

# Package: CompoundEvents (via r-universe)

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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](https://doi.org/10.1088/1748-9326/ab4df5)>.

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CompoundEvents-package

*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.

## 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.

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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 Niño-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 Niño-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	<i>Occurrence of compound dry-cold events</i>
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**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	<i>Occurrence of compound dry-hot events</i>
-------	--

---

**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	<i>Occurrence of compound wet-hot events</i>
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---

**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) # Sppecificify the compound dry-hot condition
ImpactMG(PRC, TEM, Y, u0)
```



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LMFDH	<i>Likelihood multiplication factor (LMF) or probability multiplication factor (PMF) of compound dry-hot events</i>
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**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 Niño-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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