# The El Niño Southern Oscillation (ENSO) Influence on the Meteorological Parameters in Jeddah during 2015 and 2016

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## Abstract

El Niño-Southern Oscillation (ENSO) influenced temperature over Jeddah during 2015-2016. The variability of temperature over Jeddah is affected by local climatic factors, which in turn are influenced by large-scale climatic phenomena such as the ENSO. The effects of ENSO on regional climate are often enhanced or reduced by a second large-scale climate phenomenon, the Indian Ocean Dipole (IOD). Analysis of time series of temperature over Jeddah showed that the year 2016 was warmer than 2015 and 2014. This increase of temperature revealed that the impact of ENSO was more than normal, using Global warming indices such as Oceanic Niño Index (ONI), which measured ENSO.

Analysis of seasonal temperature shows strong influence of ENSO on temperature over Jeddah in spring season. Hence, these effects can be observed in humidity, which may show an unusual decrease.

All the above discussions and facts can be applied to any city in Saudi Arabia, especially over Makkah, which received thousands of pilgrims and Umrah visitors. This study is important to Hajj and Umrah because the local meteorological parameters and ENSO can affect the health of pilgrims and Umrah visitors in Makkah and Madinah.

## Introduction

The El Niño-Southern Oscillation (ENSO) is one of the most important and longest-studied climate phenomena on the planet. It can lead to large-scale changes in sea-level pressures, sea-surface temperatures, precipitation and winds–not only in the tropics but across many other regions of the world. ENSO describes the natural year-to-year variations in the ocean and atmosphere in the tropical Pacific. Sea-surface temperatures in the central and eastern equatorial Pacific cycle between above- and below-average. An El Niño state occurs when the central and eastern equatorial Pacific sea-surface temperatures are substantially warmer than usual. La Niña conditions occur when the central and eastern equatorial Pacific waters are substantially cooler than usual.

Heureux (2014) reported that ENSO is one of the most important climate phenomena on Earth due to its ability to change the global atmospheric circulation, which in turn, influences temperature and precipitation across the globe. We also focus on ENSO because we can often predict its arrival many seasons in advance of its strongest impacts on weather and climate. He added also, though ENSO is a single climate phenomenon, it has three states, or phases, two opposite phases, “El Niño” and “La Niña,” require certain changes in both the ocean and the atmosphere because ENSO is a coupled climate phenomenon while “Neutral” is in the middle of the continuum:

El Niño: A warming of the ocean surface, or above-average sea surface temperatures (SST), in the central and eastern tropical Pacific Ocean. Over Indonesia rainfall tends to become reduced, while rainfall increases over the tropical Pacific Ocean. The low-level surface winds, which normally blow from east to west along the equator (“easterly winds”) instead weaken or, in some cases, start blowing the other direction (from west to east or “westerly winds”).

La Niña: A cooling of the ocean surface or below-average sea surface temperatures (SST) in the central and eastern tropical Pacific Ocean. Over Indonesia rainfall tends to increase, while rainfall decreases over the central tropical Pacific Ocean. The normal easterly winds along the equator become even stronger.

Neutral: Neither El Niño or La Niña. Often tropical Pacific SSTs are generally close to average. However, there are some instances when the ocean can look like it is in an El Niño or La Niña state, but the atmosphere is not playing along (or vice versa).

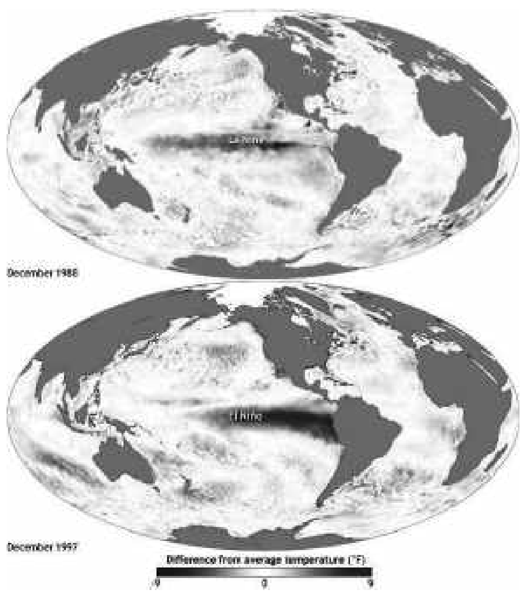


Fig. (1): Maps of sea surface temperature anomaly in the Pacific Ocean during a strong La Niña (Top, December 1988) and El Niño (Bottom, December 1997). Maps by NOAA Climate.gov, based on data provided by NOAA View. large versions La Niña | El Niño

Sir Gilbert Walker discovered the “Southern Oscillation,” or large-scale changes in sea level pressure across Indonesia and the tropical Pacific. However, he did not recognize that it was linked to changes in the Pacific Ocean or El Niño. It wasn’t until the late 1960s that Jacob Bjerknes and others realized that the changes in the ocean and the atmosphere were connected and the hybrid term "ENSO" was born. It wasn't until the 1980s or later that the terms La Niña and Neutral gained prominence.

