Package 'SPEI'

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Title Calculation of the Standardised Precipitation-Evapotranspiration
Index

Description

A set of functions for computing potential evapotranspiration and several widely used drought in-
dices including the Standardized Precipitation-Evapotranspiration Index (SPEI).

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SPEI-package	*Calculation of the Standardised Precipitation-Evapotranspiration Index*

Description

A set of functions for computing potential evapotranspiration and several widely used drought indices including the Standardized Precipitation-Evapotranspiration Index (SPEI).

Details

Functions spei and spi are the workhorse of the SPEI library. Other functions such as kern, cdfglo or pglo are auxiliary low-level functions and they will not be used directly by the typical user. Functions for computing potential evapotranspiration are provided, too, for helping computing the SPEI. They are: thornthwaite, hargreaves and penman.

Version history:

1.4. Minor fixes to functions penman and pwm. Documentation of the penman function defined by mistake ed as the saturation vapour pressure, while it should read 'actual vapour pressure'. Function zzz.R added to display basic information about the SPEI package at startup. Function SPEINews added to display the NEWS file.

1.3. Minor fixes to spei and penman functions. New option for user-supplied SPEI parameters in the spei function. New dataset cabinda.

1.2. A bug causing several functions to fail when a time series not belonging to matrix class was provided was fixed. Function plot.spei now distinguises between calls to spei and spi and labels the axis accordingly .

1.1. Functions spei and spi now yield an object of class "spei". New functions for summarizing and plotting "spei" objects are provided. An option to establish a reference period for the computation of the indices has been implemented in functions spei and spi.

1.0. First release.

Author(s)

Santiago Beguería and Sergio M. Vicente-Serrano Maintainer: Santiago Beguería

References

S.M. Vicente-Serrano, S. Beguería, J.I. López-Moreno. 2010. A Multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index – SPEI. *Journal of Climate* **23**: 1696, DOI: 10.1175/2009JCLI2909.1.

http://sac.csic.es/spei/

Datasets	*Datasets for illustrating the functions in the SPEI package.*

Description

Data used in the examples of the SPEI package: `wichita` dataset: monthly climate in Wichita (Kansas, lat=37.6475, elevation=402.6 m. a.s.l.) since January 1980; `balance` dataset: monthly climatic water balance (precipitation minus potential evapotranspiration) at eleven locations around the World, since January 1900; `cabinda`: one year of data for computing Penman-Monteith ET0 from Allen et al. (1998).

Usage

```
data(wichita)
data(balance)
data(cabinda)
```

Format

`wichita` dataset:

YEAR monthly precipitation totals, in mm.

MONTH monthly precipitation totals, in mm.

PRCP monthly precipitation totals, in mm.

TMAX monthly mean daily maximum temperature, in ºC.

TMIN monthly mean daily minimum temperature, in ºC.

TMED monthly mean temperature, in ºC.

AWND monthly mean wind speed, in km h-1

ACSH monthly mean sun hours, in h.

ACSH monthly mean cloud cover, in %.

`balance` dataset: monthly climatic water balance (precipitation minus potential evapotranspiration) at Indore (India), Kimberley (South Africa), Albuquerque (US), Valencia (Spain), Wien (Austria), Abashiri (Japan), Tampa (US), Sao Paulo (Brasil), Lahore (India), Punta Arenas (Chile) and Helsinki (Finland), in mm.

`cabinda` dataset: one year of monthly climatic data at Cabinda (Angola, -5.33S 12.11E 20 m), taken from Allen et al. (1998), page 69, figure 18:

mon month of the year

Tmin monthly mean daily minimum temperature, in ºC.

Tmax monthly mean daily maximum temperature, in ºC.

RH monthly mean relative humidity, in %.

U2 monthly mean wind speed, in km h-1

tsun monthly mean sunshine hours, in h.

Rs monthly mean dialy incoming solar radiation, MJ m-2 d-1.

