Package 'lfstat'

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Type Package

Title Calculation of Low Flow Statistics for daily stream flow data

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Description The ``Manual on Low-flow Estimation and Prediction", published by the World Meteorological Organisation (WMO), gives a comprehensive summary on how to analyse stream flow data focusing on low-flows. This packages provides functions to compute the described statistics and produce plots similar to the ones in the manual.

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`lfstat-package` *Calculates Low Flow Statistics for daily stream flow data*

Description

The "Manual on Low-flow Estimation and Prediction", published by the World Meteorological Organisation (WMO), gives an idea how to analyse stream flow data focusing on low-flow issues. This packages gives functions to compute the described statistics and produce plots similar to the one in the manual.

Details

Create lfobj (Low-Flow-Objects)

The package calculates indices and makes graphics for low flow analysis. It brings its own class "lfobj", a special data.frame format with columns "day", "month", "year", "flow", "hyear" and possibly "baseflow".

"day", "month" and "year" refer to the date, "flow" is the measured runoff (unit-independent), "baseflow" the calculated baseflow.

"hyear" refers to the hydrological year. When creating the "lfobj" you define the month where the stations hydrological year starts. If annual indices are calculated or single years are plotted, the "hyear" is taken.

Basically there are to options to create an lfobj:

If you have special data format, e.g. GRDC, you can use the function `readlfdata`, see '?readlfdata' to see which formats are currently supported. Otherwise you can use `createlfobj`. You can apply it for new data in one of two ways: 1) You create a data.frame with columns: "day", "month", "year" and "flow". 2) You create a time-series (ts) from "flow" and give the start date of the series when calling 'createlfobj'.

Preparation

lfstat does not need to know the unit of the flow, but you might want it to appear in your plots. You can use `setlfunit` to define how units are labelled in your graphics. Examples are given in '?setlfunit'.

Please check for NA-values using `lfnacheck`, indices and plots are made as if series were complete. See the manual on how to deal with missing values and, if reasonable, use `lfnainterpolate`.

Indices

Functions available `meanflow`, `Qxx`, `MAM` (mean annual minima), `BFI`, `recession` (recession constant), `streamdef` (Streamflow deficit), `tyears` (Extreme value - T-years event), `seasratio`, `seasindex` and `multistationsreport`.

Plots

`hydrograph` `recessionplot` (Diagnosis for recession) `fdc` (Flow-duration-curve) `sbplot` (seasonal barchart) `seglenplot` (select recession length for `recession`) `streamdefplot` (Streamflow deficit) `rfa` (Regional frequency analysis) `dmcurve` (Double mass curve)

Author(s)

Daniel Koffler <daniel.koffler@boku.ac.at> and Gregor Laaha <gregor.laaha@boku.ac.at>

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

BFI *Base Flow Index*

Description

Calculates the base flow index of an object of class 'lfobj'.

Usage

```
BFI(lfobj, year = "any",breakdays = NULL, yearly = FALSE)
```

Arguments

lfobj	An object of class "lfobj"
year	The year for which the BFI should be computed. If hyearstart != 1 the BFI is calculated for the hydrological year "any" means the whole series should be taken.
breakdays	A vector of breakdays if the BFI should be calculated for different seasons.
yearly	If TRUE, the BFI is calculated for each hydrological year separately.

Details

If breakdays is a single day, e.g. "01/06", the start of the hydrological year is taken as the second breakday. If more than two seasons are to be specified, a vector of all breakdays is needed.

Value

A length one vector giving the BFI for the whole series or the specified year. If yearly is true, a vector of the annual BFIs is returned. If breakdays are specified, the values are separated per season.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

bfplot

Examples

```
data(ngaruroro)
BFI(ngaruroro)
BFI(ngaruroro, breakdays = c("01/11","01/05"))
BFI(ngaruroro, year = 1991)
bfplot(ngaruroro, year = 1991)
```

---

bfplot *Base Flow Plot*

Description

Visualises the hydrograph versus the base flow hydrograph.

Usage

```
bfplot(lfobj,
       year = "any",
       col = "green",
       bfcol = "blue",
       ylog = FALSE)
```

Arguments

lfobj	An object of class "lfobj"
year	The hydrological year for which the BFI should be computed. If "any" the whole series is plotted.
col	Color of Flow
bfcol	Color of Baseflow
ylog	Log y-axis?

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

BFI

Examples

```
data(ngaruroro)
#Plot starts in December, as ngaruroro's hyearstart = 12
bfplot(ngaruroro, year = 1991)
```

createlfobj *Create an lfobj for further Low Flow Analysis*

Description

Generic function for creating a low flow object (lfobj). Low flow objects can be created out of a time series of daily flow, a data.frame with columns "flow", "day", "month" and "year".

