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The Effect of Sea Surface Temperature and 2m Air Temperature on Precipitation Events in the Southern Coasts of Caspian Sea

Hamid Nouri[1]*, Hasanali Ghayour[2], Abolfazle Masoodian[2], Majid Azadi[3] and Alireza Ildoromi[1]

[1] Department of Watershed Management, University of Malayer, Malayer, Iran.
[2] Department of Geography and climatology, University of Isfahan, Isfahan, Iran.
[3] Atmospheric Science and Meteorological Research Center, Tehran, Iran.

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ABSTRACT There are a number of ideas to generate cloud and precipitation in the southern coasts of Caspian Sea, but none of them explain the cause of precipitation particularly heavy and super heavy precipitations precisely. This study describes main thermodynamic factors when the situation and location of synoptic patterns are effective. On the basis of daily data, monthly regimes and monthly trends of the Sea Surface Temperature (SST), difference between 2m air temperature and SST over the Caspian Sea as well as the SST gradients in different distances on latitude and its anomaly were calculated. For recognition of synoptic conditions, humidity advection, geopotential and sea level pressure maps were drawn. The results showed that there are three thermodynamic factors over the Caspian Sea to produce precipitation particularly from September to December. The first factor is arrangement and well organized of the SST gradients as it decreases from the south to the north of Caspian Sea. Also, the SST over the Sea must be enough warm to produce clouds and precipitation. The last factor is the difference between 2m air temperature and SST. When the synoptic patterns in different pressure levels are suitable for instability, the air-sea interaction process is the most important factor to produce the advection humidity, clouds and precipitation particularly heavier precipitation events in the north of Iran.

Key words: *Air temperature, Caspian Sea, Precipitation, SST*

1 INTRODUCTION

It is obvious that many parameters cause atmospheric instability and cloud formation which leads to produce precipitation. But some of them are always more important especially in coastal terrains such as north of Iran. The Caspian sea is the largest closed water body on the surface of the earth. The sea has a surface area of 371,000 square kilometers and a volume of 78,200 cubic kilometers. Its basin has no outflows and is bounded by northern Iran, southern Russia, western Kazakhstan and Turkmenistan, and eastern Azerbaijan. Its complete lack of any natural connection with the oceans makes it a very special ecosystem, and as such particularly vulnerable to external forces, such as climatic conditions. On the other hand, the precipitation of the southern coasts of

Corresponding author: Department of Watershed Management, University of Malayer, Malayer, Iran. Tel: +988512355380, E-mail: hamidwatershed@yahoo.com

Caspian Sea is more than the rest of Iran (its maximum is 2000mm). The precipitation is the most significant factor within the climatic factors in this region (Masoodian, 2003).There aren't sufficient investigations in the field of precipitation particularly relationship among sea breeze conditions, sea surface temperature and precipitation in this area. Thus, it has been very important to study the min Iran.

The Sea Surface Temperature (SST) is one of the key parameters for understanding air-sea interaction process in coastal regions. Kawai and Wada (2007) reviewed the impacts of diurnal SST variation on the atmosphere at various time scales, and suggested the potential importance of diurnal variations of SST on the sea breeze circulation in coastal areas. However, many weather forecast models currently use, as their input data, objectively analyzed SST data which do not include diurnal variations even when these models are applied to the atmosphere near the coast. The numerous studies have investigated the influence of SST over rainfalls particularly for special period of year for example monsoon or winter. Zhou *et al.* (2009), and Zhou and Wu (2009) investigated the influence of SST and ENSO on winter rainfall over South China. They were found that winter rainfall over South China has a significant correlation with Niño-3 and SCS SST. The interannual variations of the East Asian summer monsoon are closely associated with SSTs in the tropical Pacific (Huang and Zhou, 2002; Huang *et al.*, 2003; Wu *et al.*, 2003; Yang and Lau, 2004 and Lin and Lu, 2009). Also, the relationship between SST and rainfall variability over South China has been studied (Chan and Zhou, 2005; Lin and Lu, 2009). The differences observed over the upper-level indicate that the SCS SST has a closer relationship with the circulation changes over mid latitudes in East Asia, as compared to those in the Niño-3 SST. It has been established that it is the absolute value of SST, rather than its anomalies determines that there is a threshold value of approximately 26ºc that typically has to be exceeded for it to happen in coasts of Peru (Woodman, 1999). Several studies have investigated the influences of SST on the precipitations over the Western Africa (Land sea and *et al.*, 1992; Biasutti and *et al.*, 2004 and Hunt, 2000). Large-scale changes in SST patterns are thought to be the major driving forces, which promote changes in atmospheric circulations (Herrmann and Hutchinson, 2005). Also, modeling studies confirmed statistical association between observed Sahel precipitation variability and tropical Atlantic SST, in the mid 1980s (Giannini and *et al.*, 2005). Therefore, large scales to regional SST were assumed in several researches to have an impact or influence on the Sahel and more general African precipitation regimes. Some papers deals with the periodic fluctuation of precipitation at some stations in the world and its links with sea surface temperature. Trends for these stations were evaluated using the Mann–Kendall (MK) nonparametric test, regression analysis, autocorrelation and the other analysis. SST of the Atlantic Ocean, Indian Ocean, and Mediterranean Sea have significant cross-correlations with precipitation in these areas in the world (Loubere, *et al.*, 2013; Hong, *et al.*, 2009; Stammer john*et al.*, 2011; Sebastien Bertrand, 2012 and Ahmedoua, 2008).

The reasons of generating of precipitation vary in the different months in the Southern Coasts of Caspian sea because of different synoptic patterns, wind directions, air temperature and SST, thus Caspian sea have more or less influence on atmospheric environmental issues such as heavy precipitation rainfall, through the land-sea breeze mechanism (Alijani, 2002, Moradi, 2003; Ghaemi, 2007 and Khalili, 2007). This research tries to investigate the impact of the SST, its anomaly and gradients in precipitation events. Also, it studies2m air temperature and SST together over the sea and precipitation in the coastal regions. However, it is necessary to investigate due to a lack of sufficient studies especially in the field of heavier precipitation events in the Southern coasts of Caspian Sea precisely.

