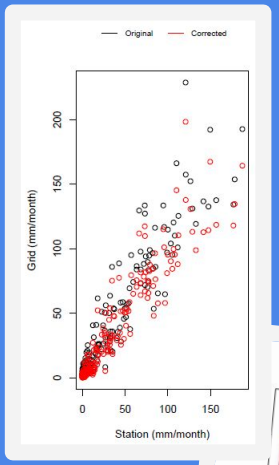

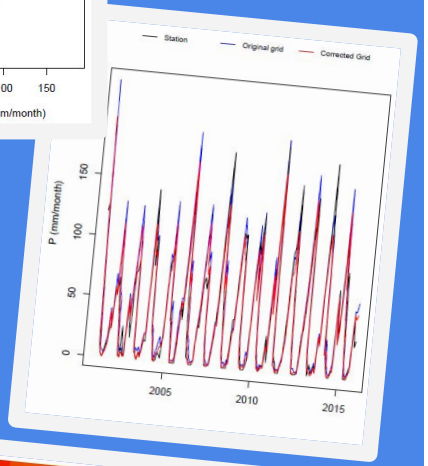

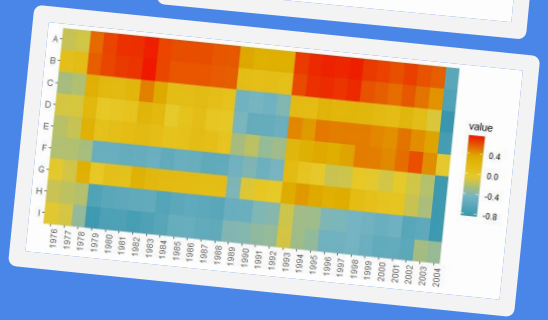

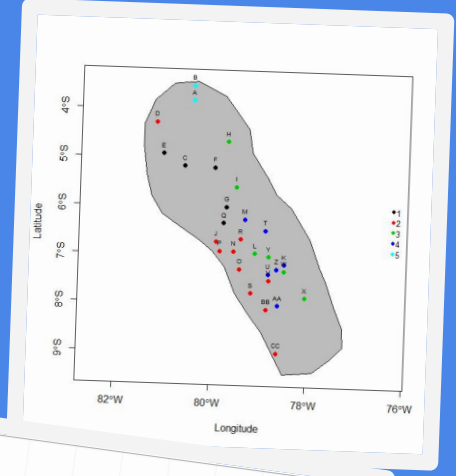

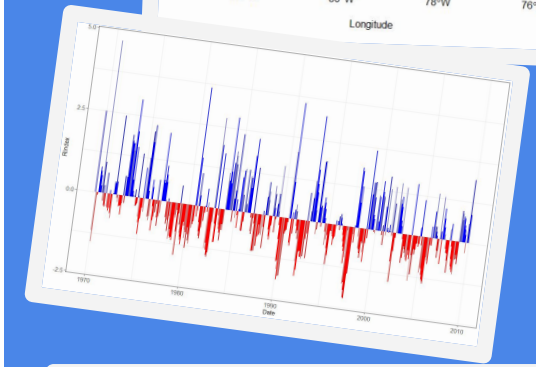

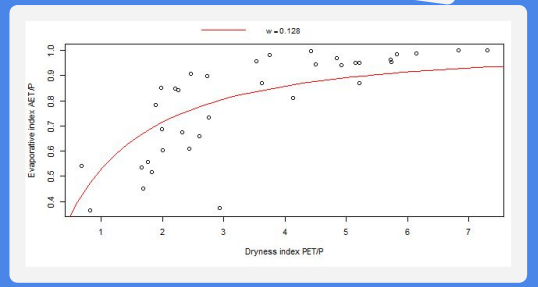

hydRopclim

An R package for easy hydroclimatic calculations

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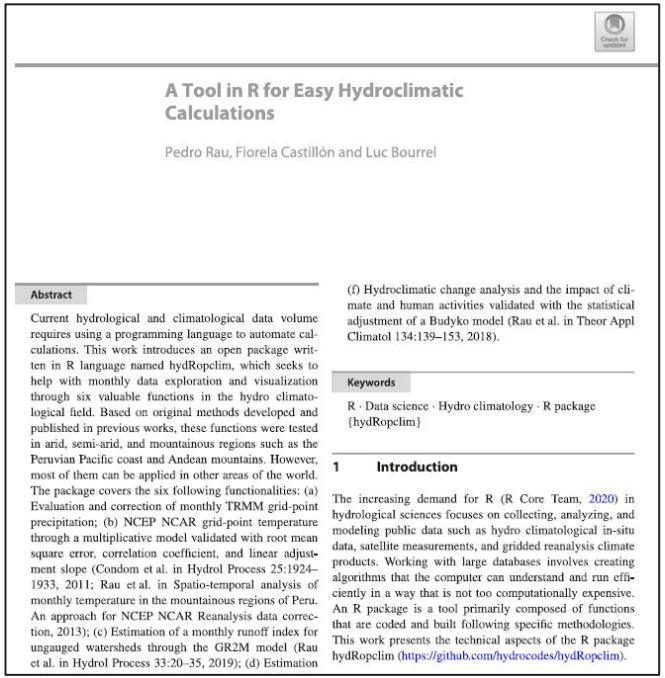
hydRopclim (Rau et al, 2023)

V1.0: Launched in January 2021
V1.3: Updating with terra package in some functions

Downloads from many parts: Peru, Colombia, Ecuador, Chile, Bolivia, China, UK, France …

CITATION:

Rau P, Castillon F, Bourrel L. 2023. A tool in R for easy hydroclimatic calculations. Advances in Science, Technology and Innovation. https://doi.org/10.1007/978-3-031-43169-2_3



A Tool in R for Easy Hydroclimatic Calculations

Pedro Rau, Fiorela Castillón and Luc Bourrel

Abstract

Current hydrological and climatological data volume requires using a programming language to automate calculations. This work introduces an open package written in R language named hydRopclim, which seeks to help with monthly data exploration and visualization through six valuable functions in the hydro climatological field. Based on original methods developed and published in previous works, these functions were tested in arid, semi-arid, and mountainous regions such as the Peruvian Pacific coast and Andean mountains. However, most of them can be applied in other areas of the world. The package covers the six following functionalities: (a) Evaluation and correction of monthly TRMM grid-point precipitation; (b) NCEP NCAR grid-point temperature through a multiplicative model validated with root mean square error, correlation coefficient, and linear adjustment slope (Condom et al. in Hydrol Process 25:1924–1933, 2011; Rau et al. in Spatio-temporal analysis of monthly temperature in the mountainous regions of Peru. An approach for NCEP NCAR Reanalysis data correction, 2013); (c) Estimation of a monthly runoff index for ungauged watersheds through the GR2M model (Rau et al. in Hydrol Process 33:20–35, 2019); (d) Estimation (f) Hydroclimatic change analysis and the impact of climate and human activities validated with the statistical adjustment of a Budyko model (Rau et al. in Theor Appl Climatol 134:139–153, 2018).

