Sequent Peak Algorithm: Worked example 5.6

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# Loading the Data

Twelve years of daily data without missing values from River Ngaruroro at Kuripapango (NZ) are used as an example (1988 – 1999).

library(tidyverse)  
library(hydroDrought)  
  
ngaruroro <- international %>%  
 filter(river == "Ngaruroro") %>%  
 select(data) %>%  
 unnest(data) %>%  
 mutate(  
 year = water\_year(time, origin = "-09-01")  
 ) %>%  
 filter(year >= 1988, year <= 1999) %>%  
 print()

## # A tibble: 4,383 x 3  
## time discharge year  
## <date> <dbl> <dbl>  
## 1 1988-09-01 30.7 1988  
## 2 1988-09-02 84.8 1988  
## 3 1988-09-03 119. 1988  
## 4 1988-09-04 139. 1988  
## 5 1988-09-05 87.5 1988  
## 6 1988-09-06 74.3 1988  
## 7 1988-09-07 56.1 1988  
## 8 1988-09-08 70.2 1988  
## 9 1988-09-09 56.1 1988  
## 10 1988-09-10 43.1 1988  
## # … with 4,373 more rows

# Calculation

1. Define the value of the desired yield (equals the threshold value). Here is used.
2. Calculate the storage according to Equation 5.5. Storage is appended as a new column to the time series tibble using the function storage() with discharge and the threshold as input values ([Table 5.9](#table)).

q90 <- lfquantile(ngaruroro$discharge, exc.freq = 0.9)   
  
ng <- ngaruroro %>%  
 mutate(  
 storage = storage(discharge = discharge, threshold = q90)  
 )

Table 5.9 SPA calculation of drought deficit volumes and duration for River Ngaruroro at Kuripapango (NZ)

## # A tibble: 4,383 x 4  
## time discharge year storage  
## <date> <dbl> <dbl> <dbl>  
## 1 1988-09-01 30.7 1988 0  
## 2 1988-09-02 84.8 1988 0  
## 3 1988-09-03 119. 1988 0  
## 4 1988-09-04 139. 1988 0  
## 5 1988-09-05 87.5 1988 0  
## 6 1988-09-06 74.3 1988 0  
## 7 1988-09-07 56.1 1988 0  
## 8 1988-09-08 70.2 1988 0  
## 9 1988-09-09 56.1 1988 0  
## 10 1988-09-10 43.1 1988 0  
## # … with 4,373 more rows

As long as the discharge is above, or equal to, the threshold, the storage is zero as only flows below the contributes to the storage. This happens the first time on 1989-03-14 and lasts only two days.

ng %>%  
 filter(storage > 0)

## # A tibble: 525 x 4  
## time discharge year storage  
## <date> <dbl> <dbl> <dbl>  
## 1 1989-03-14 5.08 1988 0.0780  
## 2 1989-03-15 5.20 1988 0.0350  
## 3 1989-03-23 5.05 1988 0.115   
## 4 1989-03-24 4.89 1988 0.387   
## 5 1989-03-25 4.88 1988 0.669   
## 6 1989-03-26 5.09 1988 0.741   
## 7 1989-03-27 4.80 1988 1.10   
## 8 1989-03-28 4.64 1988 1.62   
## 9 1989-03-29 4.55 1988 2.24   
## 10 1989-03-30 5.11 1988 2.29   
## # … with 515 more rows

Filtering for storage > 0 and assigning new event numbers when the time increment in the (filtered) time series suddenly changes allows us to identify a series of uninterrupted sequences of positive .

ng <- ng %>%  
 filter(storage > 0) %>%  
 mutate(  
 event = group\_const\_change(time)  
 ) %>%  
 print()