ET0 monthly ET0 from the original publication, in mm.

Author(s)

Data ported to R by S. Beguería.

Source

The wichita data were obtained from the Global Historical Climatology Network (GHCN, `https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/global-historical-clim` Data for the balance dataset were extracted from CRU TS V3.1 and from the 20th Century Reanalysis V2 dataset. Data for the balance dataset were taken from Allen et al. (1998), page 69, figure 18.

References

S.M. Vicente-Serrano, S. Beguería, J.I. López-Moreno. 2010. A Multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index – SPEI. *Journal of Climate* **23**: 1696, DOI: 10.1175/2009JCLI2909.1. R.G. Allen, L.S. Pereira, D. Raes, M. Smith. 1998. *JCrop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. FAO, Rome. ISBN 92-5-104219-5.

Examples

```
data(wichita)
names(wichita)
summary(wichita)

data(balance)
summary(balance)
```

Drought indices	*Calculation of the Standardized Precipitation-Evapotranspiration Index (SPEI) and the Standardized Precipitation Index (SPI).*

Description

Given a time series of the climatic water balance (precipitation minus potential evapotranspiration), gives a time series of the Standardized Precipitation-Evapotranspiration Index (SPEI).

Usage

```
spei(data, scale, kernel = list(type = 'rectangular', shift = 0),
distribution = 'log-Logistic', fit = 'ub-pwm', na.rm = FALSE,
ref.start=NULL, ref.end=NULL, x=FALSE, params=NULL, ...)

spi(data, scale, kernel = list(type = 'rectangular', shift = 0),
distribution = 'Gamma', fit = 'ub-pwm', na.rm = FALSE,
ref.start=NULL, ref.end=NULL, x=FALSE, params=NULL, ...)
```

Arguments

data	a vector, matrix or data frame with time ordered values of precipitation (for the SPI) or of the climatic balance precipitation minus potential evapotranspiration (for the SPEI).
scale	an integer, representing the time scale at which the SPEI / SPI will be computed.
kernel	optional, a list defining the type of kernel used for computing the SPEI / SPI at scales higher than one. Defaults to unshifted rectangular kernel.
distribution	optional, name of the distribution function to be used for computing the SPEI / SPI (one of 'log-Logistic', 'Gamma' and 'PearsonIII'). Defaults to 'log-Logistic' for spei, and to 'Gamma' for spi.
fit	optional, name of the method used for computing the distribution function parameters (one of 'ub-pwm', 'pp-pwm' and 'max-lik'). Defaults to 'ub-pwm'.
na.rm	optional, a logical value indicating whether NA values should be stripped from the computations. Defaults to FALSE, i.e. no NA are allowed in the data.
ref.start	optional, starting point of the reference period used for computing the index. Defaults to NULL, indicating that the first value in data will be used as starting point.
ref.end	optional, ending point of the reference period used for computing the index. Defaults to NULL, indicating that the last value in data will be used as ending point.
x	optional, a logical value indicating wether the data used for fitting the model should be kept. Defaults to FALSE.
params	optional, an array of parameters for computing the spei. This option overrides computation of fitting parameters.
...	other possible parameters.

Details

The spei and spi functions allow computing the SPEI and the SPI indices. These are climatic proxies widely used for drought quantification and monitoring. Both functions are identical (in fact, spi is just a wrapper for spei), but they are kept separated for clarity. Basically, the functions standardize a variable following a log-Logistic (or Gamma, or PearsonIII) distribution function (i.e., they transform it to a standard Gaussian variate with zero mean and standard deviation of one).

Input data: The input variable is a time ordered series of precipitation values for spi, or a series of the climatic water balance (precipitation minus potential evapotranspiration) for spei. When used with the default options, it would yield values of both indices exactly as defined in the references given below.

