Studying the Effects of El Nino Southern Oscillation on Precipitation based on Southern Oscillation Index: Case Study for the Region of Shahr-e-Kord in Iran

Tofigh Sadi[1], Zahra Arzjani[2*] and Maryam Mosa Zadeh[3]

[1]Khuzestan Water and Power Authority Co., Ahwaz, Iran
[2]Faculty of Geography, Islamic Azad University, Central Tehran Branch, Tehran, Iran
[3]Department of Environment, Science and Research Branch, Islamic Azad University, Khuzestan, Iran

Abstract

El Nino Southern Oscillation (ENSO) phenomena is one of the atmospheric events causing climatic variability Worldwide that demonstrates a teleconnection pattern on a global scale. It influences the whole southern hemisphere and a great part of northern hemisphere beyond countries and continents. The present research investigates the impacts of this phenomenon on precipitation in Shahr-e-Kord region, southwest Iran using Southern Oscillation Index. Monthly precipitation records of Shahr-e-Kord gauging station for a period of 1956-2005 were gathered for the purpose of this study and the results showed that a significant correlation of 0.01 and 0.05 exists for precipitation data of several months of the year over specific time periods. This correlation is negative which emphasizes the fact that the El Nino event is usually followed by a wet year and the La Nina phenomenon reduces the precipitation in the region.

1. Introduction

One of the most inter-annual influential climatic phenomena is El Nino and Southern Oscillation (ENSO). This event has a telecommunication pattern on a global scale and affects both northern and southern hemispheres to a great extent. The ENSO is a combination of two El Nino and Southern Oscillation events. The El Nino refers to an oceanic phenomenon in which surface water of Eastern Tropical Pacific Ocean becomes warm lasting for three seasons and even more in a typical year. The El Nino is related to the variations of atmospheric pressure called Southern Oscillation (SO). The researches have shown that the occurrence of the El Nino is accompanied by a rising temperature and a decline in atmospheric pressure in the eastern part of the Pacific Ocean. On the contrary, the atmospheric pressure on the eastern coast of Australia rises while temperature decreases compared to the long-term average value of the region. The most obvious indication of SO event is the counter-relation in the surface atmospheric pressure between Australian Darwin and Haiti Island in southern Pacific Ocean as higher pressure in one region is accompanied by lower pressure in the other region. Due to the strong relation between El Nino and SO phenomena they are called together

El Nino Southern Oscillation or so-called ENSO (Gergis and Fowler, 2006).

The relation between warm water surface along eastern and western parts of the Pacific Ocean and their impacts on global climate became a concern to the scholars since early 1960s and after the occurrence of an extreme ENSO event during winter and fall of 1957-1958 (Guang Sun and Qing Xie, 2008). The ENSO phenomenon causes droughts, strong floods, storms, the spread of various diseases and infections by changing the earth's climate incurring irrevocable life and property damages. The El Nino event of 1982-1983 which was one of the severest climate events in records powerfully affecting the world climate provoked further researches in this field. Part of the research carried out about ENSO, shows that Multivariate ENSO Index with autumn precipitation in Shahr-e-Kord region has positive significant correlation in different interruption phases (Sadi and Moghimi, 2009). Also Oceanic Nino Index has better correlation to MEI with autumn precipitation in Shahr-e-Kord (Sadi and Arzjani, 2009). Sadi and Alijani (2011) are also with use of regression and correlation method studied the relation of ENSO phenomenon and NAO with precipitation of Shahr-e-Kord. They present Early warn-

