

# Package ‘GWEX’

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**Title** Multi-Site Stochastic Models for Daily Precipitation and Temperature

**Version** 1.0.2

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**Imports** EnvStats, MASS, mvtnorm, nleqslv, fGarch, parallel, abind, foreach, doParallel, Renext, lmomco, methods, stats

**Description** Application of multi-site models for daily precipitation and temperature data. This package is designed for an application to 105 precipitation and 26 temperature gauges located in Switzerland. It applies fitting procedures and provides weather generators described in the following references:  
- Evin, G., A.-C. Favre, and B. Hingray. (2018) <[doi:10.5194/hess-22-655-2018](https://doi.org/10.5194/hess-22-655-2018)>.  
- Evin, G., A.-C. Favre, and B. Hingray. (2018) <[doi:10.1007/s00704-018-2404-x](https://doi.org/10.1007/s00704-018-2404-x)>.

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dailyPrecipGWEX	<i>daily observations of precipitation data</i>
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## Description

Example of daily observations of precipitation (mm) for three fictive stations, for a period of ten years.

## Usage

```
data(dailyPrecipGWEX)
```

## Format

matrix of Observed precipitation: 3652 days x 3 stations

## Author(s)

Guillaume Evin <guillaume.evin@irstea.fr>

## References

Evin, G., A.-C. Favre, and B. Hingray. 2018. "Stochastic Generation of Multi-Site Daily Precipitation Focusing on Extreme Events". *Hydrol. Earth Syst. Sci.* 22 (1): 655–672.

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dailyTemperGWEX	<i>daily observations of temperature data</i>
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### Description

Example of daily observations of temperature (mm) for three fictive stations, for a period of ten years.

### Usage

```
data(dailyTemperGWEX)
```

### Format

matrix of Observed temperature: 3652 days x 3 stations

### Author(s)

Guillaume Evin <guillaume.evin@irstea.fr>

### References

Evin G., A.C. Favre, and B. Hingray. 2018. Stochastic Generators of Multi Site Daily Temperature: Comparison of Performances in Various Applications. Theoretical and Applied Climatology.

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fitGwexModel	<i>fitGwexModel: fit a GWex model to observations.</i>
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### Description

fitGwexModel: fit a GWex model to observations.

### Usage

```
fitGwexModel(objGwexObs, listOption = NULL)
```

### Arguments

- |            |  |
|------------|--|
| objGwexObs | an object of class <a href="#">GwexObs</a>   |
| listOption | for precipitation, a list with the following fields: <ul style="list-style-type: none"><li>• <b>th</b>: threshold value in mm above which precipitation observations are considered to be non-zero (=0.2 by default)</li><li>• <b>nLag</b>: order of the Markov chain for the transitions between dry and wet states (=2 by default)</li></ul> |

- **typeMargin**: 'EGPD' (Extended GPD) or 'mixExp' (Mixture of Exponentials). 'EGPD' by default
- **xiHat**: pre-determined values for the xi parameters of the EGPD distribution on precipitation amounts
- **copulaInt**: 'Gaussian' or 'Student': type of dependence for amounts (= 'Student' by default)
- **isMAR**: logical value, do we apply a Autoregressive Multivariate Autoregressive model (order 1) =TRUE by default
- **is3Damount**: logical value, do we apply the model on 3D-amount. =FALSE by default
- **nChainFit**: integer, length of the runs which are generated during the fitting procedure. =100000 by default
- **nCluster**: integer, number of clusters which can be used for the parallel computation

and for temperature, a list with the following fields:

- **hasTrend**: logical value, do we fit a linear trend for the long-term change, =FALSE by default
- **objGwexPrec**: object of class [GwexObs](#) containing precipitation observations. If provided, we assume that temperature must be modelled and simulated according to the precipitation states 'dry' and 'wet'. For each state, a seasonal cycle is fitted (mean and sd).
- **typeMargin**: 'SGED' (default) or 'Gaussian': type of marginal distribution.
- **depStation**: 'MAR1' (default) or 'Gaussian': MAR1 (Multivariate Autoregressive model order 1) for the spatial and temporal dependence or 'Gaussian' for the spatial dependence only.

## Value

Return an object of class [GwexFit](#) with:

- **p**: The number of station,
- **version**: package version,
- **variable**: the type of variable,
- **fit**: a list containing the list of options `listOption` and the list of estimated parameters `listPar`.

