Package ‘ClimClass’

August 29, 2016

Type Package
Title Climate Classification According to Several Indices
Version 2.1.0
Date 2015-08-07
Description Classification of climate according to Koeppen - Geiger, of aridity indices, of continentality indices, of water balance after Thornthwaite, of viticultural bioclimatic indices. Drawing climographs: Thornthwaite, Peguy, Bagnouls-Gaussen.
License GPL (>= 3)
Depends R(>= 2.10.0)
Imports geosphere, ggplot2, reshape2
Suggests stringr
LazyData true
RoxygenNote 5.0.1
NeedsCompilation no
Author Emanuele Eccel [aut, cre],
Emanuele Cordano [aut],
Giambattista Toller [aut],
Fondazione Edmund Mach [cph]
Maintainer Emanuele Eccel <emanuele.eccel@fmach.it>
Repository CRAN
Date/Publication 2016-08-04 21:43:32

R topics documented:

arid ......................................................... 2
arid_ind_tables ....................................... 4
as.datcli ................................................. 5
bagn_gau ................................................. 6
climate .................................................. 8
clima_81_10 ............................................. 9
Aridity indices

Description

Calculates aridity according to several indices.

Usage

arid(clim_norm, coeff_rad = NULL, coeff_Hargr = rep(0.75, 12),
     monthly = FALSE, indices = 1:6)

Arguments

clim_norm  climatic normals
coeff_rad   mean monthly solar radiation; used only for Thornthwaite’s annual index Im.
            Default is NULL
coeff_Hargr (vector of monthly) correction coefficient(s) for Hargreaves’ equation
monthly     logic. Sets calculation to the monthly mode if TRUE. Default is FALSE.
indices     set of aridity indices to be listed. Default is all indices (1 to 6 for annual, 1 to 2 for monthly).
Details

clim_norm is a monthly data frame of climate normals, with column names: "P", "Tn", "Tx", "Tm" (precipitation, minimum, maximum and mean temperature, respectively). It can be the output of function `climate`.

Monthly potential evapotranspiration (PE) is calculated via the Hargreaves’ formula (Hargreaves and Samani, 1985):

\[
PE = (0.0023 \times (\text{clim_norm$Tx} - \text{clim_norm$Tn})^{0.5} \times (\text{clim_norm$Tm}+17.8) \times \text{coeff_rad}) \times \text{lmv} \times \text{coeff_Hargr}
\]

where Tn, Tx, Tm are min, max, and mean temperatures, respectively, and lmv is the number of days in any month.

coeff_rad and coeff_Hargr are needed only by Thornthwaite’s annual index Im and UNEP’s Ai index, whose PE term is calculated via Hargreaves’ equation.

coeff_rad corresponds to the mean monthly extra-atmospheric radiation (see function `ExAtRa`).

coeff_Hargr is either a single value or a vector of 12 coefficients to adjust Hargreaves’ estimation of potential evapotranspiration (implemented in Im and Ai indices). From calibration in 6 stations from the same network of `Trent_climate`, its average value is 0.75.

When `monthly` is TRUE, a data frame with monthly detail is generated for one station, instead of a synthetic single-line data frame.

indices’ values are the following:
1 De Martonne - Ia (annual or monthly). De Martonne, 1925.
2 Thornthwaite - Im (annual or monthly). Thornthwaite, 1948.
3 Emberger - Q (annual only). Emberger, 1955.
4 Lang - R (annual only) - only for positive mean annual temperature. Lang, R., 1920.
5 Rivas-Martinez - Io (annual only). Rivas - Martinez, website http://www.globalbioclimatics.org/
6 UNEP - Ai (annual only). UNEP, 1997.

A reference for the aridity degree for any index is given in the list object `arid_ind_tables` (see `Trent_climate`.

Value

Either a single-line data frame (when `monthly` = FALSE) with the desired aridity index(es), or a data frame (monthly = TRUE), with monthly values of the desired index(es).

Author(s)

Emanuele Eccel

References


Rivas-Martínez - http://www.globalbioclimatics.org/


See Also

cclimate, ExAtRa

Examples

data(Trent_climate)
# clima_81_10 is a list of data frames having climatic means of temperature and precipitation
# as required by the aridity indices algorithms, each one referring to one station.
# It can be the output of function climate.
# coeff_rad is a monthly vector of average daily extra-atmospheric solar radiation,
# calculated e.g. by function ExAtRa.

arid_ind_tables Aridity index

Description

Used for reference in aridity indices assessment (see function arid and references for data sources).

Usage

data(Trent_climate)

Format

List formed by six data frames.
Description

Transforms a data frame (see example dataset) into a data frame format like 'datcli' in 'climatol' package.

Usage

as.datcli(df, station, MonthField = "month", PrecField = "P", MinTempField = "Tn", MaxTempField = "Tx", MeanTempField = "Tm", AbsMinTempField = "AbsTn", AbsMinTempOffset = 4, StationField = "station")

Arguments

df   data frame or list
station   name
MonthField   character string for month field in df. Default is "month".
PrecField   character string for Mean Precipitation field in df. Default is "P".
MinTempField   character string for Mean Daily Minimum Temperature field in df. Default is "Tn".
MaxTempField   character string for Mean Daily Maximum Temperature field in df. Default is "Tx".
MeanTempField   character string for Mean Daily Maximum Temperature field in df. Default is "Tm".
AbsMinTempField   character string for Absolute Monthly Minimum Temperature field in df. Default is "AbsTn".
AbsMinTempOffset   estimated offset between Average Min Temperature and Absolute Min Temperature.
StationField   character string for Station field in df. Default is "station".

