Package 'bioclim'

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Type Package

Title Bioclimatic Analysis and Classification

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Description Using numeric or raster data, this package contains functions to calculate: complete water balance, bioclimatic balance, bioclimatic intensities, reports for individual locations, multi-layered rasters for spatial analysis.

License GPL-3

Encoding UTF-8

LazyData true

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Imports terra, ggplot2, berryFunctions, reshape2, rmarkdown, stats, grDevices, methods

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`bbRast` *Bioclimatic Balance*

Description

A SpatRaster containing the bioclimatic balance of the Alps.

Usage

```
bbRast
```

Format

A PackedSpatRaster with 12 monthly values of 4 variables: `B`, `b`, `bc` and `bl`.

`biobal` *Computation of Bioclimatic Balance*

Description

Computes bioclimatic balance from water balance.

Usage

```
biobal(balhid, CC)
```

Arguments

`balhid`	Water balance.
`CC`	Field capacity. It depends on water retention capacity and depth of roots. 400 as default value.

Value

data frame with 12 variables: 'p', 'Tm', 'PET', 'e', 'D', 'S', 'Cd', 'T_75', 'B', 'b', 'bl', 'bc'.

Examples

```
wb <- watbal(t = rnorm(12, 18, 6), p = rnorm(12, 50, 30), lat = 35, CC = 400)
biobal(wb, 400)
```

---

biobalRaster *Computation of Bioclimatic Balance (raster mode)*

Description

Computes bioclimatic balance from water balance in raster format.

Usage

```
biobalRaster(bh, CC, path = NULL, ncpu = 1)
```

Arguments

bh	Water balance in raster format.
CC	Field capacity. It depends on water retention capacity and depth of roots. 400 as default value. It can be a SpatRaster layer.
path	Optional. Path (folder) where the output raster files and look-up-tables will be saved.
ncpu	Number of CPUs to use. By default, sequential mode (1 cpu) is used.

Value

SpatRaster with 48 layers corresponding to the 12 monthly values of 'B', 'b','bc','bl'.

Examples

```
wb <- terra::rast(wbRast)
bb <- biobalRaster(wb, CC = 400, path=NULL, ncpu = 2)
```

bioclim_report *Function to create individual complete report*

Description

This function creates a complete report for a specific location, from temperature and precipitation data series.

Usage

```
bioclim_report(t, p, nam, lat, CC, output)
```

Arguments

t	Monthly average temperature data (12 nueric values).
p	Monthly average precipitation data (12 nueric values).
nam	Name of the location. It will be used as name of output file
lat	Latitude in degrees. For southern latitudes use negative values.
CC	Field capacity. It depends on water retention capacity and depth of roots. Use 400 as default value.
output	Path of the output pdf file.

Value

data frame with 20 variables: 'p', 'Tm', 'PET', 'e', 'D', 'S', 's_e_D', 'sum_s', 'c_D_e', 'sum_c', 'Q', 'x', 'E_e', 'D_e', 'Cd', 'T_75', 'B', 'b', 'bl', 'bc'.

Examples

```
bioclim_report(t = c(10, 11.5, 14, 16.5, 20, 24.5, 27.5, 28, 24.5, 19.5, 14.5, 11),
p = c(55, 73, 84, 58, 33, 23, 2, 2, 28, 66, 94, 71),
lat = 35, nam = 'Seville', CC = 400, output ='./seville.pdf')
```

bioint *Computation of Bioclimatic Intensities*

Description

Computes bioclimatic intensities from bioclimatic balance.

Usage

```
bioint(bb)
```

Arguments

bb	Bioclimatic balance.

Details

The function yields 10 variables at monthly scale corresponding with the warm (w) and cold (c) variants of 5 bioclimatic intensities: PBI (Potential bioclimatic intensity), RBI (Real bioclimatic intensity), CBI (Conditioned bioclimatic intensity), FBI (Free bioclimatic intensity), and DBI (Dry bioclimatic intensity).

Value

data.frame with 10 variables. See details.

Examples

```
wb <- watbal(t = rnorm(12, 18, 6), p = rnorm(12, 50, 30), lat = 35, CC = 400)
bb <- biobal(wb, 400)
bi <- bioint(bb)
```

---

biointRaster *Computation of Bioclimatic Intensities (raster mode)*

Description

Computes bioclimatic intensities from bioclimatic balance.

Usage

```
biointRaster(bb, path = NULL)
```

Arguments

bb	Bioclimatic balance in raster format.
path	Optional. Path (folder) where the output raster files will be saved.

Value

SpatRaster with 120 layers corresponding to the 12 monthly values of "IBPc","IBCc","IBLc","IBRc","IBSc","IBPf","IBCf","

Examples

```
bb <- terra::rast(bbRast)
bi <- biointRaster(bb, path=NULL)
```

biotype *Bioclimatic classification*

Description

Calculates bioclimatic classification based on bioclimatic balance.

