Package ‘marmap’

October 13, 2022

Type Package

Title Import, Plot and Analyze Bathymetric and Topographic Data

Version 1.0.6

Date 2021-11-10

Author Eric Pante, Benoit Simon-Bouhet, and Jean-Olivier Irisson

Maintainer Benoit Simon-Bouhet <besibo@gmail.com>

Depends R (>= 2.10)

Imports DBI, RSQLite, gdistance, geosphere, sp, raster, ncdf4, plotrix, shape, reshape2, adehabitatMA, ggplot2, methods

Suggests maps, mapdata, lattice, mapproj, R.rsp

BugReports https://github.com/ericpante/marmap/issues

Description Import xyz data from the NOAA (National Oceanic and Atmospheric Administration, <https://www.noaa.gov>), GEBCO (General Bathymetric Chart of the Oceans, <https://www.gebco.net>) and other sources, plot xyz data to prepare publication-ready figures, analyze xyz data to extract transects, get depth/altitude based on geographical coordinates, or calculate z-constrained least-cost paths.

License GPL (>= 3)

URL https://github.com/ericpante/marmap

VignetteBuilder R.rsp

NeedsCompilation no

Repository CRAN

Date/Publication 2021-11-10 09:20:02 UTC

R topics documented:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>aleutians</td>
<td>3</td>
</tr>
<tr>
<td>antimeridian.box</td>
<td>4</td>
</tr>
<tr>
<td>as.bathy</td>
<td>5</td>
</tr>
<tr>
<td>as.raster</td>
<td>6</td>
</tr>
<tr>
<td>as.SpatialGridDataframe</td>
<td>7</td>
</tr>
</tbody>
</table>
R topics documented:

<table>
<thead>
<tr>
<th>Function</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>as.xyz</td>
<td>8</td>
</tr>
<tr>
<td>autoplot.bathy</td>
<td>9</td>
</tr>
<tr>
<td>celt</td>
<td>11</td>
</tr>
<tr>
<td>check.bathy</td>
<td>12</td>
</tr>
<tr>
<td>col2alpha</td>
<td>13</td>
</tr>
<tr>
<td>collate.bathy</td>
<td>14</td>
</tr>
<tr>
<td>combine.buffers</td>
<td>15</td>
</tr>
<tr>
<td>create.buffer</td>
<td>16</td>
</tr>
<tr>
<td>diag.bathy</td>
<td>17</td>
</tr>
<tr>
<td>dist2isobath</td>
<td>19</td>
</tr>
<tr>
<td>etopo</td>
<td>20</td>
</tr>
<tr>
<td>florida</td>
<td>21</td>
</tr>
<tr>
<td>fortify.bathy</td>
<td>22</td>
</tr>
<tr>
<td>get.area</td>
<td>23</td>
</tr>
<tr>
<td>get.box</td>
<td>25</td>
</tr>
<tr>
<td>get.depth</td>
<td>27</td>
</tr>
<tr>
<td>get.sample</td>
<td>29</td>
</tr>
<tr>
<td>get.transect</td>
<td>30</td>
</tr>
<tr>
<td>getNOAA.bathy</td>
<td>32</td>
</tr>
<tr>
<td>griddify</td>
<td>34</td>
</tr>
<tr>
<td>hawaii</td>
<td>35</td>
</tr>
<tr>
<td>irregular</td>
<td>36</td>
</tr>
<tr>
<td>is.bathy</td>
<td>37</td>
</tr>
<tr>
<td>lc.dist</td>
<td>38</td>
</tr>
<tr>
<td>linesGC</td>
<td>40</td>
</tr>
<tr>
<td>marmap</td>
<td>42</td>
</tr>
<tr>
<td>metallo</td>
<td>42</td>
</tr>
<tr>
<td>nw.atlantic</td>
<td>44</td>
</tr>
<tr>
<td>nw.atlantic.coast</td>
<td>45</td>
</tr>
<tr>
<td>outline.buffer</td>
<td>46</td>
</tr>
<tr>
<td>palette.bathy</td>
<td>47</td>
</tr>
<tr>
<td>path.profile</td>
<td>49</td>
</tr>
<tr>
<td>plot.bathy</td>
<td>50</td>
</tr>
<tr>
<td>plot.buffer</td>
<td>53</td>
</tr>
<tr>
<td>plotArea</td>
<td>55</td>
</tr>
<tr>
<td>plotProfile</td>
<td>56</td>
</tr>
<tr>
<td>read.bathy</td>
<td>57</td>
</tr>
<tr>
<td>readGEBCO.bathy</td>
<td>59</td>
</tr>
<tr>
<td>scaleBathy</td>
<td>60</td>
</tr>
<tr>
<td>space.pies</td>
<td>62</td>
</tr>
<tr>
<td>subsetBathy</td>
<td>64</td>
</tr>
<tr>
<td>subsetSQL</td>
<td>66</td>
</tr>
<tr>
<td>summary.bathy</td>
<td>67</td>
</tr>
<tr>
<td>trans.mat</td>
<td>68</td>
</tr>
</tbody>
</table>

Index 71
Description

Bathymetric matrix of class bathy created from NOAA GEODAS data.

Usage

data(aleutians)

Details

Data imported from the NOAA GEODAS Grid Translator webpage (https://maps.ngdc.noaa.gov/viewers/wcs-client/) and transformed into an object of class bathy by as.bathy.

Value

A text file.

Author(s)

see https://maps.ngdc.noaa.gov/viewers/wcs-client/

See Also

as.bathy, read.bathy, antimeridian.box

Examples

# load celt data
data(aleutians)

# class "bathy"
class(aleutians)
summary(aleutians)

# test plot.bathy
plot(aleutians, image = TRUE,
bpal = list(c(0,max(aleutians),"grey"),
c(min(aleutians),0,"darkblue","lightblue")),
land = TRUE, lwd = 0.1, axes = FALSE)
antimeridian.box(aleutians, 10)
antimeridian.box  

Adds a box to maps including antimeridian

Description

Adds a box on maps including the antimeridian (180)

Usage

antimeridian.box(object, tick.spacing)

Arguments

object  
matrix of class bathy

tick.spacing  
spacing between tick marks (in degrees, default=20)

Value

The function adds a box and tick marks to an existing plot which contains the antimeridian line (180 degrees).

Author(s)

Eric Pante & Benoit Simon-Bouhet

See Also

plot.bathy

Examples

data(aleutians)

# default plot:
plot(aleutians,n=1)

# plot with corrected box and labels:
plot(aleutians,n=1,axes=FALSE)
antimeridian.box(aleutians, 10)
as.bathy

Convert to bathymetric data in an object of class bathy

Description
Reads either an object of class RasterLayer, SpatialGridDataFrame or a three-column data.frame containing longitude (x), latitude (y) and depth (z) data and converts it to a matrix of class bathy.

Usage
as.bathy(x)

Arguments
x Object of RasterLayer or SpatialGridDataFrame, or a three-column data.frame with longitude (x), latitude (y) and depth (z) (no default)

Details
x can contain data downloaded from the NOAA GEODAS Grid Translator webpage (http://www.ngdc.noaa.gov/mgg/gdas/gd_designagrid.html) in the form of an xyz table. The function as.bathy can also be used to transform objects of class raster (see package raster) and SpatialGridDataFrame (see package sp).

Value
The output of as.bathy is a matrix of class bathy, which dimensions and resolution are identical to the original object. The class bathy has its own methods for summarizing and plotting the data.

Author(s)
Benoit Simon-Bouhet

See Also
summary.bathy, plot.bathy, read.bathy, as.xyz, as.raster, as.SpatialGridDataFrame.

Examples
# load NW Atlantic data
data(nw.atlantic)

# use as.bathy
atl <- as.bathy(nw.atlantic)

# class "bathy"
class(atl)

# summarize data of class "bathy"
summary(atl)
as.raster

Convert bathymetric data to a raster layer

Description

Transforms an object of class bathy to a raster layer.

Usage

as.raster(bathy)

Arguments

bathy an object of class bathy

Details

as.raster transforms bathy objects into objects of class RasterLayer as defined in the raster package. All methods from the raster package are thus available for bathymetric data (e.g. rotations, projections...).

Value

An object of class RasterLayer with the same characteristics as the bathy object (same longitudinal and latitudinal ranges, same resolution).

Author(s)

Benoit Simon-Bouhet

See Also

as.xyz, as.bathy, as.SpatialGridDataFrame

Examples

# load Hawaii bathymetric data
data(hawaii)

# use as.raster
r.hawaii <- as.raster(hawaii)

# class "RasterLayer"
class(r.hawaii)

# Summaries
summary(hawaii)
summary(r.hawaii)
as.SpatialGridDataFrame

# structure of the RasterLayer object
str(r.hawaii)

## Not run:
# Plots
#require(raster)
plot(hawaii,image=TRUE,lwd=.2)
plot(r.hawaii)

## End(Not run)

as.SpatialGridDataFrame

Convert bathymetric data to a spatial grid

Description

Transforms an object of class bathy to a SpatialGridDataFrame object.

Usage

as.SpatialGridDataFrame(bathy)

Arguments

bathy an object of class bathy

Details

as.SpatialGridDataFrame transforms bathy objects into objects of class SpatialGridDataFrame as defined in the sp package. All methods from the sp package are thus available for bathymetric data (e.g. rotations, projections...).

Value

An object of class SpatialGridDataFrame with the same characteristics as the bathy object (same longitudinal and latitudinal ranges, same resolution).

Author(s)

Benoit Simon-Bouhet

See Also

as.xyz, as.bathy, as.raster
Examples

```r
# load Hawaii bathymetric data
data(hawaii)

# use as.SpatialGridDataFrame
sp.hawaii <- as.SpatialGridDataFrame(hawaii)

# Summaries
summary(hawaii)
summary(sp.hawaii)

# structure of the SpatialGridDataFrame object
str(sp.hawaii)

# Plots
plot(hawaii,image=TRUE,lwd=.2)
image(sp.hawaii)
```

---

### as.xyz

**Convert to xyz format**

**Description**

Converts a matrix of class `bathy` into a three-column data.frame containing longitude, latitude and depth data.

**Usage**

```r
as.xyz(bathy)
```

**Arguments**

- `bathy` matrix of class `bathy`.

**Details**

The use of `as.bathy` and `as.xyz` allows to switch back and forth between the long format (xyz) and the wide format of class `bathy` suitable for plotting bathymetric maps, computing least cost distances, etc. `as.xyz` is especially useful for exporting xyz files when data are obtained using `subsetSQL`, i.e. bathymetric matrices of class `bathy`.

**Value**

Three-column data.frame with a format similar to xyz files downloaded from the NOAA GEODAS Grid Translator webpage (https://maps.ngdc.noaa.gov/viewers/wcs-client/). The first column contains longitude data, the second contains latitude data and the third contains depth/elevation data.
autoplot.bathy

Author(s)

Benoit Simon-Bouhet

See Also

as.bathy, summary.bathy

Examples

# load celt data
data(celt)
dim(celt)
class(celt)
summary(celt)
plot(celt, deep= -300, shallow= -25, step=25)

# use as.xyz
celt2 <- as.xyz(celt)
dim(celt2)
class(celt2)
summary(celt2)

Description

Plots contour or image map from bathymetric data matrix of class bathy with ggplot2

Usage

## S3 method for class 'bathy'
autoplot(x, geom="contour", mapping=NULL, coast=TRUE, ...)

Arguments

x       bathymetric data matrix of class bathy, imported using read.bathy
geom    geometry to use for the plot, i.e. type of plot; can be ‘contour’, ‘tile’ or ‘raster’. contour does a contour plot. tile and raster produce an image plot. tile allows true geographical projection through coord_map. raster only allows approximate projection but is faster to plot. Names can be abbreviated. Geometries can be combined by specifying several in a vector.
mapping additional mappings between the data obtained from calling fortify.bathy on x and the aesthetics for all geoms. When not NULL, this is a call to aes()。
coast   boolean; wether to highlight the coast (isobath 0 m) as a black line
...     passed to the chosen geom(s)
Details

`fortify.bathy` is called with argument `x` to produce a data.frame compatible with ggplot2. Then layers are added to the plot based on the argument `geom`. Finally, the whole plot is projected geographically using `coord_map` (for `geom="contour"`) or an approximation thereof.

