

Package ‘LPM’

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Title Linear Parametric Models Applied to Hydrological Series

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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

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

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

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LPM-package	<i>LPM</i>
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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 Agriculture (USDA - SCS). IRRIGATION - National Engineering handbook.

Fao irrigation and drainage 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 modifying 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 recommended
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 Tallorini

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 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 displayed during application. Portmonteau Test is positive if $Q < \chi^2$

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 Environmental 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	Confidence 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 displayed during application. Portmonteau test is positive if $Q < \text{chi square}$.

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 for 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 [m ³ /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 Agriculture (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 drainage 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 characteristics.

Usage

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

Arguments

<code>x</code>	Observed series
<code>a</code>	Univariate series to modify (simulated series)
<code>ser</code>	Series identification number

Details

The no-rain frequency consequentially 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	<i>Daily Rainfall Series</i>
-----------------	------------------------------

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	<i>Daily Runoff Series</i>
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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 for 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 Agriculture (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 drainage 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)
```

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