ing models of region's precipitation on basis on large-scale signals with use of Neuro-fuzzy System (Sadi and Alijani, 2011). The researches also led to the exploring of other aspects of this phenomenon in other parts of the world and climatic indices were developed to study its impacts (Sedaghat Kerdar and Fattahi, 2008) including the Southern Oscillation Index. It is defined as the mean sea-level pressure (MSLP) difference between Tahiti and Darwin and is the standard atmospheric metric for diagnostic studies of the SO. The SOI is calculated using monthly average pressure anomalies at each station, normalized by the respective standard deviation, and provides a homogeneous index of the atmospheric pressure gradient between the eastern and western Pacific. The SOI is a dimensionless parameter since the anomaly of each factor is divided by its standard deviation. A number of studies have examined the reliability of the data and the properties of the SOI. For example, a strong annual MSLP cycle at Darwin and Tahiti makes inter-annual and lower frequency variability a small fraction of explained variance. As the SOI is based on just two stations, high-frequency phenomena such as the Madden–Julian Oscillation may obscure oscillations attributed to the Southern Oscillation (Gergis et al., 2006). The present research is aimed at finding the Southern Oscillation Index (SOI) correlation between ENSO phenomenon and precipitation in Shahr-e-Kord region and the data from Shahr-e-Kord Synoptic station were used because of the consistent records of 49 years and finally the correlation of monthly precipitation and SOI were discussed in detail.

2. Materials and Methods

2.1. Study area

The study area (Plate 1) was the Shahr-e-Kord region, southwest Iran which is a part of the Behesht Abad sub-basin within Northern Karun Basin. This basin is one of the most important hydrological regions in Iran which provides the required water supply for downstream basins with its high precipitation rate. This area borders on Zayandeh Rood basin from north, northeast and east while it is bounded by Dez river basin on northwest and west boundaries. In the south, it is bordered by Behesht Abad and Khersan basins and by Kooh Rang sub-basin and parts of the Greater Karun basin in the west (Gholami, 2007).

2.2. Data

The data and information used in this research included monthly precipitation records from Shahr-e-Kord rain-gauging station and Southern Oscillation Index. The Shahr-e-Kord station was selected based on the fact that the records of this station were a consistent representative of the climate characteristics of the region. The precipitation records were
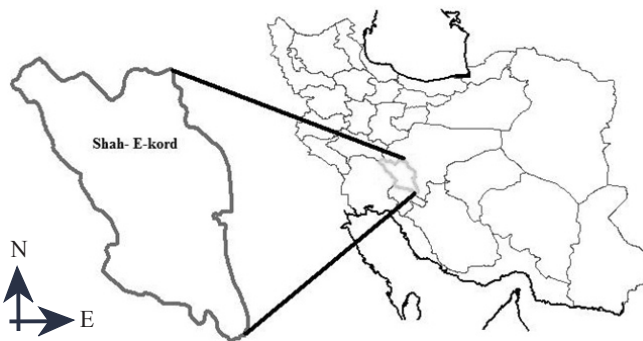

Plate 1: Study area

obtained from the National Iranian Metrological Organization and the monthly SOI data were collected from NCEP (www.cdc.noaa.gov). In order to ensure the accuracy of the data and reconstructing the gaps in records, data consistency and regression tests were conducted. Then, Pearson Correlation Method was applied to investigate the significant correlation between different variables by SPSS software. Thus, correlation coefficients over different temporal states including simultaneous state, one-month, two-month, three-month and four-month interruptions between precipitation data of the selected station and SOI were calculated. The required equations were derived using linear regression technique and finally in order to obtain the best correlation, the results of equations were compared with actual values.

3. Results and Discussion

In order to find the correlation between precipitation state of the region and ENSO event, Pearson Correlation Method was used. The correlations were found on two level of significance of 0.01 and 0.05 which were represented by two asterisk symbols (* and **), respectively. Table 1 shows the results of correlation between the total data of monthly precipitation along 49 years of Shahr-e-Kord station and SOI in different phases. And Table 2 and 3 show the results of correlation related to El Niño and La Nina years.

3.1. April

Just a simulation model obtained for April, Equation 1 and Figure 1 show with one month prior the regression equation and comparing chart of real and simulation precipitation. As noted in mentioned chart simulation precipitations in 1977, 1972 are remarkably accurate and simulations related to 1991, 1982 and 1969 have a bit of accuracy.

