Package 'BrazilMet'

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License GPL-3

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`correction_etp_thornwaite`

Correction for Thorntwaite - Potential evapotranspiration

Description

Correction for Thorntwaite - Potential evapotranspiration

Usage

```
correction_etp_thornwaite(etp, date, lat)
```

Arguments

etp	A column of a dataframe containing Thorntwaite potential evapotranspiration (ETp) data without adjustments for sunlight hours and the number of days in the month.".
date	A column of dataframe with date (i.e: 2025-01-02).
lat	A column of dataframe with latitude in degrees.

Value

Returns a vector object with the Thorntwaite ETp corrected for sunlight hours and the number of days in the month.

Author(s)

Roberto Filgueiras.

Examples

```
## Not run:
etp_cor <- correction_etp_thornwaite(etp, date, lat)

## End(Not run)
```

---

daily_eto_FAO56 — *ETo calculation based on FAO-56 Penman-Monteith methodology, with data from automatic weather stations (AWS) downloaded and processed in function *daily_download_AWS_INMET**

Description

This function will calculate the reference evapotranspiration (ETo) based on FAO-56 (Allen et al., 1998) with the automatic weather stations (AWS) data, downloaded and processed in function *daily_download_AWS_INMET*.

Usage

```
daily_eto_FAO56(lat, tmin, tmax, tmean, Rs, u2, Patm, RH_max, RH_min, z, date)
```

Arguments

lat	A numeric value of the Latitude of the AWS (decimal degrees).
tmin	A dataframe with Minimum daily air temperature (Celsius).
tmax	A dataframe with Maximum daily air temperature (Celsius).
tmean	A dataframe with Mean daily air temperature (Celsius).
Rs	A dataframe with mean daily solar radiation (MJ m-2 day-1).

u2	A dataframe with Wind speed at two meters high (m s-2).
Patm	A dataframe with atmospheric Pressure (mB).
RH_max	A dataframe with Maximum relative humidity (percentage).
RH_min	A dataframe with Minimum relative humidity (percentage).
z	A numeric value of the altitude of AWS (m).
date	A data.frame with the date information (YYYY-MM-DD).

Value

Returns a data.frame with the AWS data requested

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
eto <- daily_eto_FAO56(lat, tmin, tmax, tmean, Rs, u2, Patm, RH_max, RH_min, z, date)

## End(Not run)
```

---

design_eto *Design reference evapotranspiration (Design ETo)*

Description

Function to calculate the reference evapotranspitation for irrigation design.

Usage

```
design_eto(eto_daily_data, percentile = 0.8, grouping = NULL)
```

Arguments

eto_daily_data	A data frame containing daily reference evapotranspiration values (mm day-1) named as "ETo", and other column with dates named "date". To estimate the design reference evapotranspiration, it is recommended to use more than 10 years of historical data.
percentile	The relative position of a value within the data distribution. The recomendation to desing irrigating is greater than 80 percent (0.8). For instance: The 90th (0.90) percentile of reference evapotranspiration (ETo) represents a value that is surpassed in only 10 percent of the observed period.
grouping	specifies the column used to group the data, typically by station. Use this parameter to calculate the design ETo separately for each station, based on the corresponding station code.

Value

Returns a numeric object with the desing ETo for the respective data and percentile.

Author(s)

Roberto Filgueiras

Examples

```
## Not run:
design_eto_value <- design_eto(eto, percentile)

## End(Not run)
```

`download_AWS_INMET_daily`

Download of hourly data from automatic weather stations (AWS) of INMET-Brazil in daily aggregates

---

Description

This function will download the hourly AWS data of INMET and it will aggregate the data in a daily time scale, based on the period of time selected (start_date and end_date).

Usage

```
download_AWS_INMET_daily(stations, start_date, end_date)
```

Arguments

`stations`	The stations code (ID - WMO code) for download. To see the station ID, please see the function *see_stations_info*.
`start_date`	Date that start the investigation, should be in the following format (1958-01-01 /Year-Month-Day)
`end_date`	Date that end the investigation, should be in the following format (2017-12-31 /Year-Month-Day)

Value

Returns a data.frame with the AWS data requested

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
df <- download_AWS_INMET_daily(
  stations = c("A001", "A042"),
  start_date = "2016-01-01",
  end_date = "2018-12-31"
)

## End(Not run)
```

`download_climate_normals` *Download climatological normals from Conventional weather stations (CWS) of Inmet*

Description

This function will download the climatological normals from CWS stations available in Inmet site.

