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The impact of the inlet cyclones to the Caspian Sea on the sea level fluctuations

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ABSTRACT

In this article, source and trace of the cyclones produced on the Caspian Sea were investigated from 2012 to 2017. The required data for this research consists of water level data recorded at stations such as Amirabad port, as well as other ports, mean atmospheric pressure at the Sea surface and wind data from ECMWF Web site. Results show that source of atmospheric low pressure is from the southwest and west of the Caspian Sea and in 2016 it is from the northern region of this basin. These atmospheric low pressures mostly enter to the Caspian Sea from the northwest of the mid Caspian Sea and their moving trace is to the east and southeast of the southern Caspian Sea. With the investigation of the impact of atmospheric low pressure and wind on the water level of Caspian Sea, in the coasts of Bandar-e Anzali, Fereydunkenar and Amirabad, it was obtained that in 2013 and 2016 low pressure effect and in 2015 wind effect was the most effective phenomena on the water level. The maximum movement velocity of the atmospheric cyclones from 2012 to 2017 was respectively equal to 10.17, 7.96, 44.7, 16.7, and 2.6 m/s.

1. Introduction

The effect of atmospheric cyclones on Iranian water level fluctuations in the Persian Gulf and the Gulf of Oman has been studied in several researches [1, 2, 3]. Variation on sea level when atmospheric cyclone crosses is affected by two phenomena: firstly, wind intensity which causes momentum transmit through pushing the water level and secondly, atmosphere pressure changes which cause fluctuation on the sea level is known as inverse barometer effect [4]. If atmosphere pressure decreases in a region, and air starts to move from surround to the low pressure region, this atmosphere stream is known as cyclone. It is clear that this stream movement to cyclone center is affected by Coriolis force [5]. Pressure centers with respect to the nature and cause of formation are classified into two groups: dynamical and thermal. Thermal pressure centers depended on intensity of the sun radiation and consequently depend on latitude and seasons. Thus, high pressure thermal centers are formed at higher latitudes and during the cold seasons of the year whereas low pressure thermal centers are formed at lower latitudes and during the warm seasons of the year. In other words, the thermal centers depend on the thermal properties and the distance in proportion to the surface of the earth, which decreases in intensity and eventually disappears at an altitude of about 1500 meters above the ground. Dynamical pressure centers are affected by temperature distribution on the earth as an indirect factor, unlike thermal pressure centers [6]. Water level in various ambiances such as oceans, seas, lakes, gulfs, estuaries, rivers, regions far from or close to the coasts changes continuously because of various phenomena [7]. Some marine areas are affected by significant surges several times per year. This phenomenon has historically caused catastrophic water-level enlargements of up to 4.44 m, threatening and claiming human lives and producing major economic and material damages. The negative surges are less frequent, but when they do occur, inhibit the access to the principal harbors and waterways and disable the drinking water intakes of the Metropolitan Area [8]. One of the studies conducted on this field examines the effect of meteorology cyclones transmission on the water level fluctuation in Qeshm channel. The water level and the meteorological data were obtained from National Cartographic Center and Iranian Meteorology Organization, respectively. The results of this research indicate that the period time of the atmospheric cyclones surge in Qeshm channel is about 1-2 days. Statistical investigations, also show that Qeshm channel is mostly affected by cyclones that enter to the region from south or southeast which diminish during moving to the north. Cyclones that enter to the Persian Gulf from northwest rarely reach to the Hormoz strait and Qeshm channel [9]. An analysis of the sea level data (obtained from Kangan and Bushehr Stations-per half an hour), at the northwest of the Persian Gulf showed that in January 2014, there was none-tidal fluctuation. The prominent effects of non-tidal oscillations can also be verified through the data reports obtained from the Kangan and Bushehr Stations [10]. Also, the changes of mean sea level investigated in Persian Gulf during 11 years (starting from 1995). The range of the annually changes is 11.3 cm and the sea level is not significantly dependent on the density and temperature and it is mainly dependent on the pressure [11]. In the Caspian Sea, changes in sea level due to atmospheric circulation were conducted using the MPIM model ((Max Planck Institute for Meteorology). The results emphasize the important role of precipitation in the summer on the Caspian Sea. This study also investigated the precipitation and evaporation of the Volga River and its effect on the Caspian Sea water level [12]. Seasonal variations in water circulation, sea level, and the interaction between atmosphere and sea, investigated by Ibrayev et al. (2010). The model used in this study is the MESH model (Model for Enclosed Sea Hydrodynamics). The results of this study include three-dimensional flow, evaporation, covert heat, sensible heat and changes in the Caspian Sea level. Also, the mean square error of the simulated values and measurements from 1.4 cm at Baku Station change to 3 cm at the Krasnoyarsk station [13]. Mean sea level Equilibrium (MSLE) was studied for a period of ten years from 1999 to 2008 in the Mediterranean Sea. In this study, anomaly changes in density were considered smaller than constant value of density and state equation for density was considered linear and with constant coefficient. It was concluded that the MSLE value obtained from the region in the simulated model represents 2-3 centimeters of error in MSLE values [14]. In another research, the effect of Russia's drought in 2010 on the Caspian Sea was studied. In this hydrological study, the Caspian Sea and the Volga River were studied. This study was conducted for the period from 1993 to 2010, with the emphasis on the severe effect of the European Russia's drought on the Caspian Sea. Figure 1. shows the monthly average of the Caspian Sea water level change for 2009-2011, which shows that water level is decreasing (the numbers in this diagram should be added to the number -27). Another result of this study is the fall in rainfall in July 2010 in the Volga River region, which has led to an increase in evaporation in the area as well as a decrease in the Caspian Sea water level [15]. The model used in this study is the MESH model (Model for Enclosed Sea Hydrodynamics). 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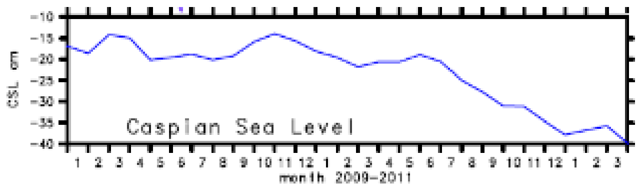


Figure 1. Monthly changes of the mean sea level in the Caspian Sea from 2009 to 2011 (Arpe, et al., 2012)

Seasonal and long-term study of the Caspian Sea water level using satellite and altimeter was conducted by Chen et al., (2017). In this study, with the recording of altimeter data for the years 2002 to 2015, it can be observed that the water level is 20 times lower than global water level furthermore; seasonal fluctuations are larger than mean water level of high seas [16]. Considering that the sea level change is caused by atmospheric cyclones and there is no comprehensive study on the effects of atmospheric cyclones on the Caspian coasts, this research is new. In addition, the use of updated measured data and more statistical periods will affect our understanding of this phenomenon. In this study, the effect of atmospheric cyclones on water fluctuations in the Caspian Sea are investigated.