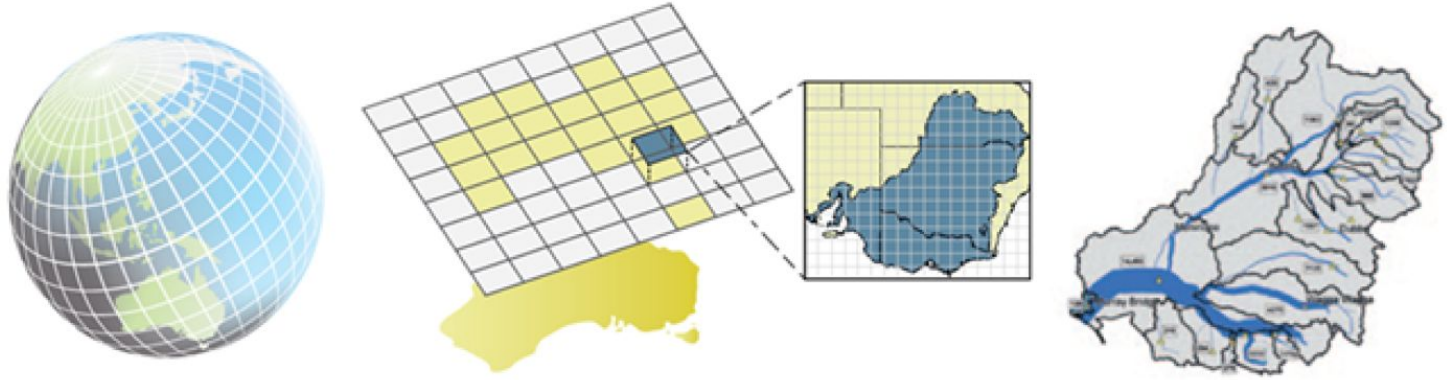
Keywords

R · Data science · Hydro climatology · R package {hydRopclim}

1 Introduction

The increasing demand for R (R Core Team, 2020) in hydrological sciences focuses on collecting, analyzing, and modeling public data such as hydro climatological in-situ data, satellite measurements, and gridded reanalysis climate products. Working with large databases involves creating algorithms that the computer can understand and run efficiently in a way that is not too computationally expensive. An R package is a tool primarily composed of functions that are coded and built following specific methodologies. This work presents the technical aspects of the R package hydRopclim (https://github.com/hydrocodes/hydRopclim).

Many datasets to analyse climatological and hydrological variables



Global climate modelling → Regional climate modelling → Hydrological modelling

Chiew et al (2022)

Regions with scarce information

- Use of satellite datasets
- Use of reanalysis datasets from climate models
- Using a hydrological model for a basin

Exploration of hydroclimatological time series

- Dynamic correlations between climate and hydrological indices
- Regionalization by clustering
- Water balance disparity for a basin

Main functions of v1.3

Function name	Description	Reference
pgridcorr	Correcting precipitation grid	Condom et al (2011)
tgridcorr	Correcting temperature grid	Rau et al (2013)
indexcorrl with subfunctions: seasavg, seasavg2, seassum, zscorem	Hydroclimatic indexes and running correlations	Bourrel et al (2015)
hydrocluster	Climatic clustering by k-means	Rau et al (2017)
hydrochange with subfunction: hydrochange2	Hydroclimatic change analysis by Budyko model	Rau et al (2018)
rindex	Runoff index in ungauged basins	Rau et al (2019)

spatial_grad () ; beta version

Setup

Install **remotes** library

```
library(remotes)
remotes::install_github("hydrocodes/hydRopclim")
```

R Code structure

```
library(hydRopclim)

library(terra)

database <- read.csv("C:/.../data.csv")

region <- vect("C:/.../region.shp")

output <- "C:/.../output_test.csv"

hydrocluster(file=database, shp=region, clusters=n)
```