Author(s)

Emanuele Cordano

See Also

Examples

### Not Run!!
# Install `climatol` from `http://www.climatol.eu/` first
### Then load the package, uncomment and run the following line
# library(climatol)
library(stringr)
data(Trent_climate)

TrentinoClimateDf <- do.call(rbind,clima_81_10)
names <- rownames(TrentinoClimateDf)
TrentinoClimateDf$station <-
  unlist(lapply(X=as_char(names, pattern="."),FUN=function(x) {x[1]}))

station <- "T0129"
datcli <- as.data.frame(TrentinoClimateDf, station=station)

### Not Run!!
# Install `climatol` from `http://www.climatol.eu/` first
### Then load the package, uncomment and run the following line
# diagwl(datcli, est=station, alt=100, per="Period", mlab="en") ## plots a Walter-Lieth's climograph

---

bagn_gau

**Bagnouls - Gaussen graphs**

### Description

Plots Bagnouls - Gaussen climatic charts of precipitation and temperature. Conventionally, in this chart the scale of precipitation has a double extension with respect to the scale of temperature (Bagnouls and Gaussen, 1953).

### Usage

```r
bagn_gau(clim_norm_sta, save_dir = NULL, format = NULL, main_title = NULL,
  st_name = NULL, trace_grid = TRUE, tick_step = 20, bar_width = 30,
  bar_col = "grey", trace_0.line = TRUE, ...)
```

### Arguments

- `clim_norm_sta` data frame with climatic normals
- `save_dir` name of destination directory for graphs (if any).
- `format` graphical format of graphs; default is NULL.
- `main_title` main title for all charts; e.g., it may include references to station id. Default is NULL.
- `st_name` name to be included into graphs titles. Only for file output. Default is NULL.
trace_grid logic. If TRUE (default) adds a grid.
tick_step step for Y axis (precipitation). Default is 20 (mm)
bar_width width of bars in the chart. Default is 30.
bar_col color of bars. Default is "grey".
trace_0.line logic. If TRUE (default), a line at P = 0 and T = 0 is traced.

Details
clim_norm_sta can be e.g. one element of the output of function climate. See examples.
If format is NULL (default), graphs are sent to the console. Otherwise, a file is produced and saved.
format is used only if the graphs are to be sent to files. Values allowed are: "png", "jpeg", "tiff", "bmp".
If one or more data are missing, the chart is not processed.
Most graphic parameters for functions plot, axis, and mtext are accepted.

Value
Bagnouls - Gaussen’s charts of precipitation and temperature.

Note
A conflict is generated if parameters already used by the function are passed (e.g. col - use col.main, col.axis, ..., instead).

Author(s)
Emanuele Eccel

References

See Also
climate

Examples

data(Trent_climate)
# clima_81_10 can be generated from monthly time series by function "climate".
par(ask=TRUE)
for(sta in 1:length(clima_81_10)) {
  bagn_gau(clim_norm_sta= clima_81_10 [[sta]],
            main_title=paste(names(clima_81_10[sta]), " 1981-2010"),
   , bar_width=40)
climate

Climate normals

Description

Creates climate mean monthly values from a monthly series of temperature and precipitation.

Usage

climate(series, first.yr = NULL, last.yr = NULL, max.perc.missing)

Arguments

- series: the monthly series of temperature and precipitation.
- first.yr: first year of the period over which climatology is calculated
- last.yr: last year of the period over which climatology is calculated
- max.perc.missing: maximum acceptable percentage of missing data in the averaging period from first.yr to last.yr (0-99).

Details

- series is a data frame with years, months, temperature (and precipitation) values. Names in series columns must include: year, month, Tn and Tx (minimum and maximum temperatures, respectively) or, as an alternative, Tm (mean temperatures).

If first.yr or last.yr are NULL (default), the lowest and highest values in series are taken as the period.

Value

A data frame with climatic monthly values of: precipitation, minimum and maximum temperatures (if existing in series), mean temperature (either averaged from existing values in series, or calculated by the function as (Tn + Tx)/2), absolute minimum monthly temperature.

Author(s)

Emanuele Eccel
Examples

data(Trent.climate)

# clima_81_10 is a list of data frames of the type series,
# each one referring to one station
# having climatic means of temperature and precipitation

clima_81_10<-lapply(listacli, FUN=climate, first.yr=1981, last.yr=2010, max.perc.missing=15)

---

clima_81_10  
Climatic normals of precipitation and temperatures

---

Description

Climatic normals of precipitation and temperature (minimum, maximum, and mean) for the climatic period 1981 - 2010. It has been calculated by function `climate`.

Usage

data(Trent.climate)

Format

A list (one table for each station) of 28 monthly climatic normals

---

ClimClass  
Classification of climate according to Koeppen - Geiger, of aridity indices, of continentality indices, of water balance after Thornthwaite, of viticultural bioclimatic indices. Drawing climographs: Thornthwaite, Peguy, Bagnous-Gaussen.

---

Description

Classification of climate according to Koeppen - Geiger, of aridity indices, of continentality indices, of water balance after Thornthwaite, of viticultural bioclimatic indices. Drawing climographs: Thornthwaite, Peguy, Bagnous-Gaussen.
ClimClass functions

The package collects several criteria for climate classification. The most general is Koeppen - Geiger’s classification, as described in Trewartha (1980), implemented in function `koeppen_geiger`. Almost all sub-classes have been considered, with the only exception of those whose attribution is based on qualitative assessment of climatic features.

A classic graphical visualization of temperature and precipitation, according to Bagnouls and Gaussen (1953), is provided by function `bagn_gau`. A similar, but more sophisticated representation of the same variable, is that of Walter - Lieth (Lieth et al., CD). This function is implemented in library `climatol` (http://www.climatol.eu/).

Function `arid` calculates a set of six annual aridity indices (Emberger, 1955; Lang, R., 1920; Rivas - Martinez, (website); and UNEP, 1997; De Martonne, 1925; Thornthwaite , 1948). For the latter two also a monthly index is calculated.

