Package 'FAO56'

January 20, 2025

Version 1.0

Date 2023-11-14

Title Evapotranspiration Based on FAO Penman-Monteith Equation

Author
Ali Ahani [aut, cre] <a_ahani@sbu.ac.ir> (<https://orcid.org/0000-0002-1441-0444>), S. Saeid Mousavi Nadoushani [aut] <sa_mousavi@sbu.ac.ir> (<https://orcid.org/0000-0001-6679-5553>)

Maintainer Ali Ahani <ali.ahani66@gmail.com>

Depends R (>= 3.5.0)

Suggests testthat (>= 3.0.0)

Description Calculation of Evapotranspiration by FAO Penman-Monteith equation based on Allen, R. G., Pereira, L. S., Raes, D., Smith, M. (1998, ISBN:92-5-104219-5) ``Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56".

License GPL (>= 2)

LazyData yes

Encoding UTF-8

RoxygenNote 7.2.3

Config/testthat/edition 3

NeedsCompilation no

Repository CRAN

Date/Publication 2023-11-14 19:30:02 UTC

Contents

FAO56-package *A package for computing the crop evapotranspiration and evapotranspiration rate from the reference surface by FAO Penman-Monteith equation*

Description

FAO56 provides the equations used to calulate the crop evapotranspiration and evapotranspiration rate from the reference surface by FAO Penman-Monteith equation based on *FAO paper No, 56: Crop evapotranspiration - Guidelines for computing crop water requirements*

AtmPres *Atmospheric Pressure (P)*

Description

`AtmPres` returns the value of atmospheric pressure.

Usage

```
AtmPres(z)
```

Arguments

`z`	A numeric scalar that denotes elevation above sea level [m].

Details

This is a function to calculate the atmospheric pressure [kPa] based on the elevation above the sea level.

Value

The function returns the value of the atmospheric pressure as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

`PsyCon`.

Examples

```
AtmPres(z = 1800)
```

CSSRad *Clear-Sky Solar Radiation (R_so)*

Description

CSSRad returns the value of clear-sky solar radiation.

Usage

```
CSSRad(a_s = 0.25, b_s = 0.5, elev = NULL, R_a)
```

Arguments

a_s	Optional. A numeric scalar that denotes regression constant, expressing the fraction ofextraterrestrial radiation reaching the earth on overcast days (n = 0). The default is a_s = 0.25.
b_s	Optional. A numeric scalar that denotes fraction of extraterrestrial radiation reaching the earth on clear days ($n = N$). The default is b_s = 0.5
elev	Optional. A numeric scalar that denotes the elevation above the sea level [m].
R_a	A numeric scalar that denotes extraterrestrial radiation [$MJ/(m^2 \times day)$]

Details

This is a function to calculate the clear-sky solar radiation. The argument elev is needed when the calibrated values of a_s and b_s are not available.

Value

The function returns the value of clear-sky solar radiation as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

ExRad.

Examples

```
CSSRad(a_s = 0.27, b_s = 0.48, R_a = 25.1)
CSSRad(elev = 100, R_a = 25.1)
```

DD2Rad *Degree to Radian Converter*

Description

DD2Rad converts the value of an angel in the unit degree to the unit radian.

Usage

```
DD2Rad(phi_deg)
```

Arguments

phi_deg	Optional. A numeric scalar that denotes the latitude in terms of degree [degree].

Details

This is a function to convert the degree unit to radian.

Value

The function convert the value of an angel in the unit degree to the unit radian as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

SunHA.

Examples

```
DD2Rad(phi_deg = 60.73)
```

DH *Daylight Hours (N)*

Description

DH returns the value of daylight hours.

Usage

```
DH(omega_s)
```

Arguments

omega_s	A numeric scalar that denotes the sunset hour angle [rad].

Details

This is a function to calculate the daylight hours.

Value

The function returns the value of daylight hours as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

SunHA.

Examples

```
DH(omega_s = 1.527)
```

`EarSunDis` *Inverse Earth-Sun Distance (d_r)*

Description

`EarSunDis` returns the inverse earth-sun distance.