1. Load hydRopclim and complementary packages

2. Read a csv and complementary databases

3. Create the CSV output file

4. Add elements to the function

01. pgridcorr

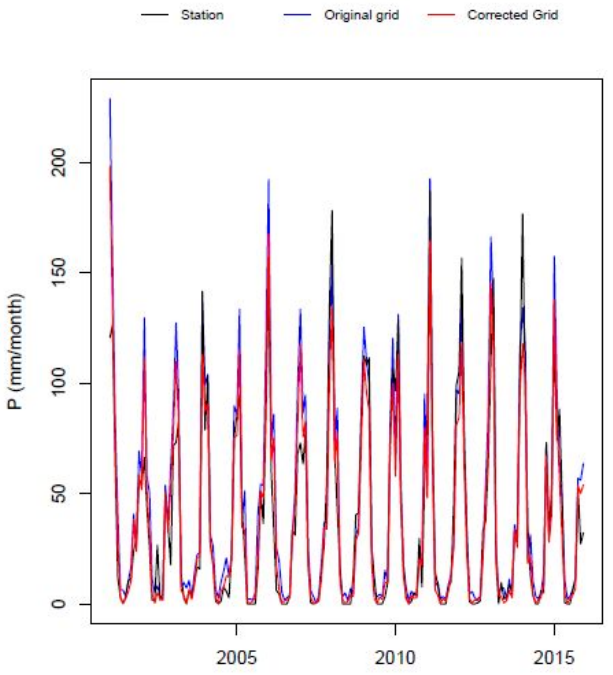
Evaluate and correct TRMM and other precipitation gridded products with a in-situ station

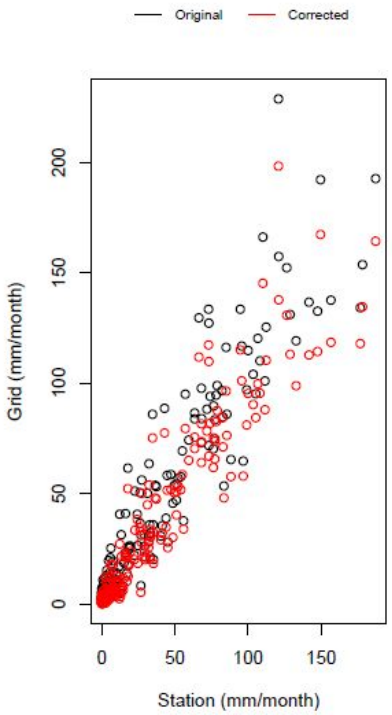
Database CSV structure

Date	Station	Grid
Jan-2001	120.7	228.8
Feb-2001	126.4	152.3
Mar-2001	68.2	83.9
Apr-2001	12.1	40.6
May-2001	3	6.4
Jun-2001	0.1	6.2
Jul-2001	3.1	3.4
Aug-2001	10.5	10.4
Sep-2001	11.5	16.8

Formatting date: %b-%Y

pgridcorr(database)



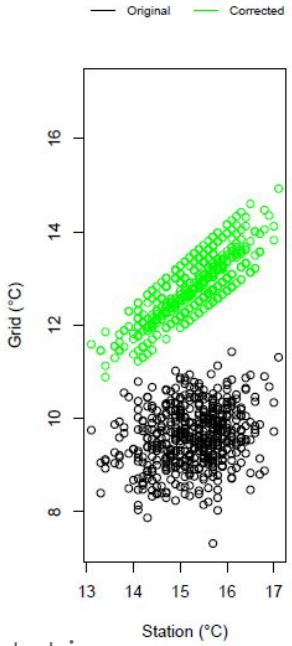


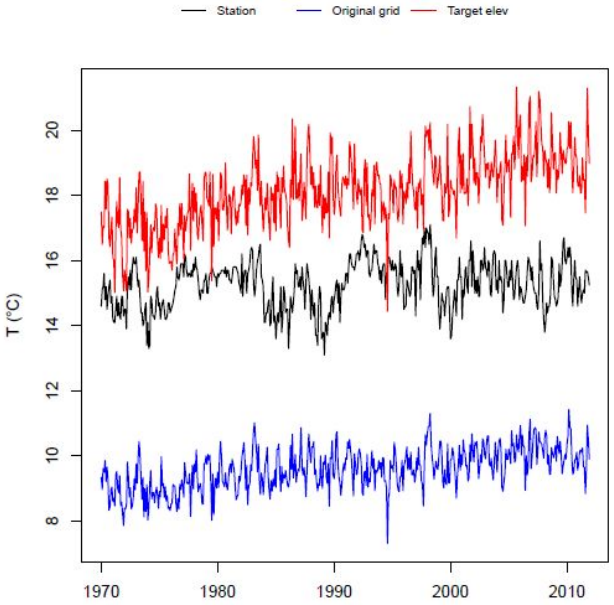
Evaluate and correct NCEP NCAR or other temperature grid at a target elevation with an in-situ station

```
tgridcorr(database, hBS, hNNR, hx, LR=gradb)
```