A set of five continentality indices is proposed by function `contin` (Gorczynski, L., 1920; Conrad, 1946; Gams, 1932; Rivas - Martinez, web page; Amann, 1929).

Thornthwaite’s method for the assessment of soil water balance (Thornthwaite, 1948; Thornthwaite and Mather, 1955; Thornthwaite and Mather, 1957) makes use of monthly series to calculate the main quantities in water balance: evapotranspiration, soil water deficit, soil water surplus. From these series, quantiles are calculated for every month, to infer climatic features concerning soil water.

Function `thornthwaite` provides such analysis, and function `plot` manages the plot of the quantiles of the relevant quantities.

The assessment of potential evapotranspiration by Thornthwaite and Mather’s algorithm requires the estimation of extra-atmospheric radiation, which is calculated by function `ExAtRa`, based on the algorithm of Allen et al., 2005.

Function `as.datcli` tranforms a data frame as in example dataset `Trent_climate` into a data frame format like datcli in climatol package. It can be used to plot Walter - Lieth’s climographs (see examples documentation).

Function `oiv_ind` calculates several bioclimatic indices for viticulture proposed by the International Organization of Viticulture, OIV (Resolution OIV-VITI 423-2012), plus one index (Branas). One index of OIV’s list, Riou’s drought index, needing daily series, is calculated by another function, `RDI`.

The data set included in the library is formed by monthly and daily time series of temperature and precipitation from Trentino, Italy (courtesy of Autonomous Province of Trento - Meteotrentino, and of Fondazione Edmund Mach, San Michele all’Adige). Climatic normals are calculated, too (output of function `climate`). The output of function `thornthwaite` is present in the data set `Trent_climate`, as input for function `plot`.

Reference tables for aridity and continentality indices are provided as lists, to rank the classifications on standard scales (`arid_ind_tables` and `continental_ind_tables`, respectively).

See a first application in Eccel et al., 2015 and an application more focused on viticultural indices in Eccel et al., 2016.

References


Gorczynski, L., 1920: Sur le calcul du degre de continentalisme et son application dans la climatologie. Geografska Annaler 2, 324-331


Rivas-Martinez: http://www.globalbioclimatics.org/


<table>
<thead>
<tr>
<th>coeff_rad</th>
<th>Radiative energy coefficients</th>
</tr>
</thead>
</table>

**Description**

"Radiative energy coefficients" for Hargreaves' equation, corresponding to the daily extra-atmospheric solar radiation energy. It is the output of function \texttt{ExAtRa}.

**Usage**

```r
data(Trent_climate)
```

**Format**

An array of 12 numerics

<table>
<thead>
<tr>
<th>contin</th>
<th>Continentality indices</th>
</tr>
</thead>
</table>

**Description**

Calculates climate continentality / oceanicity according to several indices.

**Usage**

```r
contin(clim_norm, latitude = NULL, elevation = NULL, Michalet_correction = FALSE, indices = 1:5)
```
Arguments

clim_norm  climatic normals
latitude    station latitude in degrees. Used in Gorczynski’s and Conrad’s classifications (indices 1 and 2). Default is NULL.
elevation   station elevation in m. Used in Gams’ classification (index 3). Default is NULL.
Michalet_correction  logic: if TRUE, Michalet’s correction is applied to index 3 (Gams). Default is FALSE.
indices    set of aridity indices to be listed. Default is all indices (1 to 5).

Details

clim_norm is a monthly data frame of climate normals, with column names: "P", "Tn", "Tx", "Tm" (precipitation, minimum, maximum and mean temperature, respectively). It can be the output of function climate.

indices’ values are the following:
4: Rivas-Martinez - Ic. (Rivas - Martinez, web page).
5: Amann - H. (Amann, 1929)
A reference for the continentality/oceanicity degree is given in the list object continental_ind_tables of data set Trent_climate.

If Michalet’s correction is applied to Gams’ hygric continentality index, the value of precipitation is proportionally diminished for elevations below 900 m a.s.l. See also Lebourgeoise, 2010.

Value

A single-line data frame with the desired continentality index(es).

Author(s)

Emanuele Eccel

References


See Also

climate

Examples

data(Trent_climate)

# clima_81_10 is a list of data frames having climatic means of temperature and precipitation as # required by the aridity indices algorithms, each one referring to one station. # It can be the output of function climate.

# creates a data frame with all the continentality indices for all stations in clima_81_10

latit<-coord_elev$North
elev<-coord_elev$Elevation

contin_I<-NULL
for(i in 1:length(clima_81_10)) {
  contin_I[[i]]<-contin(clima_81_10[[i]],
    latitude=latit[i],
    elevation=elev[i],
    Michalet_correction=TRUE)
}
names(contin_I)<-names(clima_81_10)
**coord_elev**

**Format**

List of 4 data frames

```
coord_elev               Geographical position for each meteorological station
```

**Description**

Coordinates and elevation for each station in the data set. Coordinates are geographical and elevation is measured in meters above mean sea level.

**Usage**

data(Trent_climate)

**ExAtRa**

**Format**

Data frame of 40 observations of 4 variables

```
ExAtRa               Extra-Atmospheric Radiation
```

**Description**

Calculates Extra-Atmospheric Radiation. Called by function `arid` for Thornthwaite’s index.

**Usage**

`ExAtRa(DOY, latitude, Gsc = 0.082, unit = "mm", T = 12)`

**Arguments**

- **DOY**: day of the year.
- **latitude**: latitude in degrees (negative for S emisphere).
- **Gsc**: solar constant in MJ m\(^{-2}\) min\(^{-1}\) (default: 0.0820).
- **unit**: unit for solar radiation. Accepted values are "mm" and "MJ".
- **T**: temperature in degrees C. Default is 12.

