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The Effect of teleconnection on the Temperature and Precipitation over the Mediterranean and the northern part of Libya

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ABSTRACT

This study analyzes the effect of large-scale forcing on the variability of the mean air temperature and precipitation of some stations of north Libya and the Mediterranean Sea, using the observed data and the National Centers for Environmental Prediction (NCEP) reanalysis gridded datasets for the period 1950-2016. The analysis reveals that the strong variability in temperature over region is closely associated with the North Atlantic Oscillation (NAO) index for all seasons however, the relationship is most prominent during the winter season, and during the negative phase of NAO, the temperature over north Libya and Mediterranean tends to increase , whereas the spring season temperature is influenced by the El Niño Southern Oscillation (ENSO), while the amount of precipitation has an inverse winter relationship, and for NAO effect the correlation is positive but some stations are negative during the winter and the rest of the seasons the relationship is positive.

Keywords: Temperature, Precipitation, ENSO, EL-Nino, NAO.

Introduction

The Mediterranean Sea, a marginal and semi-enclosed sea, is located on the western side of a large continental area and is surrounded by Europe to the north, Africa to the south, and Asia to the east. Its area, excluding the Black Sea, is about 2.5 million km2; its extent is about 3700 km in longitude, 1600 km in latitude and surrounded by 21 African, Asian and European countries (P.Lionello, 2004)

The Mediterranean climate is exposed to the South Asian Monsoon (SAM) in summer and the Siberian high pressure system in winter. The southern part of the region is mostly under the influence of the descending the Mediterranean climate region evolves on the north to the Marine West Coast Climate (from 40° to sub-polar regions) and on the south to the Subtropical Desert Climate (southward of 30° or 25°).The Mediterranean basin is regularly affected by severe convective events, often of limited predictability, which are frequently related to the cyclone activity in the region. Intense sea surface fluxes favor heavy rainfall especially in late summer and in fall. The intensification and persistence of a tropical-like cyclone in the Mediterranean Sea were shown to depend significantly on SST.

The climate in Libya is Mediterranean in the thin coastal strip, and desert in the interior. As a matter of fact, although on the coast the temperatures are typical of the Mediterranean climate, the rainfall level is very low, semi-desert in Tripolitania and Cirenaica, and desert in the Gulf of Sidra (or Sirte). Only in the hills near the coast of Cyrenaica (called Jebel Akhdar), precipitation goes from 400 to 700 millimetres per year, so that they are covered by a Maquis shrubland. Along the coast, which is the only plain area that receives non-sporadic rains, most of the rainfall occurs from October to early April, with a peak in December and January, The average maximum temperature in summer goes from 30 °C along the coast, to 35/37 °C in the north-central inland area, to 40/41 °C in the south (WWW.Climatestotravel .com)

The climate variability patterns (teleconnections) present a large amount of synoptic to meso-scale spatial variability, inter-seasonal and multi-decadal to centennial time variability. An important consequence is that the analysis of the Mediterranean Climate can be used to identify changes in the intensity and extension of global scale climate pattern like El NiñoSouthern Oscillation "ENSO"and North Atlantic Oscillation "NAO"and their region of influence (Lionello *et al.,* 2004)

"El Niño" phenomenon refers to the large-scale ocean-atmosphere climate interaction due to warming of sea surface temperatures across the central and east central Equatorial Pacific (NOAA, 2016). In more recent years, (Ramage, 1975; Weare *et al.,* 1976), and others have used the term to encompass the larger scale features of the warming event, i.e., the up- welling area along both the

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equator and the South American coast and result in changes in the local and regional ecology, and are clearly linked with anomalous global climate patterns (Trenberth, 2013).

The teleconnection pattern known as the North Atlantic Oscillation (NAO) is characterized by a dipole in the sea level pressure field with one anomaly center over the Arctic, near Greenland, and another center of opposite sign across the midlatitude sector of the North Atlantic Ocean. A negative highly significant correlation has been found between the winter north NAO and winter Mediterranean precipitation, but only a weak connection between the NAO and Mediterranean temperature (Xoplaki, 2002).