2. Material and Methods

The study area for the present research is the Caspian Sea, located between Asia and Europe Continents and at 36-48 °N and 46-55 °E. The area is surrounded by Iran, Russia, Turkmenistan, Kazakhstan and Azerbaijan. According to Figure 2, the Caspian Sea can be divided into three parts based on its physical, geographical and topographic conditions: Northern Caspian Basin (NCB), Middle Caspian Basin (MCB) and Southern Caspian Basin (SCB) [17, 18]. The total area of this basin is 168000 km^2 and the deepest point of the Caspian Sea is located at this basin which is 1025 m and the mean depth is 325 m in this basin [19, 20]. Wind and atmosphere pressure data was received from ECMWF database (provided by European Climate Prediction Studies center) during years from 2012 to 2017 with local scale 0.125˚ and time step 6 hours. Atmosphere pressure from ECMWF database is related to the height of 500 hPa, hence, in this study, the pressure centers is dynamical. The data related to the changes of the Caspian Sea level was also prepared from Caspian research center, recorded in the coasts of Caspian Sea at Bandar-e Anzali, Fereydunkenar, and Amirabad Stations (Figure 2).

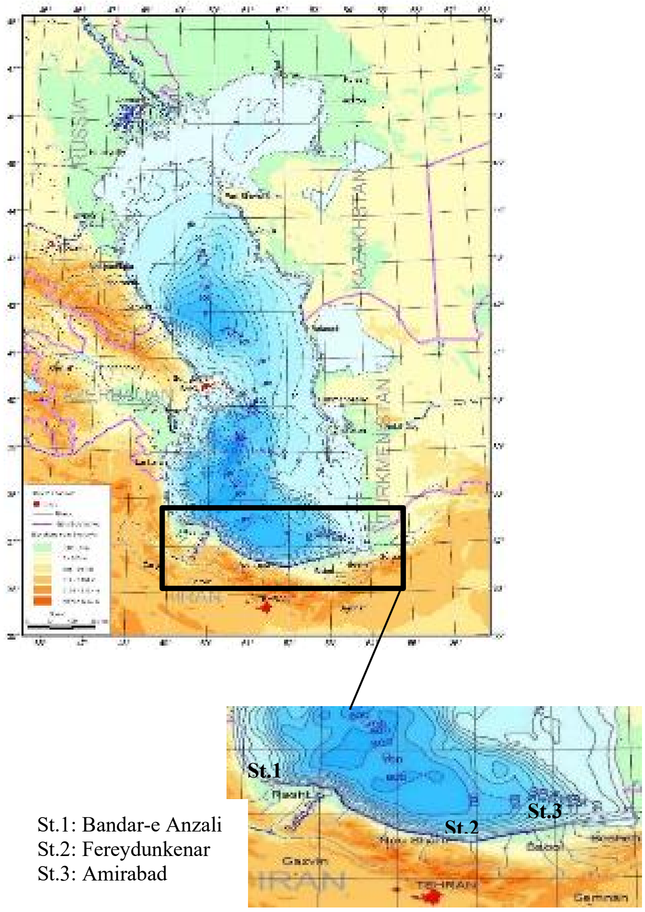


Figure 2. Geographical features of the Caspian Sea

To analyze the data, Pyferret software was applied. Pyferret software is suitable media for analyzing the complicated and numerous data. This software was designed and produced for satisfice meteorologist and oceanographer. It was run on UNIX and Mac operating systems as well. Ferret software was developed to the Pyferret version based on Python application [20, 21]. Data with formats such as Netcdf, ASCII and Binary are applicable in this software. Using wind and atmosphere pressure data obtained from ECMWF database, wind and mean surface pressure related to the Caspian Sea were drawn per 6 hours for 1 years [22]. To draw regions with low presser, surfer software was applied and some parameters were analyzed such as number of seasonal atmospheric low pressure, low pressure place, source, movement trace, velocity of atmospheric cyclone movement and the region that cyclone mostly occurs there. Moreover, using time series, the recorded data related to the Caspian Sea level at stations of Bandar-e Anzali, Fereydunkenar and Amirabad, the changes due to the wind and atmospheric low pressure were analyzed. To calculate the changes due to the wind and atmospheric low pressure, at first, the two states of low pressure and normal pressure were recorded, and the pressure difference was calculated based on Pascal. Then, the sea level changes due to the atmosphere pressure were calculated according to the hydrostatical pressure rule (per milibar, pressure decrease causes 1 cm increase in the sea level). Moreover, to calculate sea level changes due to the wind, with respect to the available data of the measurement stations, the level difference for the two mentioned states was calculated. In addition, considering that in this study, sea level changes were studied in a short-term; other factors that have insignificant effects in a short term are ignored in this study such as rivers discharge, evaporation, raining etc. Thus, as the sea level decrease due to the atmospheric pressure, the remaining sea level is allocated to the wind as the most effective factor on the sea level in a short term.

3. Results and Discussion

This study investigates the water level changes in short time ignoring those factors that are not effective in short time. Some of these ignored factors include river discharge, evaporation, raining, etc. Two main factors were investigated in this study that is, wind and mean pressure of the water level. After collecting the data (wind and mean pressure of water level) from the ECMWF database for the years 2012-2017, some parameters were analyzed, including the number of seasonal atmospheric low pressure, the location of atmospheric low pressure, the source and trace of atmospheric cyclone as well as effect of atmospheric low pressure and wind on the sea level.

3.1. Data validation

To validate the study, atmospheric low pressure and the levels of the intended stations were compared. Figure 3 is diagrams of sea level for days before and after the occurrence of the atmospheric low pressure in May (Bandar-e Anzali Station) and November (Fereydunkenar Station). Orange plots on the diagrams show the time of the atmospheric low-pressure occurrence.

