

Package ‘spDates’

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Title Analysis of Spatial Gradients in Radiocarbon Dates

Version 1.1

Description Inspired by space-time regressions often performed to assess the expansion of the Neolithic from the Near East to Europe (Pinhasi et al. 2005 <[doi:10.1371/journal.pbio.0030410](https://doi.org/10.1371/journal.pbio.0030410)>). Test for significant correlations between the (earliest) radiocarbon dates of archaeological sites and their respective distances from a hypothetical center of origin. Both ordinary least squares (OLS) and reduced major axis (RMA) methods are supported (Russell et al. 2014 <[doi:10.1371/journal.pone.0087854](https://doi.org/10.1371/journal.pone.0087854)>). It is also possible to iterate over many sites to identify the most likely origin.

Depends R (>= 3.5.0), rcarbon

Imports data.table, dplyr, ggplot2, parallel, raster, smatr, viridisLite, magrittr, rlang, sp, gstat

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centers	<i>Coordinates of 9 sites considered as potential centers of origin of the Neolithic expansion. Modified from Pinhasi et al. (2005).</i>
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Description

Coordinates of 9 sites considered as potential centers of origin of the Neolithic expansion. Modified from Pinhasi et al. (2005).

Usage

centers

Format

A data frame with 9 rows and 3 variables.

- Latitude. Site latitude in decimal degrees.
- Longitude. Site longitude in decimal degrees.
- Site. Site name.

filterDates	<i>Filter archaeological site coordinates and dates, retaining only the earliest radiocarbon date per site.</i>
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Description

Filter archaeological site coordinates and dates, retaining only the earliest radiocarbon date per site.

Usage

```
filterDates(sites, c14bp)
```

Arguments

sites	A SpatialPointsDataFrame object with archaeological sites and associated radiocarbon ages.
c14bp	A string. Name of the field with the radiocarbon ages in C14 BP format.

Value

A SpatialPointsDataFrame object with the earliest C14 date for every site.

interpolateIDW	<i>Interpolate using inverse distance weighting.</i>
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Description

Interpolate using inverse distance weighting.

Usage

```
interpolateIDW(points, attr)
```

Arguments

points	A SpatialPointsDataFrame object.
attr	A string. Name of the field with values to interpolate.

Value

A RasterLayer.

iterateSites	<i>Perform regression of dates versus distances from multiple potential origins in order to find the best model. It is also possible to specify multiple distances for the spatial binning of the dates.</i>
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Description

Perform regression of dates versus distances from multiple potential origins in order to find the best model. It is also possible to specify multiple distances for the spatial binning of the dates.

Usage

```
iterateSites(
  ftrSites,
  c14bp,
  origins,
  siteNames,
  binWidths = 0,
  nsim = 999,
  method = "rma",
  ncores = 1
)
```

Arguments

<code>ftrSites</code>	A <code>SpatialPointsDataFrame</code> object with associated earliest C14 dates per site and respective calibrated distributions (<code>CalDates</code> objects) in a field named "cal".
<code>c14bp</code>	A string. Name of the field with the radiocarbon ages in C14 BP format.
<code>origins</code>	A <code>SpatialPointsDataFrame</code> object. The sites to be tested for the most likely origin of expansion.
<code>siteNames</code>	A string. Name of the field with the site names or ids for the potential origins.
<code>binWidths</code>	A number or vector of numbers. Width(s) of the spatial bins in km.
<code>nsim</code>	A number. Number of simulations to be run during the bootstrapping procedure. Default is 999.
<code>method</code>	A string. Method to be used in the regression. One of "rma" or "ols". Default is "rma".
<code>ncores</code>	A number. Number of cores used for parallel processing. Default is 1.

Value

a list with two elements, the result of the iteration over all potential origins and the best model selected among those.

Examples

```
data(neof)
data(centers)
iter <- iterateSites(neof, "C14Age", centers, "Site", binWidths=500)
```

<code>land</code>	<i>Land polygons.</i>
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Description

Land polygons.

