Package ‘CompoundEvents’

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Title Statistical Modeling of Compound Events

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Description Tools for extracting occurrences, assessing potential driving factors, predicting occurrences, and quantifying impacts of compound events in hydrology and climatology. Please see Hao Zengchao et al. (2019) <doi:10.1088/1748-9326/ab4df5>.

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`CompoundEvents-package` *Statistical Modeling of Compound Events*

Description

Tools for extracting occurrences, assessing potential driving factors, predicting occurrences, and quantifying impacts of compound events in hydrology and climatology.

Details

Examples of compound events in hydroclimatology include, but not limited to, compound dry-hot events and compound precipitation and surge (or sea level) events. Take the compound dry and hot event as an example. The function `GetDH` is used for extracting occurrences based on thresholds of dry and hot indicators. The function `DriverLGR` is used for assessing potential driving factors of compound events based on logistic regression model. The function `PredLGR` is used for predicting occurrences of compound events. The function `ImpactMG` is used for quantifying impacts of compound dry and hot events based on meta-Gaussian model.

Author(s)

Zengchao Hao

References

Hao, Z., et al.(2013). Changes in concurrent monthly precipitation and temperature extremes. Environ. Res. Lett. 8: 034014.

Hao, Z. et al. (2019). A monitoring and prediction system for compound dry and hot events. Environ. Res. Lett., 14:114034.

Hao, Z. et al. (2019). Statistical prediction of the severity of compound dry-hot events based on ENSO . J. Hydrol., 572: 243-250.

Feng, S. et al. (2019). Probabilistic evaluation of the impact of compound dry-hot events on global maize yields. Sci. Total. Environ., 689: 1228-1234.

`DriverLGR` *Assess potential driving factors of compound dry-hot events.*

Description

Use the logistic regression model to establish relationships between climate indices (e.g., ENSO) and occurrences of compound dry-hot events.

Usage

```
DriverLGR(Y,CI)
```

Arguments

- `Y` Occurrence of compound dry-hot events (0-1 binary variable)
- `CI` Climate index as the driving factor of compound events (e.g., ENSO)

Value

slope parameter and associated p-value

References

Hao, Z. et al. (2019). A monitoring and prediction system for compound dry and hot events. Environ. Res. Lett., 14:114034.

Examples

```
CI=c(-0.7,-1.2,1.3,0.7,-0.6,1.1,-0.5,0.8,0.5,-0.5,1.6,-1.8,-0.5,-1.4,-0.1,2.2,-0.7,-1.1, 0.6, -1.7)
Y=c(0,0,1,1,0,0,0,0,0,0,1,0,1,0,0,1,0,0,0,0 )
res<-DriverLGR(Y,CI)
```

Empdis1 *Univariate empirical probability*

Description

Compute univariate empirical probability

Usage

```
Empdis1(mp)
```

Arguments

- `mp` monthly precipitation

Value

The empirical probability

References

Hao, Z. et al., 2019a. Statistical prediction of the severity of compound dry-hot events based on El Ni??o-Southern Oscillation. J. Hydrol., 572, 243-250.

Examples

```
mp=matrix(rnorm(120,0,1),ncol=1)
nd<-Empdis1(mp)
```

Empdis2 *Bivariate empirical probability*

Description

Compute bivariate empirical probability

Usage

```
Empdis2(mp,mt)
```

Arguments

mp	monthly precipitation
mt	monthly temperature

Value

The bivariate empirical probability

References

Hao, Z. et al., 2019a. Statistical prediction of the severity of compound dry-hot events based on El Ni??o-Southern Oscillation. J. Hydrol., 572, 243-250.

Examples

```
mp=matrix(rnorm(120,0,1),ncol=1)
mt=matrix(rnorm(120,0,1),ncol=1)
nd<-Empdis2(mp,mt)
```

GetDC *Occurrence of compound dry-cold events*

Description

Extract compound dry-cold occurrences based on thresholds of precipitation and temperature. The binary variable of the dry and cold (DC) event can be obtained.

Usage

```
GetDC(mp,mt,threp,thret)
```

Arguments

mp	Precipitation
mt	Temperature
threp	Threshold of precipitation (e.g., 20th percentile)
thret	Threshold of temperature (e.g., 20th percentile)

Value

The occurrence of compound wet-hot event (0-1 binary variable)

References

Hao, Z. et al (2013). Changes in concurrent monthly precipitation and temperature extremes. Environ. Res. Lett., 8(3): 034014.

Examples

```
mp=matrix(rnorm(120,0,1),ncol=1)
mt=matrix(rnorm(120,0,1),ncol=1)
threp=20
thret=20
DC<-GetDC(mp,mt,threp,thret)
```

GetDH — *Occurrence of compound dry-hot events*

Description

Extract compound dry-hot (DH) occurrences based on thresholds of precipitation and temperature. The binary variable of the DH (or dry-warm) event can be obtained.

Usage

```
GetDH(mp,mt,threp,thret)
```

Arguments

mp	Precipitation
mt	Temperature
threp	Threshold of precipitation (e.g., 20th percentile)
thret	Threshold of temperature (e.g., 80th percentile)

Value

The occurrence of compound dry-hot events (0-1 binary variable)

References

Hao, Z. et al. (2018). A multivariate approach for statistical assessments of compound extremes. J. Hydrol., 565: 87-94.