## Author(s)

Guillaume Evin

## Examples

```
# Format dates corresponding to daily observations of precipitation and temperature
vecDates = seq(from=as.Date("01/01/2005",format="%d/%m/%Y"),
to=as.Date("31/12/2014",format="%d/%m/%Y"),by='day')
```

```
#####
#           FIT THE PRECIPITATION MODEL
#####

# Format observations: create a G-Wex object
myObsPrec = GwexObs(variable='Prec',date=vecDates,obs=dailyPrecipGWEX[,1:2])

# Example of a data.frame which can be used for 'xiHat'. For each month, xi values
#can be prescribed, for example using a regionalisation method.
xiReg = data.frame(station=c('S1','S2','S3'),JAN=c(0,0,0.06),FEB=c(0,0,0.06),
MAR=c(0,0,0.01),APR=c(0,0,0.01),MAY=c(0,0,0.01),
JUN=c(0,0.01,0.14),JUL=c(0,0.01,0.14),AUG=c(0,0.01,0.14),
SEP=c(0,0,0.02),OCT=c(0,0,0.02),NOV=c(0,0,0.02),
DEC=c(0,0,0.06))

# Options: specify the threshold for precipitation (0.5 mm) to distinguish wet and
# dry states (th), xi values for the DGPD distribution (xiHat), a Student copula for
# the spatial dependence (copulaInt), a model based on 3-day aggregated values
# (is3Damount), a MAR(1) process (isMAR), a EGPD distribution for marginal intensities
# ('typeMargin'), and 200 replicates for the runs used during the fitting process
# (this value being 100,000 by default, in order to obtain a reasonable precision of the
# estimates)
list.options = list(th=0.5,nLag=1,xiHat=xiReg,copulaInt='Student',is3Damount=TRUE,isMAR=TRUE,
typeMargin='EGPD',nChainFit=200)

# Fit precipitation model
myParPrec = fitGwexModel(myObsPrec,list.options) # fit model
myParPrec # print object

#####
#           FIT THE TEMPERATURE MODEL, COND. TO PRECIPITATION
#####

# Format observations: create a G-Wex object
myObsTemp = GwexObs(variable='Temp',date=vecDates,obs=dailyTemperGWEX)

# Fit temperature model with a long-term linear trend ('hasTrend'), Gaussian margins
# ('typeMargin') and Gaussian spatial dependence ('depStation')
myParTemp = fitGwexModel(myObsTemp,listOption=list(hasTrend=TRUE,typeMargin='Gaussian',
depStation='Gaussian'))
myParTemp # print object
```

---

Gwex-class

*Class Gwex*


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### Description

Defines a generic [Gwex](#) object. GWEX objects contain two slots: - the version ('vX.X.X') - the type of variable ('Prec' or 'Temp')

**Author(s)**

Guillaume Evin

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`GwexFit`-class*Class GwexFit*

---

**Description**

Defines a [GwexFit](#) object which is a [Gwex](#) object containing 'fit', a list containing the fitted parameters, and 'p', the number of stations. See [fitGwexModel](#) for some examples.

**Author(s)**

Guillaume Evin

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`GwexObs`*Constructor*

---

**Description**

Constructor of class [[GwexObs](#)]

**Usage**

```
GwexObs(variable, date, obs)
```

**Arguments**

variable	'Prec' or 'Temp'
date	vector of class 'Date'
obs	matrix nTime x nStations of observations

**Value**

An object of class [[GwexObs](#)]

## Examples

```
# Format dates corresponding to daily observations of precipitation and temperature
vecDates = seq(from=as.Date("01/01/2005",format="%d/%m/%Y"),
to=as.Date("31/12/2014",format="%d/%m/%Y"),by='day')

# build GwexObs object with precipitation data
myObsPrec = GwexObs(variable='Prec',date=vecDates,obs=dailyPrecipGWEX)

# print GwexObs object
myObsPrec

# build GwexObs object with temperature data
myObsTemp = GwexObs(variable='Temp',date=vecDates,obs=dailyTemperGWEX)

# print GwexObs object
myObsTemp
```

---

GwexObs-class

*Class* [GwexObs](#)

---

## Description

Defines a [GwexObs](#) object which is a [Gwex](#) object containing dates and a matrix of observations.

## Author(s)

Guillaume Evin

## Examples

```
# Format dates corresponding to daily observations of precipitation and temperature
vecDates = seq(from=as.Date("01/01/2005",format="%d/%m/%Y"),
to=as.Date("31/12/2014",format="%d/%m/%Y"),by='day')

# build GwexObs object with precipitation data
myObsPrec = GwexObs(variable='Prec',date=vecDates,obs=dailyPrecipGWEX)

# print GwexObs object
myObsPrec

# build GwexObs object with temperature data
myObsTemp = GwexObs(variable='Temp',date=vecDates,obs=dailyTemperGWEX)

# print GwexObs object
myObsTemp
```

---

GwexSim-class	<i>Defines a <a href="#">GwexSim</a> object which is a <a href="#">Gwex</a> object containing 'sim', an array containing the simulations, and 'dates', a vector of dates. See <a href="#">simGwexModel</a> for some examples.</i>
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### Description

Defines a [GwexSim](#) object which is a [Gwex](#) object containing 'sim', an array containing the simulations, and 'dates', a vector of dates. See [simGwexModel](#) for some examples.

### Author(s)

Guillaume Evin

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myParPrecGWEX	<i>fitted object of a precipitation GWEX model</i>
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### Description

Example of a object return by `fit.GWex.prec` when a GWEX model for precipitation data is fitted

### Usage

```
data(myParPrecGWEX)
```

### Format

object of class [GwexFit](#)

### Author(s)

Guillaume Evin <guillaume.evin@irstea.fr>

### References

Evin, G., A.-C. Favre, and B. Hingray. 2018. "Stochastic Generation of Multi-Site Daily Precipitation Focusing on Extreme Events". *Hydrol. Earth Syst. Sci.* 22 (1): 655–672.