Author(s)

Jean-Olivier Irisson

See Also

`fortify.bathy`, `plot.bathy`, `read.bathy`, `summary.bathy`

Examples

# load NW Atlantic data and convert to class bathy
data(nw.atlantic)
atl <- as.bathy(nw.atlantic)

  # basic plot
  ## Not run:
  library("ggplot2")
  autoplot(atl)

  # plot images
  autoplot(atl, geom=c("tile"))
  autoplot(atl, geom=c("raster")) # faster but not resolution independant

  # plot both!
  autoplot(atl, geom=c("raster", "contour"))

  # geom names can be abbreviated
  autoplot(atl, geom=c("r", "c"))

  # do not highlight the coastline
  autoplot(atl, coast=FALSE)

  # better colour scale
  autoplot(atl, geom=c("r", "c")) +
  scale_fill_gradient2(low="dodgerblue4", mid="gainsboro", high="darkgreen")

  # set aesthetics
  autoplot(atl, geom=c("r", "c"), colour="white", size=0.1)

  # topographical colour scale, see ?scale_fill_etopo
  autoplot(atl, geom=c("r", "c"), colour="white", size=0.1) + scale_fill_etopo()

  # add sampling locations
  data(metallo)
  last_plot() + geom_point(aes(x=lon, y=lat), data=metallo, alpha=0.5)

  # an alternative contour map making use of additional mappings
### Bathymetric data for the North East Atlantic

**Description**

Bathymetric matrix of class `bathy` created from NOAA GEODAS data.

**Usage**

```r
data(celt)
```

**Details**

Data imported from the NOAA GEODAS Grid Translator webpage ([https://maps.ngdc.noaa.gov/viewers/wcs-client/](https://maps.ngdc.noaa.gov/viewers/wcs-client/)) and transformed into an object of class `bathy` by `as.bathy`.

**Value**

A text file.

**Author(s)**

see [https://maps.ngdc.noaa.gov/viewers/wcs-client/](https://maps.ngdc.noaa.gov/viewers/wcs-client/)

**See Also**

`as.bathy`, `read.bathy`

**Examples**

```r
# load celt data
data(celt)

# class "bathy"
class(celt)
summary(celt)

# test plot.bathy
plot(celt, deep=-300, shallow=-50, step=25)
```
check.bathy

Sort bathymetric data matrix by increasing latitude and longitude

Description

Reads a bathymetric data matrix and orders its rows and columns by increasing latitude and longitude.

Usage

check.bathy(x)

Arguments

x   a matrix

Details

check.bathy allows to sort rows and columns by increasing latitude and longitude, which is necessary for plotting with the function `image` (package `graphics`). check.bathy is used within the marmap functions `read.bathy` and `as.bathy` (it is also used in `getNOAA.bathy` through `as.bathy`).

Value

The output of check.bathy is an ordered matrix.

Author(s)

Eric Pante

See Also

read.bathy, as.bathy, getNOAA.bathy

Examples

```r
matrix(1:100, ncol=5, dimnames=list(20:1, c(3,2,4,1,5))) -> a
check.bathy(a)
```
**col2alpha**

Adds alpha transparency to a (vector of) color(s)

**Description**

Adds transparency to a color or a vector of colors by specifying one or several alpha values.

**Usage**

```r
col2alpha(color, alpha = 0.5)
```

**Arguments**

- `color`: a (vector of) color codes or names
- `alpha`: a value (or vector of values) between 0 (full transparency) and 1 (no transparency).

**Details**

When the size of `color` and `alpha` vectors are different, `alpha` values are recycled.

**Value**

A (vector) of color code(s).

**Author(s)**

Benoit Simon-Bouhet

**Examples**

```r
# Generate random data
dat <- rnorm(4000)

# plot with plain color for points
plot(dat, pch=19, col=“red”)

# Add some transparency to get a better idea of density
plot(dat, pch=19, col=col2alpha(“red”, .3))

# Same color for all points but with increasing alpha (decreasing transparency)
plot(dat, pch=19, col=col2alpha(rep(“red”, 4000), seq(0, 1, len=4000)))

# Two colors, same alpha
plot(dat, pch=19, col=col2alpha(rep(c(“red”, “purple”), each=2000), .2))

# Four colors, gradient of transparency for each color
plot(dat, pch=19, col=col2alpha(rep(c(“blue”, “purple”, “red”, “orange”), each=1000), seq(.1,.6,len=1000)))
```
# Alpha transparency applied to a gradient of colors
plot(dat,pch=19,col=col2alpha(rainbow(4000),.5))

---

**collate.bathy**

Collates two bathy matrices with data from either sides of the antimeridian

---

**Description**

Collates two bathy matrices, one with longitude 0 to 180 degrees East, and the other with longitude 0 to 180 degrees West

**Usage**

```r
collate.bathy(east, west)
```

**Arguments**

- `east`: matrix of class `bathy` with eastern data (West of antimeridian)
- `west`: matrix of class `bathy` with western data (East of antimeridian)

**Details**

This function is meant to be used with `read.bathy()` or `readGEBCO.bathy()`, when data is downloaded from either sides of the antimeridian line (180 degrees longitude). If, for example, data is downloaded from GEBCO for longitudes of 170E-180 and 180-170W, `collate.bathy()` will create a single matrix of class `bathy` with a coordinate system going from 170 to 190 degrees longitude.

`getNOAA.bathy()` deals with data from both sides of the antimeridian and does not need further processing with `collate.bathy()`.

**Value**

A single matrix of class `bathy` that can be interpreted by `plot.bathy`. When plotting collated data (with longitudes 0 to 180 and 180 to 360 degrees), plots can be modified to display the conventional coordinate system (with longitudes 0 to 180 and -180 to 0 degrees) using function `antimeridian.box()`.

**Author(s)**

Eric Pante

**See Also**

`getNOAA.bathy`, `summary.bathy`, `plot.bathy`, `antimeridian.box`
Examples

## faking two datasets using aleutians, for this example
## "a" and "b" simulate two datasets downloaded from GEBCO, for ex.
data(aleutians)
aleutians[1:181,] -> a ; "bathy" -> class(a)
aleutians[182:601,] -> b ; "bathy" -> class(b)
-(360-as.numeric(rownames(b))) -> rownames(b)

## check these objects with summary(): pay attention of the Longitudinal range
summary(aleutians)
summary(a)
summary(b)

## merge datasets:
collate.bathy(a,b) -> collated
summary(collated) # should be identical to summary(aleutians)

---

`combine.buffers`  
Create a new, (non circular) composite buffer from a list of existing buffers.

Description

Creates a new bathy object from a list of existing buffers of compatible dimensions.

Usage

`combine.buffers(...)`

Arguments

...  
2 or more buffer objects as produced by `create.buffer`. All bathy objects within the buffer objects must be compatible: they should have the same dimensions (same number of rows and columns) and cover the same area (same longitudes and latitudes).

Value

An object of class bathy of the same dimensions as the original bathy objects contained within each buffer objects. The resulting bathy object contains only NAs outside of the combined buffer and values of depth/altitude inside the combined buffer.

Author(s)

Benoit Simon-Bouhet

See Also

`create.buffer, plot.buffer, plot.bathy`
Examples

```r
# load and plot a bathymetry
data(florida)
plot(florida, lwd = 0.2)
plot(florida, n = 1, lwd = 0.7, add = TRUE)

# add points around which a buffer will be computed
loc <- data.frame(c(-80,-82), c(26,24))
points(loc, pch = 19, col = "red")

# create 2 distinct buffer objects with different radii
buf1 <- create.buffer(florida, loc[1,], radius=1.9)
buf2 <- create.buffer(florida, loc[2,], radius=1.2)

# combine both buffers
buf <- combine.buffers(buf1,buf2)

## Not run:
# Add outline of the resulting buffer in red
# and the outline of the original buffers in blue
plot(outline.buffer(buf), lwd = 3, col = 2, add=TRUE)
plot(buf1, lwd = 0.5, fg="blue")
plot(buf2, lwd = 0.5, fg="blue")
## End(Not run)
```

---

**create.buffer**  
Create a buffer of specified radius around one or several points

**Description**

Create a circular buffer of user-defined radius around one or several points defined by their longitudes and latitudes.

**Usage**

```r
create.buffer(x, loc, radius, km = FALSE)
```

**Arguments**

- `x` an object of class bathy
- `loc` a 2-column data.frame of longitudes and latitudes for points around which the buffer is to be created.
- `radius` numeric. Radius of the buffer in the same unit as the bathy object (i.e. usually decimal degrees) when km=FALSE (default) or in kilometers when radius=TRUE.
- `km` logical. If TRUE, the radius should be provided in kilometers. When FALSE (default) the radius is in the same unit as the bathy object (i.e. usually decimal degrees).
Details

This function takes advantage of the buffer function from package adehabitatMA and several functions from packages sp to define the buffer around the points provided by the user.

Value

An object of class bathy of the same size as mat containing only NAs outside of the buffer and values of depth/altitude (taken from mat) within the buffer.

Author(s)

Benoit Simon-Bouhet

See Also

outline.buffer, combine.buffers, plot.bathy

Examples

# load and plot a bathymetry
data(florida)
plot(florida, lwd = 0.2)
plot(florida, n = 1, lwd = 0.7, add = TRUE)

# add a point around which a buffer will be created
loc <- data.frame(-80, 26)
points(loc, pch = 19, col = "red")

# compute and print buffer
buf <- create.buffer(florida, loc, radius=1.5)
buf

# highlight isobath with the buffer and add outline
plot(buf, outline=FALSE, n = 10, col = 2, lwd=.4)
plot(buf, lwd = 0.7, fg = 2)
Arguments

mat a data matrix
coord whether of not to output the coordinates of the diagonal (default is FALSE)

Details

diag.bathy gets the values or coordinates from the first element of a matrix to its last elements. If
the matrix is non-square, that is, its number of rows and columns differ, diag.bathy computes an
approximate diagonal.

Value

A vector of diagonal values is coord is FALSE, or a table of diagonal coordinates if coord is FALSE

Author(s)

Eric Pante

See Also

get.transect.diag

Examples

# a square matrix: diag.bathy behaves as diag
matrix(1:25, 5, 5) -> a ; a
diag(a)
diag.bathy(a)

# a non-square matrix: diag.bathy does not behaves as diag
matrix(1:15, 3, 5) -> b ; b
diag(b)
diag.bathy(b)

# output the diagonal or its coordinates:
rownames(b) <- seq(32,35, length.out=3)
colnames(b) <- seq(-100,-95, length.out=5)
diag.bathy(b, coord=FALSE)
diag.bathy(b, coord=TRUE)
**dist2isobath**

*Computes the shortest great circle distance between any point and a given isobath*

---

**Description**

Computes the shortest (great circle) distance between a set of points and an isoline of depth or altitude. Points can be selected interactively by clicking on a map.

**Usage**

```
dist2isobath(mat, x, y=NULL, isobath=0, locator=FALSE, ...)
```

**Arguments**

- `mat`: Bathymetric data matrix of class `bathy`, as imported with `read.bathy`.
- `x`: Either a list of two elements (numeric vectors of longitude and latitude), a 2-column matrix or data.frame of longitudes and latitudes, or a numeric vector of longitudes.
- `y`: Either `NULL` (default) or a numerical vector of latitudes. Ignored if `x` is not a numeric vector.
- `isobath`: A single numerical value indicating the isobath to which the shortest distance is to be computed (default is set to 0, *i.e.* the coastline).
- `locator`: Logical. Whether to choose data points interactively with a map or not. If `TRUE`, a bathymetric map must have been plotted and both `x` and `y` are both ignored.
- `...`: Further arguments to be passed to `locator` when the interactive mode is used (`locator=TRUE`).

**Details**

dist2isobath allows the user to compute the shortest great circle distance between a set of points (selected interactively on a map or not) and a user-defined isobath. dist2isobath takes advantage of functions from packages sp (`lines()` and `SpatialLines()`) and geosphere (`dist2Line`) to compute the coordinates of the nearest location along a given isobath for each point provided by the user.

**Value**

A 5-column data.frame. The first column contains the distance in meters between each point and the nearest point located on the given isobath. Columns 2 and 3 indicate the longitude and latitude of starting points (*i.e.* either coordinates provided as `x` and `y` or coordinates of points selected interactively on a map when `locator=TRUE`) and columns 4 and 5 contains coordinates (longitudes and latitudes) arrival points *i.e.* the nearest points on the isobath.

