Package 'frost'

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Type Package

Title Prediction of Minimum Temperature for Frost Forecasting in Agriculture

Version 0.0.4

Description A compilation of empirical methods used by farmers and agronomic engineers to predict the minimum temperature to detect a frost night. These functions use variables such as environmental temperature, relative humidity, and dew point. See <http://sedici.unlp.edu.ar/handle/10915/72102> <http://www.fao.org/docrep/008/y7223e/y7223e0b. tails.

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Imports methods

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URL https://github.com/anadiedrichs/frost

BugReports https://github.com/anadiedrichs/frost/issues

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R topics documented:

`buildFAO` *Estimate the coefficients for the recommended FAO equation*

Description

Estimate the coefficients for the recommended FAO equation using: ambient temperature and dew point taken two hours after sunset, and minimum daily temperature, which were taken in nights with radiative frost (wind less than 2 m/s^2, no clouds, no fog, no rain).

Usage

```
buildFAO(dw, temp, tmin)
```

Arguments

`dw`	[°C]: an array of dew points, two hours after sunset.
`temp`	[°C]: an array of ambient temperature, two hours after sunset.
`tmin`	[°C]: minimum temperature

Details

The method was extracted from the documentation and previous implementation in FFST.xls file, which is name in the book "Frost Protection: fundamentals, practice, and economics. Volume 1. Authors: Richard L Snyder, J. Paulo de Melo-Abreu. Food and Agriculture Organization of the United Nations. 2005"

This function implements the method, resolve the equation and find the coefficients. Equation: Tmim = a * temp + b * dw + c where "temp" and "dw" are the temperature and dew point respectively, which must be taken two hours after sunset

For more details please check: <http://www.fao.org/docrep/008/y7223e/y7223e0b.htm#bm11.8> <http://www.fao.org/docrep/008/y7223e/y7223e0b.htm> FFST spreasheet <http://biomet.ucdavis.edu/frostprotection/FTrend

Value

A FAOFrostModel object with a, b, and c values, which can be used to estimate minimum temperature (Tmin) using temp and dw. This function also returns Tp (predicted temperature using the equation), Rp (residuals, the difference between tmin given and Tp) and r2 which is the coefficient of correlation (R squared).

Examples

```
x1 <- rnorm(100,mean=2,sd=5)
x2 <- rnorm(100,mean=1,sd=3)
y <- rnorm(100,mean=0,sd=2)
buildFAO(dw = x2,temp=x1,tmin=y)
#data example taken from FAO Book
t0 <- c(3.2,0.8,0.2,2.6,4.4,5.2,2.7,1.2,4.5,5.6) # temperature 2 hours after sunset
td <- c(-4.2,-8.8,-6.5,-6.2,-6.1,2.6,-0.7,-1.7,-1.2,0.1) # dew point 2 hours after sunset
tn <- c(-3.1,-5,-6.3,-5.4,-4,-2.5,-4.8,-5,-4.4,-3.3)
buildFAO(dw = td,temp=t0,tmin=tn)
```

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buildFAOTemp *Estimate the coefficients for the recommended FAO equation*

Description

Estimate the coefficients for the recommended FAO equation using temperature two hours after sunset and minimum temperature.

Usage

```
buildFAOTemp(temp, tmin)
```

Arguments

temp	[°C]: an array of ambient temperature, two hours after sunset.
tmin	[°C]: minimum temperature

Details

The method was extracted from the documentation and previous implementation in FFST.xls file, which is name in the book "Frost Protection: fundamentals, practice, and economics. Volume 1. Authors: Richard L Snyder, J. Paulo de Melo-Abreu. Food and Agriculture Organization of the United Nations. 2005"

This function implements the method, resolve the equation and find the coefficients. Equation: Tmim = a * temp + c where "temp" is the temperature which must be taken two hours after sunset

For more details please check: <http://www.fao.org/docrep/008/y7223e/y7223e0b.htm#bm11.8> <http://www.fao.org/docrep/008/y7223e/y7223e0b.htm> FFST spreasheet <http://biomet.ucdavis.edu/frostprotection/FTrenc

Value

A FAOFrostModel object with a, b, and c values, which can be used to estimate minimum temperature (Tmin) using temp and dw. This function also returns Tp (predicted temperature using the equation), Rp (residuals, the difference between tmin given and Tp) and r2 which is the coefficient of correlation (R squared).

