Worked example 5.2: Mean annual minimum n-day flow

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# Loading the Data

In this example we are again going to use river flow data from the river Ngaruroro at Kuripapango (NZ) of the International Data Set in the package **hydroDrought**. Ten years of daily data are used as an example, as in Worked Example 5.1, to estimate mean annual minimum of the -day average flow for equal to 1, 7 and 30 days. For this station the lowest flows are observed around the turn of the calendar year. Therefore the annual minima are selected from years starting 1 September and ending 31 August. Table 5.4 lists the first flow values. The first two columns show the date and the corresponding flow value, .

In order to calculate the mean annual minimum each observation will be attributed to a year according to the date of the observation using the function water\_year() which appends an additional column named year to the dataset.

library(tidyverse)  
library(hydroDrought)  
  
# attribute each observation to the correct year  
# and select only the years between 1990/91 and 2000/01  
ngaruroro <- international %>%  
 filter(river == "Ngaruroro") %>%  
 select(data) %>%  
 unnest(data) %>%  
 mutate(  
 year = water\_year(time, origin = "-09-01")  
 ) %>%  
 filter(year >= 1990, year <= 1999)  
  
smoothed <- ngaruroro %>%  
 mutate(  
 MA1 = moving\_average(discharge, n = 1),  
 MA7 = moving\_average(discharge, n = 7),  
 MA30 = moving\_average(discharge, n = 30)  
 )

Table 5.4 Calculation of -day average flow (unit: in m3s-1), River Ngaruroro at Kuripapango, NZ. A moving average with a window length introduces missing values (NA values).

## # A tibble: 31 x 6  
## time discharge year MA1 MA7 MA30  
## <date> <dbl> <dbl> <dbl> <dbl> <dbl>  
## 1 1990-09-01 19.5 1990 19.5 NA NA   
## 2 1990-09-02 17.9 1990 17.9 NA NA   
## 3 1990-09-03 16.7 1990 16.7 NA NA   
## 4 1990-09-04 17.5 1990 17.5 NA NA   
## 5 1990-09-05 21.2 1990 21.2 NA NA   
## 6 1990-09-06 30.8 1990 30.8 NA NA   
## 7 1990-09-07 24.5 1990 24.5 21.1 NA   
## 8 1990-09-08 20.7 1990 20.7 21.3 NA   
## 9 1990-09-09 18.7 1990 18.7 21.4 NA   
## 10 1990-09-10 16.9 1990 16.9 21.5 NA   
## 11 1990-09-11 15.7 1990 15.7 21.2 NA   
## 12 1990-09-12 14.6 1990 14.6 20.3 NA   
## 13 1990-09-13 13.6 1990 13.6 17.8 NA   
## 14 1990-09-14 12.8 1990 12.8 16.1 NA   
## 15 1990-09-15 12.0 1990 12.0 14.9 NA   
## 16 1990-09-16 11.3 1990 11.3 13.9 NA   
## 17 1990-09-17 10.7 1990 10.7 13.0 NA   
## 18 1990-09-18 10.2 1990 10.2 12.2 NA   
## 19 1990-09-19 9.66 1990 9.66 11.5 NA   
## 20 1990-09-20 9.22 1990 9.22 10.8 NA   
## 21 1990-09-21 8.82 1990 8.82 10.3 NA   
## 22 1990-09-22 8.54 1990 8.54 9.77 NA   
## 23 1990-09-23 8.31 1990 8.31 9.34 NA   
## 24 1990-09-24 8.14 1990 8.14 8.98 NA   
## 25 1990-09-25 8.12 1990 8.12 8.69 NA   
## 26 1990-09-26 8.05 1990 8.05 8.46 NA   
## 27 1990-09-27 7.62 1990 7.62 8.23 NA   
## 28 1990-09-28 7.42 1990 7.42 8.03 NA   
## 29 1990-09-29 7.34 1990 7.34 7.86 NA   
## 30 1990-09-30 8.67 1990 8.67 7.91 13.5  
## 31 1990-10-01 17.4 1990 17.4 9.24 13.4

# Calculation

First the annual minimum values are extracted and then the mean annual minimum values, , and are calculated by averaging the annual minimum time series. The results are tabulated in Table 5.5.

# compute the annual minima  
am <- smoothed %>%  
 select(-discharge, -time) %>%  
 group\_by(year) %>%  
 summarise\_all(min, na.rm = TRUE)  
  
# average the annual minima to get the mean annual minima  
mam <- am %>%   
 select(-year) %>%  
 summarise\_all(mean)

Table 5.5 , day, 7 days and 30 days (m3s-1).

## # A tibble: 1 x 3  
## MA1 MA7 MA30  
## <dbl> <dbl> <dbl>  
## 1 4.13 4.39 5.43

# Fast Track

Mapping over the length of the smoothing window avoids the multiple explicit calls of the function mean\_annual\_minimum(). The results are absolutely identical but the code is can be adapted more easily and is less error-prone.

# calculating each column explicitly  
ngaruroro %>%   
 select(discharge, time) %>%  
 summarise(  
 `MAM(1)` = mean\_annual\_minimum(discharge, time, origin = "-09-01", n = 1),  
 `MAM(7)` = mean\_annual\_minimum(discharge, time, origin = "-09-01", n = 7),  
 `MAM(30)` = mean\_annual\_minimum(discharge, time, origin = "-09-01", n = 30)  
 ) %>%  
 flatten\_dbl()

## MAM(1) MAM(7) MAM(30)   
## 4.130100 4.385514 5.430773

# Applying the function mean\_annual\_minimum() to each element of the vector  
c(1, 7, 30) %>%  
 map(  
 .f = mean\_annual\_minimum,   
 discharge = ngaruroro$discharge, time = ngaruroro$time, origin = "-09-01"  
 ) %>%  
 flatten\_dbl()

## MAM(1) MAM(7) MAM(30)   
## 4.130100 4.385514 5.430773