Package ‘qmap’

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Description Empirical adjustment of the distribution of variables originating from (regional) climate model simulations using quantile mapping.

License GPL (>= 2)

LazyLoad yes

NeedsCompilation no

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qmap-package *Statistical Transformations for Post-Processing Climate Model Output*

Description

Empirical adjustment (bias correction) of variables originating from (regional) climate model simulations using quantile mapping. The workhorse functions of this package are `fitQmap` and `doQmap` which offer an easy to use interface to different statistical transformations, also referred to as quantile mapping methods.

Details

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Author(s)

Lukas Gudmundsson

References

Gudmundsson, L.; Bremnes, J. B.; Haugen, J. E. & Engen-Skaugen, T. Technical Note: Downscaling RCM precipitation to the station scale using statistical transformations - a comparison of methods. Hydrology and Earth System Sciences, 2012, 16, 3383-3390, <doi:10.5194/hess-16-3383-2012>.

bernexp *The Bernoulli-Exponential distribution*

Description

Density, distribution function, quantile function and random generation for the Bernoulli-Exponential distribution with parameters `prob`, and `rate`.

Usage

```
dbernexp(x, prob, rate)
pbernexp(q, prob, rate)
qbernexp(p, prob, rate)
rbernexp(n, prob, rate)
```

Arguments

`x, q`	vector of quantiles.
`p`	vector of probabilities.
`prob`	probability of non-zero event.
`n`	number of random samples.
`rate`	rate parameter of the Exponential distribution.

Details

Mixture of the Bernoulli and the Exponential distribution. The mixture is analogue to the one described for the `berngamma` distribution.

Value

`dbernexp` gives the density (pdf), `pbernexp` gives the distribution function (cdf), `qbernexp` gives the quantile function (inverse cdf), and `rbernexp` generates random numbers.

Author(s)

Lukas Gudmundsson

See Also

`Exponential`, `berngamma`

Examples

```
data(obsprecip)

(ts <- startbernexp(obsprecip[,1]))
hist(obsprecip[,1],freq=FALSE)
lines(seq(0,max(obsprecip[,1])),
      dbernexp(seq(0,max(obsprecip[,1])),
               prob=ts$prob,
               rate=ts$rate),
      col="red")

pp <- seq(0.01,0.99,by=0.01)
qq <-quantile(obsprecip[,1],probs=pp)

plot(qq,pp)
lines(qbernexp(pp,
               prob=ts$prob,
               rate=ts$rate),
      pp,col="red")

plot(qq,pp)
lines(qq,
      pbernexp(qq,
               prob=ts$prob,
               rate=ts$rate),
      col="red")

hist(rbernexp(1000,prob=ts$prob,
              rate=ts$rate),freq=FALSE)
```

`berngamma` *The Bernoulli-Gamma distribution*

Description

Density, distribution function, quantile function and random generation for the Bernoulli-Gamma distribution with parameters `prob`, `shape`, and `scale`.

Usage

```
dberngamma(x, prob, scale, shape)
pberngamma(q, prob, scale, shape)
qberngamma(p, prob, scale, shape)
rberngamma(n, prob, scale, shape)
```

Arguments

`x, q`	vector of quantiles.
`p`	vector of probabilities.
`prob`	probability of non-zero event.
`n`	number of random samples.
`scale, shape`	shape and scale parameters of the gamma distribution.

Details

Mixture of the Bernoulli and the Gamma distribution. The Bernoulli distribution is used to model the occurrence of zero values with the probability of `1-prob`. Non-zero values follow the Gamma distribution with `shape` and `scale` parameters.

The probability density function (PDF) is defined as:

$$g(x) = \begin{cases} \pi * \gamma(x) & \text{if } x > 0 \\ 1 - \pi & \text{if } x \leq 0 \end{cases}$$

where $\gamma(x)$ is the probability density function of the gamma distribution and π is probability of a non-zero event.

The cumulative distribution function (CDF) is defined as:

$$G(x) = \begin{cases} 1 - \pi + \pi * \Gamma(x) & \text{if } x > 0 \\ 1 - \pi & \text{if } x \leq 0 \end{cases}$$

where $\Gamma(x)$ is the cumulative distribution function of the gamma distribution.

The quantile function (inverse of the CDF) is defined as

$$G^{-1}(p) = \begin{cases} \Gamma^{-1}\left(\frac{p-1+\pi}{\pi}\right) & \text{if } \pi > 1 - p \\ 0 & \text{if } p \leq 1 - p \end{cases}$$

where $\Gamma^{-1}(p)$ is the inverse CDF of the gamma distribution and p is a probability.

Value

`dberngamma` gives the density (pdf), `pberngamma` gives the distribution function (cdf), `qberngamma` gives the quantile function (inverse cdf), and `rberngamma` generates random deviates.

Note

The implementation is largely based on the `bgamma` family in the `CaDENCE`-package (Cannon, 2012) that was only available as test version at time of implementation (Mar. 2012).

For further details and meteorological application of Bernoulli-Gamma distributions (also referred to as 'Mixed Gamma' distribution) see Burger et al. 2012, Cannon 2008, Li et al. 2010, Mooley 1973, Piani et al. 2010, Thom 1968, Sloughter et al. 2007.

Author(s)

Lukas Gudmundsson

References

Burger, G.; Murdock, T. Q.; Werner, A. T.; Sobie, S. R. & Cannon, A. J. Downscaling extremes - an intercomparison of multiple statistical methods for present climate. Journal of Climate, American Meteorological Society, early online release, 2012, <doi:10.1175/JCLI-D-11-00408.1>.

Cannon, A. J. Probabilistic Multisite Precipitation Downscaling by an Expanded Bernoulli-Gamma Density Network. Journal of Hydrometeorology, American Meteorological Society, 2008, 9, 1284-1300, <doi:10.1175/2008JHM960.1>.

Cannon, A. J. Neural networks for probabilistic environmental prediction: Conditional Density Estimation Network Creation and Evaluation (CaDENCE) in R. Computers & Geosciences, 2012, 41, 126 - 135, <doi:10.1016/j.cageo.2011.08.023>.

Li, H.; Sheffield, J. & Wood, E. F. Bias correction of monthly precipitation and temperature fields from Intergovernmental Panel on Climate Change AR4 models using equidistant quantile matching. J. Geophys. Res., AGU, 2010, 115, D10101, <doi:10.1029/2009JD012882>.

Mooley, D. A. Gamma Distribution Probability Model for Asian Summer Monsoon Monthly Rainfall. Monthly Weather Review, 1973, 101, 160-176, <doi:10.1175/1520-0493(1973)101<0160:GDPMFA>2.3.CO;2>.

Piani, C.; Haerter, J. & Coppola, E. Statistical bias correction for daily precipitation in regional climate models over Europe. Theoretical and Applied Climatology, 2010, 99, 187-192, <doi:10.1007/s00704-009-0134-9>.

Thom, H. C. S. Approximate convolution of the gamma and mixed gamma distributions. Monthly Weather Review, 1968, 96, 883-886, <doi:10.1175/1520-0493(1968)096<0883:ACOTGA>2.0.CO;2>.

