Package ‘shoredate’

June 3, 2023

Type Package

Title Shoreline Dating Coastal Stone Age Sites

Version 1.1.0

Description Provides tools for shoreline dating coastal Stone Age sites. The implemented method was developed in Roalkvam (2023) <doi:10.1016/j.quascirev.2022.107880> for the Norwegian Skagerrak coast. Although it can be extended to other areas, this also forms the core area for application of the package. Shoreline dating is based on the present-day elevation of a site, a reconstruction of past relative sea-level change, and empirically derived estimates of the likely elevation of the sites above the contemporaneous sea-level when they were in use. The geographical and temporal coverage of the method thus follows from the availability of local geological reconstructions of shoreline displacement and the degree to which the settlements to be dated have been located on or close to the shoreline when they were in use. Methods for numerical treatment and visualisation of the dates are provided, along with basic tools for visualising and evaluating the location of sites.

Language en-US

License GPL (>= 3)


BugReports https://github.com/isakro/shoredate/issues

Encoding UTF-8

RoxygenNote 7.2.1

Imports ggplot2, ggrepel, ggridges, ggspatial, sf, terra, utils

Suggests covr, elevatr, rgdal, knitr, rmarkdown, testthat (>= 3.0.0), vdiffr, naturalearth

VignetteBuilder knitr

Config/testthat/edition 3

NeedsCompilation no
create_isobases

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Depends R (>= 3.5.0)
Repository CRAN
Date/Publication 2023-06-02 23:40:02 UTC

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create_isobases  Create isobases with different directions within the spatial coverage in
south-eastern Norway

Description

Function to create isobases for interpolating shoreline displacement curves within the spatial coverage in south-eastern Norway. This is done from the centre points of the supplied displacement curves. Isobases can also be created for multiple directions, which is useful for testing the sensitivity of dates to the direction of the isobases.

Usage

create_isobases(isobase_direction)

Arguments

isobase_direction

A numerical vector holding a single or multiple directions for the isobases.

Value

A simple feature holding the isobases represented as lines.
Examples

```r
# Create isobases in a specified direction
isobases <- create_isobases(327)
plot(sf::st_geometry(isobases))

# Create isobases using different directions
isobases <- create_isobases(c(327, 338))

# Plot for visualisation
plot(sf::st_geometry(isobases))
```

---

**displacement_plot**  
Plot shoreline displacement curves

**Description**

Function for plotting shoreline displacement curves. Calling to plot without providing a target curve will display the four underlying geologically derived displacement curves.

**Usage**

```r
displacement_plot(
  target_curve = NA,
  displacement_curves = c("Horten", "Porsgrunn", "Tvedestrand", "Arendal"),
  target_name = "Target curve",
  target_line = "solid",
  target_col = "red",
  target_alpha = 1,
  displacement_line = c(Horten = "solid", Porsgrunn = "solid", Tvedestrand = "solid",
                        Arendal = "solid"),
  displacement_col = c(Horten = "darkorange", Porsgrunn = "darkgreen", Tvedestrand =
                        "blue", Arendal = "black"),
  displacement_alpha = 1,
  greyscale = FALSE
)
```

**Arguments**

- `target_curve`  
  Data frame holding a shoreline displacement curve.
- `displacement_curves`  
  Character vector specifying which geologically informed displacement curves should be plotted. Accepted values are `c("Horten", "Porsgrunn", "Tvedestrand", "Arendal")`. All are included by default.
- `target_name`  
  Character value specifying the name that is given to the target curve, if provided. Defaults to "Target curve".
- `target_line`  
  Character value specifying the line type that is used for the target curve, if this is provided. Defaults to "solid".
target_col  Character value specifying the colour that is used for the target curve, if this is provided. Defaults to "red".

target_alpha  Numerical value specifying the alpha value that is used for the target curve, if this is provided. Defaults to 1.

displacement_line  Character vector specifying the line types that are used for the geological displacement curves to be plotted. Defaults to c("Horten" = "solid", "Porsgrunn" = "solid", "Tvedestrand" = "solid", "Arendal" = "solid").

displacement_col  Character vector specifying the colours that are used for the geological displacement curves to be plotted. Defaults to c("Horten" = "darkorange", "Porsgrunn" = "darkgreen", "Tvedestrand" = "blue", "Arendal" = "black").

displacement_alpha  Numerical value specifying the alpha value that are used for all of the geological displacement curves to be plotted. Defaults to 1.

greyscale  Logical value indicating whether the plot should be in greyscale or not. Defaults to FALSE.