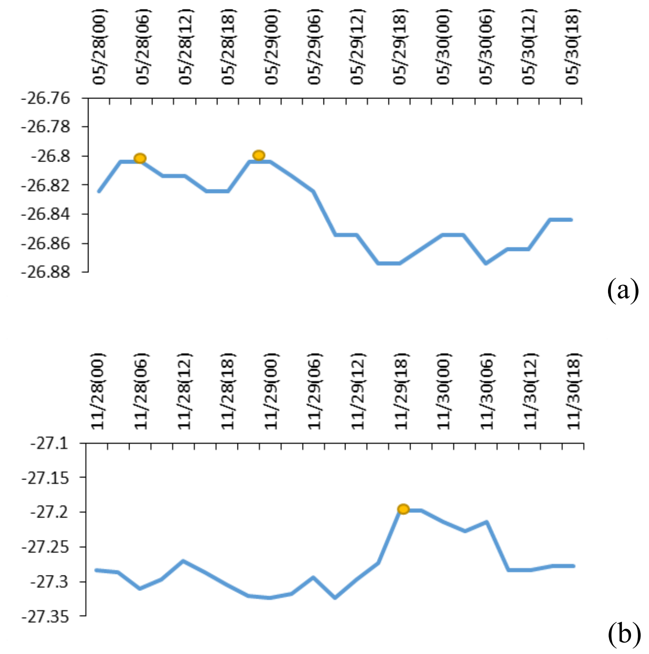
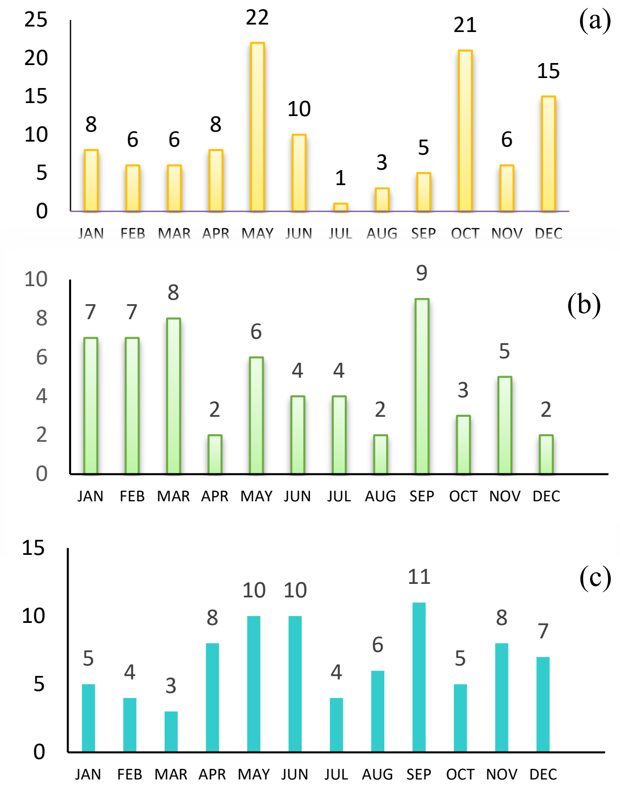


Figure 3. Changes of the Caspian Sea water level on a) May 28th-30th, 2015 at Bandar-e Anzali Station b) November 28th-30th, 2015 at Fereydunkenar Station

3.2. Atmospheric low pressure events

Figure 4 shows the number of the atmospheric low pressure events in the southern Caspian basin monthly from 2012 to 2016. According to Figure 4a, b the maximum of atmospheric low-pressure events is occurred in May and October in 2012 and September and March in 2013.



As shown in Figure 4c, in 2014, the maximum of the atmospheric low pressure events are occurred in southern basin of the Caspian Sea in September and May. In 2015, 2016 the maximum of atmospheric low pressure events are occurred in December and May (Figure 4d, e).

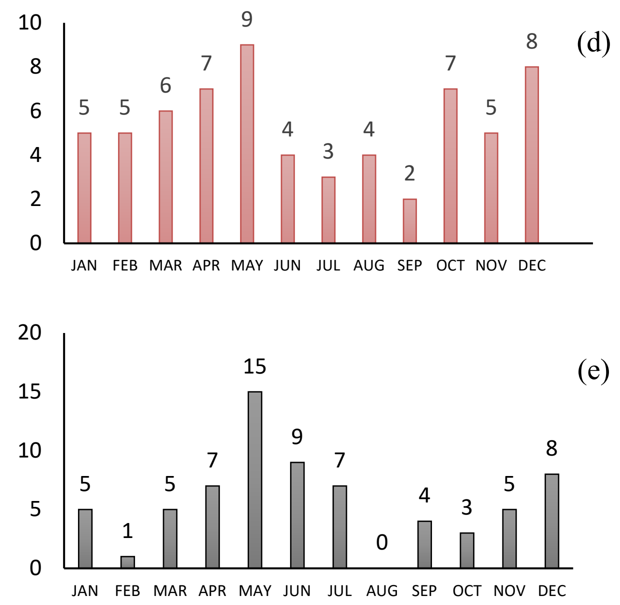


Figure 4. The number of the monthly atmospheric low pressure events in the southern Caspian basin, a) 2012 b) 2013 c) 2014 d) 2015 e) 2016

Figure 5, shows the number of the occurrences of the seasonal atmospheric low pressure in the southern basin of the Caspian Sea. Considering these diagrams and comparing them with the monthly diagrams show that in the whole years (2012-2016), except 2013, the maximum of the atmospheric low pressure events are occurred in spring and autumn.

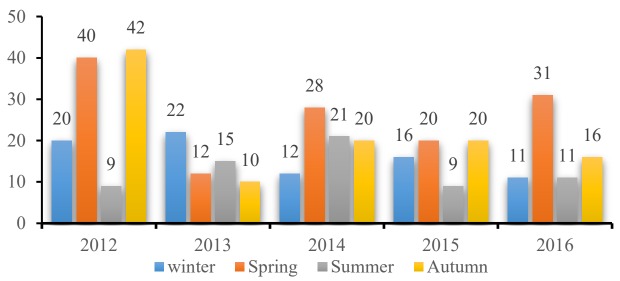


Figure 5. The number of the seasonal atmospheric low pressure events in the southern Caspian basin

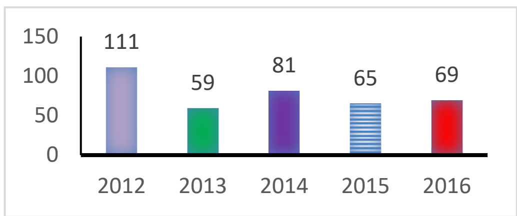


Figure 6. The number of the annual atmospheric low pressure events in the southern Caspian basin

Also, Figure 6, shows that the maximum of the atmospheric low pressure events is occurred in 2012, and the minimum is occurred in 2013. Moreover, by investigating the region with atmospheric low pressure, the latitude and longitude of the atmospheric low pressure center was recorded for 5 years (2012-2016) and plots were drawn on the Caspian Sea by Surfer software. Figure 7, shows the largest numbers of the atmospheric low pressures occurred at the south and southeast. However, in the western region of the middle Caspian basin and some parts of the eastern region of the northern basin, the atmospheric low pressures have occurred less than the southern basin. According to Figure 7, it is concluded that cyclones mostly occur in the southern coasts of the southern basin of the Caspian Sea but about the eastern coast, it is affected by the atmospheric low pressure phenomena because of being flat. It's mean the western coast is more liable to flooding.

