Package 'CropWaterBalance'

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Title Climate Water Balance for Irrigation Purposes

Version 0.2.0

Description Calculates daily climate water balance for irrigation purposes and also calculates the reference evapotranspiration (ET) using three methods, Penman and Monteith (Allen et al. 1998, ISBN:92-5-104219-5); Priestley and Taylor (1972) <doi:10/cr3qwn>; or Hargreaves and Samani (1985) <doi:10.13031/2013.26773>. Users may specify a management allowed depletion (MAD), which is used to suggest when to irrigate. The functionality allows for the use of crop and water stress coefficients as well.

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Encoding UTF-8

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Imports PowerSDI, lubridate, stats

URL https://github.com/gabrielblain/CropWaterBalance

BugReports https://github.com/gabrielblain/CropWaterBalance/issues

VignetteBuilder knitr

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`Compare` *Compare Data From Two Samples*

Description

Calculates measures of accuracy and agreement.

Usage

```
Compare(Sample1, Sample2)
```

Arguments

`Sample1`	A `vector`, 1-column `matrix` or `data.frame` with evapotranspiration or other variable.
`Sample2`	A `vector`, 1-column `matrix` or `data.frame` with evapotranspiration or other variable.

Value

A `data.frame` with:

- Absolute mean error (AME),
- square root of the mean squared error (RMSE),
- Willmott's indices of agreement:
  - original (dorig),

  - modified (dmod) and
  - refined (dref)

  , and

- Pearson determination coefficient (RQuad).

Examples

```
# See `?DataForCWB` for more on this data set
Tavg <- DataForCWB[, 2]
Tmax <- DataForCWB[, 3]
Tmin <- DataForCWB[, 4]
Rn <- DataForCWB[, 6]
WS <- DataForCWB[, 7]
RH <- DataForCWB[, 8]
G <- DataForCWB[, 9]
Sample1 <-
  ET0_PM(
    Tavg = Tavg,
    Tmax = Tmax,
    Tmin = Tmin,
    Rn = Rn,
    RH = RH,
    WS = WS,
    G = G,
    Alt = 700)
Sample2 <- ET0_PT(Tavg = Tavg, Rn = Rn, G = G)
Compare(Sample1 = Sample1, Sample2 = Sample2)
```

CWB *Crop Water Balance Accounting*

Description

Calculates several parameters of the crop water balance. It also suggests when to irrigate.

Usage

```
CWB(
  Rain,
  ET0,
  AWC,
  Drz,
  Kc = NULL,
  Irrig = NULL,
  MAD = NULL,
  InitialD = 0,
  start.date
)
```

Arguments

Rain	A vector, 1-column matrix or data.frame with daily rainfall totals in millimetres.
ET0	A vector, 1-column matrix or data.frame with daily reference evapotranspiration in millimetres.
AWC	A vector, 1-column matrix or data.frame with the available water capacity of the soil, that is: the amount of water between field capacity and permanent wilting point in millimetre of water per metres of soil, must be greater than or equal to 0.
Drz	A vector, 1-column matrix or data.frame defining the root zone depth in metres.
Kc	A vector, 1-column matrix or data.frame defining the crop coefficient. If NULL its values are assumed to be 1.
Irrig	A vector, 1-column matrix or data.frame with net irrigation amount infiltrated into the soil for the current day in millimetres.
MAD	A vector, 1-column matrix or data.frame defining the management allowed depletion. Varies between 0 and 1.
InitialD	Single number defining in millimetres, the initial soil water deficit. It is used to start the water balance accounting. Default value is 0, which assumes the root zone is at the field capacity.
start.date	Date at which the accounting should start. Formats: "YYYY-MM-DD", "YYYY/MM/DD".

Value

A data.frame of water balance accounting, including the soil water deficit.

