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Title Evapotranspiration Based on FAO Penman-Monteith Equation

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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".

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FAO56-package	<i>A package for computing the crop evapotranspiration and evapotranspiration rate from the reference surface by FAO Penman-Monteith equation</i>
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Description

FAO56 provides the equations used to calculate 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	<i>Atmospheric Pressure (P)</i>
---------	---------------------------------

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	<i>Clear-Sky Solar Radiation (R_so)</i>
--------	---

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 of extraterrestrial 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	<i>Degree to Radian Converter</i>
--------	-----------------------------------

Description

DD2Rad converts the value of an angle 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 converts the value of an angle 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	<i>Daylight Hours (N)</i>
----	---------------------------

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	<i>Inverse Earth-Sun Distance (d_r)</i>
-----------	--

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	<i>Effective Monthly Precipitation (P_{eff})</i>
---------	--

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	<i>FAO Penman-Monteith Reference Evapotranspiration (ETo) Equation</i>
---------	--

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 of extraterrestrial 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 Δ is missing, the function uses the argument 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 ϕ_{deg} , date , n , N , elev , T_{min} , T_{max} , and e_a must be present. If γ is missing, the function needs elev to compute γ . 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	<i>Crop Evapotranspiration (ET_c)</i>
------	---------------------------------------

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)
```

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	<i>Crop Coefficients (Kc) of Fibre Crops</i>
----------------	--

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	<i>Crop Coefficients (Kc) of Forages</i>
------------	--

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	<i>Mean Daily Air Temperature (T_mean)</i>
----------	--

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	<i>Net Radiation (R_n)</i>
------	----------------------------

Description

NRad returns the value of net radiation.

Usage

NRad(R_ns, R_n1)

Arguments

R_ns A numeric scalar that denotes net shortwave radiation [$MJ/(m^2 \times day)$].
R_n1 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_n1 = 3.5)

NSRad	<i>Net Shortwave Radiation (R_ns)</i>
-------	---------------------------------------

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	<i>Pan Coefficient (K_p)</i>
---------	--

Description

PanCoef returns the value of Pan Coefficient (K_p).

Usage

PanCoef(u₂, 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(u2 = 2, RHmean = 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, $1.013 \cdot 10^{-3}$ [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	<i>Solar Declination (delta)</i>
--------	----------------------------------

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	<i>Solar Radiation (R_s)</i>
--------	---

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 of extraterrestrial 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	<i>Sunset Hour Angel (omega_s)</i>
-------	------------------------------------

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")
```

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