Value
A plot displaying the underlying shoreline displacement curves and, if provided, a target curve.

Examples
# Empty plot for speed
displacement_plot(displacement_curves = "")

interpolate_curve  Interpolate displacement curve to a target location within the spatial coverage in south-eastern Norway

Description
Interpolate the trajectory of past shoreline displacement to a target location within the spatial coverage on the Skagerrak coast of south-eastern Norway. This based on the distance of the location to the shoreline isobases of the geologically derived displacement curves and is done using inverse distance weighting.

Usage
interpolate_curve(
  target,  
isobases = NA,  
power = 2,  
cal_reso = 10,  
verbose = FALSE
)
Arguments

- **target**: A spatial target location to where the new displacement curve is interpolated.
- **isobases**: 4 spatial lines representing the shoreline isobases of the existing displacement curves. Multiple sets of 4 isobases with different isobase directions can be provided (see `create_isobases()`). Defaults to isobases with a direction of 327.
- **power**: A numerical value indicating the inverse distance power for IDW. Defaults to 2.
- **cal_reso**: A numerical value specifying the resolution to use on the calendar scale. Defaults to 10.
- **verbose**: Logical value indicating whether progress should be printed to console. Defaults to FALSE.

Value

Returns a list holding an interpolated displacement curve for each isobase direction. Each displacement curve is represented by a data frame with the columns `bce` where negative values indicate years BCE and positive CE, `lower_elev`, representing the lower limit for the elevation of the shoreline for each year, `upper_elev`, the upper limit for elevation of the shoreline for each year, and `direction` which indicates the direction of the isobases used when interpolating the curve.

Examples

```r
# Create example point using the required coordinate system
# WGS84 / zone UTM32N (EPSG: 32632)
target_point <- sf::st_sfc(sf::st_point(c(579570, 6582982)), crs = 32632)

# Interpolate shoreline displacement curve to the target point location,
# setting the resolution on the calendar scale to 2000 years for speed.
target_curve <- interpolate_curve(target_point, cal_reso = 2000)
```

print.shoreline_date

Print shoreline dates to console

Description

Print the dates held in a `shoreline_date` object. Each date is printed with site name, elevation and highest density region. If the isobase direction is different or more are provided than the default, the directions and dates associated with these are printed separately.

Usage

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

Arguments

- **x**: Object of class `shoreline_date`.
- **...**: Additional arguments.
Value

Print the site names, elevations, non-default isobase directions and HDRs contained in a `shoreline_date` object to console.

Examples

target_point <- sf::st_sfc(sf::st_point(c(538310, 6544255)), crs = 32632)

# Reduce date resolution with cal_reso and elevation_reso for speed
target_date <- shoreline_date(site = target_point, 
elevation = 70, 
elev_reso = 1, 
cal_reso = 400)

# Print to console
target_date

---

**shoredate_hdr**  
Find the highest density region of shoreline dates

Description

Function to find 95% highest density region (HDR) for a provided shoreline date. Negative values denote years BCE while positive values denote CE.

Usage

```
shoredate_hdr(bce, probability, site_name, cal_reso, prob = 0.95)
```

Arguments

- **bce**: A vector holding calendar years associated with a date.
- **probability**: A vector holding the probability mass corresponding to each calendar year.
- **site_name**: A vector holding the name of the site that has been dated.
- **cal_reso**: Resolution on the calendar scale used when dating the site.
- **prob**: A numerical value between 0 and 1 indicating the probability coverage of the HDR. Defaults to 0.95.

