Package ‘LPM’

January 20, 2025

Title Linear Parametric Models Applied to Hydrological Series

Version 3.2

Depends R (>= 3.5)

Date 2024-06-15

Description Apply Univariate Long Memory Models,
Apply Multivariate Short Memory Models To Hydrological Dataset,
Estimate Intensity Duration Frequency curve to rainfall series.
NEW -- Calculate the monthly water requirement for herbaceous and arboreal plants.

Imports stats, graphics, grDevices, fracdiff, powdist, MASS

License GPL-2

Maintainer Corrado Tallerini <corrado.tallerini@gmx.com>

URL http://www.corradotallerini.altervista.org/LPM.html

BugReports http://www.corradotallerini.altervista.org/Contatti.html

Encoding UTF-8

Author Corrado Tallerini [aut, cre],
Salvatore Grimaldi [aut]

NeedsCompilation no

Repository CRAN

Date/Publication 2024-06-15 15:50:02 UTC

Contents

LPM-package *LPM*

Description

Apply Univariate Long Memory Models, Apply Multivariate Short Memory Models To Hydrological Dataset, Estimate Intensity Duration Frequency curve to rainfall series. NEW – Calculate the monthly water requirement for herbaceous and arboreal plants.

Details

See `ar.egls`, `lpm`, `mlpm` `rain.adapt` `WNeeds` `PWN`

Author(s)

Authors: Salvatore Grimaldi and Corrado Tallerini

Maintainer: Corrado Tallerini

References

Grimaldi S., Tallerini C., Serinaldi F. (2004) 'Modelli multivariati lineari per la generazione di serie di precipitazioni giornaliere' Giornata di Studio: Metodi Statistici e Matematici per l'Analisi Idrologiche Napoli 2004

Grimaldi S. , Serinaldi F. & Tallerini C. (2004) 'Multivariate linear parametric models applied to daily rainfall time series' Mediterranean Storms, 6rd EGU Plinius Conference held in Mediterranean Sea, Italy, October 2004

Lutkepohl, H. (1993) Introduction to Multiple Time Series Analysis 2nd edition, Springer-Verlag, Berlin.

Grimaldi, S., 'Linear parametric models applied on daily hydrological series', Journal of Hydrologic Engineering, Vol. 9, No 5 , September 2004.

Brockwell, P.J and Davis, R.A. (1990) Time Series: Theory and Methods 2nd edition, Springer, NY.

Hipel, K.W. and McLeod, A.I., (1994) Time Series Modelling of Water Resources and Enviromental Systems, Reading, UK.

Hosking, J.R.M. (1980) 'The Multivariate Portmanteau Statistic' Journal of the American Statistical Association, Vol.75, N.371, 502-608.

United States Department of Agricolture (USDA - SCS). IRRIGATION - National Engineering handbook.

Fao irrigation and dreinage paper N. 24 - Crop water requirement, Food and agriculture organization of the united nations ROME, rivisited 1977

Moisello U. "Idrologia Tecnica" La Goliardica Pavese.

Genovesi R., Bottau D. "L'importanza della falda nell' alimentazione idrica delle colture nella pianura emiliano-romagnola."

Regione Campania - Assessorato Agricoltura - Settore S.I.R.C.A. La tessitura del suolo (foglio divulgativo novembre - dicembre 2002)

`ar.egls` *Subset Autoregressive Model*

Description

Estimate VAR(p) model fixing some parameter values to zero

Usage

```
ar.egls(x, R, order.max , na.action = na.fail, series = NULL, ...)
```

Arguments

`x`	Univariate or multivariate series with nil mean
`R`	Matrices of parameters selection
`order.max`	Model order
`na.action`	Function to be called to handle missing values
`series`	Names for the series. Defaults to 'deparse(substitute(x))'
`...`	See ar.ols

Details

R matrix is a list of p matrices, with p the autoregressive order. In R value '1' allows parameter estimation, '0' fix the parameter value to zero.