Usage

```
createlfobj(x, ...)


## S3 method for class 'data.frame'
createlfobj(x, hyearstart = 1, baseflow = TRUE,
                    meta = list(),...)

## S3 method for class 'ts'
createlfobj(x,
            startdate,
            dateformat = "%d/%m/%Y",
            ...)
## S3 method for class 'lfobj'
createlfobj(x, hyearstart = NULL, baseflow = NULL,
                           meta = NULL,...)
```

Arguments

x	An object out of which a lfobj should be created
hyearstart	integer, which month should the hydrological year start?
baseflow	logical, should the baseflow curve be calculated? Needed, if you want to apply 'bfplot' or 'BFI' later on.
meta	A list of meta-information
startdate	Startdate of the time-series
dateformat	Format of the startdate
...	Additional arguments depending on the method used.

Details

'hyearstart' defines the starting month of the hydrological year. If 'hyearstart' is greater then 6.5, the hydrological year starts earlier then the actual date, e.g. hyearstart = 10, then the 1st of October 2011 is part of the hydrological year 2012. If hyearstart = 4, then the 31st of March 2011 ist part of the hydrological year 2010.

Value

An object of class 'lfobj'.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

readlfdata

Examples

```
#Creating a lfobj from a timeseries
#Some sample data:

somevalues <- rexp(365)
#Convert to time series:
time <- ts(somevalues)

#Lets say our data contains values from one hydrological year (Oct-Sep)
#starting on 1. Oct. 1992:
myriver <- createlfobj(time, startdate = "01/10/1992",hyearstart = 10)
#Add meta-data
createlfobj(myriver, meta = list(river = "myriver"))
```

---

dmcurve *Double Mass Curve*

Description

Calculates the double mass curve of two object of class 'lfobj'.

Usage

```
dmcurve(x, y, year = "any", namex = substitute(x), namey = substitute(y),
    na.rm = TRUE)
```

Arguments

x	An object of class "lfobj"
y	An object of class "lfobj"
year	The year for which the dmcuve should be calculated
namex	character - Label of the x-Axis in the dmcurve
namey	character - Label of the y-Axis in the dmcurve
na.rm	Remove NAs?

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

Examples

```
data(ngaruroro)
n1 <- subset(ngaruroro, year %in% 1985:1989)
n2 <- subset(ngaruroro, year %in% 1990:1995)
dmcurve(n1,n2, namex = "'Ngaruroro 1985 - 1989'", namey = "'Ngaruroro 1990
- 1995'")
```

---

fdc *Flow Duration Curve*

Description

Plots the flow duration curve for a given lfobj.

Usage

```
fdc(lfobj, year = "any", breakdays = NULL, colors = TRUE,
    xnorm = FALSE, ylog = TRUE, legend = TRUE, separate = FALSE,
    ...)
```

Arguments

lfobj	An object of class "lfobj"
year	numeric - The year for which the fdc should be computed. If hyearstart != 1 the BFI is calculated for the hydrological year! "any" means the whole series should be taken.
breakdays	A vector of breakdays if the BFI should be calculated for diffenent seasons.

colors	logical - If breakdays are specified, should the differend fdcs are displayed in different colors?
xnorm	logical - should the x-axis be normalised?
ylog	logical - The the logarithm of the y-axis?
legend	logical - Should a legend be plotted?
separate	logical - Should a separate plot be drawn for every season?
...	Graphical parameters handed to plot

Details

If breakdays is a single day, e.g. "01/06", the start of the hydrological year is taken as the second breakday. If more than two seasons are to be specified, a vector of all breakdays is needed.

Value

A vector of quantiles.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

ecdf

Examples

```
data(ngaruroro)
fdc(ngaruroro,year = 1991)
```

---

hydrograph *Hydrograph*

Description

Plots the hydrograph for a given period.

Usage

```
hydrograph(lfobj, startdate = NULL, enddate = NULL, amin = FALSE,...)
```

Arguments

lfobj	An object of class "lfobj"
startdate	Begin of hydrograph, date or hydrological year
enddate	End of hydrograph, date or hydrological year
amin	logical, mark annual minima?
...	Additional arguments handed to "plot" - please note that some changes e.g. tick-marks on x-axis are not possible

Details

Startdate and enddate can be NULL (first/last date in lfobj), a date in format "dd/mm/yyyy" (e.g. "01/10/1971") or a year yyyy (e.g 1961).