**Author(s)**

Benoit Simon-Bouhet
See Also

`linesGC`, `lc.dist`

Examples

```r
# Load NW Atlantic data and convert to class bathy
data(nw.atlantic)
atl <- as.bathy(nw.atlantic)

# Create vectors of latitude and longitude
lon <- c(-70, -65, -63, -55, -48)
lat <- c(33, 35, 40, 37, 33)

# Compute distances between each point and the -200m isobath
d <- dist2isobath(atl, lon, lat, isobath = -200)
d

# Visualize the great circle distances
blues <- c("lightsteelblue4","lightsteelblue3","lightsteelblue2","lightsteelblue1")
plot(atl, image=TRUE, lwd=0.1, land=TRUE, bpal = list(c(0,max(atl),"grey"), c(min(atl),0,blues)))
plot(atl, deep=-200, shallow=-200, step=0, lwd=0.6, add=TRUE)
points(lon,lat, pch=21, col="orange4", bg="orange2", cex=.8)
linesGC(d[2:3],d[4:5])
```

---

**etopo**

*Etopo colours*

**Description**

Various ways to access the colors on the etopo color scale

**Usage**

```r
etopo.colors(n)

scale_fill_etopo(...)
scale_color_etopo(...)
```

**Arguments**

- `n` : number of colors to get from the scale. Those are evenly spaced within the scale.
- `...` : passed to `scale_fill_gradientn` or `scale_color_gradientn`

**Details**

`etopo.colors` is equivalent to other color scales in R (e.g. `grDevices::heat.colors`, `grDevices::cm.colors`). `scale_fill/color_etopo` are meant to be used with `ggplot2`. They allow consistent plots in various subregions by setting the limits of the scale explicitly.
florida

Author(s)

Jean-Olivier Irisson

See Also

autoplot.bathy, palette.bathy

Examples

# load NW Atlantic data and convert to class bathy
data(nw.atlantic)
atl <- as.bathy(nw.atlantic)

# plot with base graphics
plot(atl, image=TRUE)

# using the etopo color scale
etopo_cols <- rev(etopo.colors(8))
plot(atl, image=TRUE, bpal=list(
    c(min(atl), 0, etopo_cols[1:2]),
    c(0, max(atl), etopo_cols[3:8]))
)

# plot using ggplot2; in which case the limits of the scale are automatic
library("ggplot2")
ggplot(atl, aes(x=x, y=y)) + coord_quickmap() +
    # background
    geom_raster(aes(fill=z)) +
    scale_fill_etopo() +
    # contours
    geom_contour(aes(z=z),
        breaks=c(0, -100, -200, -500, -1000, -2000, -4000),
        colour="black", size=0.2
    ) +
    scale_x_continuous(expand=c(0,0)) +
    scale_y_continuous(expand=c(0,0))

florida

Bathymetric data around Florida, USA

Description

Bathymetric object of class bathy created from NOAA GEODAS data.

Usage

data(florida)
Details

Data imported from the NOAA GEODAS Grid Translator webpage (https://maps.ngdc.noaa.gov/viewers/wcs-client/) and transformed into an object of class bathy by read.bathy.

Value

A bathymetric object of class bathy with 539 rows and 659 columns.

Author(s)

see https://maps.ngdc.noaa.gov/viewers/wcs-client/

See Also

plot.bathy, summary.bathy

Examples

# load florida data
data(florida)

# class "bathy"
class(florida)
summary(florida)

# test plot.bathy
plot(florida,asp=1)
plot(florida,asp=1,image=TRUE,drawlabels=TRUE,land=TRUE,n=40)

fortify.bathy

Extract bathymetry data in a data.frame

description

Extract bathymetry data in a data.frame

Usage

## S3 method for class 'bathy'
fortify(x, ...)

Arguments

x bathymetric data matrix of class bathy, imported using read.bathy
...
ignored
get.area

Get projected surface area

Description

Get projected surface area for specific depth layers

Usage

get.area(mat, level.inf, level.sup=0, xlim=NULL, ylim=NULL)
get.area

Arguments

- **mat**: bathymetric data matrix of class `bathy`, imported using `read.bathy` (no default)
- **level.inf**: lower depth limit for calculation of projected surface area (no default)
- **level.sup**: upper depth limit for calculation of projected surface area (default is zero)
- **xlim**: longitudinal range of the area of interest (default is NULL)
- **ylim**: latitudinal range of the area of interest (default is NULL)

Details

`get.area` calculates the projected surface area of specific depth layers (e.g. upper bathyal, lower bathyal), the projected plane being the ocean surface. The resolution of `get.area` depends on the resolution of the input bathymetric data. `xlim` and `ylim` can be used to restrict the area of interest. Area calculation is based on `areaPolygon` of package `geosphere` (using an average Earth radius of 6,371 km).

Value

A list of four objects: the projected surface area in squared kilometers, a matrix with the cells used for calculating the projected surface area, the longitude and latitude of the matrix used for the calculations.

Author(s)

Benoit Simon-Bouhet and Eric Pante

See Also

`plotArea`, `plot.bathy`, `contour`, `areaPolygon`

Examples

```r
## get area for the entire hawaii dataset:
data(hawaii)
plot(hawaii, lwd=0.2)

mesopelagic <- get.area(hawaii, level.inf=-1000, level.sup=-200)
bathyal <- get.area(hawaii, level.inf=-4000, level.sup=-1000)
abyssal <- get.area(hawaii, level.inf=min(hawaii), level.sup=-4000)

col.meso <- rgb(0.3, 0, 0.7, 0.3)
col.bath <- rgb(0.7, 0, 0, 0.3)
col.abys <- rgb(0.7, 0.7, 0.3, 0.3)

plotArea(mesopelagic, col = col.meso)
plotArea(bathyal, col = col.bath)
plotArea(abyssal, col = col.abys)

me <- round(mesopelagic$Square.Km, 0)
```
get.box

get.box 25

ba <- round(bathyal$Square.Km, 0)
ab <- round(abyssal$Square.Km, 0)

legend(x="bottomleft",
legend=c(paste("mesopelagic: ", me, "km2"),
paste("bathyal: ", ba, "km2"),
paste("abyssal: ", ab, "km2")),
col="black", pch=21,
pt.bg=c(col.meso, col.bath, col.abys))

# Use of xlim and ylim
data(hawaii)
plot(hawaii, lwd=0.2)

mesopelagic <- get.area(hawaii, xlim=c(-161.4,-159), ylim=c(21,23),
level.inf=-1000, level.sup=-200)
bathyal <- get.area(hawaii, xlim=c(-161.4,-159), ylim=c(21,23),
level.inf=-4000, level.sup=-1000)
abyssal <- get.area(hawaii, xlim=c(-161.4,-159), ylim=c(21,23),
level.inf=min(hawaii), level.sup=-4000)

col.meso <- rgb(0.3, 0, 0.7, 0.3)
col.bath <- rgb(0.7, 0, 0, 0.3)
col.abys <- rgb(0.7, 0.7, 0.3, 0.3)

plotArea(mesopelagic, col = col.meso)
plotArea(bathyal, col = col.bath)
plotArea(abyssal, col = col.abys)

me <- round(mesopelagic$Square.Km, 0)
ba <- round(bathyal$Square.Km, 0)
ab <- round(abyssal$Square.Km, 0)

legend(x="bottomleft",
legend=c(paste("mesopelagic: ", me, "km2"),
paste("bathyal: ", ba, "km2"),
paste("abyssal: ", ab, "km2")),
col="black", pch=21,
pt.bg=c(col.meso, col.bath, col.abys))

---

get.box  Get bathymetric information of a belt transect

Description

get.box gets depth information of a belt transect of width width around a transect defined by two points on a bathymetric map.

Usage

get.box(bathy, x1, x2, y1, y2, width, locator=FALSE, ratio=FALSE, ...)

Arguments

bathy  Bathymetric data matrix of class bathy.
x1    Numeric. Start longitude of the transect. Requested when locator=FALSE.
x2    Numeric. Stop longitude of the transect. Requested when locator=FALSE.
y1    Numeric. Start latitude of the transect. Requested when locator=FALSE.
y2    Numeric. Stop latitude of the transect. Requested when locator=FALSE.
width Numeric. Width of the belt transect in degrees.
locator Logical. Whether to choose transect bounds interactively with a map or not. When FALSE (default), a bathymetric map (plot.bathy(bathy,image=TRUE)) is automatically plotted and the position of the belt transect is added.
ratio Logical. Should aspect ratio for the wireframe plotting function (package lattice) be computed (default is FALSE).
... Other arguments to be passed to locator and lines to specify the characteristics of the points and lines to draw on the bathymetric map for both the transect and the bounding box of belt transect.

Details

get.box allows the user to get depth data for a rectangle area of the map around an approximate linear transect (belt transect). Both the position and size of the belt transect are user defined. The position of the transect can be specified either by inputing start and stop coordinates, or by clicking on a map created with plot.bathy. In its interactive mode, this function uses the locator function (graphics package) to retrieve and plot the coordinates of the selected transect. The argument width allows the user to specify the width of the belt transect in degrees.

Value

A matrix containing depth values for the belt transect. rownames indicate the kilometric distance from the start of the transect and colnames indicate the distance form the central transect in degrees. If ratio=TRUE, a list of two elements: depth, a matrix containing depth values for the belt transect similar to the description above and ratios a vector of length two specifying the ratio between (i) the width and length of the belt transect and (ii) the depth range and the length of the belt transect. These ratios can be used by the function wireframe to produce realistic 3D bathymetric plots of the selected belt transect.

Author(s)

Benoit Simon-Bouhet and Eric Pante

See Also

plot.bathy, get.transect, get.depth
get.depth

Examples

# load and plot bathymetry
data(hawaii)
plot(hawaii, im=TRUE)

# get the depth matrix for a belt transect
depth <- get.box(hawaii, x1=-157, y1=20, x2=-155.5, y2=21, width=0.5, col=2)

# plotting a 3D bathymetric map of the belt transect
require(lattice)
wireframe(depth, shade=TRUE)

# get the depth matrix for a belt transect with realistic aspect ratios
depth <- get.box(hawaii, x1=-157, y1=20, x2=-155.5, y2=21, width=0.5, col=2, ratio=TRUE)

# plotting a 3D bathymetric map of the belt transect with realistic aspect ratios
require(lattice)
wireframe(depth[,1], shade=TRUE, aspect=depth[,2])

get.depth

Get depth data by clicking on a map

Description

Outputs depth information based on points selected by clicking on a map

Usage

get.depth(mat, x, y=NULL, locator=TRUE, distance=FALSE, ...)

Arguments

mat
  Bathymetric data matrix of class bathy, as imported with read.bathy.

x
  Either a list of two elements (numeric vectors of longitude and latitude), a 2-
  column matrix or data.frame of longitudes and latitudes, or a numeric vector of
  longitudes.

y
  Either NULL (default) or a numerical vector of latitudes. Ignored if x is not a
  numeric vector.

locator
  Logical. Whether to choose data points interactively with a map or not. If TRUE
  (default), a bathymetric map must have been plotted and both x and y are both
  ignored.

distance
  whether to compute the haversine distance (in km) from the first data point on
  (default is FALSE). Only available when at least two points are provided.

... Further arguments to be passed to locator when the interactive mode is used
  (locator=TRUE).
Details

going. depth allows the user to get depth data by clicking on a map created with plot.bathy or by providing coordinates of points of interest. This function uses the locator function (graphics package); after creating a map with plot.bathy, the user can click on the map once or several times (if locator=TRUE), press the Escape button, and get the depth of those locations in a three-column data.frame (longitude, latitude and depth). Alternatively, when locator=FALSE, the user can submit a list of longitudes and latitudes, a two-column matrix or data.frame of longitudes and latitudes (as input for x), or one vector of longitudes (x) and one vector of latitudes (y). The non-interactive mode is well suited to get depth information for each point provided by GPS tracking devices. While get.transect gets every single depth value available in the bathymetric matrix between two points along a user-defined transect, get. depth only provides depth data for the specific points provided as input by the user.

Value

A data.frame with at least, longitude, latitude and depth with one line for each point of interest. If distance=TRUE, a fourth column containing the kilometric distance from the first point is added.

Author(s)

Benoit Simon-Bouhet and Eric Pante

See Also

path.profile, get.transect, read.bathy, summary.bathy, subsetBathy, nw.atlantic

Examples

# load NW Atlantic data and convert to class bathy
data(nw.atlantic)
atl <- as.bathy(nw.atlantic)

# create vectors of latitude and longitude
lon <- c(-70, -65, -63, -55)
lat <- c(33, 35, 40, 37)

# a simple example
plot(atl, lwd=.5)
points(lon, lat, pch=19, col=2)

# Use get. depth to get the depth for each point
get. depth(atl, x=lon, y=lat, locator=FALSE)

# alternatively once the map is plotted, use the interactive mode:
## Not run:
get. depth(atl, locator=TRUE, pch=19, col=3)

## End(Not run)
# click several times and press Escape
get.sample

Get sample data by clicking on a map

Description

Outputs sample information based on points selected by clicking on a map

Usage

get.sample(mat, sample, col.lon, col.lat, ...)