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`myParTempGWEX`*fitted object of a temperature GWEX model*

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**Description**

Example of a object return by `fit.GWex.temp` when a GWEX model for temperature data is fitted

**Usage**

```
data(myParTempGWEX)
```

**Format**

object of class `GwexFit`

**Author(s)**

Guillaume Evin <guillaume.evin@irstea.fr>

**References**

Evin G., A.C. Favre, and B. Hingray. 2018. Stochastic Generators of Multi Site Daily Temperature: Comparison of Performances in Various Applications. Theoretical and Applied Climatology.

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`print,Gwex-method`*print-methods: Create a method to print Gwex objects.*

---

**Description**

`print-methods`: Create a method to print Gwex objects.

**Usage**

```
## S4 method for signature 'Gwex'  
print(x)  
  
## S4 method for signature 'GwexObs'  
print(x)  
  
## S4 method for signature 'GwexFit'  
print(x)  
  
## S4 method for signature 'GwexSim'  
print(x)
```

## Arguments

x [Gwex object](#)

## Examples

```
# Format dates corresponding to daily observations of precipitation and temperature
vecDates = seq(from=as.Date("01/01/2005",format="%d/%m/%Y"),
to=as.Date("31/12/2014",format="%d/%m/%Y"),by='day')

# build GwexObs object with temperature data
myObsTemp = GwexObs(variable='Temp',date=vecDates,obs=dailyTemperGWEX)

# print GwexObs object
myObsTemp

# print GwexFit object
myParPrecGWEX
```

---

show,Gwex-method

*show-methods: Create a method to show Gwex objects.*

---

## Description

show-methods: Create a method to show Gwex objects.

## Usage

```
## S4 method for signature 'Gwex'
show(object)

## S4 method for signature 'GwexObs'
show(object)

## S4 method for signature 'GwexFit'
show(object)

## S4 method for signature 'GwexSim'
show(object)
```

## Arguments

object [Gwex object](#)

**Examples**

```
# Format dates corresponding to daily observations of precipitation and temperature
vecDates = seq(from=as.Date("01/01/2005",format="%d/%m/%Y"),
to=as.Date("31/12/2014",format="%d/%m/%Y"),by='day')

# build GwexObs object with temperature data
myObsTemp = GwexObs(variable='Temp',date=vecDates,obs=dailyTemperGWEX)

# show GwexObs object
myObsTemp

# show GwexFit object
myParPrecGWEX
```

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simGwexModel	<i>simGwexModel</i>
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**Description**

Simulate from a GWex model

**Usage**

```
simGwexModel(objGwexFit, nb.rep = 10, d.start = as.Date("01011900",
"%d%m%Y"), d.end = as.Date("31121999", "%d%m%Y"),
objGwexObs = NULL, prob.class = c(0.5, 0.75, 0.9, 0.99),
objGwexSim = NULL, nCluster = 1)
```

**Arguments**

objGwexFit	an object of class <a href="#">GwexFit</a>
nb.rep	number of repetitions of scenarios
d.start	a starting date for the simulation
d.end	an ending date for the simulation
objGwexObs	optional: an object of class <a href="#">GwexObs</a> if we need the observations to simulate (disaggregation prec 3D -> 1D)
prob.class	vector of probabilities indicating class of "similar" mean intensities
objGwexSim	optional: an object of class <a href="#">GwexSim</a> if we need simulations to simulate (temp conditional to prec)
nCluster	optional, number of clusters which can be used for the parallel computation

**Value**

GwexSim	an object of class <a href="#">GwexSim</a> . Contains sim (3D-array with the simulations) and a vector of dates
---------	---

**Author(s)**

Guillaume Evin

**Examples**

```

# vector of dates
vecDates = seq(from=as.Date("01/01/2005", format="%d/%m/%Y"),
to=as.Date("31/12/2014", format="%d/%m/%Y"), by='day')

#####
#          FIT AND SIMULATE FROM THE PRECIPITATION MODEL
#####
# Format observations: create a G-Wex object
myObsPrec = GwexObs(variable='Prec', date=vecDates, obs=dailyPrecipGWEX[,1:2])

# default options except for 'nChainFit'
list.options = list(nChainFit=1000)

# generate 2 scenarios for one year, using a existing 'GwexFit' object
mySimPrec = simGwexModel(objGwexFit=myParPrecGWEX, nb.rep=2, d.start=vecDates[1],
d.end=vecDates[365])
mySimPrec # print object

#####
#          FIT AND SIMULATE FROM THE TEMPERATURE MODEL, COND. TO PRECIPITATION
#####
# Format observations: create a G-Wex object
myObsTemp = GwexObs(variable='Temp', date=vecDates, obs=dailyTemperGWEX)

# generate 2 scenarios for one year, using a existing 'GwexFit' object
mySimTemp = simGwexModel(objGwexFit=myParTempGWEX, nb.rep=2, d.start=vecDates[1],
d.end=vecDates[365])
mySimTemp # print object

```

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