2 MATERIALS AND METHODS

2.1 Study Area

The Caspian Sea is the largest lake in the world, but this has not always been true. Scientific studies have shown that until geologically quite recent times, approximately 11 million years ago, it was linked, via the Sea of Azov, the Black Sea, and the Mediterranean Sea, to the world ocean. The Caspian is of exceptional scientific interest, because its history particularly former fluctuations in both area and depth offer clues to the complex geologic and climatic evolution of the region. Human-made changes, notably those resulting from the construction of dams, reservoirs, and canals on the immense Volga River system (which drains into the Caspian from the north), have affected the contemporary hydrologic balance. It covers an area of about 386,400km^{2}larger than Japan and its surface lies some 27 m below sea level. The maximum depth, toward the south, is 1,025 m below sea level. The sea contains some 78,200 km3 of water about one-third of the earth's inland surface water. The sea is bordered in the northeast by Kazakhstan, in the southeast by Turkmenistan, in the south by Iran, in the southwest by Azerbaijan, and in the northwest by Russia.

2.2 Data collection

The SST, its anomaly and 2mair temperature data are considered over the Caspian Sea from 1982 to 2004(http:// www.ncdc.noaa.gov and http://www.dss. ucar.edu). The precipitation events were computed on the basis of daily precipitations from 168 stations in the north of Iran provided by the Iran Meteorological Organization. Its statistical parameters such as maximum, mean and rainfall coverage area were calculated. The SST and its anomaly over all grid points in Caspian Sea have been calculated in every 10 days from 1982 to 2004. The gradient of SST for different distances of 0.25, 0.5, and 1 up to 9 degrees in latitude were computed and their correlation with daily precipitation has been accounted. Precipitation events were classified into 4 groups for each station (light, moderate, heavy and super heavy) using Principal Component Analysis (PCA) and Cluster Analysis (CA) on the basis of statistic parameters of rainfall events. The monthly regime of SST and its difference with 2m air temperature were compared to monthly regime of heavy and super heavy rainfalls respectively. In order to recognition of annual variability of SST, the monthlytrend of SST was analyzed. Finally, advection humidity, geopotential and sea level pressure maps were drawn for representative events. These maps help realizing synoptic patterns and humidity conditions in different SST and 2m air temperature.

3 RESULTS

Correlations between maximum, mean and coverage area of daily precipitations and SST gradient in 0.25º, 1º and 2ºonlatitude show that there are two positive correlation sections. The first is near to coasts and the other is between the middle partand the end of the sea in the north. Also, there is a negative correlation section between two positive correlation sections where it is near to the middle of the sea. It means that as SST gradient over the offshore in the north half of the sea increases and as SST gradient deceases in distance of 3º to 4º from coasts, daily rainfall parameters increases. Correlation maximum (21.6 %) is related to coverage area rainfall and 1º distances which it is located between 42. 5ºN to 43. 5ºN (it is significant in 5 % area). For SST gradient distances more than 2º, 3º up to 9ºon latitude, correlations are just positive. The highest correlation (22.7 %) has been allotted to coverage area rainfall for 4ºdistances on latitude and over the middle of the sea (it is significant in 5 % area). On the other hand, if data were limited to precipitations which are more than 50, 100, 120 and 150 mm, its correlations would be increased up to about 28, 34, 46 and 72%, respectively particularly for mean and coverage area of rainfalls in 0.25º and 1º distance son latitude. With increasing distances to more than 1º up to 9º on latitude, the correlations will be decreased. It means some parts of the sea perhaps have to be warmer and the other parts must be colder in 0.25ºto 1ºdistances on latitude for producing of extreme rainfalls. Also, the results show that the role of coastal offshore and the second half of the sea in daily rainfall variations especially its coverage area is very important. Correlations between maximum, mean and coverage area of daily rainfalls and anomaly SST gradient in 0.25º and 1º distances on latitude show that there are 4 to 6 positive correlation sections and 4 to 5 negative correlation sections over the sea. For 2º, 3º up to 9ºdistances on latitude, the number of sections decreased. The results show that similar to SST gradient, with rising of distances and reducing maximum amounts of daily rainfalls, its correlation coefficient decreased. SST anomaly gradient have negative correlation coefficients with mean and coverage area rainfall in 4º to 9º distances on latitudes in coastal offshore. For 9º distances, its correlations with each of rainfall parameters are relatively weak (14.4% to 15.9%) and positive. Maximum correlation coefficient is about 66.1% in 1ºdistances on latitude between 44.125º N and 45.125ºN. These coefficients are the highest for rainfalls greater than 150mm.For example; it is about 72.3% in 1º distance on latitude that is located between 44.125ºN and 45.125ºN.With regard to relationship between SST and heavier rainfalls in the previous part of this study, in the first step, daily, monthly composite, seasonally composite SST and SST anomaly maps for super heavy rainfall events are drawn. The results show that for super heavy rainfall events in spring, there is a cold pond in the middle of the Sea about 42ºN to 44ºN. Its Sea surface temperature is 14ºc which is about 5.5º to 6º lower than coastal areas in north of Iran. Thus if air mass prone to pass over the Sea, it can't usually absorb sufficient moisture through water for producing heavy and super heavy rainfall events. It was occurred because the cold air masses usually don't pass over all latitudes of the sea from it's the north to the south with regard to be weak high pressure Black and Siberia and shortage of northern, north eastern and north western cold winds in this season. On the other hand, the north half of the Sea doesn't have a suitable SST and SST gradient conditions at this time. In summer (Figure1a), the SST is higher than spring (Figure 1b) and the cold pond move to the east of Caspian Sea about 41ºN to 43.5ºN. This displacement that was happened in length of summer gradually will open the passage of air masses in order to attract of adequate moisture over the sea. The other cold pond created in north of the sea at the end of this season. There is a little difference between maximum and minimum SST in summer and spring expect of September (Figure 1c) that it is about 6º to 7º but SST in summer is 5º to 6º warmer than spring and reach 26ºc to 29ºc in the coasts. Regarding new SST and SST gradient conditions and increasing the pressures in high pressures over the northeast and northwest the sea, colder air masses can pass from the north to the east. These air masses can develop and absorb more moisture especially in September. In autumn (Figure 1e), SST gradient is well organized arrangedas the SST is gradually increased from north to south. The cold pond is located in the north part of the Caspian Sea, so the length of passage and time