Eq. (1) $P_{APR} = 40.39 + 5.21 SOI_{FEB}$

3.2. October

The significant negative correlations in all the temporal states were observed in this month. The correlations were of an α level of 0.05 which decreases simultaneous state toward

Table 1: Pearson Correlation Coefficients for monthly precipitations at Shahr-e-Kord station with (SOI) over different temporal states (N:49)

Lag time	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec
Lag 0	-0/272	-0/013	-0/114	-0/063	-0/109	-0/342*	-0/302	-0/267*
Lag 1	0/003	0/038	-0/186	0/078	-0/125	-0/496**	-0/188	-0/086*
Lag 2	-0/054	-0/062	0/073	0/159	-0/007	-0/459**	-0/3	-0/091*
Lag 3	-0/066	-0/039	-0/12	-0/055	-0/05	-0/454**	-0/363*	-0/001*
Lag 4	0/143	-0/229	-0/175	0/033	-0/066	-0/386*	-0/295*	-0/086*

**Correlation is significant at the 0.01 level (2-tailed) & *0.05 level (2-tailed)

Table 2: Pearson Correlation Coefficients for monthly precipitations at Shahr-e-Kord station with (SOI) over different temporal states (El Nino years: 20)

Lag time	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec
Lag 0	-0/272	-0/324	0/193	0/201	-0/046	-0/367	-0/296	-/522*
Lag 1	-0/177	-0/111	0/155	0/174	-0/235	-/507*	-0/429	-0/304
Lag 2	-0/015	-0/217	0/357	/556*	0/069	-/457*	-/476*	-0/301
Lag 3	0/078	-0/127	0/367	0/2	-0/014	-0/441	-/558*	-0/39
Lag 4	0/319	-0/436	0/123	0/137	-0/148	-0/394	-/511*	-0/262

**Correlation is significant at the 0.01 level (2-tailed) & *0.05 level (2-tailed)

Table 3: Pearson Correlation Coefficients for monthly precipitations at Shahr-e-Kord station with (SOI) over different temporal states (La Nina years: 14)

Lag time	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec
Lag 0	0/024	-0/287	-0/431	-0/014	-0/301	-0/266	-0/088	-0/175
Lag 1	0/029	0/16	-0/291	0/243	-0/165	-0/529	0/108	-0/084
Lag 2	-0/003	-0/111	-0/133	-0/015	0/093	-0/513	0/017	0/244
Lag 3	0/28	-0/178	-0/456	-0/305	0/344	-0/332	0/028	0/339
Lag 4	0/37	-0/434	-0/402	0/098	0/038	-0/231	0/078	0/063

**Correlation is significant at the 0.01 level (2-tailed) & *0.05 level (2-tailed)
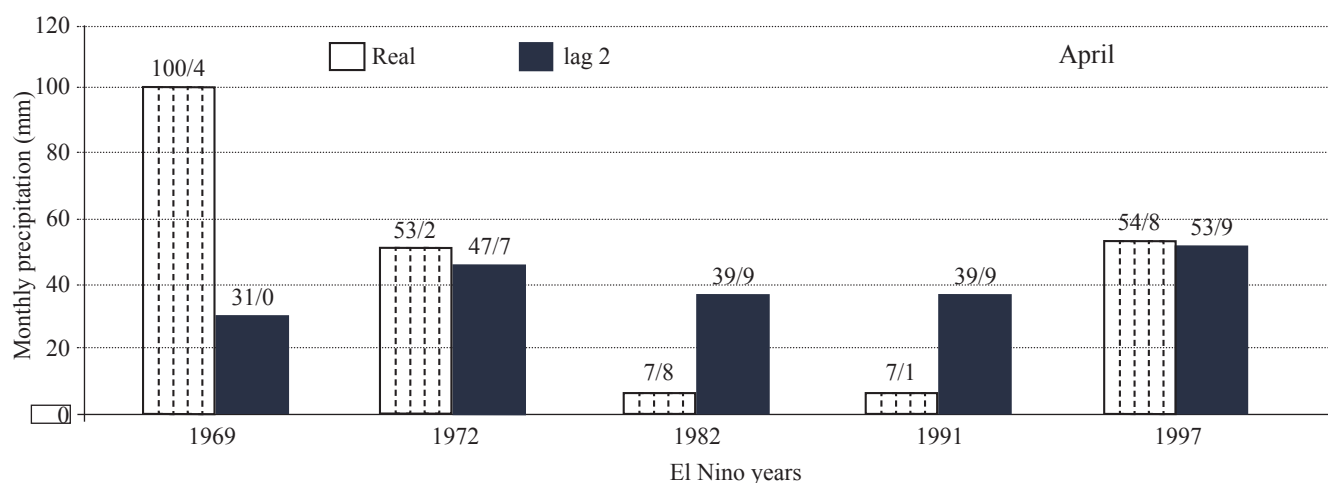