Usage

```
EarSunDis(date)
```

Arguments

`date`	Optional. A character string that denotes the date in the format "Year-Month-Day" or "Year/Month/Day".

Details

This is a function to calculate the inverse earth-sun distance.

Value

The function returns the value of inverse relative earth-sun distance as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

`JulDate`.

Examples

```
EarSunDis("2020/08/25")
```

EffPrec *Effective Monthly Precipitation (P_eff)*

Description

EffPrec returns the value of effective precipitation.

Usage

```
EffPrec(P_tot)
```

Arguments

P_tot	A numeric scalar that denotes the total monthly precipitation [mm].

Details

This is a function to calculate the effective precipitation [mm]. The function formula has been developed for Iran where the mean annual precipitation is about 250 mm. It may be used for similar semi-arid areas, but it is not recommended for the areas with different climate.

Value

The function returns the value of effective monthly precipitation [mm].

Examples

```
EffPrec(P_tot = 450)
```

ETo_FPM *FAO Penman-Monteith Reference Evapotranspiration (ETo) Equation*

Description

ETo_FPM returns the value of evapotranspiration rate from the reference surface.

Usage

```
ETo_FPM(
  Delta = SlpSVPC(T_mean),
  T_mean = (T_min + T_max)/2,
  R_n = NULL,
  G = 0,
  gamma = PsyCon(AtmPres(elev)),
  u_2 = NULL,
```

```
  u_z = NULL,
  z = NULL,
  e_s = MSVP(T_max, T_min),
  T_dew = NULL,
  e_a = NULL,
  T_min = NULL,
  T_max = NULL,
  phi_deg = NULL,
  elev = NULL,
  date = NULL,
  n = NULL,
  N = NULL,
  a_s = 0.25,
  b_s = 0.5
)
```

Arguments

Delta	Optional. A numeric scalar that denotes the slope vapour pressure curve [kPa/C].
T_mean	Optional. A numeric scalar that denotes the average temperature [C].
R_n	Optional. A numeric scalar that denotes the net radiation at the crop surface $[MJ/(m^2 \times day)]$.
G	Optional. A numeric scalar that denotes the soil heat flux density $[MJ/(m^2 \times day)]$. The default is G=0.
gamma	Optional. A numeric scalar that denotes the psychrometric constant [kPa/C].
u_2	A numeric scalar that denotes the wind speed at the height 2m above the ground surface [m/s].
u_z	A numeric scalar that denotes the wind speed at the height z above the ground surface [m/s].
z	A numeric scalar that denotes the height above the ground surface where the wind speed has been measured [m].
e_s	Optional. A numeric scalar that denotes the saturation vapour pressure [kPa].
T_dew	Optional. A numeric scalar that denotes the dew point temperature [C].
e_a	Optional. A numeric scalar that denotes the actual vapour pressure [kPa].
T_min	Optional. A numeric scalar that denotes the daily minimum temperature [C].
T_max	Optional. A numeric scalar that denotes the daily maximum temperature [C].
phi_deg	Optional. A numeric scalar that denotes the latitude in terms of degree [degree].
elev	Optional. A numeric scalar that denotes the elevation above the sea level [m].
date	Optional. A character string that denotes the date in the format "Year-Month-Day" or "Year/Month/Day".
n	Optional. A numeric scalar that denotes actual duration of sunshine [hour]
N	Optional. A numeric scalar that denotes maximum possible duration of sunshine or daylight hours [hour]

a_s — Optional. A numeric scalar that denotes regression constant, expressing the fraction ofextraterrestrial radiation reaching the earth on overcast days (n = 0). The default is a_s = 0.25.

b_s — Optional. A numeric scalar that denotes fraction of extraterrestrial radiation reaching the earth on clear days ($n = N$). The default is b_s = 0.5

Details

This is a function to calculate the evapotranspiration rate from the reference surface (ETo) by using FAO Penman-Monteith equation which is one of the most-widely used equations for this purpose. If Delta is missing, the function uses the argumnet T_mean to compute its value. If T_mean is missing, the function needs T_min and T_max to compute T_mean. If R_n is missing, the arguments phi_deg, date, n, N, elev, T_min, T_max, and e_a must be present. If gamma is missing, the function needs elev to compute gamma. If e_s is missing, the arguments T_min and T_max must be present for computation of e_s. If e_a is missing, one of the arguments T_dew or T_min must be present in order to compute e_a. If T_dew is missing and T_min is present, then T_dew is computed based on the T_min value. If u_2 is missing, the function needs the values of the arguments u_z and z to compute u_2.