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for absorbing of moisture is sufficient and suitable. The difference between the north and the south SST is about 10º. In spite of this fact that the SST in this season over the coasts is about 4º to 6º lower than spring and summer, because of increasing gradients in length of the north to the south and its suitable arrangement, enough SST and effective location and strengthening high pressures, are occurred a lot of rainfall events specially heavy and super heavy groups in this season, particularly in October (Figure1d).In spite of this fact that the SST is cooler in November(Figure1e) and December, the SST conditions, its gradients are ready for seepage water into air masses, if there had been the cold air masses over the Sea and the other suitable dynamic conditions in order to occurring a rainfall event. In winter (Figure 1f), the SST gradient is approximately similar to autumn. However, the SST is very lower in this season than autumn (about its half). This is the main reason that why rainfall does not suit for rainfall events in winter as frequency as autumn. The importance of above topics has been seen on SST composite map (Figure1g) that shows general conditions for occurrence of super heavy rainfall events. In order to explain this fact, a representative day map (1990.10.05) has been shown. In this day, maximum, mean and coverage area of rainfall are 147.2 mm, 15.1 mm and 73.2%, respectively. There are a high pressure in west of The Caspian Sea that cause air masses pass over the sea toward its southern coasts. Also, a deep trough is located on the Caspian Sea from 700 to 500 hpa levels from the north east to the south west. The SST map (Figure 1h) and humidity advection map (Figure 2) show the situation of humidity movement toward north of Iran and suitable SST and SST gradient over the Sea respectively. The results of SST anomaly study show that there are good relationships between these maps and anomaly of rainfalls when the rainfalls are generated or strengthened by Caspian Sea. The SST anomaly maps in different seasons vary for super heavy rainfalls. Figure 3shows the SST anomalies maps, the composite map and the selected days maps. It has been seen positive SST anomalies in the most important parts over the sea that it has been certainly helped to generation of super heavy rainfall events. For example 1986.09.29and 1996.11.11are selected. In these two representative days the amounts of maximum rainfall were 126 mm and 117.3 mm respectively. In the first day, anomaly rainfall was 18.7 mm and in the second day it was 18.3 mm. This is important that cold air masses pass over the part of the Sea that it has positive anomaly of SST. Humidity advection (Figures 4 and 5) from the north to the south of the sea over warm SST and suitable SST gradient helped the generation of such rainfalls. There are a high pressure in around of the Black sea and a low pressure in north east of Iran can move air masses towards north of Iran. Also, a deep trough is located from north of Caspian Sea to east of the sea Mediterranean that cause divergence in 700 to 500 hpa levels. It seems that if the SST gradients were better as they can be covered throughout the Sea from the north to the south not only the middle to south, perhaps it would be rain more heavily. The similar to this condition has been seen in1990.10.05 that maximum rainfall was 147.2 mm and its positive anomaly recorded 12.2 mm. Maximum, mean and coverage area of monthly rainfalls have good correlations with both the SST and difference between SST and 2m air temperature (2m air temperature-SST), significantly. The highest correlation coefficients are related to mean of monthly rainfalls and difference between SST and 2m air temperature over the sea (61.3%). Mean of SST over the sea and mean of coverage area of monthly rainfalls (58.4 %) and maximum of coverage area of monthly rainfalls (52.9 %) have the highest correlations.

