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A study of the Relationship between ENSO and the Annual Oscillation of the Middle East Subtropical Anticyclone in a 30-Year Period

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Introduction

The northern branch of the Hadley cell forms the anticyclone centers over the subtropical regions around the world. One of these centers is the Middle East anticyclone that plays a main role in the weather of the region. This center has an annual spatial oscillation in the north-south direction. In summertime, it goes to the high latitudes and makes the weather of the Middle East very dry and hot and in winter; it comes back to the lower latitudes and lets the mid-latitude cyclones go across the northern Middle East and Iran. The main winter precipitation of Iran is closely related to these cyclones.

Occurrence of any anomaly in the natural spatial variability changes the meteorological regimes over the region. Since ENSO is one of the global oscillations that can affect the weather in some parts of the world, this study aims to examine the likely effect of ENSO on the oscillation mentioned above.

Materials and methods

For this reason, a 30-year period from 1971 to 2000 has been selected as the basis of this study. Zonal component data of the wind at 250hPa level, that is the level of subtropical jet stream presence, as well as the Oceanic Nino Index (ONI) data received from the data bank of NOAA, are reanalyzed. ONI is the difference between the 30- year average of the Sea Surface Temperature (SST) over the NINO3/4 region and its three-month running average. According to NOAA, for ONI in the range of ±0.5 °C, ENSO is in natural phase and for more than +0.5 °C, in warm phase (El-Nino) and for less than -0.5 °C, in cold phase (La-Nina). For this study the six strongest ENSO years including three El-Nino years (1972, 1982 and 1997) with an ONI more than +1.5 °C, three La-Nina years (1973, 1975 and 1988) with an ONI less than -1.5 °C and three neutral years (1979, 1980 and 1981) are selected.

At first, the zonal wind data were separated into two parts: stationary and transient parts. The stationary part is independent from oscillations, so, ENSO does not have any effect on it. It was expected that the effect of ENSO become obvious in the transient part of the data. For this reason, the annual and seasonal anomalies of the transient part of the zonal wind (arising from the presence of all atmospheric- oceanic oscillations) for the six strongest warm and cold phases of ENSO were computed and analyzed.

Then, this study shows the net effect of ENSO. Considering the fact that there are three years (1979, 1980 and 1981) with the absence and six years with the strongest presence of ENSO, it can be supposed that in all nine selected years, all of the oscillations were active. Then, by subtracting the neutral phase anomalies from the warm and cold phase anomalies, the roughly net effect of ENSO will be gotten for any phases. In order to do this, at first, the mean of anomalies for all the phases is computed and then subtraction is done. The most important effect of this averaging is modifying the effect of other oscillations and maintaining the effect of ENSO. Because of the fact that in these six years, ENSO was very active, the averaging has no modifier effect on its impact but it is different for other oscillations. This method brings the effect of ENSO to light.

This study is followed in point of the correlation coefficient view between SST of the Nino 3/4 and zonal component of wind at the 250 hPa level over a wide area from west of the Middle East to the east of the Pacific.

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Results and discussion

The figures of the stationery part of the zonal wind at the 250 hPa level shows that the jet stream of the Middle East subtropical anticyclone has a spatial oscillation about 20 degrees in the north-south direction. According to this study, the core of the subtropical jet stream is roughly located in 25 degrees north in winter and 45 degrees north in summer over the Middle East.

In the next section, the results of the transient part show that the effect of ENSO on the annual oscillation of the Middle East subtropical anticyclone is not detectable by the distribution of annual and seasonal anomalies of the transient part, because there are different patterns of the distribution of anomalies in the same phases of ENSO. In other words, ENSO does not have a predominant and significant impact on the distribution of anomalies in the presence of other large-scale oscillations and phenomena. It is more likely that the interaction of other oscillations with ENSO substantially weakens the partial effect of ENSO.

But the results in the section of the net effect of ENSO are very interesting. Those results indicate that El-Nino keeps the annual oscillation at lower latitudes compared to La-Nina condition, and also prepares the more suitable condition for passing the mid latitude cyclones and then precipitation over Iran and the north of the Middle East region in wintertime. Moreover, the meridional wind shear is very strong in El-Nino comparing to La-Nina. It means the mid latitude cyclones are more active in El-Nino than those in La-Nina. The other notable result shows that the subtropical anticyclone is located at the maximum latitude during the summertime of La-Nina condition, where the latitude is higher than El Nino. In this condition, the easterly waves pass the southeast and south of Iran and create the summer precipitations.

Conclusion

According to this study, ENSO has no dominant effect on the annual oscillation of the subtropical anticyclone over the Middle East. It seems that its effect in a complicated interaction with other global oscillations like NAO and MJO becomes weaker and even disappear. The weak correlation coefficient of the SST over the tropical Pacific and the 250 hPa zonal wind over the Middle East confirms this weak connection. But as an individual oscillation, its warm phase (El-Nino) holds the subtropical anticyclone annual oscillation at the lower latitudes comparing to La-Nina and lets the mid latitude cyclones pass over Iran and rain. It means, the condition for the cold seasons' precipitations over Iran in El-Nino is better than it in La-Nina. At last, La-Nina moves the Middle East subtropical anticyclone to the higher latitudes in summertime and prepares condition for passing the easterly waves over south and southeast of Iran which form the summer precipitations. This condition is weaker in the summertime of El-Nino.

Key words: ENSO, annual oscillation, subtropical anticyclone, Middle East, teleconnection.