Package 'CSHShydRology'

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Type Package

Title Canadian hydrological analyses

Version 1.1.2

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Description A collection of user submitted functions to aid in the analysis of hydrological data.

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URL https://github.com/CSHS-hydRology/CSHShydRology

Depends R (>= 3.5.0)

Imports fields,
Kendall,
lubridate (>= 1.3),
plotrix,
timeDate,
stringr,
jsonlite,
curl,
RSAGA,
ggplot2,
ggspatial,
raster,
sf,
dplyr,
magrittr,
tidyhydat

Suggests knitr,
testthat,
rmarkdown

VignetteBuilder knitr

LazyData true

RoxygenNote 7.1.1

R topics documented:

`CSHShydRology-package` *Functions for Canadian hydrological analyses*

Description

CSHShydRology is intended for the use of hydrologists, particularly those in Canada. It will contain functions which focus on the use of Canadian data sets, such as those from Environment Canada. The package will also contain functions which are suited to Canadian hydrology, such as the important cold-region hydrological processes. **CSHShydRology** will also contain functions which work with Canadian hydrological models, such as Raven, CRHM, Watflood, and MESH.

This packages has been developed with the assistance of the Canadian Society for Hydrological Sciences (CSHS) https://cwra.org/en/branches/affiliates/cshs-a which is an affiliated society of the Canadian Water Resources Association (CWRA) cwra.org.

The **CSHShydRology** will contain functions grouped into several themes, including:

Statistical hydrology trend detection, data screening, frequency analysis, regionalization

Basic data manipulations input/conversion/adapter functions, missing data infilling

Visualization data visualization, standardized plotting functions

Spatial hydrology basin delineation, landscape data analysis, working with GIS

Streamflow measurement analysis rating curve analysis, velocity profiles, naturalization

Network design/analysis homogeneity assessment

Ecohydrology fisheries and ecological analysis

Wrappers/unwrappers between other packages and **CSHShydRology**

References

To cite **CSHShydRology** in publications, use the command `citation("CSHShydRology")` to get the current version of the citation.

`Basic_data_manipulation-functions`

Basic data manipulation functions

Description

These functions read in or convert values among formats

ch_read_ECDE_flows Reads a file of WSC daily flows from ECDataExplorer

ch_get_ECDE_metadata Reads station meta data from ECDataExplorer

ch_get_wscstation Reads station information from a data file produced by ECDE

ch_get_AHCCD_monthly Downloads monthly Adjusted and Homogenized Canadian Climate Data (AHCCD) values

ch_read_AHCCD_daily Reads file of daily AHCCD values

ch_read_AHCCD_monthly Reads file of monthly AHCCD values

ch_tidyhydat_ECDE Reads flows using **tidyhydat** and converts to ECDE format

ch_tidyhydat_ECDE_meta Reads station meta data using **tidyhydat** and converts to ECDE-like format

ch_axis_doy *Generates the x axis for day of year Produce a date axis starting in a specific month.*

Description

generates an axis for day of year or day of water year; used by regime_plot.

This routine deals only with the axis adjustments. Day of water year needs to be done separately

Usage

```
ch_axis_doy(wyear = 1)
```

Arguments

wyear	wyear = 1 for calendar year, = 10 for October 1.

Author(s)

Paul Whitfield

See Also

ch_regime_plot

Examples

```
## Not run:
ch_axis_doy(wyear = 1)  # starts in January
ch_axis_doy(wyear = 10) # starts in October

## End(Not run)
```

ch_binned_MannWhitney *Compares two time periods of data using Mann-Whitney test*

Description

Compares two time periods of data using Mann-Whitney.

Data are binned based upon a bin size, extracting data for two time periods and tests for change between two such periods result can be passed to ch_polar_plot or ch_decades_plot for visualization

Usage

```
ch_binned_MannWhitney(
  DF,
  step,
  range1,
  range2,
  ptest = 0.05,
  variable = "discharge",
  metadata = NULL
)
```

Arguments

DF	A data frame of hydrometric data from ch_read_ECDE_flows
step	An integer indicating the degree of smoothing eg. 1, 5, 11.
range1	The first and last year of first period, as c(first,last)
range2	The first and last year of second period, as c(first,last)
ptest	The significance level default is 0.05.
variable	Name of variable. Default is 'discharge'
metadata	datafframe of station metadata, default is HYDAT_list

Details

Performs a binned Mann-Whitney test on periods of a defined length.

Value

Returns a list containing:

StationID ID of station
Station_lname Name of station
bin_width Smoothing time step
range1 range1 years
range2 range2 years
p_used p value used
fail TRUE if test failed due to missing values
bin_method method used for binning
test_method Mann-Whitney U
series a data frame containing:
period period numbers i.e. 1:365/step
period1 median values for each bin in period 1
period2 median values for each bin in period 2
mwu Mann Whitney U-statistic for each bin between the two periods
prob probability of U for each period
code significance codes for each bin

Author(s)

Paul Whitfield <paul.h.whitfield@gmail.com>

References

Whitfield, P.H., Cannon, A.J., 2000. Recent variations in climate and hydrology in Canada. Canadian Water Resources Journal 25: 19-65.