Usage

```
land
```

Format

A `SpatialPolygonsDataFrame` object.

modelDates	<i>Perform regression of archaeological dates on great circle distances from a hypothetical origin. Dates can be filtered to retain only the earliest dates per distance bins (Hamilton and Buchanan 2007). Bootstrap is executed to account for uncertainty in calibrated dates. Regression can be either reduced major axis or ordinary least squares. If using ordinary least squares, regression is performed both on time-versus-distance and on distance-versus-time.</i>
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Description

Perform regression of archaeological dates on great circle distances from a hypothetical origin. Dates can be filtered to retain only the earliest dates per distance bins (Hamilton and Buchanan 2007). Bootstrap is executed to account for uncertainty in calibrated dates. Regression can be either reduced major axis or ordinary least squares. If using ordinary least squares, regression is performed both on time-versus-distance and on distance-versus-time.

Usage

```
modelDates(
  ftrSites,
  c14bp,
  origin,
  binWidth = 0,
  nsim = 999,
  method = "rma",
  ncores = 1
)
```

Arguments

ftrSites	A SpatialPointsDataFrame object with associated earliest C14 dates per site and respective calibrated distributions (CalDates objects) in a field named "cal". Result of applying filterDates() and calAll().
c14bp	A string. Name of the field with the radiocarbon ages in C14 BP format.
origin	A SpatialPointsDataFrame object. The site considered as hypothetical origin of expansion.
binWidth	A number. Width of the spatial bins in km, calculated as distance intervals from the hypothetical origin. Default is 0 (no bins).
nsim	A number. Number of simulations to be run during the bootstrapping procedure. Default is 999.
method	A string. Method to be used in the regression. One of "rma" or "ols". Default is "rma".
ncores	A number. Number of cores used for parallel processing. Default is 1.

Value

a dateModel object.

Examples

```
data(neof)
data(centers)
jericho <- centers[centers$Site=="Jericho",]
model <- modelDates(neof, "C14Age", jericho, method="ols")
```

neof	<i>Radiocarbon dates and coordinates of 717 Neolithic sites in the Near East and Europe. Modified from Pinhasi et al. (2005). Only the earliest dates per site are included.</i>
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Description

Radiocarbon dates and coordinates of 717 Neolithic sites in the Near East and Europe. Modified from Pinhasi et al. (2005). Only the earliest dates per site are included.

Usage

```
neof
```

Format

A data frame with 717 rows and 13 variables.

- Latitude. Site latitude in decimal degrees.
- Longitude. Site longitude in decimal degrees.
- Site. Site name.
- Location. Region where the site is located (Near East, Europe etc).
- Country. Country where the site is located.
- Period. Site period or culture (PPNA, PPNB, LBK etc.).
- LabNumber. Laboratory number of the C14 date.
- C14Age. Date in C14 years BP.
- C14SD. Standard error of the radiocarbon date.
- Material. Material dated (Charcoal, shell etc.).
- Curve. Curve to be used in the calibration of each date (intcal13, marine13).
- cal. Calibrated dates as CalDates objects.
- med. Median of the calibrated date in cal yr BP.

plot.dateMap	<i>Plot a map with the results of the iteration over multiple sites, showing an interpolated surface of r values for the sites considered as potential origins.</i>
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Description

Plot a map with the results of the iteration over multiple sites, showing an interpolated surface of r values for the sites considered as potential origins.

Usage

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

Arguments

x	a dateMap object. One of the list elements returned from the iterateSites() function.
...	ignored

Value

a spplot object.

plot.dateModel	<i>Plot the results of the regression bootstrap on archaeological dates versus distances from a hypothetical origin, with fitted lines.</i>
----------------	---

Description

Plot the results of the regression bootstrap on archaeological dates versus distances from a hypothetical origin, with fitted lines.

Usage

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

Arguments

x	a dateModel object created with modelDates().
...	ignored

Value

a ggplot object.

sampleCalDates	<i>Extract a single year estimate for ranges of calibrated dates with a probability given by the calibrated probability distribution.</i>
----------------	---

Description

Extract a single year estimate for ranges of calibrated dates with a probability given by the calibrated probability distribution.

Usage

```
sampleCalDates(calDates)
```

Arguments

calDates	A CalDates object or a vector of CalDates.
----------	--

Value

A vector of cal BP single year estimates.

summary.dateModel	<i>Return summary statistics for a dateModel object.</i>
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Description

Return summary statistics for a dateModel object.

Usage

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

Arguments

object	A dateModel object created with modelDates().
...	ignored

Value

A dataframe with estimated start date and speed of advance.

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