

# Package ‘FAO56’

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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

*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 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>
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---

**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 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>
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---

**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 (<math>d_r</math>)</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<sub>eff</sub>)</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 = SatVP(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 wind speed at 2 m height [m/s]. 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 `Delta` 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 `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 `codez` 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<sub>p</sub>)</i>
---------	--

---

**Description**

PanCoef returns the value of Pan Coefficient (K<sub>p</sub>).

**Usage**

PanCoef(u<sub>2</sub>, RH<sub>mean</sub>, FET, type, fetch)

**Arguments**

u <sub>2</sub>	A numeric scalar that denotes the wind speed at the height 2m above the ground surface [m/s].
RH <sub>mean</sub>	A numeric scalar that denotes the mean relative humidity. (30% ≤ <i>RH<sub>mean</sub></i> ≤ 84%)
FET	A numeric scalar that denotes the fetch, or distance of the identified surface type [m] ( $1m \leq FET \leq 1000m$ ) (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	<i>Psychrometric Constant (gamma)</i>
--------	---------------------------------------

---

**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 (<math>R_s</math>)</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

<code>n</code>	Optional. A numeric scalar that denotes actual duration of sunshine [hour]
<code>N</code>	Optional. A numeric scalar that denotes maximum possible duration of sunshine or daylight hours [hour]
<code>a_s</code>	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 $a_s = 0.25$ .
<code>b_s</code>	Optional. A numeric scalar that denotes fraction of extraterrestrial radiation reaching the earth on clear days ( $n = N$ ). The default is $b_s = 0.5$
<code>R_a</code>	A numeric scalar that denotes extraterrestrial radiation [ $MJ/(m^2 \times day)$ ]
<code>T_max</code>	Optional. A numeric scalar that denotes the daily maximum temperature [C].
<code>T_min</code>	Optional. A numeric scalar that denotes the daily minimum temperature [C].
<code>region</code>	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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