Arguments

mat  
bathymetric data matrix of class bathy, imported using read.bathy (no default)
sample  
data.frame containing sampling information (at least longitude and latitude) (no default)
col.lon  
column number of data frame sample containing longitude information (no default)
col.lat  
column number of data frame sample containing latitude information (no default)
...  
further arguments to be passed to rect for drawing a box around the selected area

Details

get.sample allows the user to get sample data by clicking on a map created with plot.bathy. This function uses the locator function (graphics package). After creating a map with plot.bathy, the user can click twice on the map to delimit an area (for example, lower left and upper right corners of a rectangular area of interest), and get a dataframe corresponding to the sample points present within the selected area.

Value

a dataframe of the elements of sample present within the area selected

Warning

clicking once or more than twice on the map will return a warning message: "Please choose two points from the map"

Author(s)

Eric Pante

See Also

read.bathy, summary.bathy, nw.atlantic, metallo
get.transect

Examples

## Not run:
# load metallo sampling data and add a third field containing a specimen ID
data(metallo)
metallo$id <- factor(paste("Metallo",1:38))

# load NW Atlantic data, convert to class bathy, and plot
data(nw.atlantic)
atl <- as.bathy(nw.atlantic)
plot(atl, deep=-8000, shallow=0, step=1000, col="grey")

# once the map is plotted, use get.sample to get sampling info!
get.sample(atl, metallo, 1, 2)
# click twice

## End(Not run)

---

get.transect

*Compute approximate cross section along a depth transect*

Description

Compute the depth along a linear transect which bounds are specified by the user.

Usage

```r
get.transect(mat, x1, y1, x2, y2, locator=FALSE, distance=FALSE, ...)
```

Arguments

- `mat`: bathymetric data matrix of class bathy, imported using `read.bathy` (no default)
- `x1`: start longitude of the transect (no default)
- `x2`: stop longitude of the transect (no default)
- `y1`: start latitude of the transect (no default)
- `y2`: stop latitude of the transect (no default)
- `locator`: whether to use locator to choose transect bounds interactively with a map (default is FALSE)
- `distance`: whether to compute the haversine distance (in km) from the start of the transect, along the transect (default is FALSE)
- `...`: other arguments to be passed to `locator()` to specify the characteristics of the points and lines to draw on the bathymetric map when `locator=TRUE`.  
get.transect allows the user to compute an approximate linear depth cross section either by in-
puting start and stop coordinates, or by clicking on a map created with plot.bathy. In its interac-
tive mode, this function uses the locator function (graphics package); after creating a map with
plot.bathy, the user can click twice to delimit the bound of the transect of interest (for example,
lower left and upper right corners of a rectangular area of interest), press Escape, and get a table
with the transect information.

Value
A table with, at least, longitude, latitude and depth along the transect, and if specified (distance=TRUE),
the distance in kilometers from the start of the transect. The number of elements in the resulting
table depends on the resolution of the bathy object.

Warning
Clicking once or more than twice on the map will return a warning message: "Please choose only
two points from the map". Manually entering coordinates that are outside the geographical range
of the input bathy matrix will return a warning message.

Note
The distance option of get.transect is calculated based on the haversine formula for getting the
great circle distance (takes into account the curvature of the Earth). get.transect uses an internal
function called diag.bathy that extracts the approximate diagonal of a matrix, when that matrix
has uneven dimensions (different numbers of columns and rows).

Author(s)
Eric Pante and Benoit Simon-Bouhet

See Also
read.bathy, nw.atlantic, nw.atlantic.coast, get.depth, get.sample

Examples
# load datasets
data(nw.atlantic); as.bathy(nw.atlantic) -> atl
data(nw.atlantic.coast)

# Example 1. get.transect(), without use of locator()
get.transect(atl, -65, 43,-59,40) -> test ; plot(test[,3]-test[,2],type="l")
get.transect(atl, -65, 43,-59,40, distance=TRUE) -> test ; plot(test[,4]-test[,3],type="l")

# Example 2. get.transect(), without use of locator(); pretty plot
par(mfrow=c(2,1),mai=c(1.2, 1, 0.1, 0.1))
plot(atl, deep=-6000, shallow=-10, step=1000, lwd=0.5, col="grey50",drawlabels=TRUE)
lines(nw.atlantic.coast)
getNOAA.bathy

Import bathymetric data from the NOAA server

Description

Imports bathymetric data from the NOAA server, given coordinate bounds and resolution.

Usage

getNOAA.bathy(lon1, lon2, lat1, lat2, resolution = 4,
               keep = FALSE, antimeridian = FALSE, path = NULL)

Arguments

lon1
  first longitude of the area for which bathymetric data will be downloaded

lon2
  second longitude of the area for which bathymetric data will be downloaded

lat1
  first latitude of the area for which bathymetric data will be downloaded

lat2
  second latitude of the area for which bathymetric data will be downloaded

resolution
  resolution of the grid, in minutes (default is 4)

keep
  whether to write the data downloaded from NOAA into a file (default is FALSE)

antimeridian
  whether the area should include the antimeridian (longitude 180 or -180). See
details.

path
  Where should bathymetric data be downloaded to if keep = TRUE? Where should
getNOAA.bathy() look up for bathymetric data already downloaded? Defaults to
the current working directory.
Details

getNOAA.bathy queries the ETOPO1 database hosted on the NOAA website, given the coordinates of the area of interest and desired resolution. Users have the option of directly writing the downloaded data into a file (keep = TRUE argument; see below). If an identical query is performed (i.e. using identical lat-long and resolution), getNOAA.bathy will load data from the file previously written to the disk instead of querying the NOAA database. This behavior should be used preferentially (1) to reduce the number of unnecessary queries to the NOAA website, and (2) to reduce data load time. If the user wants to make multiple, identical queries to the NOAA website without loading the data written to disk, the data file name must be modified by the user. Alternatively, the data file can be moved outside of the present working directory.

getNOAA.bathy allows users to download bathymetric data in the antimeridian region when antimeridian = TRUE. The antimeridian is the 180th meridian and is located about in the middle of the Pacific Ocean, east of New Zealand and Fidji, west of Hawaii and Tonga. For a given pair of longitude values, e.g. -150 (150 degrees West) and 150 (degrees East), you have the possibility to get data for 2 distinct regions: the area centered on the antimeridian (60 degrees wide, when antimeridian = TRUE) or the area centered on the prime meridian (300 degrees wide, when antimeridian = FALSE). It is recommended to use keep = TRUE in combination with antimeridian = TRUE since gathering data for an area around the antimeridian requires two distinct queries to NOAA servers.

Value

The output of getNOAA.bathy is a matrix of class bathy, which dimensions depends on the resolution of the grid uploaded from the NOAA server. The class bathy has its own methods for summarizing and plotting the data. If keep=TRUE, a csv file containing the downloaded data is produced. This file is named using the following format: ‘marmap_coord_COORDINATES_res_RESOLUTION.csv’ (COORDINATES separated by semicolons, and the RESOLUTION in degrees).

Author(s)

Eric Pante and Benoit Simon-Bouhet

References


See Also

read.bathy, readGEBCO.bathy, plot.bathy

Examples

## Not run:
# you must have an internet connection. This line queries the NOAA ETOP01 database
# for data from North Atlantic, for a resolution of 10 minutes.

getNOAA.bathy(lon1=-20,lon2=-90,lat1=50,lat2=20, resolution=10) -> a
plot(a, image=TRUE, deep=-6000, shallow=0, step=1000)
griddify

Fill a grid with irregularly spaced data

Description
Transforms irregularly spaced xyz data into a raster object suitable to create a bathy object with regularly spaced longitudes and latitudes.

Usage
```
griddify(xyz, nlon, nlat)
```

Arguments
- **xyz**: 3-column matrix or data.frame containing (in this order) arbitrary longitude, latitude and altitude/depth values.
- **nlon**: integer. The number of unique regularly-spaced longitude values that will be used to create the grid.
- **nlat**: integer. The number of unique regularly-spaced latitude values that will be used to create the grid.

Details
griddify takes anys dataset with irregularly spaced xyz data and transforms it into a raster object (i.e. a grid) with user specified dimensions. griddify relies on several functions from the raster package, especially rasterize and resample. If a cell of the user-defined grid does not contain any depth/altitude value in the original xyz matrix/data.frame, a NA is added in that cell. A bilinear interpolation is then applied in order to fill in most of the missing cells. For cells of the user-defined grid containing more than one depth/altitude value in the original xyz matrix/data.frame, the mean depth/altitude value is computed.

Value
The output of griddify is an object of class raster, with nlon unique longitude values and nlat unique latitude values.

Author(s)
Eric Pante and Benoit Simon-Bouhet
hawaii

References

See Also
read.bathy, readGEBCO.bathy, plot.bathy

Examples

```
# load irregularly spaced xyz data
data(irregular)
head(irregular)

# use griddify to create a 40x60 grid
reg <- griddify(irregular, nlon = 40, nlat = 60)

# switch to class "bathy"
class(reg)
bat <- as.bathy(reg)
summary(bat)

# Plot the new bathy object and overlay the original data points
plot(bat, image = TRUE, lwd = 0.1)
points(irregular$lon, irregular$lat, pch = 19, cex = 0.3, col = col2alpha(3))
```

hawaii

**Bathymetric data for Hawaii, USA**

Description
Bathymetric object of class bathy created from NOAA GEODAS data and arbitrary locations around the main Hawaiian islands.

Usage
data(hawaii)
data(hawaii.sites)

Details
hawaii contains data imported from the NOAA GEODAS Grid Translator webpage (https://maps.ngdc.noaa.gov/viewers/wcs-client/) and transformed into an object of class bathy by read.bathy. hawaii.sites is a 2-columns data.frame containing longitude and latitude of 6 locations spread at sea around Hawaii.
Value

hawaii: a bathymetric object of class bathy with 539 rows and 659 columns. hawaii.sites: data.frame (6 rows, 2 columns)

Author(s)

see https://maps.ngdc.noaa.gov/viewers/wcs-client/

See Also

plot.bathy, summary.bathy

Examples

# load hawaii data
data(hawaii)
data(hawaii.sites)

# class "bathy"
class(hawaii)
summary(hawaii)

## Not run:
## use of plot.bathy to produce a bathymetric map
# creation of a color palette
pal <- colorRampPalette(c("black","darkblue","blue","lightblue"))

# Plotting the bathymetry
plot(hawaii, image=TRUE, draw=TRUE, bpal=pal(100), asp=1, col="grey40", lwd=.7)

# Adding coastline
require(mapdata)
map("worldHires", res=0, fill=TRUE, col=rgb(.8,.95,.8,.7), add=TRUE)

# Adding hawaii.sites location on the map
points(hawaii.sites, pch=21, col="yellow", bg=col2alpha("yellow", .9), cex=1.2)

## End(Not run)

irregular

Irregularly spaced bathymetric data.

Description

Three-column data.frame of irregularly-spaced longitudes, latitudes and depths.

Usage

data(irregular)
is.bathy

Value
A three-columns data.frame containing longitude, latitude and depth/elevation data.

Author(s)
Data modified form a dataset kindly provided by Noah Lottig from the university of Wisconsin https://limnology.wisc.edu/staff/lottig-noah/ in the framework of the North Temperate Lakes Long Term Ecological Research program https://lter.limnology.wisc.edu

See Also
gridify

Examples
# load data
data(irregular)

# use griddify
reg <- griddify(irregular, nlon = 40, nlat = 60)

# switch to class "bathy"
class(reg)
bat <- as.bathy(reg)
summary(bat)

# Plot the new bathy object along with the original data
plot(bat, image = TRUE, lwd = 0.1)
points(irregular$lon, irregular$lat, pch = 19, cex = 0.3, col = col2alpha(3))

is.bathy

Test whether an object is of class bathy

Description
Test whether an object is of class bathy

Usage
is.bathy(xyz)

Arguments
xyz  three-column data.frame with longitude (x), latitude (y) and depth (z) (no default)

Value
The function returns TRUE or FALSE
Author(s)
Eric Pante

See Also
as.bathy, summary.bathy, read.bathy

Examples

# load NW Atlantic data
data(nw.atlantic)

# test class "bathy"
is.bathy(nw.atlantic)

# use as.bathy
atl <- as.bathy(nw.atlantic)

# class "bathy"
class(atl)
is.bathy(atl)

# summarize data of class "bathy"
summary(atl)

---

**lc.dist**

*Computes least cost distances between two or more locations*

Description

Computes least cost distances between two or more locations

Usage

lc.dist(trans, loc, res = c("dist", "path"), meters = FALSE, round = 0)

Arguments

<table>
<thead>
<tr>
<th>Trans</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>trans</td>
<td>transition object as computed by trans.mat</td>
</tr>
<tr>
<td>loc</td>
<td>A two-columns matrix or data.frame containing latitude and longitude for 2 or more locations.</td>
</tr>
<tr>
<td>res</td>
<td>either &quot;dist&quot; or &quot;path&quot;. See details.</td>
</tr>
<tr>
<td>meters</td>
<td>logical. When res = &quot;dist&quot;, should the results be returned in kilometers (default) or in meters.</td>
</tr>
<tr>
<td>round</td>
<td>integer indicating the number of decimal places to be used for printing results when res = &quot;dist&quot;.</td>
</tr>
</tbody>
</table>
lc.dist

Details

lc.dist computes least cost distances between 2 or more locations. This function relies on the package gdistance (van Etten, 2011. https://CRAN.R-project.org/package=gdistance) and on the trans.mat function to define a range of depths where the paths are possible.