Usage

```
download_climate_normals(variable, range_time)
```

Arguments

`variable`	The variables available to download. The available variables are: rainfall_norm, t2m_norm, rh_norm, ws_norm and etp_norm.
`range_time`	The range of time which the climatological normals were computed. The available range of time is: "1991-2020".

Value

Returns a data.frame with climatological normal required.

Author(s)

Roberto Filgueiras

Examples

```
## Not run:
df <- download_climate_normals(
  variable = "rainfall_norm",
  range_time = "1991-2020"
)

## End(Not run)
```

ea_dew_calculation *Actual vapour pressure (ea) derived from dewpoint temperature*

Description

Actual vapour pressure (ea) derived from dewpoint temperature

Usage

```
ea_dew_calculation(tdew)
```

Arguments

tdew	A dataframe with dewpoint temperature (Celsius).

Value

Returns a data.frame object with the ea from dewpoint data.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha.

Examples

```
## Not run:
ea <-ea_dew_calculation(tdew).

## End(Not run)
```

ea_rh_calculation *Actual vapour pressure (ea) derived from relative humidity data*

Description

Actual vapour pressure (ea) derived from relative humidity data

Usage

```
ea_rh_calculation(tmin, tmax, rh_min, rh_mean, rh_max)
```

Arguments

tmin	A dataframe with minimum daily air temperature (Celsius)
tmax	A dataframe with maximum daily air temperature (Celsius)
rh_min	A dataframe with minimum daily relative air humidity (percentage).
rh_mean	A dataframe with mean daily relative air humidity (percentage).
rh_max	A dataframe with maximum daily relative air humidity (percentage).

Value

Returns a data.frame object with the with ea from relative humidity data.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
ea <- ea_rh_calculation(tmin, tmax, rh_min, rh_mean, rh_max)

## End(Not run)
```

---

es_calculation *Mean saturation vapour pressure (es)*

Description

Mean saturation vapour pressure (es)

Usage

```
es_calculation(tmin, tmax)
```

Arguments

tmin	A dataframe with Minimum daily air temperature (Celsius).
tmax	A dataframe with Maximum daily air temperature (Celsius).

Value

Returns a data.frame object with the es data.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha.

Examples

```
## Not run:
es <-es_calculation(tmin, tmax)

## End(Not run)
```

es_ea_calculation *Vapour pressure deficit (es - ea)*

Description

Vapour pressure deficit (es - ea)

Usage

```
es_ea_calculation(tmin, tmax, tdew, rh_min, rh_mean, rh_max, ea_method)
```

Arguments

tmin	A dataframe with minimum daily air temperature (Celsius).
tmax	A dataframe with maximum daily air temperature (Celsius).
tdew	A dataframe with dewpoint temperature (Celsius).
rh_min	A dataframe with minimum daily relative air humidity (percentage).
rh_mean	A dataframe with mean daily relative air humidity (percentage).
rh_max	A dataframe with maximum daily relative air humidity (percentage).
ea_method	The methodology to calculate the actual vapour pressure. Assume the "rh" (default) for relative humidity procedure and "dew" for dewpoint temperature procedure.

Value

Returns a data.frame object with the ea from relative humidity data.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
ea <- es_ea_calculation(tmin, tmax, tdew, rh_min, rh_mean, rh_max, ea_method)

## End(Not run)
```

eto_hs *Hargreaves - Samani ETo*

Description

Hargreaves - Samani ETo

Usage

```
eto_hs(tmin, tmean, tmax, ra)
```

Arguments

tmin	A dataframe with Maximum daily air temperature (Celsius)
tmean	A dataframe with Mean daily air temperature (Celsius)
tmax	A dataframe with Maximum daily air temperature (Celsius)
ra	A dataframe of extraterrestrial radiation (MJ m-2 day-1)

Value

Returns a data.frame object with the ETo HS data

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
eto_hs <- eto_hs(tmin, tmean, tmax, ra)

## End(Not run)
```

etp_thorntwaite *Thorntwaite - Potential evapotranspiration*

Description

Thorntwaite - Potential evapotranspiration

Usage

```
etp_thorntwaite(tmean)
```

Arguments

tmean	A dataframe with Mean monthly air temperature (Celsius)

Value

Returns a data.frame object with the Thorntwaite ETp data

Author(s)

Roberto Filgueiras.

Examples

```
## Not run:
etp <- etp_thorntwaite(tmean)