Value

The function returns the value of evapotranspiration rate from the reference surface as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

ETo_Hrg for Hargreaves Equation.

Examples

```
ETo_FPM(u_2 = 2, e_a = 2.85, T_min = 25.6, T_max = 34.8, phi_deg = 13.73,
             elev = 2, date = '2002-04-15', n = 8.5, N = 12.31)
```

ETo_Hrg — *Hargreaves Reference Evapotranspiration (ETo) Equation*

Description

ETo_Hrg returns the value of the evapotranspiration rate from the reference surface.

Usage

```
ETo_Hrg(T_min, T_max, R_a)
```

Arguments

T_min	Optional. A numeric scalar that denotes the daily minimum temperature [C].
T_max	Optional. A numeric scalar that denotes the daily maximum temperature [C].
R_a	A numeric scalar denotes the extraterrestrial radiation $[MJ/(m^2 \times day)]$.

Details

This is a function to calculate the evapotranspiration rate from the reference surface (ETo) by using Hargreaves equation.

Value

The function returns the value of evapotranspiration rate from the reference surface calculated by Hargreaves equation [mm/day] as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

ETo_FPM for FAO Penman-Monteith Equation.

Examples

```
ETo_Hrg(T_min = 19, T_max = 25, R_a = 32)
```

ETo_Pan *Evapotranspiration based on Pan Evaporation Method*

Description

ETo_Pan returns the value of reference evapotranspiration based on the pan evaporation method.

Usage

```
ETo_Pan(K_p, E_pan)
```

Arguments

K_p	A numeric scalar that denotes the pan coefficient.
E_pan	A numeric scalar that denotes the pan evaporation [mm/day].

Details

This is a function to calculate the reference evapotranspiration [mm/day] based on the pan evaporation method.

Value

The function returns the value of the reference evapotranspiration as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

ETo_FPM, ETo_Hrg.

Examples

```
ETo_Pan(K_p = 0.6, E_pan = 5)
```

ET_c *Crop Evapotranspiration (ET_c)*

Description

ET_c returns the value of crop evapotranspiration.

Usage

```
ET_c(Kc, ETo)
```

Arguments

Kc	A numeric scalar that denotes the crop coefficient (Kc).
ETo	A numeric scalar that denotes the evapotranspiration rate from the reference surface [mm].

Details

This is a function to calculate the crop evapotranspiration.

Value

The function returns the value of crop evapotranspiration as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

ETo_FPM, ETo_Hrg, ETo_Pan.

Examples

```
# First example
ET_c(Kc = 0.6, ETo = 0.9)
# Second example
# Computing ET_c of the crop millet planted in Sahiwal, Pakistan
# for a specific day in the initial growth stage
## Loading the relevant Kc dataset
data(Kc_Cereals)
## Latitude in decimal degree
latdeg = 31.685
## Date (2020 June 7)
pdate = "2020-06-07"
## Maximum and minimum temperatures in celsius
temp_max = 38
temp_min = 28
## Actual duration of sunshine and maximum possible duration of sunshine or daylight in hours
actsunshine = 13
maxdaylight = 14
## Elevation above sea level in meter
h = 170
## Wind speed in the height 2m above the ground surface in m/s
ws = 2
##  Evapotranspiration rate from the reference surface (ETo) in mm/day
ET_ref = ETo_FPM(u_2 = ws, e_a = 2.85, T_min = temp_min, T_max = temp_max,
                 phi_deg = latdeg, elev = h, date = pdate, n = actsunshine, N = maxdaylight)
## Crop ET
CrET = ET_c(Kc = Kc_Cereals$Kc_ini[12], ETo = ET_ref)
```

ExRad *Extraterrestrial Radiation for Daily Periods (R_a)*

Description

ExRad returns the value of extraterrestrial radiation $[MJ/(m^2 \times day)]$.

