Package ‘CropWaterBalance’

April 18, 2024

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.

License  MIT + file LICENSE

Encoding  UTF-8

RoxygenNote  7.3.1

Depends  R (>= 3.10)

LazyData  true

Suggests  knitr, rmarkdown, spelling, testthat (>= 3.0.0)

Config/testthat/edition  3

Config/testthat/parallel  true

Imports  PowerSDI, lubridate, stats

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

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

VignetteBuilder  knitr

Language  en-US

NeedsCompilation  no

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**Description**

Calculates measures of accuracy and agreement.

**Usage**

```r
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),
CWB

- 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, WS, RH, 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")
```
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

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain</td>
<td>Vector, 1-column matrix or data frame with daily rainfall totals in millimetres.</td>
</tr>
<tr>
<td>ET0</td>
<td>Vector, 1-column matrix or data frame with daily reference evapotranspiration in millimetres.</td>
</tr>
<tr>
<td>AWC</td>
<td>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.</td>
</tr>
<tr>
<td>Drz</td>
<td>Vector, 1-column matrix or data frame defining the root zone depth in metres.</td>
</tr>
<tr>
<td>Kc</td>
<td>Vector, 1-column matrix or data frame defining the crop coefficient. If NULL its values are assumed to be 1.</td>
</tr>
<tr>
<td>Irrig</td>
<td>Vector, 1-column matrix or data frame with net irrigation amount infiltrated into the soil for the current day in millimetres.</td>
</tr>
<tr>
<td>MAD</td>
<td>Vector, 1-column matrix or data frame defining the management allowed depletion. Varies between 0 and 1.</td>
</tr>
<tr>
<td>InitialD</td>
<td>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.</td>
</tr>
<tr>
<td>Scheduling</td>
<td>Single integer number defining the number of days between two consecutive irrigations.</td>
</tr>
<tr>
<td>start.date</td>
<td>Date at which the accounting should start. Formats: “YYYY-MM-DD”, “YYYY/MM/DD”.</td>
</tr>
</tbody>
</table>
Value

Water balance accounting, including the soil water deficit.

Examples

```r
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, 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-approach-4-707/](https://extension.colostate.edu/topic-areas/agriculture/irrigation-scheduling-the-water-balance-approach-4-707/)

References

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

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**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\(^{-1}\)
DataForSWC

**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/](http://www.ciiagro.org.br/)

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

**Description**


**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/](https://www.fao.org/home/en/)
Descriptive

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

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()`
ET0_PM

Examples

```r
# 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

```r
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 \( \text{MJ m}^{-2} \text{day}^{-1} \).
- **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 \( \text{ms}^{-1} \).
- **G**: Optional. A vector, 1-column matrix or data frame with daily soil heat flux in \( \text{MJ m}^{-2} \text{day}^{-1} \). 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.
ET0_PT  

Reference Evapotranspiration Using the Priestley-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 $MJm^{-2}day^{-1}$.

G  
Optional. A vector, 1-column matrix or data frame with daily soil heat flux in $MJm^{-2}day^{-1}$. 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.
Soil Heat Flux

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

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 $MJm^{-2}day^{-1}$.

Examples

# See '\DataForCWB\' for more on this data set
Tavg <- DataForCWB[, 2]
Soil Heat Flux(Tavg)
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