## Site and Location

Saudi Arabia is situated in the southwest of Asia at the junction of Africa and Asia and is the largest country (occupying 80% of area) in the Arabian Peninsula (CSD, 2010). The country has mountain ranges in the western region, situated parallel to the coast of the Red Sea. The country has mountain ranges in the western region, situated parallel to the coast of the Red Sea. The Rub Al-Khali is the world's largest sand desert, which covers almost the entire southern region of Saudi Arabia (Atlas, 1984; Edgell, 2006; and Bishop, 2010). The climate of Saudi Arabia is extremely hot and dry (Almazroui, 1998; and Ragab and Prudhomme, 2000).

Jeddah is coastal city located in the western region (Lat. 21° 32', Long. 39° 10'). Data were collected from the station located in the King Abdul Aziz International Airport, Jeddah. Twenty year hourly data for air temperature, humidity, wind speed and wind direction were obtained from the above mentioned airport.

## Result and Discussions

Temperature anomalies were produced by calculating the mean for each calendar month across the whole time-series and subtracting it from the mean value for each particular month.

The variability of temperature over Jeddah is affected by local climate factors that in turn are influenced by large-scale climate phenomena such as the El Nin˜o Southern Oscillation (ENSO). The effects of ENSO on regional climate are often enhanced or reduced by a second large-scale climate phenomenon, the Indian Ocean Dipole (IOD). Analysis of time series of temperature over Jeddah shows that warm (green) and cold (red) periods based on a threshold of +/- 0.5oC for the Oceanic Niño Index (ONI). Green fluctuations of ONI in case temperature show that value of +2.3 for autumn in 2016. These were the period of the strongest El Nin˜o event in the time-series.

Analysis of time series of sea level pressure normally over Jeddah Fig. 2 (PME Presidency of Meteorological Agency) shows that the year of 2016 is with higher values compared with in years 2009 and 2003. The anomalies values were found as +1.0, +0.7 and +0.8 respectively (Fig.2). The Oceanic Niño Index ONI was +2.2 for 2016, +1.3 for 2009 and +1.1. ONI was classified as strong because it reached to a value of +2.2 in 2016 moderate (Fig.5), when reached to +1.3 in 2009 and +1.1 in 2003.

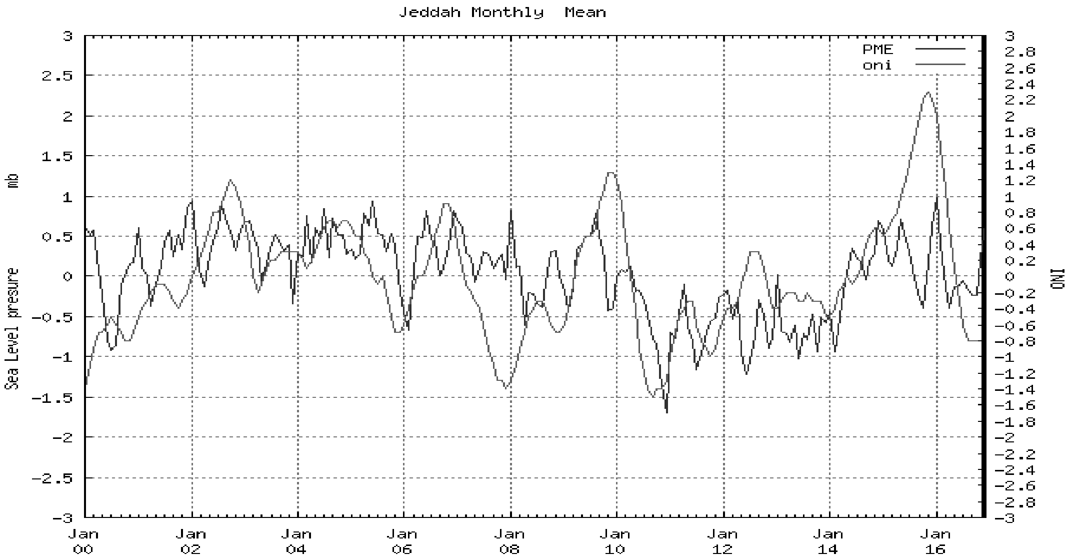


Fig. (2): Time series of sea level pressure anomalies (purple), uses to identify El Niño (warm) and La Niña (cool) based on a threshold of +/- 0.5oC for the Oceanic Niño Index (ONI, green), starting from January 2000 until January 2016 in Jeddah.

Analysis of time series of temperature over Jeddah (Fig.3), shows that the year of 2016 is warmer than 2015, 2014 and 2013. The anomalies values were found to be as +1.8, +1.2 and +1.4 respectively (Fig.3). This increase of temperature reveals that impact of the ENSO was predominant than normal. ONI was classified as strong because it reached to a value of +2.2 in 2016 (Fig.5). The anomalies value almost seems reasonable of about +0.6 in years 2006 and 2010 (Fig.3), ONI in 2010 was +1.2, which mean that it may be classified as moderate (Fig.5). Regarding with the analysis of time series of relative humidity may be shown contrary effect by negative values of about -1.3 between 2014 and 2016 but still ONI strong with value of +2.2. When anomalies between 2001 until 2005 were shown almost lower values of temperature, the humidity was shown higher values until it reached to a maxim value of +2.2 (Fig. 4).

