Package 'UKFE'

May 16, 2024

Type Package

Title UK Flood Estimation

Version 0.3.5

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Description Functions to implement the methods of the Flood Estimation Handbook (FEH), associated updates and the revitalised flood hydrograph model (ReFH). Currently the package uses NRFA peak flow dataset version 12.1. Aside from FEH functionality, further hydrological functions are available. Most of the methods implemented in this package are described in one or more of the following: ``Flood Estimation Handbook'', Centre for Ecology & Hydrology (1999, ISBN:0 948540 94 X). ``Flood Estimation Handbook Supplementary Report No. 1'', Kjeldsen (2007, ISBN:0 903741 15 7). ``Regional Frequency Analysis - an approach based on L-moments'', Hosking & Wallis (1997, ISBN: 978 0 521 01940 8). ``Proposal of the extreme rank plot for extreme value analysis: with an emphasis on flood frequency studies'', Hammond (2019, <doi:10.2166/nh.2019.157>). ``Making better use of local data in flood frequency estimation'', Environment Agency (2017, ISBN: 978 1 84911 387 8). ``Sampling uncertainty of UK design flood estimation'' , Hammond (2021, <doi:10.2166/nh.2021.059>). ``Improving the FEH statistical procedures for flood frequency estimation'', Environment Agency (2008, ISBN: 978 1 84432 920 5). ``Low flow estimation in the United Kingdom'', Institute of Hydrology (1992, ISBN 0 948540 45 1). Wallingford HydroSolutions, (2016, <http://software.hydrosolutions.co.uk/winfap4/Urban-Adjustment-Procedure-Technical-Note.pdf>). Data from the UK National River Flow Archive (<https://nrfa.ceh.ac.uk/>, terms and conditions: <https://nrfa.ceh.ac.uk/costs-terms-and-conditions>).

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Encoding UTF-8

LazyData true

RoxygenNote 7.2.3

Depends R (>= 3.5.0)

Imports xml2, methods

NeedsCompilation no

Repository CRAN

Date/Publication 2024-05-16 10:40:02 UTC

R **topics documented:**

AddGauge   *Add an AMAX sample*

Description

This function allows the user to add an AMAX sample and associated catchment descriptors for use
with the FEH process.

Usage

```
AddGauge(CDs, AMAX, ID)
```

Arguments

CDs	catchment descriptor object imported using the CDsXML function.
AMAX	Either a data.frame with date (or POSIXct) in the first column and a numeric vector in the second (the AMAX). Or an AMAX sample (a numeric vector).
ID	This is a user supplied identification number for the AMAX.

Details

The function provides the necessary AMAX sample statistics and data.frame for adding catchment
descriptors to the NRFAData data.frame. The user must then add these outputs using the rbind
function (see example). The AMAX could be read in or pasted in by the user or imported using
the AMImport function. Once they are added they can be used in the current R session. If a new
session is started (rather than a saved workspace) the added AMAX would need to be added again.

Value

A list object. The first element is a data.frame which is a row of statistics and descriptors to be
added to the NRFAData data.frame. The second element is the AMAX sample formatted to be
added to the AMSP data.frame

Author(s)

Anthony Hammond

Examples

```
#Read in AMAX and catchment descriptors
## Not run: AMAdd <- AMImport(r"{D:\NRFAPeakFlow_v12_1_0\suitable-for-neither\027003.am}")
## Not run: CDsAdd <- CDsXML(r"{D:\NRFAPeakFlow_v12_1_0\suitable-for-neither\027003.xml}")

#Apply the function and then add the results to the necessary data.frames.

## Not run: Gauge27003 <- AddGauge(CDsAdd, AMAdd, ID = "27003")
#Add the descriptors and stats (the first element of the output) to the NRFAData data.frame
## Not run: NRFAData <- rbind(NRFAData, Gauge27003[[1]])
#Add the AMAX to the AMSP data.frame.
## Not run: AMSP <- rbind(AMSP, Gauge27003[[2]])
```

AggDayHour   *Aggregate a time series*

Description

Aggregates time series data, creating hourly data from 15 minute data for example.

Usage

```
AggDayHour(x, func, Freq = "Day", hour = 9)
```

Arguments

x	a data.frame with POSIXct in the first column and numeric vector in the second.
func	the function used for aggregation; mean, max, or sum, for example.
Freq	Choices are "Day", or "Hour", or a numeric value representing the number of hours for aggregation.
hour	An integer between 0 and 23. This is used if "Day" is chosen in the Freq argument to determine when the day starts.

Details

The function can be used with a data.frame with POSIXct in the first column and a variable in the second. You can choose the level of aggregation in hours, or you can choose daily. In the daily case you can choose which hour of the day to start the aggregation. For example, you might want mean flows from 09:00 rather than midnight. You can also choose the function used to aggregate the data. For example, you might want "sum" for rainfall, and "mean" for flow. When aggregating hourly the aggregation starts at whatever hour is in the first row of x and the associated time stamps will reflect this.

Value

A data.frame with POSIXct in the first column (unless daily is chosen, then it's Date class), and the aggregated variable in the second column

Author(s)

Anthony Hammond

Examples

```
#Create a data.frame with a normally distributed variable at
#a 15 minute sampling rate.
TS <- seq(as.POSIXct("2000-01-01 00:00:00",
tz = "Europe/London"), as.POSIXct("2001-01-01 00:00:00", tz = "Europe/London"), by = 60*15)
TS <- data.frame(DateTime = TS, Var = rnorm(length(TS), 10, 2))
#use the function to aggregate to an hourly sampling rate, taking the maximum of each hour
Hourly <- AggDayHour(TS, func = max, Freq = "Hour")
#now aggregate with the mean at a daily scale
Daily <- AggDayHour(TS, func = mean, Freq = "Day")
#now aggregate with the sum at a 48 hour scale
Hr48 <- AggDayHour(TS, func = sum, Freq = 48)
#now aggregate with the sum at a 6 hour scale
Hr6 <- AggDayHour(TS, func = sum, Freq = 6)
```

AMextract   *Annual maximum extraction*

Description

Extracts the annual maximum peaks (with other options) from a data.frame which has dates (or POSIXct) in the first column and variable in the second.

Usage

```
AMextract(
  x,
  func = NULL,
  Calendar = FALSE,
  Trunc = TRUE,
  Plot = TRUE,
  Title = "Hydrological annual maximum sequence",
  Ylabel = "Magnitude"
)
```

Arguments

x	a data.frame with dates (or POSIXct) in the first column and variable in the second
func	A user chosen function to extract statistics other than maximums.
Calendar	logical. If FALSE, the hydrological year maximums are returned. If TRUE, the calendar year maximums are returned.

Trunc	logical with a default of TRUE. When true the beginning and end of the data.frame are first truncated so that it starts and ends at the start and end of the hydrological year (or Calendar year if Calendar = TRUE).
Plot	a logical argument with a default of TRUE. If TRUE the extracted annual maximum is plotted
Title	Title of the plot when. Default is "Hydrological annual maximum sequence"
Ylabel	Label for the y axis. Default is "Annual maximum quantiles"

Details

The peaks are extracted based on the UK hydrological year (unless Calendar = TRUE), which starts October 1st and ends September 30th. If Trunc = TRUE, partial years (non-full years from the beginning and end) are removed, otherwise the maximum value may not be the true annual maximum of the year. If there are NAs for full years in the data, an -Inf or NA will be returned for that year. The default is to extract maximums but the user can use the func argument to choose other statistics (mean or sum for example). Note that if the data has a sub-daily resolution, it is first aggregated to a daily resolution (with a 09:00 start) before the extraction. For example, the maximum for each day is extracted, then the annual maximums are extracted.

Value

a data.frame with columns; WaterYear and AM. By default AM is the annual maximum sample, but will be any statistic used as the func argument.

Author(s)

Anthony Hammond

Examples

```
#Extract the Thames AMAX daily mean flow and display the first six rows
ThamesAM <- AMextract(ThamesPQ[,c(1,3)])
head(ThamesAM)
#Extract the annual rainfall totals and change the plot labels accordingly
ThamesAnnualP <- AMextract(ThamesPQ[,1:2], func = sum, Title = "", Ylab = "Rainfall (mm)")
```

AMImport	*Import an annual maximum (AMAX) sample from NRFA peak flow .AM files*

Description

Imports the peak flows and dates from from NRFA peak flow .AM files, exluding the rejected years

Usage

```
AMImport(x)
```

Arguments

x   the file path for the .AM file

Details

File paths for importing data require forward slashes. On some operating systems, such as windows, the copy and pasted file paths will have backward slashes and would need to be changed accordingly.

Value

A data.frame with columns; Date and Flow

Author(s)

Anthony Hammond

Examples

```
#Import an AMAX sample and display the first six rows in the console
## Not run: AM.4003 <- AMImport("C:/Data/NRFAPeakFlow_v11/Suitable for QMED/4003.AM")
## Not run: head(AM.4003)]
```

AMplot   *Plot of the annual maximum sample*

Description

Provides two plots. First, a histogram of the sample, second, a barplot

Usage

```
AMplot(x)
```

Arguments

x   a data.frame with at least two columns. The first a date column and the second the annual maximum (AM) sequence. A third column with the station id is necessary for inclusion of the id in the plot title. An AM object derived from the GetAM or ImportAM functions.

Details

When used with a GetAM object or any data.frame with dates in the first column, the barplot is daily. Therefore, although it's an annual maximum (AM) sequence, some bars will be closer together depending on the number of days between them.

Value

a histogram of the AMAX sample and a barplot

Author(s)

Anthony Hammond

Examples

```
#Get an AMAX sample and plot
AMplot(GetAM(58002))
```

AMSP	*National River Flow Archive (NRFA) annual maximum data for sites suitable for pooling*

Description

A data.frame with three columns; Date, Flow, id. NRFA Peak Flow Dataset - Version 12.1

Usage

```
AMSP
```

Format

A data frame with 26203 rows and 3 columns

Date Date

Flow Annual maximum peak flow, m3/s

id Station identification number

Source

https://nrfa.ceh.ac.uk/peak-flow-dataset

ARF	*Areal reduction factor (ARF)*

Description

The results of applying, to a rainfall depth, the ratio of the rainfall over an area to the rainfall depth of the same duration at a representative point in the area.

Usage

```
ARF(Depth, Area, D)
```

Arguments

Depth	depth of rainfall
Area	catchment area in km2
D	duration in hours

Details

The ARF and it's use is detailed in the Flood Estimation Handbook (1999), volume 2. The DDF model is calibrated on point rainfall and the areal reduction factor converts it to a catchment rainfall for use with a rainfall runoff model such as ReFH (see details for ReFH function). The ReFH model includes a design rainfall profile for winter and summer but the depth duration frequency (DDF) model is calibrated on annual maximum peaks as opposed to seasonal peaks. A seasonal correction factor (SCF) is necessary to convert the DDF estimate to a seasonal one. The final depth, therefore is; Depth = DDFdepth x ARF x SCF.

Value

the rainfall depth or rainfall return period

Author(s)

Anthony Hammond

Examples

```
#Derive the ARF for a depth of 30, an area of 500km2 and a duration of 12 hours
ARF(30, 500, 12)
```

BFI   *Baseflow index (BFI)*

Description

Calculates the baseflow index from a daily mean flow series

Usage

```
BFI(Q, x.lim = NULL, y.lim = NULL, PlotTitle = "Baseflow plot", Plot = TRUE)
```

Arguments

Q	the daily mean flow series. Numeric vector
x.lim	the x axis limits of the plot. Numeric vector of length two Default is the extents of the data
y.lim	the y axis limits of the plot. Numeric vector of length two. Default is the extents of the data

PlotTitle	the title of the plot. The default is "Baseflow plot"
Plot	a logical argument with a default of TRUE. If TRUE the daily flow is plotted with the baseflow highlighted.

Details

The baseflow index is calculated using the method outlined in Gustard, A. Bullock, A. Dixon, J. M.. (1992). Low flow estimation in the United Kingdom. Wallingford, Institute of Hydrology, 88pp. (IH Report No.108)

Value

the baseflow index and if Plot equals TRUE, a plot showing the flow time series (black) and the associated baseflow (red)

Author(s)

Anthony Hammond

Examples

```
# Calculate the BFI from daily discharge at Kingston upon Thames;
# which is in column three of the ThamesPQ data
BFI(ThamesPQ[,3])
```

CDsXML	*Import catchment descriptors from .xml files*

Description

Imports catchment descriptors from xml files either from an FEH webservice download or from the Peakflows dataset downloaded from the national river flow archive (NRFA) website

Usage

```
CDsXML(x)
```

Arguments

x	the xml file path

Details

File paths for importing data require forward slashes. On some operating systems, such as windows, the copy and pasted file paths will have backward slashes and would need to be changed accordingly.

Value

A data.frame with columns; Descriptor and Value.

Author(s)

Anthony Hammond

Examples

```
#Import catchment descriptors from a NRFA peakflows xml file and display in console
## Not run: CDs.4003 <- CDsXML("C:/Data/NRFAPeakFlow_v11/Suitable for QMED/4003.xml")
## Not run: CDs.4003
#Import catchment descriptors from a FEH webserver xml file and display xml in the console
## Not run: CDs.MySite <- CDsXML("C:/Data/FEH_Catchment_384200_458200.xml")
```

DDF   *DDF results from a DDFImport object*

Description

Extracts results from a data frame imported using the DDFImport function

Usage

```
DDF(x, duration, RP = 100)
```

Arguments

x	A data frame of DDF13 or DDF22 results imported using the DDFImport function
duration	the duration (hrs) for which a rainfall depth estimate is required
RP	the return period (years) for which a rainfall depth estimate is required

Details

The .xml files only provide a set number of durations and return periods for DDF13 and DDF22. This function optimises the GEV distribution on the results in order to interpolate across return periods. A linear interpolation is used between durations. The interpolation method may provide results that differ from the FEH webserver in the region of 0.1mm. The result is then rounded to an integer.

Value

A DDF13 or DDF22 estimate of rainfall depth (mm)

Author(s)

Anthony Hammond

Examples

```
#Get DDF13 results from a the DDF
## Not run: DDF13.4003 <- DDFImport("C:/Data/NRFAPeakFlow_v9/Suitable for QMED/04003.xml")
#Estimate the 20-year, 5 hour depth
## Not run: DDF(DDF13.4003, duration = 5, RP = 20)
```

DDF99 *FEH99 depth duration frequency precipitation model*

Description

Estimation of design rainfall depths, and the rarity of observed rainfall

Usage

```
DDF99(Duration, RP, pars, Depth = NULL, disc = NULL)
```

Arguments

Duration	numeric. The duration of interest (in hours)
RP	return period
pars	a numeric vector of length six. The six catchment parameters for the DDF model in the order of: c, d1, d2, d3, e, f
Depth	a user supplied rainfall depth for the duration under question
disc	converts from the sliding duration to fixed duration estimate. Choices are "hourly" or "daily"

Details

The depth duration frequency rainfall model is detailed in the Flood Estimation Handbook (1999), volume 2. A note about the discretisation: The user can choose between "daily" or "hourly" for the sliding duration to fixed duration conversion. If the 'Depth' argument is used, it overrides the return period (RP) argument and provides RP as a function of depth. However, if both the 'Depth' and the 'disc' arguments are used, the sliding duration depth is provided as a function of the user input depth. This resulting depth can then be used without the 'disc' argument to determine the sliding duration RP.