## End(Not run)
```

---

get_max_eto_at_location

Get Max Reference Evapotranspiration Values by Geographic Location

---

Description

Extract maximum reference evapotranspiration (max ETo) values for one or more locations of interest, using data from the dataset provided by Dias (2018).

Usage

```
get_max_eto_at_location(img, lat, long)
```

Arguments

img	SpatRaster with the maximum reference evapotranspiration (ETo) grid downloaded from max_eto_grid_download.
lat	Numeric. Latitude of the location in decimal degrees.
long	Numeric. Longitude of the location in decimal degrees.

Value

A ‘data.frame‘ object containing the maximum reference evapotranspiration (ETo) values per pair of coordinates.

Author(s)

Roberto Filgueiras.

Examples

```
## Not run:
# Visualize Brazilian states (optional)

max_eto_df <- get_max_reference_eto_by_location(img,
                                                long = c(-51.95, -43.23),
                                                lat = c(-23.52, -21.34))

## End(Not run)
```

`hourly_weather_station_download`
Download of hourly data from automatic weather stations (AWS) of INMET-Brazil

---

Description

This function will download the hourly AWS data of INMET for whatever station of interest, based on the period of time selected (start_date and end_date) and station code.

Usage

```
hourly_weather_station_download(stations, start_date, end_date)
```

Arguments

`stations`	The station code (ID - WMO code) for download. To see the station ID, please see the function *see_stations_info*.
`start_date`	Date that start the investigation, should be in the following format (1958-01-01 /Year-Month-Day)
`end_date`	Date that end the investigation, should be in the following format (2017-12-31 /Year-Month-Day)

Value

Returns a data.frame with the AWS data requested

Author(s)

Roberto Filgueiras

Examples

```
## Not run:
df <- hourly_weather_station_download(
                                      stations = c("A001", "A042"),
                                      start_date = "2022-08-12",
                                      end_date = "2022-08-16")

## End(Not run)
```

`max_eto_grid_download` *Download maximum reference evapotranspiration (ETo) grids for Brazil*

Description

Downloads maximum reference evapotranspiration (ETo) grids for Brazil, intended for irrigation design purposes. The dataset was developed by Dias (2018).

Usage

```
max_eto_grid_download(dir_out, product = "max_12_months")
```

Arguments

`dir_out`	Character. Directory where the downloaded raster file will be saved.
`product`	Character. Specifies which maximum ETo product to download. Available options include: • `max_12_months`: maximum ETo over the full year. • `max_jan` to `max_dec`: monthly maximum ETo for each respective month (January to December).

Value

A 'SpatRaster' object containing the downloaded maximum reference evapotranspiration (ETo) grid.

Author(s)

Roberto Filgueiras.

References

Dias, S. H. B. (2018). *Evapotranspiração de referência para projeto de irrigação no Brasil utilizando o produto MOD16*. Dissertação (Mestrado) – Universidade Federal de Viçosa.

Examples

```
## Not run:
# Visualize Brazilian states (optional)
see_brazil_states()

# Download maximum ETo grid (annual)
img_max_eto <- max_eto_grid_download(dir_out = "data/", product = "max_12_months")

## End(Not run)
```

`Patm` *Atmospheric pressure (Patm)*

Description

Atmospheric pressure (Patm)

Usage

```
Patm(z)
```

Arguments

`z`	Elevation above sea level (m)

Value

Returns a data.frame object with the atmospheric pressure calculated.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
Patm <- Patm(z)

## End(Not run)
```

psy_const *Psychrometric constant*

Description

Psychrometric constant (kPa/Celsius) is calculated in this function.

Usage

```
psy_const(Patm)
```

Arguments

Patm	Atmospheric pressure (kPa)

Value

A data.frame object with the psychrometric constant calculated.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
psy_df <- psy_const(Patm)

## End(Not run)
```

radiation_conversion *Conversion factors for radiation*

Description

Function to convert the radiation data. The conversion name can be understand as follow:

- conversion_1 = MJ m-2 day-1 to J cm-2 day-1;
- conversion_2 = MJ m-2 day-1 to cal cm-2 day-1;
- conversion_3 = MJ m-2 day-1 to W m-2;
- conversion_4 = MJ m-2 day-1 to mm day-1;
- conversion_5 = cal cm-2 day-1 to MJ m-2 day-1;
- conversion_6 = cal cm-2 day-1 to J cm-2 day-1;
- conversion_7 = cal cm-2 day-1 to W m-2;

- conversion_8 = cal cm-2 day-1 to mm day-1;
- conversion_9 = W m-2 to MJ m-2 day-1;
- conversion_10 = W m-2 to J cm-2 day-1;
- conversion_11 = W m-2 to cal cm-2 day-1;
- conversion_12 = W m-2 to mm day-1;
- conversion_13 = mm day-1 to MJ m-2 day-1;
- conversion_14 = mm day-1 to J cm-2 day-1;
- conversion_15 = mm day-1 to cal cm-2 day-1;
- conversion_16 = mm day-1 to W m-2.

Usage