Value

A list holding start and end points for segments of the highest density region of a shoreline date, the weighted mean date, the probability coverage and site name.
Examples

target_point <- sf::st_sfc(sf::st_point(c(538310, 6544255)), crs = 32632)

# Reduce date resolution with cal_reso and elevation_reso for speed
target_date <- shoreline_date(sites = target_point,
    elevation = 80,
    elev_reso = 1,
    cal_reso = 400)

# shoredate_hdr() is already called under the hood with shoreline_date(),
# the result of which is printed when calling the shoreline_date object
target_date

# However, shoredate_hdr() can be applied separately by pulling the
# necessary data from the date
(shoredate_hdr(target_date[[1]][[1]]$date$bce,
    target_date[[1]][[1]]$date$probability,
    target_date[[1]][[1]]$site_name,
    target_date[[1]][[1]]$cal_reso))

shoredate_plot

Plot shoreline dates

Description

Function for plotting shoreline dates along with associated metadata.

Usage

shoredate_plot(
    shorelinedates,
    date_probability = TRUE,
    elevation_distribution = TRUE,
    displacement_curve = TRUE,
    site_name = FALSE,
    parameters = FALSE,
    isobase_direction = FALSE,
    highest_density_region = TRUE,
    hdr_label = TRUE,
    multiplot = FALSE,
    date_col = NA,
    date_fill = "darkgrey",
    displacement_col = "red",
    displacement_fill = "red",
    site_elevation_col = "#046c9a",
    site_elevation_fill = "#046c9a",
    hdr_col = "black",
    hdr_label_xadj = 0.2,
hdr_label_yadj = 0.3,
greyscale = FALSE
)

Arguments

shorlinedates  Object of class shoreline_date.
date_probability  Logical value indicating whether the probability distribution of the shoreline date should be plotted. Defaults to TRUE.
elevation_distribution  Logical value indicating whether the distribution describing the distance between site and shoreline should be displayed. Default is TRUE.
displacement_curve  Logical value indicating whether the displacement curve should be displayed. Default is TRUE.
site_name  Logical value indicating whether the name of the site should be printed in the header of the plot. Defaults to FALSE.
parameters  Logical value indicating whether the parameters of the statistical function should be displayed. Default is FALSE.
isobase_direction  Logical value indicating whether the direction of the isobases should be printed. Default is FALSE.
highest_density_region  Logical value indicating whether the 95% highest density region should be displayed. Defaults to TRUE.
hdr_label  Logical value indicating whether the numeric values for the highest density regions should be displayed. Default is TRUE.
multiplot  Logical value indicating whether multiple dates should be plotted individually, or be collapsed into a single plot. The only other graphical option with multiplot set to TRUE is highest_density_region. Default is FALSE.
date_col  Character value specifying the outline colour of the probability distribution of the shoreline date. Defaults to NA.
date_fill  Character value specifying the fill colour of the probability distribution of the shoreline date. Defaults to "darkgrey".
displacement_col  Character value specifying the outline colour of the displacement curve. Defaults to "red".
displacement_fill  Character value specifying the fill colour of the displacement curve. Defaults to "red".
site_elevation_col  Character value specifying the outline colour of the distribution describing the likely distance between site and shoreline. Defaults to "#046c9a".
site_elevation_fill  Character value specifying the fill colour of the distribution describing the likely distance between site and shoreline. Defaults to "#046c9a".
**shoredate_sumplot**

hdr_col  Character value specifying the colour of the line segment giving the highest density region of the shoreline date. Defaults to “black”.

hdr_label_xadj  Numerical value between 0 and 1 specifying the position of the HDR label on the x-axis. Increasing the value moves the label further from the plot border. Defaults to 0.2.

hdr_label_yadj  Numerical value between 0 and 1 specifying the position of the HDR label on the y-axis. Increasing the value moves the label further from the plot border. Defaults to 0.3.

greyscale  Logical value indicating whether the plot should be in greyscale or not. If TRUE, overrides other colour parameters. Defaults to FALSE.

Details

shoredate_plot() returns a plot displaying the provided shoreline dates. A single plot is created for each date, where a range of settings can be adjusted to display or hide various parameters and results. Setting the parameter multiplot to TRUE returns a sparser version for multiple dates, where the only option is whether or not to display the highest density region in addition to each date. multiplot does not allow for multiple isobase directions. Negative values denote years BCE while positive values denote CE.