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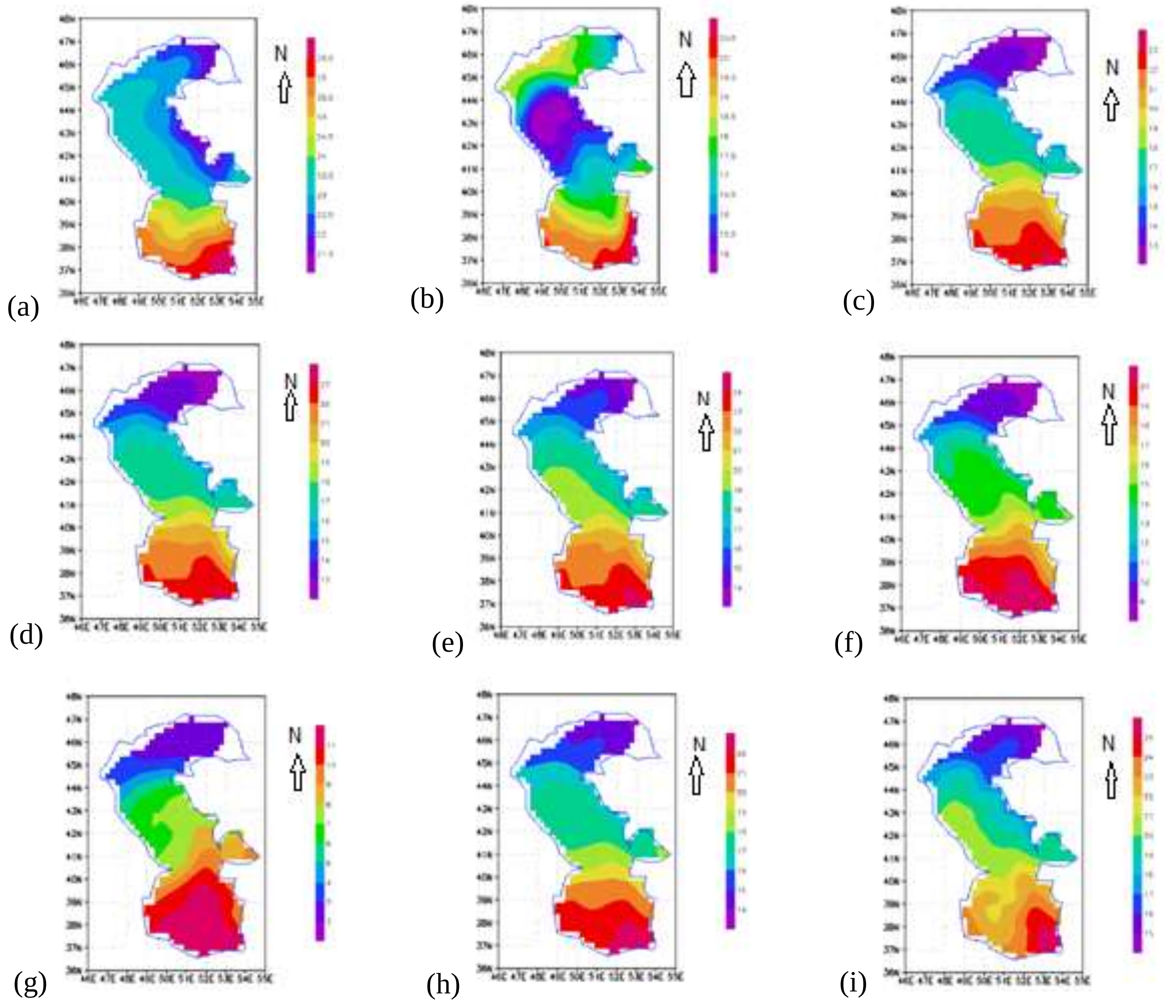

Figure 1 The SST map of super heavy rainfall events in Summer (a), Spring(b), September (c), Autumn (d), October (e), November (f), Winter (g), long term mean annually (h), 1990.10.05 (i)

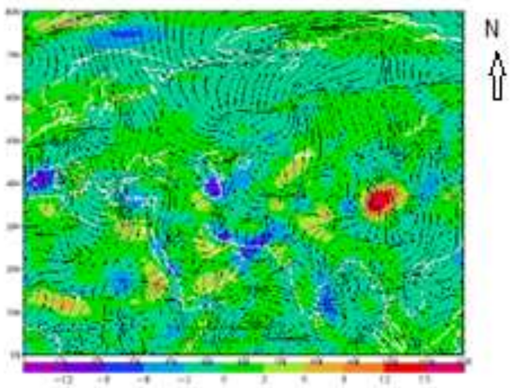

Figure 2 The humidity advection map in 1000 hpa in 1990.10.05

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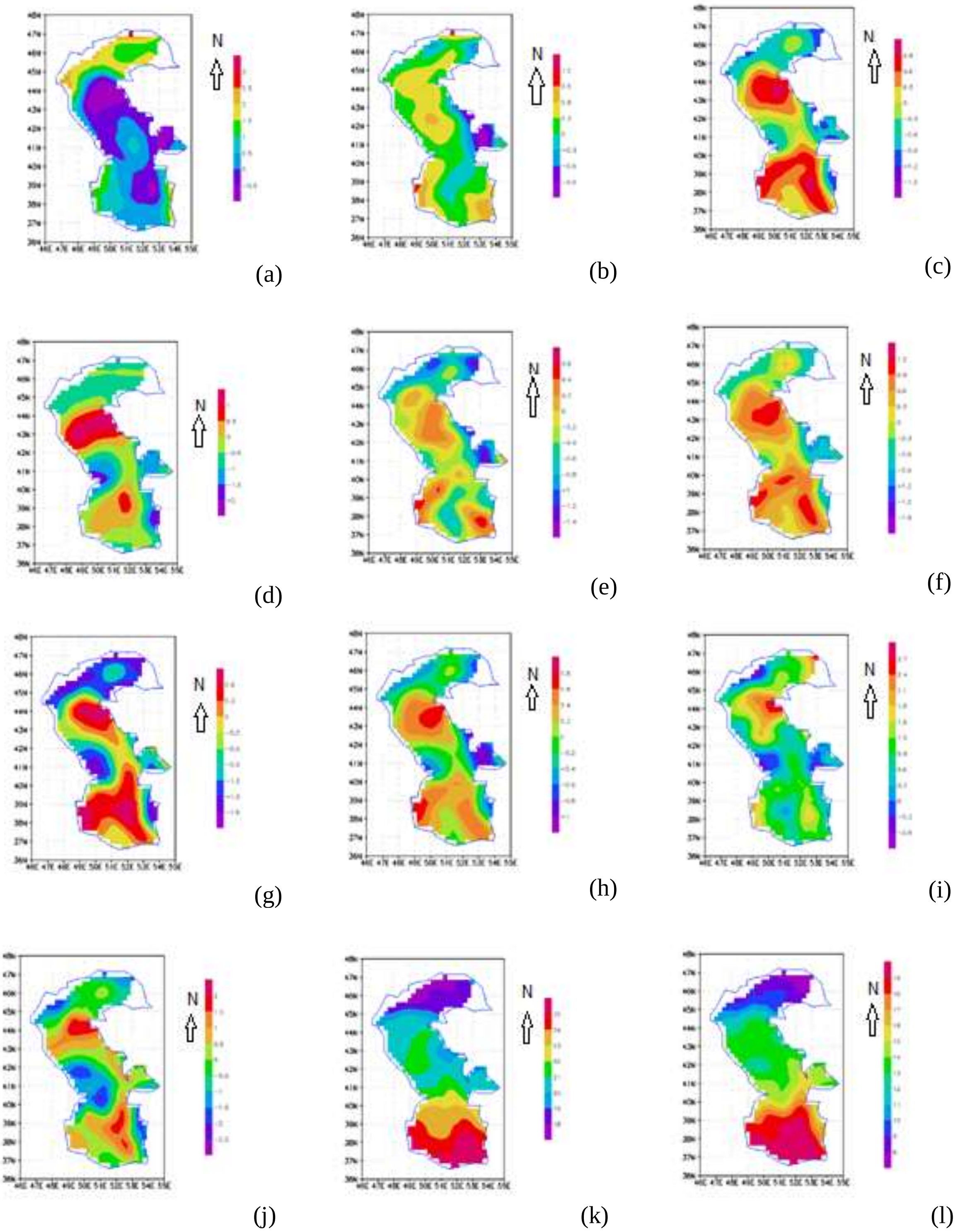