Value

Plot of hydrograph

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

bfplot

Examples

```
data(ngaruroro)
#Full period
hydrograph(ngaruroro)
#Hydrological year 1981 and 1982 with annual minima
hydrograph(ngaruroro, startdate = 1981, enddate = 1982, amin = TRUE)
#From 01/01/1981 to 31/03/1981
hydrograph(ngaruroro, startdate = "01/01/1981", enddate = "31/03/1981")
#Log - yaxis
hydrograph(ngaruroro, startdate = "01/01/1981", enddate =
"31/03/1981",log = "y")
```

`lfnacheck` *Low flow object check for missing values.*

Description

Looks for NAs in a lfobj.

Usage

```
lfnacheck(lfobj)
```

Arguments

`lfobj`	An object of class "lfobj"

Value

A list with the total number of NAs, the percentage, the NAs for every year and the durations of NA-series.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

`bfplot`

Examples

```
data(ngaruroro)
lfnacheck(ngaruroro)
```

`lfnainterpolate` *Interpolate missing values*

Description

If a lfobj contains missing values, the missing values are replaced by connecting the last available value before the break and the first after the break by a straight line.

Usage

```
lfnainterpolate(lfobj)
```

Arguments

`lfobj`	An object of class "lfobj"

Value

`lfobj`	An object of class "lfobj"

with interpolated missing values

Warning

Check carefully in advance if interpolation is a reasionable choice for filling the hydrograph

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

`bfplot`

Examples

```
data(ngaruroro)

#Part of the ngaruroro series with missing data
hydrograph(ngaruroro,startdate = "1/7/1987", enddate = "1/9/1987",amin = FALSE)

ngaruroroint <- lfnainterpolate(ngaruroro)

#The completed hydrograph
hydrograph(ngaruroroint,startdate = "1/7/1987", enddate = "1/9/1987",amin = FALSE)
```

MAM *Mean Annual Minimum*

Description

Computes the Mean Annual Minimum (MAM-n) for any given n.

Usage

```
MAM(lfobj, n = 7, year = "any",breakdays = NULL, yearly = FALSE)
```

Arguments

lfobj	An object of class "lfobj"
n	Mean Annual minimum for n-days, e.g. n=7 computes MAM7
year	The year for which the BFI should be computed. If hyearstart != 1 the BFI is calculated for the hydrological year! "any" means the whole series should be taken. If a vector of years is given, all this years are included in the calculation.
breakdays	A vector of breakdays if the BFI should be calculated for diffenent seasons.
yearly	If TRUE, the BFI is calculated for each hydrological year seperately.

Details

If breakdays is a single day, e.g. "01/06", the start of the hydrological year is taken as the second breakday. If more than two seasons are to be specified, a vector of all breakdays is needed.

Value

A length one vector giving the BFI for the whole series or the specified year. If yearly is true, a vector of the annual BFIs is returned. If breakdays are specified, separated values for every season are given.

Warning

At the moment there is no check for seasonal overlap. E.g. The MAM7 of 1991 and 1992 could take the same days for calculation if the are in n/2-days range. This problem could be avoided by choosing a "meaningfull" hyearstart and breakdays, usually dates out of the low flow seasons.

Note

The annual minima can be calculated by setting n=1 and yearly = TRUE.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

meanflow,Q95

Examples

```
data(ngaruroro)
MAM(ngaruroro)
MAM(ngaruroro, n=1) #Mean annual minimum
MAM(ngaruroro, year = c(1991,1995)) #Taking values from 1991 and 1995
MAM(ngaruroro, year = 1991:1995) #Taking values from 1991 to 1995 (1991,1992,...,1995)
MAM(ngaruroro, breakdays = c("01/11","01/05"))
MAM(ngaruroro, year = 1991)
```

---

meanflow *Mean flow*

Description

Calculates the meanflow of an object of class 'lfobj'.

Usage

```
meanflow(lfobj, year = "any", monthly = FALSE, yearly = FALSE,
breakdays = NULL, na.rm = TRUE)
```

Arguments

lfobj	An object of class "lfobj"
year	The year for which the meanflow should be computed. If hyearstart != 1 the meanflow is calculated for the hydrological year! "any" means the whole series should be taken.
monthly	logical - Should the meanflow be calculated separately for every month?.
yearly	logical - If TRUE, the meanflow is calculated for each hydrological year separately.
breakdays	A vector of breakdays if the meanflow should be calculated for different seasons.
na.rm	Should missing values be ignored?

Details

If breakdays is a single day, e.g. "01/06", the start of the hydrological year is taken as the second breakday. If more than two seasons are to be specified, a vector of all breakdays is needed.

