Extreme event characterization using climate data record and MATLAB

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Background

In this activity, we are analyzing the monthly temperature and precipitation maxima to calculate the return period of an 80-years event. We start with a quick analysis to get a result and then we will start the analysis again and performing control quality test for all models used or assumptions used.

The main objective is to develop a critical mind to the participants regarding the data that they are using, the hypothesis of the methods used and the physical meaning of their results.

We are using monthly average and maximum temperature in Minnesota from 1901 until 2009. The data are obtained from Climate at Glance (https://www.ncdc.noaa.gov/cag/global/time-series). No specific apps or extensions from MATLAB are required.

Step I – Data import and control

- Import the monthly data into Matlab, calculate the annual average and plot the results.

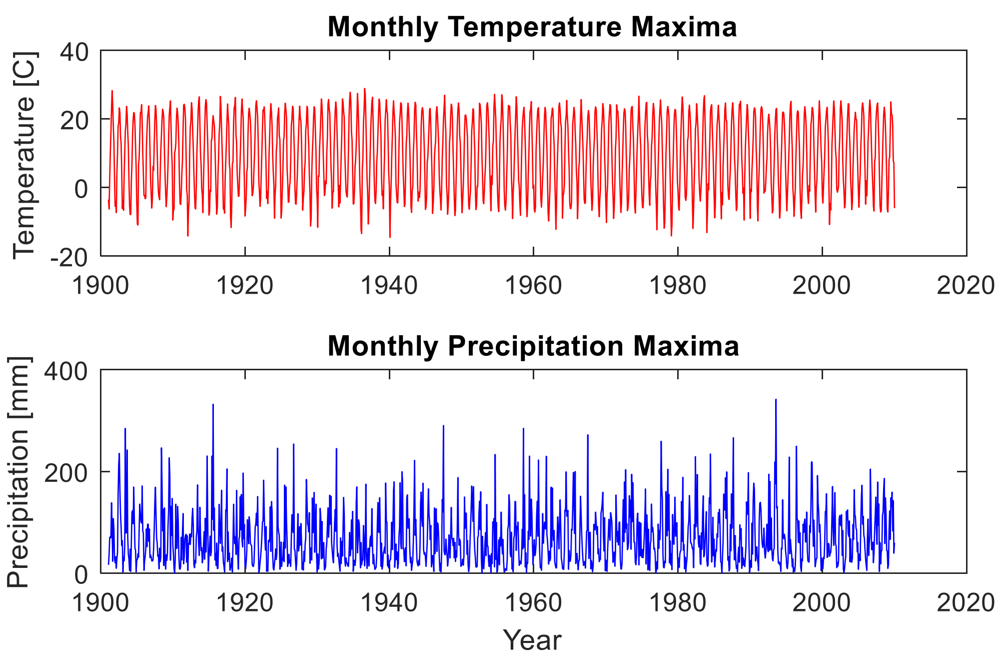

Figure 1 - Top figure: Monthly Temperature Maxima; Bottom figure: Monthly Precipitation Maxima

- Calculate the annual block maxima for each dataset.

Step II – GEV distribution

- Fit the GEV distribution on the datasets to obtain the three parameters.
- Calculate the return level associated with an extreme event of return period T.