Value

See ar.ols

Note

Function is created modifing ar.ols by Adrian Trapletti and Brian Ripley

Author(s)

Corrado Tallerini

References

Grimaldi S. , Serinaldi F. & Tallerini C. (2004) 'Multivariate linear parametric models applied to daily rainfall time series' Mediterranean Storms, 6rd EGU Plinius Conference held in Mediterranean Sea, Italy, October 2004

Lutkepohl, H. (1993) Introduction to Multiple Time Series Analysis 2nd Edition ._ Springer Verlag, NY

Examples

```
## S1=matrix(0,3,3)
## S1[1,1]=1
## S1[1,2]=1
## S=list()
## S[[1]]=S1
## S[[2]]=S1
## ar.egls(series.rainfall[,1:3],S,order.max=2)
## --> Apply a Subset VAR(2) model restricted to 4 parameters (position (1,1)
## --> and (1,2) in both matrices) to first 3 series of series.rainfall
## --> dataset
```

---

hourly.rainfall.series

hourly rainfall series

Description

Hourly rainfall series recorded in Burlington (US) during the period 2012-2015.

Usage

```
data(hourly.rainfall.series)
```

Details

Dataset is available on The Iowa Environmental Mesonet (IEM) website

Source

https://mesonet.agron.iastate.edu/request/download.phtml?

Examples

```
data(hourly.rainfall.series)
## maybe str(series.rainfall) ; plot(series.rainfall) ...
```

`IDFcurve` *Intensity duration frequency curve*

Description

Estimate IDF curve fitting a [mm/h], m ,n, b[h] parameters

Usage

```
IDFcurve(rain, g, s, tc, stvalue1 = 1, stvalue2 = fre, fre, Tr = 200,
                       MP=F, Trplot=F)
```

Arguments

`rain`	Observed Univariate rainfall series non cumulative
`g`	Maximum bound for cumulative series. For daily series g = 7 is recommended, for hourly series g=24 is racommended
`s`	Threshold for defining "event". If "10", only h > = 10 mm values are considered
`tc`	Time of concentration of Basin [h]
`stvalue1, stvalue2`	Starting values of estimation algorithm. Deault stvalue1=1, stvalue2=fre
`fre`	Series frequency [h]. For daily series fre=24, for hourly series fre=1
`Tr`	Return period [y]. Default Tr=200
`MP`	logical: TRUE for 3 parameters formula i=a/(b+t)^m , FALSE for 2 parameters formula i=a*t^(n-1), Default MP=False
`Trplot`	logical: TRUE for plotting Tr values of a(Tr) parameter. Default Trplot=False

Details

Estimate parameters of Intensity Duration Frequency curves

Value

`par`	List of estimated parameters: a(tr), m, b, h(t) [mm], i(t) [mm/h], Offset of least squares optimizer
`Curve`	IDF curve Scattered point matrix [mm/h]

Note

a(tr) is defined by Gumbel distribution.

Author(s)

Corrado Tallerini

See Also

IDFcurve2

Examples

```
##    data(hourly.rainfall.series)
##    res = IDFcurve(hourly.rainfall.series ,24, 15, 1, fre=1, Tr=200, MP=F)
## --> 2 parameters IDF curve estimation of a hourly rainfall series applying
## --> a Threshold "15 mm"  and Time of concentration t=1 h
##    res = IDFcurve(hourly.rainfall.series ,24, 15, 1, fre=1, Tr=200, MP=T)
## --> 3 parameters IDF curve estimation of a hourly rainfall series applying
## --> a Threshold "15 mm"  and Time of concentration t=1 h
## --> It's obvious the best performance of the 3 parameters formula
```

IDFcurve2 — *Intensity duration frequency curve for maximum annual rainfall series of different duration*

Description

Estimate IDF curve fitting a [mm/h], m ,n, b[h] parameters of maximum annual rainfall series