```
radiation_conversion(data_to_convert, conversion_name)
```

Arguments

`data_to_convert`	A data.frame with radiation values to convert.
`conversion_name`	A character with the conversion_name summarize in the description of this function.

Value

A data.frame object wit the converted radiation.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
radiation_conversion_df <- radiation_conversion(
  data_to_convert = df$rad,
  conversion_name = "conversion_1"
)

## End(Not run)
```

ra_calculation *Extraterrestrial radiation for daily periods (ra)*

Description

ra is expressed in MJ m-2 day-1

Usage

```
ra_calculation(latitude, date)
```

Arguments

latitude	A dataframe with latitude in decimal degrees that you want to calculate the ra.
date	A dataframe with the dates that you want to calculate the ra.

Value

A data.frame with the extraterrestrial radiation for daily periods

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
ra <- ra_calculation(latitude, date)

## End(Not run)
```

rh_calculation *Relative humidity (rh) calculation*

Description

Relative humidity is calculated in this function based on minimum air temperature of the day and the air temperature of the moment.

Usage

```
rh_calculation(tmin, tmean)
```

Arguments

tmin	A dataframe with minimum daily air temperature (Celsius)
tmean	A dataframe with mean air temperature (Celsius) that you want to calculate the relative humidity.

Value

A data.frame object with the relative humidity calculated

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
rh <- rh_calculation(tmin, tmean)

## End(Not run)
```

---

rnl_calculation *Net longwave radiation (rnl)*

Description

Net outgoing longwave radiation is calculate with this function

Usage

```
rnl_calculation(tmin, tmax, ea, rs, rso)
```

Arguments

tmin	A dataframe with Minimum daily air temperature (Celsius)
tmax	A dataframe with Maximum daily air temperature (Celsius)
ea	A dataframe with the actual vapour pressure (KPa).
rs	A dataframe with the incomimg solar radiation (MJ m-2 day-1).
rso	A dataframe with the clear-sky radiation (MJ m-2 day-1)

Value

A data.frame object with the net longwave radiation.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
rnl_df <- rnl_calculation(tmin, tmax, ea, rs, rso)

## End(Not run)
```

`rns_calculation` *Net solar or net shortwave radiation (rns)*

Description

The rns results form the balance between incoming and reflected solar radiation (MJ m-2 day-1).

Usage

```
rns_calculation(albedo, rs)
```

Arguments

`albedo`	Albedo or canopy reflectance coefficient. The 0.23 is the value used for hypothetical grass reference crop (dimensionless).
`rs`	The incoming solar radiation (MJ m-2 day-1).

Value

A data.frame object with the net solar or net shortwave radiation data.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
ra <- rns_calculation(albedo, rs)

## End(Not run)
```

rn_calculation *Net radiation (rn)*

Description

The net radiation (MJ m-2 day-1) is the difference between the incoming net shortwave radiation (rns) and the outgoing net longwave radiation (rnl).

Usage

```
rn_calculation(rns, rnl)
```

Arguments

rns	The incomimg net shortwave radiation (MJ m-2 day-1).
rnl	The outgoing net longwave radiation (MJ m-2 day-1).

Value

A data.frame object with the net radiation data.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
rn <- rn_calculation(rns, rnl)

## End(Not run)
```

rso_calculation_1 *Clear-sky solar radiation with calibrated values available*

Description

Clear-sky solar radiation is calculated in this function for near sea level or when calibrated values for as and bs are available.

Usage

```
rso_calculation_1(as, bs, ra)
```

Arguments

as	A dataframe with latitude in decimal degrees that you want to calculate the ra. The values of as = 0.25 is recommended by Allen et al. (1998).
bs	A dataframe with the dates that you want to calculate the ra. The values of bs = 0.50 is recommended by Allen et al. (1998).
ra	Extraterrestrial radiation for daily periods (ra).

Value

A data.frame object with the clear-sky radiation data

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
rso_df <- rso_calculation_1(as, bs, ra)

## End(Not run)
```

---

rso_calculation_2 *Clear-sky solar radiation when calibrated values are not available*

Description

Clear-sky solar radiation is calculated in this function for near sea level or when calibrated values for as and bs are available.