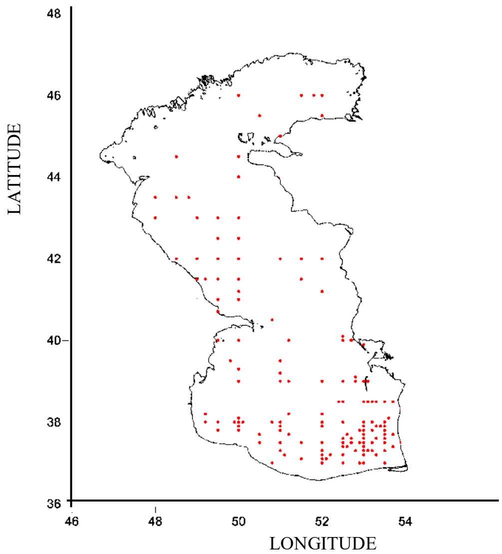
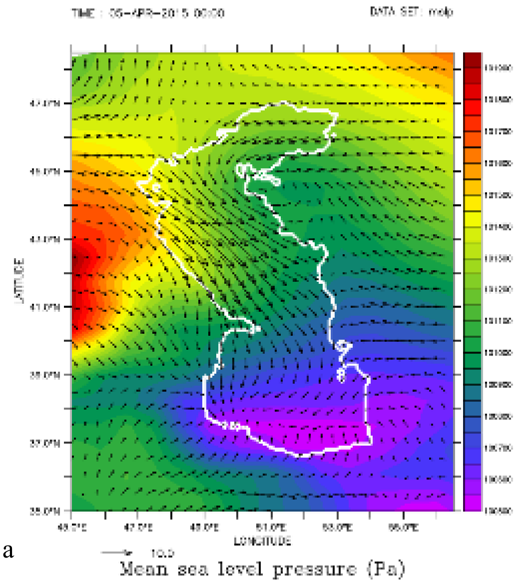


Figure 7. The atmospheric low pressure center in three basins of the Caspian Sea (2012-2017)

3.3. Changes in the Caspian Sea level

The changes in the sea level due to the two factors of atmospheric low pressure and wind in the Iranian coastal stations (Bandar-e Anzali, Amirabad, and Fereydunkenar) during 2013-2016 are shown in Table 1. In Bandar-e Anzali Station in 2015, the atmospheric pressure in the two states of low pressure (Figure 8a) and normal pressure (Figure 8b) were 100500 Pa and 100650 Pa, respectively. Pressure difference between the two mentioned states of pressures is 150 Pa (1.5 milibar). On the other hand, one milibar of pressure decrease causes 1 cm sea level increase and based on this point, the level affected by the atmospheric pressure was calculated. To calculate the changes of the sea level due to the wind, with respect to the measured data of the stations, the sea level relative to the mean sea level for the two mentioned states is -26.99 m and -26.97, respectively.



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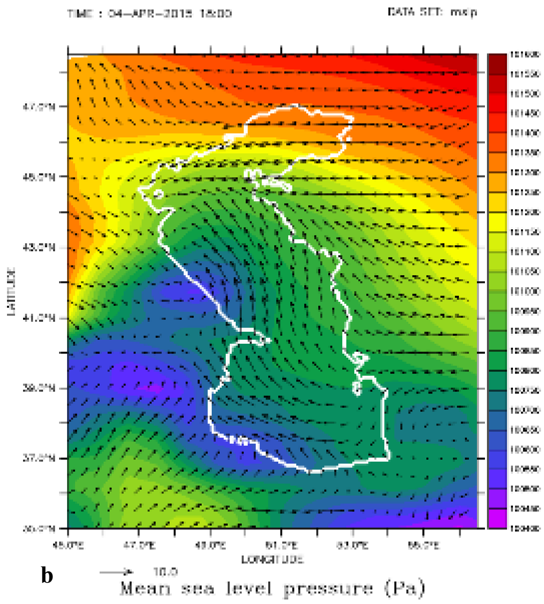


b

Figure 8. Bandar-e Anzali Station in a) low pressure b) non-low pressure, 2015

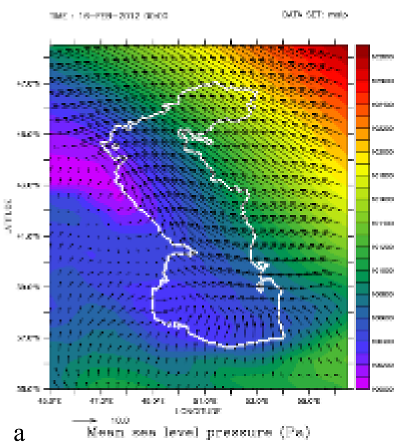
Then the level difference is 2 cm, 1.5 cm of which is due to the atmospheric pressure and 0.5 cm of which is due to the wind.

Table 1 shows that in Bandar-e Anzali Station in 2013, the atmospheric low pressure factor has had the most effect on the sea level. In 2015, it is observable that the atmospheric low pressure and wind have the most effect at the east of the southern Caspian basin (Amirabad) and the west of it (Bandar-e Anzali), respectively. According to Table 1, changes due to the wind and the atmospheric low pressure in 2016 show that the atmospheric low pressure has the most effect on the sea level in these months. An investigation of the Figures related to this year shows that most of the atmospheric low pressure is also close to the station and the wind direction is also from the coast to the sea.