Figure 3 The SST anomaly map of super heavy rainfall events in Spring (a), Summer (b), Autumn (c), Winter (d) , September (e), October (f), November (g) , long term mean (h), 1986.09.29 (i) 1996.01.11 (j) and SST map in 1986 .09.29 (k), 1996.01.11 (l).

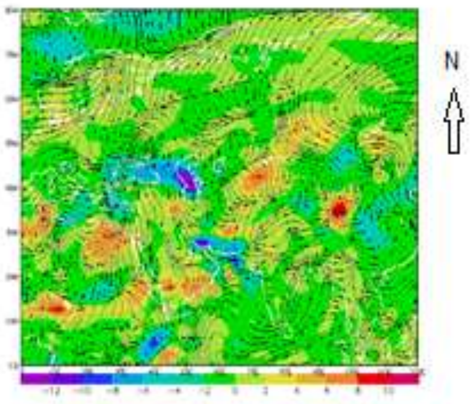

Figure 4 The humidity advection map in 29. 09. 1986

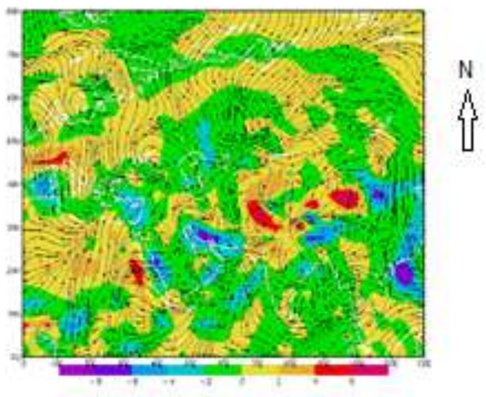

Figure 5 The humidity advection map in 11. 11. 1996

The results of the regression analysis of mean SST and mean 2m air temperature – SST over the sea and different parameters of monthly rainfall show that the highestR^2 (38.2 %) is related to mean monthly rainfalls significantly. This coefficient is maximum in September and October (66.5 %) for mean of rainfall. The regression equation has only one variable which is the difference between 2m air temperature and SST. The SST variable was omitted from the equation. In order to recognize the relationship between precipitation and 2m air temperature-SST variable have been analyzed using two variables. The first one is monthly regime and the other is the interannually monthly trend. Figure6shows that mean SST, 2m air temperature and SST as well as mean and maximum precipitation arein good agreement to each other in this area.It has been seen negative values of (2m air temperature-SST) from September to March and positive values from April to August. Maximum and mean rainfalls have a good harmony to the index as they will increase or decrease if the index go up or go down. The Figure 7reveals monthly trend of rainfalls and the 2m air temperature-SST (DTST) over the study period from 1982 to 2004. It shows that there is a good harmonious trend between them from September to February with increasing (2m air temperature-SST), the amount of rainfall is decreased and vice versa. There is not the harmony from March to August. It seems that (2m air temperature-SST) has to be much over the sea to produce heavy rainfall in the southern coasts of Caspian Sea particularly at the end of summer and autumn season. On the other hand, the SST must be more than threshold and sufficiently warm for starting of cloud formation and rainfall. The results of investigation on monthly SST and (2m air temperature-SST) and different statistical parameters rainfall in this area show that these two indexes are very important to explain the amounts of rainfalls specially, mean of rainfall and mean of coverage area of rainfall. At the beginning of September that the (2m air temperature-SST) reach to negative values and the SST are suitable, the rainfalls are increasing. The monthly (2m air temperature-SST) doesn't usually get to -1.2ºc and the monthly SST in this month is between 20.7ºc and 24.2ºc. In October that it has the highest rainfall, the (2m air temperature-SST) is increased. It is always negative and in the highest value get to -2.4ºc. Also, the SST between 15.9º and 20.8ºhas warm adequately. Then, in November, the (2m air temperature-SST) is increased. It is always negative and its maximum is -4.75ºc. Also, the SST is between 11.8ºc and 14.6ºc that it has still adequate warming for rainfall generation. In December, the (2m air temperature-SST) is increased again. It is always negative and its maximum is similar to November (4.75ºc). Also, the SST is between 8.5ºc and 10.75ºc. This month has the highest frequency from negative values of (2m air temperature-SST) more than 3ºc and 4ºc.

Although the (2m air temperature-SST) rise in both of months of November and December, but because of falling of the SST, the sea is not warm enough to produce high rainfalls. This is the reason of decreasing of rainfall in these two months than October.