Usage

```
ExRad(d_r, omega_s, phi, delta, G_sc = 0.082)
```

Arguments

d_r	A numeric scalar that denotes the inverse relative earth-sun distance.
omega_s	A numeric scalar that denotes the sunset hour angle [rad].
phi	A numeric scalar that denotes the latitude [rad].
delta	A numeric scalar that denotes the solar declination [rad].
G_sc	A numeric scalar that denotes the solar constant = 0.0820 $[MJ/(m^2 \times min)]$.

Details

This is a function to calculate the extraterrestrial radiation.

Value

The function returns the value of extraterrestrial radiation as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56.* Fao, Rome, 300(9), D05109.

See Also

EarSunDis, SunHA, SolDec, SolRad, CSSRad.

Examples

```
ExRad(d_r = 0.985, omega_s = 1.527, phi = -0.35, delta = 0.12)
```

JulDate *Julian Date*

Description

JulDate returns Julian Date.

Usage

```
JulDate(date)
```

Arguments

date	Optional. A character string that denotes the date in the format "Year-Month-Day" or "Year/Month/Day".

Details

This is a function to calculate Julian Date.

Value

The function returns Julian Date as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

DH, EarSunDis, SolDec.

Examples

```
JulDate(date = "2020-06-25")
JulDate(date = "2020/06/25")
```

Kc_Cereals *Crop Coefficients (Kc) of Cereals*

Description

A dataset containing the crop coefficients (Kc) of the cereals extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument Kc of the function ET_c.

Format

A data frame with 17 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Fibre_Crops *Crop Coefficients (Kc) of Fibre Crops*

Description

A dataset containing the crop coefficients (Kc) of the fibre crops extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 3 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Forages *Crop Coefficients (Kc) of Forages*

Description

A dataset containing the crop coefficients (Kc) of the forages extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 15 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Fruit_Trees *Crop Coefficients (Kc) of Fruit Trees*

Description

A dataset containing the crop coefficients (Kc) of the fruit trees extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 21 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Grapes_and_Berries *Crop Coefficients (Kc) of Grapes and Berries*

Description

A dataset containing the crop coefficients (Kc) of the grapes and berries extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 4 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Legumes *Crop Coefficients (Kc) of Legumes*

Description

A dataset containing the crop coefficients (Kc) of the legumes extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 13 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Oil_Crops *Crop Coefficients (Kc) of Oil Crops*

Description

A dataset containing the crop coefficients (Kc) of the oil crops extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 8 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

KC_Perennial_Vegetables *Crop Coefficients (Kc) of Perennial Vegetables*

Description

A dataset containing the crop coefficients (Kc) of the perennial vegetables extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 4 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Roots_and_Tubers *Crop Coefficients (Kc) of Roots and Tubers*

Description

A dataset containing the crop coefficients (Kc) of the roots and tubers extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 8 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Small_Vegetables *Crop Coefficients (Kc) of Small Vegetables*

Description

A dataset containing the crop coefficients (Kc) of the small vegetables extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 13 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Special *Crop Coefficients (Kc) of Special Areas*

Description

A dataset containing the crop coefficients (Kc) of the special areas extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 2 rows and 3 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Sugar_Cane *Crop Coefficients (Kc) of Sugar Cane*

Description

A dataset containing the crop coefficients (Kc) of the sugar cane extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 1 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Tropical_Fruits_and_Trees *Crop Coefficients (Kc) of Tropical Fruits and Trees*

Description

A dataset containing the crop coefficients (Kc) of the tropical fruits and trees extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 12 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

`Kc_Vegetables_Cucumber_Family` *Crop Coefficients (Kc) of Cucumber Family Vegetables*

Description

A dataset containing the crop coefficients (Kc) of the cucumber family vegetables extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 7 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

`Kc_Vegetables_Solanum_Family` *Crop Coefficients (Kc) of Solanum Family Vegetables*

Description

A dataset containing the crop coefficients (Kc) of the solanum family vegetables extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 4 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

Kc_Wetlands_Temperate_Climate *Crop Coefficients (Kc) of Wetlands Temperate Climate*

Description

A dataset containing the crop coefficients (Kc) of the wetlands temperate climate extracted from Table 12 in "Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56". It is a source to assign a suitable value to the argument `Kc` of the function `ET_c`.