Database CSV structure

Date	Station	Grid.level
Jan-1960	14.6	9.350006104
Feb-1960	15.1	8.980003357
Mar-1960	15.2	9.620002747
Apr-1960	15.6	9.510002136
May-1960	14.8	9.86000061
Jun-1960	15.2	9.220001221
Jul-1960	14.5	9.660003662
Aug-1960	14.9	9.270004272





hBS: Elevation in masl of base in-situ station
hNNR: Elevation in masl of grid level used

hx: Elevation in masl of target point
LR: Monthly lapse rate (°C/100m)

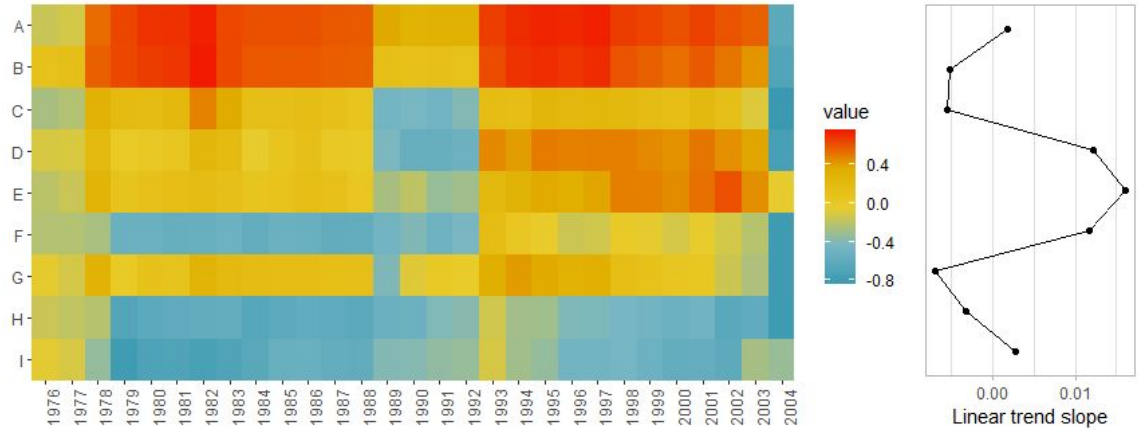
03. indexcorrl

Obtain a dynamic or running correlation between hydroclimatic stations and a climatic index

indexcorrl(index.seas, variable.seas, rwin)

Database CSV structure

Date	Index	A	B	C	D	E
Jan-1960	0.3047	0.2	13.9	158.2	8.4	140
Feb-1960	0.2884	0.5	22.4	116.1	1.1	27.
Mar-1960	-0.0231	3.9	18.3	129.7	1	121
Apr-1960	0.2022	2.8	4.9	101.9	0.4	74.
May-1960	-0.1671	2.1	8.1	95.1	0.1	23.
Jun-1960	-0.7922	0.8	0.4	24.5	0.5	6.8



index.seas: Seasonalised index by seasavg or seassum function
variable.seas: Seasonalised variables by seasavg or seassum function
rwin: length of the window of years for dynamic correlation