Value

Plot(s) displaying shoreline dates and associated metadata.

Examples

```r
# Create example point with correct coordinate reference system
target_point <- sf::st_sfc(sf::st_point(c(538310, 6544255)), crs = 32632)

# Reduce date resolution with cal_reso and elevation_reso for speed
target_date <- shoreline_date(sites = target_point, elevation = 80,
                              elev_reso = 10,
                              cal_reso = 500)

shoredate_plot(target_date)
```

Description

Plot the summed probability distribution of multiple shoreline dates.

Usage

```r
shoredate_sumplot(shoredates_sum, sample_size = TRUE)
```
Arguments

- `shoredates_sum` Object of class `shoredates_sum`.
- `sample_size` Logical indicating whether or not to display the number of summed dates on the plot. Defaults to `TRUE`.

Value

A line plot showing the provided summed probability distribution.

Examples

```r
# Create example points
target_points <- sf::st_sfc(sf::st_point(c(538310, 6544255)),
                           sf::st_point(c(538300, 6544250)))

# Set correct CRS
target_points <- sf::st_as_sf(target_points, crs = 32632)

# Reduce date resolution with cal_reso and elevation_reso for speed
target_dates <- shoreline_date(target_points,
                                elevation = c(65, 70),
                                elev_reso = 10,
                                cal_reso = 750)

# Find summed probability
target_sum <- sum_shoredates(target_dates)

# Call to plot
shoreline_date_sumplot(target_sum)
```

Description

A function for shoreline dating Stone Age sites based on their present-day elevation, their likely elevation above sea-level when in use and the trajectory of past shoreline displacement. Details and caveats pertaining to the implemented method is given in Roalkvam (2023).

Usage

```r
shoreline_date(
sites,
elevation = NA,
elev_reso = 0.01,
cal_reso = 10,
isobase_direction = 327,
sum_isobase_directions = FALSE,
```
model = "gamma",
model_parameters = c(0.286, 20.833),
elev_fun = "mean",
upper_temp_limit = -2500,
target_curve = NA,
hdr_prob = 0.95,
normalise = TRUE,
sparse = FALSE,
verbose = FALSE)

Arguments

sites Vector giving one or more site names, or, if displacement curves are to be interpolated, objects of class sf representing the sites to be dated. In the case of a spatial geometry, the first column is taken as the site name.
elevation Vector of numeric elevation values for each site or a an elevation raster of class SpatRaster from the package terra from where the elevation values are to be derived.
elev_reso Numeric value specifying the resolution with which to step through the distribution representing the distance between site and shoreline. Defaults to 0.01m.
cal_reso Numeric value specifying the resolution to use on the calendar scale. Defaults to 10.
isobase_direction A vector of numeric values defining the direction(s) of the isobases. Defaults to 327.
sum_isobase_directions Logical value indicating that if multiple isobase directions are specified in isobase_direction the results should be summed for each site using sum_shoredates. Defaults to FALSE.
model Character vector specifying the statistical model with which to model the distance from site to shoreline. Currently accepts either "none" or "gamma". Defaults to "gamma".
model_parameters Vector of numeric values specifying the parameters for the statistical model describing the distance between site and shoreline. Defaults to c(0.286, 20.833), denoting the shape and scale of the default gamma function, respectively.
elev_fun Statistic to define site elevation if this is to be derived from an elevation raster. Uses terra::extract(). Defaults to mean.
upper_temp_limit Numerical value giving the upper temporal limit. Dates with a start date after the limit are returned as NA. Defaults to -2500, i.e. 2500 BCE.
target_curve Data frame holding pre-computed shoreline displacement curve. This has to have the same or higher resolution on the calendar scale as that specified with cal_reso. interpolate_curve() will be run if nothing is provided to target_curve. Defaults to NA.
hdr_prob  Numeric value specifying the coverage of the highest density region. Defaults to 0.95.

normalise  Logical value specifying whether the shoreline date should be normalised to sum to unity. Defaults to TRUE.

sparse  Logical value specifying if only site name and shoreline date should be returned. Defaults to FALSE. Note that of the functions for further treatment, sparse dates are only compatible with `sum_shoredates()`.

verbose  Logical value indicating whether progress should be printed to console. Defaults to FALSE.