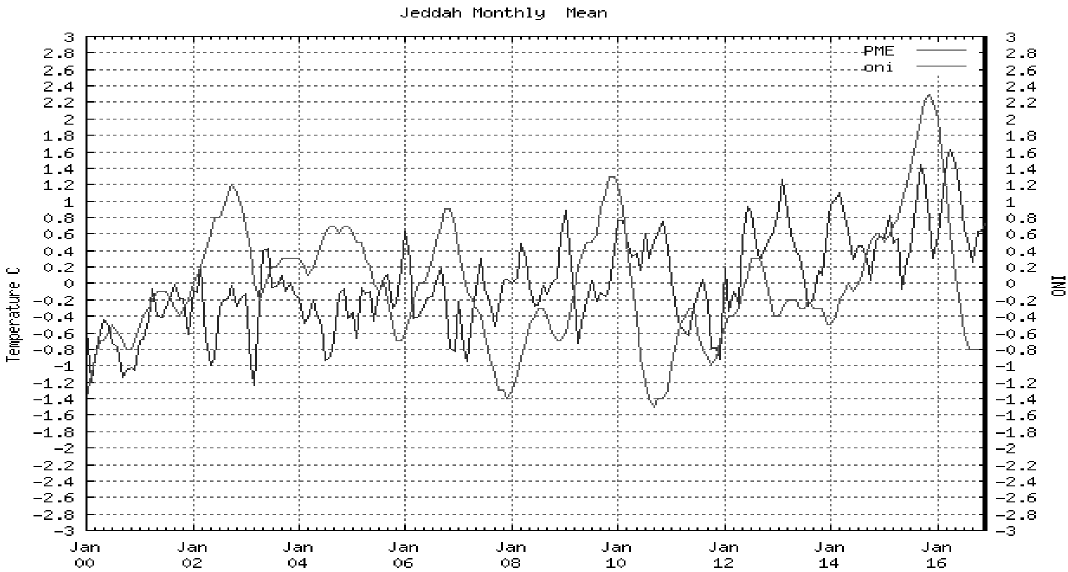


Fig. (3): Time series of temperature anomalies (purple), uses to identify El Niño (warm) and La Niña (cool) based on a threshold of +/- 0.5oC for the Oceanic Niño Index (ONI, green), starting from January 2000 until January 2016 in Jeddah.

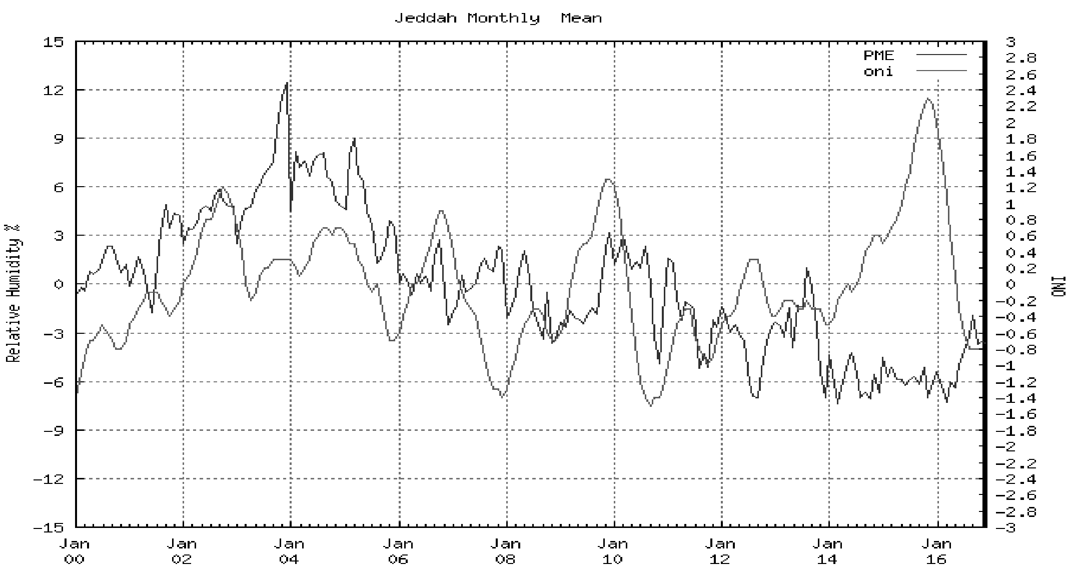


Fig. (4): Time series of relative humidity anomalies (purple), uses to identify El Niño (warm) and La Niña (cool) based on a threshold of +/- 0.5oC for the Oceanic Niño Index (ONI, green), starting from January 2000 until January 2016 in Jeddah.