Value

the rainfall depth or rainfall return period

Author(s)

Anthony Hammond

Examples

```
#Examples from FEH volume 2
#The parameters for these examples are from FEH v2
#What is the 2-day rainfall with return period 100-years for Norwich.
DDF99(Duration = 48, RP = 100, pars = c(-0.023, 0.273, 0.351, 0.236, 0.309, 2.488))
#What is the 4-hour rainfall with return period 20 years for a typical point in the Lyne catchment
DDF99(Duration = 4, RP = 20, pars = c(-0.025, 0.344, 0.485, 0.402, 0.287, 2.374))
#How rare was the rainfall of 6th August 1978 at Broughshane, County Antrim?
DDF99(Duration = 5, Depth = 47.7, pars = c(-0.022, 0.412, 0.551, 0.276, 0.261, 2.252))
```

DDF99Pars   *DDF99 parameters from .xml files*

Description

Imports the FEH 1999 depth duration frequency parameters from xml files either from an FEH webservice download or from the Peakflows dataset downloaded from the national river flow archive (NRFA) website

Usage

```
DDF99Pars(x)
```

Arguments

x   the xml file path

Details

This function is coded to import DDF99 parameters from xml files from the NRFA or the FEH webserver. File paths for importing data require forward slashes. On some operating systems, such as windows, the copy and pasted file paths will have backward slashes and would need to be changed accordingly.

Value

A list with two elements, each a data frame with columns; parameters and associated Values The first data frame is for the catchment average parameters (these still require an ARF adjustment where appropriate) and the second for the 1km2 grid point parameters.

Author(s)

Anthony Hammond

Examples

```
#Import DDF99 parameters from a NRFA peakflows xml file and display in console
## Not run: DDF99.4003 <- DDF99Pars("C:/Data/NRFAPeakFlow_v11/Suitable for QMED/04003.xml")
## Not run: DDF99.4003
#Import DDF99 parameters from a FEH webserver xml file and display in the console
## Not run: DDF99.MySite <- DDF99Pars("C:/Data/FEH_Catchment_384200_458200.xml")
```

DDFImport   *DDF13 or DDF22 results from .xml files*

Description

Imports the depth duration frequency 2013 or 2022 results from xml files either from an FEH webservice download or from the Peakflows dataset downloaded from the national river flow archive (NRFA) website

Usage

```
DDFImport(x, ARF = FALSE, Plot = TRUE, DDFVersion = 22)
```

Arguments

x	the xml file path
ARF	logical argument with a default of FALSE. If TRUE, the areal reduction factor is applied to the results. If FALSE, no area reduction factor is applied
Plot	logical argument with a default of TRUE. If TRUE the DDF curve is plotted for a few return periods
DDFVersion	Version of the DDF model (numeric). either 22 or 13. The default is 22.

Details

This function returns a data-frame of results. For further durations and return periods the separate DDF function can be applied with the data-frame as the argument/input. File paths for importing data require forward slashes. On some operating systems, such as windows, the copy and pasted file paths will have backward slashes and would need to be changed accordingly.

Value

A data frame of DDF results (mm) with columns for duration and rows for return period. If Plot equals TRUE a DDF plot is also returned.

Author(s)

Anthony Hammond

Examples

```
#Import DDF22 results from a NRFA peakflows xml file and display in console
## Not run: DDF22.4003 <- DDFImport("C:/Data/NRFAPeakFlow_v11/Suitable for QMED/04003.xml")
## Not run: DDF22.4003
#Import DDF22 results from a FEH webserver xml file and display in the console
## Not run: DDF22.MySite <- DDFImport("C:/Data/FEH_Catchment_384200_458200.xml")
```

DesHydro   *Design hydrograph extraction*

Description

Extracts a mean hydrograph from a flow series

Usage

```
DesHydro(
  x,
  qu = 0.8,
  n = 10,
  thr = 0.975,
  xst = NULL,
  xend = NULL,
  RetAll = FALSE,
  Smooth = 1
)
```

Arguments

x	a numeric vector. The flow series of interest
qu	the quantile of flow which separates peaks and truncates either side of the peak to form the event hydrograph. The default is 0.8
n	number of event hydrographs from which to derive the mean hydrograph. Default is 10. Depending on the length of x, there may be less than 10
thr	threshold above which event peaks are selected. The default is 0.975
xst	an integer to truncate the x axis of the plot and resulting design hydrograph. The first point of the design hydrograph
xend	an integer to truncate the x axis of the plot and resulting design hydrograph. The last point of the design hydrograph
RetAll	logical argument with a default of false. If TRUE, all the hydrographs from which the mean is derived are returned in a data.frame. If FALSE, the mean hydrograph is returned
Smooth	an integer (from 0 to 5). To smooth the design hydrograph. The default is 1 which provides the minimum level of smoothing. 0 is no smoothing and 5 is the highest

Details

All the peaks over a user defined threshold are identified and separated by a user defined value 'qu', which is a quantile of flow. The top n peaks are selected and the hydrographs extracted. Each hydrograph is centred on the peak and truncated either side, where the flow falls below the 'qu' quantile flow. All events are scaled to have a peak flow of one, and the mean of these is taken as the scaled design hydrograph. After an initial view of the hydrograph, it can be truncated using the 'xst' and 'xend' arguments. The default is to select 10 hydrographs for averaging, however, there may well be fewer if the sample is short.

Value

a numeric vector which is the mean of the top n peak events in the flow series. Also a plot of the n hydrographs and the design hydrograph. If the RetAll argument equals TRUE, a data.frame of the n hydrographs is returned instead.

Note

The smoothing is done by rolling average, where the the mean is of points from n to the left up to n to the right. The n is chosen by the Smooth argument.

Author(s)

Anthony Hammond

Examples

```
#Extract a design hydrograph from the Thames daily mean flow. Then print the resulting hydrograph
ThamesDesHydro <- DesHydro(ThamesPQ$Q)
ThamesDesHydro
#Do the same but truncate the design hydrograph and the plot from the first point to the 30th
DesHydro(ThamesPQ$Q, xst = 1, xend = 30)
#adjust the qu value to see the impact
ThamesDesHydro <- DesHydro(ThamesPQ$Q, qu = 0.7)
#Return all the hydrographs
ThamesHydros <- DesHydro(ThamesPQ$Q, xst = 1, xend = 30, RetAll = TRUE)
#view the first six rows of the hydrographs
head(ThamesHydros)
```

DeTrend	*Linearly detrend a sample*

Description

Applies a linear detrend to a sample

Usage

```
DeTrend(x)
```

Arguments

x   a numeric vector

Details

Adjusts all the values in the sample, of size n, by the difference between the linearly modelled ith data point and the linearly modelled nth data point.

Value

A numeric vector which is a linearly detrended version of x.

Author(s)

Anthony Hammond

Examples

```
# Get an annual maximum (AM) sample that looks to have a significant trend
AM.21025 <- GetAM(21025)
# plot the resulting AM as a bar plot. Then detrend and compare with another plot
plot(AM.21025$Flow, type = "h", ylab = "Discharge (m3/s)")
AM.Detrend <- DeTrend(AM.21025$Flow)
plot(AM.Detrend, type = "h", ylab = "Discharge (m3/s)")
```

DiagPlots   *Diagnostic plots for pooling groups*

Description

Provides 10 plots to compare the sites in the pooling group

Usage

```
DiagPlots(x, gauged = FALSE)
```

Arguments

x	pooling group derived from the Pool() function
gauged	logical argument with a default of FALSE. TRUE adds the top site in the pooling group to the plots in a different colour

Value

ten diagnostic plots for pooling groups

Author(s)

Anthony Hammond

Examples

```
#Form a gauged pooling group and plot the diagnostics with gauged = TRUE
Pool.96001 <- Pool(GetCDs(96001))
DiagPlots(Pool.96001, gauged = TRUE)
#Form an ugauged pooling group and plot the diagnostics
Pool.96001 <- Pool(GetCDs(96001), exclude = 96001)
DiagPlots(Pool.96001)
```

DonAdj   *Donor adjustment candidates & results*

Description

Provides donor adjustment candidates, descriptors, and results in order of the proximity to the centroid of the subject catchment.

Usage

```
DonAdj(CDs = NULL, x, y, QMEDscd = NULL, alpha = TRUE, rows = 10, d2 = NULL)
```

Arguments

CDs	catchment descriptors derived from either GetCDs or CDsXML
x	catchment centroid easting (for when CDs isn't used)
y	catchment centroid northing (for when CDs isn't used)
QMEDscd	QMED estimate for the catchment of interest (for when CDs isn't used)
alpha	logical argument with a default of TRUE. If FALSE the exponent of the donor adjustment equation is set to one
rows	number of sites provided; default is 10
d2	a numeric vector of length two; the two site references for the donor catchments chosen for the two donor case

Details

When d2 is FALSE the results for single donor adjustment are in the final column headed 'QMED.adj' for each site. If alpha is set to FALSE, the results in this column are from the same donor equation but with an exponent of 1. The donor adjustment method is as outlined in Science Report: SC050050 - Improving the FEH statistical procedures for flood frequency estimation. The method for two donors is outlined in 'Kjeldsen, T. (2019). Adjustment of QMED in ungauged catchments using two donor sites. Circulation - The Newsletter of the British Hydrological Society, 4'. When two donors are used, only the result is returned, rather than donor candidates. The QMEDfse column provides the gauged factorial standard error for the median of the annual maximum sample. It is worth considering this when choosing a donor site (a high value indicates a poor donor). When choosing between two donors, the site with a lower QMEDfse would be an appropriate choice (all else being equal). The QMEDfse is calculated with the QMEDfseSS() function.

Value

A data.frame with rownames of site references and columns of catchment descriptors, distance from
subect site, and associated results. When two donors are used, only the resulting adjusted QMED is
returned

Author(s)

Anthony Hammond

Examples

```
#Get some CDs and output candidate donor sites
CDs.54022 <- GetCDs(54022)
DonAdj(CDs.54022)
#Get results with inputs of x,y, and QMEDscd
DonAdj(x = 283261, y = 288067, QMEDscd = 17.931)
#Get a result with two donors
DonAdj(CDs.54022, d2 = c(54092, 54091))
```

EncProb   *Encounter probabilities*

Description

Calculates the probability of experiencing at least n events with a given return period (RP), over a
given number of years

Usage

```
EncProb(n, yrs, RP, dist = "Poisson")
```

Arguments

n	number of events
yrs	number of years
RP	return period of the events
dist	choice of probability distribution. Either "Poisson" or "Binomial"

Details

The choice of binomial or Poisson distributions for calculating encounter probablities is akin to
annual maximum (AM) versus peaks over threshold (POT) approaches to extreme value analysis.
AM and binomial assume only one "event" can occur in the blocked time period. Whereas Poisson
and POT don't make this assumption. In the case of most catchments in the UK, it is rare to
have less than two independent "events" per year; in which case the Poisson and POT choices are
more suitable. In large catchments, with seasonally distinctive baseflow, there may only be one
independent peak in the year. However, the results from both methods converge with increasing
magnitude, yielding insignificant difference beyond a 20-year return period.

Value

A probability

Author(s)

Anthony Hammond

Examples

```
#Calculate the probability of exceeding at least one 50-yr RP event
#over a 10 year period, using the Poisson distribution.
EncProb(n = 1, yrs = 10, RP = 50)
#Calculate the probability of exceeding at least two 100-yr RP events
#over a 100 year period, using the binomial distribution.
EncProb(n = 2, yrs = 100, RP = 100, dist = "Binomial")
```

EVPlot   *Extreme value plot (frequency and growth curves)*

Description

Plots the extreme value frequency curve or growth curve with observed sample points.

Usage

```
EVPlot(
  x,
  dist = "GenLog",
  scaled = TRUE,
  Title = "Extreme value plot",
  ylabel = NULL,
  LineName = NULL,
  Unc = TRUE
)
```

Arguments

x	a numeric vector. The sample of interest
dist	a choice of distribution. "GEV", "GenLog", "Kappa3","Gumbel" or "GenPareto". The default is "GenLog"
scaled	logical argument with a default of TRUE. If TRUE the plot is a growth curve (scaled by the QMED). If FALSE, the plot is a frequency curve
Title	a character string. The user chosen plot title. The default is "Extreme value plot"
ylabel	a character string. The user chosen label for the y axis. The default is "Q/QMED" if scaled = TRUE and "Discharge (m3/s)" if scaled = FALSE
LineName	a character string. User chosen label for the plotted curve
Unc	logical argument with a default of TRUE. If TRUE, 95 percent uncertainty intervals are plotted.

Details

The plotting has the option of generalised extreme value (GEV), generalised Pareto (GenPareto), Gumbel, or generalised logistic (GenLog) distributions. The uncertainty is quantified by bootstrapping.

Value

An extreme value plot (frequency or growth curve) with intervals to quantify uncertainty

Author(s)

Anthony Hammond

Examples

```
#Get an AMAX sample and plot the growth curve with the GEV distribution
AM.203018 <- GetAM(203018)
EVPlot(AM.203018$Flow, dist = "GEV")
```

EVPlotAdd   *Add lines and/or points to an extreme value plot*

Description

Functionality to add extra lines or points to an extreme value plot (derived from the EVPlot function).

Usage

```
EVPlotAdd(
  Pars,
  dist = "GenLog",
  Name = "Adjusted",
  MED = NULL,
  xyleg = NULL,
  col = "red",
  lty = 1,
  pts = NULL,
  ptSym = NULL
)
```

Arguments

Pars   a numeric vector of length two. The first is the Lcv (linear coefficient of variation) and the second is the Lskew (linear skewness).

dist   distribution name with a choice of "GenLog", "GEV", "GenPareto", "Kappa3", and "Gumbel"

Name	character string. User chosen name for points or line added (for the legend)
MED	The two year return level. Necessary In the case where the EV plot is not scaled
xyleg	a numeric vector of length two. They are the x and y position of the symbol and text to be added to the legend.
col	The colour of the points of line that have been added
lty	An integer. The type of line added
pts	A numeric vector. An annual maximum sample, for example. This is for points to be added
ptSym	An integer. The symbol of the points to be added

Details

A line can be added using the Lcv and Lskew based on one of four distributions (Generalised extreme value, Generalised logistic, Gumbel, Generalised Pareto). Points can be added as a numeric vector. If a single point is required, the base points() function can be used and the x axis will need to be log(RP-1).

Value

Additional, user specified line or points to an extreme value plot derived from the EVPlot function.