The SPEI and the SPI were defined for monthly data. Since the PDFs of the data are not homogenous from month to month, the data is split into twelve series (one for each month) and independent PDFs are fit to each series. If data is a vector or a matrix it will be treated as a sequence of monthly values starting in January. If it is a (univariate or multivariate) time series then the function [cycle](#) will be used to determine the position of each observation within the year (month), allowing the data to start in a month other than January.

Time scales: An important advantage of the SPEI and the SPI is that they can be computed at different time scales. This way it is possible to incorporate the influence of the past values of the variable in the computation enabling the index to adapt to the memory of the system under study. The magnitude of this memory is controlled by parameter `scale`. For example, a value of six would imply that data from the current month and of the past five months will be used for computing the SPEI or SPI value for a given month. By default all past data will have the same weight in computing the index, as it was originally proposed in the references below. Other kernels, however, are available through parameter `kernel`. The parameter `kernel` is a list defining the shape of the kernel and a time shift. These parameters are then passed to the function `kern`.

Probability distributions: Following the original definitions `spei` uses a log-Logistic distribution by default, and `spi` uses a Gamma distribution. This behaviour can be modified, however, through parameter `distribution`.

Fitting methods: The default method for parameter fitting is based on unbiased Probability Weighted Moments ('ub-pwm'), but other methods can be used through parameter `fit`. A valid alternative is the plotting-position PWM ('pp-pwm') method. For the log-Logistic distribution, also the maximum likelihood method ('max-lik') is available.

User-provided parameters: An option exists to override parameter fitting and provide user default parameters. This is activated with the parameter `params`. The exact values provided to this parameter depend on the distribution function being used. For log-Logistic and PearsonII it should be a three-dimensional array with dimensions (3,number of series in data,12), containing twelve parameter triads (xi, alpha, kappa) for each data series, one for each month. For Gamma, a three-dimensional array with dimensions (2,number of series in data,12), containing twelve parameter pairs (alpha, beta). It is a good idea to look at the coefficients slot of a previously fit `spei` spei object in order to understand the structure of the parameter array. The parameter `distribution` is still used under this option in order to know what distribution function should be used.

Reference period: The default behaviour of the functions is using all the values provided in `data` for parameter fitting. However, this can be modified with help of parameters `ref.start` and `ref.end`. These parameters allow defining a subset of values that will be used for parameter fitting, i.e. a reference period. The functions, however, will compute the values of the indices for the whole data set. For these options to work it is necessary that `data` will be a time series object. The starting and ending points of the reference period will then be defined as pairs of year and month values, e.g. c(1900,1).

Processing large datasets: It is possible to use the `spei` and `spi` functions for processing multivariate datasets at once. If a matrix or data frame is supplied as `data`, with time series of precipitation or precipitation minus potential evapotranspiration arranged in columns, the result would be a matrix (data frame) of spi or spei series. This makes processing large datasets extremely easy, since no loops need to be used.

Value

Functions `spei` and `spi` return an object of class `spei`. The generic functions `print` and `summary` can be used to obtain summaries of the results. The generic accessor functions `coefficients` and `fitted` extract useful features of the object.

An object of class `spei` is a list containing at least the following components:

call: the call to spei or spi used to generate the object.

fitted: time series with the values of the Standardized Precipitation-Evapotranspiration Index (SPEI) or the Standardized Precipitation Index (SPI). If data consists of several columns the function will treat each column as independent data, and the result will be a multivariate time series. The names of the columns in data will be used as column names in fitted.

coefficients: an array with the values of the coefficients of the distribution function fitted to the data. The first dimension of the array contains the three (or two) coefficients, the second dimension will typically consist of twelve values corresponding to each month, and the third dimension will be equal to the number of columns (series) in data. If a time scale greater than one has been used then the first elements will have NA value since the kernel can not be applied. The first element with valid data will be the one corresponding to the time scale chosen.

scale: the scale parameter used to generate the object.

kernel: the parameters and values of the kernel used to generate the object.

distribution: the distribution function used to generate the object.

fit: the fitting method used to generate the object.

na.action: the value of the na.action parameter used.

data: if requested, the input data used.