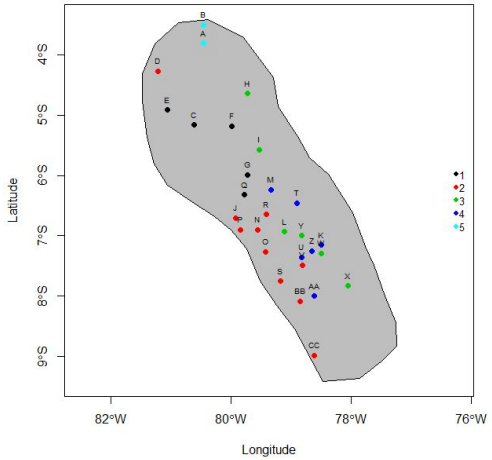
04. hydrocluster

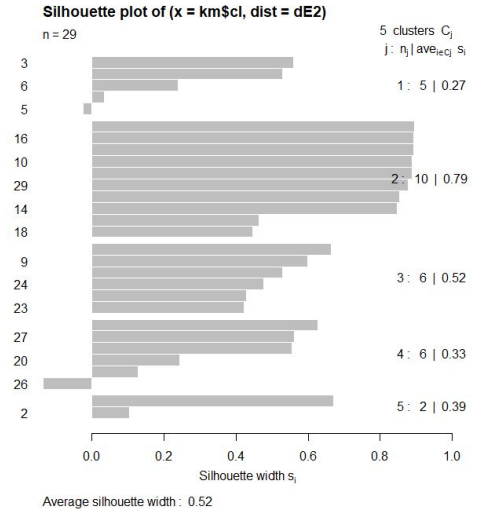
Visualizate and evaluate a k-means clustering analysis of hydroclimatic stations in a fast way

hydrocluster(database, shp=region, clusters)

Database CSV structure

station	A	B	C	D	E	F
lat	-3.81333	-3.50833	-5.166667	-4.2725	-4.917778	-5.18
long	-80.4575	-80.45722	-80.61667	-81.22395	-81.06055	-79.9
1970	617.6	241.5	74.9	106.9	36.8	640
1971	122.5	77.3	74.9	61	36.8	89
1972	160.8	136.4	74.9	107.6	5.5	215.2
1973	11	1.2	74.9	108.7	6	24.4
1974	298.8	152.5	74.9	108.7	44	105.9





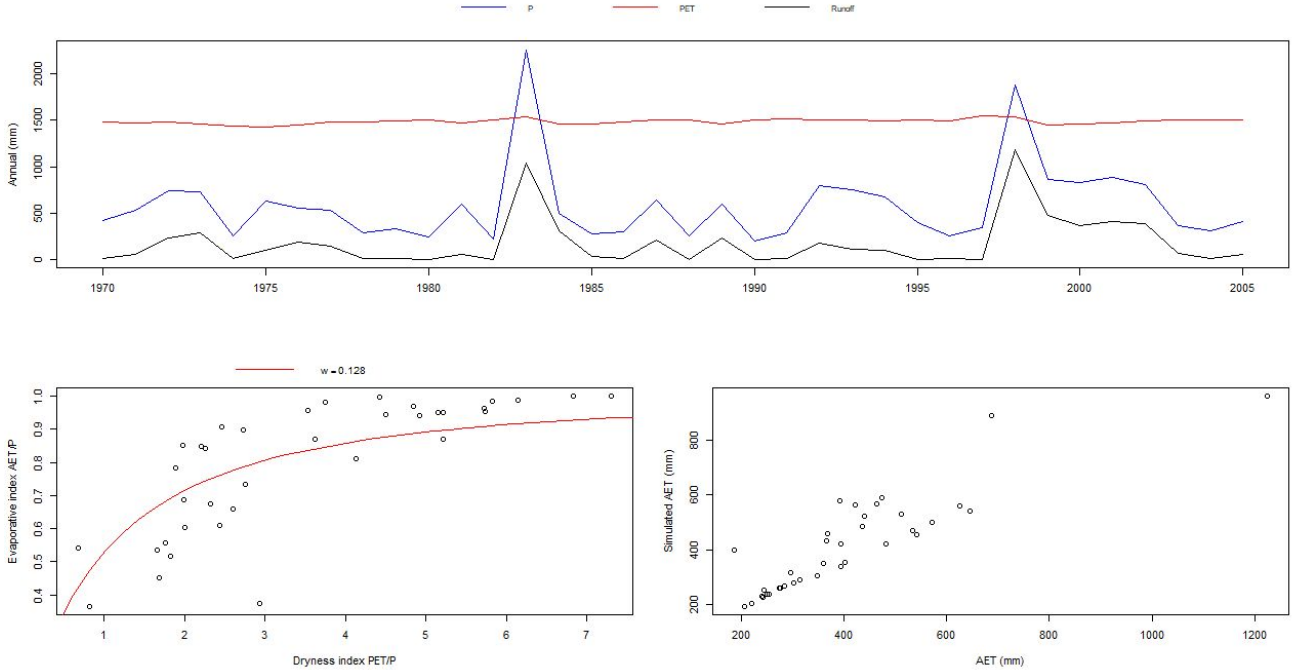
shp: A shapefile of the studied region in WGS84 coordinates.
clusters: Number of clusters for k-means