Author(s)

Anthony Hammond

Examples

```
#Get an AMAX sample and plot the growth curve with the GEV distribution
AM.203018 <- GetAM(203018)
EVPlot(AM.203018$Flow, dist = "GEV")
#Now add a line (dotted & red) for the generalised logistic distribution
#first get the Lcv and Lskew using the Lmoms function
pars <- as.numeric(Lmoms(AM.203018[,2])[c(5,6)])
EVPlotAdd(Pars = pars, dist = "GenLog", Name = "GenLog", xyleg = c(-5.2,2.65), lty = 3)
#Now add a line for the gumbel distribution which is darkgreen and dashed.
EVPlotAdd(Pars = pars[1], dist = "Gumbel", Name = "Gumbel",
xyleg = c(-5.19,2.5), lty = 3, col = "darkgreen")
#now plot afresh and get another AMAX and add the points
EVPlot(AM.203018$Flow, dist = "GEV")
AM.27090 <- GetAM(27090)
EVPlotAdd(xyleg = c(-4.9,2.65), pts = AM.27090[,2], Name = "27090")
```

EVPool *Extreme value plot for pooling groups*

Description

Plots the extreme value frequency curve or growth curve for gauged or ungauged pooled groups

Usage

```
EVPool(
  x,
  AMAX = NULL,
  gauged = FALSE,
  dist = "GenLog",
  QMED = NULL,
  Title = "Pooled growth curve",
  UrbAdj = FALSE,
  CDs
)
```

Arguments

x	pooling group derived from the Pool() function
AMAX	the AMAX sample to be plotted in the case of gauged. If NULL, & gauged equals TRUE, the AMAX from the first site in the pooling group is used
gauged	logical argument with a default of FALSE. If FALSE, the plot is the ungauged pooled curve accompanied by the single site curves of the group members. If TRUE, the plot is the gauged curve and single site curve with the observed points added
dist	a choice of distribution. Choices are "GEV", "GenLog", "Kappa3", or "Gumbel". The default is "GenLog"
QMED	a chosen QMED to convert the curve from a growth curve to the frequency curve
Title	a character string. The user chosen plot title. The default is "Pooled growth curve"
UrbAdj	a logical argument with a default of FALSE. If TRUE and urban adjustment is applied to the pooled growth curve
CDs	catchment descriptors derived from either GetCDs or CDsXML. Only necessary if UrbAdj is TRUE

Value

An extreme value plot for gauged or ungauged pooling groups

Author(s)

Anthony Hammond

Examples

```
#Get some CDs, form an ungauged pooling group and apply EVPlot.
CDs.96001 <- GetCDs(96001)
Pool.96001 <- Pool(CDs.96001, exclude = 96001)
EVPool(Pool.96001)
#Do the same for the gauged case, change the title, and convert with a QMED of 105.5.
PoolG.96001 <- Pool(CDs.96001)
EVPool(PoolG.96001, gauged = TRUE, Title = "Gauged frequency curve - Site 96001", QMED = 105.5)
#Pretend we have an extra AMAX for the gauge. Amend the pooling group Lcv and LSkew
#for the site accordingly then apply EVPool with the updated AMAX.
#Firstly, get the AMAX sample
AM.96001 <- GetAM(96001)
#Add an extra AMAX flow of 350m3/s
Append96001 <- append(AM.96001$Flow, 350)
#Amend the Lcv and Lskew in the pooling group
PoolG.96001[1, c(16, 17)] <- c(Lcv(Append96001), LSkew(Append96001))
#Now plot gauged with the updated AMAX
EVPool(PoolG.96001, AMAX = Append96001, gauged = TRUE)
```

GenLogAM   *Generalised logistic distribution - estimates directly from sample*

Description

Estimated quantiles as a function of return period (RP) and vice versa, directly from the data

Usage

```
GenLogAM(x, RP = 100, q = NULL)
```

Arguments

x	numeric vector (block maxima sample)
RP	return period (default = 100)
q	quantile (magnitude of variable)

Details

If the argument q is used, it overrides RP and provides RP as a function of q (magnitude of variable) as opposed to q as a function of RP. The parameters are estimated by the method of L-moments, as detailed in 'Hosking J. Wallis J. 1997 Regional Frequency Analysis: An Approach Based on L-moments. Cambridge University Press, New York'.

Value

quantile as a function of RP or vice versa.

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample and estimate the 50-year RP
AM.27090 <- GetAM(27090)
GenLogAM(AM.27090$Flow, RP = 50)
#Estimate the RP for a 600m3/s discharge
GenLogAM(AM.27090$Flow, q = 600)
```

GenLogEst   *Generalised logistic distribution estimates from parameters*

Description

Estimated quantiles as function of return period (RP) and vice versa, from user input parameters

Usage

```
GenLogEst(loc, scale, shape, q = NULL, RP = 100)
```

Arguments

loc	location parameter
scale	scale parameter
shape	shape parameter
q	quantile. magnitude of the variable under consideration
RP	return period

Details

If the argument q is used, it overrides RP and provides RP as a function of q (magnitude of variable) as opposed to q as a function of RP.

Value

quantile as a function of RP or vice versa

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample, estimate the parameters and estimate 50-year RP
AM.27090 <- GetAM(27090)
GenLogPars(AM.27090$Flow)
#Store parameters in an object
Pars <- as.numeric(GenLogPars(AM.27090$Flow))
#get estimate of 50-yr flow
GenLogEst(Pars[1], Pars[2], Pars[3], RP = 50)
#Estimate the RP for a 600m3/s discharge
GenLogEst(Pars[1], Pars[2], Pars[3], q = 600)
```

GenLogGF   *Generalised logistic distribution growth factors*

Description

Estimated growth factors as a function of return period, with inputs of Lcv & LSkew (linear coefficient of variation & linear skewness)

Usage

```
GenLogGF(lcv, lskew, RP)
```

Arguments

lcv	linear coefficient of variation
lskew	linear skewness
RP	return period

Details

Growth factors are calculated by the method outlined in the Flood Estimation Handbook, volume 3, 1999.

Value

Generalised logistic estimated growth factor

Author(s)

Anthony Hammond

Examples

```
#Estimate the 50-year growth factors from an Lcv and Lskew of 0.17 and 0.04, respectively.
GenLogGF(0.17, 0.04, RP = 50)
```

GenLogPars   *Generalised logistic distribution parameter estimates*

Description

Estimated parameters from a sample (with Lmoments or maximum likelihood estimation) or from L1 (first L-moment), Lcv (linear coefficient of variation), and LSkew (linear skewness)

Usage

```
GenLogPars(x = NULL, mle = FALSE, L1, LCV, LSKEW)
```

Arguments

x	numeric vector. The sample
mle	logical argument with a default of FALSE. If FALSE the parameters are estimated with Lmoments, if TRUE the parameters are estimated by maximum likelihood estimation.
L1	first Lmoment
LCV	linear coefficient of variation
LSKEW	linear skewness

Details

The L-moment estimated parameters are by the method detailed in 'Hosking J. Wallis J. 1997 Regional Frequency Analysis: An Approach Based on L-moments. Cambridge University Press, New York'

Value

Parameter estimates (location, scale, shape)

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample and estimate the parameters using Lmoments
AM.27090 <- GetAM(27090)
GenLogPars(AM.27090$Flow)
#Estimate parameters using MLE
GenLogPars(AM.27090$Flow, mle = TRUE)
#calculate Lmoments and estimate the parmeters with L1, Lcv and Lskew
Lmoms(AM.27090$Flow)
#store linear moments in an object
LPars <- as.numeric(Lmoms(AM.27090$Flow))[c(1,5,6)]
GenLogPars(L1 = LPars[1], LCV = LPars[2], LSKEW = LPars[3])
```

GenParetoEst   *Generalised Pareto distribution estimates from parameters*

Description

Estimated quantiles as function of return period (RP) and vice versa, from user input parameters

Usage

```
GenParetoEst(loc, scale, shape, q = NULL, RP = 100, ppy = 1)
```

Arguments

loc	location parameter
scale	scale parameter
shape	shape parameter
q	quantile. magnitude of the variable under consideration
RP	return period
ppy	peaks per year. Default is one

Details

If the argument q is used, it overrides RP and provides RP as a function of q (magnitude of variable) as opposed to q as a function of RP. The average number of peaks per year argument (ppy) is for the function to convert from the peaks over threshold (POT) scale to the annual scale. For example, if there are 3 peaks per year, the probability associated with the 100-yr return period estimate would be 0.01/3 (i.e. an RP of 300 on the POT scale) rather than 0.01.

Value

quantile as a function of RP or vice versa

Author(s)

Anthony Hammond

Examples

```
#Get a POT sample, estimate the parameters, and estimate 50-year RP
ThamesPOT <- POTextract(ThamesPQ[,c(1,3)], thresh = 0.90)
GenParetoPars(ThamesPOT$peak)
#Store parameters in an object
Pars <- as.numeric(GenParetoPars(ThamesPOT$peak))
#get estimate of 50-yr flow
GenParetoEst(Pars[1], Pars[2], Pars[3], ppy = 1.867, RP = 50)
#Estimate the RP for a 600m3/s discharge
GenParetoEst(Pars[1], Pars[2], Pars[3], ppy = 1.867, q = 600)
```

GenParetoGF   *Generalised Pareto distribution growth factors*

Description

Estimated growth factors as a function of return period, with inputs of Lcv & LSkew (linear coefficient of variation & linear skewness)

Usage

```
GenParetoGF(lcv, lskew, RP, ppy = 1)
```

Arguments

lcv	linear coefficient of variation
lskew	linear skewness
RP	return period
ppy	peaks per year

Details

Growth factors (GF) are calculated by the method outlined in the Flood Estimation Handbook, volume 3, 1999. The average number of peaks per year argument (ppy) is for the function to convert from the peaks over threshold (POT) scale to the annual scale. For example, if there are 3 peaks per year, the probability associated with the 100-yr return period estimate would be 0.01/3 (i.e. an RP of 300 on the POT scale) rather than 0.01.

Value

Generalised Pareto estimated growth factor

Author(s)

Anthony Hammond

Examples

```
#Get POT flow data from the Thames at Kingston (noting the no. peaks per year).
#Then estimate the 100-year growth factor with lcv and lskew estimates
TPOT <- POTextract(ThamesPQ[,c(1,3)], thresh = 0.90)
GenParetoGF(Lcv(TPOT$peak), LSkew(TPOT$peak), RP = 100, ppy = 1.867)
#multiply by the median of the POT data for an estimate of the 100-yr flood
GenParetoGF(Lcv(TPOT$peak), LSkew(TPOT$peak), RP = 100, ppy = 1.867)*median(TPOT$peak)
```

GenParetoPars *Generalised Pareto distribution parameter estimates*

Description

Estimated parameters from a sample (with Lmoments or maximum likelihood estimation) or from L1 (first L-moment), Lcv (linear coefficient of variation), and LSkew (linear skewness)

Usage

```
GenParetoPars(x = NULL, mle = FALSE, L1, LCV, LSKEW)
```

Arguments

x	numeric vector. The sample
mle	logical argument with a default of FALSE. If FALSE the parameters are estimated with Lmoments, if TRUE the parameters are estimated by maximum likelihood estimation
L1	first Lmoment
LCV	linear coefficient of variation
LSKEW	linear skewness

Details

The L-moment estimated parameters are by the method detailed in 'Hosking J. Wallis J. 1997 Regional Frequency Analysis: An Approach Based on L-moments. Cambridge University Press, New York'

Value

Parameter estimates (location, scale, shape)

Author(s)

Anthony Hammond

Examples

```
#Get a peaks over threshold sample and estimate the parameters using Lmoments
ThamesPOT <- ThamesPOT <- POTextract(ThamesPQ[,c(1,3)], thresh = 0.90)
GenParetoPars(ThamesPOT$peak)
#Estimate parameters using MLE
GenParetoPars(ThamesPOT$peak, mle = TRUE)
#calculate Lmoments and estimate the parmeters with L1, Lcv and Lskew
Lmoms(ThamesPOT$peak)
#store linear moments in an object
LPars <- as.numeric(Lmoms(ThamesPOT$peak))[c(1,5,6)]
GenParetoPars(L1 = LPars[1], LCV = LPars[2], LSKEW = LPars[3])
```

GenParetoPOT   *Generalised Pareto distribution - estimates directly from sample*

Description

Estimated quantiles as function of return period (RP) and vice versa, directly from the data

Usage

```
GenParetoPOT(x, ppy = 1, RP = 100, q = NULL)
```

Arguments

x	numeric vector (block maxima sample)
ppy	peaks per year
RP	return period (default = 100)
q	quantile (magnitude of variable)

Details

If the argument q is used, it overrides RP and provides RP as a function of q (magnitude of variable) as opposed to q as a function of RP. The average number of peaks per year argument (ppy) is for the function to convert from the peaks over threshold (POT) scale to the annual scale. For example, if there are 3 peaks per year, the probability associated with the 100-yr return period estimate would be 0.01/3 (i.e. an RP of 300 on the POT scale) rather than 0.01. The parameters are estimated by the method of L-moments, as detailed in 'Hosking J. Wallis J. 1997 Regional Frequency Analysis: An Approach Based on L-moments. Cambridge University Press, New York'.

Value

quantile as a function of RP or vice versa

Author(s)

Anthony Hammond

Examples

```
#Get a POT series and estimate the 50-year RP
ThamesPOT <- POTextract(ThamesPQ[,c(1,3)], thresh = 0.90)
GenParetoPOT(ThamesPOT$peak, ppy = 1.867, RP = 50)
#Estimate the RP for a 600m3/s discharge
GenParetoPOT(ThamesPOT$peak, ppy = 1.867, q = 600)
```

GetAM *Get an annual maximum sample from the National River Flow Archive sites suitable for pooling*

Description

Extracts the annual maximum peak flow sample and associated dates for the site of interest.

Usage

```
GetAM(ref)
```

Arguments

ref   the site reference of interest (numeric)

Value

A data.frame with columns; Date, Flow, and id

Author(s)

Anthony Hammond

Examples

```
#Get an AMAX sample and display it in the console
GetAM(203018)
#Save an AMAX sample as an object
AM.203018 <- GetAM(203018)
```

GetCDs *Get catchment descriptors from the National River Flow Archive sites considered suitable for median annual maximum flow estimation (QMED) and pooling.*

Description

Extracts the catchment descriptors for a site of interest from those suitable for QMED and pooling.

Usage

```
GetCDs(x)
```

Arguments

x   the site reference of interest (numeric)

Value

A data.frame with columns; Descriptor and Value.

Author(s)

Anthony Hammond

Examples

```
#Get CDs and display in the console
CDs.203018 <- GetCDs(203018)
CDs.203018
```

GetQMED   *QMED from a gauged site suitable for QMED*

Description

Provides QMED (median annual maximum flow) from a site suitable for QMED, using the site reference.

Usage

```
GetQMED(x)
```

Arguments

x   the gauged reference

Value

the median annual maximum

Author(s)

Anthony Hammond

Examples

```
#Get the observed QMED from sites 55002
GetQMED(55002)
```

GEVAM	*Generalised extreme value distribution - estimates directly from sample*

Description

Estimated quantiles as function of return period (RP) and vice versa, directly from the data

Usage

```
GEVAM(x, RP = 100, q = NULL)
```

Arguments

x	numeric vector (block maxima sample)
RP	return period (default = 100)
q	quantile (magnitude of variable)

Details

If the argument q is used, it overrides RP and provides RP as a function of q (magnitude of variable) as opposed to q as a function of RP. The parameters are estimated by the method of L-moments, as detailed in 'Hosking J. Wallis J. 1997 Regional Frequency Analysis: An Approach Based on L-moments. Cambridge University Press, New York'.

Value

quantile as a function of RP or vice versa.

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample and estimate the 50-year RP
AM.27090 <- GetAM(27090)
GEVAM(AM.27090$Flow, RP = 50)
#Estimate the RP for a 600m3/s discharge
GEVAM(AM.27090$Flow, q = 600)
```

GEVEst   *Generalised extreme value distribution estimates from parameters*

Description

Estimated quantiles as function of return period (RP) and vice versa, from user input parameters

Usage

```
GEVEst(loc, scale, shape, q = NULL, RP = 100)
```

Arguments

loc	location parameter
scale	scale parameter
shape	shape parameter
q	quantile. magnitude of the variable under consideration
RP	return period

Details

If the argument q is used, it overrides RP and provides RP as a function of q (magnitude of variable) as opposed to q as a function of RP.