Examples

```
Tavg <- DataForCWB[,2]
Tmax <- DataForCWB[,3]
Tmin <- DataForCWB[,4]
Rn <- DataForCWB[,6]
WS <- DataForCWB[,7]
RH <- DataForCWB[,8]
G <- DataForCWB[,9]
ET0 <- ET0_PM(Tavg, Tmax, Tmin, Rn, RH, WS, G, Alt = 700)
Rain <- DataForCWB[,10]
Drz <- DataForCWB[,11]
AWC <- DataForCWB[,12]
MAD <- DataForCWB[,13]
Kc <- DataForCWB[,14]
Irrig <- DataForCWB[,15]
CWB(Rain = Rain, ET0 = ET0, AWC = AWC, Drz = Drz,
    Kc = Kc, Irrig = Irrig, MAD = MAD, start.date = "2023-11-23")
```

CWB_FixedSchedule *Crop Water Balance Accounting With Fixed Time Periods for Irrigation*

Description

Calculates several parameters of the crop water balance. It also suggests how much irrigation to apply.

Usage

```
CWB_FixedSchedule(
  Rain,
  ET0,
  AWC,
  Drz,
  Kc = NULL,
  Irrig = NULL,
  MAD = NULL,
  InitialD = 0,
  Scheduling,
  start.date
)
```

Arguments

Rain	Vector, 1-column matrix or data frame with daily rainfall totals in millimetres.
ET0	Vector, 1-column matrix or data frame with daily reference evapotranspiration in millimetres.
AWC	Vector, 1-column matrix or data frame with the available water capacity of the soil, that is: the amount of water between field capacity and permanent wilting point in millimetres of water per metres of soil.
Drz	Vector, 1-column matrix or data frame defining the root zone depth in metres.
Kc	Vector, 1-column matrix or data frame defining the crop coefficient. If NULL its values are assumed to be 1.
Irrig	Vector, 1-column matrix or data frame with net irrigation amount infiltrated into the soil for the current day in millimetres.
MAD	Vector, 1-column matrix or data frame defining the management allowed depletion. Varies between 0 and 1.
InitialD	Single number defining in millimetre, the initial soil water deficit. It is used to start the water balance accounting. Default value is zero, which assumes the root zone is at the field capacity.
Scheduling	Single integer number defining the number of days between two consecutive irrigations.
start.date	Date at which the accounting should start. Formats: "YYYY-MM-DD", "YYYY/MM/DD".

Value

Water balance accounting, including the soil water deficit.

Examples

```
Tavg <- DataForCWB[, 2]
Tmax <- DataForCWB[, 3]
Tmin <- DataForCWB[, 4]
Rn <- DataForCWB[, 6]
WS <- DataForCWB[, 7]
RH <- DataForCWB[, 8]
G <- DataForCWB[, 9]
ET0 <- ET0_PM(Tavg, Tmax, Tmin, Rn, RH, WS, G, Alt = 700)
Rain <- DataForCWB[, 10]
Drz <- DataForCWB[, 11]
AWC <- DataForCWB[, 12]
MAD <- DataForCWB[, 13]
Kc <- DataForCWB[, 14]
Irrig <- DataForCWB[, 15]
Scheduling <- 5
CWB_FixedSchedule(
  Rain = Rain,
  ET0 = ET0,
  AWC = AWC,
  Drz = Drz,
  Kc = Kc,
  Irrig = Irrig,
  MAD = MAD,
  Scheduling = Scheduling,
  start.date = "2023-11-23"
)
```

DataForAWC *Soil Texture and Plant Available Water Capacity (AWC)*

Description

AWC is the amount of water between field capacity and permanent wilting point. Given in millimetre of water per metre of soil.

Usage

```
DataForAWC
```

Format

A data frame with 4 columns and 12 rows:

Soil.Texture Soil Texture

AWC.Low Available water capacity in millimetre of water per centimetre of soil

AWC.High Available water capacity in millimetre of water per centimetre of soil

AWC.Average Available water capacity in millimetre of water per metre of soil

Source

https://extension.colostate.edu/topic-areas/agriculture/irrigation-scheduling-the-water-balance-app

References

Irrigation Scheduling: The Water Balance Approach Fact Sheet No. 4.707 by A. A. Andales, J. L. Chávez, T. A. Bauder.