Sloughter, J. M. L.; Raftery, A. E.; Gneiting, T. & Fraley, C. Probabilistic Quantitative Precipitation Forecasting Using Bayesian Model Averaging. Monthly Weather Review, 2007, 135, 3209-3220, <doi:10.1175/MWR3441.1>.

See Also

GammaDist

Examples

```
data(obsprecip)

(ts <- startberngamma(obsprecip[,1]))
hist(obsprecip[,1],freq=FALSE)
lines(seq(0,20),dberngamma(0:20,
                           prob=ts$prob,
                           scale=ts$scale,
                           shape=ts$shape),
      col="red")

pp <- seq(0.01,0.99,by=0.01)
qq <-quantile(obsprecip[,1],probs=pp)

plot(qq,pp)
lines(qberngamma(pp,
                 prob=ts$prob,
                 scale=ts$scale,
                 shape=ts$shape),
```

```
      pp,col="red")

plot(qq,pp)
lines(qq,
      pberngamma(qq,
                 prob=ts$prob,
                 scale=ts$scale,
                 shape=ts$shape),
      col="red")

hist(rberngamma(1000,
                prob=ts$prob,
                scale=ts$scale,
                shape=ts$shape),freq=FALSE)
```

---

bernlnorm *The Bernoulli-Log-Normal distribution*

Description

Density, distribution function, quantile function and random generation for the Bernoulli-Log-Normal distribution with parameters `prob`, `meanlog`, and `sdlog`.

Usage

```
dbernlnorm(x, prob, meanlog, sdlog)
pbernlnorm(q, prob, meanlog, sdlog)
qbernlnorm(p, prob, meanlog, sdlog)
rbernlnorm(n, prob, meanlog, sdlog)
```

Arguments

`x`, `q`	vector of quantiles.
`p`	vector of probabilities.
`prob`	probability of non-zero event.
`n`	number of random samples.
`meanlog`, `sdlog`	meanlog and sdlog parameters of the Log-Normal distribution.

Details

Mixture of Bernoulli and Log-Normal distribution. The mixture is analogue to the one described for the `berngamma` distribution.

Value

`dbernlnorm` gives the density (pdf), `pbernlnorm` gives the distribution function (cdf), `qbernlnorm` gives the quantile function (inverse cdf), and `rbernlnorm` generates random deviates.

Note

The implementation is largely based on the `blnorm` family in the `CaDENCE`-package (Cannon, 2012) that was only available as test version at time of implementation (Mar. 2012).

Author(s)

Lukas Gudmundsson

References

Cannon, A. J. Neural networks for probabilistic environmental prediction: Conditional Density Estimation Network Creation and Evaluation (CaDENCE) in R. Computers & Geosciences, 2012, 41, 126 - 135, <doi:10.1016/j.cageo.2011.08.023>.

See Also

`Lognormal`, `berngamma`

Examples

```
data(obsprecip)

(ts <- startbernlnorm(obsprecip[,1]))
hist(obsprecip[,1],freq=FALSE)
lines(seq(0,20),dbernlnorm(0:20,
                           prob=ts$prob,
                           meanlog=ts$meanlog,
                           sdlog=ts$sdlog),
      col="red")

pp <- seq(0.01,0.99,by=0.01)
qq <-quantile(obsprecip[,1],probs=pp)

plot(qq,pp)
lines(qbernlnorm(pp,
                 prob=ts$prob,
                 meanlog=ts$meanlog,
                 sdlog=ts$sdlog),
      pp,col="red")

plot(qq,pp)
lines(qq,
      pbernlnorm(qq,
                 prob=ts$prob,
                 meanlog=ts$meanlog,
                 sdlog=ts$sdlog),
      col="red")

hist(rbernlnorm(1000,prob=ts$prob,
                meanlog=ts$meanlog,
                sdlog=ts$sdlog),freq=FALSE)
```

bernweibull *The Bernoulli-Weibull distribution*

Description

Density, distribution function, quantile function and random generation for the Bernoulli-Weibull distribution with parameters prob, shape, and scale.

Usage

```
dbernweibull(x, prob, scale, shape)
pbernweibull(q, prob, scale, shape)
qbernweibull(p, prob, scale, shape)
rbernweibull(n, prob, scale, shape)
```

Arguments

x, q	vector of quantiles.
p	vector of probabilities.
prob	probability of non-zero event.
n	number of random samples.
scale, shape	shape and scale parameters of the weibull distribution.

Details

Mixture of Bernoulli and Weibull distribution. The mixture is analogue to the one described for the berngamma distribution.

Value

dbernweibull gives the density (pdf), pbernweibull gives the distribution function (cdf), qbernweibull gives the quantile function (inverse cdf), and rbernweibull generates random deviates.

Note

The implementation is largely based on the bweibull family in the CaDENCE-package (Cannon, 2012) that was only available as test version at time of implementation (Mar. 2012).

Author(s)

Lukas Gudmundsson

References

Cannon, A. J. Neural networks for probabilistic environmental prediction: Conditional Density Estimation Network Creation and Evaluation (CaDENCE) in R. Computers & Geosciences, 2012, 41, 126 - 135, <doi:10.1016/j.cageo.2011.08.023>.

See Also

Weibull, berngamma

Examples

```
data(obsprecip)

(ts <- startbernweibull(obsprecip[,1]))
hist(obsprecip[,1],freq=FALSE)
lines(seq(0,max(obsprecip[,1])),
      dbernweibull(seq(0,max(obsprecip[,1])),
                   prob=ts$prob,
                   shape=ts$shape,
                   scale=ts$scale),
      col="red")

pp <- seq(0.01,0.99,by=0.01)
qq <-quantile(obsprecip[,1],probs=pp)

plot(qq,pp)
lines(qbernweibull(pp,
                   prob=ts$prob,
                   scale=ts$scale,
                   shape=ts$shape),
      pp,col="red")

plot(qq,pp)
lines(qq,
      pbernweibull(qq,
                   prob=ts$prob,
                   scale=ts$scale,
                   shape=ts$shape),
      col="red")

hist(rbernweibull(1000,prob=ts$prob,
                       shape=ts$shape,
                       scale=ts$scale),freq=TRUE)
```

---

fitQmap *Quantile mapping*

Description

fitQmap identifyes the parameters of different quantile mapping methods. doQmap performs quantile mapping using previously identified parameters.

Usage

```
fitQmap(obs,mod,method=c("PTF","DIST","RQUANT","QUANT","SSPLIN"),...)
doQmap(x, fobj, ...)
```

Arguments

`obs`	`numeric` vector, column `matrix` or `data.frame` with observed time series.
`mod`	`numeric` vector, column `matrix` or `data.frame` with modelled time series corresponding to `obs`.
`method`	A character string indicating the method to be used. See Details.
`x`	`numeric` vector or a column `matrix` of modelled time series. Should have the same number of columns as `obs`.
`fobj`	output from `fitQmap` (or of method defined via `method`).
`...`	arguments passed to the method specified by `method`.

Details

The `method` argument decides upon which method for quantile mapping is used:

`"PTF"` selects `fitQmapPTF`.