Value

quantile as a function of RP or vice versa

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample, estimate the parameters and estimate 50-year RP
AM.27090 <- GetAM(27090)
GEVPars(AM.27090$Flow)
#Store parameters in an object
Pars <- as.numeric(GEVPars(AM.27090$Flow))
#get estimate of 50-yr flow
GEVEst(Pars[1], Pars[2], Pars[3], RP = 50)
#Estimate the RP for a 600m3/s discharge
GEVEst(Pars[1], Pars[2], Pars[3], q = 600)
```

GEVGF *Generalised extreme value distribution growth factors*

Description

Estimated growth factors as a function of return period, with inputs of Lcv & LSkew (linear coefficient of variation & linear skewness)

Usage

```
GEVGF(lcv, lskew, RP)
```

Arguments

`lcv`	linear coefficient of variation
`lskew`	linear skewness
`RP`	return period

Details

Growth factors are calculated by the method outlined in the Flood Estimation Handbook, volume 3, 1999.

Value

Generalised extreme value estimated growth factor

Author(s)

Anthony Hammond

Examples

```
#Estimate the 50-year growth factors from Lcv = 0.17 and Lskew = 0.04
GEVGF(0.17, 0.04, RP = 50)
```

GEVPars   *Generalised extreme value distribution parameter estimates*

Description

Estimated parameters from a sample (with Lmoments or maximum likelihood estimation) or from
L1 (first L-moment), Lcv (linear coefficient of variation), and LSkew (linear skewness)

Usage

```
GEVPars(x = NULL, mle = FALSE, L1, LCV, LSKEW)
```

Arguments

x	numeric vector. The sample
mle	logical argument with a default of FALSE. If FALSE the parameters are estimated with Lmoments, if TRUE the parameters are estimated by maximum likelihood estimation
L1	first Lmoment
LCV	linear coefficient of variation
LSKEW	linear skewness

Details

The L-moment estimated parameters are by the method detailed in 'Hosking J. Wallis J. 1997 Regional Frequency Analysis: An Approach Based on L-moments. Cambridge University Press, New York'

Value

Parameter estimates (location, scale, shape)

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample and estimate the parameters using Lmoments
AM.27090 <- GetAM(27090)
GEVPars(AM.27090$Flow)
#Estimate parameters using MLE
GEVPars(AM.27090$Flow, mle = TRUE)
#calculate Lmoments and estimate the parmeters with L1, Lcv and Lskew
Lmoms(AM.27090$Flow)
#store linear moments in an object
LPars <- as.numeric(Lmoms(AM.27090$Flow))[c(1,5,6)]
GEVPars(L1 = LPars[1], LCV = LPars[2], LSKEW = LPars[3])
```

GumbelAM

Gumbel distribution - estimates directly from sample

Description

Estimated quantiles as a function of return period (RP) and vice versa, directly from the data

Usage

```
GumbelAM(x, RP = 100, q = NULL)
```

Arguments

x	numeric vector (block maxima sample)
RP	return period (default = 100)
q	quantile (magnitude of variable)

Details

If the argument q is used, it overrides RP and provides RP as a function of q (magnitude of variable) as opposed to q as a function of RP. The parameters are estimated by the method of L-moments, as detailed in 'Hosking J. Wallis J. 1997 Regional Frequency Analysis: An Approach Based on L-moments. Cambridge University Press, New York'.

Value

quantile as a function of RP or vice versa.

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample and estimate the 50-year RP
AM.27090 <- GetAM(27090)
GumbelAM(AM.27090$Flow, RP = 50)
#Estimate the RP for a 600m3/s discharge
GumbelAM(AM.27090$Flow, q = 600)
```

GumbelEst   *Gumbel distribution estimates from parameters*

Description

Estimated quantiles as function of return period (RP) and vice versa, from user input parameters

Usage

```
GumbelEst(loc, scale, q = NULL, RP = 100)
```

Arguments

loc	location parameter
scale	scale parameter
q	quantile. magnitude of the variable under consideration
RP	return period

Details

If the argument q is used, it overrides RP and provides RP as a function of q (magnitude of variable) as opposed to q as a function of RP.

Value

quantile as a function of RP or vice versa

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample, estimate the parameters and estimate 50-year RP
AM.27090 <- GetAM(27090)
Pars <- as.numeric(GumbelPars(AM.27090$Flow))
GumbelEst(Pars[1], Pars[2], RP = 50)
#Estimate the RP for a 600m3/s discharge
GumbelEst(Pars[1], Pars[2], q = 600)
```

GumbelGF *Gumbel distribution growth factors*

Description

Estimated growth factors as a function of return period, with inputs of Lcv & LSkew (linear coefficient of variation & linear skewness)

Usage

```
GumbelGF(lcv, RP)
```

Arguments

lcv   linear coefficient of variation

RP   return period

Details

Growth factors are calculated by the method outlined in the Flood Estimation Handbook, volume 3, 1999.

Value

Gumbel estimated growth factor

Author(s)

Anthony Hammond

Examples

```
#Estimate the 50-year growth factors from an Lcv of 0.17.
GumbelGF(0.17, RP = 50)
```

GumbelPars *Gumbel distribution parameter estimates*

Description

Estimated parameters from a sample (with Lmoments or maximum likelihood estimation) or from L1 (first L-moment), Lcv (linear coefficient of variation)

Usage

```
GumbelPars(x = NULL, mle = FALSE, L1, LCV)
```

Arguments

x	numeric vector. The sample
mle	logical argument with a default of FALSE. If FALSE the parameters are estimated with Lmoments, if TRUE the parameters are estimated by maximum likelihood estimation
L1	first Lmoment
LCV	linear coefficient of variation

Details

The L-moment estimated parameters are by the method detailed in 'Hosking J. Wallis J. 1997 Regional Frequency Analysis: An Approach Based on L-moments. Cambridge University Press, New York'

Value

Parameter estimates (location, scale)

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample and estimate the parameters using Lmoments
AM.27090 <- GetAM(27090)
GumbelPars(AM.27090$Flow)
#Estimate parameters using MLE
GumbelPars(AM.27090$Flow, mle = TRUE)
#calculate Lmoments and estimate the parmeters with L1 and Lcv
Pars <- as.numeric(Lmoms(AM.27090$Flow)[c(1,5)])
GumbelPars(L1 = Pars[1], LCV = Pars[2])
```

H2   *Heterogeneity measure (H2) for pooling groups.*

Description

Quantifies the heterogeneity of a pooled group

Usage

```
H2(x, H1 = FALSE)
```

Arguments

x	pooling group derived from the Pool() function
H1	logical with a default of FALSE. If TRUE, the function applies the 'H1' version of the test (see Hosking & Wallis 1997 reference). If FALSE, the default H2 version is applied.

Details

The H2 measure was developed by Hosking & Wallis and can be found in their book 'Regional Frequency Analysis: an approach based on LMoments (1997). It was also adopted for use by the Flood Estimation Handbook (1999) and is described in volume 3.

Value

A vector of two characters; the first representing the H2 score and the second stating a qualitative measure of heterogeneity.

Author(s)

Anthony Hammond

Examples

```
#Get CDs, form a pooling group and calculate H2
CDs.203018 <- GetCDs(203018)
Pool.203018 <- Pool(CDs.203018)
H2(Pool.203018)
```

HydroPlot	*Hydrological plot of concurrent discharge and precipitation*

Description

Plots concurrent precipitation and discharge with precipitation along the top and discharge along the bottom

Usage

```
HydroPlot(
  x,
  Title = "Concurrent Rainfall & Discharge",
  from = NULL,
  to = NULL,
  adj.y = 1.5,
  plw = 1,
  qlw = 1.8,
  Return = FALSE
)
```

Arguments

x	a data.frame with three columns in the order of date (or POSIXct), precipitation, and discharge
Title	a character string. The user chosen plot title. The default is "Concurrent Rainfall & Discharge"
from	a starting time for the plot. In the form of a date or POSIXct object. The default is the first row of x
to	an end time for the plot. In the form of a date or POSIXct object. The default is the last row of x
adj.y	a numeric value to adjust the closeness of the preciptation and discharge in the plot. Default is 1.5. A lower value brings them closer and a larger value further apart
plw	a numeric value to adjust the width of the precipitation lines. Default is one. A larger value thickens them and vice versa
qlw	a numeric value to adjust the width of the discharge line. Default is 1.8. A larger value thickens them and vice versa
Return	a logical argument with a default of FALSE. If TRUE the data-frame of time, precipitation, and flow is returned

Details

The input of x is a dataframe with the first column being time. If the data is sub daily this should be class POSIXct with time as well as date.

Value

A plot of concurrent precipitation and discharge. With the former at the top and the latter at the bottom. If the Return argument equals true the associated data-frame is also returned.

Author(s)

Anthony Hammond

Examples

```
#Plot the Thames precipitation and discharge for the 2013 hydrological year,
#adjusting the y axis to 1.8.
HydroPlot(ThamesPQ, from = "2013-10-01", to = "2014-09-30", adj.y = 1.8)
```

Kappa3AM   *Kappa3 distribution - estimates directly from sample*

Description

Estimated quantiles as a function of return period (RP) and vice versa, directly from the data

Usage

```
Kappa3AM(x, RP = 100, q = NULL)
```

Arguments

x	numeric vector (block maxima sample)
RP	return period (default = 100)
q	quantile (magnitude of variable)

Details

If the argument q is used, it overrides RP and provides RP as a function of q (magnitude of variable) as opposed to q as a function of RP. The parameters are estimated by the method of L-moments, as detailed in 'Hosking J. Wallis J. 1997 Regional Frequency Analysis: An Approach Based on L-moments. Cambridge University Press, New York'. The Kappa3 distribution is as defined by This is the Kappa3 distribution as defined in Kjeldsen, T (2019), 'The 3-parameter Kappa distribution as an alternative for use with FEH pooling groups.'Circulation - The Newsletter of the British Hydrological Society, no. 142.

Value

quantile as a function of RP or vice versa.

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample and estimate the 50-year RP
AM.27090 <- GetAM(27090)
Kappa3AM(AM.27090$Flow, RP = 50)
#Estimate the RP for a 600m3/s discharge
Kappa3AM(AM.27090$Flow, q = 600)
```

Kappa3Est   *Kappa3 distribution estimates from parameters*

Description

Estimated quantiles as function of return period (RP) and vice versa, from user input parameters

Usage

```
Kappa3Est(loc, scale, shape, q = NULL, RP = 100)
```

Arguments

`loc`	location parameter
`scale`	scale parameter
`shape`	shape parameter
`q`	quantile. magnitude of the variable under consideration
`RP`	return period

Details

If the argument q is used, it overrides RP and provides RP as a function of q (magnitude of variable) as opposed to q as a function of RP. This is the Kappa3 distribution as defined in Kjeldsen, T (2019), 'The 3-parameter Kappa distribution as an alternative for use with FEH pooling groups.'Circulation - The Newsletter of the British Hydrological Society, no. 142.

Value

quantile as a function of RP or vice versa

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample, estimate the parameters and estimate 50-year RP
AM.27090 <- GetAM(27090)
#Get parameters and Store as an object
Pars <- as.numeric(Kappa3Pars(AM.27090$Flow))
#get estimate of 50-yr flow
Kappa3Est(Pars[1], Pars[2], Pars[3], RP = 50)
#Estimate the RP for a 600m3/s discharge
Kappa3Est(Pars[1], Pars[2], Pars[3], q = 600)
```

Kappa3GF   *Kappa3 distribution growth factors*

Description

Estimated growth factors as a function of return period, with inputs of Lcv & LSkew (linear coefficient of variation & linear skewness)

Usage

```
Kappa3GF(lcv, lskew, RP)
```

Arguments

lcv	linear coefficient of variation
lskew	linear skewness
RP	return period

Details

Growth factors are calculated by the method outlined in Kjeldsen, T (2019), 'The 3-parameter Kappa distribution as an alternative for use with FEH pooling groups.'Circulation - The Newsletter of the British Hydrological Society, no. 142

Value

Kappa3 distribution estimated growth factor

Author(s)

Anthony Hammond

Examples

```
#Get a ungauged pooled Lcv and LSkew for catchment 15006
PooledRes <- as.numeric(QuickResults(GetCDs(15006), plot = FALSE)[[2]])
#Calculate Kappa growth factor for the 100-year flood
Kappa3GF(PooledRes[1], PooledRes[2], RP = 100)
```

Kappa3Pars   *Kappa3 distribution parameter estimates*

Description

Estimated parameters from a sample (using Lmoments) or from user supplied L1 (first L-moment), Lcv (linear coefficient of variation), and LSkew (linear skewness)

Usage

```
Kappa3Pars(x = NULL, L1, LCV, LSKEW)
```

Arguments

x	numeric vector. The sample
L1	first Lmoment
LCV	linear coefficient of variation
LSKEW	linear skewness

Details

The L-moment estimated parameters are by the method detailed in 'Hosking J. Wallis J. 1997 Regional Frequency Analysis: An Approach Based on L-moments. Cambridge University Press, New York'. The Kappa3 distribution is as defined by This is the Kappa3 distribution as defined in Kjeldsen, T (2019), 'The 3-parameter Kappa distribution as an alternative for use with FEH pooling groups.'Circulation - The Newsletter of the British Hydrological Society, no. 142.

Value

Parameter estimates (location, scale, shape)

Author(s)

Anthony Hammond

Examples

```
#Get an annual maximum sample and estimate the parameters.
AM.27090 <- GetAM(27090)
Kappa3Pars(AM.27090$Flow)
#calculate Lmoments and estimate the parmeters with L1, L2, Lcv, and Lskew
LPars <- as.numeric(Lmoms(AM.27090$Flow))[c(1,2,5,6)]
Kappa3Pars(L1 = LPars[1], LCV = LPars[2], LSKEW = LPars[3])
```

Lcv   *Linear coefficient of variation (Lcv)*

Description

Calculates the Lcv from a sample of data

Usage

```
Lcv(x)
```

Arguments

x   a numeric vector. The sample of interest

Details

Lcv calculated according to methods outlined by Hosking & Wallis (1997): Regional Frequency Analysis and approach based on LMoments. Also in the Flood Estimation Handbook (1999), volume 3.

Value

Numeric. The Lcv of a sample.

Author(s)

Anthony Hammond

Examples

```
#Get an AMAX sample and calculate the Lmoments
AM.96001 <- GetAM(96001)
Lcv(AM.96001$Flow)
```

LcvUrb   *Urban adjustment for the linear coefficient of variation (Lcv)*

Description

Urbanises or de-urbanises the Lcv using the methods outlined in the guidance by Wallingford HydroSolutions: 'WINFAP 4 Urban Adjustment Procedures'

Usage

```
LcvUrb(lcv, URBEXT2000, DeUrb = FALSE)
```

Arguments

`lcv`	the Lcv (numeric)
`URBEXT2000`	quantiication of urban and suburbanisation for the subject catchment
`DeUrb`	logical argument with a default of FALSE. If set to TRUE, de-urbanisation adjustment is performed, if FALSE, urbanisation adjustment is performed

Details

The method for de-urbanisation isn't explicitly provided in 'WINFAP 4 Urban Adjustment Procedures', but the procedure is a re-arrangement of the urbanisation equation, solving for Lcv rather than Lcv-urban.

Value

The urban adjust Lcv or the de-urbanised Lcv

Author(s)

Anthony Hammond

Examples

```
#Choose an urban site (site 53006) from the NRFA data then apply a de-urban
#adjustment using the Lcv and URBEXT2000 displayed
NRFAData[which(rownames(NRFAData) == 53006),]
LcvUrb(0.21, 0.1138, DeUrb = TRUE)
#Get the pooled Lmoment ratios results for catchment 53006 and apply the
#urban adjustment using the pooled Lcv, and the URBEXT2000 for site 53006.
CDs.53006 <- GetCDs(53006)
QuickResults(CDs.53006)[[2]]
LcvUrb(0.196, 0.1138)
```

LKurt | *Linear Kurtosis (LKurt)*

Description

Calculates the LKurtosis from a sample of data

Usage

```
LKurt(x)
```

Arguments

`x`	a numeric vector. The sample of interest

Details

LKurtosis calculated according to methods outlined by Hosking & Wallis (1997): Regional Frequency Analysis and approach based on LMoments. Also in the Flood Estimation Handbook (1999), volume 3.

Value

Numeric. The LSkew of a sample.

Author(s)

Anthony Hammond

Examples

```
#Get an AMAX sample and calculate the Lmoments
AM.96001 <- GetAM(96001)
LKurt(AM.96001$Flow)
```

Lmoms	*Lmoments & Lmoment ratios*

Description

Calculates the Lmoments and Lmoment ratios from a sample of data

Usage

```
Lmoms(x)
```

Arguments

x   a numeric vector. The sample of interest

Details

Lmoments calculated according to methods outlined by Hosking & Wallis (1997): Regional Frequency Analysis and approach based on LMoments. Also in the Flood Estimation Handbook (1999), volume 3.

Value

A data.frame with one row and column headings; L1, L2, L3, L4, Lcv, LSkew, and LKurt. The first four are the Lmoments and the next three are the Lmoment ratios.

Author(s)

Anthony Hammond

Examples

```
#Get an AMAX sample and calculate the Lmoments
AM.96001 <- GetAM(96001)
Lmoms(AM.96001$Flow)
```

LRatioChange   *Adjust L-Ratios in a pooling group*

Description

Adjusts the linear coefficient of variation (Lcv) and the linear skewness (LSkew) for a chosen site in a pooling group

Usage