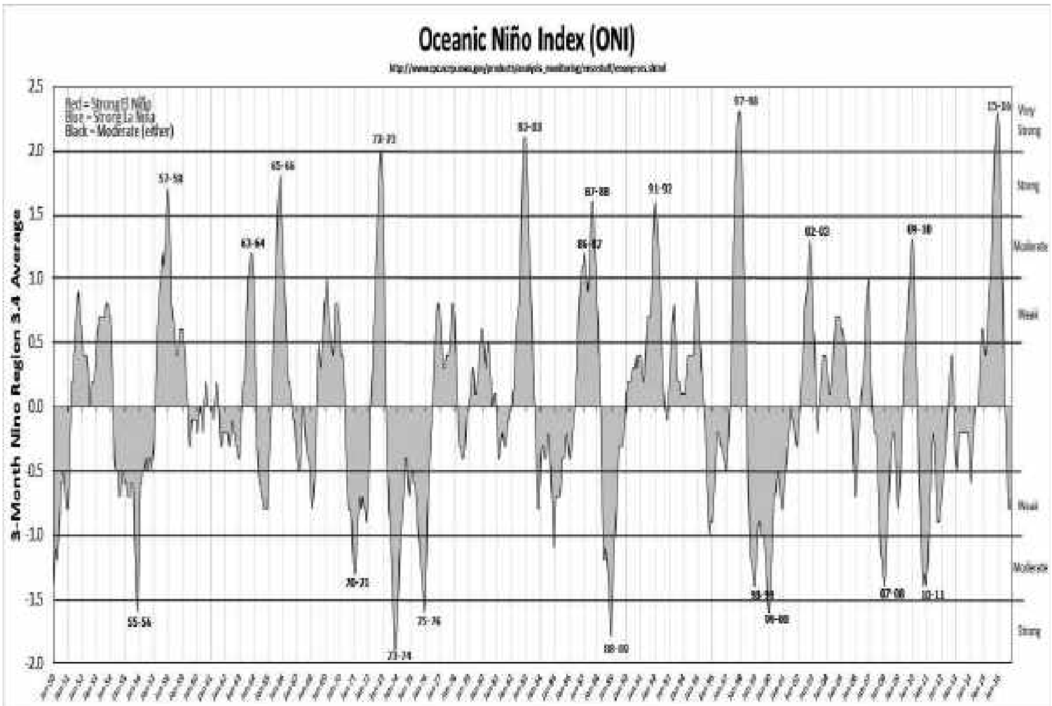


Fig. (5): The Oceanic Niño Index (ONI) classifications

In our case, we didn't present the time series of monthly mean values of wind speed anomalies because it has never shown any correlation.

We will present some results from our data analysis, mean values of sea level pressure anomalies and values of ONI for sea level pressure. The results of this study can be explained as follows:

1- Fig. 6 shows that values of pressure anomalies and ONI for pressure were almost identical in May every year between 2000 and 2016.

2- Figure 7 show that values of pressure anomalies and ONI for pressure were almost identical in September every year between 2000 and 2016.

3- Fig. 8 shows that values of pressure anomalies and ONI for pressure were almost identical except in 2004 where the pressure anomalies found the value of +2. This figure was in November every year between 2000 and 2016.

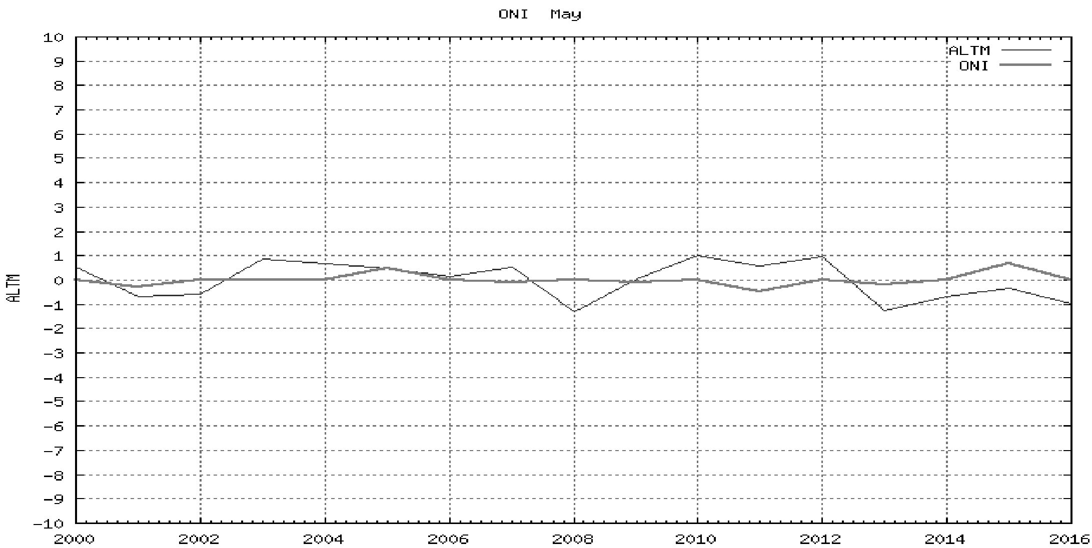


Fig. (6): Mean values of sea level pressure anomalies (purple) and values of ONI (green) for sea level pressure in the month of May each year starting from May 2000 until May 2016 in Jeddah.

