



Alma Mater Studiorum  
University of Bologna

# Multiyear drought assessment for long term rainfall and river flows

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# OBJECTIVES

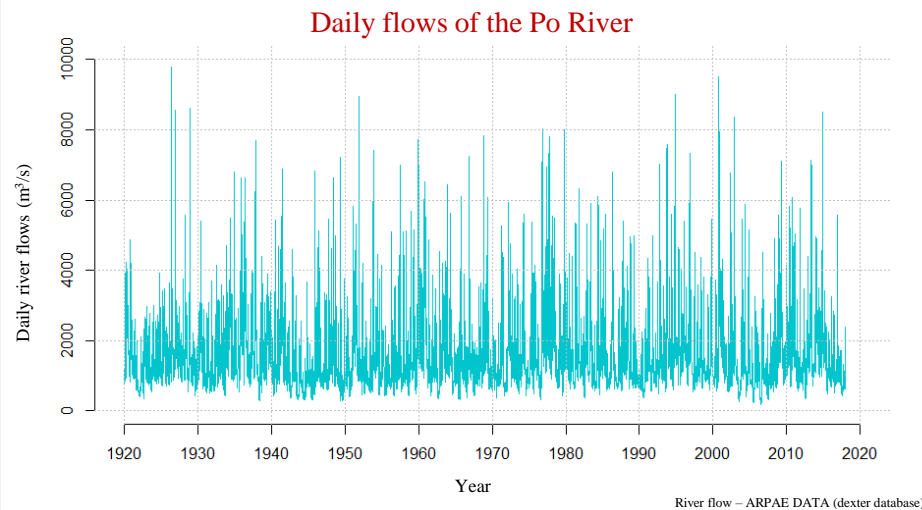
These data sets are a valuable opportunity to assess long term changes of precipitation and water resources availability and the effect of recent climate change. The occurrence of multiyear droughts is a major concern in the context of Italy for the potential impact on irrigation as well as water supply for civil and industrial use.

In this study we analyzed the long-term time series of daily rainfall observed in Bologna, and the daily river flows of the Po River closure section at Pontelagoscuro.

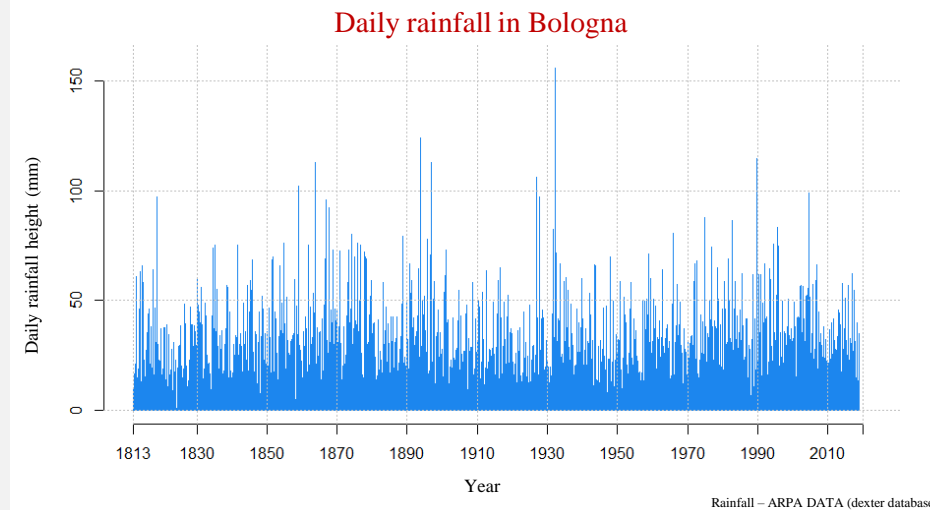
The goal of the study is to detect and investigate the annual and summer low flows of both series through the application of the theory of runs.