```
LRatioChange(x, SiteID, lcv, lskew)
```

Arguments

x	pooling group derived with the Pool function
SiteID	the identification number of the site in the pooling group that is to be changed (character or integer)
lcv	The user supplied Lcv. numeric
lskew	The user supplied LSkew. numeric

Details

Pooling groups are formed from the NRFAData data.frame and all the Lcv and LSkew values are precalculated using the National River Flow Archive Peak flow dataset noted in the description file. The resulting pooled growth curve is calculated using the Lcv and Lskew in the pooled group. The user may have further data and be able to add further peak flows to the annual maximum samples within a pooling group. If that is the case a new Lcv and Lskew can be determined using the Lmoms function. These new values can be added to the pooling group with this LRatioChange function. Also the permeable adjustment function may have been applied to a site, which provides a new Lcv and LSkew. In which case, the LRatioChange function can be applied. The function creates a new pooling group object and x will still exist in it's original state after the function is applied.

Value

A new pooling group, the same as x except for the user adjusted Lcv and Lskew for the user selected site.

Author(s)

Anthony Hammond

Examples

```
# Get some catchment descriptors and create a pooling group.
CDs.39001 <- GetCDs(39001)
Pool.39001 <- Pool(CDs.39001, iug = TRUE)
# apply the function to create a new adjusted pooling group,
#changing the subject site lcv and lskew to 0.187 and 0.164, respectively
Pool.39001Adj <- LRatioChange(Pool.39001, SiteID = 39001, lcv = 0.187, lskew = 0.164)
```

LSkew   *Linear Skewness (LSkew)*

Description

Calculates the LSkew from a sample of data

Usage

```
LSkew(x)
```

Arguments

x   a numeric vector. The sample of interest

Details

LSkew calculated according to methods outlined by Hosking & Wallis (1997): Regional Frequency Analysis and approach based on LMoments. Also in the Flood Estimation Handbook (1999), volume 3.

Value

Numeric. The LSkew of a sample.

Author(s)

Anthony Hammond

Examples

```
#Get an AMAX sample and calculate the Lmoments
AM.96001 <- GetAM(96001)
LSkew(AM.96001$Flow)
```

LSkewUrb   *Urban adjustment for the linear skewness (LSkew)*

Description

Urbanises or de-urbanises the LSkew using the methods outlined in the guidance by Wallingford HydroSolutions: 'WINFAP 4 Urban Adjustment Procedures'

Usage

```
LSkewUrb(lskew, URBEXT2000, DeUrb = FALSE)
```

Arguments

lskew	the LSkew (numeric)
URBEXT2000	quantiication of urban and suburbanisation for the subject site
DeUrb	logical argument with a default of FALSE. If set to TRUE, de-urbanisation adjustment is performed, if FALSE, urbanisation adjustment is performed

Details

The method for de-urbanisation isn't explicitly provided in 'WINFAP 4 Urban Adjustment Procedures', but the procedure is a re-arrangment of the urbanisation equation, solving for LSkew rather than LSkew-urban.

Value

The urban adjust Lcv or the de-urbanised Lcv

Author(s)

Anthony Hammond

Examples

```
#Choose an urban site (site 53006) from the NRFA data then apply a de-urban
#adjustment using the Lcv and URBEXT2000 displayed
NRFAData[which(rownames(NRFAData) == 53006),]
LSkewUrb(0.124, 0.1138, DeUrb = TRUE)
#Get the pooled Lmoment ratios results for catchment 53006 and apply the urban
#Get the CDS & adjustment using the pooled LSkew, and the URBEXT2000 for site 53006.
CDs.53006 <- GetCDs(53006)
QuickResults(CDs.53006)[[2]]
LSkewUrb(0.194, 0.1138)
```

MonthlyStats   *Monthly Statistics*

Description

Derives monthly statistics from a data.frame with Dates or POSIXct in the first column and variable of interest in the second

Usage

```
MonthlyStats(
  x,
  stat,
  AggStat = NULL,
  Plot = FALSE,
  ylab = "Magnitude",
  main = "Monthly Statistics",
  col = "grey"
)
```

Arguments

x	a data.frame with Dates or POSIXct in the first column and numeric vector in the second.
stat	the function of interest. mean or sum for example.
AggStat	the aggregating statistic. The default is mean. See details
Plot	logical argument with a default of TRUE. If TRUE the monthly statistics are plotted.
ylab	A label for the y axis of the plot. The default is "Magnitude"
main	A title for the plot. The default is "Monthly Statistics"
col	A choice of colour for the bar plot. A single colour or a vector (a colour for each bar).

Details

The statistic of interest for each month is calculated for each calendar year in the data.frame. An aggregated result is also calculated for each month using an aggregating statistic (the mean by default). The data.frame is first truncated at the first occurrence of January 1st and last occurrence of December 31st.

Value

A list with two elements. The first element is a data.frame with year in the first column and months in the next 12 (i.e. each row has the monthly stats for the year). The second element is a dataframe with month in the first column and the associated aggregated statistic in the second. i.e. the aggregated statistic (default is the mean) for each month is provided.

Author(s)

Anthony Hammond

Examples

```
# Get the mean flows for each month for the Thames at Kingston
QMonThames <- MonthlyStats(ThamesPQ[,c(1,3)], stat = mean,
ylab = "Discharge (m3/s)", main = "Thames at Kingston monthly mean flow")
# Get the monthly sums of rainfall for the Thames at Kingston
PMonThames <- MonthlyStats(ThamesPQ[,c(1,2)], stat = sum,
ylab = "Rainfall (mm)", main = "Thames as Kingston monthly rainfall")
```

NGRDist   *British national grid reference (NGR) distances*

Description

Calculates the euclidean distance between two british national grid reference points using the pythagorean method

Usage

```
NGRDist(i, j)
```

Arguments

i	a numeric vector of length two. The first being the easting and the second being the northing of the first site
j	a numeric vector of length two. The first being the easting and the second being the northing of the second site

Details

Note, that the result is converted to km when six digits are used for easting and northing, when six digits would usually provide a result in metres.

Value

A distance in kilometres (if six digits for easting and northing are used)

Author(s)

Anthony Hammond

Examples

```
#Calculate the distance between the catchment centroid for the
#Kingston upon Thames river gauge and the catchment centroid for the
#gauge at Ardlethen on the River Ythan. First view the eastings and northings
GetCDs(10001)
GetCDs(39001)
NGRDist(i = c(381355, 839183), j = c(462899, 187850))
```

NonFloodAdj   *Non-flood adjustment*

Description

Adjusts the linear coefficient of variation (Lcv) and the linear skewness to account for non-flood years

Usage

```
NonFloodAdj(x)
```

Arguments

x   The annual maximum sample. Numeric vector

Details

The method is the "permeable adjustment method" detailed in chapter 19, volume three of the Flood Estimation Handbook, 1999. The method makes no difference for sites where there are no annual maximums (AM) in the sample that are < median(AM)/2. Once applied the results can be used with the LRatioChange function to update the associated member of a pooling group. There is also the NonFloodAdjPool() function which can be used for multiple sites in a pooling group.

Value

A list is returned. The first element of the list is a dataframe with one row and two columns. Lcv in the first column and Lskew in the second. The second element of the list is another dataframe with one row and three columns. Number of non-flood years in the first column, sample size in the second and the percent of non-flood year in the third.

Author(s)

Anthony Hammond

Examples

```
# Get an anuual maximum sample with a BFIHOST above 0.65 and with some
# annual maximums lower than median(AM)/2. And then apply the function.
NonFloodAdj(GetAM(44013)[,2])
```

NonFloodAdjPool   *Non-flood adjustment for pooling groups*

Description

Applies the NonFloodAdj function to adjust the LCV and LSKEW of one or more sites in a pooling group.

Usage

```
NonFloodAdjPool(x, Index = NULL, AutoP = NULL, ReturnStats = FALSE)
```

Arguments

x	A pooling group, derived from the Pool() or PoolSmall() functions.
Index	An vector of indices (row numbers) of sites to be adjusted. If Index = NULL (the default) the function is applied to all sites.
AutoP	A percentage (numeric) of non flood years. Any sites in the group exceeding this value will be adjusted. This is an automated approach so that the user doesn't need to specify Index. If no sites are above AutoP, the function is applied to all sites.
ReturnStats	Logical with a default of FALSE. If set to TRUE, a dataframe of non-flood year stats is returned (see 'Value' section below) instead of the adjusted Pooling group.

Details

For more details of the method for individual sites see the details section of the NonFloodAdj function. As a default this function applies NonFloodAdj to every member of the pooling group. Index can be supplied which is the row name/s of the members you wish to adjust. Or AutoP can be applied and is a percentage. Any member with a greater percentage of non-flood years than AutoP is then adjusted.

Value

By default the pooling group is returned with adjusted LCVs and LSKEWs for all sites indexed (or all sites when Index = NULL), or all sites with percentage of non-flood years above AutoP. No difference will be seen for sites with no AMAX < 0.5QMED. If ReturnStats is set to TRUE, a dataframe with Non-flood year stats is returned. The dataframe has a row for each site in the pooling group and three columns. The forst the number of non-flood years, the second is the number of years, and the third is the associated percentage.

Author(s)

Anthony Hammond

Examples

```
# Set up a pooling group for site 44013. Then apply the function.
Pool44013 <- Pool(GetCDs(44013))
PoolNF <- NonFloodAdjPool(Pool44013)
#return the non flood stats for the pooling group
NonFloodAdjPool(Pool44013, ReturnStats = TRUE)
```

NRFAData   *National River Flow Archive descriptors and calculated statistics for sites suitable for pooling*

Description

A data.frame of catchment descriptors, Lmoments, Lmoment ratios, sample size and median annual maximum flow (QMED). NRFA Peak Flow Dataset - Version 12.1.

Usage

```
NRFAData
```

Format

A data frame with 544 rows and 27 variables

Details

The functions for pooling group formation and estimation rely on this dataframe. However, the data frame is open for manipulation in case the user wishes to add sites that aren't included, or change parts where local knowledge has improved on the data. Although, usually, in the latter case, such changes will be more appropriately applied to the formed pooling group. If changes are made, they will only remain within the workspace. If a new workspace is opened and the UKFE package is loaded, the data frame will have returned to it's original state.

Source

<https://nrfa.ceh.ac.uk/peak-flow-dataset>

OptimPars   *Optimise distribution parameters*

Description

Estimates the parameters of the Generalised extreme value, generalised logistic, Kappa3, or Gumbel distribution from known return period estimates

Usage

```
OptimPars(x, dist = "GenLog")
```

Arguments

x   a data.frame with RPs in the first column and associated estimates in the second
                column

dist   a choice of distribution for the estimates. The choices are "GenLog", "GEV",
                "Kappa3", or "Gumbel" - the generalised logistic, generalised extreme value,
                Kappa3, and Gumbel distribution, respectively. The default is "GenLog"

Details

Given a dataframe with return periods (RPs) in the first column and associated estimates in the second column, this function provides an estimate of the distribution parameters. Ideally the first RP should be 2. Extrapolation outside the RPs used for calibration comes with greater uncertainty.

Value

The parameters of one of four user chosen distributions; Generalised logistic, generalised extreme value, Gumbel, and Kappa3.

Author(s)

Anthony Hammond

Examples

```
#Get some catchment descriptors and some quick results. Then estmate the GenLog parameters
Results <- QuickResults(GetCDs(96001), plot = FALSE)[[1]]
OptimPars(Results[,1:2])
```

Pool *Create pooling group*

Description

Function to develop a pooling group based on catchment descriptors

Usage

```
Pool(
  CDs = NULL,
  AREA,
  SAAR,
  FARL,
  FPEXT,
  N = 500,
  exclude = NULL,
  iug = FALSE,
  UrbMax = 0.03,
  DeUrb = FALSE
)
```

Arguments

CDs	catchment descriptors derived from either GetCDs or CDsXML
AREA	catchment area in km2
SAAR	catchment standard average annual rainfall (1961-1990) in mm
FARL	catchment flood attenuation from reservoirs & lakes
FPEXT	catchment floodplain extent. The proportion of the catchment that is estimated to be inundated by a 100-year flood
N	minimum Number of total gauged record years for the pooling group
exclude	sites to exclude from the pooling group. Either a single site reference or a vector of site references (numeric)
iug	iug stands for 'include urban gauge' - which refers to a gauged subject site if it's > UrbMax. It's a logical argument with default of FALSE. TRUE will over-ride the default and add the closest site in catchment descriptor space (should be the gauge of interest) to the pooling group if it has URBEXT2000 >= UrbMax
UrbMax	Maximum URBEXT2000 level with a default of 0.03. Any catchment with URBEXT2000 above this level will be excluded from the pooling group
DeUrb	logical argument with a default of FALSE. If true, the Lcv and LSkew of any site in the pooling group with URBEXT2000 > 0.03 will be de-urbanised

Details

A pooling group is created from a CDs object, derived from GetCDs or CDsXML, or specifically with the catchment descriptors (see arguments). To change the default pooling group, one or more sites can be excluded using the 'exclude' option, which requires either a site reference or multiple site references in a vector. If this is done, the site with the next lowest similarity distance measure is added to the group (until the total number of years is at least N). Sites with URBEXT2000 (urban extent) > 0.03 are excluded by default and this can be adjusted with UrbMax. If a gauged assessment is required and the site of interest is > UrbMax it can be included by setting iug = TRUE. De-urbanise the Lcv and Lskew (L-moment ratios) for sites with URBEXT2000 > UrbMax by setting DeUrb = TRUE. If the user has more data available for a particular site within the pooling group, the Lcv and Lskew for the site can be updated after the group has been finalised. An example of doing so is provided below. The pooling method is outlined in Science Report: SC050050 - Improving the FEH statistical procedures for flood frequency estimation.

Value

A data.frame of the pooling group with site reference row names and 24 columns, each providing catchment & gauge details for the sites in the pooling group.

Author(s)

Anthony Hammond

Examples

```
#Get some catchment descriptors
CDs.73005 <- GetCDs(73005)
#Set up a pooling group object called Pool.73005 excluding sites 79005 & 71011.
#Then print the group to the console
Pool.73005 <- Pool(CDs.73005, exclude = c(79005, 71011))
Pool.73005
#Form a pooling group, called PoolGroup, with the catchment descriptors specifically
PoolGroup <- Pool(AREA = 1000, SAAR = 800, FARL = 1, FPEXT = 0.01)
#Form a pooling group using an urban catchment which is intended for enhanced
#single site estimation - by including it in the group.
CDs.39001 <- GetCDs(39001)
Pool.39001 <- Pool(CDs.39001, iug = TRUE, DeUrb = TRUE)
#Change the Lcv and LSkew of the top site in the pooling group to 0.19 & 0.18,
#respectively.
PoolUpdate <- LRatioChange(Pool.39001, SiteID = 39001, 0.19, 0.18)
```

PoolEst   *Pooled flood estimates*

Description

Provides pooled results from a pooling group - gauged, ungauged and with urban adjustment if necessary.

Usage