Evaluate an hydroclimatic change analysis by a Budyko model quantifying impacts of climate and human activities on runoff

hydrochange(database, lat)

Database CSV structure

Date	P	Tm	R
1970	420.5	23.1	17.9
1971	537	22.8	55.0
1972	742.2	23	231.1
1973	727.7	22.7	287.4
1974	251	22.3	11.3
1975	633.3	22.1	100.0
1976	554.7	22.4	188.1



lat: Latitude in sexagesimal degrees of studied basin

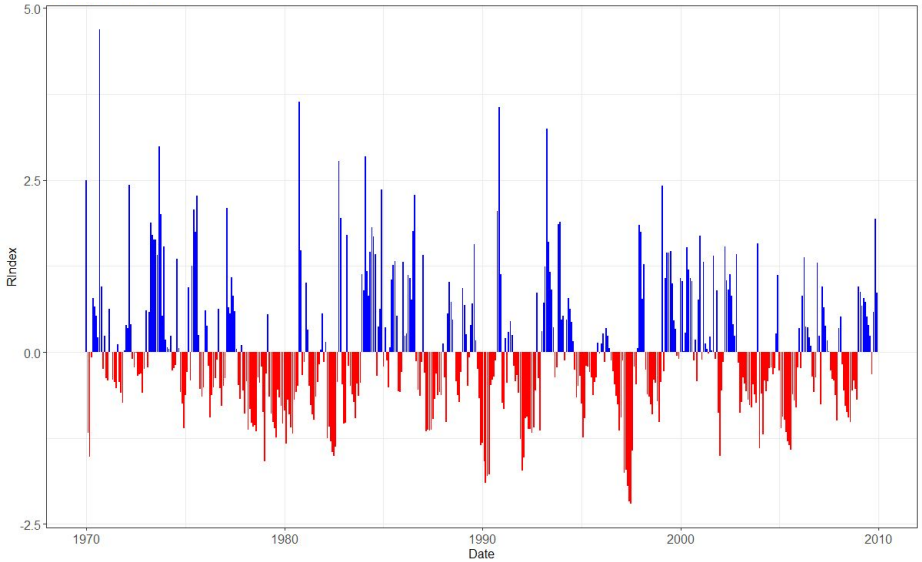
06. rindex

Estimating runoff index time series from precipitation, potential evapotranspiration and geomorphometric parameters in an ungauged basin

```
rindex(database, a, l, p)
```

Database CSV structure

Date	P	PET
Jan-1960	230.5	43
Feb-1960	48.5	40.9
Mar-1960	74.2	43.4
Apr-1960	61.1	36.7
May-1960	19	28.2
Jun-1960	1.7	23.8



a Basin area in km2
p: Basin perimeter in km

l: Basin main river length in km

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https://github.com/hydrocodes/hydRopclim