Usage

```
biotype(t = NULL, p = NULL, lat = NULL, wb = NULL, bb = NULL, CC = NULL, mode)
```

Arguments

t	Numeric. Monthly temperature required for water balance calculation.
p	Numeric. Monthly precipitation required for water balance calculation.
lat	Numeric. Latitude required for water balance calculation.
wb	Water balance in data.frame format from watbal() function. If provided, 't' and 'p' are not used.
bb	Bioclimatic balancein data.frame format from biobal() function. If provided, 't', 'p' and 'wb' are not used.
CC	Field capacity. It depends on water retention capacity and depth of roots. 400 as default value.
mode	Type of output: "TBR", "sub", or "zonal". See details.

Details

Argument "mode" defines the type of return ("TBR": Types of Bioclimatic Regime; "zonal": zonal units; "sub": bioclimatic regime subtypes)

Value

character defining the type of climate.

Examples

```
# calculation of water balance
wb <- watbal(t = rnorm(12, 18, 6), p = rnorm(12, 50, 30), lat = 35, CC = 400)
# calculation of bioclimatic balance
bb <- biobal(wb, 400)

# bioclimatic classification at TBR levels
biotype(bb = bb, mode = 'TBR')

# bioclimatic classification at zonal levels
biotype(bb = bb, mode = 'zonal')

# bioclimatic classification at subtypes levels (requires water balance)
```

```
wb <- watbal(t = rnorm(12, 18, 6), p = rnorm(12, 50, 30), lat = 35, CC = 400)
biotype(wb = wb, CC = 400, mode = 'sub')
```

`biotypeRaster` *Bioclimatic classification (raster mode)*

Description

Calculates bioclimatic classification based on bioclimatic balance.

Usage

```
biotypeRaster(
  temp = NULL,
  prec = NULL,
  CC = NULL,
  path = NULL,
  ncpu = 1,
  PET = NULL,
  bh = NULL
)
```

Arguments

`temp`	SpatRaster object with 12 layers representing temperature from January to December.
`prec`	SpatRaster object with 12 layers representing precipitation from January to December.
`CC`	Field capacity. It can be numeric (1 value) or a SpatRaster object.
`path`	Optional. Path (folder) where the output raster files and look-up-tables will be saved.
`ncpu`	number of cores to use in calculation. If not provided, sequential mode is used (1 core).
`PET`	Potential evapotranspiration. Optional. It must be a SpatRaster object.
`bh`	Water balance. Optional. It must be a SpatRaster object.

Value

SpatRaster with 3 variables ("TBR": Types of Bioclimatic Regime; "zonal": zonal units; "sub": bioclimatic regime subtypes).

Examples

```
wb <- terra::rast(wbRast)
btr <- biotypeRaster(bh = wb)
```

ith *Function to calculate Thornthwaite's index*

Description

This function calculates Thornthwaite's index to refine the bioclimatic classification.

Usage

```
ith(bh)
```

Arguments

bh	Water balance in data.frame format from watbal() function.

Value

Character, describing the humid characteristics of the climate.

Examples

```
wb <- watbal(t = rnorm(12, 18, 6), p = rnorm(12, 50, 30), lat = 35, CC = 400)
ith(wb)
```

ithRaster *Function to calculate Thornthwaite's index (raster format)*

Description

This function calculates Thornthwaite's index to refine the bioclimatic classification.

Usage

```
ithRaster(bh)
```

Arguments

bh	Water balance in SpatRaster format from watbalRaster() function.

Value

Numeric, describing the humid characteristics of the climate. 1: 'HyperArid', 2: 'Arid', 3: 'Semi-arid', 4: 'Dry humid', 5: 'Moist humid', 6 'Low humid', 7: 'Moderate humid', 8: 'Highly humid', 9: 'Very humid', 10: 'Perhumid'.

Examples

```
wb <- terra::rast(wbRast)
itr <- ithRaster(wb)
```

`plotBiobal` *Function to plot bioclimatic balance*

Description

Function to plot bioclimatic balance.

Usage

```
plotBiobal(intens)
```

Arguments

`intens`	bioclimatic intensities in data.frame format from bioint() function.

Value

Plot of bioclimatic balance

Examples

```
wb <- watbal(t = c(10, 11.5, 14, 16.5, 20, 24.5, 27.5, 28, 24.5, 19.5, 14.5, 11),
             p = c(55, 73, 84, 58, 33, 23, 2, 2, 28, 66, 94, 71), lat = 35, CC = 400)
bb <- biobal(wb, 400)
bi <- bioint(bb)
plotBiobal(bi)
```

`plotWatbal` *Function to plot water balance*

Description

Function to plot water balance.

Usage

```
plotWatbal(bh)
```

Arguments

bh	Water balance in data.frame format from watbal() function.