Examples

```
x1 <- rnorm(100,mean=2,sd=5)
x2 <- rnorm(100,mean=1,sd=3)
y <- rnorm(100,mean=0,sd=2)
buildFAO(dw = x2,temp=x1,tmin=y)
#data example taken from FAO Book
t0 <- c(3.2,0.8,0.2,2.6,4.4,5.2,2.7,1.2,4.5,5.6) # temperature 2 hours after sunset
tn <- c(-3.1,-5,-6.3,-5.4,-4,-2.5,-4.8,-5,-4.4,-3.3)
buildFAOTemp(temp=t0,tmin=tn)
```

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buildMdz *Empiric equation for minimum temperature used in Mendoza*

Description

According to Maldonado (see [1]), the empirical equation used in Mendoza to estimate the minimum temperature in the night is:

Tmin = ((Tmax + dew)/2)) - K

, where K is a constant calculated for each place, Tmax: maximum temperature of previous day, dew: dew point in °C, Tmin: is the forecaste minimum temperature. Given an array of the information of dw, tempMax and tmin, this function calculates K constant using linear regression. [1] Ortiz Maldonado, Alberto. Adversidades agrometeorológicas de Mendoza. 1991.

Usage

```
buildMdz(dw, tempMax, tmin)
```

Arguments

dw	[°C] Dew Point in °C
tempMax	[°C] Maximum temperature of the previous day
tmin	[°C] Minimum temperature measure that day.

Value

an object of class MdzFrostModel

Examples

```
# just a random example
dw <- c(-2,-5,2,6,8)
tempMax <- c(10,20,30,25,29)
tmin <- c(-1,-2,3,5,10)
buildMdz(dw,tempMax,tmin)
```

`calcDewPoint` *Dew point estimation given relative humidity and temperature*

Description

This function is a wrapper to access to one of the dew point calculation methods offered in this package. Read more about the method in calcDewPoint.A, calcDewPoint.B,calcDewPoint.C functions.

Usage

```
calcDewPoint(RH, temp, mode = "A")
```

Arguments

`RH`	[in percentage] an integer or double value between 0 and 100.
`temp`	[°C] an integer or double value between -20 and 60 °C.
`mode`	string values "A", "B" or "C". Default "A". * Mode "A" : calls calcDewPoint.A function * Mode "B" : calls calcDewPoint.B function * Mode "C": calls calcDewPoint.C function

Value

dew point value (double)

Examples

```
temp <- 25
rh <- 54
calcDewPoint(rh,temp) # it takes mode = "A" by default
calcDewPoint(rh,temp,mode="B")
```

calcDewPoint.A *Calculates dew point from ambient temperature and relative humidity.*

Description

The following formula is used for dew point estimation: $$ (RH/100)^(1/8) * (110+temp) -110) $$,where RH is relative humidity and temp is ambient temperature. The formula was taken from this wikipedia page: <https://es.wikipedia.org/wiki/Punto_de_roc

Usage

```
calcDewPoint.A(RH, temp)
```

Arguments

RH	[in percentage] relative humidity, an integer or double value between 0 and 100.
temp	[°C] environmental temperature, an integer or double value between -20 and 60 °C

Value

dew point value (double)

Examples

```
library(frost)
temp <- 25
rh <- 54
calcDewPoint(rh,temp,mode="A")
```

calcDewPoint.B *Calculates dew point from ambient temperature and relative humidity.*

Description

Calculation of dew point using the Mark G. Lawrence approach given in the following paper: * "The Relationship between Relative Humidity and the Dewpoint Temperature in Moist Air: A Simple Conversion and Applications", DOI: <https://doi.org/10.1175/BAMS-86-2-225>, URL: <https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-86-2-225>

Usage

```
calcDewPoint.B(RH, temp)
```

Arguments

RH	[in percentage] relative humidity, an integer or double value between 0 and 100.
temp	[°C] environmental temperature, an integer or double value between -20 and 60 °C

Value

dew point value (double)

Examples

```
library(frost)
temp <- 25
rh <- 54
calcDewPoint(rh,temp,mode="B")
```

---

calcDewPoint.C *Calculates dew point from ambient temperature and relative humidity.*

Description

Calculation of dew point using the approach given in the following paper: Alduchov and Eskridge (1996), Improved Magnus' form approximation of saturation vapor pressure. J. Appl. Meteor., 35, 601–609.

