On the relationship between seasonal precipitation of Iran and Sea Surface Temperature of regional water bodies

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Introduction

Sea Surface Temperature (SST) is a critical factor in humidity providing and climatic structure of the regions mainly surrounded by oceans and seas. Major amount of humidity resources of Iran is provided by regional water bodies of Caspian, Oman, Mediterranean and Black Seas, Persian Gulf and North of the Indian Ocean (Alijani 1999: 221).

Colder than normal of winter time Caspian Sea surface temperature can increase winter precipitation of South-West and South-Central parts of Caspian Sea, Central and Southern parts of Fars province and all regions of the Khuzestan province. Usually above normal sea surface temperature of Caspian Sea accompany by 20% decrease in winter precipitation in Southern beach of Caspian Sea, North of Fars and all regions of Khuzestan provinces. Warm winter SST of Caspian Sea increases spring precipitation of all weather stations located in the Southern beach of the Caspian Sea (Nazemosadat 2004: 1-14).

There are other studies that investigated the impact of sea surface temperature over seasonal precipitation of Iran (Moosavi baygi et. al. 2008: 217-224, Nazemosadat and Shirvani 2005: 1-10, Ghasemi and Khalili 2008: 116-133). Relation between sea surface temperature of Pacific Ocean and precipitation over America, Caribbean Sea countries, Southeast Asia, Australia and Africa have been studied by many scientists (Markovsky and North 2003: 856-877, Wear 1987: 2687-2698, Lim et al 2007: 33-39, Li and Zhang 2008: 237-243, Misra 2003, 2408-2418).

Different statistical methods of principal component analysis, canonical correlation and empirical orthogonal function are widely used in recent studies for investigation the relation between sea surface temperature and

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precipitation. Principal component analysis has been used for analysis of the relation between large scale weather patterns and winter droughts over Iran (Ghasemi and Khalili 2008: 116-133). Principal component of Persian Gulf SST are extracted for seasonal sea surface temperature prediction (Nazemosadat 2005:1-10).

Methodology and Data

Two types of data including sea surface temperature and precipitation are used in this research. We used ERSST v.2 grided sea surface temperature in the period of 1980-2009 with 2*2 latitude and longitude resolution and seasonal precipitation of 141 synoptic stations of Iran. EERSST data is extended reconstructed sea surface temperature data that have been obtained by using various observed in-situ marine data and remote sensing data from satellite observations. Precipitation data have been extracted from I. R. of Iran Meteorological Organization in the same period of 1980-2009. Area of study for sea surface temperature all water bodies in Middle East including Caspian, Black, Mediterranean, Red and Oman Sea, Persian Gulf and north of Indian Ocean. We applied Principal Component Analysis (PCA) to the seasonal Sea Surface Temperature over six main water bodies around Iran. Number of 483 initial SST parameters has been reduced to less than 10 orthogonal SST modes having around 90% of initial SST variance.

Discussion and Results

The results of the monthly and seasonal SST PCAs over the period 1980-2009 are presented first. There are 9 significant center of SST change which is located over southern beach of India, Sudan beach, East of Mediterranean-Black Sea, north of Arabian Sea, west of Mediterranean Sea, Bay of Bengal, Caspian Sea, and Yemen beach. Major part of variances is concentrated in the first seasonal modes, varying from 29.9% in autumn over southern beach of India to 37.2% in winter near water bodies around Sudan. The results are summarized in table 1.

Table 1. Principal components of the Sea Surface Temperature of the regional water bodies

PCAs	Autumn		Winter		Spring		Summer	
	Change Center	Variance	Change Center	Variance	Change Center	Variance	Change Center	Variance
PCA1	South of India	29.9	Sudan beach	37.2	Sudan beach	34.8	Yemen beach and Sudan	32.8
PCA2	Sudan beach	21.6	East of Med. and Black Seas	13.9	South of India	16.4	East of Med., Black and Caspian	20.7
PCA3	East of Med., Black and Caspian	15.4	North of Arabian Sea	12.7	North east of Arabian Sea	13.4	South of India	15.5
PCA4	North of Arabian Sea	8.1	Bay of Bengal	9.3	East of Med. And Black Sea	13.1	Sudan beach	10.6
PCA5	West of Med. Sea	5.5	South of India	6.4	West of Med.	6.3	North of Arabian Sea	3.1
PCA6	Bay of Bengal	4.2	West of Med.	5.8	Caspian Sea	2.9	West of Central African beach	3

Regarding to the amount of variance presented in table 1, it is clear that the most of SST variability are concentrated over the water bodies around South of India, Sudan and Yemen beaches. Cluster analysis was used to obtain mean seasonal SST patterns. The first and important seasonal patterns of SST are shown in figure 1. In the figure, circles with + and - signs inside show positive and negative anomalies, respectively. Figure 1 shows that the important mode of SST variability in the autumns is bellow normal temperature in all water bodies under study, especially over Caspian Sea. The first mode of SST in winters accompanies by above normal SST over Caspian, Black and East of Mediterranean Sea and bellow normal SST around Sudan beaches and West of Mediterranean Sea.