`"DIST"` selects `fitQmapDIST`

`"RQUANT"` selects `fitQmapRQUANT`

`"QUANT"` selects `fitQmapQUANT`

`"SSPLIN"` selects `fitQmapSSPLIN`

`doQmap` investigates the class of `fobj` and chooses the appropriate method for quantile mapping.

Value

`fitQmap` returns an object which class and structure depends on the selected `method` (see Details).

`doQmap` returns a `numeric` vector, `matrix` or `data.frame` depending on the format of `x`.

Author(s)

Lukas Gudmundsson

References

Gudmundsson, L.; Bremnes, J. B.; Haugen, J. E. & Engen-Skaugen, T. Technical Note: Downscaling RCM precipitation to the station scale using statistical transformations - a comparison of methods, Hydrology and Earth System Sciences, 2012, 16, 3383-3390, <doi:10.5194/hess-16-3383-2012>.

See Also

`fitQmapDIST`, `fitQmapPTF`, `fitQmapRQUANT`, `fitQmapQUANT`, `fitQmapSSPLIN`

Examples

```
data(obsprecip)
data(modprecip)

## call to fitQmapPTF and doQmapPTF
qm1.fit <- fitQmap(obsprecip,modprecip,
              method="PTF",
              transfun="expasympt",
              cost="RSS",wett.day=TRUE)
qm1 <- doQmap(modprecip,qm1.fit)

## call to fitQmapDIST and doQmapDIST
qm2.fit <- fitQmap(sqrt(obsprecip),sqrt(modprecip),
              method="DIST",qstep=0.001,
              transfun="berngamma")
qm2 <- doQmap(sqrt(modprecip),qm2.fit)^2

## call to fitQmapRQUANT and doQmapRQUANT
qm3.fit <- fitQmap(obsprecip,modprecip,
              method="RQUANT",qstep=0.01)
qm3 <- doQmap(modprecip,qm3.fit,type="linear")


## call to fitQmapRQUANT and doQmapRQUANT
qm4.fit <- fitQmap(obsprecip,modprecip,
              method="QUANT",qstep=0.01)
qm4 <- doQmap(modprecip,qm4.fit,type="tricub")

## call to fitQmapSSPLIN and doQmapSSPLIN
qm5.fit <- fitQmap(obsprecip,modprecip,qstep=0.01,
                   method="SSPLIN")
qm5 <- doQmap(modprecip,qm5.fit)

sqrtquant <- function(x,qstep=0.001){
  qq <- quantile(x,prob=seq(0,1,by=qstep))
  sqrt(qq)
}

op <- par(mfrow=c(1,3))
for(i in 1:3){
  plot(sqrtquant(modprecip[,i]),
       sqrtquant(obsprecip[,i]),pch=19,col="gray",
       main=names(obsprecip)[i])
  lines(sqrtquant(modprecip[,i]),
        sqrtquant(qm1[,i]),col=1)
  lines(sqrtquant(modprecip[,i]),
        sqrtquant(qm2[,i]),col=2)
  lines(sqrtquant(modprecip[,i]),
        sqrtquant(qm3[,i]),col=3)
  lines(sqrtquant(modprecip[,i]),
        sqrtquant(qm4[,i]),col=4)
  lines(sqrtquant(modprecip[,i]),
```

```
        sqrtquant(qm5[,i]),col=5)
}
legend("topleft",
       legend=c("PTF","DIST","RQUANT","QUANT","SSPLIN"),
       lty=1, col=1:5)
par(op)
```

---

fitQmapDIST *Quantile mapping using distribution derived transformations*

Description

`fitQmapDIST` fits a theoretical distribution to observed and to modelled time series and returns these parameters as well as a transfer function derived from the distribution. `doQmapDIST` uses the transfer function to transform the distribution of the modelled data to match the distribution of the observations.

Usage

```
fitQmapDIST(obs, mod, ...)
## Default S3 method:
fitQmapDIST(obs,mod,distr="berngamma",start.fun,
qstep=NULL,mlepar,...)
## S3 method for class 'matrix'
fitQmapDIST(obs, mod, ...)
## S3 method for class 'data.frame'
fitQmapDIST(obs, mod, ...)
doQmapDIST(x,fobj,...)
## Default S3 method:
doQmapDIST(x,fobj,...)
## S3 method for class 'matrix'
doQmapDIST(x,fobj,...)
## S3 method for class 'data.frame'
doQmapDIST(x,fobj,...)
```

Arguments

`obs`	`numeric` vector, column `matrix` or `data.frame` with observed time series.
`mod`	`numeric` vector, column `matrix` or `data.frame` with modelled time series, corresponding to `obs`.
`distr`	A character string `"name"` naming a distribution for which the corresponding density function (`dname`), the corresponding distribution function (`pname`) and the quantile function (`qname`) must be defined (see for example `GammaDist`, `berngamma` or `bernweibull`.
`start.fun`	function estimating starting values for parameter optimisation. Default starting values are provided for `berngamma`, `bernweibull`, `bernlnorm`, `bernexp` and the distributions mentioned in the documentation of `mledist`.

qstep	NULL or a numeric value between 0 and 1. If !is.null(qstep) than mod and obs are aggregated to quantiles before model identification as: quantile(x,probs=seq(0,1,by=qstep). This effectively reduces the sample-size and can be used to speedup computations - but may render estimates less reliable.
mlepar	a named list. Names correspond to parameters passed to mledist note that start may be overwritten by start.fun See examples.
x	numeric vector or a column matrix of modelled time series
fobj	output from fitQmapDIST
...	Further arguments passed to methods

Details

Quantile mapping using distribution derived transformations to adjust the distribution of a modelled variable (P_m) such that it matches the distribution of an observed variable (P_o). The distribution derived transfer function is defined as

$$P_o = F_o^{-1}(F_m(P_m))$$

where F is a CDF and F^{-1} is the corresponding quantile function (inverse CDF). The subscripts o and m indicate parameters of the distribution that correspond to observed and modelled data respectively.

Value

fitQmapDIST returns an object of class fitQmapDIST containing following elements:

tfun	The function used to transform the distribution of modelled values such that the distribution of observations. The function is build internally based on the distribution function ("pname") and quantile function ("qname") corresponding to distr.
par	A matrix. The (named) columns correspond to the parameters of the distribution specified in distr estimated for the observed (suffix .o) and the modelled (suffix .m) data. The rows correspond to each pair of time series in obs and mod.

doQmapDIST returns a numeric vector, matrix or data.frame depending on the format of x.

Author(s)

Lukas Gudmundsson

References

Piani, C.; Haerter, J. & Coppola, E. Statistical bias correction for daily precipitation in regional climate models over Europe. Theoretical and Applied Climatology, 2010, 99, 187-192, <doi:10.1007/s00704-009-0134-9>.

Li, H.; Sheffield, J. & Wood, E. F. Bias correction of monthly precipitation and temperature fields from Intergovernmental Panel on Climate Change AR4 models using equidistant quantile matching. J. Geophys. Res., 2010, 115, D10101, <doi:10.1029/2009JD012882>.

Ines, A. V. & Hansen, J. W. Bias correction of daily GCM rainfall for crop simulation studies. Agricultural and Forest Meteorology, 2006, 138, 44 - 53, <doi:10.1016/j.agrformet.2006.03.009>.