Value

Plot of water balance

Examples

```
wb <- watbal(t = c(10, 11.5, 14, 16.5, 20, 24.5, 27.5, 28, 24.5, 19.5, 14.5, 11),
p = c(55, 73, 84, 58, 33, 23, 2, 2, 28, 66, 94, 71), lat = 35, CC = 400)
plotWatbal(wb)
```

---

plotWL *Function to plot Walter and Lieth diagram*

Description

Function to plot Walter and Lieth diagram.

Usage

```
plotWL(t, p)
```

Arguments

t	Monthly average temperature data (12 nueric values).
p	Monthly average precipitation data (12 nueric values).

Value

Plot of Walter and Lieth diagram

Examples

```
plotWL(t = rnorm(12, 18, 6), p = rnorm(12, 50, 30))
```

postemp *Function to Positive Temperature index*

Description

Computes Positive Temperature index from monthly temperature.

Usage

```
postemp(t)
```

Arguments

t	Monthly average temperature data (12 nueric values).

Value

Positive Temperature index

Examples

```
postemp(rnorm(12, 18, 6))
```

preRast *Monthly precipitation*

Description

A SpatRaster containing the monthly precipitation of the Alps.

Usage

```
preRast
```

Format

A PackedSpatRaster with 12 monthly values precipitation:

thermind *Function to Compensated Thermal Index*

Description

Computes Compensated Thermal Index from monthly temperature.

Usage

```
thermind(t)
```

Arguments

t	Monthly average temperature data (12 nueric values).

Value

Compensated Thermal Index

Examples

```
thermind(rnorm(12, 18, 6))
```

thornthwaite *Function to calculate Thornthwaite potential evapotranspiration*

Description

This function calculates Thornthwaite's potential evapotranspiration.

Usage

```
thornthwaite(Tave, lat, na.rm = FALSE)
```

Arguments

Tave	a numeric vector, matrix or time series of monthly mean temperatures, ºC.
lat	a numeric vector with the latitude of the site or sites, in degrees.
na.rm	optional, a logical value indicating whether NA values should be stripped from the computations.

Details

This function is a modified version of SPEI::thornthwaite() function.

Value

A time series with the values of monthly potential or reference evapotranspiration, in mm. If the input is a matrix or a multivariate time series each column will be treated as independent data (e.g., diferent observatories), and the output will be a multivariate time series.

Author(s)

Santiago Begueria

Examples

```
thornthwaite(rnorm(12, 18, 6), 35)
```

---

tmpRast *Monthly temperature*

Description

A SpatRaster containing the monthly temperature of the Alps.

Usage

```
tmpRast
```

Format

A PackedSpatRaster with 12 monthly values temperature:

---

watbal *Function to calculate water balance*

Description

Computes water balance from temperature and precipitation data.

Usage

```
watbal(t, p, lat, CC)
```

Arguments

t	Monthly average temperature data (12 nueric values).
p	Monthly average precipitation data (12 nueric values).
lat	Latitude in degrees. For southern latitudes use negative values.
CC	Field capacity. It depends on water retention capacity and depth of roots. Use 400 as default value.

Value

data frame with 12 variables: 'Tmp', 'Pcp', 'PET', 'P_PET', 'ppa', 'ST', 'i_ST', 'ETR', 'Dh', 'S', 'r', 'rP'.

Examples

```
watbal(t = rnorm(12, 18, 6), p = rnorm(12, 50, 30),
       lat = 35, CC = 400)
```

---

watbalRaster *Water balance in raster format*

Description

Computes water balance from temperature and precipitation in raster format.

Usage

```
watbalRaster(temp, prec, PET = NULL, CC, path = NULL, ncpu = 2)
```

Arguments

temp	SpatRaster containing 12 layers with monthly temperature from January to December.
prec	SpatRaster containing 12 layers with monthlyprecipitation from January to December.
PET	Optional. Potential evapotranspiration in raster format.
CC	Field capacity. It depends on water retention capacity and depth of roots. 400 as default value. It can be a SpatRaster layer.
path	Optional. Path (folder) where the output raster files and look-up-tables will be saved.
ncpu	Number of cores used for the most demanding calculations.

Value

SpatRaster with 144 layers corresponding to the 12 monthly values of 'temp', 'prec','PET','P_PET','PPA','ST','i_ST','RET',

Examples

```
tmp <- terra::rast(tmpRast)
pre <- terra::rast(preRast)
wb <- watbalRaster(tmp, pre, PET = NULL, CC = 400, path=NULL, ncpu = 2)
```

wbRast *Water Balance*

Description

A SpatRaster containing the water balance of the Alps.

Usage

```
wbRast
```

Format

A PackedSpatRaster with 12 monthly values of 12 variables: `temp`, `prec`, `PET`, `P_PET`, `PPA`, `ST`, `i_ST`, `RET`, `HD`, `HEX`, `r`, `rP`.

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