Trends in large-scale atmospheric circulation patterns affect trends in Mediterranean temperature and precipitation. The interaction with topography and land-sea contrasts can produce a variety of regional responses with different trend signs, although they have the same origin. (Xoplaki *et al.,* 2003) showed that the 300 hPa geopotential height, 700-1000 hPa thickness and Mediterranean 29 SST large-scale fields account for more than 50% of the Mediterranean summer temperature variability over the period 1950-1999. The most important summer warming pattern is associated with blocking conditions, subsidence and stability. This mode is responsible for the 0.4°C (0.5 °C) warming during the period 1950-1999, (Xoplaki *et al.,* 2004) show that around 30% of the October-March precipitation variability can be accounted for by four large-scale circulation modes. The CCA of (Dünkeloh and Jacobeit, 2003) indicates that 76% of the October-March rainfall variability is accounted for by five coupled patterns with 61% explained variance for the five large-scale circulation modes. The most important mode is significantly correlated with the NAO and the AO (Arctic Oscillation) pattern. It is connected with above (below) normal precipitation over most of the Mediterranean with highest (lowest) values at (1900-1999) the western coasts of the peninsulas and lowest (highest) in the southeastern regions.

Calculated the relative contributions of 6 daily rainfall intensity categories to the annual rainfall amounts during 1951-1995, over Spain, Italy, Cyprus and Israel. Linear as well as monotone non-linear (Spearman's) time test show significant increases in heavy daily rainfall in spite of decreases in the annual totals. For instance, in Italy, torrential rainfall (%) above 128 mm/d increased by a factor of 4 in 1951-1995. Most interesting the torrential rainfall peaks were observed in the El-Nino years (Alpert *et al.,* 2002).

The current study investigates the impacts of large-scale forcings on the variability of the mean air temperature and precipitation of some stations of north Libya and the Mediterranean Sea, using the observed data and the National Centers for Environmental Prediction (NCEP) reanalysis gridded datasets for the period 1950-2016. The paper is organized as follows: Section 2 includes the data and methodology, and section 3 contains the results and analyses. The summary and conclusions are introduced in section 4.

Data and Methodology

The monthly mean temperature and precipitation data of 20 stations in the region of latitude 30-40 N^0 and longitude from 10-35 E^0, as shown in figure, during the years 1950-2016 on Libya and Mediterranean, were acquired from center National Centers for Environmental Prediction (NCEP), and Reanalysis data the large-scale features of correlation seasonal EL-Nino 3.4, NAO for temperature and precipitation rate at the National Oceanic and Atmospheric Administration (NOAA).

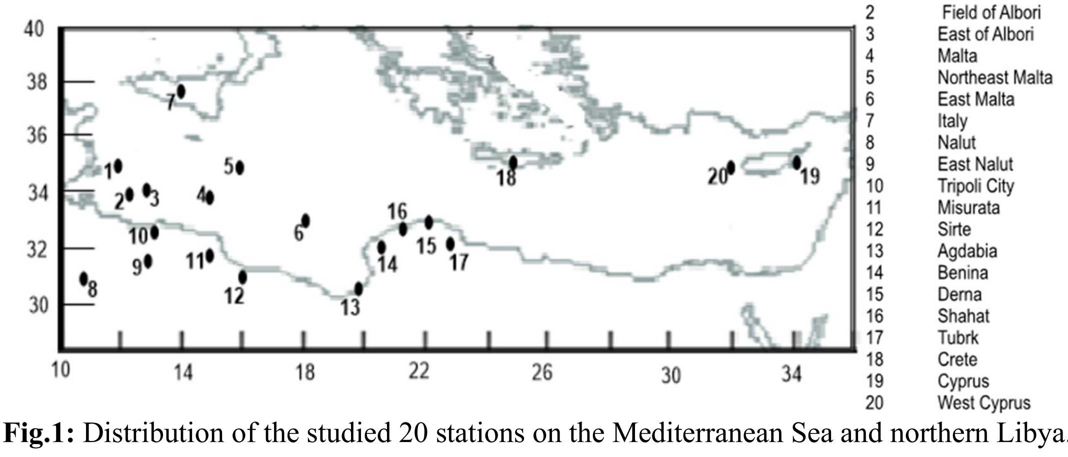


Fig.1: Distribution of the studied 20 stations on the Mediterranean Sea and northern Libya.