Format

A data frame with 5 rows and 4 variables:

Crop name of the crop

Kc_ini the crop coefficient in the growth initial stage

Kc_mid the crop coefficient in the growth mid-season stage

Kc_end the crop coefficient in the growth late-season stage

Source

https://www.fao.org/3/x0490E/x0490e00.htm

MeanRH *Mean Relative Humidity (RH_mean)*

Description

`MeanRH` returns the value of mean relative humidity.

Usage

```
MeanRH(T_min, T_max)
```

Arguments

`T_min`	Optional. A numeric scalar that denotes the daily minimum temperature [C].
`T_max`	Optional. A numeric scalar that denotes the daily maximum temperature [C].

Details

This is a function to calculate the mean relative humidity.

Value

The function returns the value of the mean relative humidity as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

SatVP.

Examples

```
MeanRH(T_min = 19, T_max = 26)
```

MeanTemp *Mean Daily Air Temperature (T_mean)*

Description

MeanTemp returns the value of mean daily air temperature [C].

Usage

```
MeanTemp(T_min, T_max)
```

Arguments

T_min	Optional. A numeric scalar that denotes the daily minimum temperature [C].
T_max	Optional. A numeric scalar that denotes the daily maximum temperature [C].

Details

This is a function to calculate the mean daily air temperature [C].

Value

The function returns the value of the mean daily air temperature [C] as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

AtmPres.

Examples

```
MeanTemp(T_min = 5, T_max = 35)
```

MSVP *Mean Saturation Vapour Pressure (e_s)*

Description

MSVP returns the value of mean saturation vapour pressure.

Usage

```
MSVP(T_max, T_min)
```

Arguments

T_max	Optional. A numeric scalar that denotes the daily maximum temperature [C].
T_min	Optional. A numeric scalar that denotes the daily minimum temperature [C].

Details

This is a function to calculate the mean saturation vapour pressure [kPa].

Value

The function returns the value of the mean saturation vapour pressure [kPa] as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56.* Fao, Rome, 300(9), D05109.

See Also

SatVP.

Examples

```
MSVP(T_max = 35, T_min = 1)
```

NLRad *Net Longwave Radiation (R_nl)*

Description

NLRad returns the value of net longwave radiation.

Usage

```
NLRad(T_max, T_min, e_a, R_s, R_so)
```

Arguments

T_max	Optional. A numeric scalar that denotes the daily maximum temperature [C].
T_min	Optional. A numeric scalar that denotes the daily minimum temperature [C].
e_a	Optional. A numeric scalar that denotes the actual vapour pressure [kPa].
R_s	A numeric scalar that denotes the incoming solar radiation [$MJ/(m^2 \times day)$].
R_so	A numeric scalar that denotes clear-sky radiation [$MJ/(m^2 \times day)$].

Details

This is a function to calculate the net longwave radiation [$MJ/(m^2 \times day)$].

Value

The function returns the value of net solar or net shortwave radiation as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56.* Fao, Rome, 300(9), D05109.

See Also

CSSRad, NLRad, NRad.

Examples

```
NLRad(T_max = 25.1, T_min = 19.1, e_a = 2.1, R_s = 14.5, R_so = 18.8)
```

NRad *Net Radiation (R_n)*

Description

NRad returns the value of net radiation.

Usage

```
NRad(R_ns, R_nl)
```

Arguments

R_ns	A numeric scalar that denotes net shortwave radiation [$MJ/(m^2 \times day)$].
R_nl	A numeric scalar that denotes net longwave radiation [$MJ/(m^2 \times day)$].

Details

This is a function to calculate the net radiation [$MJ/(m^2 \times day)$].