**Details**

If `unit = "mm"`, the calculated value represents the water height evaporated by solar radiation, calculated by the latent heat for vaporization. Otherwise (`unit = "MJ"`) output is the solar radiation energy in MJ. Temperature T is used only for the assessment of latent heat of vaporization, when `unit = "mm"`. 
Value
The daily extra-atmospheric solar radiation energy, expressed either in MJ or in mm of evaporated water.

Author(s)
Emanuele Eccel

See Also
arid

Examples

data(Trent_climate)
# creates a vector with middle days for every month in a year
quinci <- paste(2015, "/", 1:12, "/", 2014, sep="")
posixlt <- strptime(quinci, format="%d/%m/%Y")
yDay <- posixlt$yday+1  # field yday starts from 0
latitude<-46

# generates 12 values, one for each month
coeff_rad<- ExAtRa(DOY=yDay,latitude=latitude, unit="mm")

koeppen_geiger  Koeppen - Geiger's climate classification

Description
General climate classification after Koeppen - Geiger.

Usage
koeppen_geiger(clim_norm, A_B_C_special_sub.classes = FALSE,
clim.resume_verbose = TRUE, class.nr = FALSE)

Arguments
clim_norm average values (climate normals) for the desired period.
A_B_C_special_sub.classes logical. Sets if calculations have to consider sub-classes based on rain features in climate types A, B, and C (see details). Default is FALSE.
clim.resume_verbose logical. If TRUE (default) a resume of the climatic indices used for the Koeppen - Geiger classification is added to the output.
class.nr logical. If FALSE (default) class is expressed by letters, otherwise by numbers (see details).

Koeppen - Geiger
Details

clim_norm is a monthly data frame of climate normals, with column names: "P", "Tn", "Tx", "Tm" (precipitation, minimum, maximum and mean temperature, respectively). It can be the output of function `climate`.

Koeppen - Geiger's classification is based on Trewartha and Lyle, 1980. The function also holds for Southern hemisphere, except for the "Gange" sub-type ("Ag" and "Cg"). Type "H" (highland climate) and sub-types "Bn" and "Cn" (where n stands for Nebel) are never attributed, being based on a qualitative description in the quoted reference.

Sub-type "w" (wet-and-dry) or "m" (monsoon) in climate "A" is set according to the definition after Encyclopaedia Britannica (http:OOwwwNbritannicaNcomOebcheckedOtopicOSRRP6XOkoppenMclimateMclassification): if P in the 4 driest months is less than 1/5 of the wettest months and if both the 4 driest and wettest months are split over non-contiguous seasons (either 2 months per season or 1 and 3 months per season), then sub-type is ""

For climate "A", the letter "m" is attributed to the first sub-type.


A_B_C_special_sub_classes, if TRUE, adds a letter to the second sub-type of climates: "i" or "g" (climate A), "w" or "s" (climate B), and "i", "g", or "x" (climate C).

The returned data frame contains the following fields:

- T_wNm = temperature of the warmest month (degrees C)
- T_cNm = temperature of the coldest month (degrees C)
- T_avg = average temperature (degrees C)
- P_tot = total precipitation depth (mm)
- P_wint = precipitation depth in the 6 coldest (winter) months (mm)
- P_summ = precipitation depth in the 6 warmest (summer) months (mm)
- P_d.m = precipitation depth in the driest month (mm)
- P_d.m.summ = precipitation depth in the driest month of "summer" half of the year (mm)
- P_d.m.wint = precipitation depth in the driest month of "winter" half of the year (mm)
- P_w.m = precipitation depth in the wettest month (mm)
- P_w.m.summ = precipitation depth in the driest month of "summer" half of the year (mm)
- P_w.m.wint = precipitation depth in the wettest month of "winter" half of the year (mm)
- T_4th_w.m = temperature of the 4th warmest month (degrees C)

class = climatic class. If class.nr=FALSE (default), it results from the merging of "climate" (A to E) and sub-type(s). If class.nr=TRUE the class comes from the sum of the numeric equivalent of "type" (A...E) + "first sub type" (only first letter), according to the following scheme:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>f</td>
<td>W</td>
<td>s</td>
<td>s</td>
<td>T</td>
</tr>
<tr>
<td>w</td>
<td>S</td>
<td>w</td>
<td>f</td>
<td>-- 2</td>
</tr>
<tr>
<td>m</td>
<td>f</td>
<td>f</td>
<td>f</td>
<td>--&gt; 3</td>
</tr>
</tbody>
</table>

(e.g: Af = 11, Cw = 32, EF = 52)
Value

A one-line data frame reporting a resume of climatic features useful for the classification (if `clim.resume_verbose` is TRUE), and one last field (1 type - or "climate" - plus 1 or 2 sub-types) reporting Koeppen - Geiger's climate classification. See details.

Author(s)

Emanuele Eccel

References


See Also

`climate`

Examples

data(Trent_climate)
# clima_81_10 is a list of data frames having climatic means of temperature and precipitation as 
# required by Koeppen - Geiger classification, each one referring to one station. 
# It can be the output of function `climate`.
class_clim_l<-lapply(clima_81_10, FUN=koeppen_geiger, A_B_C_special_sub.classes=TRUE)

lista_cli

Dataset of meteorological measures

Description

A list of 28 data frames (one for each station of the meteorological network), with monthly time series of precipitation and temperature (minimum and maximum).

