

# Package ‘spDates’

October 8, 2020

**Title** Analysis of Spatial Gradients in Radiocarbon Dates

**Version** 1.0

**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>). Test for significant correlations between the (earliest) radiocarbon dates of archaeological sites and their respective distances from a hypothetical center of origin. Distances can be either great-circle or least-cost paths calculated from a friction surface. Both ordinary least squares (OLS) and reduced major axis (RMA) methods are supported (Russell et al. 2014 <doi: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, gdistance, ggplot2, parallel, raster, smatr, viridisLite, magrittr, rlang, sp, gstat

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**RoxygenNote** 7.1.1

**NeedsCompilation** no

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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.

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cost	<i>Cost surface to calculate shortest paths (least-cost paths) of Neolithic expansion from the Near East to Europe. Values are 1 (easiest, coast), 2 (land below 1750 m) and 3 (hardest, ocean and land above 1750 m).</i>
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### Description

Cost surface to calculate shortest paths (least-cost paths) of Neolithic expansion from the Near East to Europe. Values are 1 (easiest, coast), 2 (land below 1750 m) and 3 (hardest, ocean and land above 1750 m).

### Usage

cost

**Format**

A RasterLayer object.

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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.

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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.

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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,
  cost = NULL,
  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".
c14bp	A string. Name of the field with the radiocarbon ages in C14 BP format.
origins	A SpatialPointsDataFrame object. The sites to be tested for the most likely origin of expansion.
siteNames	A string. Name of the field with the site names or ids for the potential origins.
binWidths	A number or vector of numbers. Width(s) of the spatial bins in km.
nsim	A number. Number of simulations to be run during the bootstrapping procedure. Default is 999.
cost	Optional. A RasterLayer with friction values to calculate least cost path distances instead of great circle distances.
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 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)
```

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

Land polygons.

**Usage**

land

**Format**

A SpatialPolygonsDataFrame object.

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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. If a cost surface is provided, distances are calculated using least cost paths instead of great circle distances. 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. If a cost surface is provided, distances are calculated using least cost paths instead of great circle distances. 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,
  cost = NULL,
  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". Result of applying <code>filterDates()</code> and <code>calAll()</code> .
<code>c14bp</code>	A string. Name of the field with the radiocarbon ages in C14 BP format.
<code>origin</code>	A <code>SpatialPointsDataFrame</code> object. The site considered as hypothetical origin of expansion.
<code>binWidth</code>	A number. Width of the spatial bins in km, calculated as distance intervals from the hypothetical origin. Default is 0 (no bins).
<code>nsim</code>	A number. Number of simulations to be run during the bootstrapping procedure. Default is 999.
<code>cost</code>	Optional. A <code>RasterLayer</code> with friction values to calculate least cost path distances instead of great circle distances.
<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 `dateModel` object.

**Examples**

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

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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.

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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 splot object.

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



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

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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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