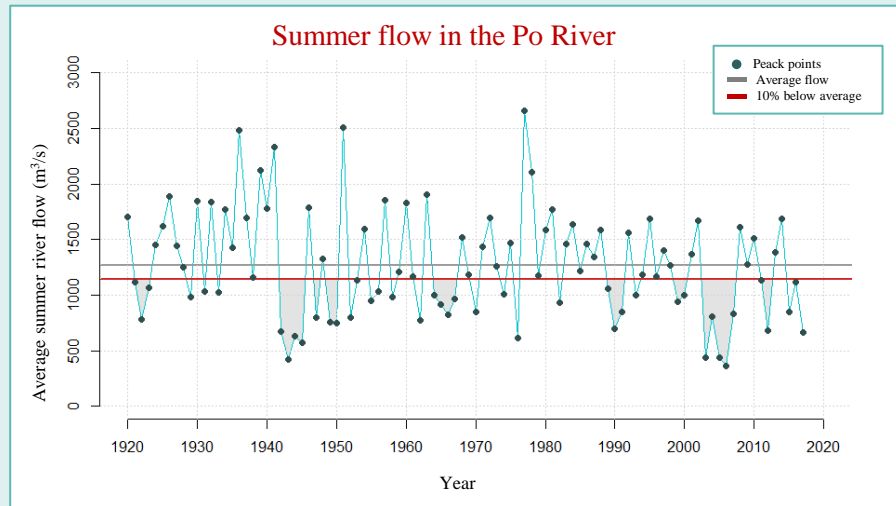
**The date range: 01/01/1920 – 12/31/2017**



**The data range: 01/01/1813 – 12/31/2019**

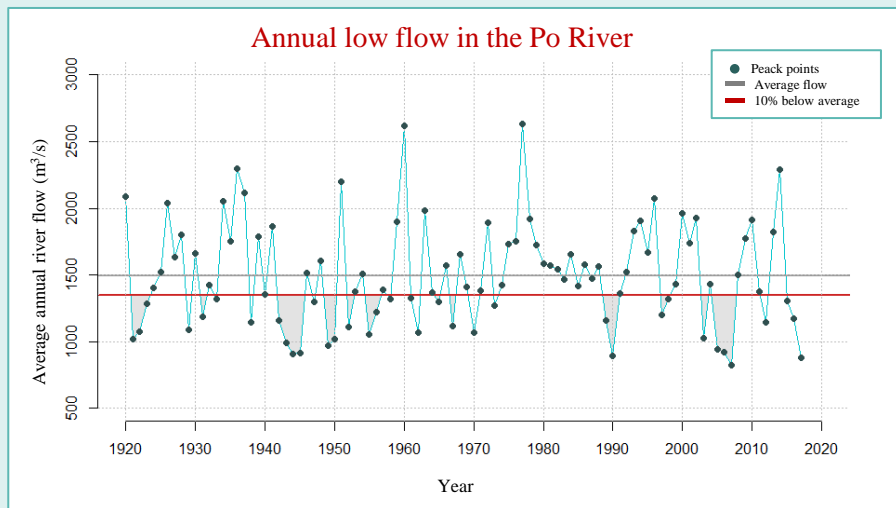


# MULTI-YEAR DROUGHTS IN THE THE PO RIVER FLOWS



*Table 1 Summer flow in the Po River*

Starting year	Length [Yr]	The average deficit	The maximum deficit
<b>1921</b>	3	22%	38%
<b>1942</b>	4	55%	67%
<b>1947</b>	4	29%	55%
<b>1964</b>	4	27%	39%
<b>1989</b>	3	32%	45%
<b>1999</b>	3	13%	26%
<b>2003</b>	5	55%	71%
<b>2011</b>	3	16%	47%



*Table 2 Annual low flow in the Po River*

Starting year	Length [Yr]	The average deficit	The maximum deficit
<b>1921</b>	5	16%	32%
<b>1931</b>	3	13%	27%
<b>1942</b>	9	23%	39%
<b>1952</b>	7	14%	32%
<b>1965</b>	3	11%	25%
<b>1989</b>	4	18%	41%
<b>1997</b>	3	12%	20%
<b>2003</b>	6	26%	45%