Note

Dependencies: the spei function depends on the library lmomco.

Author(s)

Santiago Beguería and Sergio M. Vicente-Serrano. Maintainer: Santiago Beguería.

References

S.M. Vicente-Serrano, S. Beguería, J.I. López-Moreno. 2010. A Multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index – SPEI. *Journal of Climate* **23**: 1696, DOI: 10.1175/2009JCLI2909.1.

Beguería S, Vicente-Serrano SM, Reig F, Latorre B. 2014. Standardized precipitation evapotranspiration index (SPEI) revisited: parameter fitting, evapotranspiration models, tools, datasets and drought monitoring. *International Journal of Climatology* **34(10)**: 3001-3023.

http://sac.csic.es/spei/

See Also

kern for different kernel functions available. thornthwaite, hargreaves and penman for ways of calculating potential evapotranspiration. summary.spei and print.spei for summaries of spei objects. plot.spei for plotting spei objects.

Examples

```
# Load data
data(wichita)

# Compute potential evapotranspiration (PET) and climatic water balance (BAL)
wichita$PET <- thornthwaite(wichita$TMED, 37.6475)
wichita$BAL <- wichita$PRCP-wichita$PET

# Convert to a ts (time series) object for convenience
wichita <- ts(wichita[,-c(1,2)], end=c(2011,10), frequency=12)
plot(wichita)

# One and tvelwe-months SPEI
spei1 <- spei(wichita[,'BAL'], 1)
spei12 <- spei(wichita[,'BAL'], 12)
class(spei1)

# Extract information from spei object: summary, call function, fitted values, and coefficients
summary(spei1)
names(spei1)
spei1$call
spei1$fitted
spei1$coefficients

# Plot spei object
par(mfrow=c(2,1))
plot(spei1, main='Wichita, SPEI-1')
plot(spei12, main='Wichita, SPEI-12')

# One and tvelwe-months SPI
spi_1 <- spi(wichita[,'PRCP'], 1)
spi_12 <- spi(wichita[,'PRCP'], 12)

par(mfrow=c(2,1))
plot(spi_1, 'Wichita, SPI-1')
plot(spi_12, 'Wichita, SPI-12')

# Time series not starting in January
par(mfrow=c(1,1))
plot(spei(ts(wichita[,'BAL'], freq=12, start=c(1980,6)), 12))

# Using a particular reference period (1980-2000) for computing the parameters
plot(spei(ts(wichita[,'BAL'], freq=12, start=c(1980,6)), 12,
ref.start=c(1980,1), ref.end=c(2000,1)))

# Using different kernels
spei24 <- spei(wichita[,'BAL'],24)
spei24_gau <- spei(wichita[,'BAL'], 24, kernel=list(type='gaussian', shift=0))
par(mfrow=c(2,1))
plot(spei24, main='SPEI-24 with rectangular kernel')
plot(spei24_gau, main='SPEI-24 with gaussian kernel')
```

```
# Computing several time series at a time
# Dataset balance contains time series of the climatic water balance at 12 locations
data(balance)
head(balance)
bal_spei12 <- spei(balance, 12)
plot(bal_spei12)

# Using custom (user provided) parameters
coe <- spei1$coefficients
dim(coe)
spei(wichita[,'BAL'], 1, params=coe)
```

Generalized Logistic   *Generalized Logistic distribution function.*

Description

Cumulative distribution function of the Generalized Logistic probability distribution function, and maximum likelihood fitting function.

Usage

```
pglo(x, para)

parglo.maxlik(x, ini)
```

Arguments

x	vector of quantiles for which to evaluate the PDF.
para	a list of parameters of a generalized Logistic distribution function, as yield by function `parglo`.
ini	a vector of initial values of the parameters to be fit.