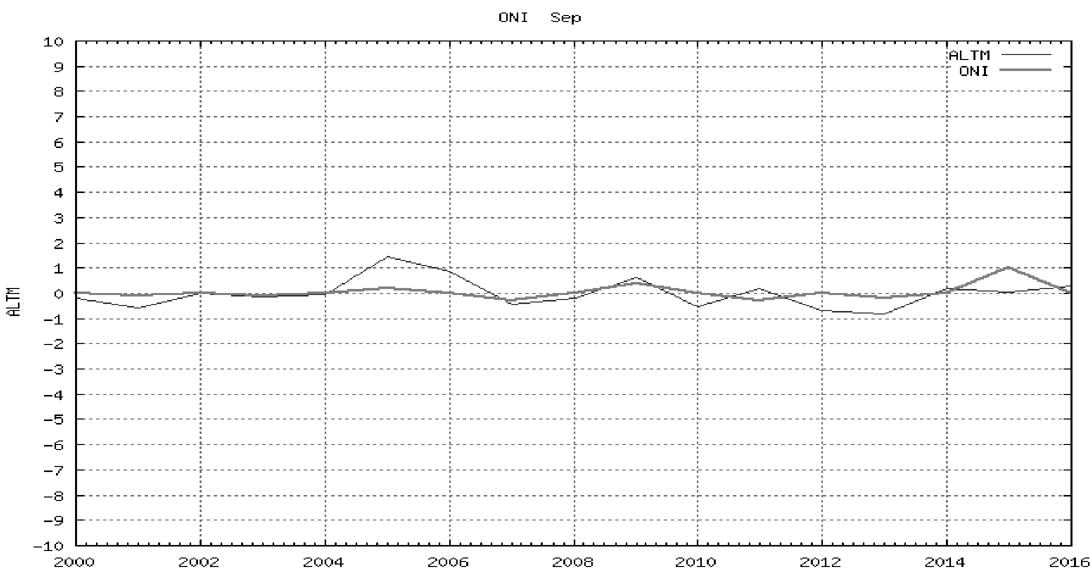


Fig. (7): Mean values of sea level pressure anomalies (purple) and values of ONI (green) for sea level pressure in the month of September each year starting from September 2000 until September 2016 in Jeddah.

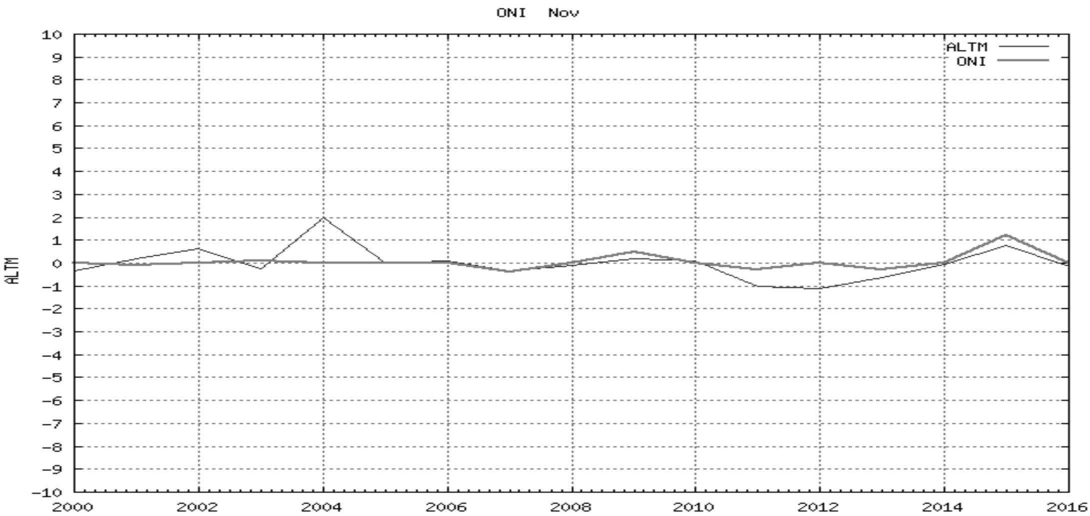

Fig. (9): Mean values of sea level pressure anomalies (purple) and values of ONI (green) for sea level pressure in the month of November each year starting from November 2000 until November 2016 in Jeddah.

Here, we will present some results from the analysis, mean values of air temperature anomalies each month and values of ONI for temperature were drawn during the whole period of study. The results of this study can be explained as follows:

1- Fig. 10 shows that the curve of temperature anomalies was irregular and ONI for temperature were almost increasing and decreasing in average at +/- 0.5 in the whole period of March of every year between 2000 and 2016. It was noticed that there were several peak values of temperature anomalies one was at~+1 in 2009 while the other one was at +1.2 in 2013. On the other hand, the lowest values of the temperature anomalies ware found at -1.1 in 2003 and at~-1 in 2007.

2- Fig. 11 shows that values of ONI for temperature reached to its peak values at +0.8 in 2005, at +0.9 2008, at +1 in 2010, at +1.8 in 2014 and at +2 in 2016 during the period of June. The ONI in 2016 was high compared with in 2014 There was -1 value of temperature anomalies found in 2008

3- Fig. 12 shows that temperature anomalies were too irregular showing values of +0.7 in years: 2005, 2008 and 2010. Also +1.5 in 2014 and +2 in 2016 while ONI for temperature almost fluctuating in average at +/- 0.3 in the whole period of July of every year between 2000 and 2016 except when reached to its peak value of +0.8 in 2015.

10- Fig. 13 shows that the temperature anomalies were in their lower values less than +/- 0.5 except in 20125 when it was reached to +1. The ONI for temperature were also in their lower values less than +/- 0.5 except in 2010 at +0.8 and +1.2 in 2012 during the whole period in October between 2000 and 2016 Only the value -0.8 of ONI for temperature that was found in 2004

It may be wondered that there was always a share in a peak value of temperature anomalies in all months except in August, September and October 2010.