Figure 1: Comparing graph of actual and simulation precipitation in April based on SOI in lag time 2

three month interruption state. Thus, one can conclude that with a negative SOI (El Nino) the precipitation increases during October while as this index is positive (La Nina) the precipitation decreases. Equation 2 and 4, and Figure 2 show the precipitation amounts in the region during October over different temporal phases including simultaneous phase and one-month and two-month interruptions based on SOI:

Eq. (2) $P_{OCT} = 9.10 - 4.21 SOI_{SEP}$
Eq. (3) $P_{OCT} = 7.7 - 4.2 SOI_{AUG}$

3.3. November

The results of November in Table 2 to 4, and Figure 3 show that in three month interruptions, precipitation in Shahr-e-Kord station with SOI has negative significant correlation and in El Nino years in 2 to 4 month interruptions phases shows negative significant correlation, this means, that with these states, the precipitation of November with El Nino will have wet year.

Eq. (4) $P_{NOV} = 26.23 - 10.06 SOI_{SEP}$
Eq. (5) $P_{NOV} = 19.92 - 13 SOI_{AUG}$
Eq. (6) $P_{NOV} = 21.27 - 12.17 SOI_{JULY}$

3.3. December

The results of December in Figure 4 shows that between precipitation and SOI is just one correlation negative significant in simultaneous state that it is related to El Niño states , this means with very strong El Niño, the precipitation of December will wet year.

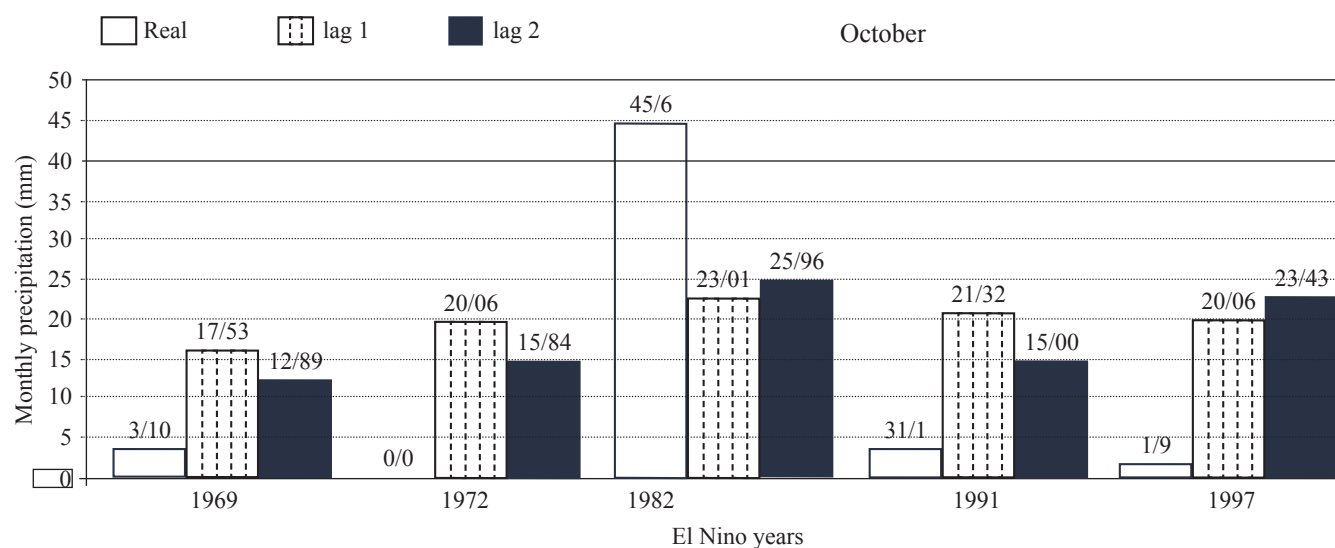Eq. (7) $P_{DEC} = 43.76 - 12.19 SOI_{DEC}$