Details

This functions are used internally by `spei` and `spi` and are supposed to never be needed by the regular user. Initial values for maximum likelihood estimation can be provided by `parglo`.

Value

A vector of cumulative probabilities corresponding to the quantiles in x.

Author(s)

Santiago Beguería

References

S.M. Vicente-Serrano, S. Beguería, J.I. López-Moreno. 2010. A Multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index – SPEI. *Journal of Climate* **23**: 1696, DOI: 10.1175/2009JCLI2909.1.

Generic methods for spei objects
Generic methods for spei *objects.*

Description

Generic methods for extracting information and plotting spei objects.

Usage

```
## S3 method for class 'spei'
print(x, ...)

## S3 method for class 'spei'
summary(object, ...)

## S3 method for class 'spei'
plot(x, main, ...)
```

Arguments

x	an object of class spei.
object	an object of class spei.
main	an (optional) title for the plot.
...	additional parameters, not used at present.

Details

This functions allow extracting information and plotting spei objects. print yields the fitted values, i.e. a time series of SPEI or SPI values. summary reports the function call, the parameters of the PDF used, and the time series of SPEI or SPI values. plot produces a plot of the time series of SPEI or SPI values, with blue and red colors for positive and negative values, respectively. If a reference period was used in the function call it is shown by a shaded area. In the unlikely case that NA or Inf values were produced, these are shown by circles.

Author(s)

Santiago Beguería

References

S.M. Vicente-Serrano, S. Beguería, J.I. López-Moreno. 2010. A Multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index – SPEI. *Journal of Climate* **23**: 1696, DOI: 10.1175/2009JCLI2909.1.

Kernel functions	*Time kernel for computing the SPEI at different time scales.*

Description

Function kern is used internally by [spei](#) and [spi](#)for computing drought indices at different time scales.

Usage

```
kern(scale, type = 'rectangular', shift = 0)

kern.plot(scale = 12, shift = 0)
```

Arguments

scale	numeric, time scale or length of the kernel.
type	character, shape of the kernel function.
shift	numeric, shifting of the kernel peak.

Details

Drought indices, such as the SPEI or the SPI, are usually computed at different time scales to adapt to the different response times of systems affected by drought. This is acomplished by applying a kernel function to the data prior to computation of the SPEI. Aplication of a kernel has the effect of smoothing the temporal variability of the resulting SPEI, allowing for the major patterns to emerge from the noise. Other way of considering it is that the kernel allows incorporating information of previous time steps into the calculation of the current time step, so the resulting values of the SPEI adapt to the memory of the system under study.

The most common kernel function is rectangular, i.e. all the data of the previous *n* time steps are given equal weight. This was the way the Standardized Precipitation Index (SPI) was defined, and it is also the way the SPEI is computed. This would be the default option for the kern function. However, data from the past can be thought of as having a decreasing influence in the current state of the system as the temporal lag between them increases. The function kern allows weighting the past data as a function of the time lapse, according to a series of pre-defined shapes. Available options are 'rectangular' (default), 'triangular', 'circular' and 'gaussian'.

By default the highest weight will be given to the observation of the current month. However, it is possible to modify this by setting the shift parameter to a value higher than zero. This will cause the highest weight be given to the *n* antecedent observation.

kern.plot produces plots of the weighting factor against the time lag for the four different kernel shapes so they can be compared.

Value

A vector of lenght equal to `scale` with weights used for computing the drought index.

Author(s)

Santiago Beguería

References

S.M. Vicente-Serrano, S. Beguería, J.I. López-Moreno. 2010. A Multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index – SPEI. *Journal of Climate* **23**: 1696, DOI: 10.1175/2009JCLI2909.1.

Examples

```
# A rectangular kernel with a time scale of 12 and no shift
kern(12)

# A gaussian kernel with a time scale of 12 and no shift
kern(12,'gaussian')

# Comparison of the four kernels, with and without shift
kern.plot(12)
kern.plot(12,2)
```

Potential evapotranspiration

Computation of potential evapotranspiration.