Value

A length one vector giving the meanflow for the whole series or the specified year. If yearly is true, a vector of the annual meanflows is returned. If breakdays are specified, the values are separated per season.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

MAM

Examples

```
data(ngaruroro)
meanflow(ngaruroro)
meanflow(ngaruroro, breakdays = c("01/11","01/05"))
meanflow(ngaruroro, year = 1991)
```

---

multistationsreport *Report for several stations*

Description

Calculates indices for several stations at once.

Usage

```
multistationsreport(...,indices = c("meanflow", "Q95", "MAM1", "MAM7",
    "MAM10", "MAM30", "MAM90", "baseflowindex", "recession"),
    recessionmethod = "MRC", recessionseglength = 7, recessionthreshold = 70,
    recessiontrimIRS = 0.1,lflist = NULL)
```

Arguments

...	Objects of class "lfobj"
indices	A vector of indices to calculate
recessionmethod	See recession
recessionseglength	See recession

recessionthreshold
: See recessionthreshold

recessiontrimIRS
: See recessiontrimIRS

lflist
: Alternative give a list containing "lfobj"s.

Value

A data.frame containing the calculated indices.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

meanflow, Q95,MAM,BFI,recession

Examples

```
data(ngaruroro)
multistationsreport(ngaruroro, indices = c("meanflow", "MAM7"))

seventies <- subset(ngaruroro, hyear %in% 1970:1979)
eighties <- subset(ngaruroro, hyear %in% 1980:1989)
nineties <- subset(ngaruroro, hyear %in% 1990:1999)

multistationsreport(seventies, eighties, nineties)
```

---

ngaruroro *Daily stream flow data from Ngaruroro River in New Zealand*

Description

This data set gives the streamflow records from 20/09/1963 to 31/12/2000. The data structure is a low flow object (lfobj) as used in the package lfstat. The rivers hydrological year starts with December.

Usage

```
data(ngaruroro)
```

Format

A lfobj createlfobj

Source

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

Qxx *Qxx, Q95, Q90, Q70*

Description

Calculates the quantiles of an object of class 'lfobj'.

Usage

```
Qxx(lfobj, Qxx, year = "any", monthly = FALSE, yearly = FALSE,
breakdays = NULL, na.rm = TRUE)

Q95(lfobj, year = "any", monthly = FALSE, yearly = FALSE,
breakdays = NULL, na.rm = TRUE)

Q90(lfobj, year = "any", monthly = FALSE, yearly = FALSE,
breakdays = NULL, na.rm = TRUE)

Q70(lfobj, year = "any", monthly = FALSE, yearly = FALSE,
breakdays = NULL, na.rm = TRUE)
```

Arguments

lfobj	An object of class "lfobj"
Qxx	The quantile to calculate, e.g. 70 would refer to Q70
year	The year for which the Q95 should be computed. If hyearstart != 1 the Q95 is calculated for the hydrological year! "any" means the whole series should be taken.
monthly	logical - Should the Q95 be calculated separately for every month?.
yearly	logical - If TRUE, the Q95 is calculated for each hydrological year separately.
breakdays	A vector of breakdays if the Q95 should be calculated for different seasons.
na.rm	Should NA's be ignored?

Details

If breakdays is a single day, e.g. "01/06", the start of the hydrological year is taken as the second breakday. If more than two seasons are to be specified, a vector of all breakdays is needed.

Value

A length one vector giving the Q95 for the whole series or the specified year. If yearly is true, a vector of the annual Q95s is returned. If breakdays are specified, the values are separated per season.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

MAM

Examples

```
data(ngaruroro)
Q95(ngaruroro)
Q95(ngaruroro, breakdays = c("01/11","01/05"))
Q95(ngaruroro, year = 1991)
#Calculate Q99
Qxx(ngaruroro, Qxx = 99)
```

---

readlfdata *Reads data sheets*

Description

Reads data sheets of different formats directly as lfobjs.

Usage

```
readlfdata(file, type = c("GRDC", "HZB", "LFU", "TU"), lfobj = TRUE, readmeta = TRUE,...)
```

Arguments

file	The name of the file which the data are to be read from.
type	The style of the sheet, currently the following formats are accepted: "GRDC", "HZB" (Austria), "LFU" (Germany, Bavaria), "TU" (Technical University Vienna)
lfobj	logical, should a lfobj be created?
readmeta	logical, should metainformation from data sheets be saved?
...	Handed to createlfobj, could be "hyearstart", "baseflow" or "meta", if "readmeta" is FALSE

Value

A lfobj or data.frame depending on "lfobj".