Usage

data(Trent_climate)

Format

List of 28 elements, each is a data frame of 5 variables and 636 observations
Description

Usage

```
oiv_ind(daily_Tn = NULL, daily.Tx = NULL, daily_Tm = NULL,
        daily_P = NULL, first.yr = NULL, last.yr = NULL, subs_missing = TRUE,
        coeff_HI = 1.04, quant_Tn_rest = 0.5, quant_Tn_veg = 0.5,
        quant_Tx_veg = 0.5, indices = 1:10)
```

Arguments

- `daily_Tn`: series of daily minimum temperature (data frame). Must include the following columns (and names): "year", "month", "day" and one or more station id(s), each column one Tn series.
- `daily_Tx`: series of daily maximum temperature (data frame). Must include the following columns (and names): "year", "month", "day" and one or more station id(s), each column one Tx series.
- `daily_Tm`: series of daily mean temperature (data frame). Must include the following columns (and names): "year", "month", "day" and one or more station id(s), each column one Tm series.
- `daily_P`: series of daily precipitation (data frame). Must include the following columns (and names): "year", "month", "day" and one or more station id(s), each column one P series.
- `first.yr`: first year of the period over which indices are calculated
- `last.yr`: last year of the period over which indices are calculated
- `subs_missing`: logical: if TRUE (default), missing values in input series are replaced by corresponding average values for each day in the series.
- `coeff_HI`: Huglin's daylength correction, as long as the number of stations, or a single coefficient; in this case it is recycled on all stations. See details.
- `quant_Tn_rest`: quantile (0..1) for the choice of the position of the representative year in the series, referred to the minimum temperature during "rest" period. Default is 0.5 (median)
- `quant_Tn_veg`: quantile (0..1) for the choice of the position of the representative year in the series, referred to the minimum temperature during the "vegetative" period. Default is 0.5 (median)
- `quant_Tx_veg`: quantile (0..1) for the choice of the position of the representative year in the series, referred to the maximum temperature during the "vegetative" period. Default is 0.5 (median)
- `indices`: set of OIV indices to be listed. Default is all indices (1 to 10). See details for numbered list of indices.
Details

General info about OIV indices can be sought at http://www.oiv.int/oiv/info/enresolution2012?lang=en.

In general, if first.yr or last.yr are NULL (default), the lowest and highest values in series are taken as begin and end of calculation period. A coherence check is done on input of start / end years.

If any input is missing, corresponding indices are not be calculated. If daily_Tm is missing and both daily_Tn and daily_Tx are passed to the function, daily_Tm is calculated as the mean of daily_Tn and daily_Tx.

OIV indices are the following:

- **Tm_veg**: 1 - mean temperature during vegetation period. The latter is April - October (N emisphere) or October - April (S emisphere). The case (N or S) is automatically recognised by temperature data.

- **WI**: 2 - Winkler index (degree days with a 10 C base, summation over vegetative period), see note on Tm_veg. Ref: Amerine and Winkler, 1944.

- **BEDD**: 3 - biologically active degree days. Degree days with a lower threshold of 10 C and an upper threshold at 19 C. Ref: Gladstone, 2004.

- **HI**: 4 - heliothermic Huglin index. A degree day summation of the average between mean and maximum temperature above 10 C, corrected by a coefficient of daylength duration. The coefficient is given by the author in a table according to latitude. If one value is given, it is used for all stations. Default is 1.04 (lat. 44-46). Ref.: Huglin, P., 1978

- **CNI**: 5 - cool night index. Mean of September (N emisphere) or March (S emisphere) minimum temperatures. Ref.: Tonietto and Carbonneau, 2004.

- **FSI**: 6 - Fregoni's simplified index. Given by the product between the summation of thermal range (Tx - Tn) and the number of days with Tm > 10 C, for 30 days before ripening. The period before ripening is taken as September (N emisphere) or March (S emisphere). Ref.: Fregoni et Pezzutto, 2000.

- **BI**: 7 - Branas' hydrothermic index. The only index not included in OIV list, used for fungine infection proneness. It is given by the product of precipitation (mm) by the mean temperature (C) during the period April - October (N emisphere) or October - April (S emisphere). Ref: Eynard and Dal Masso, 1990.

- **Tn_rest**: 8 - minimum temperature during rest period. Useful for assessing winter severity. The rest period is November - March (N emisphere) or May - September (S emisphere). The case (N or S) is automatically recognised by temperature data.

- **Tn_veg**: 9 - minimum temperature during vegetative period. Useful for assessing spring frosts. See note on Tm_veg for periods.

- **Tx_veg**: 10 - maximum temperature during vegetative period. Useful for assessing summer hot spells. See note on Tm_veg for periods.

quant_Tn_rest, quant_Tn_veg, quant_Tx_veg define the statistical rank of the year to be chosen as representative for assessing Tn_rest, Tn_veg, and Tx_veg, respectfully. 0.5 (default) is the median year, 0 is the minimum (lowest temperature), 1 is the maximum (highest temperature).

The only missing index among those selected by OIV is Riou's Drought Index, which is calculated by function RDI on monthly series.
Value
A table (one line per station) reporting OIV bioclimatic indices. The Branas’ index is added.

Author(s)
Emanuele Eccel

References


See Also
RDI

Examples
data(Trent_climate)
oiv_ind(daily_Tn=Tn, daily_Tx=Tx, daily_P=P, first.yr=1981, last.yr=2010, subs_missing=FALSE)

P

Precipitation

Description
The daily data frame of precipitation for a number of stations. It is used in function oiv_ind

Usage
data(Trent_climate)
Format

Data frame: 19358 observations of 39 variables (stations)

peguy

Peguy Climograph

Description

Representation of Peguy Climograph from monthly weather data (Mean Temperature, Precipitation)

Usage

peguy(data = NULL, TemperatureTriangleCoords = c(0, 23.4, 15),
PrecipitationTriangleCoords = c(0, 40, 200), ylab = "Precipitation[mm]",
xlim = "Mean Temperature [degC]", lambda.label = 1.75,
climate.label = c("Temperate", "Cold", "Arid", "Hot"), xField = c("Tn",
"P"), pointsField = "month", StationsField = "station",
color.scale = "monthly", ...)