Description

Potential evapotranspiration (PET) is the amount of evaporation and transpiration that would occur if a sufficient water source were available. Reference evapotranspiration (ET0) is the amount of evaporation and transpiration from a reference vegetation of grass. They are usually considered equivalent. This set of functions calculate PET or ET0 accordind to the Thornthwaite, Hargreaves or Penman-Monteith equations.

Usage

```
thornthwaite(Tave, lat, na.rm = FALSE)

hargreaves(Tmin, Tmax, Ra = NA, lat = NA, Pre = NA, na.rm = FALSE)

penman(Tmin, Tmax, U2, Ra = NA, lat = NA, Rs = NA, tsun = NA,
CC = NA, ed = NA, Tdew = NA, RH = NA, P = NA, P0 = NA,
z = NA, crop='short', na.rm = FALSE)
```

Arguments

Tave	a numeric vector, matrix or time series of monthly mean temperatures, ºC.
lat	a numeric vector with the latitude of the site or sites, in degrees.
na.rm	optional, a logical value indicating whether NA values should be stripped from the computations.
Tmax	a numeric vector, matrix or time series of monthly mean daily maximum temperatures, ºC.
Tmin	a numeric vector, matrix or time series of monthly mean daily minimum temperatures, ºC.
Ra	optional, a numeric vector, matrix or time series of monthly mean daily external radiation, MJ m-2 d-1.
Pre	optional, a numeric vector, matrix or time series of monthly total precipitation, mm.
U2	a numeric vector, matrix or time series of monthly mean daily wind speeds at 2 m height, m s-1.
Rs	optional, a numeric vector, matrix or time series of monthly mean dialy incoming solar radiation, MJ m-2 d-1.
tsun	optional, a numeric vector, matrix or time series of monthly mean daily bright sunshine hours, h.
CC	optional, numeric a vector, matrix or time series of monthly mean cloud cover, %.
ed	optional, numeric a vector, matrix or time series of monthly mean actual vapour pressure at 2 m height, kPa.
Tdew	optional, a numeric vector, matrix or time series of monthly mean daily dewpoint temperature (used for estimating ed), ºC
RH	optional, a numeric vector, matrix or time series of monthly mean relative humidity (used for estimating ed), %.
P	optional, a numeric vector, matrix or time series of monthly mean atmospheric pressure at surface, kPa.
P0	optional, a numeric vector, matrix or time series of monthly mean atmospheric pressure at sea level (used for estimating P), kPa.
z	optional, a numeric vector of the elevation of the site or sites, m above sea level.
crop	optional, character string, type of reference crop. Either one of 'short' (default) or 'tall'.

Details

thornthwaite computes the monthly potential evapotranspiration (PE) according to the Thornthwaite (1948) equation. It is the simplest of the three methods, and can be used when only temperature data are available.

hargreaves computes the monthly reference evapotranspiration (ET0) of a grass crop based on the original Hargreaves equation (1994). However, if precipitation data Pre is provided a modified form due to Droogers and Allen (2002) will be used; this equation corrects ET0 using the amount

of rain of each month as a proxy for insolation. The Hargreaves method requires data on the mean external radiation, Ra. If such data are not available it can be estimated from the latitude lat and the month of the year.