See Also

ch_polar_plot ch_polar_plot_prep

Examples

```
data(HYDAT_list)
data(W05AA008)
## Not run:
# first example fails due to missing data in both periods
range1 <- c(1960,1969)
range2 <- c(1990,1999)
b_MW <- ch_binned_MannWhitney(W05AA008, step = 5, range1, range2, ptest = 0.05)

range1 <- c(1970,1979)
range2 <- c(1990,1999)
b_MW <- ch_binned_MannWhitney(W05AA008, step = 5, range1, range2, ptest = 0.05)

## End(Not run)
```

---

ch_booth_plot *Create a Booth plot of peaks over a threshold*

Description

A Booth plot is a plot of peaks over threshold flood events with duration on the horizontal and either magnitude (default) or volume on the vertical axis

Usage

```
ch_booth_plot(events, threshold, title, type = "mag", colour1 = 1, colour2 = 1)
```

Arguments

events	A data frame of POT events from the function ch_get_peaks
threshold	The threshold used by ch_get_peaks
title	Plot title
type	The plot type, either 'mag' (magnitude, the default) or 'vol' (volume)

colour1	A vector of length 12 with line colours of rings or symbols. Defaults to those used by Booth.
colour2	A vector of length 12 with fill colours of rings or symbols. Defaults to those used by Booth.

Value

No value is returned; a standard R graphic is created.

References

Booth, E.G., Mount, J.F., Viers, J.H. 2006. Hydrologic Variability of the Cosumnes River Floodplain. San Francisco Estuary & Watershed Science 4:21.

Whitfield, P.H., and J.W. Pomeroy. 2016. Changes to flood peaks of a mountain river: implications for analysis of the 2013 flood in the Upper Bow River, Canada. Hydrological Processes 30:4657-73. doi: 10.1002/hyp.10957.

See Also

ch_get_peaks

Examples

```
threshold <- 0.1 * max(W05AA008$Flow)  # arbitrary threshold
peaks <- ch_get_peaks(W05AA008, threshold)
events <- peaks$POTevents
ch_booth_plot(events, threshold, title = "05AA008", type='mag')
ch_booth_plot(events, threshold, title = "05AA008", type='vol')
```

---

ch_cut_block *Allows the user to extract a specific time period from a longer record.*

Description

Could be used to get the same period of time from several station for comparison.

Usage

```
ch_cut_block(DF, st_date, end_date)
```

Arguments

DF	A daily streamflow data frame as from ch_read_ECDE_flows
st_date	starting date format is %Y/%m/%d
end_date	ending date format is %Y/%m/%d

Author(s)

Paul Whitfield

Examples

```
data(W05AA008)
subset <- ch_cut_block(W05AA008,"2000/01/01", "2010/12/31")
```

---

ch_date_subset *Subsets dates by string*

Description

Subsets a data frame by an specified date range, provided as a string by the `prd` argument. This function is meant to emulate the subsetting capability of the **xts** package.

Usage

```
ch_date_subset(df, prd)
```

Arguments

`df`	data frame of time series data; includes a variable called `Date`
`prd`	date range as string formatted as 'YYYY-MM-DD/YYYY-MM-DD'

Value

`df`	subsetted data frame

Author(s)

Robert Chlumsky <rchlumsk@gmail.com>

Examples

```
{
dd <- seq.Date(as.Date("2010-10-01"), as.Date("2013-09-30"), by = 1)
x <- rnorm(length(dd))
y <- abs(rnorm(length(dd)))*2
df <- data.frame("Date" = dd,x,y)
prd <- "2011-10-01/2012-09-30"
summary(ch_date_subset(df,prd))}
```

ch_decades_plot *Plots output from ch_binned_MannWhitney on x/y*

Description

creates a simple plot comparing two decades from the output of ch_binned_MannWhitney

Usage

```
ch_decades_plot(mplot)
```

Arguments

mplot	output from the function ch_binned_MannWitney

Value

a list containing

Author(s)

Paul Whitfield

Examples

```
## Not run:
# mplot from ch_binned_MannWhitney
ch_decades_plot(mplot)

## End(Not run)
```

ch_doys *Days of year and water year*

Description

Converts an array of dates into a dataframe with date, Year, month, doy, wyear, dowy. Calculates day of year and day of water year since 10.01 of present water year, using base::isodate.

Usage

```
ch_doys(Date, water_yr = 10)
```

Arguments

Date	an array as.Date
water_yr	the month starting the water year, default is 10 (October).

Details

Converts a date array and produces a data frame with years, wateryears, and days of year and of water year.

Value

a dataframe with different date information

Date in Date format

year numeric calendar year

month number calendar month

doy numeric day of year

wyear numeric water year starting on day 1 of selected month

dwy numeric day of water year

Author(s)

Paul Whitfield

Examples

```
dd <- seq.Date(as.Date("2010-01-01"), as.Date("2018-01-01"),by = 1)
output <- ch_doys(dd, water_yr=10)
head(output)
```

---

ch_fdcurve *Plot Flow Duration Curve*

Description

A flow duration curve is a plot of flow magnitude against exceedance probability. The plot may contain the Gustard Curves or they can be omitted. The default is for curves to be plotted against probability, but an option is to plot against the normalized exceedance probability. In that case, the x axis represents a normal distribution.

Usage

```
ch_fdcurve(DF, normal = FALSE, gust = TRUE, metadata = NULL)
```

Arguments

DF	- dataframe of daily flows from ch_read_ECDE_flows
normal	If normal = TRUE then exceedance probability is normalized. Default is FALSE
gust	If TRUE (the default), adds the curves from Gustard et al. 1992 are added
metadata	dataframe of metadata, defaults to HYDAT_list

Details

Create a Flow Duration Curve based upon Observations.