Arguments

data input dataset with climatological monthly weather data
TemperatureTriangleCoords Temperature coordinates for triangle vertices in the Peguy Climograph. Default coordinates are expressed in Celsius Degrees.
PrecipitationTriangleCoords Precipitation coordinates for triangle vertices in the Peguy Climograph. Default coordinates are expressed in millimeters.
xlab, ylab xy axis labels
lambda.label numeric value used to locate climate attribute labels
climate.label string vector containing climate attributes. Default is c("Temperate", "Cold", "Arid", "Hot"). Alternatively it can be translated into any other language.
xyField column names of data for the x and y variables used in the Peguy Climate Diagram.
pointsField column name of data containing the fields to be represented with different point colors. Default is "month".
StationsField column name of data containing the fields with station ID names. Default is "station".
color.scale character scale indicating a use of a specific color scale. Default is "monthly".
...

Author(s)

Emanuele Cordano
plot.thornthwaite

References


Examples

library(stringr)
data(Trent_climate)

TrentinoClimateDf <- do.call(rbind,clima_81_10)
names <- rownames(TrentinoClimateDf)
TrentinoClimateDf$station <- unlist(lapply(X=str_split(names,pattern="\.[ ]"),FUN=function(x) (x[1])))

data <- TrentinoClimateDf[TrentinoClimateDf$station %in% unique(TrentinoClimateDf$station)[1:3],]
p <- peguy(data=data)

plot.thornthwaite Thornthwaite - Mather's quantile plot

Description

'plot' method implementation for 12-month quantile climate charts from output of function thornthwaite (Thornthwaite and Mather's water balance).

Usage

## S3 method for class 'thornthwaite'
plot(x, save_dir = NULL, format = NULL,
     variables = c("Precipitation", "Et0", "Storage", "Prec. - Evap.", "Deficit",
                   "Surplus"), title = TRUE, trace_grid = TRUE, st_name = NULL,
     u_y_scale_magn = 0.2, l_y_scale_magn = 0, leg_pos = "topleft", ...)

Arguments

x a list of quantile data frames of water balance variables to be plotted, as output of function thornthwaite.
save_dir name of destination directory for graphs (if any). Default is NULL.
format graphic format of graphs; default is NULL (charts are sent to console).
variables character vector of variables to be plotted.
title logic. If TRUE inserts titles in charts.
trace_grid logic. If TRUE (default) adds a grid.
plot.thornthwaite

st_name name to be included into graphs titles. If NULL (default), no title is written.
u_y_scale_magn magnification of range above upper limit, to set upper y-scale limit; default is 0.
l_y_scale_magn magnification of range below lower limit, to set lower y-scale limit; default is 0.1.
leg_pos legend position. Default is "topleft". If NULL, no legend is added.
... arguments to be passed to methods, such as graphical parameters (see par).

Details
Default for plot variables is all those calculated by function thornthwaite: "Precipitation", "Et0", "Storage", "Prec. - Evap.", "Deficit", "Surplus". See function thornthwaite for details on variables.

If format is NULL (default), graphs are sent to the console. Otherwise, a file is produced and saved to the save_dir directory. Values allowed are: "png", "jpeg", "tiff", "bmp".

l_y_scale_magn and u_y_scale_magn are the magnification coefficients (lower and upper, respectively), for y scale. If rng is the range between maximum and minimum values in all sets of series within a plot, the lower limit for y scale will be (rng * l_y_scale_magn) below the lower value, and the upper limit will be (rng * u_y_scale_magn) above the upper value of series.

Allowed values for leg_pos are the same of x in function legend.

Most graphic parameters for functions plot and legend are accepted.

Value
Charts of quantiles for water balance variables (12-month climatic values). They can be sent to the console or saved as graphic files.

Note
A conflict is generated if parameters already used by the function are passed (e.g. x for legend: use leg_pos instead).

Author(s)
Emanuele Eccel

See Also
thornthwaite

Examples

data(Trent_climate)

# quantiles is the list ("thornthwaite" S3 object) of quantile tables generated
# by function thornthwaite;
# it is the second element of the output list,
quantiles

# which can be split into two separate lists (see function thornthwaite)
sta <- 1  # 1st station in the list of quantile tables
q_list <- quantiles[[sta]]
class(q_list) <- "thornthwaite"  # q_list is coerced to a "thornthwaite" S3 object
plot(q_list,
st_name = names(quantiles)[sta], variables = c("Precipitation", "Et0"),
leg_pos = "topleft", col = c(1:6), pch = c(1:6, 16),
lty = 1, horiz = TRUE, y.intersp = 0.1)

quantiles

Monthly quantiles of the meteorological variables

Description

The second list (quantiles) in thorn_list organized according to stations. See Examples in function thornthwaite for its construction.

Usage

data(Trent_climate)

Format

Data frame of 28 observations of 4 variables

RDI

Riou's drought index

Description

Calculation of Riou's drought index described in OIV bio-climatic indices for viticulture (see references)

Usage

RDI(series, clim_norm = NULL, first.yr = NULL, last.yr = NULL,
     TAW = 200, coeff_rad, coeff_Hargr = rep(0.75, 12), quant = c(0, 0.1, 0.5))
Arguments

- **series**: series of mean monthly weather values
- **clim_norm**: the reference climatic values for each month, used for gap filling. Default is NULL (no replacement of missing values)
- **first.yr**: of the period over which water balance is calculated. Default is NULL (calculations start with the first year of the series)
- **last.yr**: of the period over which water balance is calculated. Default is NULL (calculations start with the last year of the series)
- **TAW**: total available water content of soil
- **coeff_rad**: vector of solar radiation coefficients (12 values) for calculation of potential evapotranspiration
- **coeff_Hargr**: (vector of monthly) correction coefficient(s) for Hargreaves’ equation
- **quant**: vector of quantiles for the statistical ranking of the year representative for balance (0..1)

Details


**series** is a data frame of the monthly series (means) of: cumulated precipitation (mm), minimum temperature, maximum temperature, mean temperature (optional) - all in deg. C. Includes the following columns (and names): "year", "month", "P", "Tn", "Tx", "Tm" (optional), for precipitation, minimum, maximum and mean temperature, respectively. If Tm is missing it is calculated as (Tn + Tx)/2. Format is the same of lista_cli.