penman calculates the monthly reference evapotranspiration (ET0) of a hypothetical reference crop according to the FAO-56 Penman-Monteith equation described in Allen et al. (1994). This is a simplification of the original Penman-Monteith equation, and has found widespread use. By default the original parameterization of Allen et al. (1994) is used, corresponding to a short reference crop of 0.12 m height. Parameterization for a tall reference crop of 0.5 m height due to Walter et al. (2002) can also be used, by setting the crop parameter to 'tall'. The method requires data on the incoming solar radiation, Rs; since this is seldom available, the code will estimate it from data on the bright sunshine duration tsun, or alternatively from data on the percent cloud cover CC. Similarly, if data on the saturation water pressure ed are not available, it is possible to estimate it from the dewpoint temperature Tdew, from the relative humidity RH or even from the minimum temperature Tmin (sorted from least to most uncertain method). Similarly, the atmospheric surface pressure P required for computing the psychrometric constant can be calculated from the atmospheric pressure at sea level P0 and the elevation z, or else it will be assumed to be constant (101.3 kPa). The code will produce an error message if a valid combination of input parameters is not provided.

If the main input object (Tave, Tmin, Tmax) is a vector or a matrix, data will be treated as a sequence of monthly values starting in January. If it is a time series then the function cycle will be used to determine the position of each observation within the year (month), allowing the data to start in a month different than January.

Value

A time series with the values of monthly potential or reference evapotranspiration, in mm. If the input is a matrix or a multivariate time series each column will be treated as independent data (e.g., diferent observatories), and the output will be a multivariate time series.

Author(s)

Santiago Beguería

References

Thornthwaite, C. W. (1948). An approach toward a rational classification of climate. *Geographical Review* **38**: 55–94. doi:10.2307/2107309.

Hargreaves G.H. 1994. Defining and using reference evapotranspiration. *Journal of Irrigation and Drainage Engineering* **120**: 1132–1139.

Droogers P., Allen R. G., 2002. Estimating reference evapotranspiration under inaccurate data conditions. *Irrigation and Drainage Systems* **16**: 33–45.

Allen R. G., Smith M., Pereira L. S., Perrier A., 1994. An update for the calculation of reference evapotranspiration. *ICID Bulletin of the International Commission on Irrigation and Drainage*, 35–92.

Allen R.G., Pereira L.S.,Raes D., Smith, M. 1998. *JCrop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. FAO, Rome. ISBN 92-5-104219-5.

Walter I.A. and 14 co-authors, 2002. The ASCE standardized reference evapotranspiration equation. Rep. Task Com. on Standardized Reference Evapotranspiration July 9, 2002, EWRI–Am. Soc. Civil Engr., Reston, VA, 57 pp.

Examples

```
# Load data for Tampa, lat=37.6475N, elevation=402.6 m. a.s.l.
# Data consists on monthly values since January 1980
data(wichita)
attach(wichita)
names(wichita)

# PET according to Thornthwaite
tho <- thornthwaite(TMED,37.6475)
# Hargreaves
har <- hargreaves(TMIN,TMAX,lat=37.6475)
# Penman, based on sun hours, ignore NAs
pen <- penman(TMIN,TMAX,AWND,tsun=TSUN,lat=37.6475,z=402.6,na.rm=TRUE)
# Penman, based on cloud cover
pen2 <- penman(TMIN,TMAX,AWND,CC=ACSH,lat=37.6475,z=402.6,na.rm=TRUE)
# Plot them together
plot(cbind(tho,har,pen,pen2))

# Now consider the data started in June 1900
thornthwaite(ts(TMED,start=c(1900,6),frequency=12),37.6475)

# Comparison with example from Allen et al. (1998), p. 69, fig. 18:
# Data from Cabinda, Angola (-5.33S, 12.11E, 20 m a.s.l.)
data(cabinda)
pen.cab <- penman(cabinda$Tmin,cabinda$Tmax,cabinda$U2,
Rs=cabinda$Rs,tsun=cabinda$tsun,RH=cabinda$RH,lat=-5.33,z=20)
plot(cabinda$ET0,pen.cab)
abline(0,1,lt='dashed')
summary(lm(pen.cab~cabinda$ET0))$r.squared
```

SPEINews   *Show the NEWS file*

Description

Show the NEWS file of the **SPEI** package.

Usage

```
SPEINews()
```

Value

None.

Index