For a general assessment of the methods see:

Gudmundsson, L.; Bremnes, J. B.; Haugen, J. E. & Engen-Skaugen, T. Technical Note: Downscaling RCM precipitation to the station scale using statistical transformations - a comparison of methods. Hydrology and Earth System Sciences, 2012, 16, 3383-3390, <doi:10.5194/hess-16-3383-2012>.

See Also

doQmap, startberngamma, berngamma, startbernweibull, bernweibull, startbernlnorm, bernlnorm, startbernexp, bernexp, mledist, fitdist

Examples

```
data(obsprecip)
data(modprecip)

qm.fit <- fitQmapDIST(obsprecip[,1],modprecip[,1],
                      distr="berngamma",
                      qstep=0.001)
qm <- doQmapDIST(modprecip[,1],qm.fit)


# adjusting settings of the maximum likelyhood estimator
# here changing the convergence criterion in the optimizer 'optim'
# Note: the selected value might be to large for true applications.
# Please check for your context.
qm.lnorm.fit <- fitQmapDIST(obsprecip[,1],modprecip[,1],
                      distr="bernlnorm",
                      qstep=0.001,
                      mlepar = list(control = list(
                            reltol = 1e-2
                      )))
qm.lnorm <- doQmapDIST(modprecip[,1],qm.lnorm.fit)

qm.weibu.fit <- fitQmapDIST(obsprecip[,1],modprecip[,1],
                      distr="bernweibull",
                      qstep=0.001)
qm.weibu <- doQmapDIST(modprecip[,1],qm.weibu.fit)

qm.exp.fit <- fitQmapDIST(sqrt(obsprecip[,1]),sqrt(modprecip[,1]),
                      distr="bernexp",
                      qstep=0.001)
qm.exp <- doQmapDIST(sqrt(modprecip[,1]),qm.exp.fit)^2


## utility function.
## plots are easier to investigate if
## precipitation data are sqrt transformed
sqrtquant <- function(x,qstep=0.01){
```

```
  qq <- quantile(x,prob=seq(0,1,by=qstep))
  sqrt(qq)
}

plot(sqrtquant(modprecip[,1]),
     sqrtquant(obsprecip[,1]))
lines(sqrtquant(modprecip[,1]),
      sqrtquant(qm),col="red")
lines(sqrtquant(modprecip[,1]),
      sqrtquant(qm.lnorm),col="blue")
lines(sqrtquant(modprecip[,1]),
      sqrtquant(qm.weibu),col="green")
lines(sqrtquant(modprecip[,1]),
      sqrtquant(qm.exp),col="orange")
legend("topleft",
       legend=c("berngamma","bernlnorm","bernweibull","bernexp"),
       lty=1,
       col=c("red","blue","green","orange"))

## effect of qstep on speed of fitting process:
system.time(
qm.a.fit <- fitQmapDIST(obsprecip[,2],modprecip[,2],
                        distr="berngamma",
                        start.fun=startberngamma,
                        qstep=0.001)
)

system.time(
qm.b.fit <- fitQmapDIST(obsprecip[,2],modprecip[,2],
                        distr="berngamma",
                        start.fun=startberngamma,
                        qstep=0.01)
)

qm.a <- doQmapDIST(modprecip[,2],qm.a.fit)
qm.b <- doQmapDIST(modprecip[,2],qm.b.fit)

plot(sqrtquant(modprecip[,2]),
     sqrtquant(obsprecip[,2]))
lines(sqrtquant(modprecip[,2]),
     sqrtquant(qm.a),col="red")
lines(sqrtquant(modprecip[,2]),
     sqrtquant(qm.b),col="blue")
legend("topleft",
       legend=c("qstep=0.001","qstep=0.01"),
       col=c("red","blue"),
       lty=1)


## method for matrix
## the sqrt() transformation renders the
## fitting procedure more stable
qm2.fit <- fitQmapDIST(sqrt(obsprecip),sqrt(modprecip),
```

```
                       distr="berngamma",
                       qstep=0.001)
qm2 <- doQmapDIST(sqrt(modprecip),qm2.fit)^2

if(!any(is.na(qm2.fit$par))){
  op <- par(mfrow=c(1,3))
  for(i in 1:3){
    plot(sqrtquant(modprecip[,i]),
         sqrtquant(obsprecip[,i]))
    lines(sqrtquant(modprecip[,i]),
          sqrtquant(qm2[,i]),col="red")
  }
 par(op)
}
```

---

fitQmapPTF *Quantile mapping using parametric transformations*

Description

`fitQmapPTF` fits a parametric transformations to the quantile-quantile relation of observed and modelled values. `doQmapPTF` uses the transformation to adjust the distribution of the modelled data to match the distribution of the observations.

Usage

```
fitQmapPTF(obs, mod, ...)
## Default S3 method:
fitQmapPTF(obs, mod, transfun=c("power","linear","expasympt",
"scale","power.x0","expasympt.x0"), wet.day=TRUE,
cost=c("RSS","MAE"), qstep=0.001,opar,...)
## S3 method for class 'matrix'
fitQmapPTF(obs, mod, ...)
## S3 method for class 'data.frame'
fitQmapPTF(obs, mod, ...)
doQmapPTF(x,fobj,...)
## Default S3 method:
doQmapPTF(x,fobj,...)
## S3 method for class 'matrix'
doQmapPTF(x,fobj,...)
## S3 method for class 'data.frame'
doQmapPTF(x,fobj,...)
```

Arguments

`obs`	`numeric` vector, column `matrix` or `data.frame` with observed time series.
`mod`	`numeric` vector, column `matrix` or `data.frame` with modelled time series, corresponding to `obs`.

transfun	either a character string specifying a predefined function used for the transformation (see Details) or a function with x as first argument e.g. `function(x,a,b){a*x^b}`
wet.day	`logical` indicating whether to perform wet day correction or not. OR a `numeric` threshold below which all values are set to zero. See Details.
cost	Criterion for optimisation. "RSS" minimises the residual sum of squares and produces a least square fit. "MAE" minimises the mean absolute error, which is less sensitive to outliers.
qstep	`NULL` or a numeric value between 0 and 1. See Details.
opar	a named list with arguments passed to `optim`. Note that `method` is chosen automatically. If `transfun` is a character string default values for `par` are available (but can be overwritten). See examples.
x	`numeric` vector or a column `matrix` of modelled time series
fobj	output from `fitQmapDIST`
...	Further arguments passed to methods

Details

Before further computations the empirical cumulative distribution functions (CDF) of the observed (`obs`) and modelled (`mod`) are estimated. If `!is.null(qstep)` than `mod` and `obs` are aggregated to quantiles before model identification as: `quantile(x,probs=seq(0,1,by=qstep)`. If `!is.null(qstep)` than `mod` and `obs` are sorted to produce an estimate of the empirical CDF. In case of different length of `mod` and `obs` than `quantile(x,probs=seq(0,1,len=n)]` is used, where `n <- min(length(obs),length(mod))`. NOTE that large values of `qstep` effectively reduce the sample-size and can be used to speedup computations - but may render estimates less reliable.