Figure 2: Comparing graph of actual and simulation precipitation in October based on SOI in lag time 1 months and 2 months
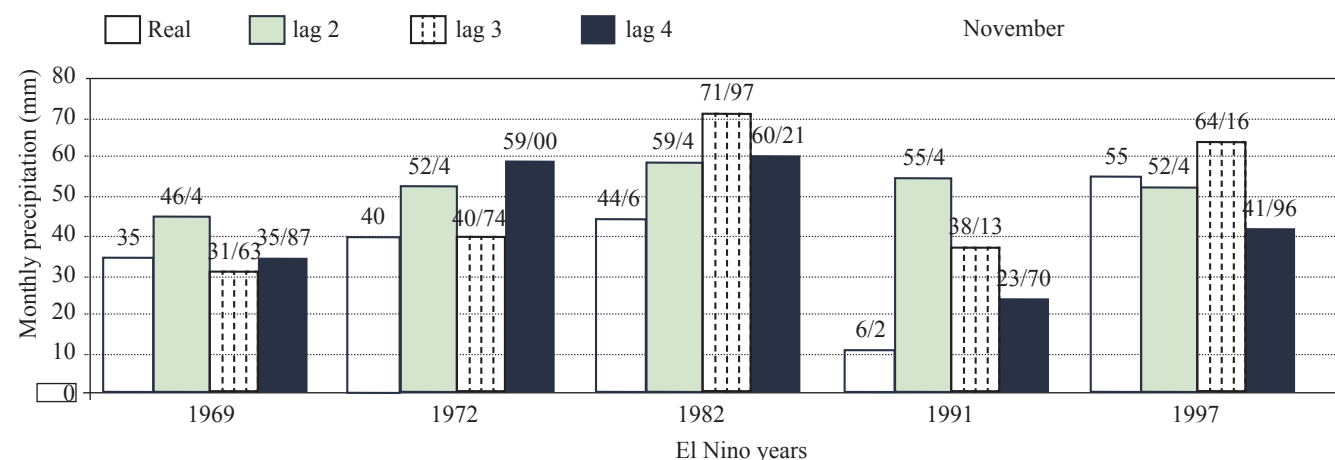