In January, the (2m air temperature-SST) is decreased as it is usually about 2ºc and the highest value is 3.4ºc. The SST is between 6.3ºcand 8.7ºcand is not warm enough to produce precipitations. In February, the 2m air temperature-SST is decreased about 1ºc than a month ago. The SST is between 5.7ºc and 7.6ºc that it has not warming enough to produce precipitations. After this month, even though there are not favorable and harmonious monthly trends between the (2m air temperature-SST) and rainfall but some rainfall events are occurred in cause of these processes. In these months both the water and the air are warmer until the end of August. These conditions cannot usually help lifting the air through thermodynamic processes because of stability. There are some cases for confirming this idea. For example in September 2002 that the (2m air temperature-SST) is the highest mean of positive values among the September and October months and about +0.5ºc, mean of rainfall in this area is the most weak and about 0.5 mm. Although the Sea is enough warm but because the air mass absorb the less moisture, the precipitations are low. On 20 and 21 of September 2002 that the (2m air temperature-SST) had been reached to about -1.8ºc, the maximum of rainfall had been more than 50 mm. There are these conditions in September 1984 too. At this time the (2m air temperature-SST) is +0.3 and rainfall is 0.5 mm. Conversely, in October 1987 and 1982 and November 1993 that the amounts of (2m air temperature-SST) for them are low and -2.4ºc, -2.1ºc and -4.8ºc respectively, monthly rainfalls are 5mm, 4.7 mm and 5.1mm respectively. Also, there are a lot of daily cases that it is explained such conditions. For example, in date of 1995.10.17, a heavy rainfall was occurred in this area. Maximum and mean of rainfall were 180mm and 11.1mm respectively. Mean of 2m air temperature-SST, over the Sea was about -7 ºc that is one of the highest negative values in this area. Also, the SST was 17.2ºc that is warm enough for rainfall. The other example is on 1998.10.08 that a heavy rainfall was occurred in this area. Maximum and mean of rainfall were 202mm and 18mm respectively. Mean of 2m air temperature-SST over the Sea was about -5.6ºc that is the high negative value in this area. Also, the SST was 19.1ºc that is warm enough to produce precipitation.

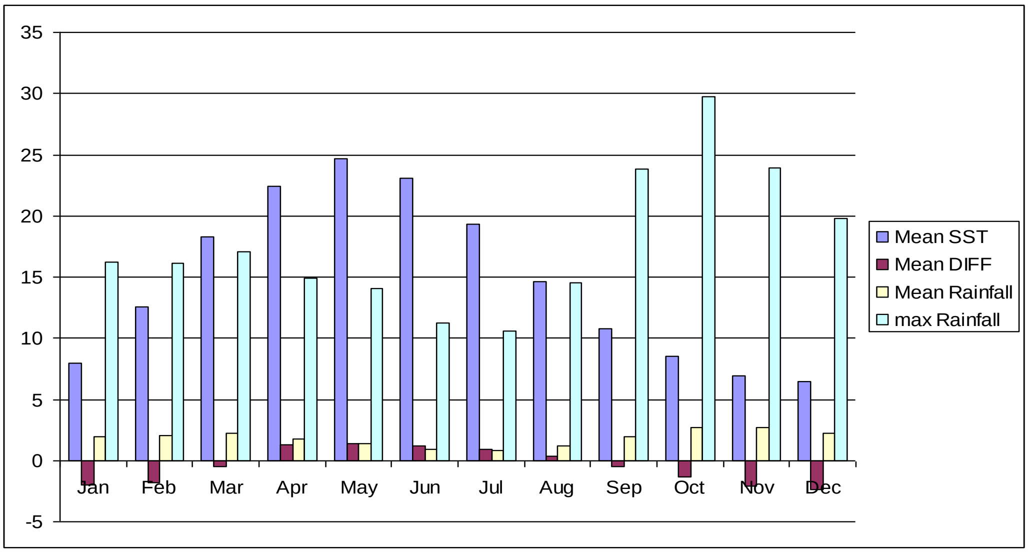

Figure 6 Monthly regimes of mean SST and 2m air temperature-SST over the Caspian sea for all precipitation events in North of Iran