Note

If you like other file formats (national standards) to be includes, send some examples with a remark how NAs are marked to the author

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

createlfobj

Examples

```
#Finding the sample file on your computer
path <- system.file("samplesheets/9104020.day", package = "lfstat")

grdc <- readlfdata(path, type = "GRDC", baseflow = FALSE)
#Some test...
head(grdc)
```

`recession` *Recession Constant*

Description

Does recession analysis using either the MRC (Master recession curve) or IRS (individual recession segments) method.

Usage

```
recession(lfobj,
          method = c("MRC", "IRS"),
          seglength,
          threshold,
          peaklevel = 0.95,
          seasonbreakdays = NULL,
          thresbreaks = c("fixed", "monthly","seasonal"),
          thresbreakdays = NULL,
          plotMRC = TRUE,
          trimIRS = 0,
          na.rm = TRUE)
```

Arguments

`lfobj`	An object of class "lfobj"
`method`	"MRC" or "IRS"
`seglength`	The length of the duration segments - see the WMO-manual and use `seglenplot` to choose a good value.
`threshold`	The threshold level (70 means Q70)
`peaklevel`	A level between 0 and 1 or a logical vector, see details.
`seasonbreakdays`	A vector of breakdays. Needed if the recession constant should be calculated individually for differnt seasons, see details.
`thresbreaks`	"fixed" uses a fixed threshold level, "monthly" calculates the threshold for every month separatly, "seasonal" calculates thresholds for every season defined using "thresbreakdays".
`thresbreakdays`	Needed if "thresbreaks = 'seasonal'" to define the periodes for which separate thresholds should be calculated, see details
`plotMRC`	logical, if TRUE and "method = 'MRC'" a plot like figure 5.4 in the manual is given.
`trimIRS`	Should a trimmed mean be used for calculating the IRS-constant? (0 means no, 0.1 means trim by 10 %)
`na.rm`	Should NAs in the series be ignored?

Details

For recession analysis it is neccessary to define flood discharge peaks in the hydrograph. Peaklevel defines a day to be a descharge peak, if peaklevel * flow > flow[day before] and peaklevel * flow > flow[day after]. Use recessionplot to find a good level or hand a logical vector where TRUE means rainpeak.

If thresbreakdays or seasonbreakdays is a single day, e.g. "01/06", the start of the hydrological year is taken as the second breakday. If more than two seasons are to be specified, a vector of all breakdays is needed.

Value

The overall recession rate in days. If seasons are defined a rate for every season is calculated.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

seglenplot, recessionplot

Examples

```
## Not run:
data(ngarurоro)
recession(ngarurоro,method = "MRC",seglen = 7,threshold = 70)

## End(Not run)
```

---

recessionplot *Recession diagnostic plot*

Description

Helps to define peaklevel of a lfobj and visualises recession periodes.

Usage

```
recessionplot(lfobj,
              peaklevel = 0.95,
              plot = TRUE,
              peakreturn = FALSE,
              thresplot = TRUE,
              threscol = "blue",
              threshold = 70,
              thresbreaks = c("fixed","monthly","seasonal"),
              thresbreakdays = c("01/06","01/10"),
              recessionperiod = TRUE,
              recessioncol = "darkblue",
              seglength = 7,
              ...)
```

Arguments

lfobj	A object of class lfobj
peaklevel	A level between 0 and 1 or a logical vector, see details.
plot	Should a plot be made
peakreturn	Should a logical with rainpeaks be returned
thresplot	Should the threshold be plotted
threscol	Color of threshold in plot
threshold	Threshold level (70 refers to Q70)
thresbreaks	"fixed" uses a fixed threshold level, "monthly" calculates the threshold for every month separatly, "seasonal" calculates thresholds for every season defined using "thresbreakdays".
thresbreakdays	Needed if "thresbreaks = 'seasonal'" to define the periodes for which separate thresholds should be calculated, see details
recessionperiod	Should recession periodes be marked
recessioncol	Color of recessionperiod marks
seglength	The minimum number of days to be marked as recession period
...	Further arguments handed to hydrograph.

Details

For recession analysis it is neccessary to define flood discharge peaks in the hydrograph. Peaklevel defines a day to be a discharge peak, if peaklevel * flow > flow[day before] and peaklevel * flow > flow[day after].

This function can be used to check different values of peaklevel.