`wet.day` is intended for the use for precipitation data. Wet day correction attempts to equalise the fraction of days with precipitation between the observed and the modelled data. If `wet.day=TRUE` the empirical probability of nonzero observations is found (`obs>=0`) and the corresponding modelled value is selected as a threshold. All modelled values below this threshold are set to zero. If `wet.day` is `numeric` the same procedure is performed after setting all `obs<wet.day` to zero. The transformations are then only fitted to the portion of the distributions corresponding to observed wet days. See Piani et. al (2010) for further explanations.

Transformations (`transfun`):

NOTE: If wet day correction is performed (see `wet.day`), the transformations are only fitted to the portion of the empirical CDF with nonzero observations.

A series of predefined transformations are available and can be accessed by setting `transfun` to one of the following options (P_o refers to observed and P_m to modelled CDFs):

`"power"`:

$$P_o = b * P_m^c$$

`"linear"`:

$$P_o = a + b * P_m$$

`"expasympt"` (exponential tendency to an asymptote):

$$P_o = (a + b * P_m) * (1 - exp(-P_m/\tau))$$

`"scale"`:

$$P_o = b * P_m$$

`"power.x0"`:

$$P_o = b * (P_m - x0)^c$$

`"expasympt.x0"` (exponential tendency to an asymptote):

$$P_o = (a + b * P_m) * (1 - exp(-(P_m - x0)/\tau))$$

Value

`fitQmapPTF` returns an object of class `fitQmapPTF` containing following elements:

`tfun`	The function used to transform the distribution of the modelled values to match the distribution of the observations.
`par`	A matrix. The (named) columns correspond to the parameters of the transfer function. The rows correspond to pairs of time series in `obs` and `mod`.
`wet.day`	`logical`, indicating whether to perform wet day correction or not. OR a `numeric` threshold below which all values are set to zero.

`doQmapPTF` returns a `numeric` vector, `matrix` or `data.frame` depending on the format of `x`.

Author(s)

Lukas Gudmundsson

References

The implementation is closely related to the methods published in:

Piani, C.; Weedon, G.; Best, M.; Gomes, S.; Viterbo, P.; Hagemann, S. & Haerter, J. Statistical bias correction of global simulated daily precipitation and temperature for the application of hydrological models. Journal of Hydrology, 2010, 395, 199 - 215, <doi:10.1016/j.jhydrol.2010.10.024>.

Dosio, A. & Paruolo, P. Bias correction of the ENSEMBLES high-resolution climate change projections for use by impact models: Evaluation on the present climate. J. Geophys. Res., AGU, 2011, 116, D16106, <doi:10.1029/2011JD015934>.

For a general assessment of the methods see:

Gudmundsson, L.; Bremnes, J. B.; Haugen, J. E. & Engen-Skaugen, T. Technical Note: Downscaling RCM precipitation to the station scale using statistical transformations - a comparison of methods. Hydrology and Earth System Sciences, 2012, 16, 3383-3390, <doi:10.5194/hess-16-3383-2012>.

See Also

`fitQmap`, `optim`

Examples

```
data(obsprecip)
data(modprecip)

## data.frame example
qm.fit <- fitQmapPTF(obsprecip,modprecip,
                     transfun="power.x0",
                     cost="RSS",wet.day=TRUE,
                     qstep=0.001)
qm <- doQmapPTF(modprecip,qm.fit)

## application to "single time series"
qm.b.fit <- fitQmapPTF(obsprecip[,1],modprecip[,1],
                     transfun="expasympt.x0",
                     cost="RSS",wet.day=0.1,
                     qstep=0.001)
qm.b <- doQmapPTF(modprecip[,1],qm.b.fit)
qm.c.fit <- fitQmapPTF(obsprecip[,1],modprecip[,1],
                     transfun="expasympt",
                     cost="RSS",wet.day=TRUE,
                     qstep=0.001)
qm.c <- doQmapPTF(modprecip[,1],qm.c.fit)

## user defined transfer function
## and usage of the 'opar' argument
## (same as transfun="power")
myff <- function(x,a,b) a*x^b

qm3.fit <- fitQmapPTF(obsprecip[,1],modprecip[,1],
                     transfun=myff,
                     opar=list(par=c(a=1,b=1)),
                     cost="RSS",wet.day=TRUE,
                     qstep=0.001)
qm3 <- doQmapPTF(modprecip[,1],qm3.fit)


sqrtquant <- function(x,qstep=0.01){
  qq <- quantile(x,prob=seq(0,1,by=qstep))
  sqrt(qq)
}
plot(sqrtquant(modprecip[,1]),
     sqrtquant(obsprecip[,1]))
lines(sqrtquant(modprecip[,1]),
      sqrtquant(qm[,1]),col="red")
lines(sqrtquant(modprecip[,1]),
      sqrtquant(qm.b),col="blue")
lines(sqrtquant(modprecip[,1]),
      sqrtquant(qm.c),col="green")
lines(sqrtquant(modprecip[,1]),
      sqrtquant(qm3),col="orange")
legend("topleft",
       legend=c("power.x0","expasympt.x0",
```

```
    "expasympt","myff"),
  col=c("red","blue","green","orange"),lty=1)
```

`fitQmapQUANT` *Non-parametric quantile mapping using empirical quantiles.*

Description

`fitQmapQUANT` estimates values of the empirical cumulative distribution function of observed and modelled time series for regularly spaced quantiles. `doQmapQUANT` uses these estimates to perform quantile mapping.

Usage

```
fitQmapQUANT(obs, mod, ...)
## Default S3 method:
fitQmapQUANT(obs,mod,wet.day=TRUE,qstep=0.01,
nboot = 1,...)
## S3 method for class 'matrix'
fitQmapQUANT(obs, mod, ...)
## S3 method for class 'data.frame'
fitQmapQUANT(obs, mod, ...)
doQmapQUANT(x,fobj,...)
## Default S3 method:
doQmapQUANT(x,fobj, type=c("linear","tricub"),...)
## S3 method for class 'matrix'
doQmapQUANT(x,fobj,...)
## S3 method for class 'data.frame'
doQmapQUANT(x,fobj,...)
```

Arguments

`obs`	`numeric` vector, column `matrix` or `data.frame` with observed time series.
`mod`	`numeric` vector, column `matrix` or `data.frame` with modelled time series, corresponding to `obs`.
`wet.day`	`logical` indicating whether to perform wet day correction or not. OR a `numeric` threshold below which all values are set to zero. See details.
`qstep`	a numeric value between 0 and 1. The quantile mapping is fitted only for the quantiles defined by `quantile(0,1,probs=seq(0,1,by=qstep)`.
`nboot`	number of bootstrap samples used for estimation of the observed quantiles. If `nboot==1` the estimation is based on all (and not resampled) data. See details.
`x`	`numeric` vector or a column `matrix` of modelled time series
`fobj`	output from `fitQmapQUANT`
`type`	type of interpolation between the fitted transformed values. See details.
`...`	Further arguments passed to methods

Details

fitQmapQUANT estimates the empirical cumulative distribution function of mod and obs for the quantiles defined by seq(0,1,by=qstep). The quantiles of mod are estimated using the empirical quantiles. If nboot>1 the quantiles of obs are estimated as the mean of nboot bootstrap samples (if nboot>1).

doQmapQUANT transforms the variable x based on the transformation identified using fitQmapQUANT. For all values that are not in quantile(mod,probs=seq(0,1,by=qstep)) the transformation is estimated using interpolation of the fitted values. Available interpolation options are:

type="linear": linear interpolation using approx, but using the extrapolation suggested by Boe et al. (2007) for values of x larger than max(mod) (constant correction).

type="tricube": monotonic tricubic spline interpolation using splinefun. Spline interpolation is performed using a _monotone_ Hermite spline (method="monoH.FC" in splinefun).

wet.day is intended for the use for precipitation data. Wet day correction attempts to equalise the fraction of days with precipitation between the observed and the modelled data. If wet.day=TRUE the empirical probability of nonzero observations is found (obs>=0) and the corresponding modelled value is selected as a threshold. All modelled values below this threshold are set to zero. If wet.day is numeric the same procedure is performed after setting all obs<wet.day to zero.