Value

The function returns the value of net solar radiation as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

NLRad, NSRad.

Examples

```
NRad(R_ns = 11.1, R_nl = 3.5)
```

NSRad *Net Shortwave Radiation (R_ns)*

Description

NSRad returns the value of net shortwave radiation.

Usage

```
NSRad(R_s)
```

Arguments

R_s	A numeric scalar that denotes the incoming solar radiation $[MJ/(m^2 \times day)]$.

Details

This is a function to calculate the net shortwave radiation.

Value

The function returns the value of net shortwave radiation as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

SolRad, NLRad, NRad.

Examples

```
NSRad(R_s = 14.5)
```

PanCoef *Pan Coefficient (K_p)*

Description

PanCoef returns the value of Pan Coefficient (K_p).

Usage

```
PanCoef(u_2, RH_mean, FET, type, fetch)
```

Arguments

u_2	A numeric scalar that denotes the wind speed at the height 2m above the ground surface [m/s].
RH_mean	A numeric scalar that denotes the mean relative humidity. ($30\% <= RH_mean <= 84\%$)
FET	A numeric scalar that denotes the fetch, or distance of the identified surface type [m] ($1m <= FET <= 1000m$) (grass or short green agricultural crop for case A, dry crop or bare soil for case B upwind of the evaporation pan)
type	A character string that denotes the type of pan and can take the options "Class A" for Class A pan and "Colorado" for Colorado sunken pan.
fetch	A character string that denotes the fetch state and can take the options "dry" and "green".

Details

This is a function to calculate the pan coefficient used in the pan evaporation method to calculate the reference evapotranspiration.

Value

The function returns the value of the pan coefficient.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

ETo_Pan, MeanRH.

Examples

```
PanCoef(u_2 = 2, RH_mean = 50, FET = 3, type = "Class A", fetch = "dry")
```

PsyCon *Psychrometric Constant (gamma)*

Description

PsyCon returns the value of psychrometric constant.

Usage

```
PsyCon(P, lambda = 2.45, c_p = 1.013 * 10^(-3), eps = 0.622)
```

Arguments

P	A numeric scalar that denotes the atmospheric pressure [kPa].
lambda	A numeric scalar that denotes the latent heat of vaporization, 2.45 [MJ/kg].
c_p	A numeric scalar that denotes the specific heat at constant pressure, 1.013*10^(-3) [MJ/(kg*C).
eps	A numeric scalar that denotes the ratio molecular weight of water vapour/dry air = 0.622.

Details

This is a function to calculate the psychrometric constant [kPa/C].

Value

The function returns the value of the psychrometric constant [kPa/C] as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

AtmPres.

Examples

```
PsyCon(P = 81.8)
```

RelHum *Relative Humidity (RH)*

Description

RelHum returns the value of relative humidity.

Usage

```
RelHum(e_a, e0T)
```

Arguments

e_a	Optional. A numeric scalar that denotes the actual vapour pressure [kPa].
e0T	A numeric scalar that denotes the saturation vapour pressure at a specific air temperature [kPa].

Details

This is a function to calculate the relative humidity.

Value

The function returns the value of the relative humidity as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

SatVP.

Examples

```
RelHum(e_a = 0.7, e0T = 0.9)
```

SatVP *Saturation Vapour Pressure at a specific Air Temperature (e0T)*

Description

SatVP returns the value of saturation vapour pressure at the air temperature Temp [kPa].

Usage

```
SatVP(Temp)
```

Arguments

Temp	A numeric scalar that denotes the air temperature [C].

Details

This is a function to calculate the saturation vapour pressure at the air temperature Temp [kPa].

Value

The function returns the value of the saturation vapour pressure at the air temperature Temp [kPa] as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

MSVP.

Examples

```
SatVP(Temp = 25)
```

SlpSVPC *Slope of Saturation Vapour Pressure Curve (Delta)*

Description

SlpSVPC returns the value of slope of saturation vapour pressure curve at a specific air temperature.

Usage

```
SlpSVPC(Temp)
```

Arguments

Temp	A numeric scalar that denotes the air temperature [C].