## # A tibble: 525 x 5  
## time discharge year storage event  
## <date> <dbl> <dbl> <dbl> <dbl>  
## 1 1989-03-14 5.08 1988 0.0780 1  
## 2 1989-03-15 5.20 1988 0.0350 1  
## 3 1989-03-23 5.05 1988 0.115 2  
## 4 1989-03-24 4.89 1988 0.387 2  
## 5 1989-03-25 4.88 1988 0.669 2  
## 6 1989-03-26 5.09 1988 0.741 2  
## 7 1989-03-27 4.80 1988 1.10 2  
## 8 1989-03-28 4.64 1988 1.62 2  
## 9 1989-03-29 4.55 1988 2.24 2  
## 10 1989-03-30 5.11 1988 2.29 2  
## # … with 515 more rows

# Selection of the drought deficit volume and duration

The deficit volume is the maximum value in an uninterrupted sequence of positive , and the drought duration is the time from the beginning of the depletion period to the time of the maximum depletion. Accordingly, the duration of the first event is only one day. The date of the maximum depletion is also displayed.

spa <- ng %>%  
 group\_by(event) %>%  
 summarise(  
 volume = max(storage),   
 duration = which.max(storage),  
 time = time[which.max(storage)]  
 )

Table 5.10 An extract of drought deficit volumes and durations for River Ngaruroro at Kuripapango (NZ), calculated by SPA

## # A tibble: 5 x 4  
## event volume duration time   
## <dbl> <dbl> <int> <date>   
## 1 1 0.0780 1 1989-03-14  
## 2 2 39.8 38 1989-04-29  
## 3 3 2.72 7 1989-05-24  
## 4 4 11.7 14 1990-03-09  
## 5 5 8.26 13 1990-04-24

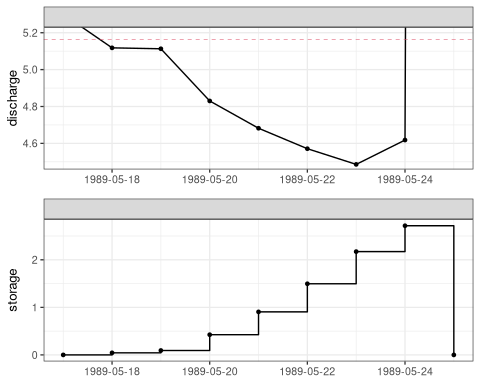


Figure x.xx The relationship between between discharge and storage for the third drought event starting 1989-05-24.

# Results

An extract of the drought duration and deficit volumes for the 12-year series is given in the output below. Note that the time series starts with a flow value less than the threshold (not knowing the previous flow values), thus the first event should be omitted from the analysis. Even though the SPA procedure is pooling minor and dependent droughts, the obtained time series of events still contains a number of minor drought events.

# Fast Track

ngaruroro %>%  
 drought\_events(threshold = q90, pooling = "sequent-peak")

## # A tibble: 41 x 8  
## event first.day last.day duration dbt volume qmin tqmin   
## <int> <date> <date> <drtn> <drtn> <dbl> <dbl> <date>   
## 1 1 1989-03-14 1989-03-15 1 days 2 days 0.0780 5.08 1989-03-14  
## 2 2 1989-03-23 1989-05-04 38 days 43 days 39.8 3.3 1989-04-29  
## 3 3 1989-05-18 1989-05-24 7 days 7 days 2.72 4.49 1989-05-23  
## 4 4 1990-02-24 1990-03-09 14 days 14 days 11.7 3.87 1990-03-09  
## 5 5 1990-04-12 1990-04-24 13 days 13 days 8.26 4.18 1990-04-23  
## 6 6 1990-12-27 1991-01-29 29 days 34 days 23.2 3.80 1991-01-14  
## 7 7 1991-02-11 1991-02-17 7 days 7 days 4.86 4.09 1991-02-16  
## 8 8 1991-03-30 1991-04-09 10 days 11 days 4.38 4.47 1991-04-08  
## 9 9 1991-12-19 1991-12-23 5 days 5 days 0.918 4.77 1991-12-22  
## 10 10 1991-12-28 1991-12-29 1 days 2 days 0.0590 5.10 1991-12-28  
## # … with 31 more rows