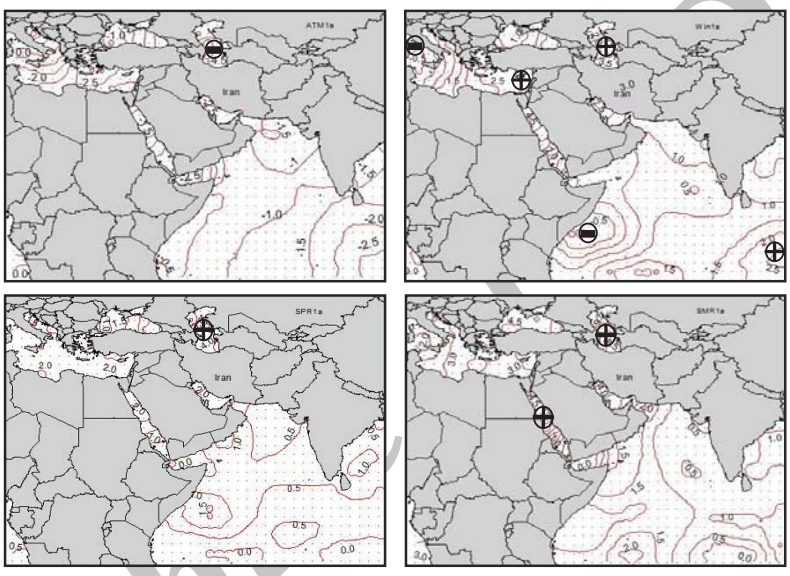

Fig 1. The first seasonal SST anomaly patterns of autumn (top-left), winter (top-right), spring (bellow-left) and summer (bellow-right).

In the sprigs the first mode of SST variability is characterized by more than normal over all water bodies, but the maximum SST increase is located over Caspian Sea. SST variability in summers is same with spring but amount of positive SST anomaly is significant over Red sea as well as Caspian Sea.

Seasonal precipitations of all 141 synoptic stations of Iran were correlated with 6 first SST PCAs of regional water bodies. Numbers of stations with significant precipitation correlation with regional SST patterns are shown in figure 2. Maximum and minimum number of stations with significant correlation was found to be in spring and autumn with 105 and 57 stations out of 141, respectively.

Conclusion

The thermodynamic interaction between Sea Surface Temperature and precipitation takes place through the

process of SST and humidity exchange at the sea-atmosphere-land interface. In this process, SST plays an important role, particularly in providing atmospheric water content and humidity resources of adjacent continental area. In this paper, seasonal precipitation of 141 synoptic stations of Iran are correlated to the SST PCAs patterns of regional water bodies consists of Caspian, Mediterranean, Black, Red, Oman and Arabian seas, Persian Gulf and north of Indian ocean. We found that the most important center of seasonal SST variability is located over water bodies nearing to Sudan beach and western-north part of Indian Ocean (winter and spring), South of India (autumn), East of Arabian sea, from Yemen to Sudan adjacent water bodies (summer). We found that water bodies near North of Indian Ocean and the Caspian Sea have maximum and minimum role in regional SST variability, among all water bodies around Middle East, respectively. Mean seasonal SST patterns were extracted using cluster analysis.

The study reveals that correlation between normalized precipitations between 141 synoptic stations of Iran and mean seasonal SST patterns over regional water bodies are significant in large number of weather stations. Numbers of stations with significant correlation out of 141 are 105, 83, 73 and 58 in spring, summer, winter and autumn, respectively. The results concluded that there are significant high correlations between SST of regional water bodies and precipitation of Iran, so, the major amount of precipitation variability over Iran can be explained by SST anomalies of regional water bodies. Linkage between SST and precipitation presented in this paper can be used as one of important components for seasonal precipitation prediction over Iran stations.

Keywords: Seasonal precipitation, regional water bodies, ERSST, Principal Component Analysis

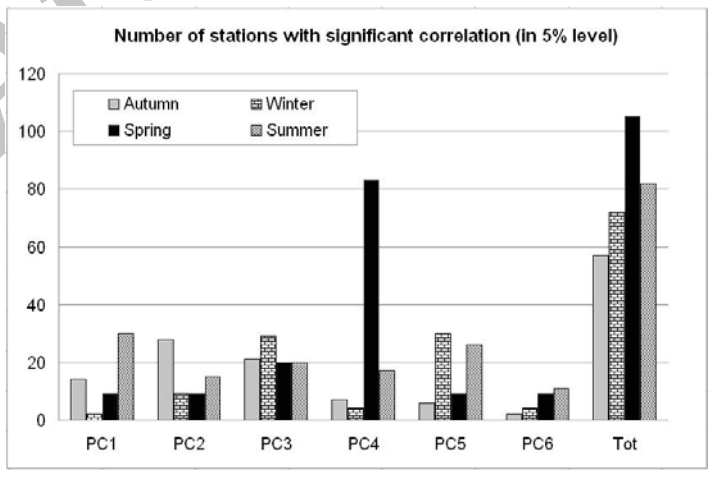

Fig 2. Number of stations with significant correlation between precipitation and different SST PCAs of regional water bodies.