Value

Plots the flow duration curve and returns a data frame containing the exceedance probability and flow

Author(s)

Paul Whitfield

References

Gustard, A., A. Bullock, and J.M. Dixon. 1992. Low flow estimation in the United Kingdom. Institute of Hydrology, 292. Wallingford: Institute of Hydrology.

Vogel, R.M., and N.M. Fennessy. 1994. Flow-duration curves. I: New Interpretation and confidence intervals. Journal of Water Resources Planning and Management ASCE 120:485-504.

Vogel, R.M., and N.M. Fennessy. 1995. Flow duration curves II: A review of applications in water resources planning. Water Resources Bulletin 31:1030-9.

Examples

```
data(HYDAT_list)
data(W05AA008)
# plot with Gustard 1992 curves
test <- ch_fdcurve(W05AA008, normal = FALSE, gust = TRUE)
# plot with normalized exceedance probability
test <- ch_fdcurve(W05AA008, normal = TRUE, gust = FALSE)
```

---

ch_flow_raster *Raster plot of daily streamflows*

Description

Produces a raster plot: years by day of year, showing magnitude of flow. This produces a plot showing the flow data in colours, showing different context than i n a hydrograph. High flows are in warm colours.

Usage

```
ch_flow_raster(
  DF,
  rastercolours = c("lightblue", "cyan", "blue", "slateblue", "orange", "red"),
  metadata = NULL
)
```

Arguments

DF	A data frame of daily flow data as read by ch_read_ECDE_flows.
rastercolours	A vector of colours used for the flow magnitudes.
metadata	a dataframe of station metadata, defaults to HYDAT_list The default is c("lightblue","cyan","blue", #' @return No value is returned; a standard R graphic is created.

Author(s)

Paul Whitfield

See Also

ch_read_ECDE_flows

ch_flow_raster_trend ch_flow_raster_qa

Examples

```
ch_flow_raster(W05AA008)
```

---

ch_flow_raster_qa *Raster plot of daily streamflows with WSC quality flags*

Description

Raster plot with WSC quality flags. This produces a plot showing the flow data in grayscale overlain by the Water Survey of Canada quality flags. Colours are consistent with ECDataExplorer. Raster layout lets the use see the flags in a different context than in a hydrograph.

Usage

```
ch_flow_raster_qa(DF, metadata = NULL)
```

Arguments

DF	dataframe of daily streamflow read by ch_read_ECDE_flows
metadata	dataframe of metadata or defaults to "HYDAT_lst"

Details

Produces a raster plot: years against day of year, showing the data flags:

- A(Partial) green
- B(Backwater) blue
- D(Dry) yellow
- EEstimated) red

Value

No value is returned; a standard R graphic is created.

Author(s)

Paul Whitfield

See Also

ch_read_ECDE_flows

ch_flow_raster_trend ch_flow_raster

Examples

```
data(HYDAT_list)
data(W05AA008)
qaplot <- ch_flow_raster_qa(W05AA008)
```

---

ch_flow_raster_trend *Raster plot and simple trends of observed streamflows by periods*

Description

Creates a raster plot plus trend plots for day of year, which may be binned by a number of days (step =), and the max, min and median across years. The plot contains four panels based upon binned data.

Usage

```
ch_flow_raster_trend(
  DF,
  step = 5,
  missing = FALSE,
  metadata = NULL,
  colours = c("lightblue", "cyan", "blue", "slateblue", "darkblue", "red")
)
```

Arguments

DF	- dataframe of daily flow data as read by ch_read_ECDE_flows
step	- a number indicating the degree of smoothing eg. 1, 5, 11.
missing	If FALSE years with missing data are excluded. If TRUE partial years are included.
metadata	a dataframe of station metadata, default is HYDAT_list.
colours	A vector of colours used for the raster plot. The default is c("lightblue","cyan","blue","slateblue'

Details

The annual maximum,minimum,and median flow with a trend test for each period: red arrows indicate decreases, blue arrows indicate increases. The scale bar for the colours used in the raster plot, The raster plot with a colour for each period and each year where data exist, and A time series plot of the minimum, median, and maximum annual bin values. If there is no trend ($p > 0.05$) the points are black. Decreasing trend are in red, increasing trends are in blue.

Value

a list containing:

- stationIDStation ID eg. 05BB001
- missingHow missing values were used FALSE = used, TRUE = removed
- stepnumber of days in a bin
- periodsnumber of periods in a year
- periodperiod numbers i.e. 1:365/step
- binsvalues for each period in each year
- med_periodmedian for each period
- max_periodmaximum for each period
- min_periodminimum for each period
- tau_periodKendalls Tau for each period
- prob_periodprobability of Tau for each period
- yearyears spanning the data
- median_yearmedian bin for each year
- max_yearmaximum bin for each year
- min_yearminimum bin for each year
- tau_median_yearvalue of tau and probability for annual median
- tau_maximum_yearvalue of tau and probability for annual maximum
- tau_minimum_yearvalue of tau and probability for annual minimum

Author(s)

Paul Whitfield

References

Whitfield, P. H., Kraaijenbrink, P. D. A., Shook, K. R., and Pomeroy, J. W. 2021. The Spatial Extent of Hydrological and Landscape Changes across the Mountains and Prairies of Canada in the Mackenzie and Nelson River Basins Based on data from a Warm Season Time Window, Hydrology and Earth Systems Sciences Discussions.