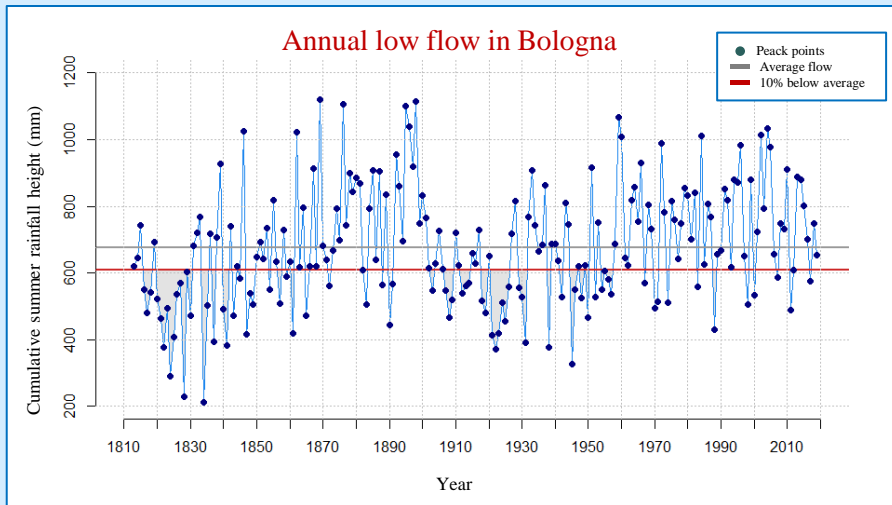
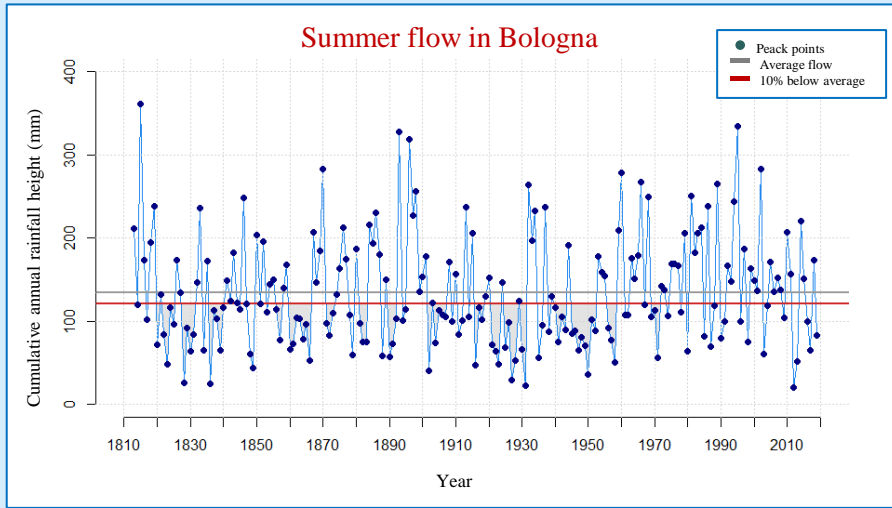
# MULTI-YEAR DROUGHTS IN THE DAILY RAINFALL IN BOLOGNA

Table 3 Summer flow in Bologna

Starting year	Length [Yr]	The average deficit	The maximum deficit
1820	6	32%	64%
1828	5	39%	81%
1836	5	37%	81%
1856	3	18%	43%
1860	7	39%	60%
1871	4	21%	38%
1881	3	38%	56%
1890	3	42%	57%
1902	6	30%	69%
1916	4	26%	65%
1921	11	46%	83%
1938	6	25%	44%
1945	8	43%	73%
1956	3	45%	62%
1969	6	18%	58%

Table 4 Annual low flow in Bologna

Starting year	Length [Yr]	The average deficit	The maximum deficit
1816	17	25%	66%
1834	5	25%	69%
1840	6	19%	44%
1847	8	13%	39%
1857	5	15%	38%
1903	25	16%	45%
1929	3	27%	42%
1938	5	14%	44%
1945	6	23%	52%
1954	5	12%	22%
1988	3	14%	37%