Usage

```
IDFcurve2(rain, tc, stvalue1 = 1, stvalue2 = 1, t, Tr = 200, MP = F, Trplot = F)
```

Arguments

`rain`	Observed Maximum annual rainfall series [mm] of increasing duration
`tc`	Time of concentration of Basin [h] , maybe h(t) and i(t) duration must be calculated
`stvalue1, stvalue2`	Starting values of estimation algorithm. Deault stvalue1=1, stvalue2=1
`t`	observed rainfall series duration [h] example t=c(1,3,6,12,24) for durations 1,3,6,12,24 hours
`Tr`	Return period [y]. Default Tr=200
`MP`	logical: TRUE for 3 parameters formula i=a/(b+t)^m , FALSE for 2 parameters formula i=a*t^(n-1), Default MP=False
`Trplot`	logical: TRUE for plotting Tr values of a(Tr) parameter. Default Trplot=False

Details

Estimate parameters of Intensity Duration Frequency curves for maximum annual rainfall series of different duration

Value

par	List of estimated parameters: a(Tr), m, b, h(t) [mm], i(t) [mm/h], Offset of least squares optimizer
I	I(t) curve scattered point matrix [mm/h]
Curve	IDF curve scattered point matrix [mm/h]

Note

a(Tr) is defined by Gumbel distribution.

Author(s)

Corrado Tallerini

See Also

IDFcurve

Examples

```
##     data(milano)
##     ris=IDFcurve2(milano, 1, stvalue1 = 1, stvalue2 = 1,
##     t=c(0.25,0.5,0.75,1,1.25,1.5,2,2.5,3,4,6), Tr = 200, MP=F)
## --> 2 parameters IDF curve estimation of annual maximum rainfall
##     series recorded in Palazzo Marino - Milan (Italy)
##     ris=IDFcurve2(milano, 1, stvalue1 = 1, stvalue2 = 1,
##     t=c(0.25,0.5,0.75,1,1.25,1.5,2,2.5,3,4,6), Tr = 200, MP=T)
## --> 3 parameters IDF curve estimation of annual maximum rainfall
##     series recorded in Palazzo Marino - Milan (Italy)
## --> It's obvious the best performance of the 3 parameters formula
```

---

lpm *Linear Parametric Model*

Description

Estimate ARMA and FARMA models, make simulations and ed eventually apply a corrective procedure to rainfall synthetic series. Besides you can remove seasonal components with STL modified method.

Usage

```
lpm(x, p, q, n, smean, svar, outer=0, prob = 0.95, fre = 365,
fractional = F, Plag = 20, lsign=0.05, n1 = 399, trasfo = F, des = T, rain = F, graph = F)
```

Arguments

`x`	Univariate series
`p`	AR order
`q`	MA order
`n`	Number of series to simulate
`outer`	Number of outer loops for STL modified method. Default outer = 0
`smean, svar`	Mean and Variance smoothing windows of STL modified method
`prob`	Parameter confidence interval. Default prob = 0.95
`fre`	Series frequency. Default fre = 365 (for daily series)
`fractional`	Logical variable: T to apply FARMA model. Default fractional = F
`Plag`	Maximum lag of ACF used in the Portmanteau test. Default Plag = 20
`lsign`	Portmanteau Test significance level. Default lsign = 0.05
`n1`	Number of parameters of infinite MA model . Default n1 = 399
`trasfo`	Logical variable: T for preventive logarithmical trasformation. Default trasfo = F
`des`	Logical variable: T to remove seasonal components. Default des = T
`rain`	Logical variable: T to apply the corrective procedure to daily rainfall simulated series. Default rain = F
`graph`	Logical variable: T to receive some graphics. Default graph = F

Details

Need integer periodical dataset. Function to complete modelling univariate series.