Value

Results can be presented either as a kilometric distance matrix between all possible pairs of locations (argument res="dist") or as a list of paths (i.e. 2-columns matrices of routes) between pairs of locations (res="path").

Author(s)

Benoit Simon-Bouhet

References


See Also

trans.mat

Examples

# Load and plot bathymetry
data(hawaii)
pal <- colorRampPalette(c("black","darkblue","blue","lightblue"))
plot(hawaii,image=TRUE,bpal=pal(100),asp=1,col="grey40",lwd=.7,
    main="Bathymetric map of Hawaii")

# Load and plot several locations
data(hawaii.sites)
sites <- hawaii.sites[-c(1,4),]rownames(sites) <- 1:4
points(sites,pch=21,col="yellow",bg=col2alpha("yellow",.9),cex=1.2)
text(sites[,1],sites[,2],lab=rownames(sites),pos=c(3,4,1,2),col="yellow")

## Not run:
# Compute transition object with no depth constraint
trans1 <- trans.mat(hawaii)

# Compute transition object with minimum depth constraint:
# path impossible in waters shallower than -200 meters depth
trans2 <- trans.mat(hawaii,min.depth=-200)

# Computes least cost distances for both transition matrix and plots the results on the map
out1 <- lc.dist(trans1,sites,res="path")
out2 <- lc.dist(trans2,sites,res="path")
lapply(out1,lines,col="yellow",lwd=4,lty=1) # No depth constraint (yellow paths)
lapply(out2,lines,col="red",lwd=1,lty=1) # Min depth set to -200 meters (red paths)

# Computes and display distance matrices for both situations
dist1 <- lc.dist(trans1,sites,res="dist")
dist2 <- lc.dist(trans2,sites,res="dist")
dist1
dist2

# plots the depth profile between location 1 and 3 in the two situations
dev.new()
par(mfrow=c(2,1))
path.profile(out1[[2]],hawaii,pl=TRUE,
    main="Path between locations 1 & 3
Profile with no depth constraint")
path.profile(out2[[2]],hawaii,pl=TRUE,
    main="Path between locations 1 & 3
Profile with min depth set to -200m")

## End(Not run)

---

**linesGC**

*Add Great Circle lines on a map*

**Description**

linesGC draws Great Circle lines between a set of start and end points on an existing map.

**Usage**

```r
linesGC(start.points, end.points, n = 10, antimeridian = FALSE, ...)
```

**Arguments**

- **start.points** Two-column data.frame or matrix of longitudes and latitudes for start points.
- **end.points** Two-column data.frame or matrix of longitudes and latitudes for end points. The dimensions of start.points and end.points must be compatible (*i.e.* they must have the same number of rows).
- **n** Numeric. The number of intermediate points to add along the great circle line between the start end end points.
- **antimeridian** Logical indicating if the map on which the great circle lines will be plotted covers the antimeridian region. The antimeridian (or antemeridian) is the 180th meridian and is located in the middle of the Pacific Ocean, east of New Zealand and Fidji, west of Hawaii and Tonga.
- **...** Further arguments to be passed to lines to control the aspect of the lines to draw.
Details

_linesGC_ takes advantage of the gcIntermediate function from package geosphere to plot lines following a great circle. When working with marmap maps encompassing the antimeridian, longitudes are numbered from 0 to 360 (as opposed to the classical numbering from -180 to +180). It is thus critical to set antimeridian=TRUE to avoid plotting incoherent great circle lines.

Author(s)

Benoit Simon-Bouhet

See Also

dist2isobath, lc.dist

Examples

# Load NW Atlantic data and convert to class bathy
data(nw.atlantic)
atl <- as.bathy(nw.atlantic)

# Create vectors of latitude and longitude
lon <- c(-70, -65, -63, -55, -48)
lat <- c(33, 35, 40, 37, 33)

# Compute distances between each point and the -200m isobath
d <- dist2isobath(atl, lon, lat, isobath = -200)
d

# Create a nice palette of bleus for the bathymetry
blues <- c("lightsteelblue4","lightsteelblue3","lightsteelblue2","lightsteelblue1")

# Visualize the great circle distances
plot(atl, image=TRUE, lwd=0.1, land=TRUE, bpal = list(c(0,max(atl),"grey"), c(min(atl),0,blues)))
points(lon,lat, pch=21, col="orange4", bg="orange2", cex=.8)
linesGC(d[2:3],d[4:5])

# Load aleutians data and plot the map
data(aleutians)
plot(aleutians, image=TRUE, lwd=0.1, land=TRUE, bpal = list(c(0,max(aleutians),"grey"), c(min(aleutians),0,blues)))

# define start and end points
start <- matrix(c(170,55, 190, 60), ncol=2, byrow=TRUE, dimnames=list(1:2, c("lon","lat")))
end <- matrix(c(200, 56, 201, 57), ncol=2, byrow=TRUE, dimnames=list(1:2, c("lon","lat")))
start
end

# Add points and great circle distances on the map
points(start, pch=21, col="orange4", bg="orange2", cex=.8)
points(end, pch=21, col="orange4", bg="orange2", cex=.8)
linesGC(start, end, antimeridian=TRUE)
marmap

Import, plot and analyze bathymetric and topographic data

Description

marmap is a package designed for downloading, plotting and manipulating bathymetric and topographic data in R. It can query the ETOPO1 bathymetry and topography database hosted by the NOAA, use simple latitude-longitude-depth data in ascii format, and take advantage of the advanced plotting tools available in R to build publication-quality bathymetric maps. Functions to query data (bathymetry, sampling information, etc...) are available interactively by clicking on marmap maps. Bathymetric and topographic data can also be used to calculate projected surface areas within specified depth/altitude intervals, and constrain the calculation of realistic shortest path distances.

Details

Package: marmap
Type: Package
Version: 1.0.6
Date: 2021-11-10

Import, plot and analyze bathymetric and topographic data

Author(s)

Eric Pante, Benoit Simon-Bouhet and Jean-Olivier Irisson
Maintainer: Benoit Simon-Bouhet <besibo@gmail.com>

References


metallo

Coral sampling information from the North West Atlantic

Description

Coral sampling data from Thoma et al 2009 (MEPS)

Usage

data(nw.atlantic)
Details

Sampling locations (longitude, latitude, depth in meters) for the deep-sea octocoral species Metallogorgia melanotrichos (see Thoma et al 2009 for details, including cruise information)

Value

A 3-column data frame

References


See Also

nw.atlantic

Examples

# load NW Atlantic data and convert to class bathy
data(nw.atlantic,metallo)
atl <- as.bathy(nw.atlantic)

## the function plot below plots:
## - the coastline in blue,
## - isobaths between 8000-4000 in light grey,
## - isobaths between 4000-500 in dark grey (to emphasize seamounts)

# 1st example: function points uses first two columns ; 3rd column contains depth info
plot(atl, deep=c(-8000,-4000,0), shallow=c(-4000,-500,0), step=c(500,500,0),
     lwd=c(0.5,0.5,1.5),lty=c(1,1,1),
     col=c("grey80", "grey20", "blue"),
     drawlabels=c(FALSE,FALSE,FALSE) )
points(metallo, cex=1.5, pch=19,col=rgb(0,0,1,0.5))

# 2nd example: plot points according to coordinates
plot(atl, deep=c(-8000,-4000,0), shallow=c(-4000,-500,0), step=c(500,500,0),
     lwd=c(0.5,0.5,1.5),lty=c(1,1,1),
     col=c("grey80", "grey20", "blue"),
     drawlabels=c(FALSE,FALSE,FALSE) )
subset(metallo, metallo$lon>-55) -> s # isolate points from the Corner Rise seamounts:
points(s, cex=1.5, pch=19,col=rgb(0,0,1,0.5)) # only plot those points

# 3rd example: point colors corresponding to a depth gradient:
par(mai=c(1,1,1,1.5))
plot(atl, deep=c(-6500,0), shallow=c(-50,0), step=c(500,0),
     lwd=c(0.3,1), lty=c(1,1),
     col=c("black","black"),
     drawlabels=c(FALSE,FALSE,FALSE))
```
max(metallo$depth, na.rm=TRUE) -> mx
colorRamp(c("white","lightyellow","lightgreen","blue","lightblue1","purple")) -> ramp
rgb(ramp(seq(0, 1, length = mx)), max = 255) -> blues
points(metallo, col="black", bg=blues[metallo$depth], pch=21,cex=1.5)
require(shape); colorlegend(zlim=c(-mx,0), col=rev(blues), main="depth (m)",posx=c(0.85,0.88))
```

---

**nw.atlantic**

_Bathymetric data for the North West Atlantic_

**Description**

Data imported from the NOAA GEODAS server

**Usage**

data(nw.atlantic)

**Details**

Data imported from the NOAA GEODAS Grid Translator webpage (https://maps.ngdc.noaa.gov/viewers/wcs-client/). To prepare data from NOAA, fill the custom grid form, and choose "XYZ (lon,lat,depth)" as the "Output Grid Format", "No Header" as the "Output Grid Header", and either of the space, tab or comma as the column delimiter (either can be used, but "comma" is the default import format of `read.bathy`). Choose "omit empty grid cells" to reduce memory usage.

**Value**

A three-columns data.frame containing longitude, latitude and depth/elevation data.

**Author(s)**

see https://maps.ngdc.noaa.gov/viewers/wcs-client/

**See Also**

plot.bathy, summary.bathy

**Examples**

```r
# load NW Atlantic data
data(nw.atlantic)

# use as.bathy
atl <- as.bathy(nw.atlantic)

# class "bathy"
class(atl)
```
nw.atlantic.coast

summary(atl)

# test plot.bathy
plot(atl, deep=-8000, shallow=-1000, step=1000)

nw.atlantic.coast  Coastline data for the North West Atlantic

Description
Coastline data for the North West Atlantic, as downloaded using the NOAA Coastline Extractor tool.

Usage
data(nw.atlantic.coast)

Details
Coastline data for the NW Atlantic was obtained using the NOAA Coastline Extractor tool. To get more coastline data, go to https://www.ngdc.noaa.gov/mgg/shorelines/.

Value
A 2-column data frame

References
see https://www.ngdc.noaa.gov/mgg/shorelines/

See Also
nw.atlantic

Examples
# load NW Atlantic data and convert to class bathy
data(nw.atlantic,nw.atlantic.coast)
atl <- as.bathy(nw.atlantic)

## the function plot below plots only isobaths:
## - isobaths between 8000-4000 in light grey,
## - isobaths between 4000-500 in dark grey (to emphasize seamounts)
plot(atl, deep=c(-8000,-4000), shallow=c(-4000,-500), step=c(500,500),
  lwd=c(0.5,0.5,1.5),lty=c(1,1,1),
  col=c("grey80", "grey20", "blue"),
  drawlabels=c(FALSE,FALSE,FALSE) )
## the coastline can be added from a different source, 
## and can therefore have a different resolution:
lines(mw.atlantic.coast)

## add a geographical reference on the coast:
points(-71.064,42.358, pch=19); text(-71.064,42.358,"Boston", adj=c(1.2,0))

---

### outline.buffer

**Get a composite buffer in a format suitable for plotting its outline**

**Description**

Get a buffer (i.e. a non-circular buffer as produced by `combine.buffers()`) in a format suitable for plotting its outline. `outline.buffer()` replaces any NA values in a buffer or bathy object by 0 and non-NA values by -1.

**Usage**

```r
outline.buffer(buffer)
```

**Arguments**

- `buffer` a buffer object of class bathy (i.e. bathy matrix containing depth/altitude values within the buffer and NAs outside)

**Details**

This function is essentially used to prepare a composite buffer for plotting its outline on a bathymetric map. Plotting a single circular buffer should be done using the `plot.buffer()` function since it offers a more straightforward method for plotting and much smoother outlines, especially for low-resolution bathymetries.

**Value**

An object of class bathy of the same dimensions as `buffer` containing only zeros (outside the buffer area) and -1 values (within the buffer).