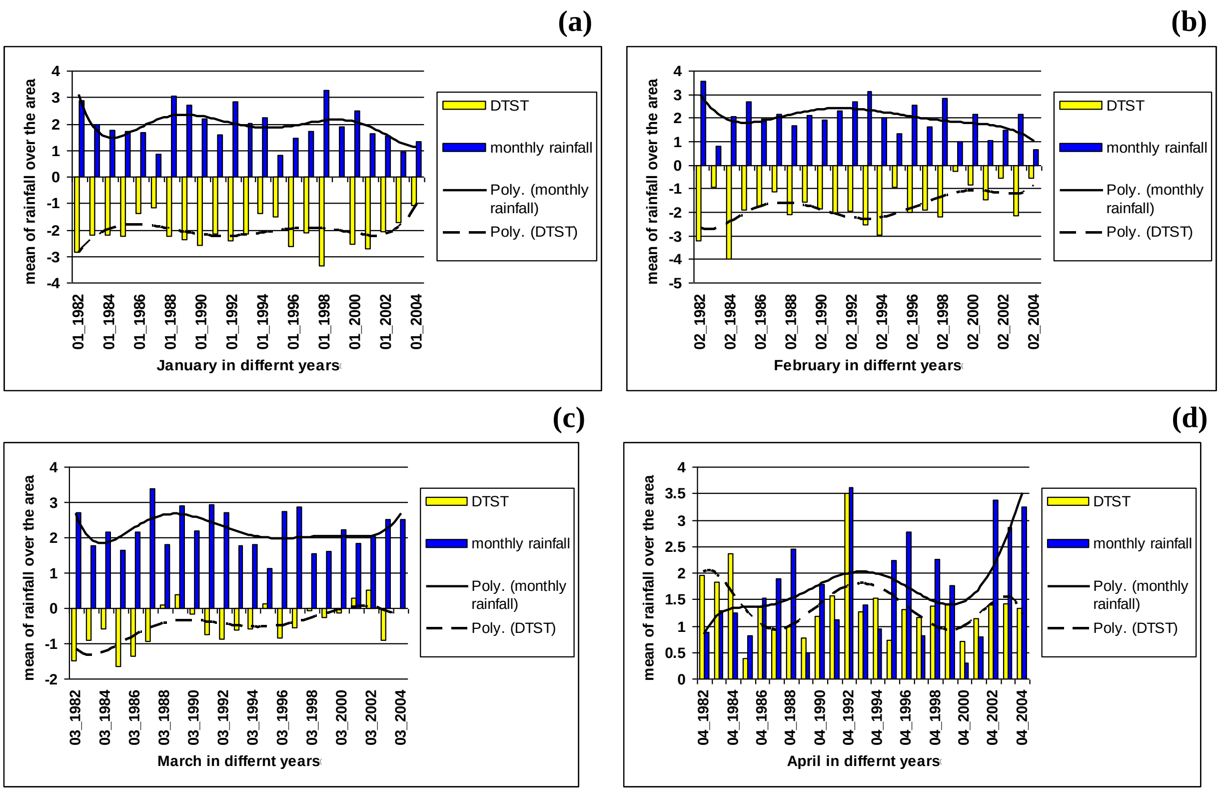

Figure 7 Trends of mean precipitation and 2m air temperature-SST in different months during 1982-2004

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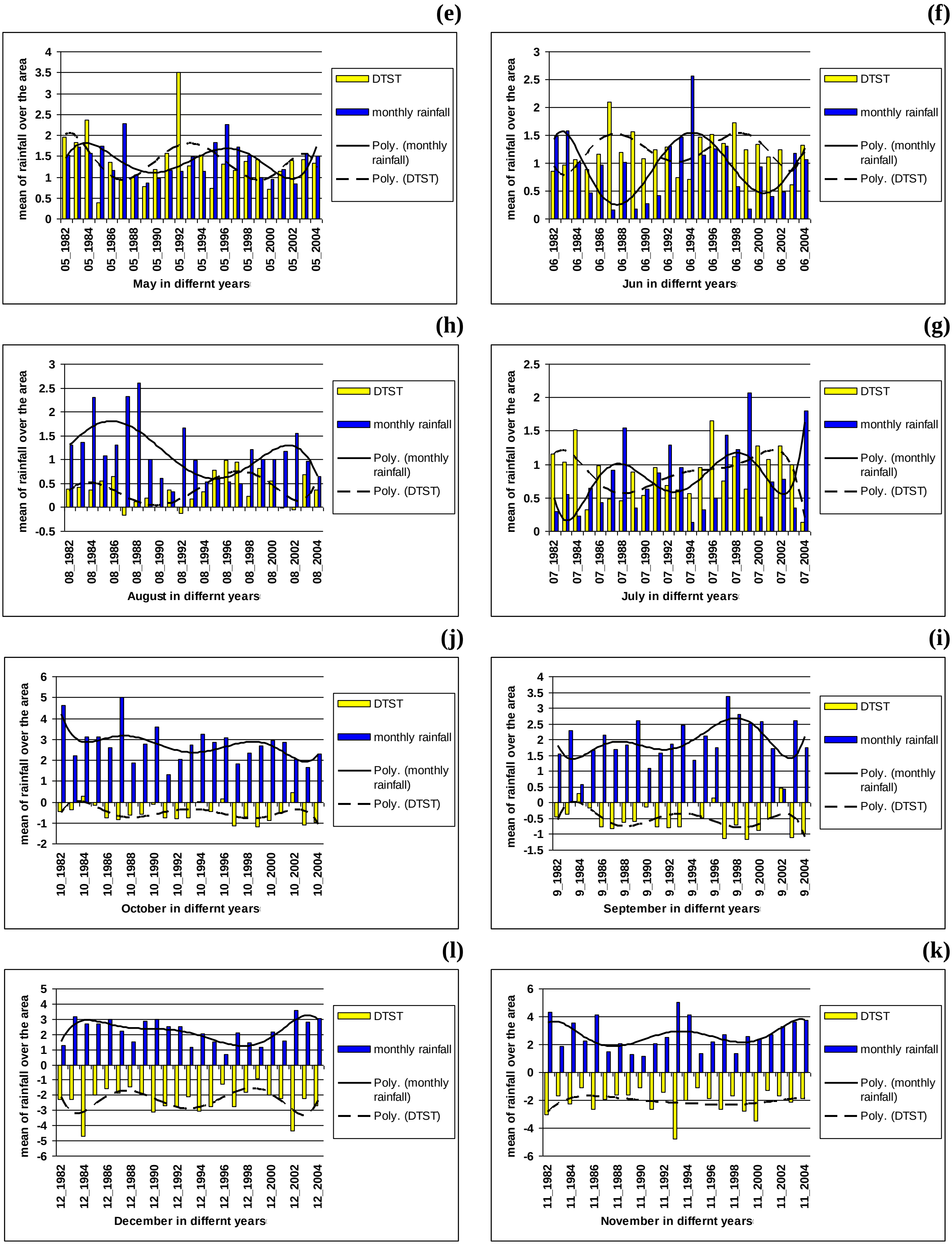

Figure 7 (Continue)

4 DISCUSSION

The Precipitation in the north of Iran and the southern coasts of the Caspian Sea is different from the rest of the country. Season of precipitation in the most parts of Iran is in winter and its annually average is less than 250 mm but the precipitation events in north of Iran have a high frequency in the end of summer and autumn as well as its annually average is more than 1000mm. The results that have been mentioned in previous study in the world(Chen, 1977, Huang and Wu, 1989; Yang and Lau, 1998; Chang *et al.,* 2000; Lau and Weng, 2001; Huang and Zhou, 2002; Huang *et al.*, 2003; Wu and *et al.,* 2003; Yang and Lau, 2004 and Lin and Lu, 2009) and in Iran (Alijani, 2002, Moradi, 2003; Ghaemi, 2007 and Khalili, 2007) are confirmed in this study such as effect of SST, cold air masses and thermodynamic conditions on rainfalls especially heavier precipitations. The results of this research agree with the ones insome papers in the world that SST of the Atlantic Ocean, the Indian Ocean, and the Mediterranean Sea have significant cross-correlations with precipitation in these areas (Loubere *et al.,* 2013; Hong *et al.,* 2009; Stammer john *et al.,* 2011; Sebastien Bertrand, 2012; Ahmedoua, 2008). Moreover, the SST gradients and its anomaly are important over the Caspian Sea. Alsothe most effective factor is 2m air temperature-SST over the sea and this factor is more important than SST values. This study reveals the vital role of Caspian sea especially coastal offshore and the second half of the sea to produce precipitation from September to December.

