

# Package ‘LPM’

July 21, 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

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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 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 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.

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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 <sup>3</sup> /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, revisited 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>
---------------	----------------------------

---

**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](http://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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