Table 1. Changes in the Caspian Sea water level due to the atmospheric low pressure and the wind pressure at the Southern Caspian coastal stations (2013-2016)

Station		Date	Pressure (Pa)	Measured water level in station (m)	Increase due to the low pressure (cm)	Increase due to the wind (cm)
Bandar-e Anzali	Low pressure	5/16/2013	100550	-26.365	1.5	0.5
	Non-low pressure	5/15/2013	100400	-26.385		
	Low pressure	7/2/2013	99600	-26.634	4.8	1.2
	Non-low pressure	7/1/2013	100080	-26.694		
	Low pressure	3/9/2013	100950	-26.555	10.5	1.5
	Non-low pressure	3/8/2013	102000	-26.435		
Bandar-e Anzali	Low pressure	11/3/2014	100950	-26.555	1.5	1.5
	Non-low pressure	11/2/2014	102000	-26.435		
Bandar-e Anzali	Low pressure	2/4/2015	100950	-26.994	1	1
	Non-low pressure	2/3/2015	101050	-26.974		
Bandar-e Anzali	Low pressure	5/29/2015	100350	-26.874	1	4
	Non-low pressure	5/28/2015	100450	-26.824		
	Low pressure	8/16/2015	100340	-27.017	1.6	2.4
	Non-low pressure	8/15/2015	100500	-27.977		
Amirabad	Low pressure	11/29/2015	101350	-27.22	2.5	0.5
	Non-low pressure	11/27/2015	101600	-27.25		
	Low pressure	4/5/2015	100500	-26.99	1.5	0.5
	Non-low pressure	4/4/2015	100650	-26.97		
Fereydunkenar	Low pressure	11/29/2015	101400	-27.217	1.5	5.5
	Non-low pressure	11/27/2015	101550	-27.287		
Bandar-e Anzali	Low pressure	2/15/2016	102250	-27.134	3	1
	Non-low pressure	2/14/2016	101950	-27.174		
	Low pressure	3/5/2016	100640	-27.124	3.6	0.4
	Non-low pressure	3/4/2016	101000	-27.164		
Amirabad	Low pressure	2/15/2016	102200	-27.19	2.5	0.5
	Non-low pressure	2/14/2016	101950	-27.16		
	Low pressure	11/14/2016	101850	-27.09	4.5	0.5
	Non-low pressure	11/13/2016	102300	-27.04		
	Low pressure	12/1/2016	101240	-27.11	1.6	2.4
	Non-low pressure	11/30/2016	101400	-27.07		
	Low pressure	5/29/2016	100400	-26.86	4.5	0.5
	Non-low pressure	5/28/2016	100850	-26.91		

Figures 9a-e show, the entry and exit of an atmospheric low pressure system that was studied for 24 hours (from 12 midnights on February 16th, until 12 midnights on February 17th). Based on Figure 9a, an atmospheric low pressure system with a pressure 100000 pa enters from the northwest of the middle basin to the Caspian Sea. This phenomenon, with the velocity of 10.17 m/s and direction of 48.9 degree after 6 hours affects the western coasts of the middle basin and some parts of the southwest coasts of the Caspian Sea (Figure 9b).



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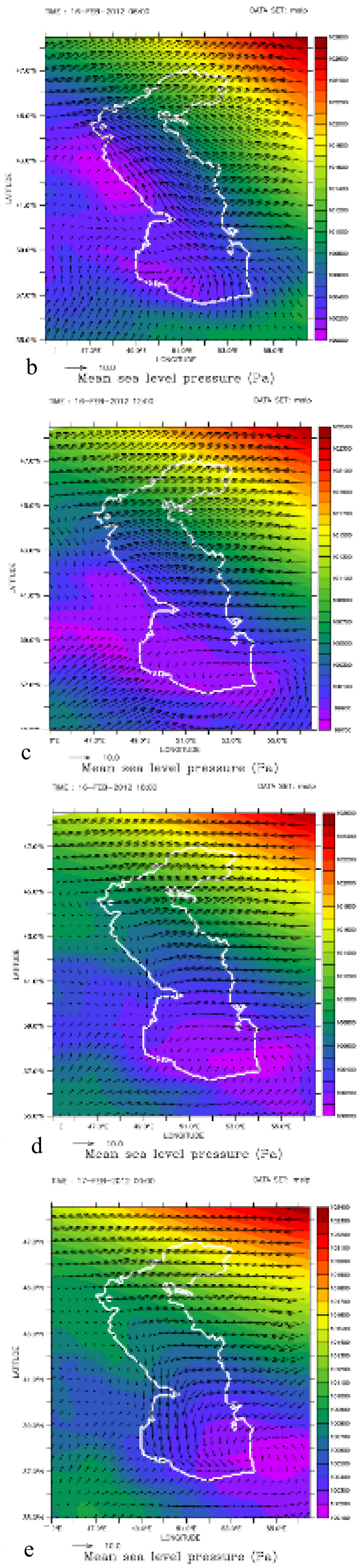


Figure 9. Atmospheric low pressure system on February 16th and 17th, 2012

On August 17th, the atmospheric low pressure creation starts from the southern Caspian basin, with a value 100100 pa (Figure 10a). This system moves with the velocity of 4.83 m/s and the direction of 32 degrees at the east of this basin (Figure 10b). After 6 hours, at 12 o'clock on August, 17th, this atmospheric low pressure vanishes (Figure 10c).

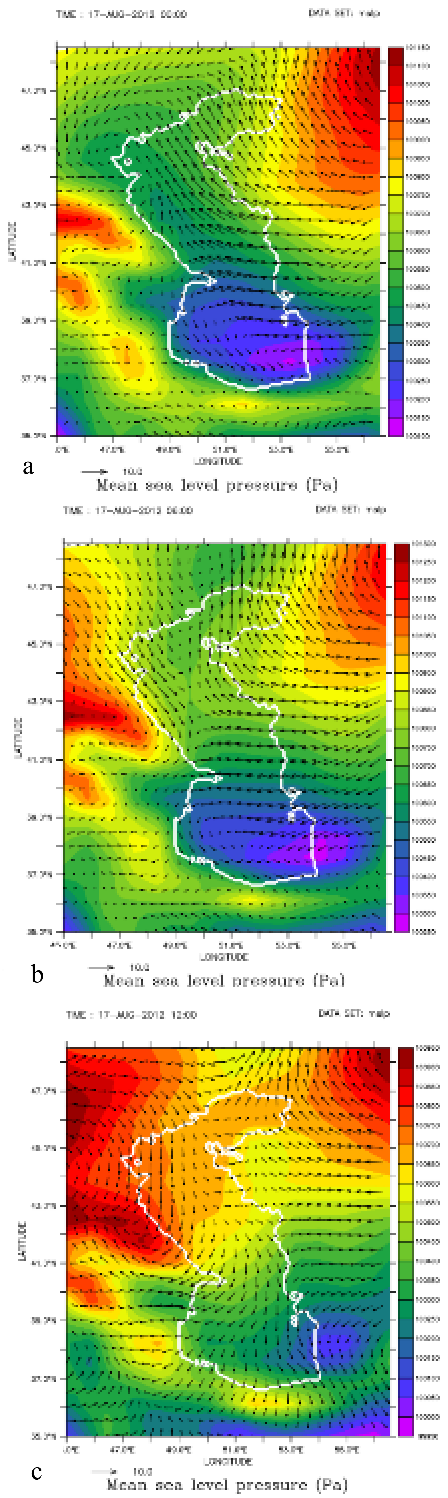


Figure 10. Atmospheric low pressure system on August 17th, 2012

Also, the atmospheric low pressure system enters from the northwest of the middle basin to the Caspian Sea (Figure 11a). It moves with the velocity of 7.96 m/s and direction of 47.72 degree align with the western coasts of the middle Caspian basin (Figure 11b).