See Also

ch_flow_raster

Examples

```
data(W05AA008)
mplot <- ch_flow_raster_trend(W05AA008, step=5)
```

---

ch_get_AHCCD_monthly *Retrieve AHCCD data from EC datamart*

Description

Retrieve AHCCD data from EC datamart

Usage

```
ch_get_AHCCD_monthly(
  station,
  province,
  variable,
  url = "http://dd.weather.gc.ca/climate/ahccd/geojson/historical/monthly/"
)
```

Arguments

station	Required. The station number - either as numeric or as a string.
province	Required. Name of province/territory. Must one of AB, BC, MB, NB, NL, NS, NT, NU, ON, PE, QC, SK, YT.
variable	Required. Must be one of

variable	meaning
PCP	total precipitation
RA	rainfall
SN	snowfall
TMAX	max air temp
TMEAN	mean air temp
TMIN	max air temp

PSFC surface air pressure

SFCWND surface wind speed

SLP sea level pressure

`url` Required. The default url currently works to access the data on the Environment Canada server. The url can be changed in case the site is moved.

Value

Returns a data frame with the monthly values and associated variables.

Note

Not all variables are available at all stations. Attempting to retrieve a non-existent variable will result in an error being returned.

Author(s)

Kevin Shook

References

Use of the data must cite *Mekis, E and L.A. Vincent, 2011: An overview of the second generation adjusted daily temperature and precipitation dataset for trend analysis in Canada. Atmosphere-Ocean, 49 (2), 163-177.*

See Also

`ch_read_AHCCD_daily` `ch_read_AHCCD_monthly`

Examples

```
stoon_monthly_precip <- ch_get_AHCCD_monthly("4057120", "SK", "PCP")
```

---

ch_get_ECDE_metadata *Reads Environment Canada Date Explorer (ECDE) meta data file*

Description

Reads the file that is generated from ECDE 'save favourite stations' to capture the ECDE metadata. The dataframe returned contains 21 fields of metadata for each station.

Usage

```
ch_get_ECDE_metadata(filename, writefile = NULL)
```

Arguments

filename	The name of the ECDE file, 'FavHydatStations.tb0'.
writefile	Default is NULL, but if it is a filename e.g. 'filename.csv' then the dataframe is saved to a csv file.

Value

Returns a dataframe consisting of

- Station - StationID
- StationName - Station Name
- HYDStatus - Active or Discontinued
- Prov - Province
- Latitude
- Longitude
- DrainageArea - km2
- Years - # of years with data
- From - Start Year
- To - End Year
- Reg. - Regulated?
- Flow - if TRUE/Yes
- Level - if TRUE/Yes
- Sed - if TRUE/Yes
- OperSched - Continuous or Seasonal
- RealTime - if TRUE/Yes
- RHBN - if TRUE/Yes is in the reference hydrologic basin network
- Region - Name of regional office
- Datum - Elevation datum
- Operator - Operator

Author(s)

Paul Whitfield <paul.h.whitfield@gmail.com>

Examples

```
## Not run:
filename <- "FavHydatStations.tb0"
meta0 <- ch_get_ECDE_metadata (filename)
meta1 <- ch_get_ECDE_metadata(filename, writefile="study52_metadata.csv")

## End(Not run)
```

`ch_get_peaks` *Extracts peak flows over a threshold*

Description

This function is development code being shared as is. It is expected that the user will be interested in the dataframe returned for POT analysis and for plotting (i.e. Booth_plots).

Usage

```
ch_get_peaks(dataframe, threshold)
```

Arguments

`dataframe`	a data frame of streamflow data containing columns named '`Date`' and '`Flow`'
`threshold`	a value for the threshold. Values above the threshold are tested for peaks.

Details

This function retrieves peaks greater than the prescribed threshold. It returns a dataframe of peak characteristics suitable for subsequent analysis.

The portion under development is the It also returns a list of the flows during an event with the values of the three preceeding dates and three subsequnt dates.

Value

a list containing:

POTevents a dataframe contining details of the events

events a vector with the value 0 when the flow is below the threshold and 1 when above.

event_num a vector with the value 0 when the flow is below a threshold or the index of the events when the threshold was exceeded. i.e. 1,2,3, etc

st_date start date of events

case a list of the flows in each individual event (see details for more information)

The `POTevents` dataframe contains five columns: st_date (starting date), max_date (date of maximum in the event), max (maximum discharge), volume (volume of the event), and duration (in days).

The `case` list contains the flows during an event and also for three preceeding and subsequent days. The lists range from seven to n days in length.

References

Burn, D.H., Whitfield, P.H., Sharif, M., 2016. Identification of changes in floods and flood regimes in Canada using a peaks over threshold approach. Hydrological Processes, 39: 3303-3314. DOI:10.1002/hyp.10861

Whitfield, P.H., and J.W. Pomeroy. 2016. Changes to flood peaks of a mountain river: implications for analysis of the 2013 flood in the Upper Bow River, Canada. Hydrological Processes 30:4657-73. doi: 10.1002/hyp.10957.

See Also

ch_booth_plot

Examples

```
threshold <- 0.9*max(W05AA008$Flow)  # arbitrary threshold
my_peaks <- ch_get_peaks(W05AA008, threshold)
str(my_peaks)
```

---

ch_get_wscstation *Reads station information from a data file produced by ECDE Retrieves station information for an individual Water Survey of Canada site, adds a text string at position 21 that combines key elements for a title.*

Description

Reads station information from a data file produced by ECDE Retrieves station information for an individual Water Survey of Canada site, adds a text string at position 21 that combines key elements for a title.

