m, 4))
IDs = paste("ID",1:length(mydata))
mydata = data.frame(values = signif(mydata,3), ID=IDs)
stfdf = STFDF(sp, time, mydata)
as.data.frame(stfdf, row.names = IDs)
unstack(stfdf)
t(unstack(stfdf))
unstack(stfdf, which = 2)
```

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