`DataForCWB` *Data for Water Balance Accounting*

Description

Daily meteorological data from a weather station in Campinas, Brazil and other parameters required for calculating the crop water balance. The meteorological data belongs to the Agronomic Institute (IAC).

Usage

```
DataForCWB
```

Format

An object of class `data.frame` with 129 rows and 15 columns.

Details

@format ## `DataForCWB` A data frame with 15 columns and 129 rows:

date date

tmed Average air temperature in Celsius degrees

tmax Maximum air temperature in Celsius degrees

tmin Minimum air temperature in Celsius degrees

Ra Extraterrestrial solar radiation in MJ M-2 DAY-1

Rn Net radiation in MJ M-2 DAY-1

W Wind speed in M S-1

RH Relative Humidity in %

G Soil Heat Flux in MJ M-2 DAY-1

Rain Rain in millimetres

Drz Depth of the root zone in metres

AWC available water capacity (amount of water between field capacity and permanent wilting point) in millimetre of water per metre of soil

MAD management allowed depletion (between 0 and 1)

Kc Crop coefficient (between 0 and 1)

Irrig Applied net irrigation in millimetres

@source http://www.ciiagro.org.br/

`DataForSWC` *Typical Soil Water Characteristics for Different Soil Types (Teta)*

Description

Soil water content at field capacity and at permanent wilting point. Given in m-3 m-3. Extracted from: Allen, R.G.; Pereira, L.S.; Raes, D.; Smith, M. Crop evapotranspiration. In Guidelines for Computing Crop Water Requirements. Irrigation and Drainage Paper 56; FAO: Rome, Italy, 1998; p. 300.

Usage

```
DataForSWC
```

Format

An object of class `data.frame` with 9 rows and 5 columns.

Details

@format ## `DataForSWC` A data frame with 5 columns and 9 rows:

Soil type Soil Type

Teta_FC_Min Minimum values for soil water content at field capacity

Teta_FC_Max Maximum values for soil water content at field capacity

Teta_PWP_Min Minimum values for soil water content at permanent wilting point

Teta_PWP_Max Maximum values for soil water content at permanent wilting point

@source https://www.fao.org/home/en/

Descriptive *Descriptive Statistics for Weather Variables*

Description

Calculates descriptive statistics for rainfall, evapotranspiration, or other variables.

Usage

```
Descriptive(Sample)
```

Arguments

Sample	A vector, 1-column matrix or data frame with rainfall, evapotranspiration, or other variable.

Value

A dataframe with:

- sample mean (Avg),
- sample median (Med),
- sample standard variation (SD)
- sample standard Error (SE)
- maximum value (MaxValue)
- minimum value (MinValue)
- frequency of zeros (FreqZero%)

Examples

```
Rain <- DataForCWB[, 10]
Descriptive(Sample = Rain)
```

Dinitial *Soil Water Deficit in the Root Zone*

Description

Estimates initial values for soil water deficit. Required to initiate the water balance accounting.

Usage

```
Dinitial(teta_FC, teta_Obs, Drz)
```

Arguments

teta_FC	Soil water content for the effective root zone at the field capacity $m3/m3$
teta_Obs	Soil water content for the effective root zone at the wilting point $m3/m3$
Drz	Vector, 1-column matrix or data frame defining the root zone depth in metres.

Value

Initial soil water deficit in the root zone (millimetres).

Examples

```
teta_FC <- 0.30
teta_Obs <- 0.17
Drz <- 0.3048
Dinitial(teta_FC = teta_FC, teta_Obs = teta_Obs, Drz = Drz)
```

ET0_HS *Reference Evapotranspiration Using Hargreaves-Samani Method*

Description

Calculates daily reference evapotranspiration amounts using the Hargreaves-Samani method.

Usage

```
ET0_HS(Ra, Tavg, Tmax, Tmin)
```

Arguments

Ra	A vector, 1-column matrix or data.frame with extraterrestrial solar radiation in MJ M-2 DAY-1.
Tavg	A vector, 1-column matrix or data.frame column with daily average air temperature.
Tmax	A vector, 1-column matrix or data.frame with daily maximum air temperature in Celsius degrees.
Tmin	A vector, 1-column matrix or data.frame with daily minimum air temperature in Celsius degrees.