After 6 hours, at 12 o’clock on February 16th, the southwest coasts of the southern Caspian basin (especially the Iranian coasts) are affected by the atmospheric low-pressure system 100000 Pa (Figure 11b).

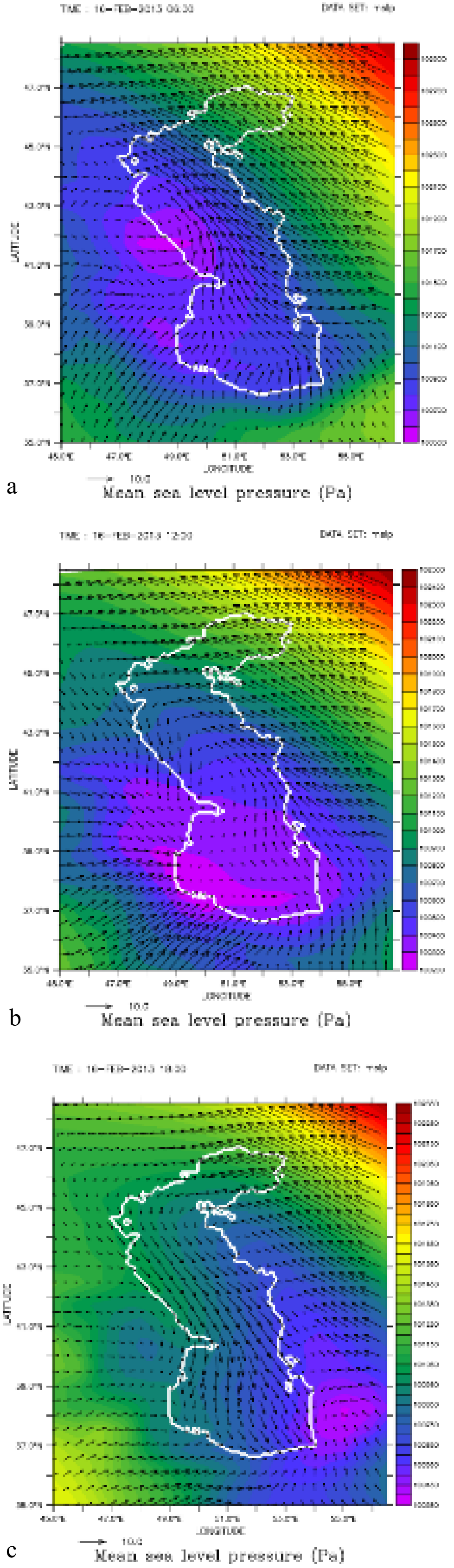
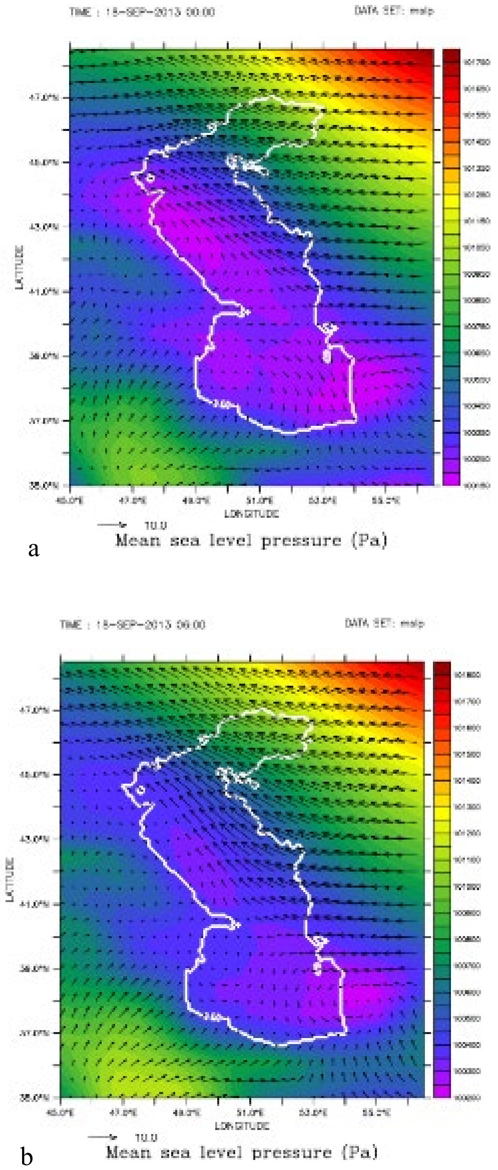


Figure 11. Atmospheric low-pressure system on February 16th, 2013

This atmospheric low-pressure moves with the velocity and direction of 5.02 and 5.7, from the west to the east and at 18 o’clock on February 16th, respectively, it egresses from the southern basin (Figure 11c).

Figure 12, shows the changes of atmospheric low-pressure and the wind pattern for September 18th, in 2013. Based on Figure 12a, the atmospheric low-pressure system surrounded a large part of the middle and the southern Caspian basin and its tense gradually decreases when it moves to the south and the southern region (Figure 12b). Although at 12 o’clock on September 16th, this atmospheric low-pressure system egresses totally from the Caspian Sea basin (Figure 12c), after 6 hours, it moves to the north and along the eastern coasts of the southern Caspian basin with the velocity of 44.7 m/s and direction of 46.3 degree (Figure 12d).