Usage

```
calcDewPoint.C(RH, temp)
```

Arguments

RH	[in percentage] relative humidity, an integer or double value between 0 and 100.
temp	[°C] environmental temperature, an integer or double value between -20 and 60 °C

Value

dew point value (double)

Examples

```
library(frost)
temp <- 25
rh <- 54
calcDewPoint(rh,temp,mode="C")
```

convert.temperature *Temperature conversion*

Description

Temperature conversion from/to Fahrenheit (°F), degress Celsius (°C) and Kelvin (K)

Usage

```
convert.temperature(from = "F", to = "C", values)
```

Arguments

from	possible values, "F" for Fahrenheit, "C" degress Celsius and "K" Kelvin.
to	possible values, "F" for Fahrenheit, "C" degress Celsius and "K" Kelvin.
values	can be an vector, array, or a numeric single value.

Value

value (double)

Examples

```
library(frost)
convert.temperature(from="K", to="C",350)
cels <- convert.temperature(from="F",to="C",c(120,80,134,110))
k <- convert.temperature(from="C", to="K",cels)
```

getTrend *Temperature trend during a frost night.*

Description

Predict the trend of the temperature during a frost night. This equation has been taken from UC Davis formula [1] which was also published in the FAO book mentioned in predFAO function.

[1] <http://biomet.ucdavis.edu/frostprotection/fp002.htm>

Usage

```
getTrend(Tmin, t2, n, plot = FALSE)
```

Arguments

Tmin	predicted minimum temperature.
t2	temperature 2 hours after sunset, where t2 > Tmin
n	how many hours between sunset and sunrise, an integer value where n > 2
plot	TRUE if you want to see the trend plot, otherwise FALSE. Default value: FALSE

Value

A data frame with the (x,y) points plotted, where y values are the n-2 values of estimated temperatures

Examples

```
getTrend(Tmin = 22.2,t2 = 33.7,n = 15) # in °F degress
getTrend(Tmin = -5.45,t2 = 0.95,n = 15,plot=TRUE) # in °C degress
```

---

predFAO *Predict the minimum temperature using the recommended FAO equation*

Description

Predict the minimum temperature using the recommended FAO equation, which can be applied to nights with radiative frost (wind less than 2 m/s^2, no clouds, no fog, no rain).

Usage

```
predFAO(model, t, dw = NULL)
```

Arguments

model	: a FAOFrostModel object
t	[°C]: an array of ambient temperature, two hours after sunset.
dw	[°C]: an array of dew points, two hours after sunset, by default is NULL.

Details

The method was extracted from the documentation and previous implementation in FFST.xls file, which is name in the book "Frost Protection: fundamentals, practice, and economics. Volume 1. Authors: Richard L Snyder, J. Paulo de Melo-Abreu. Food and Agriculture Organization of the United Nations. 2005"

This function returns Tmim = a * temp + b * dew + c if dew argument is not null. Otherwise, return Tmin = a * temp + c, if dew is NULL.

For more details please check: <http://www.fao.org/docrep/008/y7223e/y7223e0b.htm#bm11.8> <http://www.fao.org/docrep/008/y7223e/y7223e0b.htm> FFST spreasheet <http://biomet.ucdavis.edu/frostprotection/FTrend

Value

tmin [°C]: minimum temperature

Examples

```
t0 <- c(3.2,0.8,0.2,2.6,4.4,5.2,2.7,1.2,4.5,5.6) # temperature 2 hours after sunset
td <- c(-4.2,-8.8,-6.5,-6.2,-6.1,2.6,-0.7,-1.7,-1.2,0.1) # dew point 2 hours after sunset
tn <- c(-3.1,-5,-6.3,-5.4,-4,-2.5,-4.8,-5,-4.4,-3.3)
out <- buildFAO(dw = td,temp=t0,tmin=tn)
current_temp <- 10
current_dw <- 2
ptmin <- predFAO(out,current_temp,current_dw)
cat("The predicte minimum temperature is ",ptmin," °C")
```

---

predMdz *empiric equation for minimum temperature used in Mendoza*

Description

According to Maldonado (see [1]), the empirical equation used in Mendoza to estimate the minimum temperature in the night is:

Tmin = ((Tmax + dew)/2)) - K

Usage

```
predMdz(dw, tempMax, model)
```

Arguments

dw	Dew Point in °C
tempMax	Maximum temperature of the previous day
model	an object of class MdzFrostModel, returned by buildMdz

Value

predicted minimum temperature

Examples

```
# just an example
dw <- c(-2,-5,2,6,8)
tempMax <- c(10,20,30,25,29)
tmin <- c(-1,-2,3,5,10)
out <- buildMdz(dw,tempMax,tmin)
predMdz(dw = -3, tempMax = 15, out)
```

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