Value

fitQmapQUANT returns an object of class fitQmapQUANT containing following elements:

par	A list containing:
par$modq	a matrix. Each column i corresponds to the output of quantile(mod[,i],probs=seq(0,1,by=qstep)).
par$fitq	observed empirical quantiles corresponding to par$modq.
wet.day	logical, indicating whether to perform wet day correction or not. OR a numeric threshold below which all values are set to zero.

doQmapQUANT returns a numeric vector or matrix depending on the format of x.

Author(s)

Lukas Gudmundsson

References

Boe, J.; Terray, L.; Habets, F. & Martin, E. Statistical and dynamical downscaling of the Seine basin climate for hydro-meteorological studies. International Journal of Climatology, 2007, 27, 1643-1655, <doi:10.1002/joc.1602>.

For a general assessment of the methods see:

Gudmundsson, L.; Bremnes, J. B.; Haugen, J. E. & Engen-Skaugen, T. Technical Note: Downscaling RCM precipitation to the station scale using statistical transformations - a comparison of methods. Hydrology and Earth System Sciences, 2012, 16, 3383-3390, <doi:10.5194/hess-16-3383-2012>.

See Also

fitQmap

Examples

```
data(obsprecip)
data(modprecip)

qm.fit <- fitQmapQUANT(obsprecip[,2],modprecip[,2],
                      qstep=0.1,nboot=1,wet.day=TRUE)
qm.a <- doQmapQUANT(modprecip[,2],qm.fit,type="linear")
qm.s <- doQmapQUANT(modprecip[,2],qm.fit,type="tricub")


sqrtquant <- function(x,qstep=0.01){
  qq <- quantile(x,prob=seq(0,1,by=qstep))
  sqrt(qq)
}

plot(sqrtquant(modprecip[,2]),
     sqrtquant(obsprecip[,2]))
lines(sqrtquant(modprecip[,2]),
      sqrtquant(qm.a),col="red")
lines(sqrtquant(modprecip[,2]),
      sqrtquant(qm.s),col="blue")
points(sqrt(qm.fit$par$modq),sqrt(qm.fit$par$fitq),
       pch=19,cex=0.5,col="green")
legend("topleft",
       legend=c("linear","tricub","support"),
       lty=c(1,1,NA),pch=c(NA,NA,19),
       col=c("red","blue","green"))


qm2.fit <- fitQmapQUANT(obsprecip,modprecip,
                      qstep=0.01,nboot=1,wet.day=TRUE)
qm2 <- doQmapQUANT(modprecip,qm2.fit,type="tricub")

op <- par(mfrow=c(1,3))
for(i in 1:3){
  plot(sqrtquant(modprecip[,i]),
       sqrtquant(obsprecip[,i]),
       main=names(qm2)[i])
  lines(sqrtquant(modprecip[,i]),
        sqrtquant(qm2[,i]),col="red")
  points(sqrt(qm2.fit$par$modq[,i]),
         sqrt(qm2.fit$par$fitq[,i]),
       pch=19,cex=0.5,col="green")

}
par(op)
```

fitQmapRQUANT *Non-parametric quantile mapping using robust empirical quantiles.*

Description

fitQmapRQUANT estimates the values of the quantile-quantile relation of observed and modelled time series for regularly spaced quantiles using local linear least square regression. doQmapRQUANT performs quantile mapping by interpolating the empirical quantiles.

Usage

```
fitQmapRQUANT(obs, mod, ...)
## Default S3 method:
fitQmapRQUANT(obs,mod,wet.day=TRUE,qstep=0.01,
nlls = 10,nboot = 10,...)
## S3 method for class 'matrix'
fitQmapRQUANT(obs, mod, ...)
## S3 method for class 'data.frame'
fitQmapRQUANT(obs, mod, ...)
doQmapRQUANT(x,fobj,...)
## Default S3 method:
doQmapRQUANT(x,fobj,slope.bound=c(lower=0,upper=Inf),
type=c("linear","linear2","tricub"),...)
## S3 method for class 'matrix'
doQmapRQUANT(x,fobj,...)
## S3 method for class 'data.frame'
doQmapRQUANT(x,fobj,...)
```

Arguments

obs	numeric vector, column matrix or data.frame with observed time series.
mod	numeric vector or column matrix/data.frame with modelled time series, corresponding to obs
wet.day	logical, indicating whether to perform wet day correction or not. OR a numeric threshold below which all values are set to zero. See details.
qstep	A numeric value between 0 and 1. The values quantile-quantile plot are estimated at the position of the values defined by: quantile(mod,probs=seq(0,1,by=qstep)).
nlls	number of nearest data points to apply in the local regression
nboot	number of bootstrap samples in the estimation of the transformation. If nboot==1 the estimation is based on all (and not resampled) data.
x	numeric vector or a column matrix of modelled time series
fobj	output from fitQmapRQUANT
slope.bound	bounds for the slopes in case of extrapolation. Applies only if type="linear2"
type	type of interpolation between the fitted transformed values. See details
...	Further arguments passed to methods

Details

`fitQmapRQUANT` produces a robust estimate of the empirical quantile-quantile plot (QQ-plot) of `mod` vs `obs` for the `seq(0,1,by=qstep)` quantiles `mod`. The corresponding value of the quantiles of `obs` is estimated using local linear least squares regression. For each quantile of `mod` the `nlls` nearest data points in the QQ-plot are identified and used to fit a local regression line. This regression line is then used to estimate value of the quantile of `obs`. The estimation is replicated for `nboot` bootstrap samples and the mean of the bootstrap replicates is returned.

This procedure results in a table with empirical quantiles of `mod` and a corresponding table with robust estimates of the empirical quantiles of `obs`.

`doQmapRQUANT` uses the tables of robust empirical quantiles identified using `fitQmapRQUANT` to transform the variable `x`. For values that are not in

`quantile(mod,probs=seq(0,1,by=qstep))` the transformation is estimated using interpolation of the fitted values. Available interpolation options are:

`type="linear"`: linear interpolation using `approx`, but using the extrapolation suggested by Boe et al. (2007) for values of `x` larger than max(mod) (constant correction).

`type="linear2"`: linear interpolation using `approx`. For any value of `x` outside `range(mod)` the transformation is extrapolated using the slope of the local linear least squares regression at the outer most points.

