Package ‘drought’

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Title Statistical Modeling and Assessment of Drought
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Description Provide tools for drought monitoring based on univariate and multivariate drought indicators. Statistical drought prediction based on Ensemble Streamflow Prediction (ESP), drought risk assessments, and drought propagation are also provided. Please see Hao Zengchao et al. (2017) <doi:10.1016/j.envsoft.2017.02.008>.

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Description


Details

Package: drought
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References


Hao, Z., and V. P. Singh (2015), Drought characterization from a multivariate perspective: A review J. Hydrol., 527


Hao, Z. et al. (2014). Global integrated drought monitoring and prediction system. Scientific Data, 1

Examples

```r
# X=runif(120, min = 0, max = 100) # 10-year monthly data
# Yc<-ACCU(X,ts=6) # Compute the 6 month accumulated series
# fit1<-SDI(X,ts=6) # Get the standardized drought index (or SPI)
# z=matrix(t(fit1$SDI),ncol=1)
# Res <- RunDS(z, -1)# Get drought duration and severity based on threshold SPI=-1
# Y=runif(120, min = 0, max = 100) # 10-year monthly data
```
ACCU

Obtain the accumulation of monthly hydro-climatic variables

Description
Obtain the accumulation of monthly hydro-climatic variables

Usage
ACCU(X, ts = 6)

Arguments
X The vector of monthly hydro-climatic variables of n years. ts is the accumulated time scale.

Examples
X = runif(120, min = 0, max = 100) # 10-year monthly data
Y <- ACCU(X, ts=3) # Compute the 3 month accumulated series

BiEmp

Compute the bivariate empirical joint probability

Description
Compute the bivariate empirical joint probability

Usage
BiEmp(X, Y)

Arguments
X The vector of a monthly hydro-climatic variable of n years (e.g., August).
Y The vector of a monthly hydro-climatic variable of n years (e.g., August).

Value
The empirical joint probability of X and Y for a specific month (Gringorten plotting position)
Examples

```r
X = runif(20, min = 0, max = 100) # 20 monthly values (e.g., August)
Y = runif(20, min = 0, max = 100)
fit <- BiEmp(X, Y)
```

Description

Drought prediction with ESP method

Usage

```r
ESPPred(X, Y, L = 1, m = 7, ts = 6)
```

Arguments

- **X** is the monthly variables.
- **Y** is the monthly variables.
- **L** is the lead time.
- **m** is the start time of prediction (or ending of observations)
- **ts** is the time scale of monthly variables.

Value

The prediction of univariate and multivariate drought index based on ESP

Examples

```r
X = runif(120, min = 0, max = 100) # 10-year monthly data
Y = runif(120, min = 0, max = 100)
ESPPred(X, Y, L = 1, m = 7, ts = 6)
```
JDSI

*Compute Joint Drought Severity Index with joint distribution*

**Description**

The JDSI can be computed based on joint distribution or kendall distribution

**Usage**

```
JDSI(X, Y, ts = 6, type = 1)
```

**Arguments**

- **X** is the vector of a monthly hydro-climatic variable of n years.
- **Y** is the vector of a monthly hydro-climatic variable of n years.
- **ts** is the accumulated time scale.
- **type** is the method used to compute the JDSI (1 is Joint distribution and 2 is the Kendall function).

**Value**

The multivariate drought index based on the joint distribution or Kendall distribution

**References**


**Examples**

```
X=runif(120, min = 0, max = 100) # 10-year monthly data
Y=runif(120, min = 0, max = 100) # 10-year monthly data
fit<-JDSI(X,Y,ts=6)
z=matrix(t(fit$JDSI),ncol=1)
plot(z, type="l", col=1, lwd=2, lty=1, xlim=c(0,120), xlab="Time", ylab="JDSI")
```
Compute the Multivariate Standardized Drought Index (MSDI)

Description

Based on a pair of monthly hydro-climatic variable (or corresponding marginals), the MSDI is computed using the joint distribution (parametric or nonparametric forms). The current version is based on the Gringorten plotting position. It can be extended to higher dimensions, such as trivariate case including meteorological, agricultural, and hydrological droughts. For the high dimension case, the copula or vine copula method can be employed.

Usage

MSDI(X, Y, ts = 6)

Arguments

X is the vector of a monthly hydro-climatic variable of n years.
Y is the vector of a monthly hydro-climatic variable of n years.
ts is the accumulated time scale.