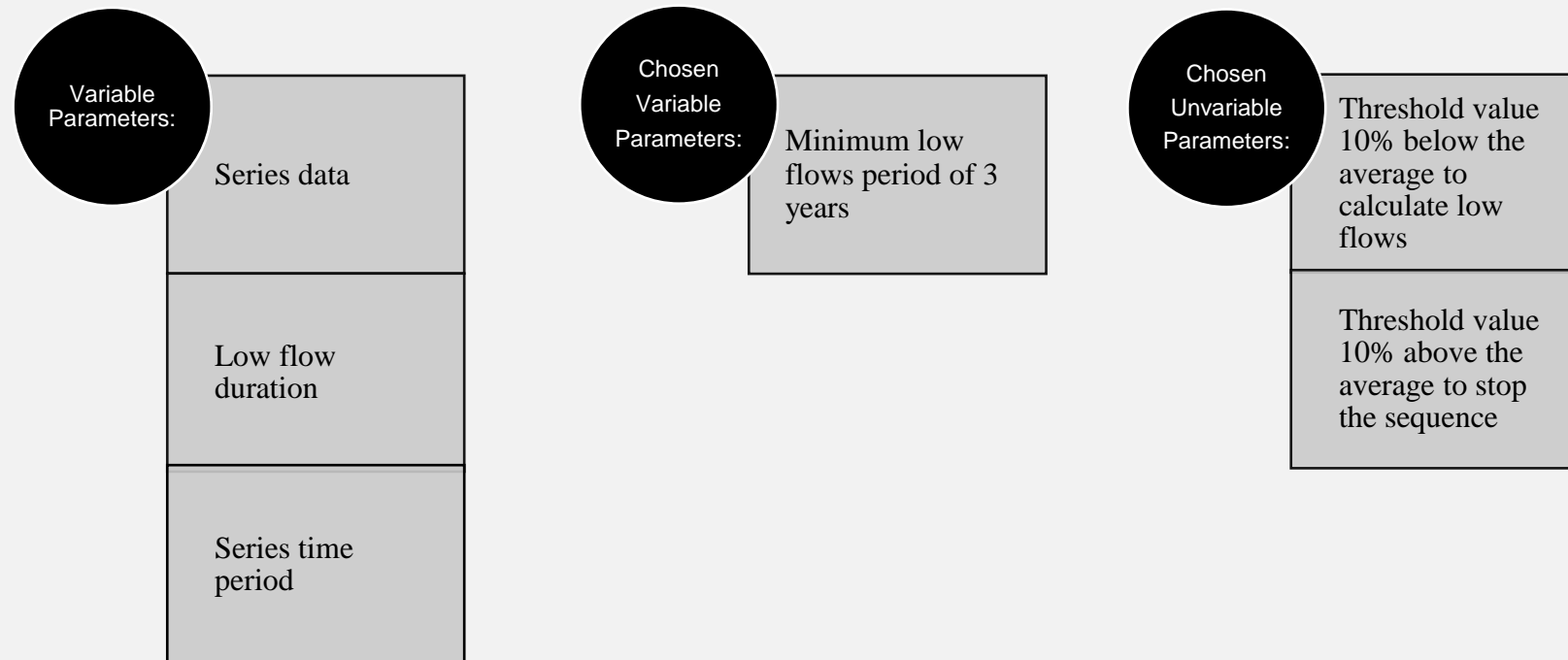




# DATA ANALYSIS

Starting from the daily data, we obtained the annual series by calculating the sum of the Bologna's rainfall and the average flow rate of the Po River, of which we represented the trends over time.

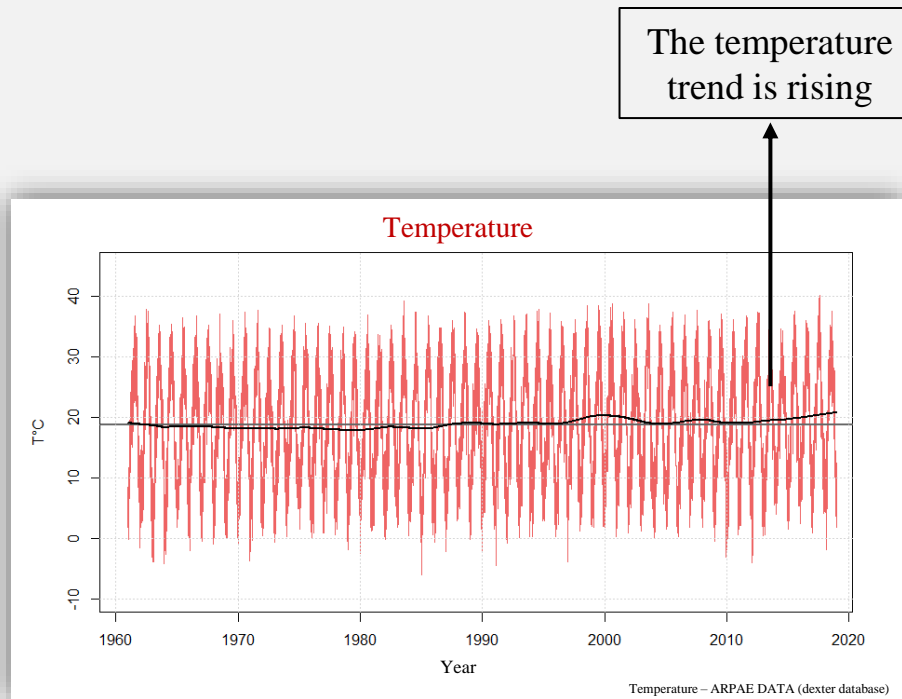
We developed a code in R-studio that calculates the multi-years low flows:



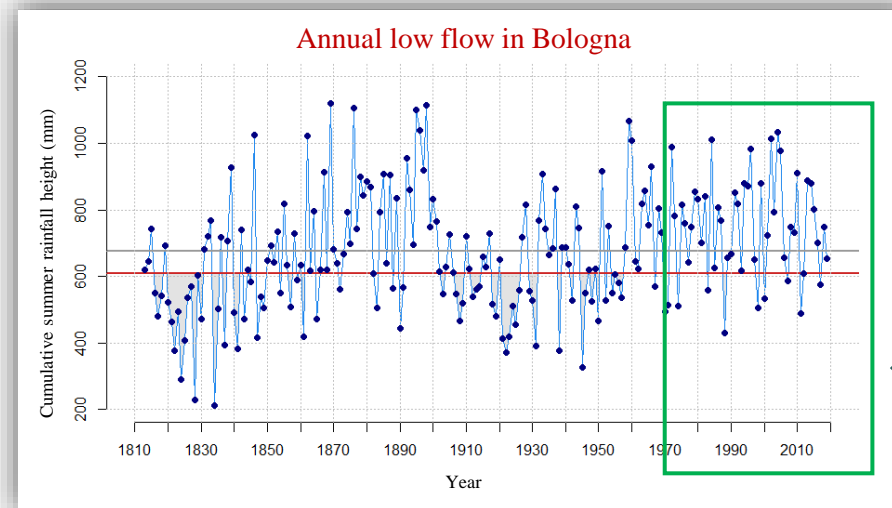
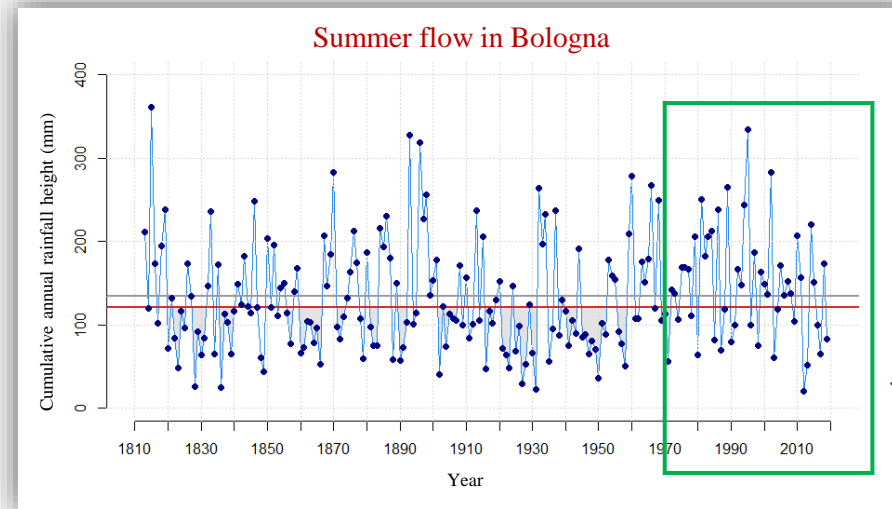
Finally, we reported on the graphs the values of the low flows that we identified.



# THE TEMPERATURE TREND



Comparative analysis between temperature and precipitations in Bologna since 1970.



# CONCLUSIONS



- Our results point out the occurrence of **critical events** along the whole span of the considered observation period. By focusing on the period after 1970 one notes that:
  - a) **Po river:** drought events occurred in the years 1989, 1999, 2003, 2011; The most important multi-year drought happened in 2003, with a duration of 5 years.
  - b) **Bologna:** no significant events have occurred after 1970.
- Summer-annual low flow comparison:
  - a) **Po river:** the low flows occur approximately with the same frequency;
  - b) **Bologna:** the frequency of the low flows in the summer period is greater than the annual one.
- The contingency of a number of recent **droughts** point out a condition of potential **vulnerability**.
- There is a slight increase in **temperature trends** over the last 30 years.



**THANK YOU**