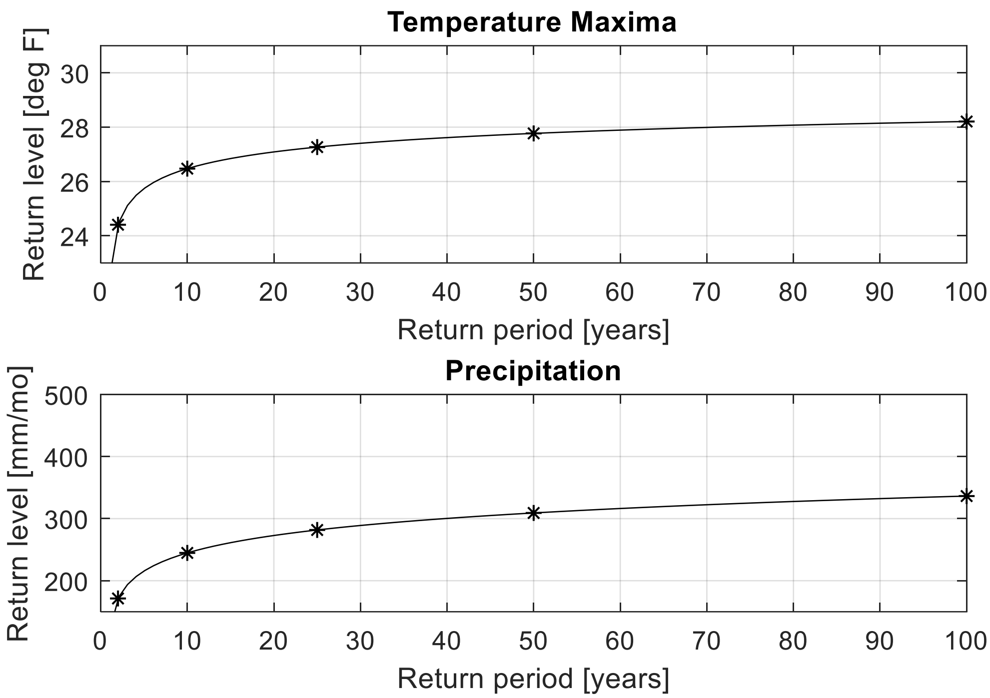

Figure 2 - Return levels of different return periods for both temperature and precipitation

A 40-years extreme event would be 300mm of precipitation or 27.8^{o}C for temperature.
A 80-years extreme event would be 325mm of precipitation or 28.0^{o}C for temperature.

Question: How reliable are these results?

Control#1 – Fitting the GEV and getting the 95% confidence interval

- Fit the GEV distribution and get the confidence interval.
- Visually ensure that the GEV is fitting.
- Perform the Kolmogorov-Smirnov test to test the null hypothesis H0 that the empirical and GEV distribution are drawn from the same distribution. If the result is 0, we can’t reject the null hypothesis.

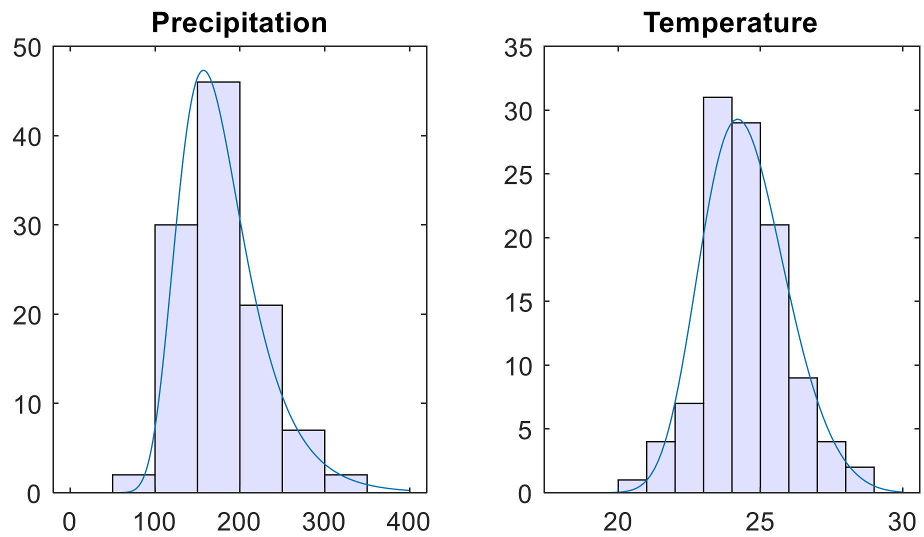

Figure 3 – GEV distribution and empirical distribution

- Now calculate the return levels of the previous return periods as well as the 95% confidence interval.