Usage

```
ch_get_wscstation(stnID, metadata = NULL)
```

Arguments

stnID	A Water Survey of Canada station number
metadata	a data frame of station information from ECDataExplorer. The data frame 'HYDAT_list' is supplied with this package.

Value

Returns a data frame with 21 variables

- Station StationID
- StationName Station Name
- HYDStatus Active or Discontinued
- Prov Province
- Latitude
- Longitude
- DrainageArea km2
- Years # of years with data
- From Start Year
- To End Year

- Reg. Regulated
- Flow if TRUE/Yes
- Level if TRUE/Yes
- Sed if TRUE/Yes
- OperSched Continuous or Seasonal
- RealTime if TRUE/Yes
- RHBN if TRUE/Yes is in the reference hydrologic basin network
- Region if TRUE/Yes is in the reference hydrologic basin network
- Datum if TRUE/Yes is in the reference hydrologic basin network
- Operator if TRUE/Yes is in the reference hydrologic basin network
- Station_lname Added field combining ID, Name, Province and if RHBN an * is added

Author(s)

Paul Whitfield

Examples

```
data("HYDAT_list")
s_info <- ch_get_wscstation("05BB001", metadata = HYDAT_list)
title <- s_info[21]
print(title)
```

`ch_hydrograph_plot` *Plot hydrographs*

Description

Creates a hydrograph plot for simulated, observed, and inflow hydrograph series, including precipitation if provided. The secondary y axis will be used to plot the precip time series. The function assumes that the supplied time series have the same length and duration in time. If this is not true, then the defined period or period calculated from the first available flow series will be used to determine the plotting limits in time. If the data is take from output from the **Raven** model, this is not a concern. The supplied time series should be in **xts** format, which can be obtained directly by using the `hyd.extract` function in the package **RavenR** . Note that a plot title is purposely omitted in order to allow the automatic generation of plot titles.

Usage

```
ch_hydrograph_plot(
  flows = NULL,
  precip = NULL,
  prd = NULL,
  winter_shading = FALSE,
  range_mult_flow = NULL,
  range_mult_precip = 1.5,
  flow_labels = NULL,
  ylabel = "Flow [m3/s]",
  precip_label = "Precipitation [mm]",
  leg_pos = NULL,
  leg_box = NULL,
  zero_axis = T,
  plot_mode = "base"
)
```

Arguments

flows	data frame of flows to plot
precip	data frame of precipitation values to plot
prd	period to use in plotting
winter_shading	optionally adds a transparent cyan shading for the December 1st to March 31st period in each year that is plotted. Default is FALSE.
range_mult_flow	range multiplier for max value in hydrograph. This is useful in preventing overlap if precip is also plotted. This value should not be less than 1.0, otherwise the values will be cutoff in the plot.
range_mult_precip	range multiplier for max value in precipitation plot (default 1.5)
flow_labels	string vector of labels for flow values
ylabel	text label for y-axis of the plot (default 'Flow [m3/s]')
precip_label	text label for precipitation y-axis (default 'Precipitation [mm]')
leg_pos	string specifying legend placement on plot e.g. 'topleft', 'right', etc., and is consistent with the legend function options. If NULL, the function will place the legend left, if precip added, on the topleft otherwise).
leg_box	boolean on whether to put legend in an opaque white box or not. If NULL (the default), the function will automatically not use a white box and leave the background of the legend transparent.
zero_axis	fixes the y axis to start exactly at zero (default TRUE). By default, R will plot the values with a small buffer for presentation. Be warned that if this option is set to TRUE, the minimum value is set to zero without checking if any flow values are less than zero. This option should not be used for reservoir stage plotting, since most reservoir stage is typically reported as an elevation.
plot_mode	plot mode as 'base' or 'ggplot'. Currently only 'base' plot type is supported, 'ggplot' is under construction.

Value

Returns TRUE if the function is executed properly.

Author(s)

Robert Chlumsky <rchlumsk@gmail.com>

Examples

```
# example with synthetic random data
dd <- seq.Date(as.Date("2010-10-01"), as.Date("2013-09-30"),by = 1)
x <- abs(rnorm(length(dd)))
y <- abs(rnorm(length(dd))) * x
df <- data.frame("Date" = dd, x, y)
myprd <- "2011-10-01/2012-09-30"

precip <- data.frame("Date" = dd," precip" = abs(rnorm(length(dd))) * 10)

# basic hydrograph plot
ch_hydrograph_plot(flows = df, winter_shading = FALSE)

# with different labels
ch_hydrograph_plot(flows = df, winter_shading = FALSE, flow_labels = c("simulated", "observed"))

# with a few more options turned on
ch_hydrograph_plot(flows = df, precip = precip)

# increase the plot ranges to separate flows and precip; add a legend box
ch_hydrograph_plot(flows = df, precip = precip, range_mult_flow = 1.7,
range_mult_precip = 2, leg_box = TRUE)
```

---

ch_polar_plot *Polar plot of daily streamflows*

Description

Produces a polar plot similar to that used in *Whitfield and Cannon, 2000*. It uses output from the function ch_binned_MannWhitney or a data structure created using the function ch_polar_plot_prep.

Usage

```
ch_polar_plot(
  bmw,
  lcol1 = c("black", "gray50"),
  lcol2 = c("black", "gray50"),
  lfill = c("yellow", "green"),
  lsig = c("red", "blue")
)
```

Arguments

bmw	output from binned_MannWhitney
lcol1	line colour, default is c("black","gray50")
lcol2	point colour, default is c("black","gray50")
lfill	fill colour, default is c("yellow","green")
lsig	significance symbol colour, default is ("red","blue")

Value

No value is returned; a standard R graphic is created.