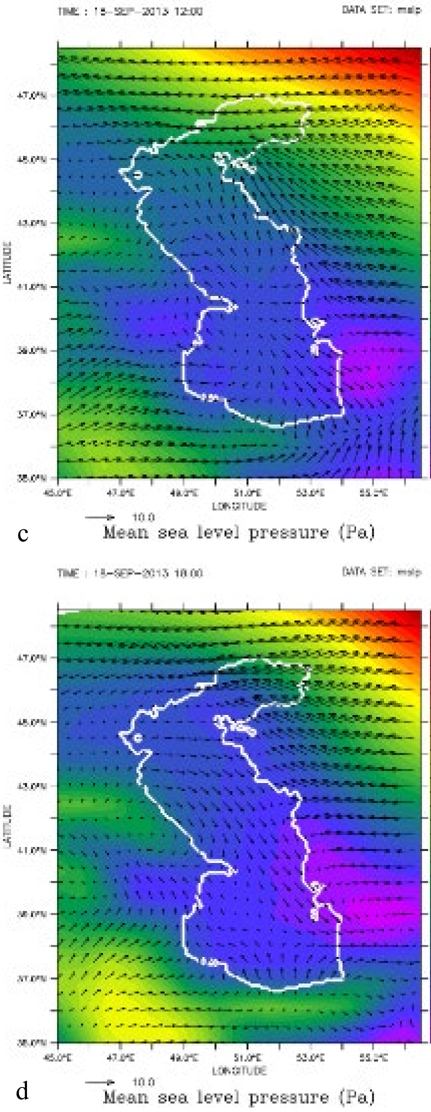


Figure 12. Atmospheric low-pressure system on September 18th, 2013

Figure 13a shows that the atmospheric low-pressure system affected most of the regions of the southern Caspian basin. After 6 hours, this system (at 6 o'clock, February 16th) egresses with the velocity of 1.6 m/s and the direction of 16.6 degree from the east of the southern Caspian basin (Figure 13b, c). At 12 o'clock, February 16th, the southern region of the Caspian Sea (the Iranian coasts of the Northern Province) are mostly affected by atmospheric low-pressure.

Figure 14 shows the changes of the atmospheric low-pressure and the wind pattern for August 19th, in 2013. Based on Figure 14a, the atmospheric low-pressure system enters from the northwest of the middle Caspian basin with the velocity of 44.7 m/s and direction of 46.3 degree to the eastern region of the southern Caspian basin and reaches this region at 6 o'clock, August 19th. This system is egressing with the velocity of 7.58 m/s and direction of 27.92 degree from the eastern region of the southern Caspian (Figure 14b).

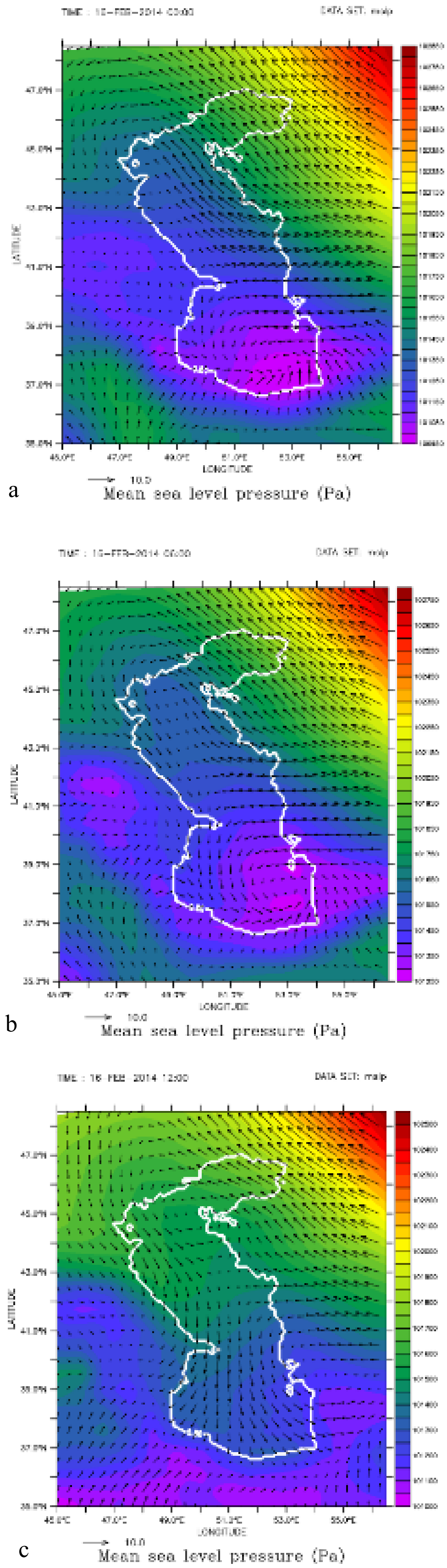


Figure 13. Atmospheric low pressure system on February 16th, 2014

As shown in Figure 15a, the atmospheric low-pressures enter from the west of the mid Caspian to the Caspian Sea and affects the western coasts of the mid Caspian.

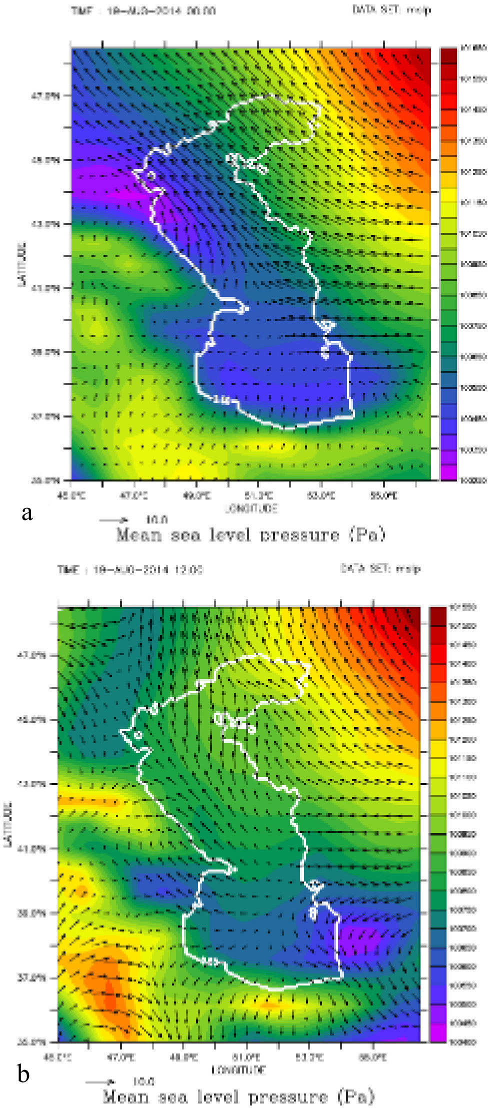
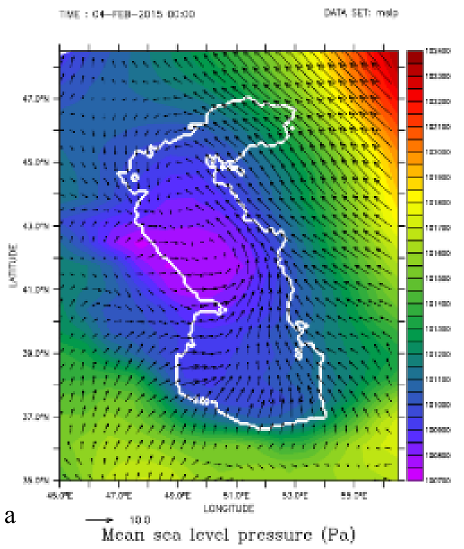


Figure 14. Atmospheric low-pressure system on August 19th, 2014

This atmospheric low-pressure with the velocity and direction of 16.7 m/s and 47.4 degree, respectively, after 6 hours affects the most of the southern Caspian basin and the south of the middle Caspian basin (Figure 15b).