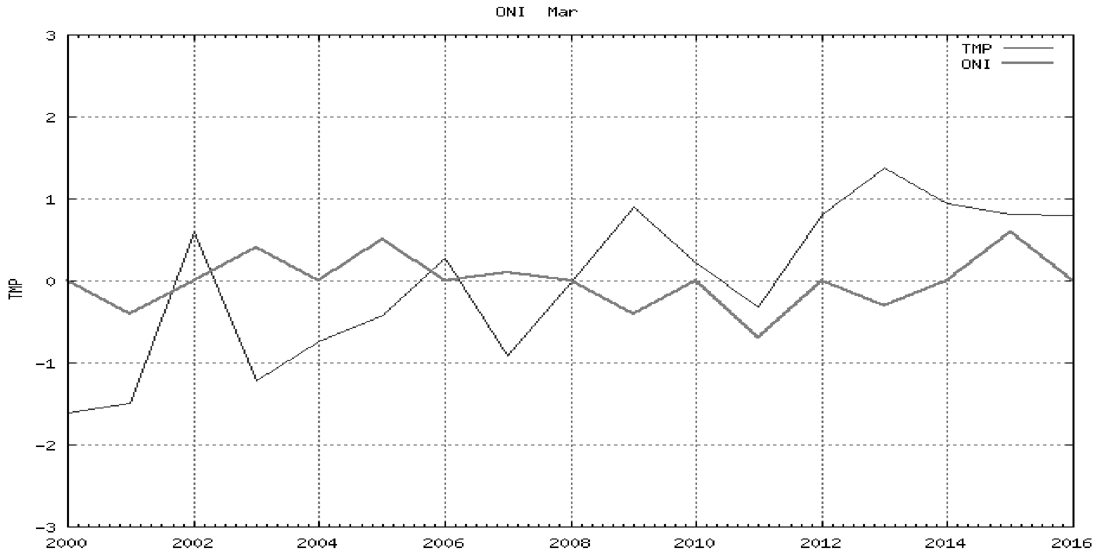


Fig. (10): Mean values of air temperature anomalies (purple) and values of ONI for air temperature (green) in the month of March each year starting from March 2000 until March 2016 in Jeddah.

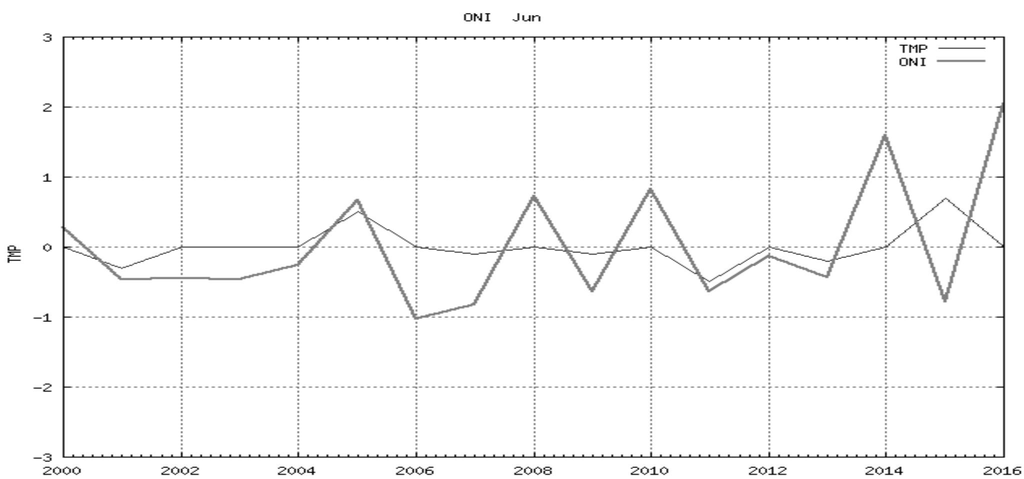


Fig. (11): Mean values of air temperature anomalies (purple) and values of ONI for air temperature (green) in the month of June each year starting from June 2000 until June 2016 in Jeddah.

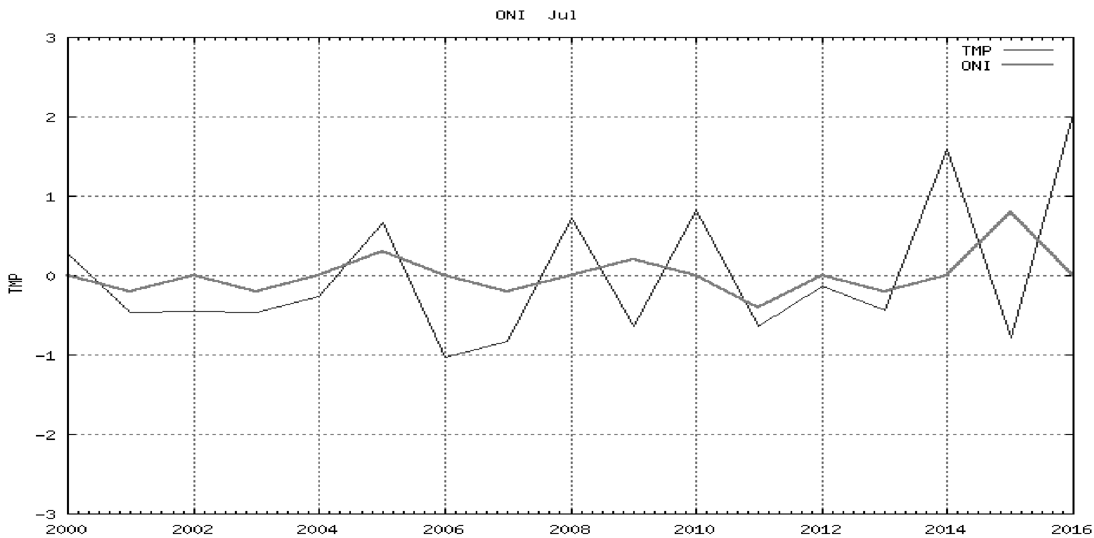


Fig. (12): Mean values of air temperature anomalies (purple) and values of ONI for air temperature (green) in the month of July each year starting from July 2000 until July 2016 in Jeddah.

