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The Impact of ENSO on Ground Water Table Variability in Iran

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Abstract

In this study, the impact of ENSO atmospheric and oceanic phenomenon on the GWT changes was investigated using the Southern Oscillation Index (SOI) in Iran. For this purpose the information of 30 piezometeric wells selected from different points of the country were used. Pearson correlation analysis conducted on relationship between SOI and GWT. Results showed that minimum GWT changes occurred in La Nina phase at 37 % of stations. On the contrary, the maximum GWT changes occurred in El Nino phase at 80% of the stations. Application of Pearson correlation analysis revealed that a negative correlation exists between SOI and GWT fluctuations at more than 93% of the stations. Furthermore, variation of GWT in La Nina phase to neutral phase was 207.3 % which was comparable with 6.8% for the average GWT changes in El Nino phase to neutral phase. Results showed that the percentage changes of GWT in La Nina phase is more than El Nino phase.

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•Introduction

Environmental modeling and assessment, as it is undertaken in specific locations, requires good characterization of local system properties and behaviors. Natural groundwater systems can be influenced by a number of spatial and temporal properties. Since groundwater is the major portion of freshwater (especially in arid and arid areas) investigating a possible relationship between teleconnection and the groundwater table (GWT) fluctuation would be very useful in water resources management.

Groundwater resources assessment is necessary to evaluate and quantify groundwater availability at various time scales in most watersheds especially in arid and semiarid regions where groundwater is the sole or the major water sources. Renewable groundwater resources from shallower unconfined aquifers are affected mainly by rainfall, climatic and surface water variations. There is no doubt that the interaction between surface and subsurface water components is very complex. Such interaction depends on several parameters mainly the spatial and temporal pattern of rainfall. To simplify this complex relationship, it is necessary to identify the major sources of water variability within the hydrosystem and to define a proper time scale. For example, evaluation groundwater fluctuation at larger time scale such as seasonal to inter-annual scales is more important than groundwater assessment at short time scales like hourly, daily and weekly. The role of climate heterogeneity and anomaly on water resources availability is interesting, though the effect of climate variability on groundwater has received less attention so far. One reason might be data scarcity in most of regions.

There are limited studies conducted on the effect of some teleconnection indices and weather parameters in Iran. Ghasemi and Khalili (2008b) studied the relationship between winter precipitation over Iran and large-scale atmospheric circulation patterns. They identified five anomalous pressure centers over Kazakhstan, Syria, the Indian Peninsula, the North Sea and the northwestern African coast that influence precipitation variability during wet conditions in Iran. Sabziparvar et al. (2010) reported that there are significant correlations between ENSO events and the reference crop evapotranspiration, ET0, in more than 50% of the stations selected from warm climate condition in Iran.

Although the above studies describe ENSO influence on single meteorological variables, there is still a need to extend the investigation addressing the effect of ENSO condition on GWT changes, especially in arid and semiarid areas such as Iran. Although most of the studies in Iran conducted on the impact of ENSO on climatologic parameters (Nazemosadat and Ghasemi, 2004; Nazemosadat et al., 2006, Sabziparvar et al., 2010), whowever, based on our best knowledge no scientific study is done about the association of ENSO and GWT fluctuations. Therefore, the main aim of this study is to evaluate the possible impacts of different ENSO phases (El Nino, La Nina and neutral) on GWT fluctuations in Iran. It is assumed that there are statistical differences between GWT changes values for El Nino, La Nina and neutral phases.

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•Methodology

In order to study the relationship between ENSO and GWT 30 piezometeric stations having long-term meteorological records during a period of 26 years (1985–2010) were selected around different points of Iran (Fig. 1).

At every station, the mean GWT observations and meteorological parameters observed at meteorological stations gathered from Regional Water Organization (RWO) and Iranian Meteorological Organization, respectively. Negative values of GWT indicate GWT declines whereas positive reciprocal represent increasing in GWT. The minimum and maximum GWT changes were -5.75 and 9.46 m respectively, for Charmahal and Kohgiluyeh. The overall average of GWT for all sites was about -0.37 m. This implies that Iran country's GWT diminished about 0.37 m in the last 26-years time period (1985-2010). The previous study on mean air temperature (Ghahraman 2006) indicated that mean temperature at the majority of the stations in Iran increased in recent decades. Also, Tabari and Hosseinzadeh Talaee (2011) reported that the significant negative trends of precipitation mostly occurred in of Iran. The decrease in Iran annual precipitation and the increase in Iran air temperature led to water scarcity in the country.