**Author(s)**

Benoit Simon-Bouhet

**See Also**

`create.buffer`, `combine.buffers`, `plot.bathy`
Examples

```r
# load and plot a bathymetry
data(florida)
plot(florida, lwd = 0.2)
plot(florida, n = 1, lwd = 0.7, add = TRUE)

# add points around which a buffer will be computed
loc <- data.frame(c(-80,-82), c(26,24))
points(loc, pch = 19, col = "red")

# create 2 distinct buffer objects with different radii
buf1 <- create.buffer(florida, loc[1,], radius=1.9)
buf2 <- create.buffer(florida, loc[2,], radius=1.2)

# combine both buffers
buf <- combine.buffers(buf1,buf2)

## Not run:
# Add outline of the resulting buffer in red
# and the outline of the original buffers in blue
plot(outline.buffer(buf), lwd = 3, col = 2, add=TRUE)
plot(buf1, lwd = 0.5, fg="blue")
plot(buf2, lwd = 0.5, fg="blue")

## End(Not run)
```

---

`palette.bathy`  
*Builds a bathymetry- and/or topography-constrained color palette*

**Description**

Builds a constrained color palette based on depth / altitude bounds and given colors.

**Usage**

```r
palette.bathy(mat, layers, land=FALSE, default.col="white")
```

**Arguments**

- `mat`  
a matrix of bathymetric data, class bathy not required.
- `layers`  
a list of depth bounds and colors (see below)
- `land`  
logical. Wether to consider land or not (default is FALSE)
- `default.col`  
a color for the area of the matrix not bracketed by the list supplied to layers
palette.bathy allows the production of color palettes for specified bathymetric and/or topographic layers. The layers argument must be a list of vectors. Each vector corresponds to a bathymetry/topography layer (for example, one layer for bathymetry and one layer for topography). The first and second elements of the vector are the minimum and maximum bathymetry/topography, respectively. The other elements of the vector (3, onward) correspond to colors (see example below). palette.bathy is called internally by plot.bathy when the image argument is set to TRUE.

Value

A vector of colors which size depends on the depth / altitude range of the bathy matrix.

Author(s)

Eric Pante and Benoit Simon-Bouhet

See Also

plot.bathy

Examples

# load NW Atlantic data and convert to class bathy
data(nw.atlantic)
atl <- as.bathy(nw.atlantic)

# creating depth-constrained palette for the ocean only
newcol <- palette.bathy(mat=atl,
layers = list(c(min(atl), 0, "purple", "blue", "lightblue")),
land = FALSE, default.col = "grey")
plot(atl, land = FALSE, n = 10, lwd = 0.5, image = TRUE,
bpal = newcol, default.col = "grey")

# same:
plot(atl, land = FALSE, n = 10, lwd = 0.5, image = TRUE,
bpal = list(c(min(atl), 0, "purple", "blue", "lightblue")),
default.col = "gray")

# creating depth-constrained palette for 3 ocean "layers"
newcol <- palette.bathy(mat = atl, layers = list(
c(min(atl), -3000, "purple", "blue", "grey"),
c(-3000, -150, "white"),
c(-150, 0, "yellow", "green", "brown")),
land = FALSE, default.col = "grey")
plot(atl, land = FALSE, n = 10, lwd = 0.7, image = TRUE,
bpal = newcol, default.col = "grey")

# same
plot(atl, land = FALSE, n = 10, lwd = 0.7, image = TRUE,
bpal = list(c(min(atl), -3000, "purple", "blue", "grey"),
c(-3000, -150, "white"),
c(-150, 0, "yellow", "green", "brown")),
land = FALSE, default.col = "grey")

# same
plot(atl, land = FALSE, n = 10, lwd = 0.7, image = TRUE,
bpal = list(c(min(atl), -3000, "purple", "blue", "grey"),
c(-3000, -150, "white"),
c(-150, 0, "yellow", "green", "brown")),
land = FALSE, default.col = "grey")
c(-150, 0, "yellow", "green", "brown")),
default.col = "grey")

# creating depth-constrained palette for land and ocean
newcol <- palette.bathy(mat= atl, layers = list(
c(min(atl),0,"purple","blue","lightblue"),
c(0, max(atl), "gray90", "gray10"),
land = TRUE)
plot(atl, land = TRUE, n = 10, lwd = 0.5, image = TRUE, bpal = newcol)

# same
plot(atl, land = TRUE, n = 10, lwd = 0.7, image = TRUE,
bpal = list(
c(min(atl), 0, "purple", "blue", "lightblue"),
c(0, max(atl), "gray90", "gray10")))

---

path.profile

**Geographic coordinates, kilometric distance and depth along a path**

Description

Computes and plots the depth/altitude along a transect or path

Usage

```r
path.profile(path,bathy,plot=FALSE, ...)
```

Arguments

- **path**: 2-columns matrix of longitude and latitude as obtained from lc.dist with argument dist=TRUE.
- **bathy**: bathymetric data matrix of class bathy.
- **plot**: logical. Should the depth profile be plotted?
- **...**: when plot=TRUE, other arguments to be passed to plotProfile, such as graphical parameters (see par and plotProfile).

Value

A four-columns matrix containing longitude, latitude, kilometric distance from the start of a route and depth for a set of points along a route. Optionally (i.e. when plot=TRUE) a bivariate plot of depth against the kilometric distance from the starting point of a transect or least cost path.

Author(s)

Benoit Simon-Bouhet

See Also

plotProfile
Examples

# Loading an object of class bathy and a data.frame of locations
require(mapdata)
data(hawaii)
data(hawaii.sites)

# Preparing a color palette for the bathymetric map
pal <- colorRampPalette(c("black","darkblue","blue","lightblue"))

# Plotting the bathymetric data and the path between locations
# (the path starts on location 1)
plot(hawaii, image=TRUE, bpal=pal(100), col="grey40", lwd=.7,
    main="Bathymetric map of Hawaii")
map("worldHires", res=0, fill=TRUE, col=rgb(.8,.95,.8,.7), add=TRUE)
lines(hawaii.sites[,1], hawaii.sites[,2], type="o", lty=2, lwd=2, pch=21,
    col="yellow", bg=col2alpha("yellow",.9), cex=1.2)
text(hawaii.sites[,1], hawaii.sites[,2], lab=rownames(hawaii.sites),
    pos=c(3,3,4,4,1,2), col="yellow")

# Computing and plotting the depth profile for this path
profile <- path.profile(hawaii.sites, hawaii, plot=TRUE,
    main="Depth profile along the path connecting the 6 sites")
summary(profile)

plot.bathy

Plotting bathymetric data

Description

Plots contour map from bathymetric data matrix of class bathy

Usage

## S3 method for class 'bathy'
plot(x, image=FALSE, bpal=NULL, land=FALSE,
    deepest.isobath, shallowest.isobath, step, n=20,
    lwd=1, lty=1, col="black", default.col="white", drawlabels = FALSE,
    xlab="Longitude", ylab="Latitude", asp=1, ...)

Arguments

x       bathymetric data matrix of class bathy, imported using read.bathy
image   whether or not to color depth layers (default is FALSE)
bpal    if image is TRUE, either NULL (default: a simple blue color palette is used), a
        vector of colors, or a list of depth bounds and colors (see below)
land    whether or not to use topographic data that may be available in the bathy dataset
        (default is FALSE)
plot.bathy

deepest.isobath
deepest isobath(s) to plot

shallowest.isobath
shallowest isobath(s) to plot

step
distance(s) between two isobaths

n
if the user does not specify the range within which isobaths should be plotted, about n isobaths are automatically plotted within the depth range of the bathy matrix (default is 20).

lwd
isobath line(s) width (default is 1)

lty
isobath line type(s) (default is 1)

col
isobath line color(s) (default is black)

default.col
if image is TRUE, a color for the area of the matrix not bracketed by the list supplied to bpal (see below; default is white)

drawlabels
whether or not to plot isobath depth as a label (default is FALSE); may contain several elements

xlab
label for the x axis of the plot

ylab
label for the y axis of the plot

asp
numeric, giving the aspect ratio y/x of the plot. See plot.window

... Other arguments to be passed either to contour (default) or to image when argument image=TRUE.

Details

plot.bathy uses the base contour and image functions. If a vector of isobath characteristics is provided, different types of isobaths can be added to the same plot using a single call of plot.bathy (see examples)

If image=TRUE, the user has three choices for colors: (1) bpal can be set to NULL, in which case a default blue color palette is generated; (2) colors can be user-defined as in example 4, in which case the palette can be generated with function colorRampPalette (colors are then supplied as a vector to plot.bathy) ; (3) colors can be constrained to bathymetry- and/or topography. In this last case, a list of vectors is supplied to plot.bathy (example 7): each vector corresponds to a bathymetry/topography layer (for example, one layer for bathymetry and one layer for topography). The first and second elements of the vector are the minimum and maximum bathymetry/topography, respectively. The other elements of the vector (3, onward) correspond to colors (see example 7).

Value

a bathymetric map with isobaths

Note

plot.bathy uses a matrix of class bathy, and can therefore be substituted for plot.

Author(s)

Eric Pante and Benoit Simon-Bouhet
References


See Also

read.bathy, summary.bathy, nw.atlantic, metallo

Examples

# load NW Atlantic data and convert to class bathy
data(nw.atlantic)
atl <- as.bathy(nw.atlantic)

## Example 1: a simple marine chart
plot(atl) # without specifying any isobath parameters
plot(atl, n=5, drawlabels=TRUE) # with about 5 isobaths
plot(atl, deep=-8000, shallow=0, step=1000) # with isobath parameters

## Example 2: taking advantage of multiple types of isobaths
plot(atl, deep=c(-8000,-2000,0), shallow=c(-2000,-100,0), step=c(1000,100,0), lwd=c(0.5,0.5,1), lty=c(1,1,1), col=c("grey80","red", "blue"), drawlabels=c(FALSE,FALSE,FALSE) )

## Example 3: plotting a colored map with the default color palette
plot(atl, image=TRUE, deep=c(-8000,0), shallow=c(-1000,0), step=c(1000,0), lwd=c(0.5,1), lty=c(1,1), col=c("grey","black"), drawlabels=c(FALSE,FALSE,FALSE))

## Example 4: make a pretty custom color ramp
colorRampPalette(c("purple","lightblue","cadetblue2","cadetblue1","white")) -> blues

plot(atl, image=TRUE, bpal=blues(100), deep=c(-6500,0), shallow=c(-50,0), step=c(500,0), lwd=c(0.3,1), lty=c(1,1), col=c("black","black"), drawlabels=c(FALSE,FALSE))

scaleBathy(atl, deg=3, x="bottomleft", inset=5)

## Example 5: add points corresponding to sampling locations
## point colors correspond to the sampling depth
par(mai=c(1,1,1,1.5))
plot(atl, deep=c(-4500,0), shallow=c(-50,0), step=c(500,0), lwd=c(0.3,1), lty=c(1,1), col=c("black","black"), drawlabels=c(FALSE,FALSE))

# add a title to the plot
title(main="Distribution of coral samples\non the New England and Corner Rise seamounts")
# add a scale
scaleBathy(atl, deg=3, x="bottomleft", inset=5)

# add a geographical reference on the coast:
points(-71.064,42.358, pch=19)
text(-71.064,42.358,"Boston", adj=c(1.2,0))
# prepare colors for the sampling locations:
data(metallo) ## see dataset metallo
max(metallo$depth, na.rm=TRUE) -> mx
colorRampPalette(c("white","lightyellow","lightgreen","blue","lightblue1","purple")) -> ramp
blues <- ramp(max(metallo$depth))

# plot sampling locations:
points(metallo, col="black", bg=blues[metallo$depth], pch=21,cex=1.5)
library(shape)
colorlegend(zlim=c(-mx,0), col=rev(blues), main="depth (m)",posx=c(0.85,0.88))

## Example 6: use packages maps and mapdata in combination with marmap
# use maps and mapdata to plot the coast
library(maps)
library(mapdata)
map(VarVarworldHires, xlim=c(-75,-46), ylim=c(32,44), fill=TRUE, col="grey")
box();axis(1);axis(2)

# add bathymetric data from 'bathy' data
  plot(atl, add=TRUE, lwd=.3, deep=-4500, shallow=-10, step=500,
       drawlabel=FALSE, col="grey50")

## Example 7: provide a list of depths and colors to argument bpal to finely tune palette
# check out ?palette.bathy to see details on how the palette is handled

# creating depth-constrained palette for the ocean only
plot(atl, land = FALSE, n = 10, lwd = 0.5, image = TRUE,
     bpal = list(c(min(atl), 0, "purple", "blue", "lightblue")),
     default.col = "gray")

# creating depth-constrained palette for 3 ocean "layers"
plot(atl, land = FALSE, n = 10, lwd = 0.7, image = TRUE,
     bpal = list(c(min(atl), -3000, "purple", "blue", "grey"),
                c(-3000, -150, "white"),
                c(-150, 0, "yellow", "green", "brown")),
     default.col = "grey")

# creating depth-constrained palette for land and ocean
plot(atl, land = TRUE, n = 10, lwd = 0.7, image = TRUE,
     bpal = list(c(min(atl), 0, "purple", "blue", "lightblue"),
                c(0, max(atl), "gray90", "gray10"))

---

**plot.buffer**  
*Plots a circular buffer and or its outline*

**Description**

plot.buffer is a generic function that allows the plotting of objects of class buffer, either as new plots or as a new layer added on top of an existing one. The plotting of both the bathymetry/hypsometry as well as the outline of the buffer is possible.
Usage

```r
## S3 method for class 'buffer'
plot(x, outline = TRUE, add = TRUE, ...)
```

Arguments

- `x`: an object of class `buffer` as produced by the `create.buffer()` function.
- `outline`: Should the outline of the buffer be plotted (default) or the bathymetric/hypsometric data within the buffer.
- `add`: Should the plot be added on top of an existing bathymetric/hypsometric plot (default) or as a new plot.
- `...`: Further arguments to be passed to the `symbols()` function from the `graphics` package when `outline = TRUE` (default) or to `plot.bathy()` when `outline = FALSE`.