Value

`para`	List of estimated parameters
`res`	Residual series
`simdes`	List of simulated series without application of corrective procedure
`sim`	List of simulated series
`BIC`	Bayesian Information criterion index of estimated model

Note

Portmonteau test and BIC index are displaied during application. Portmonteau Test is positive if Q < chi square

Author(s)

Salvatore Grimaldi

References

Grimaldi, S., 'Linear parametric models applied on daily hydrological series', Journal of Hydrologic Engineering, Vol.9, No 5, September 2004.

Grimaldi S., F. Napolitano, L. Ubertini, 'A procedure to use linear parametric models for daily rainfall series simulation'

Brockwell, P.J and Davis, R.A. (1990) Time Series: Theory and Methods 2nd edition, Springer, NY.

Hipel, K.W. and McLeod, A.I., (1994) Time Series Modelling of Water Resources and Enviromental Systems, Reading, UK.

See Also

rain.adapt

Examples

```
##---  lpm(series.runoff,1,1,0,30,30,fractional=T,trasfo=T)
##--   Apply a FARMA(1,d,1) model to series.runoff after e preventive
##     logarithmical trasformation and deseasonalization with smoothing 30.
```

---

milano — *Maximum annual rainfall series for different durations*

Description

Maximum annual rainfall series for different durations recorded at the pluviograph of Palazzo Marino, Milan (Italy)

Usage

```
data(milano)
```

Details

Maximum annual precipitation series for 0.25, 0.5, 0.75, 1, 1.25, 1.50, 2, 2.5, 3, 4, 6 [h] 1931-1970

Source

dataset of Palazzo Marino pluviograph , Milan (Italy)

Examples

```
data(milano)
## maybe str(series.rainfall) ; plot(series.rainfall) ...
```

mlpm *Multivariate Linear Parametric Model*

Description

Multivariate modelling using VAR(p) and SVAR(p) different estimation methods, simulation, daily rainfall simulated series correction and deseasonalization are performed

Usage

```
mlpm(x, p, prob, nsim, smean, svar, fre = 365, outer = 0,plot = F,
rain = T, over = T, estimate = "ols", CCFlag = 20, Plag = 20, lsign = 0.05, des = T)
```

Arguments

`x`	Multivariate series
`p`	Model order
`prob`	Condifidence interval used to fix parameters in SVAR(p) model
`nsim`	Number of series to simulated
`smean, svar`	Mean and Variance smoothing windows of STL modified method
`fre`	Series frequency. Default fre = 365
`outer`	Outer loops of STL modified method. Default outer = 0
`plot`	Logical variable: T to receive some graphics. Default plot = F
`rain`	Logical variable: T to apply rain adaptor to simulated series. Default rain = F
`over`	Logical variable: T to use SVAR(p) model estimated with EGLS method. Need estimate = 'ols' Default over = T
`estimate`	Define VAR(p) estimation method. 'ols', 'burg', 'yw' (Yule-Walker). Default estimate = 'ols'
`CCFlag`	Lag of (Partial) Auto-CrossCorrelation function graphics . Default CCFlag = 20
`Plag`	Maximum lag of A-CCF used in the Portmanteau Test. Default Plag = 20
`lsign`	Portmanteau Test significance level. Default lsign = 0.05
`des`	Logical variable: T to remove seasonal components

Details

Need integer periodical datasets. Simulation use Lutkepohl algorithm with a residuals vectorial permutation to obtain innovations. Parameters selections of EGLS method is defined by t-ratio approach.

Value

`coeff`	List of estimated coefficients matrix
`coeffstd`	List of estimated standard deviations coefficients matrix. Only for OLS and EGLS method
`struct`	List of 'structure' of SVAR(p) model (1 define position of estimated parameter). Only for EGLS method
`res`	Residual series
`fit`	Output List of ar function
`aic`	Akaike Information Criterion index
`Q`	Portmonteau statistic
`sim`	List of simulated series

Note

Portmonteau test, AIC e SBC index are displaied during application. Portmonteau test is positive if Q < chi square.