Value

A nested list of class `shoreline_date` holding the shoreline date results and associated metadata for each dated site for each isobase direction. The elements of each date is:

- `site_name` name of the site.
- `site_elev` elevation of the site.
- `date` data frame with the columns `bce` where negative values indicate years BCE and positive CE, as well as `probability`, which gives the probability mass for each year.
- `weighted_mean` the weighted mean date.
- `hdr_start` start values for the HDR ranges.
- `hdr_end` end values for the HDR ranges.
- `hdr_prob` probability level for the HDR.
- `dispcurve` data frame holding the displacement curve used for dating the site. This has the columns `bce`, giving years BCE/CE. `lowerelev`, the lower limit for the elevation of the shoreline for each year. `upperelev`, the upper limit for elevation of the shoreline for each year.
- `dispcurve_direction` direction of the isobases in use.
- `model_parameters` parameters for the statistical model.
- `modeldat` data frame holding the model distribution. The column `offset` denotes the vertical distance (m) from the shoreline, as specified by the `elev_reso` argument. `px` is the cumulative probability at each step of `offset`, and `probs` is the probability of each step found by subtracting the preceding value from each value of `px`.
- `cal_reso` resolution on the calendar scale.

References


Examples

```r
# Create example point using the required CRS WGS84 UTM32N (EPSG: 32632)
target_point <- sf::st_sfc(sf::st_point(c(538310, 6544255)), crs = 32632)
```
sum_shoredates

# Date target point, manually specifying the elevation instead of providing
# an elevation raster. Reducing elev_reso and cal_reso for speed.
shoreline_date(sites = target_point,
               elevation = 80,
               elev_reso = 1,
               cal_reso = 400)

sum_shoredates  Sum the probability of multiple shoreline dates

Description

Function for finding the summed probability distribution of multiple shoreline dates.

Usage

sum_shoredates(
  shoreline_dates,
  cut_off = -2500,
  cut_off_level = 1,
  normalise = TRUE
)

Arguments

shoreline_dates  Object of class shoreline_date.
cut_off  Calendar year specifying where dates should be cut off. Defaults to 2500 BCE.
cut_off_level  Numerical value between 0 and 1 indicating the probability mass that has to fall
               after the cut-off for a date to be excluded. Defaults to 1, retaining all dates.
normalise  Logical value indicating whether the probability sum of the dates should be
            normalised to sum to unity. Defaults to TRUE.

Value

List of class shoredate_sum holding the elements:

- sum data frame with the columns bce where negative values indicate years BCE and positive
  CE, as well as probability, which gives the probability mass for each year.
- dates_n number of dates that make up the sum after applying any specified cut-off. One date
  per site per isobase direction.
target_plot

Examples

target_points <- sf::st_sfc(sf::st_point(c(538310, 6544255)),
                        sf::st_point(c(538300, 6544250)))
target_points <- sf::st_as_sf(target_points, crs = 32632)

# Shoreline date, reducing resolultion on elevation and calendar scales for
# speed.
target_dates <- shoreline_date(target_points,
                               elevation = c(65, 70),
                               elev_reso = 10,
                               cal_reso = 500)

sum_shoredates(target_dates)

target_plot

Plot a map with target locations

Description

Function to plot the centroids of sites to be dated and shoreline isobases of employed displacement curves on a basemap. Defaults to displaying a light-weight version of the spatial coverage in south-eastern Norway. However, spatial geometries covering other regions can also be provided or temporarily downloaded with the function.