Value

A matrix of 1-column with the same length as 'the input values with the daily potential evapotranspiration values in millimetres.

See Also

ET0_PM() ET0_PT()

Examples

```
# See `?DataForCWB` for more on this data set
Tavg <- DataForCWB[, 2]
Tmax <- DataForCWB[, 3]
Tmin <- DataForCWB[, 4]
Ra <- DataForCWB[, 5]
ET0_HS(Ra = Ra, Tavg = Tavg, Tmax = Tmax, Tmin = Tmin)
```

ET0_PM *Reference Evapotranspiration Using the Penman and Monteith Method*

Description

Calculates daily reference evapotranspiration amounts using the Penman and Monteith method.

Usage

```
ET0_PM(Tavg, Tmax, Tmin, Rn, RH, WS, G = NULL, Alt)
```

Arguments

Tavg	A vector, 1-column matrix or data frame with daily average air temperature.
Tmax	A vector, 1-column matrix or data frame with daily maximum air temperature in Celsius degrees.
Tmin	A vector, 1-column matrix or data frame with daily minimum air temperature in Celsius degrees.
Rn	A vector, 1-column matrix or data frame with daily net radiation in $MJm - 2day - 1$.
RH	A vector, 1-column matrix or data frame with daily relative Humidity in \%.
WS	A vector, 1-column matrix or data frame with daily wind speed in $ms - 1$.
G	Optional. A vector, 1-column matrix or data frame with daily soil heat flux in $MJm - 2day - 1$. Default is NULL and if NULL it is assumed to be zero. May be provided by Soil_Heat_Flux
Alt	A single number defining the altitude at crop's location in metres.

Value

A matrix of daily reference evapotranspiration amounts in millimetres.

Examples

```
# See `?DataForCWB` for more on this data set
Tavg <- DataForCWB[, 2]
Tmax <- DataForCWB[, 3]
Tmin <- DataForCWB[, 4]
Rn <- DataForCWB[, 6]
WS <- DataForCWB[, 7]
RH <- DataForCWB[, 8]
G <- DataForCWB[, 9]
ET0_PM(Tavg = Tavg,
       Tmax = Tmax,
       Tmin = Tmin,
       Rn = Rn,
       RH = RH,
       WS = WS,
       G = G,
       Alt = 700)
```

ET0_PT *Reference Evapotranspiration Using the Preistley-Taylor Method*

Description

Calculates daily reference evapotranspiration amounts using the Priestley-Taylor method.

Usage

```
ET0_PT(Tavg, Rn, G = NULL, Coeff = 1.26)
```

Arguments

Tavg	A vector, 1-column matrix or data frame with daily average air temperature.
Rn	A vector, 1-column matrix or data frame with daily net radiation in $MJm-2day-1$.
G	Optional. A vector, 1-column matrix or data frame with daily soil heat flux in $MJm-2day-1$. May be provided by Soil_Heat_Flux
Coeff	Single number defining the Priestley and Taylor coefficient. Default is 1.26.

Value

A matrix object of the daily potential evapotranspiration values in millimetres.

Examples

```
# See `?DataForCWB` for more on this data set
Tavg <- DataForCWB[, 2]
Rn <- DataForCWB[, 6]
G <- DataForCWB[, 9]
ET0_PT(Tavg = Tavg, Rn = Rn, G = G)
```

Soil_Heat_Flux *Soil Heat Flux*

Description

Calculates the daily amounts of soil heat flux.

Usage

```
Soil_Heat_Flux(Tavg)
```

Arguments

Tavg	A vector, 1-column matrix or data frame with daily average air temperature.

Value

Daily amounts of soil heat flux in $MJm - 2day - 1$.

Examples

```
# See `?DataForCWB` for more on this data set
Tavg <- DataForCWB[, 2]
Soil_Heat_Flux(Tavg)
```

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