Value

Either a plot of the outline of a buffer (default) or a bathymetric map with isobaths of a buffer when `outline = FALSE`.

Author(s)

Benoit Simon-Bouhet

See Also

- `create.buffer`, `combine.buffers`, `plot.bathy`

Examples

```r
# load and plot a bathymetry
data(florida)
plot(florida, lwd = 0.2)
plot(florida, n = 0, lwd = 0.7, add = TRUE)

# add points around which a buffer will be computed
loc <- data.frame(-80, 26)
points(loc, pch = 19, col = "red")

# compute buffer
buf <- create.buffer(florida, loc, radius=1.5)

# plot buffer bathymetry
plot(buf, outline=FALSE, n=10, lwd=0.5, col="red")

# add buffer outline
plot(buf, lwd=.7, fg=2)
```
plotArea

Plotting projected surface areas

Description

Highlights the projected surface area for specific depth layers on an existing bathymetric/hypsometric map

Usage

plotArea(area, col)

Arguments

area        a list of 4 elements as produced by get.area.
col         color of the projected surface area on the map.

Author(s)

Benoit Simon-Bouhet

See Also

get.area, plot.bathy, areaPolygon

Examples

# load and plot a bathymetry
data(florida)
plot(florida, lwd = 0.2)
plot(florida, n = 1, lwd = 0.7, add = TRUE)

# Create a point and a buffer around this point
loc <- data.frame(-80, 26)
buf <- create.buffer(florida, loc, radius=1.8)

# Get the surface within the buffer for several depth slices
surf1 <- get.area(buf, level.inf=-200, level.sup=-1)
surf2 <- get.area(buf, level.inf=-800, level.sup=-200)
surf3 <- get.area(buf, level.inf=-3000, level.sup=-800)

s1 <- round(surf1$Square.Km)
s2 <- round(surf2$Square.Km)
s3 <- round(surf3$Square.Km)

# Add buffer elements on the plot
col.surf1 <- rgb(0.7, 0.7, 0.3, 0.3)
col.surf2 <- rgb(0, 0.7, 0.3, 0.3)
col.surf3 <- rgb(0.7, 0, 0, 0.3)
plotProfile

Ploting bathymetric data along a transect or path

Description

Plots the depth/altitude along a transect or path

Usage

plotProfile(profile, shadow=TRUE, xlim, ylim, col.sea, col.bottom, xlab, ylab, ...)

Arguments

- **profile**: 4-columns matrix obtained from get.transect with argument dist=TRUE, or from path.profile.
- **shadow**: logical. Should the depth profile cast a shadow over the plot background?
- **xlim, ylim**: numeric vectors of length 2, giving the x and y coordinates ranges. If unspecified, xlim values are based on the length of the transect or path and ylim values are based on the depth range of the bathymetric matrix bathy.
- **col.sea**: color for the sea area of the plot. Defaults to rgb(130/255,180/255,212/255)
- **col.bottom**: color for the bottom area of the plot. Defaults to rgb(198/255,184/255,151/255)
- **xlab, ylab**: titles for the x and y axes. If unspecified, xlab="Distance from start of transect (km)" and ylab="Depth (m)"
- **...**: arguments to be passed to methods, such as graphical parameters (see par)

Value

A bivariate plot of depth against the kilometric distance from the starting point of a transect or least cost path.

Note

path.profile with argument plot set to TRUE plots depth profiles with default values for all arguments of plotProfile.
**read.bathy**

*Author(s)*

Benoit Simon-Bouhet

*See Also*

`path.profile`, `plot.bathy`

*Examples*

```r
# Example 1:
data(celt)
layout(matrix(1:2,nc=1),height=c(2,1))
par(mar=c(4,4,1,1))
plot(celt,n=40,draw=TRUE)
points(c(-6.34,-5.52),c(52.14,50.29),type="o",col=2)

tr <- get.transect(celt, x1 = -6.34, y1 = 52.14, x2 = -5.52, y2 = 50.29, distance = TRUE)
plotProfile(tr)

# Example 2:
layout(matrix(1:2,nc=1),height=c(2,1))
par(mar=c(4,4,1,1))
plot(celt,n=40,draw=TRUE)
points(c(-5,-6.34),c(49.8,52.14),type="o",col=2)

tr2 <- get.transect(celt, x1 = -5, y1 = 49.8, x2 = -6.34, y2 = 52.14, distance = TRUE)
plotProfile(tr2)

# Example 3: click several times on the map and press ESC
## Not run:
layout(matrix(1:2,nc=1),height=c(2,1))
par(mar=c(4,4,1,1))
data(florida)
plot(florida,image=TRUE,dra=TRUE,land=TRUE,n=40)

out <- path.profile(as.data.frame(locator(type="o",col=2,pch=19,cex=.8)),florida)
plotProfile(out)
## End(Not run)
```

---

**Read bathymetric data in XYZ format**

*Description*

Reads a three-column table containing longitude (x), latitude (y) and depth (z) data.
### Usage

```r
read.bathy(xyz, header = FALSE, sep = ",", ...)```

### Arguments

- `xyz`: three-column table with longitude (x), latitude (y) and depth (z) (no default)
- `header`: whether this table has a row of column names (default = FALSE)
- `sep`: character separating columns, (default=",")
- `...`: further arguments to be passed to `read.table()`

### Details

Allows direct import of data from the NOAA GEODAS Grid Translator webpage ([https://maps.ngdc.noaa.gov/viewers/wcs-client/](https://maps.ngdc.noaa.gov/viewers/wcs-client/)). To prepare data from NOAA, fill the custom grid form, and choose "XYZ (lon, lat, depth)" as the "Output Grid Format", "No Header" as the "Output Grid Header", and either of the space, tab of comma as the column delimiter (either can be used, but "comma" is the default import format of `read.bathy`). Choose "omit empty grid cells" to reduce memory usage.

### Value

The output of `read.bathy` is a matrix of class `bathy`, which dimensions depends on the resolution of the grid uploaded from the NOAA GEODAS server (Grid Cell Size). The class `bathy` has its own methods for summarizing and plotting the data.

### Author(s)

Eric Pante

### See Also

`summary.bathy`, `plot.bathy`, `readGEBCO.bathy`

### Examples

```r
# load NW Atlantic data
data(nw.atlantic)

# write example file to disk
write.table(nw.atlantic, "NW_Atlantic.csv", sep="", quote=FALSE, row.names=FALSE)

# use read.bathy
read.bathy("NW_Atlantic.csv", header=TRUE) -> atl

# remove temporary file
system("rm NW_Atlantic.csv") # remove file, for unix-like systems

# class "bathy"
class(atl)`
# summarize data of class "bathy"
summary(atl)

readGEBCO.bathy

## Read bathymetric data from a GEBCO file

### Description
Imports 30-sec and 1-min bathymetric data from a .nc file downloaded on the GEBCO website.

### Usage

```r
readGEBCO.bathy(file, resolution = 1, sid = FALSE)
```

### Arguments

- `file` : name of the .nc file
- `resolution` : resolution of the grid, in units of the selected database (default is 1; see details)
- `sid` : logical. Is the data file containing SID information?

### Details

`readGEBCO.bathy` reads a 30 arcseconds or 1 arcminute bathymetry file downloaded from the GEBCO (General Bathymetric Chart of the Oceans) website (British Oceanographic Data Center). The website allows the download of bathymetric data in the netCDF format. `readGEBCO.bathy` uses the `ncdf4` package to load the data into R, and parses it into an object of class `bathy`.

Data can be downloaded from the 30 arcseconds database (GEBCO_08) or the 1 arcminute database (GEBCO_1min, the default). A third database type, GEBCO_08 SID, is available from the website. This database includes a source identifier specifying which grid cells have depth information based on soundings; it does not include bathymetry or topography data. `readGEBCO.bathy` can read this type of database when `sid` is set to `TRUE`. Then only the SID information will be included in the object of class `bathy`. Therefore, to display a map with both the bathymetry and the SID information, you will have to download both datasets from GEBCO, and import and plot both independently.

The argument `resolution` specifies the resolution of the object of class `bathy`. Because the resolution of GEBCO data is rather fine, we offer the possibility of downsizing the dataset with `resolution`. `resolution` is in units of the selected database: in "GEBCO_1min", `resolution` is in minutes; in "GEBCO_08", `resolution` is in 30 arcseconds (that is, `resolution = 3` corresponds to 3x30sec, or 1.5 arcminute).

### Value

The output of `readGEBCO.bathy` is a matrix of class `bathy`, which dimensions depends on the `resolution` specified (one-minute, the original GEBCO resolution, is the default). The class `bathy` has its own methods for summarizing and plotting the data.
scaleBathy

Adds a scale to a map

Description

Uses geographic information from object of class bathy to calculate and plot a scale in kilometer.

Author(s)

Eric Pante and Benoit Simon-Bouhet

References

British Oceanographic Data Center: General Bathymetric Chart of the Oceans gridded bathymetric data sets (accessed July 10, 2020) https://www.bodc.ac.uk/data/hosted_data_systems/gebco_gridded_bathymetry_data/


See Also

getNOAA.bathy, read.bathy, plot.bathy

Examples

## Not run:
# This example will not run, and we do not provide the dummy "gebco_file.nc" file,
# because a copyright license must be signed on the GEBCO website before the data can be
# downloaded and used. We just provide this line as an example for syntahx.
readGEBCO.bathy(file="gebco_file.nc", resolution=1) -> nw.atl

# Second not-run example, with GEBCO_08 and SID:
readGEBCO.bathy("gebco_08_7_38_10_43_corsica.nc") -> med
summary(med) # the bathymetry data

readGEBCO.bathy("gebco_SID_7_38_10_43_corsica.nc") -> sid
summary(sid) # the SID data

colorRampPalette(c("lightblue","cadetblue1","white")) -> blues # custom col palette
plot(med, n=1, im=T, bpal=blues(100)) # bathymetry

as.numeric(rownames(sid)) -> x.sid
as.numeric(colnames(sid)) -> y.sid
contour(x.sid, y.sid, sid, drawlabels=FALSE, lwd=.1, add=TRUE) # SID

## End(Not run)
Usage

scaleBathy(mat, deg=1, x="bottomleft", y=NULL, inset=10, angle=90, ...)
space.pies

Automatic placement of piecharts on maps

Description

Attempts to automatically place piecharts on maps, avoiding overlap. Work in progress...

Usage

```r
space.pies(x, y, pie.slices, pie.colors=NULL, pie.radius=1, pie.space=5,
link=TRUE, seg.lwd=1, seg.col=1, seg.lty=1, coord=NULL)
```

Arguments

- `x` the longitude of the anchor point for the piechart
- `y` the latitude of the anchor point for the piechart
- `pie.slices` a table with the counts to draw pies (col: pie categories, or slices; rows: sites on the map)
- `pie.colors` a table with the colors to draw pies (col: pie categories, or slices; rows: sites on the map)
- `pie.radius` size of the piechart
- `pie.space` factor of spacing between the anchor and the pie (the larger, the farther the pie from the anchor)
- `link` logical; whether to add a segment to link pie and anchor
- `seg.lwd` the line width of the link
- `seg.col` the line color of the link
- `seg.lty` the line type of the link
- `coord` when coord = NULL (default), placement is automatic. Otherwise, a 2-col table of lon/lat for pies.
space.pies

Details

space.pies tries to position piecharts on a map while avoiding overlap between them. The function heavily relies on two other functions. floating.pie from package plotrix is used to draw individual piecharts. floating.pie treats one pie at a time; space.pies can handle one or multiple pies by looping floating.pie. pointLabels from package maptools was modified to find the best placement for the pies, given their size and distance from their anchor point. pointLabels was originally meant to automatically place text labels, not objects; the modified version contained in space.pies uses the coordinates chosen by pointLabels for text. The algorithm used is simulating annealing (SANN). You can get a different result each time you run space.pies, because pointLabel finds one good solution out of many. If you are not satisfied by the solution, you can try running the function again.