Value

The monthly MSDI series of different time scales (based on Gringorten plotting position)

References


Examples

X=runif(120, min = 0, max = 100) # 10-year monthly data
Y=runif(120, min = 0, max = 100) # 10-year monthly data
fit<-MSDI(X,Y,ts=6) # Compute the 6 month drought index
fit$ProbEmp2 # Get the empirical drought index (e.g., Gringorten plotting position)
**Description**

Compute the pearson correlation between multi-time scale SPI and 1-month SRI to reflect the most possible propagation time (PT) from meteorological drought to hydrological drought. Note here the propagation of meteorological to hydrological drought is used as an example. The propagation of other types of drought can also be computed.

**Usage**

```r
PropagationMCC(X, Y, acc = 12, lim = c(-1, 1), color = NA)
```

**Arguments**

- `X` The vector of monthly meteorological variable (e.g., precipitation)
- `Y` The vector of monthly hydrological variables (e.g., runoff)
- `acc` Maximum of propagation time (or accumulation periods)
- `lim` The limits interval for color
- `color` Color vector in plot

**Value**

Plot of correlation matrix

**References**


**Examples**

```r
X <- runif(120, min = 0, max = 100) # 10-year monthly data
Y <- runif(120, min = 0, max = 100) # 10-year monthly data
acc <- 12
lim <- c(-1, 1)
PropagationMCC(X, Y, acc, lim)
```
RunDS

Compute drought duration and severity based on run theory

Description

The input data is monthly drought indices. Duration is defined as the length of consecutive time series when drought index is below the threshold value (e.g., -1). Severity is defined as the summation of drought index below the threshold. This analysis based on run theory is also referred to as threshold level method. Here the standardized drought index (SDI) is used as the example to compute the drought characteristics. Other univariate and multivariate drought indices can also be used.

Usage

RunDS(DI, thre)

Arguments

DI The vector of the drought index (e.g., monthly SPI)
thre The threshold of drought index (e.g., -0.5, -1)

Value

The duration and severity of each drought event

References


Examples

X=runif(120, min = 0, max = 100) # 10-year monthly data
thre=-1 # specify the threshold value
fit<-SDI(X,ts=3) # Compute the univariate drought index, such as SPI
z=matrix(t(fit$SDI),ncol=1) # Reshape the matrix to a vector
Res <- RunDS(z, thre) # Compute the duration and severity
**SDI**

*Compute the standardized drought index*

**Description**

Based on the vector of monthly variables, the standardized drought index is computed. Note here the standardized precipitation index (SPI) is used as the example of the drought index in the univariate case. It also represents other drought indices computed in the similar way as SPI.

**Usage**

```r
SDI(X, ts = 6, dist = "EmpGrin")
```

**Arguments**

- `X` The vector of a monthly hydro-climatic variable of n years.
- `ts` is the accumulated time scale.
- `dist` is a distribution function. The inputs can be "EmpGrin", "EmpWeib", "Gamma", "Lognormal".

**Details**

Apart from the standardized drought index, the percentile (probability) is also provided.

**Value**

The (univariate) standardized drought index of different time scales from both the empirical and parametric distribution

**Examples**

```r
X = runif(120, min = 0, max = 100) # 10-year monthly data
fit <- SDI(X, ts = 3) # Compute the 3 month drought index
fit$SDI # Get the empirical drought index
z = matrix(t(fit$SDI), ncol = 1)
plot(z, type = "l", col = 1, lwd = 2, lty = 1, xlim = c(0, 120), xlab = "Time", ylab = "SDI")
```

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**UMFreq**

*Univariate and multivariate return period*

**Description**

Univariate and multivariate return period

**Usage**

```r
UMFreq(X, Y, EL = 1)
```
Arguments

X is the drought properties (e.g., duration) or indices (e.g., SPI)
Y is the drought properties (e.g., duration) or indices (e.g., SRI)
EL is the average recurrence time

Value

The univariate and multivariate return period

Examples

X=runif(60, min = 0, max = 100) # 60 drought duration values or index values
Y=runif(60, min = 0, max = 100)
fit<-UMFreq(X,Y,1)

UniEmp

Compute the univariate empirical joint probability (EMP)

Description

Compute the univariate empirical joint probability (EMP)

Usage

UniEmp(X, dist = "Gringorten")

Arguments

X The vector of a monthly hydro-climatic variable of n years.
dist is the function for the plotting position formula (Gringorten or Weibull).

Value

The univariate EMP

Examples

X=runif(20, min = 0, max = 100) # 20 monthly values of precipitation (e.g., August)
fit<-UniEmp(X,dist = "Gringorten")
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