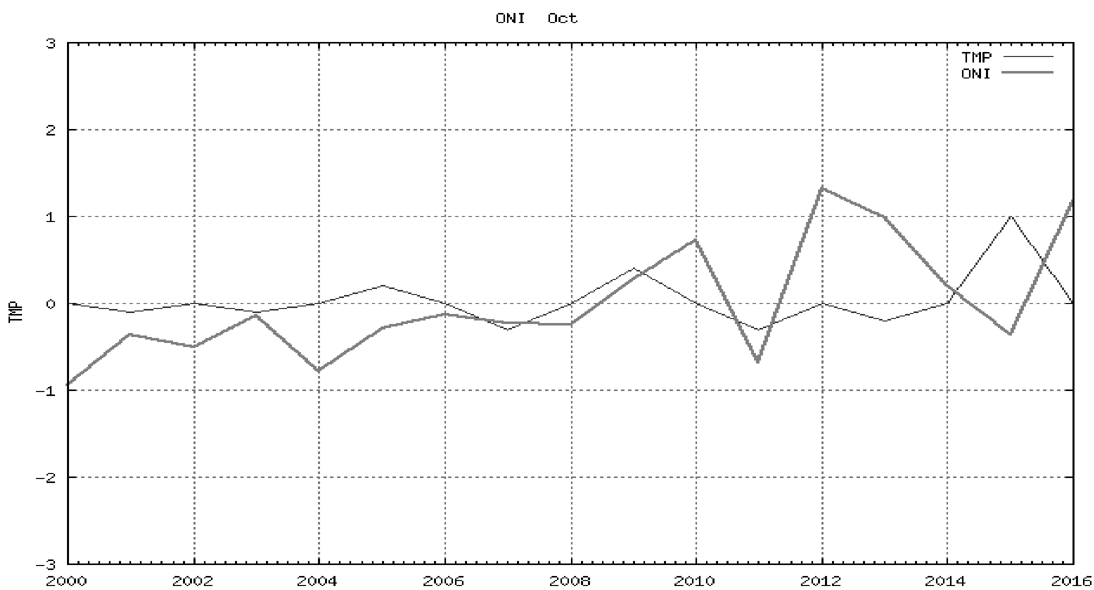


Fig. (13): Mean values of air temperature anomalies (purple) and values of ONI for air temperature (green) in the month of October each year starting from October 2000 until October 2016 in Jeddah.

1- Fig. 14 shows that the curve of relative humidity was irregular and ONI for relative humidity were almost normal and nearly straight line in the whole period of March of every year between 2000 and 2016. It was noticed that there were several peak values of relative humidity; one was at~6% high in humidity in 2002, 10% in 2005 and 5% in 2010, while the first lower value of humidity other one was at -4% in 2008

2- Fig. 15 shows that the relative humidity anomalies were found to be as high at value of about 10% in 2004 Three lower values were found as; -2% in 2009, -4% in 2012 and -6% in 2014 The ONI for relative humidity showing a straight line in the whole period of May of every year between 2000 and 2016

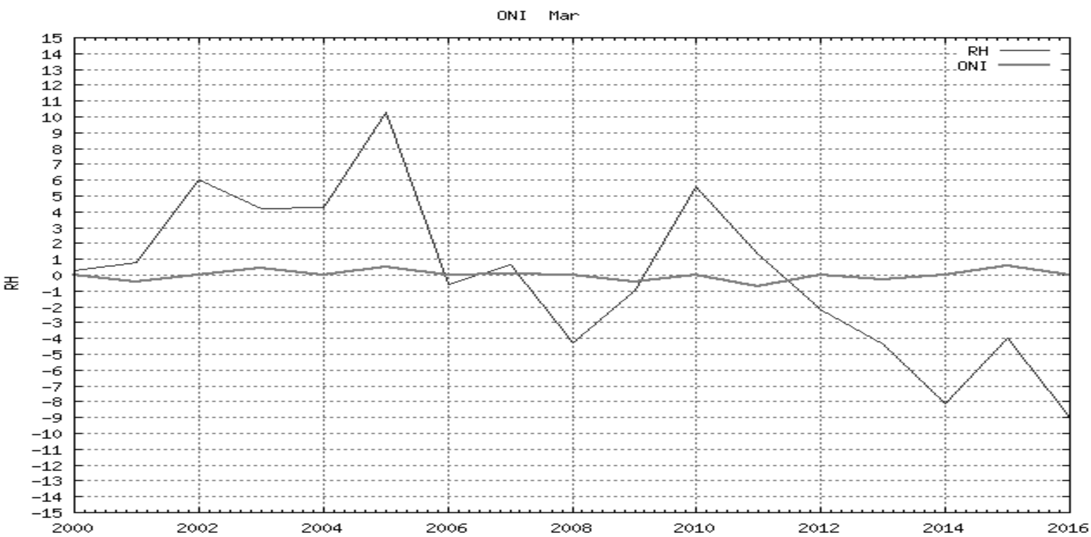


Fig. (14): Mean values of relative humidity anomalies (purple) and values of ONI for relative humidity (green) in the month of March each year starting from March 2000 until March 2016 in Jeddah.