Author(s)

Paul Whitfield <paul.h.whitfield@gmail.com>

References

Whitfield, P.H. and A.J. Cannon. 2000. Polar plotting of seasonal hydrologic and climatic data. Northwest Science 74: 76-80.

Whitfield, P.H., Cannon, A.J., 2000. Recent variations in climate and hydrology in Canada. Canadian Water Resources Journal 25: 19-65.

See Also

ch_binned_MannWhitney ch_polar_plot_prep

Examples

```
range1 <- c(1970,1979)
range2 <- c(1990,1999)
b_MW <- ch_binned_MannWhitney(W05AA008, step = 5, range1, range2,
ptest = 0.05)
ch_polar_plot(b_MW)
```

---

ch_polar_plot_prep *Creates a data structure to be passed to* ch_polar_plot.

Description

Could be used to move data from a different type of analysis different to the binned_MannWhitney function which uses flows. The two series need to be of the same length and their length is related to the step size. For examples 73 periods links to 5 day periods.

Usage

```
ch_polar_plot_prep(
  station,
  plot_title,
  step,
  x0,
  x1,
  stat,
  prob,
  test_s,
  variable = "discharge",
  bin_method = "unstated",
  test_method = "unstated",
  lline1 = "Period 1",
  lline2 = "Period 2",
  pvalue = 0.05
)
```

Arguments

station	Typically a station number
plot_title	Polar plot title - usually a station name
step	The number of days binned
x0	Time series of length n for a single seasonal cycle
x1	Time series of length n for a single seasonal cycle
stat	Time series of length n for statistical test value for each bin
prob	Time series of length n of probability of test value
test_s	Vector with values of -1, 0, 1 for significance, -1 negative, 1 positive, 0 not significant
variable	Name of variable plotted. Default is "discharge"
bin_method	Default is "unstated"
test_method	Default is "unstated"
lline1	Names of first period, default is "Period 1"
lline2	Names of second period, default is "Period 2"
pvalue	Value of p used. Default is 0.05

Value

Returns a list containing:

StationID ID of station

Station_lname Name of station

variable Name of variable

bin_width Smoothing time step

range1 range1 years

range2 range2 years

p_used p value used

fail TRUE if test failed due to missing values

bin_method method used for binning

test_method Mann-Whitney U

series a data frame containing:

period period numbers i.e. 1:365/step

period1 median values for each bin in period 1

period2 median values for each bin in period 2

mwu Mann Whitney U-statistic for each bin between the two periods

prob probability of U for each period

code significance codes for each bin

Author(s)

Paul Whitfield <paul.h.whitfield@gmail.com>

References

Whitfield, P.H. and A.J. Cannon. 2000. Polar plotting of seasonal hydrologic and climatic data. Northwest Science 74: 76-80.

Whitfield, P.H., Cannon, A.J., 2000. Recent variations in climate and hydrology in Canada. Canadian Water Resources Journal 25: 19-65.

See Also

ch_binned_MannWhitney ch_polar_plot

---

ch_qa_hydrograph *Plots a hydrograph with the data quality symbols and prints a report*

Description

Plots a hydrograph of a WSC daily data file read from from ECDataExplorer (ECDE). The hydrograph shows individual days with data quality symbols [SYM] in colour and counts cases of each and reports them in the legend. The colours and symbols are those produced by ECDataExplorer. The option is to provide start and end dates to show only part of the time period for which data exists and the plot is annotated to indicate this.

Usage

```
ch_qa_hydrograph(
  DF,
  st_date = NULL,
  end_date = NULL,
  cts = TRUE,
  rescale = FALSE,
  metadata = NULL
)
```

Arguments

DF	Data frame retrieved from ECDataExplorer as returned by the function ch_read_ECDE_flows.
st_date	Optional start date in the form 'yyyy-mm-dd'. Default is NULL
end_date	Optional end date in the form 'yyyy-mm-dd'. Default is NULL
cts	If TRUE (the default) shows the counts of SYM in the legend. If FALSE
rescale	If FALSE (the default), the y-axis scaling is determined by the time period. If TRUE then determined by the whole dataset.
metadata	a dataframe of station metadata, default is HYDAT_list. counts are not shown, as in ECDE.

Value

Produces a plot and returns a list that contains the station name, start and end dates provided, the number of data points and a summary of the SYMs.

Author(s)

Paul Whitfield

Examples

```
m_test <- ch_qa_hydrograph(W05AA008)
m_test <- ch_qa_hydrograph(W05AA008, st_date="1980-01-01", end_date="1999-12-31")
```

---

ch_read_AHCCD_daily *Reads AHCCD daily file*

Description

This program reads an Adjusted and Homogenized Canadian Climate Data (AHCCD) of daily precipitation or temperatures. The values are arranged as month x day, which makes them difficult to read using standard R functions.

Usage

```
ch_read_AHCCD_daily(daily_file)
```

Arguments

daily_file	Required. Name of the file to be read.

Value

If successful, returns the values in a dataframe, consisting of the date, the value and the data code. If unsuccessful, returns the value FALSE.