Figure 3: Comparing graph of actual and simulation precipitation in November based on SOI in lag time 2 months, 3 months and 4 months
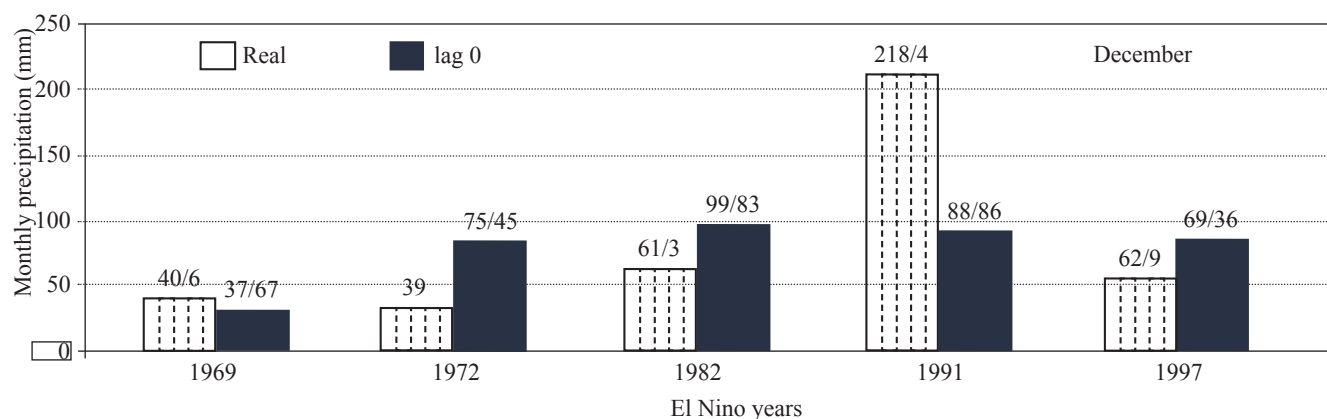
Figure 4: Comparing graph of actual and simulation precipitation in December based on SOI in lag time 1 month

4. Conclusion

Considering the results of the study, we can conclude that the precipitation at Shahr-e-Kord station has a negative correlation with SOI in fall. This correlation is stronger during early fall and it is expected that the precipitation increases during November and October under La Nina conditions while it decreases during the La Nina event in the same months. A comparison of results from the study of different temporal phases also shows a decrease in SOI impact on temporal interruptions and the variability of precipitation is mostly influenced by simultaneous variations in Tropical Pacific Ocean as such that the correlations become less strong towards the four-month interruption phase.

5. References

Gergis, J., Braganza, K., Fowler, A., Mooney, S., Risbey, J., 2006. Reconstructing El Nino-Southern Oscillation (ENSO) from high-resolution palaeoarchives. Journal of Quaternary Science 21, 707-722.

Gergis, J., Fowler, A., 2006. How unusual was late 20th century El Nino-Southern Oscillation (ENSO)? Assessing evidence from tree-ring, coral, ice-core and documentary palaeoarchives, A.D. 1525-2002. European Geosciences Union Journal of Advances in Geosciences 6, 173-179.

Gholami, M., 2007. Evaluation and hazard Zonation of landslide in Behesht Abad dam reservoir. M.A. Thesis, Isfahan University, Iran.

Guang Sun, L., Qing Xie, Z., 2008. Hot cradle of El Nino. www.precedings.nature.com/documents/1764/version/1

Sadi, T., 2008. Forecasting of precipitation situation in Behesht Abad and Koohrang sub basins (upper parts of Karoon Basin) according to continental indices of ONI, ENSO and NAO. M.A. Thesis, Central Tehran Branch of Islamic Azad University, Iran.

Sadi, T., Moghimi, Sh., 2009. Studying the effects of ENSO on precipitation based on MEI: case study for the region of Shahr-e-Kord. International Journal of Agriculture and Environment and Biotechnology 2(3), 190-193.

Sadi, T., Arzjani, Z., 2009. Studying the effects of ENSO on precipitation based on ONI: case study for the region of Shahr-e-Kord. Research on Crops 10(3), 755-758.

Sadi, T., Alijani, B., 2011. Early Warning of precipitation situation in Behesht Abad and Koohrang sub basins from North Karun Basin based on the phenomena of El Niño/Southern Oscillation and North Atlantic Oscillation. Khuzestan Water & Power industry technical institute, Ahwaz, Iran.

Sedaghat Kerdar, A., Fattahi, E., 2008. Drought early warning methods over Iran. Iranian Journal of Development and Geography 11, 56-79.