Analysis and Discussion

Seasonal and Annual precipitation Climatology

The seasonal mean of precipitation rate over 1950- 2016 during the winter (Dec-Feb) is about 0-5 mm/day as shown in fig. (2.a) on the central and western Mediterranean. The highest value was recorded in the Cyprus station and the lowest value on the Libyan coast. During the spring season (Mar-May) in fig. (2.b) the quantities were 0-2 mm/day. The precipitation decreased gradually in the summer (Jun-Aug), and then began to increase markedly in the autumn (Sep-Nov) as the northwestern parts showing an increase in precipitation amount and reached 3 mm/day in Italy, and over the northeast and west of Cyprus the precipitation reached 2.5 mm/day. While on the north of Libya, the quantities were 0-0.5 mm/day as in fig (2.d).

The distribution of annual mean precipitation is displayed in fig. (2.f). Generally, the amount of precipitation in Cyprus station is 2.4 mm/day, while on northern Libya 0-0.3 mm/day, and on Italy and Malta were 1.8 and 0.9 mm/day respectively.

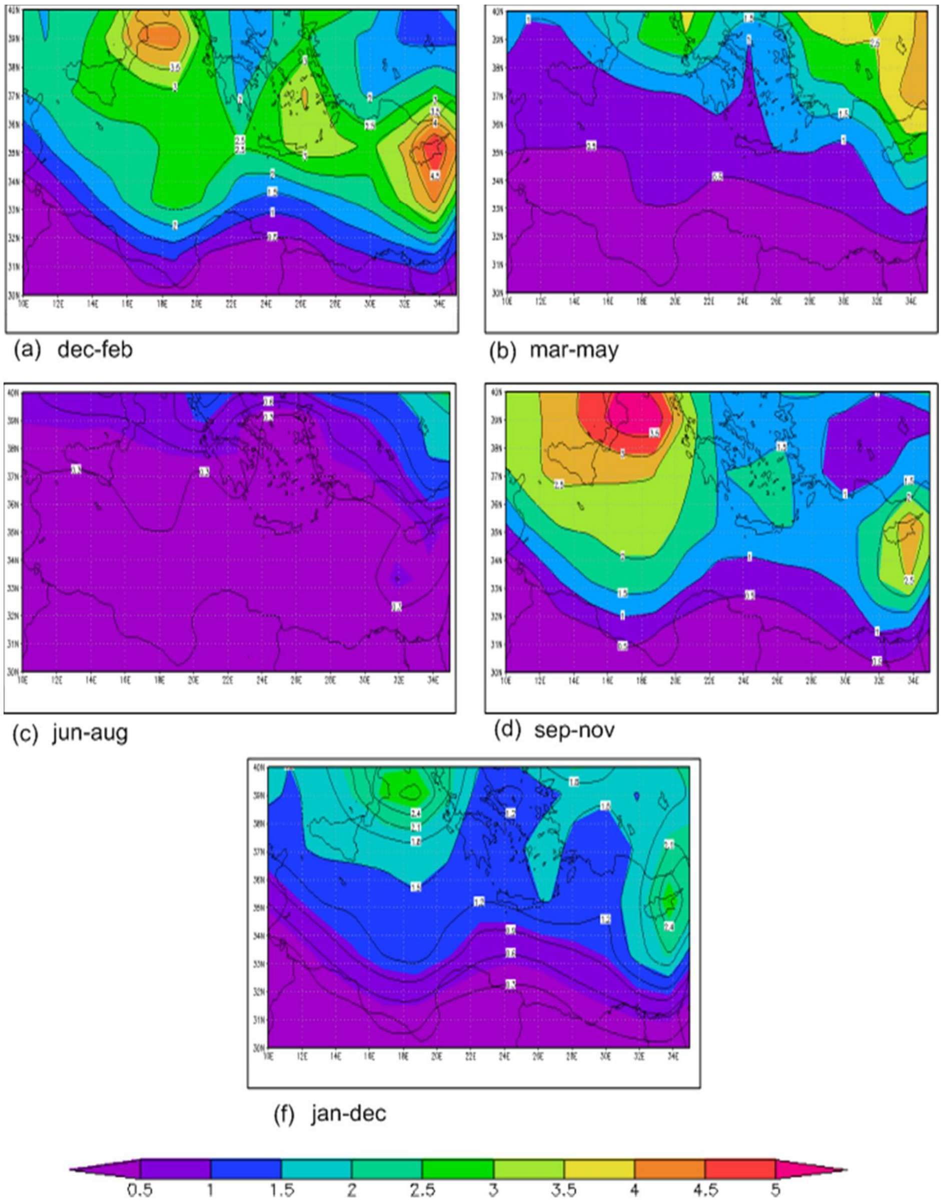


Fig. 2: Distribution of seasonal mean and annual mean Precipitation (mm/day). climatology obtained from the NCEP data for the (a) Winter, (b) Spring, (c) Summer, (d) Autumn seasons, and (f) annual mean over 1950-2016.

Seasonal and Annual Temperature Climatology

The distributions of seasonal and annual mean temperature over 1950-2016 are shown in figure (3). In winter season, temperature reduced by an average of 8-16 C^0 on the north of Libya, as an extension to the north-west of the Mediterranean and reached Italy <14C^0 in the east. The temperature over Crete and Cyprus reached 16 and 14 C^0, respectively, as shown in fig (3.a). While in the spring the temperature ranged between 18-22C^0 over Libyan coast and between 15-17C^0 over the Mediterranean as in fig (3.b). In the summer, the temperature of most stations over Libya is about 25-30 C^0 and over Italy by about < 23C^0 and over Cyprus and Crete about 24C^0as shown in fig (3.c).In the autumn season, it appears to be low and its average reaches 20-23 C^0on Libya and the Mediterranean Sea 19-22 C^0 as in fig (3.d) and the annual average reaches 20-22 C^0 on the Libyan coast and on the Mediterranean 18-19 C^0 as in fig (3.f).