Value

If peakreturn = TRUE: A logical vector giving rainpeaks as TRUE

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

recession

Examples

```
## Not run:
data(ngaruroro)
#To few points identified as peak flood discharge
recessionplot(ngaruroro, peaklevel = .5, start = 1991, end = 1991)

#To many
recessionplot(ngaruroro, peaklevel = .999, start = 1991, end = 1991)

#Good choice?
recessionplot(ngaruroro, peaklevel = .92, start = 1991, end = 1991)

#Getting peakdays for 1991
peak <- recessionplot(ngaruroro, peaklevel = .92, plot = FALSE)
rain1991 <- subset(ngaruroro, subset = hyear == 1991 && peak, select = c(day, month, year))
## End(Not run)
```

---

rfa *Regional Frequency Analysis*

Description

This function uses J.R.M. Hosking's package produce an object of class "rfd", containing the specification of the regional frequency distribution.

Usage

```
rfa(lflist, n = 7, event = 100, dist =  c("wei","gev","ln3","gum","pe3"))
```

Arguments

lflist	A list of "lfobj"s
n	MAM-n is used (e.g. n=7 means MAM7)
event	A value for T, e.g. event = 100 means the 100 years extreme low flow event
dist	A vector of distribution to fit, the names are according to Hostking's in his "lmom" package. Can be an of "wei","gev","ln3","gum","pe3".

Author(s)

Daniel Koffler and Gregor Laaha

References

Manual on Low-flow Estimation and Prediction, Operational Hydrology Report No. 50, Koblenz 2009

J. R. M. Hosking (2012). L-moments. R package, version 1.6. URL: http://CRAN.R-project.org/package=lmom.

See Also

lmom,lmomRFA

Examples

```
data(ngaruroro)

#Toy example to get some more "rivers"
seventies <- subset(ngaruroro, hyear %in% 1970:1979)
eighties <- subset(ngaruroro, hyear %in% 1980:1989)
nineties <- subset(ngaruroro, hyear %in% 1990:1999)

toyrfa <- rfa(list(seventies,eighties,nineties), n=3,dist = "gev")

#Now you can work on using Hoskings lmomRFA-package, e.g.
regquant(c(1/1000,1/100),toyrfa)
sitequant(1/100,toyrfa)
```

---

rfaplot *Regional Frequency Analysis*

Description

This function uses J.R.M. Hosking's package lmom to produce a L-moment diagram.

Usage

```
rfaplot(lflist, n = 7,...)
```

Arguments

lflist	A list of "lfobj"s
n	MAM-n is used (e.g. n=7 means MAM7)
...	is passed to Hosking's function lmrd.

Author(s)

Daniel Koffler and Gregor Laaha

References

Manual on Low-flow Estimation and Prediction, Operational Hydrology Report No. 50, Koblenz 2009

J. R. M. Hosking (2012). L-moments. R package, version 1.6. URL: http://CRAN.R-project.org/package=lmom.

See Also

lmom, rfa

Examples

```
data(ngaruroro)

#Toy example to get some more "rivers"
seventies <- subset(ngaruroro, hyear %in% 1970:1979)
eighties <- subset(ngaruroro, hyear %in% 1980:1989)
nineties <- subset(ngaruroro, hyear %in% 1990:1999)

rfaplot(list(seventies,eighties,nineties), n=3)
```

---

sbplot *Seasonal Barchart*

Description

Plots a seasonal barchart for daily streamflow data

Usage

```
sbplot(lfobj,hyearorder = TRUE)
```

Arguments

lfobj	A lfobj, as created with 'createlfobj'
hyearorder	logical, if TRUE the bars are plotted according to the hydrological year, if FALSE they start with January.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

createlfobj

Examples

```
data(ngaruroro)
sbplot(ngaruroro)
#Starting with january
sbplot(ngaruroro, hyearorder = FALSE)
```

---

seasindex *Seasonality Index*

Description

Calculates the seasonality index.

Usage

```
seasindex(lfobj,
          Q = 95,
          na.rm = TRUE)
```

Arguments

lfobj	An object of class "lfobj"
Q	Which quantile to use (standard = Q95)
na.rm	Should missing values be ignored?

Value

A list descriping the arrow

theta	Angle in radians
D	Julian Date
r	Length

Author(s)

Daniel Koffler and Gregor Laaha

References

Laaha, G. and Bl\"oschl, G. (2006), Seasonality indices for regionalizing low flows. Hydrol. Process., 20

Laaha,G. Process Based Regionalisation of Low Flows, Band 198 von Wiener Mitteilungen, Inst. f\"ur Wasserbau u. Ingenieurhydrologie, Techn. Univ. Wien, 2006, ISBN 3852340896

See Also

seasindex

Examples

```
data(ngaruroro)
#Start of the hydrological year (01/12) is taken as second breakday
seasindex(ngaruroro)
```

---

seasratio *Seasonality Ratio*

Description

Calculates the seasonality ratio for two seasons.