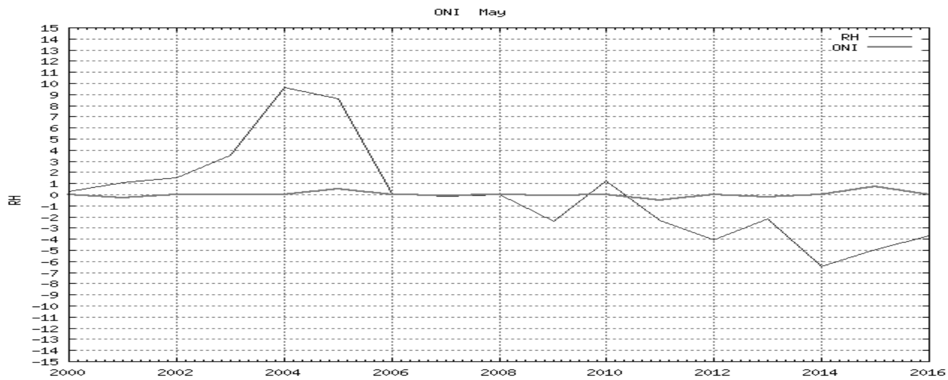


Fig. (15): Mean values of relative humidity anomalies (purple) and values of ONI for relative humidity (green) in the month of May each year starting from May 2000 until May 2016 in Jeddah.

In conclusion, from all above explanation, the next curves in Fig. 16 show the time series of monthly correlation mean values of pressure, temperature and relative humidity anomalies for full year in Jeddah. Oceanic Niño Index (ONI) may be affected during this period. The highest correlation values of pressure ware noticed at +0.6 in March and September. The lowest correlation value was found to be as -0.2 in November. Regarding with monthly correlation mean values of temperature, three maximum values were noticed: first; +0.2 in March, +0.1 in June and +0.3 in October. These values don't make any difference in our climate. The lowest correlation coefficient value was found as -0.2 in May. Referring with relative humidity anomalies, the lowest correlated value was -0.4 in May while increased after June until December to a range of about -0.3.

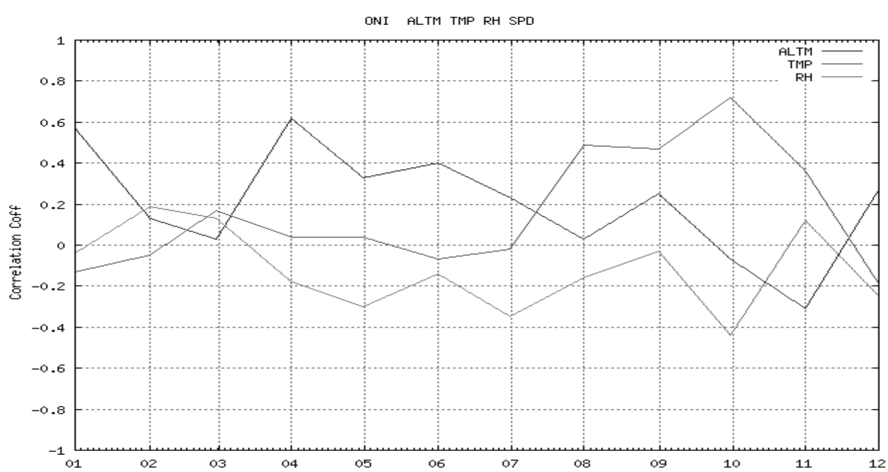


Fig. (16): Time series of monthly mean values of pressure (red), temperature (green) and relative humidity (blue) anomalies for full year in Jeddah. Oceanic Niño Index (ONI) may be affected during this period.

## Acknowledgement

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## References

[1] Al-Mazroui, M. (1998): Climatological Study over the Southwestern Region of the Kingdom of Saudi Arabia with Special Reference to Rainfall Distribution, Msc. thesis, Department of Meteorology, Faculty of Meteorology, Environment and Arid Land Agriculture, King Abdulaziz University, Jeddah, Saudi Arabia.

[2] Atlas, (1984): Water atlas of Saudi Arabia. Water Resource department. Ministry of Agriculture and Water, Riyadh.

[3] Bishop, M. A. (2010) Nearest neighbor analysis of mega barchanoid dunes, Ar Rub' al Khali, sand sea: The application of geographical indices to the understanding of dune field self-organization, maturity and environmental change. Geomorphol. 120: 186-194.

[4] Bou-Zeid, E. and El-Fadel, M. (2002) Climate change and water resources in the Middle East.

[5] CSD (2010): Multicutural topics in CSD. Introduction to Saudi Arabia. Available at http://www.multicsd.org/doku.php.

[6] Edgell, H. S. (2006): Arabian Deserts: Nature, Origin and Evolution. Springer, The Netherlands.

[7] L'Heureux, M. (2014): What is the El Niño–Southern Oscillation (ENSO) in a nutshell?. Available at https://www.climate.gov/news.../enso/what-el-niño–southern-oscillation-enso-nutshell.

[8] Ragab, R. and Prudhomme, C. (2000) Climate change and water resources management in the southern Mediterranean and Middle East countries. The Second World Water Forum, 17-22, March 2000, The Hague.