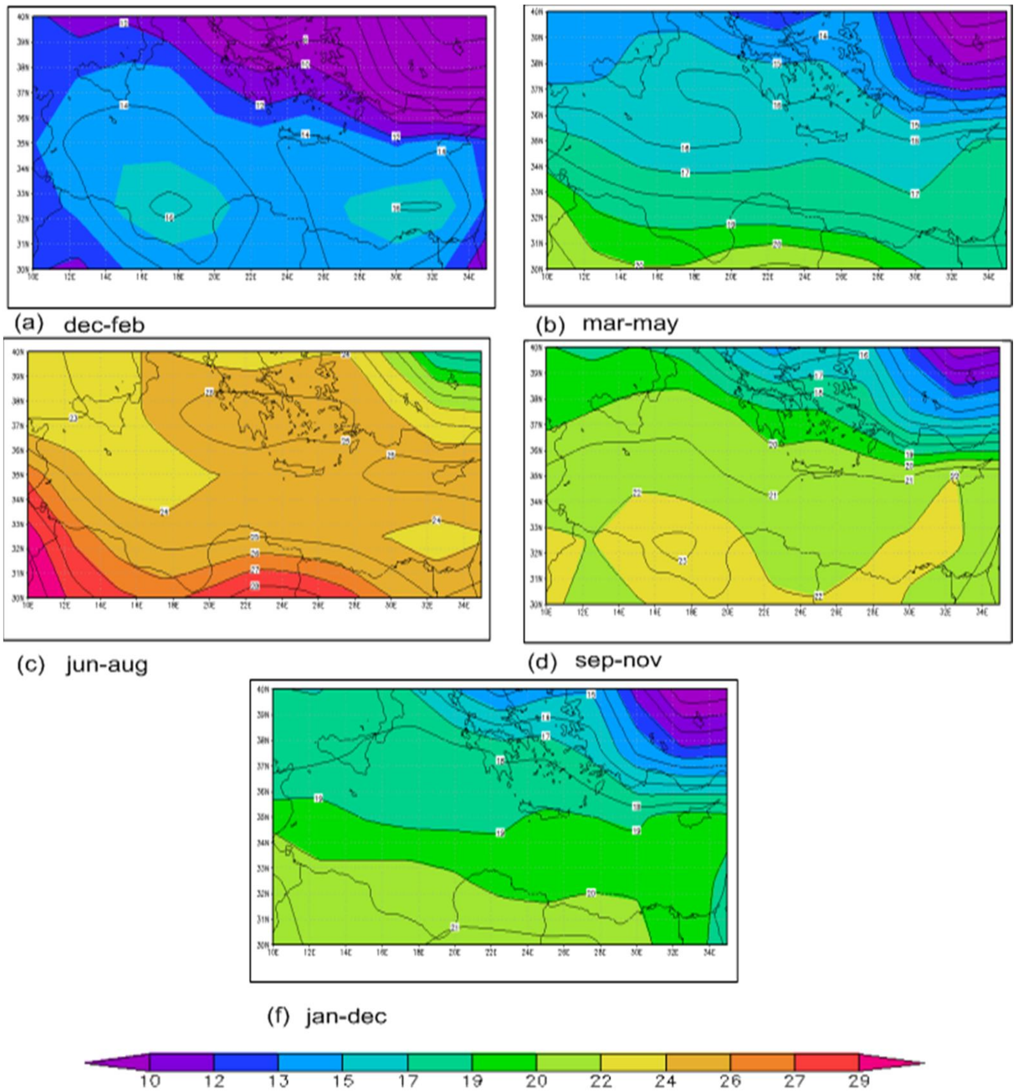


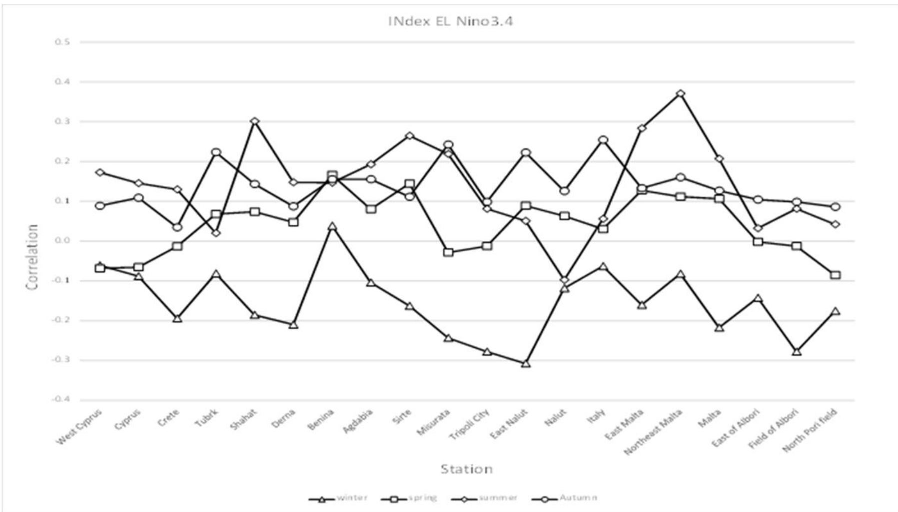
Fig. 3 : Distribution of seasonal mean and annual mean Temperature (C) climatology obtained from the NCEP data for the (a) Winter, (b) Spring, (c) Summer, (d) Autumn seasons, and (f) annual mean over 1950-2016.

Effect of the EL-Nino 3.4 Index

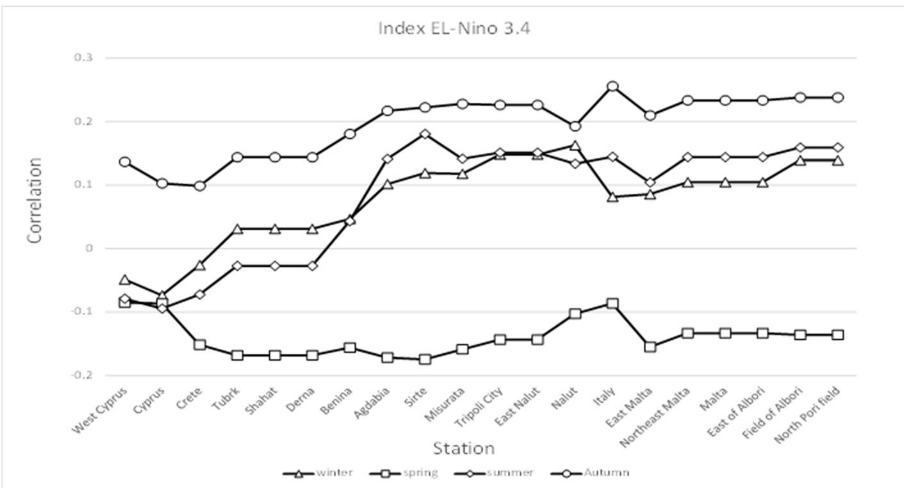
The negative correlation between ENSO and the temperatures or precipitation over an areaindicates that the positive phase of ENSO (El Niño) is accompanying with decrease in temperatures or precipitation over this area, while the negative phase of ENSO (La Nina) is accompanying with increasing of temperatures or precipitation over this area. Accordingly, the winter precipitation of region was influenced by ENSO as shown in Figures. (4.a) which illustrates the correlation between