`type="tricube"`: monotonic tricubic spline interpolation using `splinefun`. Spline interpolation is performed using a _monotone_ Hermite spline (`method="monoH.FC"` in `splinefun`).

`wet.day` is intended for the use for precipitation data. Wet day correction attempts to equalise the fraction of days with precipitation between the observed and the modelled data. If `wet.day=TRUE` the empirical probability of nonzero observations is found (`obs>=0`) and the corresponding modelled value is selected as a threshold. All modelled values below this threshold are set to zero. If `wet.day` is `numeric` the same procedure is performed after setting all `obs<wet.day` to zero.

Value

`fitQmapRQUANT` returns an object of class `fitQmapRQUANT` containing following elements:

`par`	A list containing:
`par$modq`	a matrix. Each column `i` corresponds to the output of `quantile(mod[,i],probs=seq(0,1,by=qstep))`.
`par$fitq`	the fitted values of the local linear least square regression corresponding to `par$modq`
`par$slope`	a matrix. the columns correspond to the columns of `mod`. The rows contain the slope of the `"lower"` and the `"upper"` extreme points of the local linear fit and is used for extrapolation if `type="linear2"`.
`wet.day`	`logical`, indicating whether to perform wet day correction or not. OR a `numeric` threshold below which all values are set to zero.

`doQmapRQUANT` returns a `numeric` vector or `matrix` depending on the format of `x`.

Author(s)

John Bjornar Bremnes and Lukas Gudmundsson

References

Boe, J.; Terray, L.; Habets, F. & Martin, E. Statistical and dynamical downscaling of the Seine basin climate for hydro-meteorological studies. International Journal of Climatology, 2007, 27, 1643-1655, <doi:10.1002/joc.1602>.

See Also

fitQmap

Examples

```
data(obsprecip)
data(modprecip)

## single series example
qm.fit <- fitQmapRQUANT(obsprecip[,2],modprecip[,2],
                      qstep=0.1,nboot=10,wet.day=TRUE)
qm.a <- doQmapRQUANT(modprecip[,2],qm.fit,type="linear")
qm.b <- doQmapRQUANT(modprecip[,2],qm.fit,type="tricub")

sqrtquant <- function(x,qstep=0.01){
  qq <- quantile(x,prob=seq(0,1,by=qstep))
  sqrt(qq)
}

plot(sqrtquant(modprecip[,2]),
     sqrtquant(obsprecip[,2]))
lines(sqrtquant(modprecip[,2]),
      sqrtquant(qm.a),col="red")
lines(sqrtquant(modprecip[,2]),
      sqrtquant(qm.b),col="blue")
points(sqrt(qm.fit$par$modq),sqrt(qm.fit$par$fitq),
       pch=19,cex=1,col="green")
legend("topleft",
       legend=c("linear","tricub","support","data"),
       lty=c(1,1,NA,NA),pch=c(NA,NA,19,21),
       col=c("red","blue","green","black"))

qm2.fit <- fitQmapRQUANT(obsprecip,modprecip,
                       qstep=0.02,nboot=1,
                       wet.day=TRUE)
qm2 <- doQmapRQUANT(modprecip,qm2.fit,type="tricub")

op <- par(mfrow=c(1,3))
for(i in 1:3){
  plot(sqrtquant(modprecip[,i]),
       sqrtquant(obsprecip[,i]),
       main=names(qm2)[i])
  lines(sqrtquant(modprecip[,i]),
        sqrtquant(qm2[,i]),col="red")
  points(sqrt(qm2.fit$par$modq[,i]),
         sqrt(qm2.fit$par$fitq[,i]),
```

```
        pch=19,cex=0.5,col="green")

}
par(op)
```

fitQmapSSPLIN *Quantile mapping using a smoothing spline*

Description

`fitQmapSSPLIN` fits a smoothing spline to the quantile-quantile plot of observed and modelled time series. `doQmapSSPLIN` uses the spline function to adjust the distribution of the modelled data to match the distribution of the observations.

Usage

```
fitQmapSSPLIN(obs, mod, ...)
## Default S3 method:
fitQmapSSPLIN(obs,mod,wet.day=TRUE,qstep=0.01,
spline.par,...)
## S3 method for class 'matrix'
fitQmapSSPLIN(obs, mod, ...)
## S3 method for class 'data.frame'
fitQmapSSPLIN(obs, mod, ...)
doQmapSSPLIN(x,fobj,...)
## Default S3 method:
doQmapSSPLIN(x,fobj,...)
## S3 method for class 'matrix'
doQmapSSPLIN(x,fobj,...)
## S3 method for class 'data.frame'
doQmapSSPLIN(x,fobj,...)
```

Arguments

`obs`	`numeric` vector, column `matrix` or `data.frame` with observed time series.
`mod`	`numeric` vector, column `matrix` or `data.frame` with modelled time series, corresponding to `obs`.
`wet.day`	`logical`, indicating whether to perform wet day correction or not. OR a `numeric` threshold below which all values are set to zero. See details.
`qstep`	`NULL` or a numeric value between 0 and 1. See Details.
`spline.par`	a named list with parameters passed to `smooth.spline`.
`x`	`numeric` vector or a column `matrix` of modelled time series
`fobj`	output from `fitQmapDIST`
`...`	Further arguments passed to methods

Details

Before further computations the empirical cumulative distribution functions (CDF) of the observed (obs) and modelled (mod) are estimated. If !is.null(qstep) than mod and obs are aggregated to quantiles before model identification as: quantile(x,probs=seq(0,1,by=qstep). If !is.null(qstep) than mod and obs are sorted to produce an estimate of the empirical CDF. In case of different length of mod and obs than quantile(x,probs=seq(0,1,len=n)] is used, where

n <- min(length(obs),length(mod)). NOTE that large values of qstep effectively reduce the sample-size and can be used to speedup computations - but may render estimates less reliable.

wet.day is intended for the use for precipitation data. Wet day correction attempts to equalise the fraction of days with precipitation between the observed and the modelled data. If wet.day=TRUE the empirical probability of nonzero observations is found (obs>=0) and the corresponding modelled value is selected as a threshold. All modelled values below this threshold are set to zero. If wet.day is numeric the same procedure is performed after setting all obs<wet.day to zero. The transformations are then only fitted to the portion of the distributions corresponding to observed wet days.

Value

fitQmapSSPLIN returns an object of class fitQmapSSPLIN containing following elements:

par — A list containing objects of class smooth.spline.fit, which are equivalent to the value of the element fit in the output of smooth.spline. The spline coefficients are checked for monotony and adjusted if necessary by replacement with the previous value. If mod is a matrix the names of par correspond to colnames(mod).

wet.day — logical, indicating whether to perform wet day correction or not. OR a numeric threshold below which all values are set to zero.

doQmapSSPLIN returns a numeric vector or matrix depending on the format of x.

Author(s)

Lukas Gudmundsson

References

Gudmundsson, L.; Bremnes, J. B.; Haugen, J. E. & Engen-Skaugen, T. Technical Note: Downscaling RCM precipitation to the station scale using statistical transformations - a comparison of methods. Hydrology and Earth System Sciences, 2012, 16, 3383-3390, <doi:10.5194/hess-16-3383-2012>.