Author(s)

Kevin Shook

References

Monthly AHCCD data are available from http://www.ec.gc.ca/dccha-ahccd. Daily values must be requested. Any use of the data must cite *Mekis, E and L.A. Vincent, 2011: An overview of the second generation adjusted daily precipitation dataset for trend analysis in Canada. Atmosphere-Ocean, 49 (2), 163-177.*

See Also

ch_read_AHCCD_monthly ch_get_AHCCD_monthly

Examples

```
## Not run:
stoon_daily_tmax <- ch_read_AHCCD_daily("dx40657120.txt")
## End(Not run)
```

---

ch_read_AHCCD_monthly *Reads AHCCD monthly file*

Description

This program reads an Adjusted and Homogenized Canadian Climate Data (AHCCD) data of precipitation or temperatures. The values are arranged as year x month, which makes them difficult to read using standard R functions.

Usage

```
ch_read_AHCCD_monthly(monthly_file = NULL)
```

Arguments

monthly_file	Required. Name of the file to be read.

Value

If successful, returns the values in a dataframe, consisting of the `year`, the `month`, the value and the data `code`. The meanings of the codes can be found in the

Author(s)

Kevin Shook

References

Monthly AHCCD data are available from https://www.canada.ca/en/environment-climate-change/services/climate-change/science-research-data/climate-trends-variability/adjusted-homogenized-canad surface-air-temperature-access.html. Any use of the data must cite *Mekis, E and L.A. Vincent, 2011: An overview of the second generation adjusted daily temperature and precipitation dataset for trend analysis in Canada. Atmosphere-Ocean, 49 (2), 163-177.*

See Also

ch_read_AHCCD_daily ch_get_AHCCD_monthly

Examples

```
## Not run:
Stoon_monthly_precip <- ch_read_AHCCD_monthly("mt4057120.txt")
NB_monthly_tmean <- ch_read_AHCCD_monthly("mm4045695.txt")
## End(Not run)
```

`ch_read_ECDE_flows` *Reads a file of WSC daily flows from ECDataExplorer Reads in a file WSC daily flows as returned from the program ECDataExplorer, and omits the last 3 lines as these contain the data disclaimer.*

Description

Reads a file of WSC daily flows from ECDataExplorer Reads in a file WSC daily flows as returned from the program ECDataExplorer, and omits the last 3 lines as these contain the data disclaimer.

Usage

```
ch_read_ECDE_flows(filename)
```

Arguments

`filename`	Datafile retrieved from ECDataExplorer

Value

Returns a dataframe with the last three rows removed and the Date as Date

Author(s)

Paul Whitfield <paul.h.whitfield@gmail.com>

Examples

```
## Not run:
# Using a dummy file name as an example
mfile <- "04JD005_Daily_Flow_ts.csv"
mdata <- ch_read_ECDE_flows(mfile)
## End(Not run)
```

---

ch_regime_plot *Plots the regime of daily streamflows*

Description

Produces a regime hydrograph similar to that in the reference. It shows the flow quantiles for each day of the year and the maximum and minimum. Parameters can be set to change colours and fix the y scale to allow plots of same scale to be produced.

Usage

```
ch_regime_plot(
  DF,
  wyear = 1,
  colour = TRUE,
  mx = 1,
  metadata = NULL,
  quant = c(0.95, 0.9, 0.75, 0.5, 0.25, 0.1, 0.05)
)
```

Arguments

DF	dataframe of daily flow data
wyear	set wyear = 10 for October water year, = 1 for calendar year, can be any month
colour	if TRUE plot is in colour, if FALSE plot is grayscale.
mx	set the maximum y value; if = 1 then maximum value of the flows is used to set
metadata	a dataframe of metadata, defaults to HYDAT_list. the y-axis value. The value of mx can be specified to produce a series of plots with the same scale.
quant	quantiles; default is quant= c(0.95,0.9,0.75,0.5,0.25,0.1,0.05). Can be changed but the length must be 7 and the 4th value must be 0.5 (median)

Value

No value is returned; a standard R graphic is created.

Author(s)

Paul Whitfield

References

MacCulloch, G. and P. H. Whitfield (2012). Towards a Stream Classification System for the Canadian Prairie Provinces. Canadian Water Resources Journal 37: 311-332.

Examples

```
data(W05AA008)
ch_regime_plot(W05AA008, colour = TRUE, wyear = 1)
```

---

ch_sub_set_Years *Helper function for selecting points for an axis so not all are necessary*

Description

Sub-samples a vector every n places. Many times there are so many years the labels on the plot overlap. This function returns the position and label for the subset. The function can be used on any type of simple array.

Usage

```
ch_sub_set_Years(years, n)
```

Arguments

years	a vector of years
n	sample size

Value

a list containing:

position array of axis positions

label array of labels

Author(s)

Paul Whitfield <paul.h.whitfield@gmail.com>

Examples

```
myears <- c(1900:2045)
myears <- ch_sub_set_Years(myears, 20)
myears

a <- LETTERS
my_alpha <- ch_sub_set_Years(a, 5)
my_alpha
```

`ch_tidyhydat_ECDE` *Converts tidyhydat daily flow tibble data to ECDE format*

Description

Accessing daily flow data using **tidyhydat** is quick and efficient. However, it sometimes conflicts with other functions as **tidyhydat** changes variable names and some default entries. This function converts a tibble obtained from a **tidyhydat** tibble to a dataframe with standard Environment and Climate Change Canada Data Explorer (ECDE) headings.

Usage

```
ch_tidyhydat_ECDE(data)
```

Arguments

`data`	Tibble of daily flows retrieved using **tidyhydat** function `hy_daily_flows`.

