Climate variability in the Middle East

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The objectives of the WLC climate modelling sub-project are to:

- Improve understanding of the controls on climate and its variability and change in the MENA region
- Provide high resolution limited area climate simulation for representative periods in the past, present and future suitable for driving hydrological models

So far, the climate modelling project has focused on gathering data, understanding the basic processes controlling climate in the Middle East on seasonal to decadal scales and carrying out preliminary model integrations, which will enable us to evaluate the regional model.

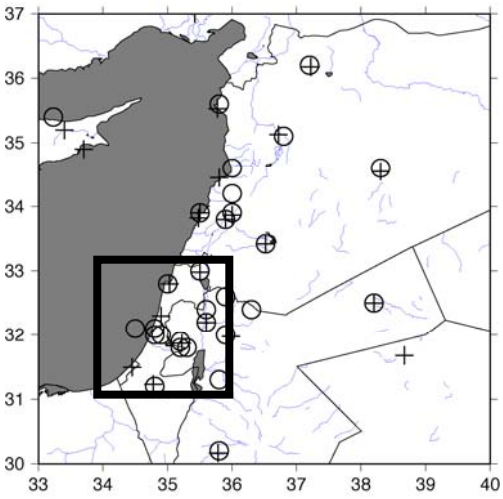

Figure 1: Data availability and location of the time series and seasonal cycle used in Figures 2 and 3. The circles show publicly available Global Historical Climate Network (GHCN) data and the crosses show data provided by Ron Manley.

Monthly rain gauge data have been used to assess rainfall variability in the Middle East on seasonal-decadal time scales. Figure 1 shows that in the region of interest there is a good density of stations. Although the time period considered in this article is 1958-1999, data from a few gauges are available from 1845. Figure 2 shows the mean seasonal cycle in rainfall between 1961-1990 for the region highlighted in Figure 1. It can be seen that the Middle East experiences most precipitation between November and March, and that the summer is completely dry. Rainfall in the Levant originates from mid-latitude cyclones during their eastward migration over the Mediterranean. Because these cyclones have a relatively large synoptic scale the seasonal-interannual variability of rainfall is spatially coherent within the area of interest (highlighted on Figure 1).

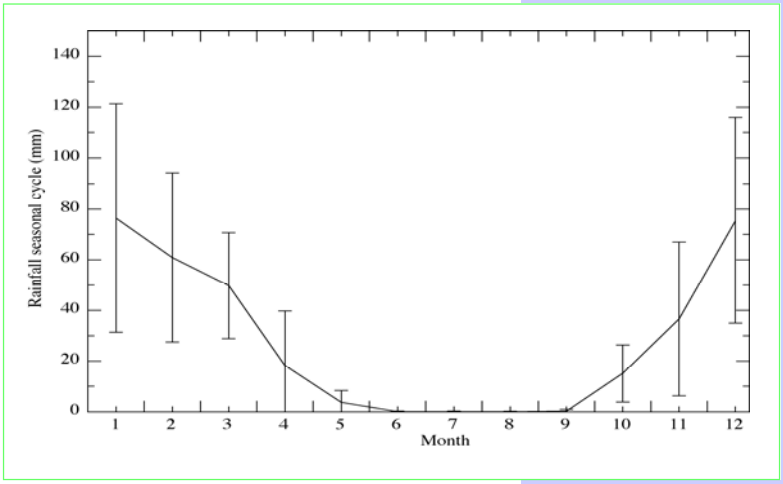

Figure 2: Mean seasonal cycle for rainfall in the box shown in Figure 1. The error bars represent one standard deviation from the mean. The seasonal cycle is calculated for 1961-1990. All stations with at least 28 years of data are included in the calculation of the mean.

It is clear from Figure 2 that there is considerable interannual variability in Middle Eastern rainfall. Published work has found that this variability is associated with changes in the large-scale circulation (see for example Enzel et al. (2003)). This raises the question of how large-scale modes of atmospheric variability, such as the North Atlantic Oscillation, affect rainfall in the Middle East.