**clim_norm** is a monthly data frame of 12 climate normals, with the same column names of series, except "year". It can be the output of function **climate**. If **clim_norm** is not NULL, any missing value in the monthly series is substituted by the corresponding climatic value in **clim_norm**.

A default value of 200 mm for **TAW** is suggested by the authors of the index. It can be changed according to the known pedological features of soil.

**coeff_rad** corresponds to the mean monthly extra-atmospheric radiation (see function ExAtRa). It is required in Hargreaves’ equation.

**coeff_Hargr** is either a single value or a vector of 12 coefficients to adjust Hargreaves’ estimation of potential evapotranspiration. From calibration in 6 stations from the same network of Trent_climate, its average value is 0.75.

**quant_vector** a vector of minimum one element. 0 yields minimum absolute case, 0.5 the median. Values range from 0 to 1 (inappropriate if > 0.5).

The algorithm described in OIV assesses water balance at the last month of the ripening period, early autumn. However, in humid or sub-humid climates the driest period for soil generally falls in summer. For this reason, the output table reports both cases ("harvest" time value and monthly minimum over the season, "WB_harv" and "WB_min", respectfully). Harvest time is conventionally September (N emisphere) or March (S emisphere).
Value

A two-column table reporting Riou’s drought indices for each quantile chosen (one line each, minimum is 1). Both "harvest time" and minimum values are calculated (see details).

Author(s)

Emanuele Eccel

References


See Also

oiv_ind, arid

Examples

data(TrentClimate)
RDI(lista_cli[[1]], clim_norm=clima_81_10[[1]], first.yr=1981, last.yr=2010, coeff_rad=coeff_rad)

thornthwaite | Thornthwaite and Mather’s water balance

Description

Calculates Thornthwaite and Mather’s water balance from monthly series of precipitation and temperature. Aimed at a classification of a site’s climate according to its water balance features.

Usage

thornthwaite(series, latitude, clim_norm = NULL, first.yr = NULL, last.yr = NULL, quant = c(0, 0.1, 0.25, 0.5, 0.75, 0.9, 1), snow.init = 20, Tsnow = -1, TAW = 100, fr.sn.acc = 0.95, snow_melt_coeff = 1)
Arguments

series the monthly series of temperature and precipitation.
latitude latitude of the station in degrees.
clim_norm climatic normals.
first.yr first year of the period over which water balance is calculated. Default is NULL (calculations start with the first year of the series).
last.yr last year of the period over which water balance is calculated. Default is NULL (calculations stop with the last year of the series).
quant vector of quantiles for which water balance has to be assessed. Default is: min, 10th, 25th 50th, 75th, 90th, max.
snow.init initial water equivalent for snowpack (mm). Default is 20.
Tsnow maximum temperature (monthly mean) for precipitation to be treated as snowfall. Default is -1 degree C.
TAW maximum (field capacity) for soil water retention, and initial soil water content (mm). Default is 100.
fr.sn.acc fraction of snow that contributes to snowpack (0-1). 1 - fr.sn.acc is treated as liquid monthly precipitation. Default is 0.95.
snow.melt.coeff monthly coefficient(s) for snowmelt. Default is 1.

Details

The algorithm for the calculation of water balance is adapted from Thornthwaite, 1948; Thornthwaite and Mather, 1955; Thornthwaite and Mather, 1957.

series is a data frame with years, months, temperature and precipitation values. Names in series columns must include: year, month, Tn and Tx (minimum and maximum temperatures, respectively) or, as an alternative, Tm (mean temperatures), and P (mandatory).

clim_norm is a monthly data frame of climate normals, with column names: "P", "Tn", "Tx", "Tm" (precipitation, minimum, maximum and mean temperature, respectively). It can be the output of function climate. If clim_norm is not NULL, any missing value in the monthly series is substituted by the corresponding climatic value in clim_norm.

At any winter season, the maximum monthly snowpack height is attained in the last month before "spring" conditions (Tm >= Tsnow), even if a month with Tm < Tsnow may occur later.

snow.melt.coeff is (are) the coefficient(s) for snow melt fraction(s) at any month where the condition for melting exists. If snow.melt.coeff = 1 (default), all the melting occurs in the first month when Tm >= Tsnow; if it is a vector, melting is spread over more than one month. If the sum of coefficients is less than 1, the residual melting occurs in one further month.

The output function is a list of two lists of data frames (balance and quantile). In both lists, data frame (and names) are the following (all variables in mm):

Precipitation (repeats input values);
Et0 (potential evapotranspiration);
Storage (water stored in soil);
Prec. - Evap. (difference between precipitation and potential evapotranspiration);
Deficit (difference between potential and real evapotranspiration, due to water unavailability in soil);
Surplus (water surplus in soil, routed to runoff).
Please, refer to the quoted references for details.
This function requires the function `daylength` (libr. `geosphere`).

**Value**

A `thornthwaite` S3 object, consisting on a list of two lists. The first (name: W_balance) is a list of data frames containing the monthly series of all indices, the second (name: quantiles) the relevant quantiles. See details for meanings of single variables.

