Package ‘AquaBEHER’

December 8, 2022

Type Package

Title Estimation of rainy season calandar and soil water balance for agriculture

Version 0.1.0

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Description This R package computes and integrates daily reference evapotranspiration (Eto) into FAO56 water balance model. The AquaBEHER package can estimate daily parameters of crop and soil water balances parameters for agricultural crops. The package can also estimate rainy season calandar (Onset, Cessation and Duration) based on agroclimatic approach.

License GPL (>= 3)

Encoding UTF-8

LazyData true

RoxygenNote 7.2.2

Roxygen list(markdown = TRUE)

Suggests knitr,
rmarkdown,
prettydoc

VignetteBuilder knitr

Depends soiltexture, ggplot2, dplyr, lubridate,
R (>= 2.10)

R topics documented:

`AgroClimateData` *Example AgroClimate data from NASA POWER*

Description

NASA/POWER CERES/MERRA2 Native Resolution Daily Data from 01/01/1996 through 12/31/2020 extracted for a grid located in located in Angochen, Nampula province of Mozambique.

Usage

```
AgroClimateData
```

Format

A data frame containing daily observations of AgroClimate parameters:

`Source` Source of the data.

`Lat` latitude of the site in decimal degrees.

`Lon` longitude of the site in decimal degrees.

`Elev` elevation above sea level in (meters).

`Year` year of record "YYYY".

`Month` month of record "MM".

`Day` day of record "DD".

`Rain` MERRA-2 Precipitation Corrected (mm/day).

`Tmax` MERRA-2 Temperature at 2 Meters Maximum (°C).

`Tmin` MERRA-2 Temperature at 2 Meters Minimum (°C).

`Rs` CERES SYN1deg All Sky Surface Shortwave Downward Irradiance (MJ/m^2/day).

`RH` MERRA-2 Relative Humidity at 2 Meters (%).

`Tdew` MERRA-2 Dew/Frost Point at 2 Meters (°C).

`U2` MERRA-2 Wind Speed at 2 Meters (m/s).

Source

https://power.larc.nasa.gov/data-access-viewer/

See Also

climateData, calcEto

Examples

```
# load example data:
data(AgroClimateData)

# Get the structure of the data frame:
str(AgroClimateData)

# Get the head of the data frame:
head(AgroClimateData)
```

`calcEto` *Potential Evapotranspiration*

Description

This function calculates Penman-Monteith, Priestley Taylor and Hargreaves-Samani Potential Evapotranspiration using the method described by Allen et al, (1998)

Usage

```
calcEto(data, method = "PM", crop = "short", Zh = NULL)
```

Arguments

`data` a dataframe containing the required climate variables: columns must contain the following parameters:

- `Lat`: *latitude of the site in decimal degrees.*
- `Lon`: *longitude of the site in decimal degrees.*
- `Elev`: *elevation above sea level in (meters).*
- `Year`: *year of record "YYYY".*
- `Month`: *month of record "MM".*
- `Day`: *day of record "DD".*
- `Tmax`: *daily maximum temperature at 2-m height in (°C).*
- `Tmin`: *daily minimum temperature at 2-m height in (°C).*
- `Rs`: *daily surface incoming solar radiation in (MJ/m^2/day).*
- `RH` or `RHmax` and `RHmin`: *daily relative humidity at 2-m height.*
- `Tdew`: *daily dew point temperature at 2-m height in (°C).*
- `U2` or `Uz`: *daily wind speed at 2-m or Z-m(custom) height (m/s).*

`method` the formulation used to compute Eto; default is *method = "PM"* gives the the Penman-Monteith formulation; *method = "PT"* gives the Priestley-Taylor formulation and *method = "HS"* gives the Hargreaves Samani formulation.

`crop` either *crop = "short"* (default) or *crop = "tall"*; short indicates that the method for FAO-56 hypothetical short grass will be applied (Allen et al.1998); tall indicates that the method for ASCE-EWRI standard crop will be applied (ASCE, 2005).

`Zh` height of wind speed measurement in meters,

Details

Penman-Monteith: If all variables of Tmax, Tmin, Rs, either U2 or Uz, and either RHmax and RHmin or RH or Tdew are available and crop surface (short or tall) is specified in argument the Penman-Monteith FAO56 formulation is used (Allen et al.1998).

Priestley-Taylor: If all variables of Tmax, Tmin, Rs and either RHmax and RHmin or RH or Tdew are available the Priestley-Taylor formulation is used (Priestley and Taylor, 1972).

Hargreaves-Samani: If only Tmax and Tmin are available, the Hargreaves-Samani formulation is used or estimating reference crop evapotranspiration (Hargreaves and.Samani, 1985).

Value

The function generates a list containing the following objects:

`ET.Daily`: daily estimations of reference crop evapotranspiration (mm/day)

`Ra.Daily`: daily estimations of extraterristrial radiation (MJ/m2/day)

`Slope.Daily`: daily estimations of slope of vapour pressure curve (kPa/°C)

`ET.type`: type of the estimation obtained

References

Allen, R.G., L.S. Pereira, D. Raes, and M. Smith. 1998. 'Crop evapotranspiration-Guidelines for Computing Crop Water requirements FAO Irrigation and Drainage Paper 56'. FAO, Rome 300: 6541.