Usage

```
rso_calculation_2(z, ra)
```

Arguments

z	Station elevation above sea level (m)
ra	Extraterrestrial radiation for daily periods (ra).

Value

A data.frame object with the clear-sky solar radiation

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
rso_df <- rso_calculation_2(z, ra)

## End(Not run)
```

`rs_nearby_calculation` *Solar radiation data from a nearby weather station*

Description

The solar radiation data is calculated based in a nearby weather station.

Usage

```
rs_nearby_calculation(rs_reg, ra_reg, ra)
```

Arguments

`rs_reg`	A dataframe with the solar radiation at the regional location (MJ m-2 day-1).
`ra_reg`	A dataframe with the extraterrestrial radiation at the regional location (MJ m-2 day-1).
`ra`	A dataframe with the extraterrestrial radiation for daily periods (ra).

Value

A data.frame object with the Solar radiation data based on a nearby weather station

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
rs_nearby_df <- rs_nearby_calculation(rs_reg, ra_reg, ra)

## End(Not run)
```

see_stations_info *Localization of the automatic weather station of INMET*

Description

Function to see the localization of the automatic weather station of INMET.

Usage

```
see_stations_info()
```

Value

A data.frame with informations of OMM code, latitude, longitude and altitude of all AWS stations available in INMET.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
see_stations_info()

## End(Not run)
```

selectAWSstations *Select Automatic Weather Stations*

Description

Select automatic weather stations of INMET based on sf object.

Usage

```
selectAWSstations(aoi, as_sf = FALSE)
```

Arguments

aoi	sf object. Area of interest.
as_sf	logical. Inmet stations inventory result should be export as sf object. Default = FALSE.

Value

a vector or sf object with station located at area of interest (aoi)

Examples

```
## Not run:

es = geobr::read_municipality(code_muni = "ES")

esStations = selectStations(aoi = es, as_sf = F); es


## End(Not run)
```

`sr_ang_calculation` *Solar radiation based in Angstrom formula (sr_ang)*

Description

If global radiation is not measure at station, it can be estimated with this function.

Usage

```
sr_ang_calculation(latitude, date, n, as, bs)
```

Arguments

`latitude`	A dataframe with latitude in decimal degrees that you want to calculate the ra.
`date`	A dataframe with the dates that you want to calculate the ra.
`n`	The actual duration of sunshine. This variable is recorded with Campbell-Stokes sunshine recorder.
`as`	A dataframe with latitude in decimal degrees that you want to calculate the ra. The values of as = 0.25 is recommended by Allen et al. (1998).
`bs`	A dataframe with the dates that you want to calculate the ra. The values of bs = 0.50 is recommended by Allen et al. (1998).

Value

A data.frame object with solar radiation data

Author(s)

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Examples

```
## Not run:
sr_ang <- sr_ang_calculation(latitude, date, n, as, bs)

## End(Not run)
```

sr_tair_calculation *Solar radiation data derived from air temperature differences*

Description

If global radiation is not measure at station, it can be estimated with this function.

Usage

```
sr_tair_calculation(latitude, date, tmax, tmin, location_krs)
```

Arguments

latitude	A dataframe with latitude in decimal degrees that you want to calculate the ra.
date	A dataframe with the dates that you want to calculate the ra.
tmax	A dataframe with Maximum daily air temperature (Celsius)
tmin	A dataframe with Minimum daily air temperature (Celsius)
location_krs	Adjustment coefficient based in location. Please decide between "coastal or "interior". If coastal the krs will be 0.19, if interior the krs will be 0.16.

Value

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Examples

```
## Not run:
sr_tair <- sr_tair_calculation(latitude, date, tmax, tmin, location_krs)

## End(Not run)
```

u2_calculation *Wind speed at 2 meters high*

Description

Wind speed at two meters high can be calculated with this function.

Usage

```
u2_calculation(uz, z)
```

Arguments

uz	measured wind speed at z meters above ground surface
z	height of measurement above ground surface.

Value

A data.frame with the wind speed at 2 meters high calculated.

Author(s)

Roberto Filgueiras, Luan P. Venancio, Catariny C. Aleman and Fernando F. da Cunha

Examples

```
## Not run:
u2_df <- u2_calculation(uz, z)

## End(Not run)
```

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