Usage

```
seasratio(lfobj,
          breakdays,
          Q = 95)
```

Arguments

lfobj	An object of class "lfobj"
breakdays	One or two dates defining the summer/winter season
Q	Which quantile to use (standard = Q95)

Details

If breakdays is a single day, e.g. "01/06", the start of the hydrological year is taken as the second breakday. If other seasons are to be specified, a vector of two breakdays is needed.

Value

The seasonality ratio.

Author(s)

Daniel Koffler and Gregor Laaha

References

Laaha, G. and Bl\"oschl, G. (2006), Seasonality indices for regionalizing low flows. Hydrol. Process., 20

See Also

seasindex

Examples

```
data(ngaruroro)
#Start of the hydrological year (01/12) is taken as second breakday
seasratio(ngaruroro, breakdays = "01/07")

#Two breakdays
seasratio(ngaruroro, breakdays = c("01/03","01/09"))
```

---

seglenplot *Barchart of recession length*

Description

Plots a barchart to find a good value for 'seglength' when using recession.

Usage

```
seglenplot(lfobj,
           threslevel = 70,
           thresbreaks = c("fixed","monthly","seasonal"),
           thresbreakdays = NULL,
           rainpeaklevel = 0.95,
           na.rm = TRUE)
```

Arguments

lfobj	An object of class "lfobj"
threslevel	The threshold level (70 means Q70)
thresbreaks	"fixed" uses a fixed threshold level, "monthly" calculates the threshold for every month separatly, "seasonal" calculates thresholds for every season defined using "thresbreakdays".
thresbreakdays	Needed if "thresbreaks = 'seasonal'" to define the periodes for which separate thresholds should be calculated, see details
rainpeaklevel	A level between 0 and 1 or a logical vector, see details.
na.rm	Should NAs in the series be ignored?

Details

For recession analysis it is neccessary to define flood discharge peaks (rainpeaks) in the hydrograph. Rainpeaklevel defines a day to be a descharge peak, if rainpeaklevel * flow > flow[day before] and rainpeaklevel * flow > flow[day after].

If thresbreakdays or seasonbreakdays is a single day, e.g. "01/06", the start of the hydrological year is taken as the second breakday. If more than two seasons are to be specified, a vector of all breakdays is needed.

Value

A barchart

Warning

Other then in the manual, we implemented a barchart instead of a histogram. To save space, empty bars are not plotted!

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

recession

Examples

```
## Not run:
data(ngaruroro)
seglenplot(ngaruroro)
## End(Not run)
```

---

setlfunit *Define the unit to use in lf-plots*

Description

Sets the option for the unit in plots.

Usage

```
setlfunit(string = "")
```

Arguments

string	String of the unit

Details

The unit string should be readable for the R-function expression, for common units see example below.

Warning

No calculation on data is done by setting this string.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

Examples

```
data(ngaruroro)
#Default: no unit
bfplot(ngaruroro, year = 1991)

#The plot does not change, just the y-label does!
setlfunit("m^3/s")
bfplot(ngaruroro,year = 1991)

#Some possible labels:
setlfunit("m^3/s")
setlfunit("m^{3}*s^{-1}")
setlfunit("scriptscriptstyle(frac(m^3,s))")
setlfunit("l/s")
setlfunit("l*s^{-1}")
setlfunit("scriptscriptstyle(frac(l,s))")
setlfunit("m^3/s/km^2")
setlfunit("m^3*s^{-1}*km^{-2}")
setlfunit("scriptscriptstyle(frac(m^3,s%.%km^2))")
setlfunit("l/s/km^2")
setlfunit("l*s^{-1}*km^{-2}")
setlfunit("scriptscriptstyle(frac(l,s%.%km^2))")
```

streamdef *Streamflow Deficite*

Description

Calculates the streamflow deficite

Usage

```
streamdef(lfobj,
          pooling = c("none", "MA", "IT", "IC"),
          threslevel = 70,
          thresbreaks = c("fixed","monthly","daily","seasonal"),
          breakdays = c("01/06","01/10"),
          MAdays = 7,
          tmin = 5,
          IClevel = 0.1,
          mindur = 0,
          minvol = 0,
          table = c("all", "volmax", "durmax"),
          na.rm = TRUE)
```