```
PoolEst(
  x,
  gauged = FALSE,
  QMED,
  dist = "GenLog",
  RP = c(2, 5, 10, 20, 50, 75, 100, 200, 500, 1000),
  UrbAdj = FALSE,
  CDs = NULL,
  URBEXT = NULL,
  fseQMED = 1.46
)
```

Arguments

x	pooling group derived from the Pool function
gauged	logical argument with a default of FALSE. TRUE for gauged results and FALSE for ungauged
QMED	estimate of the median annual maximum flow
dist	a choice of distribution for the estimates. The choices are "GenLog", "GEV", "Kappa3", or "Gumbel"; the generalised logistic, generalised extreme value, Kappa3, and Gumbel distribution, respectively. The default is "GenLog"
RP	return period of interest. By default the following RPs are provided: 2, 5, 10, 20, 50, 75, 100, 200, 500, 1000
UrbAdj	logical argument with a default of FALSE. When TRUE, an urban adjustment is applied to the pooled Lcv and LSkew
CDs	catchment descriptors derived from either GetCDs or CDsXML
URBEXT	the catchment URBEXT2000, to be supplied if UrbAdj is TRUE and if CDs have not been
fseQMED	factorial standard error of the median annual maximum (QMED) estimate, used for quantifying ungauged uncertainty. Default is 1.46

Details

PoolEst is a function to provide results from a pooling group derived using the Pool function. QMED (median annual maximum flow) needs to be supplied and can be derived from the QMED function for ungauged estimates or the annual maximum sample for gauged estimates. If the catchment of interest is urban, the UrbAdj argument can be set to TRUE. If this is done, either URBEXT (urban extent) needs to be provided or the catchment descriptors, derived from CDsXML or GetCDs. The methods for estimating pooled growth curves are according to Science Report: SC050050 - Improving the FEH statistical procedures for flood frequency estimation. The methods for estimating the L-moments and growth factors are outlined in the Flood Estimation Handbook (1999), volume 3. The methods for quantifying uncertainty are detailed in Hammond, A. (2022). Easy methods for quantifying the uncertainty of FEH pooling analysis. Circulation - The Newsletter of the British Hydrological Society (152). When UrbAdj = TRUE, urban adjustment is applied to the QMED estimate according to the method outlined in the guidance by Wallingford HydroSolutions: 'WINFAP 4 Urban Adjustment Procedures'.

Value

If RP is default then a list of length 4. Element one is a data frame with columns; return period (a range from 2 - 1000), peak flow estimates (Q), growth factor estimates (GF), lower and upper intervals of uncertainty (68 percent intervals for ungauged and 95 percent for gauged). The second element is the estimated Lcv and Lskew. The third provides distribution parameters for the growth curve. The fourth provides distribution parameters for the frequency curve. If RP is not the default only the first two elements are returned.

Author(s)

Anthony Hammond

Examples

```
#Get some catchment descriptors and form a pooling group. It's urban and
#therefore the site of interest is not included.
CDs.27083 <- GetCDs(27083)
Pool.27083 <- Pool(CDs.27083)
#Get results for the ungauged case, with urban adjustment
PoolEst(Pool.27083, QMED = 12, UrbAdj = TRUE, CDs = CDs.27083)
#Form the group again with the urban gauge included & undertake a gauged estimate
#with urban adjustment. QMED in this example is estimated as the median of the annual
#maximum series for site 27083.
PoolG.27083 <- PoolG.27083 <- Pool(CDs.27083, iug = TRUE, DeUrb = TRUE)
PoolEst(PoolG.27083, QMED = 12.5, UrbAdj = TRUE, CDs = CDs.27083)
```

PoolSmall	*Create pooling group for small catchments*

Description

Function to develop a small catchments pooling group based on catchment descriptors

Usage

```
PoolSmall(
  CDs = NULL,
  AREA,
  SAAR,
  N = 500,
  exclude = NULL,
  iug = FALSE,
  UrbMax = 0.03,
  DeUrb = FALSE
)
```

Arguments

CDs	catchment descriptors derived from either GetCDs or CDsXML
AREA	catchment area in km2
SAAR	catchment standard average annual rainfall (1961-1990) in mm
N	minimum Number of total gauged record years for the pooling group
exclude	sites to exclude from the pooling group. Either a single site reference or a vector of site references (numeric)
iug	iug stands for 'include urban gauge' - which refers to a gauged subject site if it's > UrbMax. It's a logical argument with default of FALSE. TRUE will over-ride the default and add the closest site in catchment descriptor space (should be the gauge of interest) to the pooling group if it has URBEXT2000 >= UrbMax
UrbMax	Maximum URBEXT2000 level with a default of 0.03. Any catchment with URBEXT2000 above this level will be excluded from the pooling group
DeUrb	logical argument with a default of FALSE. If true, the Lcv and LSkew of any site in the pooling group with URBEXT2000 > 0.03 will be de-urbanised

Details

A pooling group is created from a CDs object, derived from GetCDs or CDsXML, or specifically with the necessary catchment descriptors (see arguments). To change the default pooling group one or more sites can be excluded using the 'exclude' option, which requires either a site reference or multiple site references in a vector. If this is done, the site with the next lowest similarity distance measure is added to the group (until the total number of years is at least N). Sites with URBEXT2000 (urban extent) > 0.03 are excluded by default and this can be adjusted with the UrbMax argument. If a gauged assessment is required and the site of interest is > UrbMax it can be included by setting iug = TRUE. De-urbanise the Lcv and Lskew (L-moment ratios) of sites with URBEXT2000 > 0.03 by setting DeUrb = TRUE. If the user has more data available for a particular site within the pooling group, the Lcv and Lskew for the site can be updated after the group has been finalised.

Value

A data.frame of the pooling group with site reference row names and 24 columns, each providing catchment & gauge details for the sites in the pooling group.

Author(s)

Anthony Hammond

Examples

```
#Get some catchment descriptors
CDs.21001 <- GetCDs(21001)
#Set up a pooling group object called Pool.21001 excluding site 206006
#Then print the group to the console
Pool.21001 <- PoolSmall(CDs.21001, exclude = 206006)
Pool.21001
```

```
#Form a pooling group, called PoolGroup, with the catchment descriptors specifically
PoolGroup <- PoolSmall(AREA = 22, SAAR = 1702)
```

POTextract   *Peaks over threshold (POT) data extraction*

Description

Extracts independent peaks over a threshold from a sample

Usage

```
POTextract(
  x,
  div = NULL,
  TimeDiv = NULL,
  thresh = 0.975,
  Plot = TRUE,
  ylab = "Magnitude",
  xlab = "Time",
  main = "Peaks over threshold"
)
```

Arguments

x	either a numeric vector or dataframe with date (or POSIXct) in the first column and hydrological variable in the second
div	numeric percentile (between 0 and thresh), either side of which two peaks over the threshold are considered independent. Default is the mean of the sample.
TimeDiv	Number of timesteps to define independence (supplements the div argument). As a default this is NULL and only 'div' defines independence. Currently this is only applicable for data.frames.
thresh	user chosen threshold. Default is 0.975
Plot	logical argument with a default of TRUE. When TRUE, the full hydrograph with the peaks over the threshold highlighted is plotted
ylab	Label for the plot yaxis. Default is "Magnitude"
xlab	Label (character) for the plot x axis. Default is "Time".
main	Title for the plot. Default is "Peaks over threshold"

Details

If the x argument is a numeric vector, the peaks will be extracted with no time information. x can instead be a data.frame with dates in the first column and the numeric vector in the second. In this latter case, the peaks will be time-stamped and a hydrograph, including POT, will be plotted by default. The method of extracting independent peaks assumes that there is a value either side of

which, events can be considered independent. For example, if two peaks above the chosen threshold are separated by the mean flow, they could be considered independent, but not if flow hasn't returned to the mean at any time between the peaks. Mean flow may not always be appropriate, in which case the 'div' argument can be applied (and is a percentile). The TimeDiv argument can also be applied to ensure the peaks are separated by a number of time-steps either side of the peaks. For extracting POT rainfall a div of zero could be used and TimeDiv can be used for further separation - which would be necessary for sub-daily time-series. In which case, with hourly data for example, TimeDiv could be set to 120 to ensure each peak is separated by five days either side as well as at least one hour with 0 rainfall. When plotted, the blue line is the threshold, and the green line is the independence line (div).

Value

Prints the number of peaks per year and returns a data.frame with columns; Date and peak, with the option of a plot. Or a numeric vector of peaks is returned if only a numeric vector of the hydrological variable is input.

Author(s)

Anthony Hammond

Examples

```
#Extract POT data from Thames mean daily flow 2000-10-01 to 2015-09-30 with
#div = mean and threshold = 0.95. Then display the first six rows
ThamesQPOT <- POTextract(ThamesPQ[, c(1,3)], thresh = 0.9)
head(ThamesQPOT)
#Extract Thames POT from only the numeric vector of flows and display the
#first six rows
ThamesQPOT <- POTextract(ThamesPQ[, 3], thresh = 0.9)
head(ThamesQPOT)
#Extract the Thames POT precipitation with a div of 0, the default
#threshold, and 5 timesteps (days) either side of the peak. Then display the first six rows
ThamesPPOT <- POTextract(ThamesPQ[, c(1,2)], div = 0, TimeDiv = 5)
head(ThamesPPOT)
```

POTt   *Peaks over threshold (POT) data extraction (quick)*

Description

Extracts independent peaks over a threshold from a sample, using time as the independence criteria.

Usage

```
POTt(
  x,
  threshold = 0.975,
  div,
```

```
    Plot = TRUE,
    PlotType = "l",
    main = "Peaks over threhsold",
    ylab = "Magnitude",
    xlab = "Time"
)
```

Arguments

x	either a numeric vector or dataframe with date (or POSIXct) in the first column and hydrological variable in the second
threshold	user chosen threshold. Default is 0.975
div	number of time steps between peaks to ensure independence.
Plot	logical argument with a default of TRUE. When TRUE, the full hydrograph with the peaks over the threshold highlighted is plotted
PlotType	Type of plot with a default of "l" for line graph. For rainfall type "h" for bars could be used.
main	Title for the plot. Default is "Peaks over threshold"
ylab	Label (character) for the plot y axis. Default is "Magnitude"
xlab	Label (character) for the plot x axis. Default is "Time".

Details

This provides a quicker option than the POTextract function - useful for very long time series'. It only has the option of time division to ensure independence between peaks. If the x argument is a numeric vector, the peaks will be extracted with no time information. x can instead be a data.frame with dates in the first column and the numeric vector in the second. In this latter case, the peaks will be time-stamped and a hydrograph, including POT, will be plotted by default.

Value

A data.frame with columns; Date and peak, with the option of a plot. Or a numeric vector of peaks is returned if only a numeric vector of the variable is input as x.

Author(s)

Anthony Hammond

Examples

```
#Extract POT data from Thames catchment daily rainfall 2000-10-01 to 2015-09-30 with
#div = 14 (14 days) and threshold = 0.975. Then display the first six rows
ThamesPPOT <- POTt(ThamesPQ[, c(1,2)], div = 14)
head(ThamesPPOT)
#Extract Thames rainfall POT from only the numeric vector of rainfall, with threshold
#set to 0.95 and div set to 14. Then display the first six rows
ThamesPPOT <- POTt(ThamesPQ[, 2], threshold = 0.95, div = 14)
head(ThamesPPOT)
```

QMED	*QMED (median annual maximum flow) estimate from catchment descriptors*

Description

Estimated median annual maximum flow from catchment descriptors and donor sites

Usage

```
QMED(
  CDs = NULL,
  Don1 = NULL,
  Don2 = NULL,
  UrbAdj = FALSE,
  DonUrbAdj = FALSE,
  AREA,
  SAAR,
  FARL,
  BFIHOST,
  URBEXT2000 = NULL
)
```

Arguments

CDs	catchment descriptors derived from either GetCDs or CDsXML
Don1	numeric site reference for the a single donor (for donor candidates see DonAdj function)
Don2	vector of two site references for two donors (for donor candidates see DonAdj function)
UrbAdj	logical argument with a default of FALSE. True applies an urban adjustment
DonUrbAdj	logical argument with a defailt of FALSE. If TRUE, an urban adjustement is applied to the donor/s QMEDcds estimate.
AREA	catchment area in km2
SAAR	standard average annual rainfall (mm)
FARL	flood attenuation from reservoirs and lakes
BFIHOST	baseflow index calculated from the catchment hydrology of soil type classification
URBEXT2000	measure of catchment urbanisation

Details

QMED is estimated from catchment descriptors: QMED = 8.3062*AREA^0.8510 0.1536^(1000/SAAR) FARL^3.4451 0.0460^(BFIHOST^2) as derived in Science Report: SC050050 - Improving the FEH statistical procedures for flood frequency estimation. The single donor method is from the same paper. The method for two donors is outlined in 'Kjeldsen, T. (2019). Adjustment of QMED in ungauged catchments using two donor sites. Circulation - The Newsletter of the British Hydrological Society, 4'. When UrbAdj = TRUE, urban adjustment is applied to the QMED estimate according to the method outlined in the guidance by Wallingford HydroSolutions: 'WINFAP 4 Urban Adjustment Procedures'. Urban donors should be avoided, but in the case that the subject catchment is rural, and the donor is urban, the QMEDcd estimate of the donor (or donors) can be urban adjusted by setting the DonUrbAdj argument to TRUE. For flexibility there is the option to input the relevant catchment descriptors directly rather than a CDs object.

Value

An estimate of QMED from catchment descriptors. If two donors are used the associated weights are also returned

Author(s)

Anthony Hammond

Examples

```
#Get some catchment descriptors and calculate QMED as if it was ungauged, with
#no donors, one donor, and two donors
CDs.55004 <- GetCDs(55004)
QMED(CDs.55004)
QMED(CDs.55004, Don1 = 55012)
QMED(CDs.55004, Don2 = c(55012, 60007))
#Get CDs for urban gauge and calculate QMED with urban adjustment
CDs.27083 <- GetCDs(27083)
QMED(CDs.27083, UrbAdj = TRUE)
```

QMEDData	*National River Flow Archive descriptors and calculated statistics for sites suitable for QMED & pooling*

Description

A data.frame of catchment & data descriptors relating to the median annual maximum flow (QMED). NRFA Peak Flow Dataset - Version 12.1

Usage

QMEDData

Format

A data frame with 894 rows and 26 variables

Details

The functions for QMED estimation and retreieval of catchment descriptors rely on this dataframe. However, the data frame is open for manipulation in case the user wishes to add sites that aren't included, or change parts where local knowledge has improved on the data. If changes are made, they will only remain within the workspace. If a new workspace is opened and the UKFE package is loaded, the data frame will have returned to it's original state.

Source

https://nrfa.ceh.ac.uk/peak-flow-dataset

QMEDDonEq *QMED donor adjustment*

Description

Applies a donor adjustment to the median annual maximum flow (QMED) estimate

Usage

```
QMEDDonEq(
  AREA,
  SAAR,
  FARL,
  BFIHOST,
  QMEDgObs,
  QMEDgCds,
  xSI,
  ySI,
  xDon,
  yDon,
  alpha = TRUE
)
```

Arguments

AREA	catchment area in km2
SAAR	standardised average annual rainfall in mm
FARL	flood attenuation from reservoirs and lakes
BFIHOST	the baseflow index as a function of soil type
QMEDgObs	the observed QMED at the donor site

QMEDgCds	the QMED equation derived QMED at the donor site
xSI	the catchment centroid easting for the site of interest
ySI	the catchment centroid northing for the site of interest
xDon	the catchment centroid easting for the donor site
yDon	the catchment centroid northing for the donor site
alpha	a logical argument with a default of TRUE. When FALSE the exponent in the donor equation is set to one. Otherwise it is determined by the distance between the donor and the subject site

Details

Although a single donor adjustment can be applied with the DonAdj() function and the QMED(), this is provided for flexibility. The method is that of Science Report: SC050050 - Improving the FEH statistical procedures for flood frequency estimation (2008).

Author(s)

Anthony Hammond

Examples

```
#Get observed QMED for site 96003
Qob <- median(GetAM(96003)[,2])
#Get QMED equation estimated QMED for the donor site
QCD <- QMED(CDs = GetCDs(96003))
#display CDs for site 96001 & note the easting and northing
GetCDs(96001)
#display CDs for site 96003 & note the easting and northing
GetCDs(96003)
#Apply the QMEDDonEq function with the information gained
QMEDDonEq(194, 1096, 0.955, 0.297, Qob, QCD, xSI = 289289,ySI = 947523,xDon = 280908,yDon = 953653)
```

QMEDfseSS   *QMED factorial standard error for gauged sites*

Description

Estimates the median annual maximum flow (QMED) factorial standard error (FSE) by bootstrapping the sample

Usage