Value

A dataframe or a list of flows with formats consistent with datafiles from ECDE

Author(s)

Paul Whitfield <paul.h.whitfield@gmail.com>

Examples

```
## Not run:
library(tidyhydat)
mdata <- hy_daily_flow(station_number=c("05CK004"))
m_data <- ch_tidyhydat_ECDE(mdata)

mdata <- hy_daily_flows(station_number=c("05CK004","08MF005","05BB001"))
mnew <- ch_tidyhydat_ECDE(mdata)
str(mnew[[1]])
str(mnew[[2]])
str(mnew[[3]])
#note the order is in increasing alphabetical order
## End(Not run)
```

`ch_tidyhydat_ECDE_meta` *Creates an ECDE-like dataframe of metadata*

Description

Extracts tombstone (meta) data for stations from **tidyhydat** in a format similar to that used by the Environment Canada Data Explorer (ECDE). The result does not capture all the fields in ECDE as ECDE reports the most recent status of many fields such as operating schedule.

Usage

```
ch_tidyhydat_ECDE_meta(stations)
```

Arguments

`stations`	A vector of WSC station IDs, i.e. c("05BB001", "05BB003", "05BB004", "05BB005")

Value

Returns a list with three items:

- `meta` - a dataframe of metadata from **tidyhydat** in ECDE form (not all ECDE fields are reproduced in this summary)
- `H_version` - version information, and
- `th_meta` - a dataframe with all **tidyhdat** fields including:
  - Station - StationID
  - StationName - Station Name
  - HYDStatus - Active or Discontinued
  - Prov - Province
  - Latitude
  - Longitude
  - DrainageArea - km^2
  - Years - number of years with data
  - From - Start Year
  - To - End Year
  - Reg. - Regulated?
  - Flow - not captured (differs from ECDE)
  - Level - not captured (differs from ECDE)
  - Sed - not captured (differs from ECDE)
  - OperSched - not captured (differs from ECDE)
  - RealTime - if TRUE/Yes
  - RHBN - if TRUE/Yes is in the reference hydrologic basin network

- Region - number of region instead of name (differs from ECDE)
- Datum - reference number (differs from ECDE)
- Operator - reference number (differs from ECDE)

Author(s)

Paul Whitfield <paul.h.whitfield@gmail.com>

See Also

ch_get_ECDE_metadata ch_tidyhydat_ECDE

Examples

```
stations <- c("05BB001", "05BB003", "05BB004", "05BB005")
result <- ch_tidyhydat_ECDE_meta(stations)
metadata <- result[[1]]
version <- result[[2]]
```

---

ch_wtr_yr *Designation of the water year*

Description

Display water year

Usage

```
ch_wtr_yr(dates, start_month = 10)
```

Arguments

dates	A vector of dates with actual year
start_month	Month in which the year starts (defaults to October)

Value

Year starting in start_month

Source

http://stackoverflow.com/questions/27626533/r-create-function-to-add-water-year-column

Examples

```
date <- seq(as.Date("1910/1/1"), as.Date("1912/1/1"), "days")
wtr_yr_date <- ch_wtr_yr(dates=date, start_month=10)
data.frame(wtr_yr_date,date)
```

HYDAT_list *HYDAT_list*

Description

A dataframe of station information, as extracted from the EC Data Explorer

Usage

```
HYDAT_list
```

Format

A dateframe with 7791 rows and 20 columns.

Source

Water Survey of Canada

Variables:

- Station StationID
- StationName Station Name
- HYDStatus Active or Discontinued
- Prov Province
- Latitude
- Longitude
- DrainageArea km2
- Years # of years with data
- From Start Year
- To End Year
- Reg. Regulated
- Flow if TRUE/Yes
- Level if TRUE/Yes
- Sed if TRUE/Yes
- OperSched Continuous or Seasonal
- RealTime if TRUE/Yes
- RHBN if TRUE/Yes is in the reference hydrologic basin network
- Region if TRUE/Yes is in the reference hydrologic basin network
- Datum if TRUE/Yes is in the reference hydrologic basin network
- Operator if TRUE/Yes is in the reference hydrologic basin network
- Station_lname Added field combines ID,Name,Province and if RHBN an * is added

StatisticalHydrology-functions

Statistical analysis functions

Description

These functions perform statistical analyses

ch_binned_MannWhitney Compares two time periods of data using Mann-Whitney test

ch_fdcurve Finds flow exceedence probabilities

ch_get_peaks Finds peak flows over a specified threshold

Visualization-functions

Visualization functions

Description

These functions are primarily intended for graphing, although some analyses may also be done.

ch_booth_plot Plot of peaks over a threshold

ch_flow_raster Raster plot of streamflows

ch_flow_raster_qa Raster plot of streamflows with WSC quality flags

ch_flow_raster_trend Raster plot and simple trends of observed streamflows

ch_hydrograph_plot Plots hydrographs and/or precipitation

ch_polar_plot Polar plot of daily streamflows

ch_regime_plot Plots the regime of daily streamflows

W05AA008

W05AA008

Description

A dataframe of Water Survey of Canada (WSC) daily flows for station W05AA008, CROWSNEST RIVER AT FRANK Alberta.

Usage

```
W05AA008
```

Format

A dateframe with 25252 rows and 5 columns spanning the period 1910-2013.

Source

Water Survey of Canada

Variables:

- ID StationID
- PARAMParameter 1=Flow, 2=Level
- DateR date
- FlowDaily flow in m^3/s
- SYMWater Survey FLags A, B, D, E

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