The evaluate how the GWT fluctuations at every station is affected by the El Nino and La Nina phases, the SOI values considered in ascending order. Then the reciprocal values of SOI for GWT data were considered too. The percentage of GWT that changed in El Nino and La Nina years computed. For each station, the difference between an average GWT change in each ENSO phase and an average GWT changes in neutral phase corresponding to GWT changes in the neutral phase were calculated as follows (Sabziparvar et al., 2010).

$$\%El/N_i = \frac{|GWT_E| - |GWT_N|}{|GWT_N|} \times 100 \qquad (1)$$

$$\%La/N_i = \frac{|GWT_L| - |GWT_N|}{|GWT_N|} \times 100 \qquad (2)$$

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• Results and Discussions

Results showed that during 1985 to 2010 period, there were overall seven El Ninio years, seven La Nina years and 12 neutral years in Iran. To examine the impact of ENSO on the minimum and maximum GWT changes, the years of maximum and minimum GWT were determined for each station type according to the ENSO phases. The results were shown in Table 2. As it can be seen from Table 2 in 37 % of stations (11 stations) minimum GWT changes occurred in the La Nina phases. However, in 80% of the stations (24 stations) the maximum GWT changes followed by the El Nino phases in Iran. At three stations namely Ardabil, Charmahal and Kerman minimum and maximum GWT changes demonstrated in the neutral phase. Since the maximum GWT has occurred in El Nino phase, it can be concluded that GWT were in higher level during the El Nino events while GWT were in a lower level compare to the La Nina events

Table 2. Comparing ENSO phases (Neutral – El Nino - La Nina) in maximum and minimum GWT changes occurrence during the 26 years in selected stations of Iran

Station	min	max	Station	min	max
Arak	N	E	Kermanshah	N	E
Ardebil	N	N	Khorasan#	L	E
Azar- Gharbi	L	E	Khorasan(s)	E	E
Azar Shargi	L	E	Khozestan	N	E
Booshehr	N	E	Kohgiluyeh	N	E
Charmahal	N	N	Lorestan	N	E
Ilam	L	E	Semnan	E	L
Fars	N	E	Sistan	L	E
Gazvin	L	N	Tehran	L	E
Ghom	N	E	Yazd	L	E
Gilan	E	E	Zanjan	L	E
Golestan	L	L	Esfahan	N	E
Hamedan	N	E	Mazandaran	N	E
Hormozgan	L	E	Khorasan (s)	E	E
Kerman	N	N	Kordestan	N	E

N: Neutral, E: El Nino and L: La Nina phases

Table 3. Statistics of SOI– GWT correlations for selected stations of Iran

Stations	Correlation	El/N (%)	La/N (%)	Stations	Correlation	El/N (%)	La/N (%)
Arak	-.494*	-95.4	32.3	Kermanshah	-.491*	-64.9	127.7
Ardebil	-.341	-68.3	58.8	Khorasan#	-.581**	-44.7	23.7
Azar- Gharbi	-.381	-87.1	230.7	Khorasan(s)	-.392	-58.4	10.2
Azar Shargi	-.594**	-37.6	78.6	Khozestan	-.310	-26.2	270.9
Booshehr	-.517**	138.1	404.4	Kohgiluyeh	-.517**	739.5	494.5
Charmahal	-.412*	204.4	2347.3	Lorestan	-.411*	186.9	218.8
Ilam	-.695**	53.3	219.2	Semnan	.076	3.8	0.4
Fars	-.530**	32.9	599.8	Sistan	-.354	-33.4	81.1
Gazvin	-.424*	-53.4	76.4	Tehran	-.651**	-82.0	173.1
Ghom	-.153	-46.5	-1.7	Yazd	-.425*	-11.5	20.3
Gilan	-.082	-56.3	-74.1	Zanjan	-.648**	-53.8	29.1
Golestan	-.180	-99.5	99.2	Esfahan	-.570**	-87.7	270.1
Hamedan	-.334**	-44.6	148.9	Mazandaran	-.037	-47.2	-91.6
Hormozgan	-.360	-42.4	302.2	Khorasan (s)	.159	11.7	2.0
Kerman	-.225	-20.2	-2.1	Kordestan	-.384**	-38.0	47.6

In order to evaluate the impact of ENSO phases on GWT changes in Iran we used the coefficient of variation index. Table 3 represents this index for all stations. According to Table 3 it can be concluded that average ratio for the GWT changes in the El Nino phase in compare to the reciprocal value in the neutral phase is corresponded to 6.8%. This value implies that, in the El Nino phase, GWT located about 6.8 % higher than that of neutral phase. More detailed comparison shows that in more than 73% of the stations (22 stations), changes in the GWT correspond to the El Nino phase is less than the GWT changes in the neutral phase. Maximum reduction (-95.4 %) is observed at Arak station. Only in 8 stations GWT changes in the El Nino phase is more than GWT changes in neutral phase that maximum amount of GWT increase is related to Kohgiluyeh station with 739.5 %. In contrast, the ratio of GWT changes during the La Nina phase to the neutral phase is not similar to the El Nino phase. So, at most stations (26 stations) GWT changes in the La Nina phase is more than GWT changes in the neutral phase.

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Conclusions

1. In 37 % of the stations minimum GWT changes was occured during the La Nina phase whereas in 80% of the stations (24 stations) the maximum GWT changes was calculated in the El Nino phase.
2. In more than 93% of the stations, the correlation between GWT changes and SOI appear to be negative and only two stations had a positive correlation. The significant correlation (P<0.05 and P<0.01) values was found in the case of 53% of stations (16 stations). Thus it can be stated that the ENSO phenomenon justified GWT changes over 53 % of the stations.

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References

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