```
QMEDfseSS(x)
```

Arguments

| x | a numeric vector. The sample of interest |

Details

The bootstrapping procedure resamples from the sample N*500 times with replacement. After splitting into 500 samples of size N, the median is calculated for each. Then the exponent of the standard deviation of the log transformed residuals is taken as the FSE. i.e. exp(sd(log(x)-mean(log(x)))), where x is the bootstrapped medians.

Value

The factorial standard error for the median of a sample.

Author(s)

Anthony Hammond

Examples

```
#Extract an AMAX sample and estimate the QMED factorial standard error
AM.203018 <- GetAM(203018)
QMEDfseSS(AM.203018$Flow)
```

QMEDLink   *QMED Linking equation*

Description

Estimates the median annual maximum flow (QMED) from non-flood flows

Usage

```
QMEDLink(Q5dmf, Q10dmf, DPSBAR, BFI)
```

Arguments

Q5dmf	numeric. The daily mean flow that is exceeded 5 percent of the time
Q10dmf	numeric. The daily mean flow that is exceeded 10 percent of the time
DPSBAR	a catchment descriptor. The average drainage path slope of the catchment
BFI	the baseflow index of the gauged flow

Details

The QMED Linking equation estimates QMED as a function of the flow that is exceeded five percent of the time, the flow that is exceeded 10 percent of the time, the baseflow index, and the catchment desciptor; drainage path slope (DPSBAR). All of these can be found for sites on the National River Flow Archive (NRFA) website. The method is provided in the guidance note 'WINFAP 4 QMED Linking equation' (2016) by Wallingford HydroSolutions.

Author(s)

Anthony Hammond

Examples

```
#Calculate the QMED for site 1001 (Wick at Tarroul)
QMEDLink(10.14, 7.352, 29.90, 0.39)
```

QMEDPOT   *Empirical estimate of QMED from peaks over threshold (POT) data*

Description

Estimates the median annual maximum flow (QMED) from peaks over threshold data

Usage

```
QMEDPOT(x, ppy)
```

Arguments

x	numerical vector. POT data
ppy	number of peaks per year in the POT data

Details

If there are multiple peaks per year, the peaks per year (ppy) argument is used to convert to the annual scale to derive QMED. If ppy is one, then the median of the POT sample is returned (the median of x).

Author(s)

Anthony Hammond

Examples

```
#Extract some POT data and estimate QMED
ThamesPOT <- POTextract(ThamesPQ[,c(1,3)], thresh = 0.90)
QMEDPOT(ThamesPOT$peak, ppy = 1.867263)
```

QuickResults   *Quick pooled results*

Description

Provides pooled gauged, ungauged, or fake ungauged results, directly from the catchment descriptors

Usage

```
QuickResults(
  CDs,
  gauged = FALSE,
  dons = 2,
  Qmed = NULL,
  FUngauged = FALSE,
  plot = TRUE,
  dist = "GenLog"
)
```

Arguments

CDs	catchment descriptors derived from either GetCDs or CDsXML
gauged	logical argument with a default of FALSE. TRUE for gauged results and FALSE for ungauged
dons	number of donors required with a choice of 0, 1, or 2
Qmed	user supplied QMED which overrides the default QMED estimate
FUngauged	logical argument with a default of FALSE. TRUE provides an ungauged estimate whilst excluding the gauged site (the site with the most similar CDs)
plot	logical argument with a default of TRUE. TRUE provides an extreme value plot. FALSE prevents the plot
dist	a choice of distribution for the estimates. The choices are "GenLog", "GEV", "Kappa3", or "Gumbel; the generalised logistic, generalised extreme value, Kappa3,and Gumbel distributions, respectively. The default is "GenLog"

Details

The quick results function provides results with a default pooling group. If gauged = FALSE the median annual maximum flood (QMED) is estimated from catchment descriptors using the QMED equation and then adjusted with two of the closest un-urban gauged sites (can be changed to 0 or 1 donors). If the site is urban, an urban adjustment is made to the QMED and to the pooled growth curve. If gauged = TRUE QMED is the median of the gauged annual maxima and the growth curve is formed with the gauged weighting procedure (often known as enhanced single site). If the gauged catchment is urban, it's included in the pooling group and deurbanised before an urban adjustment is made to the final growth curve. If FUngauged = TRUE, the top site in the pooling group is

excluded and the estimate is performed henceforth in the manner of gauged = FALSE. If the CDs are from a gauged site that is not in the list of sites that are considered suitable for pooling, it won't be included in the pooling group. In which case, if gauged = TRUE, the result will be erroneous.

Value

A list of length two. Element one is a data frame with columns; return period (RP), peak flow estimates (Q) and growth factor estimates (GF). Two additional columns quantify the uncertainty. The second element is the estimated Lcv and Lskew (linear coefficient of variation and skewness). By default an extreme value plot is also returned

Author(s)

Anthony Hammond

Examples

```
#Get some catchment descriptors
CDs.73005 <- GetCDs(73005)
#Get default ungauged results
QuickResults(CDs.73005)
#Get gauged results with a GEV distribution
QuickResults(CDs.73005, gauged = TRUE, dist = "GEV")
#Get fake ungauged results with one donor
QuickResults(CDs.73005, FUngauged = TRUE, dons = 1)
```

RainEA   *Get Environment Agency rainfall data (England).*

Description

Extract rainfall data from the Environment Agency's API.

Usage

```
RainEA(
  Lat = 54,
  Lon = -2,
  Range = 10,
  WISKI_ID = NULL,
  Period = 0.25,
  DateSt = "2015-12-01",
  DateEnd = "2015-12-31"
)
```

Arguments

Lat	Latitude of the point of interest. Provided when the user wants information about available local rain gauges
Lon	Longitude of the point of interest. Provided when the user wants information about available local rain gauges
Range	The radius (km) from the point of interest (Lat, Lon) for which the user wants rain gauge information.
WISKI_ID	The WISKI identification (as "character") for the rain gauge of interest
Period	The sampling rate of the rainfall in hours (generally 0.25 or 24. Default is 0.25 (15 minutes).
DateSt	The start date of the data extraction in the form of "YYYY-MM-DD".
DateEnd	The end date of the data extraction in the form of "YYYY-MM-DD".

Details

The function provides one of two outputs. Either information about available local rain gauges, or the data from a specified gauge (specified by WISKI ID). The process is to find the local information (including WISKI ID) by using the latitude and longitude and range. Then use the WISKI ID to get the data. If data requested is not available, for example - outside the date range or not available at the requested sampling rate, an error message is returned stating "no lines available in input". There is currently a limit to how many lines of data can be extracted (100,000) for each use. That is approximately 274 years of daily rainfall, but only 2.85 years of 15 minute data.

Value

A data.frame with POSIXct (DateTime) in the first column, and rainfall (mm) in the second column. Unless the WISKI_ID is null, then information about rain gauges approximately within a radius (Range) of the Lat and Lon is povided.

Author(s)

Anthony Hammond

Examples

```
#Get information about available rain gauges.
#within a 10km radius of Lat = 54.5, Lon = -3.2
## Not run:  RainEA(Lat = 54.5, Lon = -3.2)
#Now we'll use the WISKI reference for the Honister rain gauge
# to get some data for the Dec 2015 (default dates)
## Not run:  Honister15 <- RainEA(WISKI_ID = "592463")
#Now we'll have a look at the top of the data and plot it
## Not run:  head(Honister15)
## Not run:  plot(Honister15, type = "h", ylab = "Rainfall (mm)")
#Now we'll get the daily rain for the same period and plot it
## Not run:  Honister24 <- RainEA(WISKI_ID = "592463", Period = 24)
## Not run:  plot(Honister24, type = "h", ylab = "Rainfall (mm)")
```

RainSEPA   *Get Scottish Environment Protection Agency (SEPA) hourly rainfall*
                                  data.

Description

Extract hourly rainfall data from SEPA's API.

Usage

```
RainSEPA(StationName, From = "2022-10-01", To = "ToDate")
```

Arguments

StationName   The name of the station for which you want rainfall. If you type something other
                than one of the available stations, the list of stations will be returned.

From   A start date for the data in the form of "YYYY-MM-DD".

To   An end date for the data in the form of "YYYY-MM-DD". The default is the
                most recent date available.

Details

If the "From" date used is significantly before (approx. 30 years) the start of the available data, the
function will fail with an error message saying the connection cannot be opened.

Value

A data.frame with POSIXct in the first column, and rainfall in the second column. Unless the
StationName provided is not in the available list, then the available list is returned.

Author(s)

Anthony Hammond

Examples

```
#Get the list of available stations
## Not run:  RainSEPA("AnythingButAStationName")
#Now we'll get rain from the Bannockburn station
## Not run:  Bannockburn <- RainSEPA("Bannockburn", From = "1998-10-01", To = "1998-10-31")
#Now we'll have a look at the top of the data and plot it
## Not run:  head(Bannockburn)
## Not run:  plot(Bannockburn, type = "h", ylab = "Rainfall (mm)")
```

Rating   *Stage-Discharge equation optimisation*

Description

Optimises a power law rating equation from observed discharge and stage

Usage

```
Rating(x, a = NULL)
```

Arguments

x   a data.frame with discharge in the first column and stage in the second

a   a user defined stage correction

Details

The power law rating equation optimised here has the form $q = c(h+a)^n$; where 'q' is flow, 'h' is the stage, c' and 'n' are constants, and 'a' is the stage when flow is zero. The optimisation uses all the data provided in the dataframe (x). If separate rating limbs are necessary, x can be subset per limb. i.e. the rating function would be used multiple times, once for each subset of x. There is the option, with the 'a' argument, to hold the stage correction parameter (a), at a user defined level. If 'a' is NULL it will be calibrated with 'c' & 'n' as part of the optimisation procedure.

Value

A list with three elements. The first is a vetor of the three calibrated rating parameters. The second is the rating equation; discharge as a function of stage. The third is the rating equation; stage as a function of discharge. A rating plot is also returned.

Author(s)

Anthony Hammond

Examples

```
# Make up Some data:
Q <- c(177.685, 240.898, 221.954, 205.55, 383.051, 154.061, 216.582)
Stage <- c(1.855, 2.109, 2.037, 1.972, 2.574, 1.748, 2.016)
Observations <- data.frame(Q, Stage)
#apply the rating function:
Rating(Observations)
#Hold the stage correction at zero
Rating(Observations, a = 0)
```

ReFH   *Revitalised Flood Hydrograph Model (ReFH)*

Description

Provides outputs of the ReFH model from catchment descriptors or user defined inputs

Usage

```
ReFH(
  CDs = NULL,
  Depth = NULL,
  duration = NULL,
  timestep = NULL,
  scaled = NULL,
  PlotTitle = NULL,
  RPa = NULL,
  alpha = TRUE,
  season = NULL,
  AREA = NULL,
  TP = NULL,
  BR = NULL,
  BL = NULL,
  Cmax = NULL,
  Cini = NULL,
  BFini = NULL,
  Rain = NULL
)
```

Arguments

CDs	catchment descriptors derived from either GetCDs or ImportCD
Depth	a numeric value. The depth of rainfall used as input in the estimation of a design hydrograph. The default, when Depth = NULL, is a two year rainfall.
duration	a numeric value. A duration (hrs) for the design rainfall
timestep	a numeric value. A user defined data interval. The default changes depending on the estimated time to peak to formulate a sensible looking result
scaled	a numeric value of peak flow in m3/s
PlotTitle	a character string. A user defined title for the ReFH plot
RPa	return period for alpha adjustment. This is only for the purposes of the alpha adjustment, it doesn't change the rainfall input
alpha	a logical argument with default TRUE. If TRUE the alpha adjustment is applied based on RPa. If FALSE, no alpha adjustment is made
season	a choice of "summer" or "winter". The default is "summer" in urban catchments (URBEXT2000 > 0.03) and "winter" in rural catchments

AREA	numeric. Catchment area in km2.
TP	numeric. Time to peak parameter (hours)
BR	numeric. Baseflow recharge parameter
BL	numeric. Baseflow lag parameter (hours)
Cmax	numeric. Maximum soil moisture capacity parameter (mm)
Cini	numeric. Initial soil moisture content (mm)
BFini	numeric. Initial baseflow (m3/s)
Rain	numeric. User input rainfall (hourly). A numeric vector

Details

The ReFH is described in the Flood Estimation Handbook Supplementary Report No.1 (2007). The method to derive design rainfall profiles is described in the Flood Estimation Handbook (1999), volume 2. Users can also input their own rainfall with the 'Rain' argument. As a default, when catchment descriptors (CDs) are provided the ReFH function uses catchment descriptors to estimate the parameters of the ReFH model and the two year rainfall for the critical duration. The latter is based on a quadratic interpolation of the catchment descriptors RMED1H, RMED1D, and RMED2D (then a seasonal correction factor is applied). Parameters and initial conditions can also be individually input by the user. If a parameter argument is used for one or more of the parameters, then these overwrite the CD derived parameters. If a value for the scaled argument is provided (m3/s), a scaled hydrograph is returned. The RPa argument doesn't change the rainfall input and is only needed for the alpha adjustment (see the FEH supplement report no.1).

Value

A list with two elements, and a plot. First element of the list is a data.frame of parameters, initial conditions and the catchment area. The second is a data.frame with columns Rain, NetRain, Runoff, Baseflow, and TotalFlow. If the scale argument is used a numeric vector containing the scaled hydrograph is returned instead of the results dataframe. The plot is of the ReFH output, with rainfall, net-rainfall, baseflow, runoff and total flow. If the scaled argument is used, a scaled hydrograph is plotted.

Author(s)

Anthony Hammond

Examples

```
#Get CDs and apply the ReFH function
CDs.203018 <- GetCDs(203018)
ReFH(CDs.203018)
#Apply the ReFH function, scale to a 100-year flow estimate and change the plot title accordingly
ReFH(CDs.203018, scaled = 182, PlotTitle = "100-Year Design Hydrograph - Site 203018")
#Apply the ReFH function with a user defined initial baseflow
ReFH(CDs.203018, BFini = 6)
```

SCF   *Seasonal correction factor (SCF)*

Description

The results of applying the ratio of the seasonal annual maximum rainfall for a given duration to the annual maximum rainfall for the same duration

Usage

```
SCF(SAAR, duration)
```

Arguments

SAAR   standardised average annual rainfall. Numeric

duration   duration in hours. Numeric

Details

The SCF and it's use is detailed in R&D Technical Report FD1913/TR - Revitalisation of the FSR/FEH rainfall runoff method (2005). The ReFH model has a design rainfall profile included for winter and summer but the depth duration frequency (DDF) model is calibrated on annual maximum peaks as opposed to seasonal peaks. The SCF is necessary to convert the DDF estimate to a seasonal one. Similarly, the DDF model is calibrated on point rainfall and the area reduction factor converts it to a catchment rainfall for use with a rainfall runoff model such as ReFH (see details of the ReFH function).The final depth, therefore is; Depth = DDFdepth x ARF x SCF.

Value

A data.frame of one row and two columns: SCFSummer and SCFWinter.

Author(s)

Anthony Hammond

Examples

```
#Derive the SCFs for a SAAR of 1981 and a duration of 6.5
SCF(1981, 6.5)
```

SimData   *Data simulator*

Description

Simulation of a random sample from the generalised extreme value, generalised logistic, Gumbel, Kappa3, or generalised Pareto distributions

Usage

```
SimData(n, pars = NULL, dist = "GenLog", GF = NULL)
```

Arguments

n	sample size to be simulated
pars	vector of parameters in the order of location, scale, shape (only location and shape for Gumbel)
dist	choice of distribution. Either "GEV", "GenLog", "Gumbel", "Kappa3", or "Gen-Pareto"
GF	vector of GF inputs in the order of Lcv, LSkew, QMED (only Lcv and QMED if dist = "Gumbel")

Details

The simulated sample can be generated using distribution parameters, or the growth factor (GF) inputs; linear coefficient of variationn (Lcv), linear skewness (LSkew) & the median annual maximum (QMED).

Value

A random sample of size n for the chosen distribution.

Author(s)

Anthony Hammond

Examples