Allen, R. G. 2005. The ASCE standardized reference evapotranspiration equation. Amer Society of Civil Engineers.

Guo, Danlu & Westra, Seth & Maier, Holger. (2016). An R package for modelling actual, potential and reference evapotranspiration. Environmental Modelling & Software. 78. 216-224. 10.1016/j.envsoft.2015.12.019.

Hargreaves, G.H.Samani, Z.A. 1985, Reference crop evapotranspiration from ambient air temperature. American Society of Agricultural Engineers.

Priestley, C. & Taylor, R. 1972, On the assessment of surface heat flux and evaporation using large-scale parameters'. Monthly Weather Review, vol. 100, no. 2, pp. 81-92.

See Also

`climateData`, `calcWatBal`, `calcSeasCal`

Examples

```
# load example data:
data(climateData)

calcEto(climateData, method = "HS")

# load example data:
data(AgroClimateData)
```

```
calcEto(AgroClimateData, method = "PM", crop = "short")
```

`calcSeasCal` *Rainy Season Calendar*

Description

This function estimates the rainy season calendar, i.e onset date, cessation date and duration of the rainy season based on Agroclimatic approach. The agroclimatic approach defines the onset of the rainy season as the optimal date that ensures sufficient soil moisture during planting and early growing periods to avoid crop failure after sowing and requires information on rainfall, reference evapotranspiration and accounting of the daily soil water balance parameters.

Usage

```
calcSeasCal(data, onsetWind.start, onsetWind.end, cessaWind.end, soilWHC)
```

Arguments

`data`	an R object of dataframe as returned by `calcWatBal` or a dataframe having similar parameters.
`onsetWind.start`	Earliest possible start date of the onset window.
`onsetWind.end`	The latest possible date for end of the onset window.
`cessaWind.end`	The latest possible date for end of the cessation window.
`soilWHC`	Water holding capacity of the soil at root zone depth in (mm).

Details

As per agroclimatic approach, a normal rainy season (growing season) is defined as one when there is an excess of precipitation over potential evapotranspiration (PET). Such a period met the evapotransiration demands of crops and recharge the moisture of the soil profile (FAO 1977; 1978; 1986). Thus, the rainy season calendar defined accordingly:

Onset

The *onset* of the rainy season will start on the first day after *onsetWind.start*, when the actual-to-potential evapotranspiration ratio is greater than 0.5 for 7 consecutive days, followed by a 20-day period in which plant available water remains above wilting over the root zone of the soil layer.

Cesation

The rainy season will end, *cessation*, on the first day after *onsetWind.end*, when the actual-to-potential evapotranspiration ratio is less than 0.5 for 7 consecutive days, followed by 12 consecutive non-growing days in which plant available water remains below wilting over the root zone of the soil layer.

Duration

The *duration* of the rainy season is the total number of days from onset to cessation of the season.

Value

The function generates list of data frames with columns of variables:

`Onset.dF`: a data frame with columns of onset variables:
- *Year:* year of the season under investigation, "YYYY".
- *onset.Year:* year of the season under investigation, "YYYY".
- *onset.Month:* month of the onset of the season in "MM".
- *onset.Day:* day of the onset of the season in "DD".
- *JD:* onset date of the season in Julian day, "DOY".
- *YYYYDOY:* onset date of the season in "YYYY-DOY".
- *Year:* year of the season under investigation, "YYYY".

`Cessation.dF`: a data frame with columns of onset variables:
- *Year:* year of the season under investigation, "YYYY".
- *cessation.Year:* year of the season under investigation, "YYYY".
- *cessation.Month:* month of the cessation of the season in "MM".
- *cessation.Day:* day of the cessation of the season in "DD".
- *JD:* cessation date of the season in Julian day, "DOY".
- *YYYYDOY:* cessation date of the season in "YYYY-DOY".

`Duration.dF`: a data frame with columns of onset variables:
- *Year:* year of the season under investigation, "YYYY".
- *onset.YYYYDOY:* onset date of the season in "YYYY-DOY".
- *cessation.YYYYDOY:* cessation date of the season in "YYYY-DOY".
- *Duration:* duration of the season in "days".

References

FAO, 1977. Crop water requirements. FAO Irrigation and Drainage Paper No. 24, by Doorenbos J and W.O. Pruitt. FAO, Rome, Italy.

FAO 1978. Forestry for Local Community Development Food and Agriculture Organization of the United Nation (FAO), FAO Forestry paper, No 7, Rome.