EL-Nino 3.4 Index and the mean precipitation of the different seasons over different 20 stations. There was a negative correlation in the winter at most of the western stations of Libya and the middle of the Mediterranean mainly in the station of East Nalut and the Tripoli City, as well as the Field Albori about -0.3, while in Malta, Misurata, and Shahat and Crete by -0.2.In the spring season, the negative correlation over Cyprus and the West Cyprus was about -0.1, and there is a weak positive correlation over Benina by 0.2.While in the summer, the correlation is positive in the middle of the Mediterranean and extended on the Libyan coast to reach 0.3 in Shahat, Sirte and East Malta, while it was 0.4 in northeastern Malta, and there was a weak negative correlation in Nalut by -0.1.In the autumn, the correlation was 0.3 for Italy and 0.2 for most stations in northern Libya.

Figures (4.b) shows the correlation between the seasonal mean temperature over the same stations and the EL-Nino 3.4 Index.In the winter, there was a weak negative correlation extended from the stations of the western region to the middle of the Mediterranean and reaches about -0.1, and there was a positive correlation in the west stations reached 0.2 in Nalut.While in the spring, the correlation was negative (-0.2) on the most stations. In the summer, a negative correlation of -0.1 was dominant on the western stations and there was a positive correlation in the eastern stations reached about 0.2 on the Tripoli City, east Nalutand the Field of Albori. In autumn, there was a positive correlation up to 0.3 on Italy.



(a)



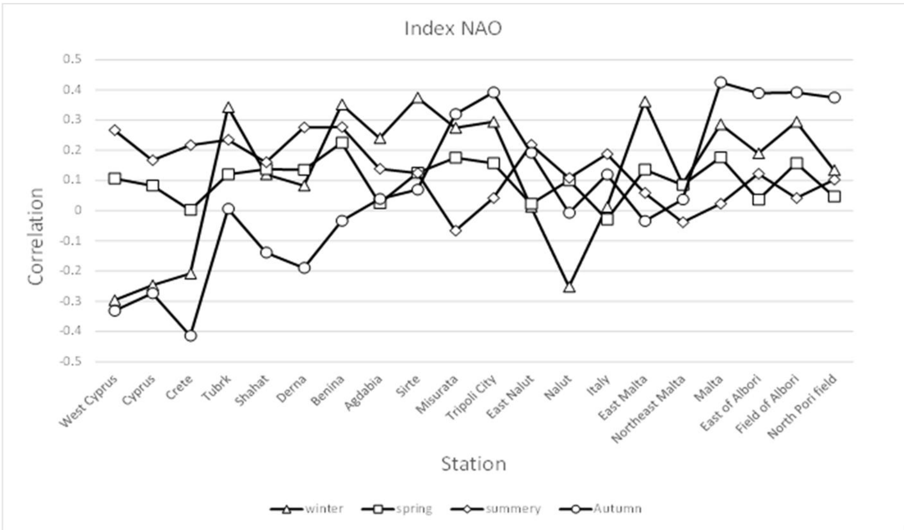
(b)

Fig. 6: The correlation of EL-Nino3.4 index and (a) the mean precipitation and (b) the mean temperatures over 20 stations, obtained from the observed data for the winter, spring, summer, and autumn seasons averaged over 1950-2016.