The argument coord allows to choose between the automatic placement outlined above, and a user-defined list of longitudes and latitudes (in a two-column table format) for plotting the piecharts.

Anchor point: spatial location of the data corresponding to the piechart (e.g. a sampling point).

Value

Piechart(s) added to a plot.

Author(s)

Eric Pante, using functions plotrix::floating.pie and maptools::pointLabel.

References


See Also

plot.bathy, plotrix::floating.pie, maptools::pointLabel

Examples

```r
# fake frequencies to feed to space.pies()
sample(seq(10,90,5), 11) -> freq.a
100-freq.a -> freq.b
rep("lightblue",11) -> col.a
rep("white",11) -> col.b

# some coordinates on the NW Atlantic coast, and on seamounts
x = c(-74.28487,-73.92323,-73.80753,-72.51728,-71.12418,
     -69.81176,-69.90715,-70.43201,-70.17135,-69.43912,-65.49608)
y = c(39.36714,39.98515,40.40316,40.79654,41.49872,41.62076,
     41.99805,42.68061,43.40714,43.81499,43.36471)
```
subsetBathy

Creates bathy objects from larger bathy objects

Description

Generates rectangular or non rectangular bathy objects by extracting bathymetric data from larger bathy objects.

Usage

subsetBathy(mat, x, y=NULL, locator=TRUE, ...)

Arguments

mat Bathymetric data matrix of class bathy, as imported with read.bathy.

x Either a list of two elements (numeric vectors of longitude and latitude), a 2-column matrix or data.frame of longitudes and latitudes, or a numeric vector of longitudes.

y Either NULL (default) or a numerical vector of latitudes. Ignored if x is not a numeric vector.

locator Logical. Whether to choose data points interactively with a map or not. If TRUE (default), a bathymetric map must have been plotted and both x and y are both ignored.

... Further arguments to be passed to locator when the interactive mode is used (locator=TRUE).
Details

subsetBathy allows the user to generate new bathy objects by extracting data from larger bathy objects. The extraction of bathymetric data can be done interactively by clicking on a bathymetric map, or by providing longitudes and latitudes for the boundaries for the new bathy object. If two data points are provided, a rectangular area is selected. If more than two points are provided, a polygon is defined by linking the points and the bathymetric data is extracted within the polygon only. subsetBathy relies on the point.in.polygon function from package sp to identify which points of the initial bathy matrix lie within the boundaries of the user-defined polygon.

Value

A matrix of class bathy.

Author(s)

Benoit Simon-Bouhet

References


See Also

plot.bathy, get.depth, summary.bathy, aleutians

Examples

# load aleutians dataset
data(aleutians)

# create vectors of latitude and longitude to define the boundary of a polygon
lon <- c(188.56, 189.71, 191, 193.18, 196.18, 196.32, 194.34, 188.83)
lat <- c(54.33, 55.88, 56.06, 55.85, 55.23, 54.19, 52.01, 50.52, 51.71)

# plot the initial bathy and overlay the polygon
plot(aleutians, image=TRUE, land=TRUE, lwd=.2)
polygon(lon,lat)

# Use of subsetBathy to extract the new bathy object
zoomed <- subsetBathy(aleutians, x=lon, y=lat, locator=FALSE)

# plot the new bathy object
dev.new() ; plot(zoomed, land=TRUE, image=TRUE, lwd=.2)

# alternatively once the map is plotted, use the interactive mode:
## Not run:
plot(aleutians, image=TRUE, land=TRUE, lwd=.2)
zoomed2 <- subsetBathy(aleutians, pch=19, col=3)
dev.new() ; plot(zoomed2, land=TRUE, image=TRUE, lwd=.2)

## End(Not run)
# click several times and press Escape

---

**subsetSQL**

Creating and querying local SQL database for bathymetric data

**Description**

subsetSQL queries the local SQL database created with setSQL to extract smaller data subsets.

**Usage**

```r
setSQL(bathy, header = TRUE, sep = ",", db.name = "bathy_db")
subsetSQL(min_lon, max_lon, min_lat, max_lat, db.name = "bathy_db")
```

**Arguments**

- `bathy`:
  A text file containing a comma-separated, three-column table with longitude, latitude and depth data (no default)
- `header`:
  does the xyz file contains a row of column names (default = TRUE)
- `sep`:
  character separating columns in the xyz file, (default=",")
- `min_lon`:
  minimum longitude of the data to be extracted from the local SQL database
- `max_lon`:
  maximum longitude of the data to be extracted from the local SQL database
- `min_lat`:
  minimum latitude of the data to be extracted from the local SQL database
- `max_lat`:
  maximum latitude of the data to be extracted from the local SQL database
- `db.name`:
  The name of (or path to) the SQL database to be created on disk by setSQL or from which subsetSQL will extract data ("bathy_db" by default)

**Details**

Functions setSQL and subsetSQL were built to work together. setSQL builds an SQL database and saves it on disk. subsetSQL queries that local database and the fields min_lon, max_lon, etc, are used to extract a subset of the database. The functions were built as two entities so that multiple queries can be done multiple times, without re-building the database each time. These functions were designed to access the very large (>5Go) ETOPO1 file that can be downloaded from the NOAA website ([https://www.ngdc.noaa.gov/mgg/global/global.html](https://www.ngdc.noaa.gov/mgg/global/global.html))

**Value**

setSQL returns TRUE if the database was successfully created. subsetSQL returns a matrix of class bathy that can directly be used with plot.bathy.
Note

If unspecified, db.name is set to "bathy_db" by default. Thus, there must be no database file called bathy_db in the working directory prior to running setSQL unless a different name is used for the new database. Make sure that your "bathy" input is a xyz text file (for function setSQL) with 3 columns containing longitude, latitude and depth data, in that order. setSQL and subsetSQL were modified on Nov. 2, 2014 to comply with RSQLite 1.0.0.

Author(s)

Eric Pante

References


Examples

```r
## Not run:  
# load NW Atlantic data  
data(nw.atlantic)

# write data to disk as a comma-separated text file  
write.table(nw.atlantic, "NW_Atlantic.csv", sep="", quote=FALSE, row.names=FALSE)

# prepare SQL database  
setSQL(bathy="NW_Atlantic.csv")

# uses data from the newly-created SQL database:  
subsetSQL(min_lon=-70, max_lon=-50,  
min_lat=35, max_lat=41) -> test

# visualize the results (of class bathy)  
summary(test)

# remove temporary database and CSV files  
system("rm bathy_db") # remove file, for unix-like systems  
system("rm NW_Atlantic.csv") # remove file, for unix-like systems

## End(Not run)
```

Summary of bathymetric data of class bathy

Summary of bathymetric data of class bathy. Provides geographic bounds and resolution (in minutes) of the dataset, statistics on depth data, and a preview of the bathymetric matrix.
Usage

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

Arguments

- `object` object of class `bathy`
- `...` additional arguments affecting the summary produced (see base function `summary`).

Value

Information on the geographic bounds of the dataset (minimum and maximum latitude and longitude), resolution of the matrix in minutes, statistics on the depth data (e.g. min, max, median...), and a preview of the data.

Author(s)

Eric Pante and Benoit Simon-Bouhet

See Also

`read.bathy`, `plot.bathy`

Examples

```r
# load NW Atlantic data
data(nw.atlantic)

# use as.bathy
atl <- as.bathy(nw.atlantic)

# class bathy
class(atl)

# summarize data of class bathy
summary(atl)
```

---

**trans.mat**

**Transition matrix**

Description

Creates a transition object to be used by `lc.dist` to compute least cost distances between locations.

Usage

```r
trans.mat(bathy, min.depth=0, max.depth=NULL)
```
trans.mat

Arguments

bathy A matrix of class bathy.
min.depth, max.depth Numeric. The range of depth between which the path will be possible. The default (min.depth=0 and max.depth=NULL) indicates that the transition between cells of the grid is possible between 0 meters depth and the maximum depth of bathy. See details.

Details


The transition object contains the probability of transition from one cell of a bathymetric grid to adjacent cells and depends on user defined parameters. trans.mat is especially usefull when least cost distances need to be calculated between several locations at sea. The default values for min.depth and max.depth ensure that the path computed by lc.dist will be the shortest path possible at sea avoiding land masses. The path can be constrained to a given depth range by setting manually min.depth and max.depth. For instance, it is possible to limit the possible paths to the continental shelf by setting max.depth=-200. Inaccuracies of the bathymetric data can occasionally result in paths crossing land masses. Setting min.depth to low negative values (e.g. -10 meters) can limit this problem.

trans.mat takes also advantage of the function geoCorrection from package gdistance (van Etten, 2012. https://CRAN.R-project.org/package=gdistance) to take into account map distortions over large areas.

Value

A transition object.

Warning

Please be aware that the use of trans.mat can be time consumming for large bathymetric datasets. The function takes about one minute to compute a transition matrix for the hawaii bathymetric data (bathymetric data of class bathy with 599 rows and 419 columns, see hawaii) on a MacBook Pro with a 2.66 GHz Intel Core i7 processor and 4 Go of RAM.

Author(s)

Benoit Simon-Bouhet

References

See Also

`lc.dist.hawaii`

Examples

```r
# Load and plot bathymetry
data(hawaii)
summary(hawaii)
plot(hawaii)

## Not run:
# Compute transition object with no depth constraint
trans1 <- trans.mat(hawaii)

# Compute transition object with minimum depth constraint:
# path impossible in waters shallower than -200 meters depth
trans2 <- trans.mat(hawaii, min.depth=-200)

# Visualizing results
par(mfrow=c(1,2))
plot(raster(trans1), main="No depth constraint")
plot(raster(trans2), main="Constraint in shallow waters")

## End(Not run)
```
Index

aleutians, 3, 65
antimeridian.box, 3, 4, 14
areaPolygon, 24, 55
as.bathy, 3, 5, 6, 7, 9, 11, 12, 38
as.raster, 5, 6, 7
as.SpatialGridDataFrame, 5, 6, 7
as.xyz, 5–7, 8, 23
autoplot.bathy, 9, 21, 23
celt, 11
check.bathy, 12
coll2alpha, 13
collate.bathy, 14
combine.buffers, 15, 17, 46, 54
tour, 24
coord_map, 9, 10
create.buffer, 15, 16, 46, 54
diag, 18
diag.bathy, 17
dist2isobath, 19, 41
etopo, 20

florida, 21
fortify.bathy, 9, 10, 22
get.area, 23, 55
get.box, 25
get.depth, 26, 27, 31, 65
get.sample, 29, 31
get.transsect, 18, 26, 28, 30
getNOAA.bathy, 12, 14, 32, 60
graphical parameters, 49, 56
graphics, 26
griddify, 34, 37

ehawaii, 35, 69, 70

irregular, 36
is.bathy, 37

lc.dist, 20, 38, 41, 70
lines, 26
linesGC, 20, 40
locator, 26

marmap, 42
metallo, 29, 42, 52

nw.atlantic, 28, 29, 31, 43, 44, 45, 52
nw.atlantic.coast, 31, 45

outline.buffer, 17, 46

palette.bathy, 21, 47
par, 49, 56

path.profile, 28, 49, 57
plot.bathy, 4, 5, 10, 14, 15, 17, 22, 24, 26, 33, 35, 36, 44, 46, 48, 50, 54, 55, 57, 58, 60, 61, 63, 65, 68
plot.buffer, 15, 53
plot.window, 51
plotArea, 24, 55
plotProfile, 49, 56
print.buffer (create.buffer), 16

read.bathy, 3, 5, 9–12, 22, 28, 29, 31, 33, 35, 38, 52, 57, 60, 68
readGEBCO.bathy, 33, 35, 58, 59
rect, 29

scale_color_etopo (etopo), 20
scale_colour_etopo (etopo), 20
scale_fill_etopo (etopo), 20
setScaleBathy, 60
setSQL (subsetSQL), 66
space.pies, 62
subsetBathy, 28, 64
subsetSQL, 66
summary.bathy, 5, 9, 10, 14, 22, 28, 29, 36, 38, 44, 52, 58, 65, 67

trans.mat, 39, 68