FAO, 1986. Early Agrometeorological crop yield forecasting. FAO Plant Production and Protection paper No. 73, by M. Frère and G.F. Popov. FAO, Rome, Italy

See Also

calcEto, calcWatBal

Examples

```
# load example data:
data(AgroClimateData)

# Estimate daily PET:
PET <- calcEto(AgroClimateData, method = "PM", crop = "short")

# Add the estimated PET 'ET.Daily' to a new column in AgroClimateData:
AgroClimateData$Eto <- PET$ET.Daily

# Estimate daily water balance for the soil having 100mm of WHC:
```

```
watBal <- calcWatBal(AgroClimateData, soilWHC = 100)

# estimate the rainy season calandar (Onset, Cessation and Duration):
onsetWind.start = "1996-09-01"  # earliest possible start data of the onset window
onsetWind.end = "1997-01-31"   # the late possible date for end of the onset window
cessaWind.end = "1997-06-30"   # the late possible date for end of the cessation window

seasCal.lst <- calcSeasCal(watBal, onsetWind.start, onsetWind.end, cessaWind.end, soilWHC = 100)

str(seasCal.lst)
```

---

calcWatBal *Soil Water Balance*

Description

Function to estimate a budget-based daily soil water balance. It calculates the amount of water present in the root zone of a homogeneous grass canopy growing on a well-drained and homogeneous soil.

Usage

```
calcWatBal(data, soilWHC)
```

Arguments

data a dataframe containing the required variables: Columns must contain the following parameters:

```
Lat: latitude of the site in decimal degrees.
Lon: longitude of the site in decimal degrees.
Elev: elevation above sea level in (meters).
Year: year of record "YYYY".
Month: month of record "MM".
Day: day of record "DD".
Rain: daily rainfall in (mm).
Eto: daily potential evapotranspiration in (mm).
```

soilWHC Water holding capacity of the soil in (mm).

Value

The function generates a data frame containing the following components:

DRAIN: amount of deep drainage in (mm).

TRAN: amount of water lost by transpiration (after drainage) in (mm).

RUNOFF: surface runoff in (mm).

AVAIL: available soil moisture storage in (mm).

R: actual-to-potential evapotranspiration ratio.

References

Allen, R.G.; Pereira, L.S.; Raes, D.; Smith, M. Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements; FAO Irrigation and Drainage Paper no. 56; FAO: Rome, Italy, 1998; ISBN 92-5-104219-5.

Doorenbos, J. and Pruitt, W.O. 1975. Guidelines for predicting crop water requirements, Irrigation and Drainage Paper 24, Food and Agriculture Organization of the United Nations, Rome, 179 p.

See Also

calcEto, calcSeasCal

Examples

```
# load example data:
data(AgroClimateData)

# Estimate daily PET:
PET <- calcEto(AgroClimateData, method = "PM", crop = "short")

# Add the estimated PET 'ET.Daily' to a new column in AgroClimateData:
AgroClimateData$Eto <- PET$ET.Daily

# Estimate daily water balance for the soil having 100mm of WHC:
watBal<- calcWatBal(AgroClimateData, soilWHC = 100)

# Visualizing water balance parameters for 2019/20 season
watBal.19T20 <- watBal[watBal$Year %in% c(2019, 2020),]
date.vec <- as.Date.character(paste0(watBal.19T20$Year, "-",
                                     watBal.19T20$Month, "-", watBal.19T20$Day))

plot(y = watBal.19T20$AVAIL, x = date.vec, ty="l", col="black", xlab="", ylab=" Water (mm)",
       main="Daily Water Balance Parameters", lwd = 1, lty = 2)
 lines(y = watBal.19T20$Eto, x = date.vec, col="red", lwd = 3, lty = 1)
 lines(y = watBal.19T20$Rain, x = date.vec, col="blue", lwd = 1, lty = 1)

  legend("bottomright",c("Rain","Eto","Available Moisture"),
        horiz=FALSE, bty='n', cex=1.2,lty=c(1,1,2),lwd=c(1,3,1), inset=c(0,0.7),
        xpd=TRUE, col=c("blue","red","black"))
```

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climateData *A dataframe containing raw climate data*

Description

The R data object was obtained from Instituto Nacional de Meteorologia (INAM). This example data set contains the daily raw climate data over the period between 1/1/1996 and 12/31/2020 from a weather station located in Angochen, Nampula province of Mozambique.

Usage

```
data(climateData)
```

Format

A data frame containing daily observations of climate parameters:

- `Station_Name`: *name of the weather station.*
- `Lat`: *latitude of the site in decimal degrees.*
- `Lon`: *longitude of the site in decimal degrees.*
- `Elev`: *elevation above sea level in (meters).*
- `Year`: *year of record "YYYY".*
- `Month`: *month of record "MM".*
- `Day`: *day of record "DD".*
- `Rain`: *daily rainfall in (mm).*
- `Tmax`: *daily maximum temperature at 2-m height in (°C).*
- `Tmin`: *daily minimum temperature at 2-m height in (°C).*

Source

INAM - Instituto Nacional de Meteorologia, Mozambique https://www.inam.gov.mz/

See Also

`AgroClimateData`, `calcEto`

Examples

```
# load example data:
data(climateData)

# Get the structure of the data frame:
str(climateData)

# Get the head of the data frame:
head(climateData)
```

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