Author(s)

Corrado Tallerini

References

Grimaldi S., Tallerini C., Serinaldi F. (2004) 'Modelli multivariati lineari per la generazione di serie di precipitazioni giornaliere' Giornata di Studio: Metodi Statistici e Matematici per l'Analisi Idrologiche Napoli 2004

Grimaldi S. , Serinaldi F. & Tallerini C. (2004) 'Multivariate linear parametric models applied to daily rainfall time series' Mediterranean Storms, 6rd EGU Plinius Conference held in Mediterranean Sea, Italy, October 2004

Lutkepohl, H. (1993) Introduction to Multiple Time Series Analysis 2nd edition, Springer-Verlag, Berlin.

Grimaldi, S., 'Linear parametric models applied on daily hydrological series', Journal of Hydrologic Engineering, Vol. 9, No 5 , September 2004.

Brockwell, P.J and Davis, R.A. (1990) Time Series: Theory and Methods 2nd edition, Springer, NY.

Hipel, K.W. and McLeod, A.I., (1994) Time Series Modelling of Water Resources and Enviromental Systems, Reading, UK.

Hosking, J.R.M. (1980) 'The Multivariate Portmanteau Statistic' Journal of the American Statistical Association, Vol.75, N.371, 502-608.

See Also

`lpm`, `ar.egls`, `rain.adapt`

Examples

```
##-- Mrain=mlpm(series.rainfall,3,0.95,0,120,120)
##-- Apply a SVAR(3) model with selection probability 95 % to series.rainfall
##-- after preventive deseasonalization with smoothing 120.
```

Pistoia *Dataset of Pistoia (Italy)*

Description

Bivariate series of observed rainfall-temperature for Pistoia (Italy) during the period 1951-2012

Usage

```
data(Pistoia)
```

Format

A data frame with 744 observations on the following 2 variables.

`V1` Monthly cumulative rainfall (mm)

`V2` Average monthly temperature (degree)

Source

Ce.Spe.Vi. (Centro sperimentale per il vivaismo) Web: http://www.cespevi.it

Examples

```
data(Pistoia)
## maybe str(Pistoia) ; plot(Pistoia) ...
```

PWN *Crop Water requirement*

Description

Calculate the monthly irrigation requirement of crops based on cumulative probability [p] and daily watering duration of irrigation [h]

Usage

```
PWN(x1, frvol, R, p, irr)
```

Arguments

`x1`	Bivariate series of monthly cumulative rainfall and average monthly temperatures
`frvol`	Volume fraction of the soil. It is 0.10 for sandy soil, 0.20 fpr loamy soil, 0.18 for clayey soil, 0.13 for medium-textured soil
`R`	Length of plant roots [cm] — see FAO-24 Mannini reworked, maximum extraction depth
`p`	Cumulative probability of plant's water requirement [percent]
`irr`	Daily watering duration of irrigation [h]

Value

`Values`	Monthly water requirement values [m3/ha] relating to the cumulative probability indicated (p)
`Flow`	Irrigation flow [l/s/ha] relating to the daily watering duration (irr) and cumulative probability (p)

Author(s)

Corrado Tallerini

References

United States Department of Agricolture (USDA - SCS). IRRIGATION - National Engineering handbook.

Moisello U. "Idrologia Tecnica" La Goliardica Pavese.

Genovesi R., Bottau D. "L'importanza della falda nell' alimentazione idrica delle colture nella pianura emiliano-romagnola."

Regione Campania - Assessorato Agricoltura - Settore S.I.R.C.A. La tessitura del suolo (foglio divulgativo novembre - dicembre 2002)

Fao irrigation and dreinage paper N. 24 - Crop water requirement, Food and agriculture organization of the united nations ROME, rivisited 1977

Grimaldi, S. Tallerini, C., Serinaldi, F., "Modelli multivariati lineari per la generazione di serie di precipitazioni giornaliere", Giornata di Studio: Metodi Statistici e Matematici per l'Analisi delle Serie Idrologiche, Napoli, maggio 2004

Examples

```
##---- data(Pistoia)
##---- PWN(Pistoia,0.13,40,75,16)
##---- Calculate the monthly irrigation requirement of a plant (Length of plant roots 40 cm in
##---- a medium-textured soil) based on a 75% cumulative probability and 16 hours daily irrigation
```

rain.adapt *Rainfall Adaptor*

Description

Apply a corrective procedure to daily rainfall series to enforce actual caracteristics.