Hao, Z. et al. (2019). A monitoring and prediction system for compound dry and hot events. Environ. Res. Lett., 14:114034.

Examples

```
mp=matrix(rnorm(20,0,1),ncol=1) # 20-year precipitation of a specific month (e.g., August)
mt=matrix(rnorm(20,0,1),ncol=1) # 20-year temperature of a specific month (e.g., August)
threp=20
thret=80
DH<-GetDH(mp,mt,threp,thret)
```

`GetWH` *Occurrence of compound wet-hot events*

Description

Extract compound wet-hot (WH) occurrences based on thresholds of precipitation and temperature.The binary variable of the WH (or wet-warm,WW) event can be obtained.

Usage

```
GetWH(mp,mt,threp,thret)
```

Arguments

mp	Precipitation
mt	Temperature
threp	Threshold of precipitation (e.g., 80th percentile)
thret	Threshold of temperature (e.g., 80th percentile)

Value

The occurrence of compound wet-hot events (0-1 binary variable)

References

Hao, Z. et al (2013). Changes in concurrent monthly precipitation and temperature extremes. Environ. Res. Lett., 8(3): 034014.

Examples

```
mp=matrix(rnorm(120,0,1),ncol=1)
mt=matrix(rnorm(120,0,1),ncol=1)
threp=80
thret=80
WH<-GetWH(mp,mt,threp,thret)
```

ImpactMG *Impacts under droughts and hot extremes*

Description

Use the meta-Gaussian model to construct conditional distributions of the impact variable (Y) given drought and hot conditions P(Y|PRC,TEM).

Usage

```
ImpactMG(PRC,TEM,Y,u0)
```

Arguments

PRC	Precipitation or drought indicator corresponding to the impact variable Y
TEM	Temperature or heat indicator corresponding to the impact variable Y
Y	Impact variable (e.g., Crop yield)
u0	Initial condition of (PRC,TEM)

Value

A vector of conditional mean and variance evaluated at u0

References

Feng, S. et al. (2019). Probabilistic evaluation of the impact of compound dry-hot events on global maize yields. Sci. Total. Environ., 689: 1228-1234.

Hao, Z. et al. (2018). A multivariate approach for statistical assessments of compound extremes. J. Hydrol., 565: 87-94.

Examples

```
PRC=matrix(rnorm(60,0,1),ncol=1)
TEM=matrix(rnorm(60,0,1),ncol=1)
Y=matrix(rnorm(60,0,1),ncol=1)
u0=c(-1.2,1.2) # Speficify the compound dry-hot condition
ImpactMG(PRC,TEM,Y,u0)
```

LMFDH *Likelihood multiplication factor (LMF) or probability multiplication factor (PMF) of compound dry-hot events*

Description

Compute joint probabilities of compound dry-hot events and the independent case.

Usage

```
LMFDH(mp,mt,threp,thret)
```

Arguments

`mp`	Precipitation
`mt`	Temperature
`threp`	Threshold of precipitation (e.g., 50th percentile)
`thret`	Threshold of temperature

Value

Joint probability of DH divided by that of independent case

References

Zscheischler, J. and S. I. Seneviratne (2017). Dependence of drivers affects risks associated with compound events. Science Advances, 3(6): e1700263.

Examples

```
mp=matrix(rnorm(120,0,1),ncol=1)
mt=matrix(rnorm(120,0,1),ncol=1)
threp=20
thret=80
res<-LMFDH(mp,mt,threp,thret)
```

PredLGR *Prediction of compound event occurrences*

Description

Fit the logistic regression model (LGR) based on occurrences of compound events (Y) and climate index (CI).The output is the predicted probability of compound event occurrence for the given climate index value CI0

Usage

```
PredLGR(Y,CI,CI0)
```

Arguments

`Y`	Occurrences of compound dry-hot events (0-1 binary variable) (L lead time)
`CI`	Climate index (CI) as the driving factor of compound events (e.g., ENSO)
`CI0`	Specified CI value based on which the prediction is issued

Value

Probability of occurrences estimated at CI0

References

Hao, Z. et al. (2019). Statistical prediction of the severity of compound dry-hot events based on ENSO . J. Hydrol., 572: 243-250.

Examples

```
CI=c(-0.7,-1.2,1.3,0.7,-0.6,1.1,-0.5,0.8,0.5,-0.5,1.6,-1.8,-0.5,-1.4,-0.1,2.2,-0.7,-1.1, 0.6, -1.7)
Y=c(0,0,1,1,0,0,0,0,0,0,1,0,1,0,0,1,0,0,0,0 )
PredLGR(Y,CI,2)
```

SCEI *Standardized Compound Event Indicator (SCEI)*

Description

Compute SCEI based on monthly precipitation and temperature.

Usage

```
SCEI(mp,mt,ts)
```

Arguments

mp	monthly precipitation
mt	monthly temperature
ts	time scale

Value

The monthly SCEI series

References

Hao, Z. et al., 2019a. Statistical prediction of the severity of compound dry-hot events based on El Ni??o-Southern Oscillation. J. Hydrol., 572, 243-250.

Examples

```
mp=matrix(rnorm(120,0,1),ncol=1)
mt=matrix(rnorm(120,0,1),ncol=1)
ts=3; # ts<=12 otherwise you should revise line 98
nd<-SCEI(mp,mt,ts)
d=cbind(mp,mt,nd)
testd<-matrix(d, ncol=3,byrow=FALSE)
```

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