```
#Simulate a sample of size 30 using parameters GenLog and parameters 299, 51, -0.042
SimData(30, pars = c(299, 51, -0.042), dist = "GenLog")
#Now simulate using the Lcv, Lskew, and median (0.17, 0.04, 310)
SimData(30, GF = c(0.17, 0.04, 310), dist = "GenLog")
```

ThamesPQ	*Kingston upon Thames daily flow and catchment precipitation 2000-10-01 to 2015-09-30*

Description

A data.frame of four columns; Date, Precipitation (P), & daily mean flow (Q)

Usage

```
ThamesPQ
```

Format

A data frame with 5478 rows and 4 columns:

Date Date

P Precipitation, in mm

Q Daily mean discharge, in m3/s

Source

https://nrfa.ceh.ac.uk/data/station/meanflow/39001

TrendTest	*Trend hypothesis test*

Description

A hypothesis test for the correlation between the variable of interest and time

Usage

```
TrendTest(x, method = "kendall", alternative = "two.sided")
```

Arguments

x	a numeric vector or a data.frame with dates in the first column and chronologically ordered variable in the second.
method	a choice of test method. Choices are "pearson", "spearman", and "kendall"
alternative	the alternative hypothesis. The default is "two.sided". See details for other options

Details

The test can be performed on a numeric vector, or a data.frame with dates in the first column and the associated variable of interest in the second. A choice can be made between a Pearson's, Spearman's Rho or Kendall's tau test. The Spearman and Kendall are based on ranks and will therefore have the same results whether dates are included or not. The default is kendall (note: for very long time series the kendall method takes a touch longer). The default is to test for any trend (alternative = "two.sided"). For positive trend set alternative to "greater". And for negative trend, set it to "less"

Value

A data.frame with columns and associated values: P_value, correlation coefficient, and method specific statistic.

Author(s)

Anthony Hammond

Examples

```
#Get AMAX sample and apply a trend test with the default kendall test.
AM.27083 <- GetAM(27083)
TrendTest(AM.27083)
#Apply the test with the pearson method with dates included and not
TrendTest(AM.27083, method = "pearson")
TrendTest(AM.27083$Flow, method = "pearson")
```

UAF   *Urban adjustment factor (UAF) and percentage runoff urban adjust-*
                       ment factor (PRUAF)

Description

UAF and PRUAF from catchment descriptors for QMED estimation in ungauged urban catchments

Usage

```
UAF(CDs = NULL, URBEXT2000, BFIHOST)
```

Arguments

CDs	catchment descriptors derived from either GetCDs or CDsXML
URBEXT2000	quantification of catchment urbanisation (used when CDs is not)
BFIHOST	baseflow index as a function of hydrological soil type of the catchment (used when CDs is not)

Value

a data.frame with columns UAF and PRUAF

Author(s)

Anthony Hammond

Examples

```
#Get some catchment descriptors for an urban catchment calculate the UAF & PRUAF
CDs.53006 <- GetCDs(53006)
UAF(CDs.53006)
#Calculate UAF and PRUAF using a user input URBEXT2000 and BFIHOST
UAF(URBEXT2000 = 0.1138, BFIHOST = 0.3620)
```

UEF   *Urban expansion factor*

Description

This function provides a coefficient to multiply by URBEXT2000 to adjust it to a given year

Usage

```
UEF(Year)
```

Arguments

Year   The year for consideration. Numeric

Details

The urban expansion factor is detailed in Bayliss, A. Black, K. Fava-Verde, A. Kjeldsen, T. (2006). URBEXT2000 - A new FEH catchment descriptor: Calculation, dissemination and application. R&D Technical Report FD1919/TR, DEFRA, CEH Wallingford

Value

A numeric urban expansion factor.

Author(s)

Anthony Hammond

Examples

```
# Get an expansion factor for the year 2023
UEF(2023)
```

UKOutline   *UK outline*

Description

Easting and northing national grid reference points around the coast of the UK

Usage

```
UKOutline
```

Format

A data frame with 3867 rows and 2 variables

X_BNG Easting, British national grid reference

Y_BNG Northing, British national grid reference

Source

<https://environment.data.gov.uk/>

Uncertainty   *Uncertainty quantification for gauged and ungauged pooled estimates*

Description

Quantification of uncertainty for pooling results for the gauged and ungauged case

Usage

```
Uncertainty(
  x,
  gauged = FALSE,
  RP = 100,
  dist = "GenLog",
  qmed = NULL,
  QMEDfse = 1.46,
  UrbAdj = FALSE,
  CDs = NULL,
  conf = 0.95
)
```

Arguments

x	the pooled group derived from the Pool() function
gauged	a logical argument with a default of FALSE. If FALSE the uncertainty intervals are calculated for the ungauged case. If TRUE they are calculated for the gauged case
RP	the return period of interest. Default is 100
dist	a choice of distribution to use for the estimates. Choices are "GEV", "GenLog" or "Gumbel". The default is "GenLog"
qmed	the QMED estimate for the ungauged case. Or for the gauged if the user wishes to override the median from the NRFA data
QMEDfse	The factorial standard error of the QMED estimate for when an ungauged assessment has been undertaken. The default is 1.46
UrbAdj	applies an urban adjustment to the growth curves
CDs	catchment descriptors derived from either GetCDs or CDsXML. Necessary if a UrbAdj is TRUE
conf	the confidence level of the intervals for the gauged case. Default is 0.95. Must be between 0 and 1

Details

Uncertainty in the ungauged case is calulated as detailed in Hammond, A. (2022). Easy methods for quantifying the uncertainty of FEH pooling analysis. Circulation - The Newsletter of the British Hydrological Society (152). The 68 percent and 95 percent intervals are returned. For the gauged case the pooled group is bootstrapped 500 times and the enhanced single site weighted linear skewness (LSkew) and linear coefficient of variation (Lcv) are calculated 500 times accordingly and 500 associated growth factors are calculated. Each growth factor (GF) is multiplied by a randomly selected median annual maximum flow (QMED) from the uncertainty distribution of median estimates for the gauged subject site. The distribution of medians is derived from bootstrapping the gauged site 500 times. The intervals are then the upper and lower quantiles (depending on the conf input) of the distribution of median * GFs. For the gauged case the user can choose the level for the intervals. The default is 0.95. Occasionally the single site central estimate will be outside the uncertainty intervals. In these cases the intervals are widened to incorporate it. i.e. if above the intervals, the upper interval is increased to the single site estimate and vice versa if below. This occurs regardless of the confidence setting. For details about the calculations of weighted growth curves & urban adjustment see the PoolEst() function details. The gauged method is detailed in Hammond, A. (2021). Sampling uncertainty of UK design flood estimation. Hydrology Research, 52 (6), 1357–1371.

Value

For the ungauged case a data.frame of four values relating to the lower 68 and upper 68 percent interval and the lower 95 and upper 95 percent intervals. These are headed by the associated percentiles. For the gauged case a numeric vector of two values is provided with the lower and upper intervals of the chosen conf level.

Author(s)

Anthony Hammond

Examples

```
#Get CDs, form an ungauged pooling group and quantify the uncertainty of the
#50-year pooled estimate when using a CDs estimate of QMED with no donors
CDs.203018 <- GetCDs(203018)
Pool.203018 <- Pool(CDs.203018, exclude = 203018)
Uncertainty(Pool.203018, qmed  = QMED(CDs.203018), RP = 50)
#Form pooling group with subject site included. Quantify the uncertainty of the
#50-year pooled estimate at the 99% level.
 Pool.203018 <- Pool(CDs.203018)
 Uncertainty(Pool.203018, gauged = TRUE, RP = 50, conf = 0.99)
```

UncSS   *Uncertainty for the single site*

Description

Quantifies the aleatoric uncertainty for a single site estimate, by bootstrapping the sample

Usage

```
UncSS(x, func, conf = 0.95, RP = NULL)
```

Arguments

x	a numeric vector. The sample of interest
func	the function to be applied
conf	the confidence level of the intervals
RP	return period. Necessary if func requires RP

Details

The bootstrapping procedure resamples from a sample N*500 times with replacement. After splitting into 500 samples of size N, the statsitic of interest is calculated on each. upper and lower quantiles of the resulting distribution are used as the quantification of uncertainty. Any function that provides an estimate based on a sample of data can be used. Including any function that provides estimates as a function of return period.

Value

A data.frame of three values; central, lower, and upper bootstrapped estimates.

Author(s)

Anthony Hammond

Examples

```
#Extract an AMAX sample and quantify uncertainty for the GEV estimated 50-year flow
AM.203018 <- GetAM(203018)
UncSS(AM.203018$Flow, func = GEVAM, RP = 50)
#Quantify uncertainty for the sample standard deviation at the 90 percent confidence level
UncSS(AM.203018$Flow, func = sd, conf = 0.90)
```

WeightsGLcv   *Site gauged linear coefficient of variation (Lcv) weightings*

Description

Provides the gauged Lcv weights for each site in a pooling group

Usage

```
WeightsGLcv(x)
```

Arguments

x   pooling group derived with the Pool() function

Details

Weighting method as according to Science Report: SC050050 - Improving the FEH statistical procedures for flood frequency estimation

Value

A data.frame with site references in the first column and associated weights in the second

Author(s)

Anthony Hammond

Examples

```
#Get some CDs, form a gauged pooling group, and estimate gauged Lcv
CDs.96001 <- GetCDs(96001)
Pool.96001 <- Pool(CDs.96001)
WeightsGLcv(Pool.96001)
```

WeightsGLSkew   *Site gauged linear skewness (LSkew) weightings*

Description

Provides the gauged LSkew weights for each site in a pooling group

Usage

```
WeightsGLSkew(x)
```

Arguments

x   pooling group derived with the Pool() function

Details

Weighting method as according to Science Report: SC050050 - Improving the FEH statistical procedures for flood frequency estimation

Value

A data.frame with site references in the first column and associated weights in the second

Author(s)

Anthony Hammond

Examples

```
#Get some CDs, form a gauged pooling group, and estimate gauged LSkew
CDs.96001 <- GetCDs(96001)
Pool.96001 <- Pool(CDs.96001)
WeightsGLSkew(Pool.96001)
```

WeightsUnLcv   *Site ungauged linear coefficient of variation (Lcv) weightings*

Description

Provides the ungauged Lcv weights for each site in a pooling group

Usage

```
WeightsUnLcv(x)
```

Arguments

x   pooling group derived with the Pool() function

Details

Weighting method as according to Science Report: SC050050 - Improving the FEH statistical pro-
cedures for flood frequency estimation

Value

A data.frame with site references in the first column and associated weights in the second

Author(s)

Anthony Hammond

Examples

```
#Get some CDs, form an ungauged pooling group, and estimate ungauged Lcv
CDs.96001 <- GetCDs(96001)
Pool.96001 <- Pool(CDs.96001, exclude = 96001)
WeightsUnLcv(Pool.96001)
```

WeightsUnLSkew   *Site ungauged linear skewness (LSkew) weightings*

Description

Provides the ungauged LSkew weights for each site in a pooling group

Usage

```
WeightsUnLSkew(x)
```

Arguments

x   pooling group derived with the Pool() function

Details

Weighting method as according to Science Report: SC050050 - Improving the FEH statistical pro-
cedures for flood frequency estimation

Value

A data.frame with site references in the first column and associated weights in the second

Author(s)

Anthony Hammond

Examples

```
#Get some CDs, form an ungauged pooling group, and estimate ungauged LSkew
CDs.96001 <- GetCDs(96001)
Pool.96001 <- Pool(CDs.96001, exclude = 96001)
WeightsUnLSkew(Pool.96001)
```

WGaugLcv	*Gauged pool weighted linear coefficient of variation (Lcv)*

Description

Calculates the gauged weighted Lcv from a pooling group (enhanced single site)

Usage

```
WGaugLcv(x)
```

Arguments

x   pooling group derived with the Pool() function

Details

Weighting method as according to Science Report: SC050050 - Improving the FEH statistical procedures for flood frequency estimation

Value

the gauged weighted Lcv from a pooling group

Author(s)

Anthony Hammond

Examples

```
#Get some CDs, form a gauged pooling group, and estimate gauged Lcv
CDs.96001 <- GetCDs(96001)
Pool.96001 <- Pool(CDs.96001)
WGaugLcv(Pool.96001)
```

WGaugLSkew   *Gauged pool weighted linear skewness (LSkew)*

Description

Calculates the gauged weighted LSkew from a pooling group (enhanced single site)

Usage

```
WGaugLSkew(x)
```

Arguments

x   pooling group derived with the Pool() function

Details

Weighting method as according to Science Report: SC050050 - Improving the FEH statistical procedures for flood frequency estimation

Value

the gauged weighted LSkew from a pooling group

Author(s)

Anthony Hammond

Examples

```
#Get some CDs, form a gauged pooling group, and estimate gauged LSkew
CDs.96001 <- GetCDs(96001)
Pool.96001 <- Pool(CDs.96001)
WGaugLSkew(Pool.96001)
```

WungLcv   *Ungauged pool weighted linear coefficient of variation (Lcv)*

Description

Calculates the ungauged weighted Lcv from a pooling group

Usage

```
WungLcv(x)
```

Arguments

x   pooling group derived with the Pool() function

Details

Weighting method as according to Science Report: SC050050 - Improving the FEH statistical procedures for flood frequency estimation

Value

the ungauged weighted Lcv from a pooling group

Author(s)

Anthony Hammond

Examples

```
#Get some CDs, form an ungauged pooling group, and estimate ungauged Lcv
CDs.96001 <- GetCDs(96001)
Pool.96001 <- Pool(CDs.96001, exclude = 96001)
WungLcv(Pool.96001)
```

WungLSkew   *Ungauged pool weighted linear skewness (LSkew)*

Description

Calculates the ungauged weighted LSkew from a pooling group

Usage

```
WungLSkew(x)
```

Arguments

x   pooling group derived with the Pool() function

Details

Weighting method as according to Science Report: SC050050 - Improving the FEH statistical procedures for flood frequency estimation

Value

the ungauged weighted LSkew from a pooling group

Author(s)

Anthony Hammond

Examples

```
#Get some CDs, form an ungauged pooling group, and estimate ungauged LSkew
CDs.96001 <- GetCDs(96001)
Pool.96001 <- Pool(CDs.96001, exclude = 96001)
WungLSkew(Pool.96001)
```

Zdists   *Zdist Goodness of fit measure for pooling groups*

Description

Calculates the goodness of fit score for pooling groups.

Usage

```
Zdists(x)
```

Arguments

x   pooling group derived from the Pool() function

Details

The goodness of fit measure provides a Z-Score which quantifies the number of standard deviations from the mean of a normal distribution. To determine goodness of fit for a given distribution (assume GEV for this example), 500 pooling groups are formed which match the number of sites and samples sizes of the pooling group of interest. These are formed by simulation with the GEV distribution having LCV and LSKEW which are the weighted mean LCV and LSKEW of the pooling group (weighted by sample size) and a median of 1. The weighted mean L-Kurtosis of the observed pooling group (tR4) is compared to the mean and standard deviation (sd) of L-Kurtosis from the simulated pooling groups (tR4_Dist) by calculating the associated Z-score: (tR4 – mean(tR4_Dist)) / sd(tR4_Dist). The fit of the distribution can be considered acceptable if the absolute Z-Score is less than 1.645 (essentially a hypothesis test with alpha level equal to 0.1). This is done for all candidate distributions and the lowest absolute score is considered the best fit.

Value

A list with the first element a data.frame of four Z-Scores related to the columns; "GEV", "GenLog", "Gumbel", and "Kappa3". The second element is a character stating which has the best fit.

Author(s)

Anthony Hammond

Examples

```
#Get CDs, form a pooling group and calculate the Zdist
CDs.203018 <- GetCDs(203018)
Pool.203018 <- Pool(CDs.203018)
Zdists(Pool.203018)
```

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