**Author(s)**

Giambattista Toller and Emanuele Eccel

**References**

Thornthwaite, C. W., and Mather, J.R., 1955: The water balance. Publications in Climatology, Volume 8(1), Laboratory of Climatology
Thornthwaite, C. W., and Mather, J.R., 1957: Instructions and tables for computing potential evapotranspiration and the water balance. Publications in climatology, Volume 10(3), Laboratory of Climatology

**See Also**

`climate`, `ExAtRa`, `plot.thornthwaite`

**Examples**

```r
# lista_cli is a list of data frames of the type "series",
# each one referring to one station - see function "climate".
# clima_81_10 is a list of data frames having climatic means
# of temperature and precipitation, each one referring to one station.
# It can be the output of function "climate".
library(geosphere) # required for function daylength
thornt_lst<-NULL
lista_cli <- lista_cli[1:3] # lista_cli is reduced to diminish elapsed time of execution!
for(k in 1 : length(lista_cli[1:3])) {
  thornt_lst[k]<-thornthwaite(series=lista_cli[[k]],
    clim_norm=clima_81_10[[k]],
    latitude = 46, first.yr=1981,
```
last.yr=2010, snow_melt_coef=c(0.5,0.5 ) )
}
names(thornt_lst)<-names(lista_cli)

# splits list into two lists
W_balance<-NULL; quantiles<-NULL
for(k in 1 : length(lista_cli))
{
    W_balance[[k]]<-thornt_lst[[k]]$W_balance
    quantiles[[k]]<-thornt_lst[[k]]$quantiles
}
names(W_balance)<-names(thornt_lst); names(quantiles)<-names(thornt_lst)

---

**thornt_lst**

**Input for the Thornthwaite function**

**Description**

For every station, the first element (a list, Thornt .W. _bal) reports the monthly series of water balance quantities for the station, each in one data frame (see function thornthwaite for details). The second list (quantiles) reports the monthly quantiles for the same quantities.

**Usage**

data(Trent_climate)

**Format**

S3 object: a "hyperlist" (list of lists of lists), one list of lists for each station

---

**Tm**

**Mean daily temperature**

**Description**

The daily data frame of mean daily temperature for a number of stations, used in function oiv_ind

**Usage**

data(Trent_climate)

**Format**

Data frame: 19358 observations of 15 variables (stations)
\[ T_n \]

**Minimum daily temperature**

**Description**

The daily data frame of minimum daily temperature for a number of stations, used in function \texttt{oiv_ind}

**Usage**

\texttt{data(Trent_climate)}

**Format**

Data frame: 19358 observations of 15 variables (stations)

---

**Trent_climate**

*Data set of Trentino climate*

**Description**

A group of datasets used consistently throughout the ClimClass manual and examples. It is used as reference definition of the climate for the Trentino region, Italy. It includes monthly series of temperature and precipitation, and reference tables for the definition of aridity and continentality/oceanicity.

**Usage**

\texttt{data(Trent_climate)}

**Details**

Series like "Txxxx" were supplied by the Autonomous Province of Trento - Meteotrentino (I). Series like "FEMxx" were supplied by Fondazione Edmund Mach, San Michele all’Adige (I).
**W_balance**

<table>
<thead>
<tr>
<th>Description</th>
<th>The daily data frame of maximum daily temperature for a number of stations, used in function <code>oiv_ind</code></th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage</td>
<td><code>data(Trent_climate)</code></td>
</tr>
<tr>
<td>Format</td>
<td>Data frame: 19358 observations of 15 variables (stations)</td>
</tr>
</tbody>
</table>

---

**W_balance**

<table>
<thead>
<tr>
<th>Water balance</th>
</tr>
</thead>
</table>

| Description | Is the first list (`W_balance`) in `thornt_lst` organized according to stations. See Examples in function `thornthwaite` for its construction. |
| Usage       | `data(Trent_climate)`                                                                             |
| Format      | List of 28 elements, each is a data frame of 5 variables and 636 observations                      |
Index

*Topic -
ClimClass, 9

*Topic **Bagnouls**
ClimClass, 9

*Topic **Koeppen**
ClimClass, 9

*Topic **OIV**
ClimClass, 9

*Topic **Peguy**
ClimClass, 9

*Topic **Thornthwaite**
ClimClass, 9

*Topic **aridity**
ClimClass, 9

*Topic **bioclimatic**
ClimClass, 9

*Topic **climate**
ClimClass, 9

*Topic **continenity**
ClimClass, 9

*Topic **datasets**

arid_ind_tables, 4
clima_81_10, 9
coeff_rad, 12
continental_ind_tables, 14
coord_elev, 15
lista_cli, 18
P, 21
quantiles, 25
thornt_lst, 30
Tm, 30
Tn, 31
Trent_climate, 31
Tx, 32
W_balance, 32

arid, 2, 4, 10, 15, 16, 26, 27
arid_ind_tables, 4, 10
as.datacli, 5, 10
axis, 7

bagn_gau, 6, 10
clima_81_10, 9
climate, 3, 4, 7, 8, 9, 10, 13, 14, 17, 18, 26, 28, 29
ClimClass, 9
ClimClass-package (ClimClass), 9
coeff_rad, 12
contin, 10, 12, 14
continental_ind_tables, 10, 14
coord_elev, 15
daylight, 29
ExAtRa, 3, 4, 10, 12, 15, 26, 29
geosphere, 29
koeppen_geiger, 10, 16
legend, 24
lista_cli, 18
mtext, 7
oiv_ind, 10, 19, 21, 27, 30–32
P, 21
par, 7, 24
peguy, 22
plot, 7, 10, 24
plot.thornthwaite, 23, 29
quantiles, 25
RDI, 10, 21, 25
thornt_lst, 30
thornthwaite, 10, 23–25, 27, 30, 32
Tm, 30
Tn, 31
Trent_climate, 3, 10, 13, 31
Tx, 32
W_balance, 32