It is well known that winter precipitation and temperature over Europe are modulated by the North Atlantic Oscillation (see for example Hurrell et al. (2003)). Cullen et al. (2002) and Cullen and Demenocal (2000) showed that the influence of the NAO extends as far east as Turkey. The impact of the NAO further south on rainfall in the Levant is, however, less clear. This study aims to tackle this issue by comparing time series of the NAO and rainfall in the area of interest.

Figure 3 compares the time series of the NAO with that of rainfall in the area of interest for December. It is evident that the distribution of rainfall is different for NAO positive and NAO negative years. During NAO positive years, there is greater variability, which is reflected by a greater proportion of very rainy years. In fact, nine out of the ten rainiest Decembers occur when the NAO is in its positive phase. The relationship between NAO-positive years and high rainfall is not universal - during some positive NAO years, rainfall is well below average. Moreover, there is no converse relationship between NAO-negative years and very low rainfall.

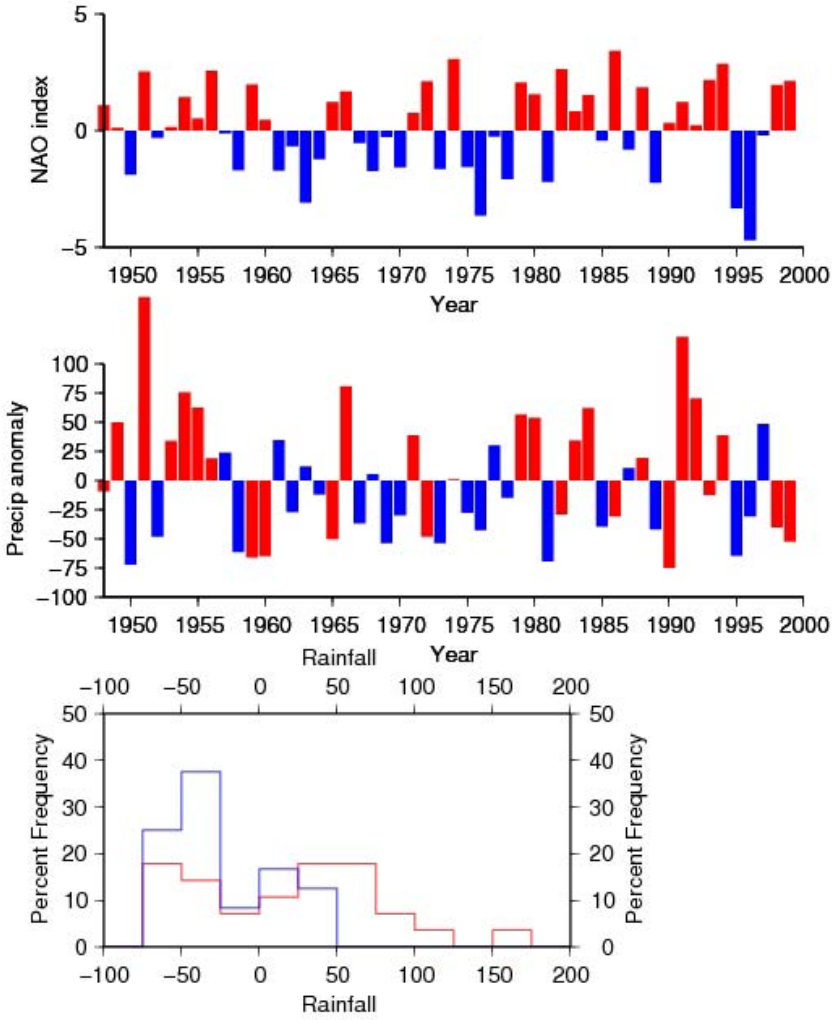

Figure 3: The relationship between the NAO index and precipitation in the location shown in Figure 1 for December.

Top: Station based December NAO index. Negative values are blue and positive values are red.

Middle: Rainfall anomalies for December. Positive NAO years are red and negative NAO years are blue.

Bottom: Histogram of rainfall anomalies for positive (red) and negative (blue) NAO years.

The strength of the relationship between the NAO and Middle Eastern rainfall varies within the rainy season, being strongest in November, December, January and February and weak in October and March. Study of longer time series shows that the relationship is fairly stable through time for November and December, but varies decadally for January.

References

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