Usage

target_plot(
  targets = NA,  
isobases = sf::st_read(system.file("extdata/isobases.gpkg", package = "shoredate",  
                          mustWork = TRUE), quiet = TRUE),      
  basemap = sf::st_read(system.file("extdata/naturalearth_basemap.gpkg", package =  
                              "shoredate", mustWork = TRUE), quiet = TRUE),
  crs_epsg = 32632,
  naturalearth_basemap = FALSE,
  naturalearth_zoom = c(20000, 20000),
  target_labels = TRUE,
  scalebar = TRUE,
  scalebar_width = 0.4,
  scalebar_style = "ticks",
  scalebar_location = "br",
  base_fill = "grey",
  base_col = NA,
  target_shape = 21,
  target_col = "black",
  target_fill = "red",
  target_size = 2.25,
  isobase_line = c(Horten = "solid", Porsgrunn = "solid", Tvedestrand = "solid", Arendal"
```r
= "solid"),
isobase_col = c(Arendal = "black", Porsgrunn = "darkgreen", Tvedestrand = "blue",
Horten = "darkorange"),
greyscale = FALSE
)

Arguments

targets Objects of class sf representing the sites to be dated. The first column beyond
geom is taken as site name.

isobases Spatial lines as object of class sf representing the shoreline isobases. Defaults
to isobases with a direction of 327 within the spatial limit in SE Norway, but
create_isobases() can be used to create isobases with other directions that
can then be passed to target_plot().

basemap Object of class sf representing a background map. Defaults to a light-weight
basemap for the spatial limit in SE Norway.

crs_epsg Numeric value specifying the EPSG code of the coordinate reference system
(CRS) to be used. Geometries with a different CRS will be re-projected. De-
defaults to 32632, which is WGS 84 / UTM zone 32N (EPSG:32632).

naturalearth_basemap Logical value specifying if a background map should be downloaded to be used
as a basemap. Downloaded files are stored with base::tempdir() and deleted
when the R session is closed. If TRUE, overrides the basemap argument. Defaults
to FALSE.

naturalearth_zoom A vector of two numerical values specifying the amount of cropping that is
done around provided targets when naturalearth_basemap is set to TRUE.
Be aware of whether a projected or geographical CRS is specified in crs_epsg.
Defaults to c(20000, 20000).

target_labels Logical value specifying whether the targets should be labelled in the plot. Takes
the first column beyond the one holding the geometries to represent names. If
this is not present the targets are labelled by row number. Defaults to TRUE.

scalebar Logical specifying whether a scale bar should be added to the plot. Defaults to
TRUE.

scalebar_width Numerical value specifying the width of the scale bar by passing it to the width_hint
argument of ggspatial::annotation:scale(). Defaults to 0.4.

scalebar_style Character value specifying the style of the scale bar by passing it to the style
argument of ggspatial::annotation:scale(). Defaults to "ticks".

scalebar_location Character value specifying the location of the scale bar on the plot by passing it
to the location argument of ggspatial::annotation:scale(). Defaults to "br".

base_fill Character value specifying the fill colour of the basemap. Defaults to "grey".

base_col Character value specifying the outline colour of the basemap. Defaults to NA.

target_shape Numerical value specifying the point shape that represent the centroids of the
targets. Defaults to 21.
target_col Character value specifying the colour parameter for the points that represent the centroids of the targets. Defaults to "black".

target_fill Character value specifying the fill parameter for the points that represent the centroids of the targets. Defaults to "red".

target_size Numerical value specifying the size of the points that represent the centroids of the targets. Defaults to 2.25.

isobase_line Vector of character values specifying the linetype that is used to represent the isobases of the geologically derived displacement curves. Defaults to c("Horten" = "solid", "Porsgrunn" = "solid", "Tvedestrand" = "solid", "Arendal" = "solid").

isobase_col Vector of character values specifying the colours used for the lines that represent the isobases of the geologically derived displacement curves. Defaults to c("Arendal" = "black", "Porsgrunn" = "darkgreen", "Tvedestrand" = "blue", "Horten" = "darkorange").

greyscale Logical value indicating whether the plot should include colours or not. Overrides other graphical parameters. When set to TRUE. Defaults to FALSE.

Value

A ggplot that displays a background map with the location of the shoreline isobases within the spatial coverage in south-eastern Norway, unless geometries for other regions are provided. If provided, the function also plots the position of target locations represented as centroids.

Examples

# Display the background map and default isobases
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