5 CONCLUSION

There are 3 important conditions which lead to produce clouds and precipitations in the southern coasts of the Caspian Sea.

1- The arrangement of the SST gradients over the sea is the main factor in complement of this process. The SST must be colder in the north and warmer in the south as it increases from the North to the South gradually. In these conditions, cold air masses that move from the North to South and next to the north of Iran can become humid adequately, because the air masses have an enough time to get warm. The mean and coverage area of heavier rainfalls have the more correlation coefficient than lighter rainfalls significantly with the SST gradients in 0.25 degree distances in latitude and the SST anomaly gradients in 1 degree distances in latitude. Also, the results show that the role of coastal offshore and the second half of the Sea in daily rainfall variations especially its coverage area is very important.

2-The SST over the Sea must be more than threshold which it is necessary to produce precipitation. This threshold for the SST monthly mean of throughout of the Sea is usually about 6ºc. The SST over the Sea from the end of August to December is enough warm to produce clouds and precipitation. After December air temperatures get to Zero and less than in the half of northern part of the Sea, so the SST is low. On the other hand the occurrence of a rainfall event anomaly needs to existing one or some of parameters anomaly such as surface wind anomaly or jet, sea level pressure anomaly, geopotential height anomaly in different levels as well as humidity anomaly, vorticity anomaly and SST anomaly. These anomalies can be unique for each event. The results show that rainfalls anomaly such as heavy and super heavy rainfalls suit with the SST anomaly over the Sea mostly.

3-The difference between 2m air temperature and SST is the most important factor to produce precipitation in this area. This factor shows the role of interfacing of the Sea and atmosphere to generate rainfall events obviously. Mentioned index can cause that cold air masses absorb the moisture and become unstable if it is negative. This characteristic can be seen always from September to March but

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because the SST in January, February and March aren't warm sufficiently, there is suitable precipitation just from September to December. In addition, the index mean and the index in the great areas over the sea is very important than the index in each grid point in different parts. Besides, monthly trend show that there is a good arrangement between the 2m air temperature-SST and precipitation. Every year that the monthly index increases, the monthly precipitation increases and too vice versa.

Thus, in the north of Iran, this index is more important than the SST and the SST anomaly, even though the high SST is the main factor to produce extreme monthly rainfall in some parts of the world such as Peru (Woodman, 1999).

By the way, mentioned conditions are the most important to generate sea-breeze circulation and to produce precipitation particularly heavy and super heavy events, especially in autumn but they aren't all reasons certainly. Location of high pressures, moving air masses direction and humidity advection as well as the existence of a low pressure in 700 to 500 hpa levels are the other main causes that due to generate or enhance the rainfall events in the north of Iran. Thus, if some synoptic and dynamic conditions are suitable, the precipitation will have a good correlation with (2m air temperature-SST) and precipitation anomaly have a good correlation with SST anomaly too.

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اثر دمای سطح آب و دمای هوا روی بارش سواحل جنوبی خزر

حمید نوری[۱]، حسنعلی غیور[۲]، ابوالفضل مسعودیان[۲]، مجید آزادی[۳] و علیرضا ایلدرومی[۱]

۱- گروه آبخیزداری، دانشگاه ملایر، ملایر، ایران

۲- گروه جغرافیا و اقلیم شناسی، دانشگاه اصفهان، اصفهان، ایران

۳- مرکز تحقیقات علوم جوی و هواشناسی، تهران، ایران

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چکیدهنظریات مختلفی در مورد علل ایجاد بارش در سواحل جنوبی خزر مطرح می‌شود. اما هیچکدام از آن‌ها علت رخداد بارش‌ها به ویژه بارش‌های سنگین و فوق سنگین را به طور دقیق شرح نمی‌دهند.این مطالعه شرایط ترمودینامیک جو را در زمان تاثیر الگوهای همدید رخداد بارش‌ها بررسی می‌کند. رژیم و روند ماهانه دمای سطح آب، اختلاف بین دمای سطح آب و دمای هوا، گرادیان‌های دمای سطح آب درعرض‌های جغرافیایی مختلف و ناهنجاری آن با استفاده از داده‌های روزانه، محاسبه شدند. برای تحلیل شرایط همدید رویدادها، نقشه‌های فرارفت رطوبت، ارتفاع ژئوپتانسیل و فشار سطح دریا ترسیم شدند. نتایج نشان می‌داد سه عامل ترمودینامیک روی دریای خزر باعث ایجاد شرایط رخداد بارش به ویژه در ماه‌های سپتامبر تا دسامبر می‌شوند. اولین عامل آرایش منظم گرادیان‌های دمای آب است به طوری‌که از شمال تا جنوب دریای خزر مقدار دمای آب به طور منظم افزایش می‌یابد. همچنین دمای آب دریا برای ایجاد بارش باید به اندازه کافی گرم باشد. آخرین عامل تفاوت بین دمای آب و دمای هواست. وقتی الگوهای همدید ترازهای مختلف جوی باعث ناپایداری می‌شوند، فرایند تاثیر متقابل آب و هوا، مهم‌ترین عامل ایجاد فرارفت رطوبت، ابرها و تولید بارش به ویژه بارش‌های سنگین در شمال ایران هستند.

کلمات کلیدی: بارش، دریای خزر، دمای سطح آب، دمای هوا