Arguments

lfobj	An object of class "lfobj"
pooling	The pooling procedure used, "MA" stands for moving average, "IT" is the inter event time and "IC" is Lena Tallaksens interevent time and volume criterion.
threslevel	The threshold level, 70 means that Q70 should be used as threshold
thresbreaks	The periods for which seperated thresholds should be used, "fixed" uses a constant threshold, "monthly" uses monthly breaks, "daily" takes daily thresholdlevels. If "seasonal" is specified, you can enter the breakdays manualy using "breakdays".
breakdays	A vector of breakdays if thresbreaks = "seasonal". Please enter the breakdays using the format "
MAdays	If pooling = "MA" this is the number of days that should be averaged
tmin	Defines the number of days that low flow events must be seperatet within the "IT" or "IC" method.
IClevel	The ratio between inter-event excess volume in the "IC" method
mindur	The minimal duration of a low flow event in "IC" and "IT" method
minvol	The minimal deficit in a low flow period in "IC" and "IT" method
table	Should the output be a table of "all" deficit, "volmax" annual volume maxima or "durmax" annual duration maxima
na.rm	Should NAs be removed?

Details

When method "MA" is applied, the first and last MAdays/2 are not averaged, their original value is taken instead!

Value

A data frame containing characteristics of all low flow periods.

d	The duration of the low flow event
v	The drought volume (negative Values, as it is a deficite)
mi	The drought magnitude, i.e. the (positive) ratio between deficit volume and deficite duration
Qmin	The minimum flow of the low flow period
startyear	Year of the start of the low flow period
startmonth	Month of the start of the low flow period
startday	Day of the start of the low flow period

Please note that when using the "IT" method the end date of the low flow periode is not necessarily startdate + duration.

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

streamdefplot, createlfobj

Examples

```
data(ngaruroro)
#Full Table
streamdef(ngaruroro,pooling = "MA", MAdays = 6)
#Annual Volume-Maxima only
streamdef(ngaruroro,pooling = "MA", MAdays = 6,table = "volmax")
```

streamdefplot *Streamflow Deficite Plot*

Description

Gives a plot for a given hydrological year that showes deficite duration, occurance and volume.

Usage

```
streamdefplot(lfobj, year, threslevel = 70, thresbreaks = c("fixed",
                "monthly", "daily", "seasonal"), breakdays =
                c("01/06", "01/10"))
```

Arguments

lfobj	An object of class "lfobj"
year	The hydrological year that should be plotted
threslevel	The threshold level, 70 means that Q70 should be used as threshold
thresbreaks	The periods for which seperated thresholds should be used, "fixed" uses a constant threshold, "monthly" uses monthly breaks, "daily" takes daily thresholdlevels. If "seasonal" is specified, you can enter the breakdays manualy using "breakdays".
breakdays	A vector of breakdays if thresbreaks = "seasonal". Please enter the breakdays using the format "

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

streamdef

Examples

```
data(ngaruroro)
streamdefplot(ngaruroro, year = 1991)
```

tyears *T-Years Event*

Description

Fits a mixed extreme value distribution and estimates the T-Years event.

Usage

```
tyears(lfobj,
       event = 100,
       n = 7,
       dist = c("wei","gev","ln3","gum","pe3"),
       legend = TRUE,
       zetawei = NULL)
```

Arguments

lfobj	An object of type "lfobj"
event	A value for T, e.g. event = 100 means the 100 years extreme low flow event
n	The n in the AM(n-day) series, e.g. n=7 the annual 7 day minima are predicted
dist	A vector of distribution to fit, the names are according to Hostking's in his "lmom" package. Use ?cdf... (... is the distribution-name, e.g. ?cdfwei) for more information.
legend	logical, should R add a legend to the plot?
zetawei	Manualy set the zeta parameter of the Weibull distribution

Details

According to paragraph 7.4.2 in the manual, we have to take care of censored series. The parameters/plots are always for G(x) in (7.4), the T-Years-Event is calculated for F(x)*. If a Weibull distribution is fitted and zeta takes a value smaller than 0 it is set to 0. If you want to specify zeta otherwise, use the zetawei argument!

Value

A list containing

T_Years_Event	The expected T-Years event of all used distributions
pnull	The estimated value for p_0, i.e. the estimated probablility for 0 as AM(n) minimum.
parameters	The parameters of the fitted distributions
lmom	The estimated L-Moments

Author(s)

Daniel Koffler and Gregor Laaha

References

Gustard, A. & Demuth, S. (2009) (Eds) Manual on Low-flow Estimation and Prediction. Operational Hydrology Report No. 50, WMO-No. 1029, 136p.

See Also

lmom, cdfwei

Examples

```
data(ngaruroro)
#TYEARS EXAMPLE!!!
```

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