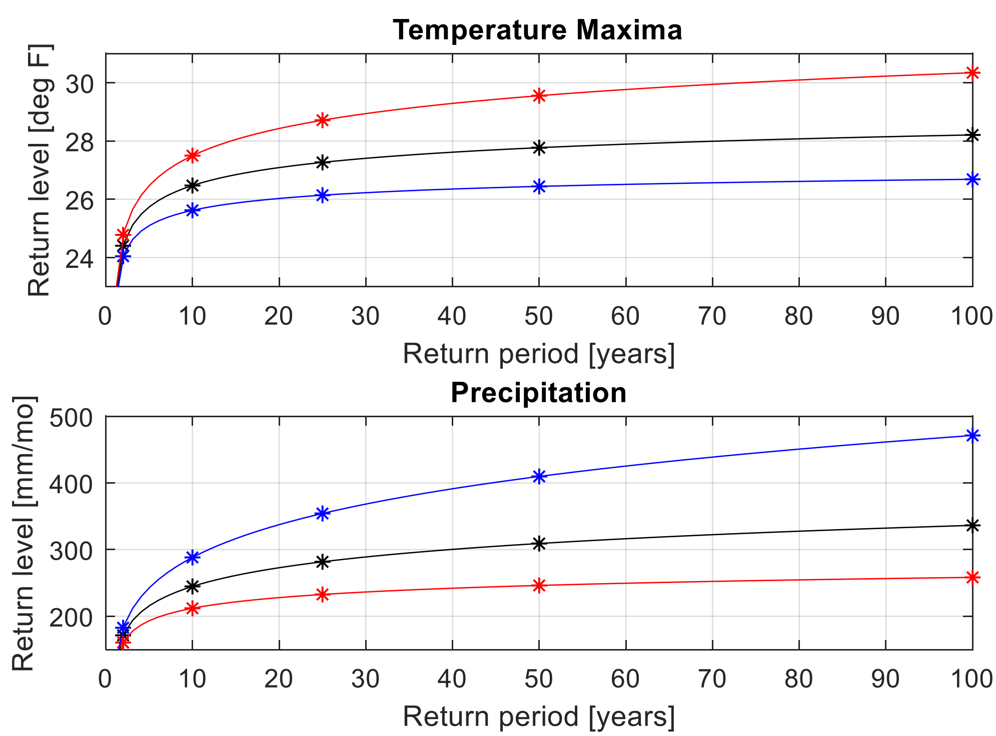

Figure 4 - Return levels for temperature and precipitation with their 95% confidence interval

Now a 40-years event is between 26 to 29ºC and between 250mm to 400mm of precipitation.

- Plot the uncertainty vs the return level.

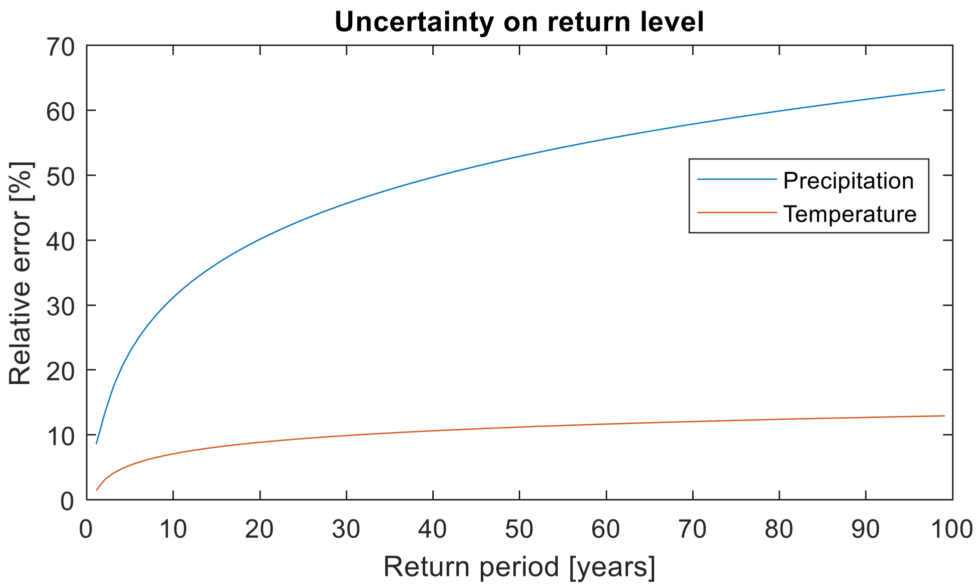

Figure 5 - Uncertainty vs return period

- **Discuss** why precipitation has a higher uncertainty. (Hint: How do we measure the data?).

Control # 2 – Use of half dataset and full dataset.

- Perform the same analysis using half a dataset and compare with the previous results.
- Discuss the results.
- Using this dataset, can we really calculate the return level of a 100-years event?

Table 1 - Summary of the results

	Return level precipitation		**Return level Temperature**	
Return period	Full dataset	Half dataset	Full dataset	Half dataset
40-years	300mm [250mm-400mm]	300mm [225mm-450mm]	27.8^{o}C [26^{o}C-29^{o}C]	28^{o}C [26^{o}C-31^{o}C]
80-years	325mm [250mm-450mm]	375mm [225mm-550mm]	28.0^{o}C [26.5^{o}C-30^{o}C]	28.5^{o}C [26.5^{o}C-32^{o}C]