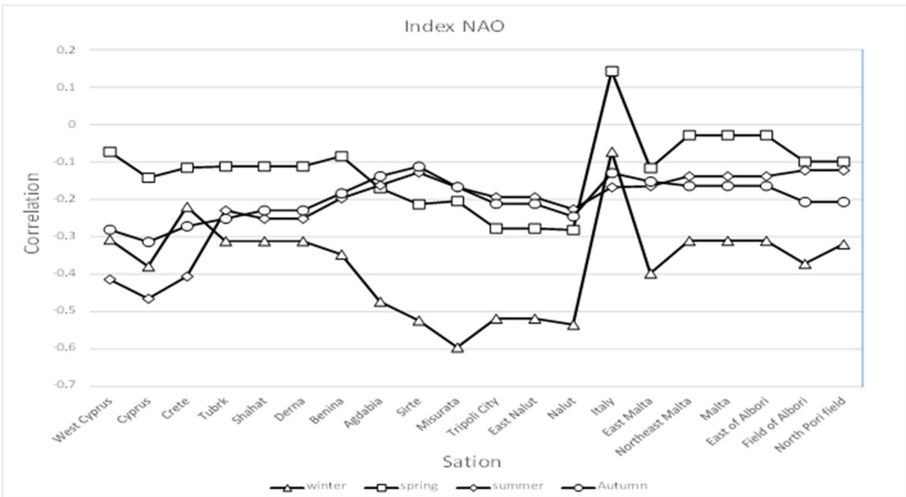
Effect of the NAO Index

The correlation between the NAO index and the seasonal mean precipitation for the period 1950-2016 over the 20 stations is shown in Figure (7.a). During the winter season, the correlation was generally positive on the Libyan stations reaching about 0.4 in Sirte, Benina, and extending to Malta and East Malta, and there was a negative correlation in Nalut, West Cyprus, about -0.3. In spring, the correlation was positive over most of stations up to 0.2. In the summer, the correlation was generally positive, up to 0.3 in Darna, Benina and West Cyprus, and up to -0.1 in Misurata.In the autumn, the positive correlation reached 0.4 on Tripoli, Malta and the Field of Albori, while there was a negative correlation -0.4 on Crete and -0.3 on Cyprus and West Cyprus and on Derna about -0.2.

Figure (7.b) shows the correlation between NAO and seasonal mean temperature, indicating a negative correlation in the winter, up to -0.6 in Misurata and - 0.5 in Sirte, Agdabia, Tripoli City, Malta and East, and up to -0.4 in eastern Malta, . In the spring, the correlation was negative and reached -0.3 on Nalut, East and Tripoli. In the summer, the negative correlation was about -0.5 on Cyprus and -0.4 on Crete and at Shahat and Derna station, reaching -0.3. In autumn, the correlation was negative and reached -0.3 in Tobruk, Crete, Cyprus and West Cyprus.



(a)



(b)

Fig. 7: The correlation between NAOindex and (a) the mean precipitation and (b) the mean temperatures on the 20 stations obtained from the observed data for the winter, spring, summer, and autumn seasons averaged over1950-2016.

Conclusion

The seasonal and annual precipitation rate and temperatures at 20 stations over north Libya and Mediterranean obtained from the NCEP data have been analyzed for the period 1950-2016.

In the summer, the heating extended from Libya to the Mediterranean Sea. The effects of large-scale forcings, specifically EL-Nino and NAO, on precipitation rate and mean temperatures. It is found that the high variability in the temperature over the 20 stations was closely associated with the large-scale forcings, for instance, the NAO index is strongly related to the temperature with a negative correlation in all seasons, during the negative phase of NAO. The correlation between NAO and the mean precipitation was positive in winter correlation over most of stations except Nalut, Crete, Cyprus and West Cyprus. In the spring and summer, the correlations were positive in all stations, while in the autumn, there was positive correlation except Derna, Shahat, Crete, Cyprus and West Cyprus.

Whereas EL-Nino events affected the spring temperature with negative correlation leading to high temperature during the season, while in the rest of the seasons the correlation was positive. For the precipitation, there was a negative correlation in the winter while in the rest of the seasons the correlation was positive for winter precipitation, whereas the correlation was positive for the rest of the seasons except Nalut station had a negative correlation in the summer.

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