Usage

```
rain.adapt(x, a, ser)
```

Arguments

x	Observed series
a	Univariate series to modify (simulated series)
ser	Series identification number

Details

The no-rain frequency consequentally the total rainfall depth of the observed series are enforced on the synthetic series

Value

Corrected series

Author(s)

Salvatore Grimaldi

References

Grimaldi S., F. Napolitano, L. Ubertini, 'A procedure to use linear parametric models for daily rainfall series simulation'

Examples

```
##   rain=lpm(series.rainfall[,1],1,1,1,120,120)
##   rain.adapt(series.rainfall[,1],rain$sim[[1]],1)
##-- ==>  Apply rain adaptor to a simulated series with a ARMA(1,1) model
```

series.rainfall — *Daily Rainfall Series*

Description

Group of 5 daily rainfall series recorded in Tuscany region of Italy during the period 1958-1979.

Usage

```
data(series.rainfall)
```

Details

Dataset is created removing lacking years and replacing lacking days with the mean of previous and successive value. Beside 29 february day values are removed to obtain integer periodical dataset.

Source

Rudari, R. 'Predicibilita' del clima europeo ed influenze delle forzanti a scala sinottica su eventi regionali di precipitazione intensa', PDh Thesis 2001

Examples

```
data(series.rainfall)
## maybe str(series.rainfall) ; plot(series.rainfall) ...
```

series.runoff — *Daily Runoff Series*

Description

Daily runoff series of Tiber river observed to Ripetta station during the period 1930-1983

Usage

```
data(series.runoff)
```

Details

29 february day values are removed to obtain integer periodical dataset

Source

Available on the web site www.gndci.cnr.it. "Gruppo nazionale per la difesa delle catastrofi idrogeologiche"

Examples

```
data(series.runoff)
## maybe str(series.runoff) ; plot(series.runoff) ...
```

WNeeds *Crop water requirement*

Description

Calculates the water requirement [m3/ha] of herbaceous or arboreal crops

Usage

```
WNeeds(x, frvol, R)
```

Arguments

`x`	Bivariate series of monthly cumulative rainfall [mm] and average monthly temperatures [degree]
`frvol`	Volume fraction of the soil. It is 0.10 for sandy soil, 0.20 fpr loamy soil, 0.18 for clayey soil, 0.13 for medium-textured soil
`R`	Length of plant roots [cm] — see FAO-24 Mannini reworked, maximum extraction depth

Author(s)

Corrado Tallerini

References

United States Department of Agricolture (USDA - SCS). IRRIGATION - National Engineering handbook.

Moisello U. "Idrologia Tecnica" La Goliardica Pavese.

Genovesi R., Bottau D. "L'importanza della falda nell' alimentazione idrica delle colture nella pianura emiliano-romagnola."

Regione Campania - Assessorato Agricoltura - Settore S.I.R.C.A. La tessitura del suolo (foglio divulgativo novembre - dicembre 2002)

Fao irrigation and dreinage paper N. 24 - Crop water requirement, Food and agriculture organization of the united nations ROME, rivisited 1977

Grimaldi, S. Tallerini, C., Serinaldi, F., "Modelli multivariati lineari per la generazione di serie di precipitazioni giornaliere", Giornata di Studio: Metodi Statistici e Matematici per l'Analisi delle Serie Idrologiche, Napoli, maggio 2004

Examples

```
## data(Pistoia)
## A1=WNeeds(Pistoia,0.13,60)
## edit(A1)
```

Index