See Also

fitQmap, smooth.spline

Examples

```
data(obsprecip)
data(modprecip)

qm.a.fit <- fitQmapSSPLIN(obsprecip[,2],modprecip[,2],
                      qstep=0.01,wet.day=TRUE)
qm.a <- doQmapSSPLIN(modprecip[,2],qm.a.fit)

## example on how to use spline.par
## (this example has little effect)
qm.b.fit <- fitQmapSSPLIN(obsprecip[,2],modprecip[,2],
                          qstep=0.01,wet.day=TRUE,
                          spline.par=list(cv=TRUE))
qm.b <- doQmapSSPLIN(modprecip[,2],qm.b.fit)

sqrtquant <- function(x,qstep=0.01){
  qq <- quantile(x,prob=seq(0,1,by=qstep))
  sqrt(qq)
}

plot(sqrtquant(modprecip[,2]),
     sqrtquant(obsprecip[,2]))
lines(sqrtquant(modprecip[,2]),
      sqrtquant(qm.a),col="red")
lines(sqrtquant(modprecip[,2]),
      sqrtquant(qm.b),col="blue")
legend("topleft",legend=c("cv=FALSE","cv=TRUE"),
       lty=1,col=c("red","blue"))

qm2.fit <- fitQmapSSPLIN(obsprecip,modprecip,
                      qstep=0.1,wet.day=TRUE)
qm2 <- doQmapSSPLIN(modprecip,qm2.fit)


op <- par(mfrow=c(1,3))
for(i in 1:3){
  plot(sqrtquant(modprecip[,i]),
       sqrtquant(obsprecip[,i]),
       main=names(qm2)[i])
  lines(sqrtquant(modprecip[,i]),
        sqrtquant(qm2[,i]),col="red")
}
par(op)
```

---

obsprecip *Daily precipitation data at three locations in Norway.*

Description

Observed (`obsprecip`) and simulated (`modprecip`) daily precipitation data for three locations in Norway covering the 1961 - 1990 period.

Usage

```
data(obsprecip)
data(modprecip)
```

Format

Data frame(s) with rows representing days and with the following 3 variables.

`MOSS` Daily Precipitation at Moss [mm/day]

`GEIRANGER` Daily Precipitation at Geiranger [mm/day]

`BARKESTAD` Daily Precipitation at Barkestad [mm/day]

Details

The time series in `obsprecip` stem from the observation-system of the Norwegian Meteorological Institute.

The time series in `modprecip` are based on simulations of HIRHAM2/NorACIA regional climate model forced with simulation the HadAM3H. The simulation setup is further described in Forland et al. 2011. The simulations are free-running and there is consequently no direct correspondence in the temporal evolution of `modprecip` and `obsprecip`.

NOTE that all months in the modelled data (`modprecip`) have 30 days (in contrast to the observations (`obsprecip`) which have true calender days.

Source

The observations are taken form the observation network of the Norwegian meteorological institute (https://www.met.no/).

References

Forland, E. J.; Benestad, R.; Hanssen-Bauer, I.; Haugen, J. E. & Skaugen, T. E. Temperature and Precipitation Development at Svalbard 1900-2100. Advances in Meteorology, 2011, Volume 2011, 893790, <doi:10.1155/2011/893790>.

Examples

```
data(obsprecip)
data(modprecip)
```

`startbernexp` *Rough parameter estimate for the Bernoulli-Exponential distribution*

Description

Estimates rough starting values for the Bernoulli-Exponential distribution using the method of moments for the `rate` parameter. The probability of non-zero events is estimated as the fraction of values that are larger than zero.

Usage

```
startbernexp(x)
```

Arguments

`x`	numeric vector.

Value

A list containing:

`prob`	probability of non-zero event.
`rate`	rate parameter of the Exponential distribution.

Note

In this package `startbernexp` is intended to be used in conjunction with `fitQmapDIST` (and `mledist`) with parameter `distr="bernexp"`.

Author(s)

Lukas Gudmundsson

See Also

`fitQmapDIST`, `bernexp`, `fitdist`

Examples

```
gg <- rbernexp(n=300, prob=0.2, rate=1)
startbernexp(gg)
mledist(gg,"bernexp",startbernexp(gg))
```

`startberngamma` *Rough parameter estimate for the Bernoulli-Gamma distribution*

Description

Estimates rough starting values for the Bernoulli-Gamma distribution using the method of moments for the `shape` and the `scale` parameters. The probability of non-zero events is estimated as the fraction of values that are larger than zero.

Usage

```
startberngamma(x)
```

Arguments

`x`	numeric vector.

Value

A list containing:

`prob`	probability of non-zero event.
`scale`	scale parameter of the gamma distribution.
`shape`	shape parameter of the gamma distribution.

Note

In this package `startberngamma` is intended to be used in conjunction with `fitQmapDIST` (and `mledist`) with parameter `distr="berngamma"`.

Author(s)

Lukas Gudmundsson

See Also

`fitQmapDIST`, `berngamma`, `fitdist`

Examples

```
gg <- rberngamma(n=300, prob=0.2, scale=1, shape=1)
startberngamma(gg)
mledist(gg,"berngamma",startberngamma(gg))
```

startbernlnorm — *Rough parameter estimate for the Bernoulli-Log-Normal distribution*

Description

Estimates rough starting values for the Bernoulli-Log-Normal distribution using the method of moments for the `meanlog` and the `sdlog` parameters. The probability of non-zero events is estimated as the fraction of values that are larger than zero.

Usage

```
startbernlnorm(x)
```

Arguments

`x`	numeric vector.

Value

A list containing:

`prob`	probability of non-zero event.
`meanlog`	meanlog parameter of the Log-Normal distribution.
`sdlog`	sdlog parameter of the Log-Normal distribution.

Note

In this package `startbernlnorm` is intended to be used in conjunction with `fitQmapDIST` (and `mledist`) with parameter `distr="bernlnorm"`.

Author(s)

Lukas Gudmundsson

See Also

`fitQmapDIST`, `bernlnorm`, `fitdist`

Examples

```
gg <- rbernlnorm(n=300, prob=0.2, meanlog=1, sdlog=1)
startbernlnorm(gg)
mledist(gg,"bernlnorm",startbernlnorm(gg))
```

startbernweibull *Rough parameter estimate for the Bernoulli-Weibull distribution*

Description

Estimates rough starting values for the Bernoulli-Weibull distribution using the method of moments for the `shape` and the `scale` parameters. The probability of non-zero events is estimated as the fraction of values that are larger than zero.

Usage

```
startbernweibull(x)
```

Arguments

`x`	numeric vector.

Value

A list containing:

`prob`	probability of non-zero event.
`scale`	scale parameter of the weibull distribution.
`shape`	shape parameter of the weibull distribution.

Note

In this package `startbernweibull` is intended to be used in conjunction with `fitQmapDIST` (and `mledist`) with parameter `distr="bernweibull"`.

Author(s)

Lukas Gudmundsson

See Also

`fitQmapDIST`, `bernweibull`, `fitdist`

Examples

```
gg <- rbernweibull(n=300, prob=0.2, scale=1, shape=1)
startbernweibull(gg)
mledist(gg,"bernweibull",startbernweibull(gg))
```

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