Details

This is a function to calculate the slope of saturation vapour pressure curve at the air temperature Temp [kPa/C].

Value

The function returns the value of the slope of saturation vapour pressure curve at air temperature Temp as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

SatVP.

Examples

```
SlpSVPC(Temp = 25)
```

SolDec *Solar Declination (delta)*

Description

SolDec returns the solar declination.

Usage

```
SolDec(date)
```

Arguments

date	Optional. A character string that denotes the date in the format "Year-Month-Day" or "Year/Month/Day".

Details

This is a function to calculate the value of solar declination.

Value

The function returns the value of solar declination as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

See Also

JulDate, SunHA.

Examples

```
SolDec("2020/08/25")
```

SolRad *Solar Radiation (R_s)*

Description

SolRad returns the value of solar radiation.

Usage

```
SolRad(
  n = NULL,
  N = NULL,
  a_s = 0.25,
  b_s = 0.5,
  R_a,
  T_max = NULL,
  T_min = NULL,
  region = NULL
)
```

Arguments

n	Optional. A numeric scalar that denotes actual duration of sunshine [hour]
N	Optional. A numeric scalar that denotes maximum possible duration of sunshine or daylight hours [hour]
a_s	Optional. A numeric scalar that denotes regression constant, expressing the fraction ofextraterrestrial radiation reaching the earth on overcast days (n = 0). The default is a_s = 0.25.
b_s	Optional. A numeric scalar that denotes fraction of extraterrestrial radiation reaching the earth on clear days ($n = N$). The default is b_s = 0.5
R_a	A numeric scalar that denotes extraterrestrial radiation [$MJ/(m^2 \times day)$]
T_max	Optional. A numeric scalar that denotes the daily maximum temperature [C].
T_min	Optional. A numeric scalar that denotes the daily minimum temperature [C].
region	A character string that introduce the type of region and can be assigned "inter" for interior locations and "coast" for coastal locations for Hargreaves radiation formula (alternative)

Details

This is a function to calculate the solar radiation based on the land type. If one of the arguments n or N is missing, the function needs to use the values of the arguments T_min, T_max, and region. If calibrated values of a_s and b_s are available, they can replace the default values.

Value

The function returns the value of solar radiation based as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56.* Fao, Rome, 300(9), D05109.

See Also

ExRad.

Examples

```
SolRad(n = 7.1, N = 10.9, R_a = 25.1)
SolRad(R_a = 25.1, T_max = 30, T_min = 20, region = "inter")
```

SunHA *Sunset Hour Angel (omega_s)*

Description

SunHA returns the value of sunset hour angel [rad].

Usage

```
SunHA(phi, delta)
```

Arguments

phi	A numeric scalar that denotes the latitude [rad].
delta	A numeric scalar that denotes the solar declination [rad].

Details

This is a function to calculate the sunset hour angel.

Value

The function returns the value of sunset hour angel as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56.* Fao, Rome, 300(9), D05109.

See Also

SolDec.

Examples

```
SunHA(phi = -0.35, delta = 0.12)
```

WndSp2m *Wind Speed at the height 2 m Above Ground Surface*

Description

WndSp returns the value of wind speed at the height 2 m above the ground surface.

Usage

```
WndSp2m(u_z, z, speed = NULL)
```

Arguments

u_z	Optional. A numeric scalar that denotes the measured wind speed at z m above ground surface [m/s].
z	A numeric scalar that denotes the height of measurement above ground surface [m].
speed	Optional. A character string that denotes the wind speed general class and can be assigned "str" for strong winds, "mod2str" for moderate to strong winds, "lig2mod" for light to moderate winds, and "lig" for light winds.

Details

This is a function to calculate the wind speed [m/s]. If u_z is missing, the function estimate the wind speed based on wind general or empirical classes.

Value

The function returns the value of the wind speed [m/s] as a numeric scalar.

Reference

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Fao, Rome, 300(9), D05109.

Examples

```
WndSp2m(u_z = 3.2, z = 10)
WndSp2m(speed = "mod2str")
```

Index