Package 'AquaBEHER'

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Type Package

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

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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)

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Depends soiltexture,
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)
```

`calcCropWR` *Crop Water Requirement*

Description

This function computes crop water requirement/water demand and crop coefficients using the method described in FAO56

Usage

```
calcCropWR(
  data,
  Crop = NULL,
  pheno = c(Ph_ini = NULL, Ph_dev = NULL, Ph_mid = NULL, Ph_late = NULL),
  Kc.Type = "Single",
  Kc = c(Kc_ini = NULL, Kc.mid = NULL, Kc.end = NULL),
  CropHmax = NULL,
  plantDate = NULL,
  WHC = NULL,
  SoilTex = NULL
)
```

Arguments

`data`	a dataframe containing the required climate data, see `calcEto`
`Crop`	character. Name of the crop , Default: NULL
`pheno`	length of crop growth stages, Default: c(Ph_ini = NULL, Ph_dev = NULL, Ph_mid = NULL, Ph_late = NULL)
`Kc.Type`	the type of Kc used for estimation, either "single" or "double", Default: 'Single'
`Kc`	defaoult Kc values in the form of: c(Kc_ini = NULL, Kc.mid = NULL, Kc.end = NULL)
`CropHmax`	maximum crop height in (m)
`plantDate`	a dataframe containing columens with 'Year' in YYYY and 'plantDate' in julian date.
`WHC`	soil water holding capacity
`SoilTex`	a character specfying the name of soil textural class according to USDA

Value

The function generates a data frame containing the following components:

Crop: the crop name that water requirement estimated for .

Eto: .daily estimations of reference crop evapotranspiration (mm/day).

tabKc: daily tabulated Kc values over the growing period.

adjKc: daily adjested Kc values over the growing period.

CropWR: daily estimates of crop water requirement over the growing period.

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.

See Also

calcEto, calcSeasCal, calcWatBal

Examples

```
# load example data:
data(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".
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).
Rs: daily surface solar radiation in (MJ/m^2/day).
RH or RHmax and RHmin: daily relative humidity at 2 Meters (%).
Tdew: daily dew point temperature at 2 Meters (°C).
U2 or Uz: daily wind speed at 2 Meters (m/s).
```

`method` the formulation used to compute Eto; default is method = "PM" gives the the Penman-Monteith formulation (including the method for FAO-56 hypothetical short grass and the method for ASCE-EWRI Standardised crop) for estimating reference crop evapotranspiration; method ="PT" gives the Priestley-Taylor formulation for potential evaporation; method = "HS" gives the Hargreaves-Samani formulation for estimating reference crop evapotranspiration Hargreaves-Samani equation.FAO Penman-Monteith (method_ETo="PM").

`crop` either short (default) or 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 Standardised crop will be applied (ASCE, 2005).

`Zh` height of wind speed measurement in m,

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 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 components:

`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

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 data 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 and temperature as well as the soil water balance at daily time scale.

Usage

```
calcSeasCal(
  data,
  onsetWind.start,
  onsetWind.end,
  e_thresh = 0.25,
  AW_thr = 10,
  soilWHC
)
```

Arguments

`data`	an object as returned by calcWatBal or a dataframe having similar parameters.
`onsetWind.start`	Earliest possible start data of the onset window.
`onsetWind.end`	The late possible date for end of the onset window.
`e_thresh`	Threshold value of actual-to-potential evapotranspiration (Ea/Ep); *default value: e_thresh = 0.25*.
`AW_thr`	Threshold value of plant available water (PAW); *default value: AW_thr = 10mm*.
`soilWHC`	Water holding capacity of the soil 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 meets 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 *(e_thresh)* is greater than 0.25 and is followed by a 20-day period in which plant available water *(AW_thr)* remains above 10mm.

Cesation

The rainy season will end, *cessation*, on the first day after *onsetWind.end*, when the actual-to-potential evapotranspiration ratio *(e_thresh)* is less than or equal to 0.25 and followed 12 consecutive non-growing days *(AW_thr <= 10mm)*.

Duration

The *duration* of the rainy season is taken as the difference between the Julian day numbers of the determined cessation date and the determined onset date for that season, i.e. the number of days from onset to cessation.

Value

The function generates a data frame containing the following components:

`Year: year of the rainy season in "YYYY".`

`Onset.DOY: onset date of the rainy season in julian day.`

`Cesation.DOY: cessation date of the rainy season in julian day.`

`SeasDur: durtion 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(climateData)

# 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 = "2019-09-01"  # earliest possible start data of the onset window
onsetWind.end = "2020-01-31"   # the late possible date for end of the onset window

seasCal.dF <- calcSeasCal(watBal, onsetWind.start, onsetWind.end,
                          e_thresh = 0.25, AW_thr = 10, soilWHC = 100)

str(seasCal.dF)
```

`calcWatBal` *Soil Water Balance*

Description

Calculates a daily soil water balance computation for the root zone according to methods described in the FAO Irrigation and drainage paper 56 (Doorenbos et al, 1975; Allen et al, 1998)

Usage

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

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".`
	`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).`
	`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:

cumRAIN: accumulated rainfall since the begning of the calculation in (mm).

DEMAND: aamospheric water demand (total moisture flux to atmospher) in (mm).

RUNOFF: surface runoff in (mm).

ERATIO: actual-to-potential evapotranspiration ratio.

AVAIL: available soil moisture storage in (mm).

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

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

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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