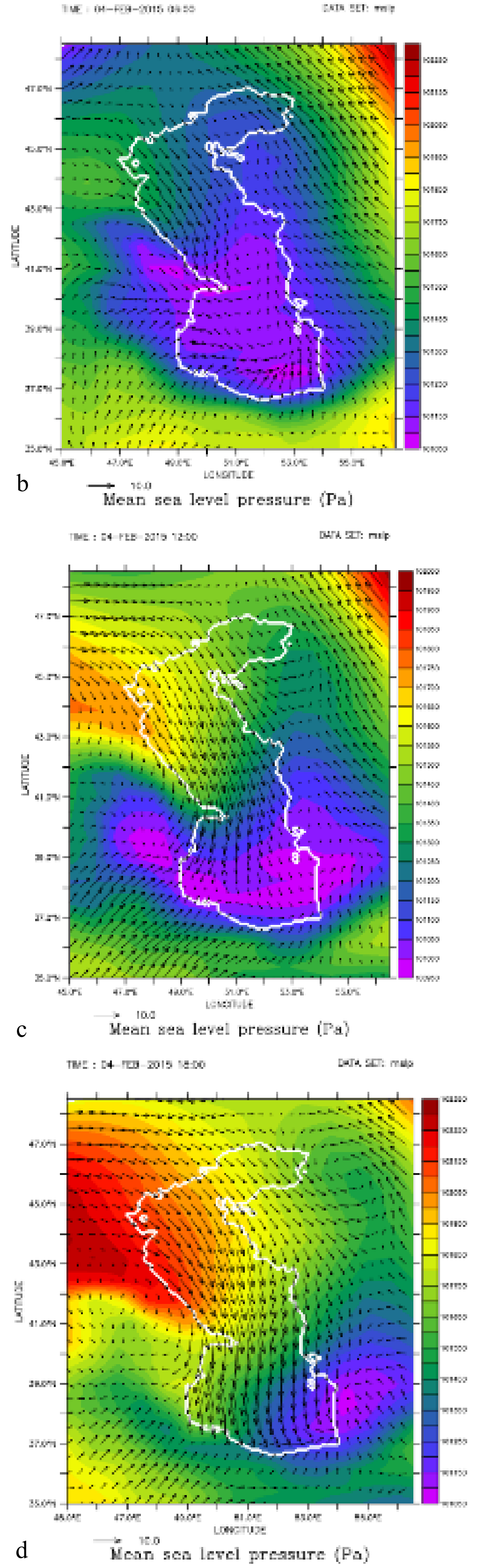


Figure 15. Atmospheric low pressure system on February 4th, 2015

After 6 hours at 12 o'clock, February 4th, the eastern coasts and some coasts at the southwest of the southern Caspian (Bandar-e Anzali) are affected by the atmospheric low-pressure 10095 Pa (Figure 15c). Finally, this atmospheric low-pressure system egresses from the east of the southern Caspian with the velocity of 10.8 and direction of 7.6 degree (Figure 15d).

Based on Figure 16a, the atmospheric low-pressure phenomenon starts from the southeast region of the southern Caspian Sea and far from the coasts. This atmospheric low-pressure is moving with the velocity and direction of 3.91 m/s and 22.78 degree, respectively, toward the eastern region of the southern Caspian basin.

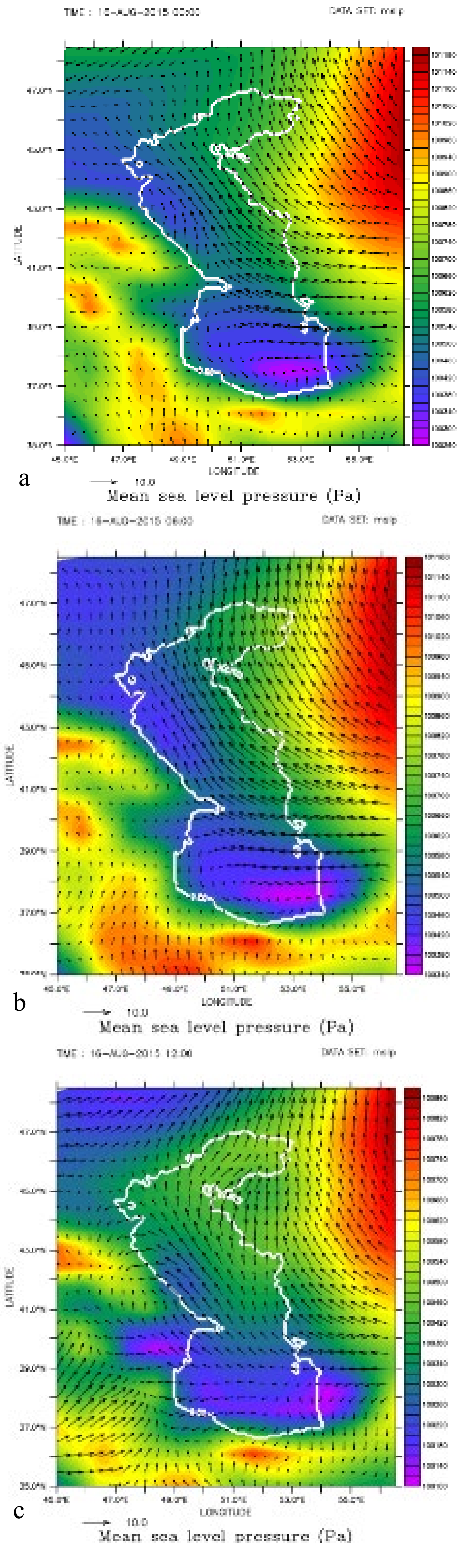


Figure 16. Atmospheric low-pressure system on August 16th, 2015

At 12 o'clock, on August 16th, the atmospheric low-pressure at the southeast of the southern Caspian basin egresses this basin while another atmospheric low-pressure is entering it from the northwest of the southern Caspian (Figure 16b). This system is moving with the velocity of 10.23 m/s to the center and the southeast of the southern Caspian Sea (Figure 16c).

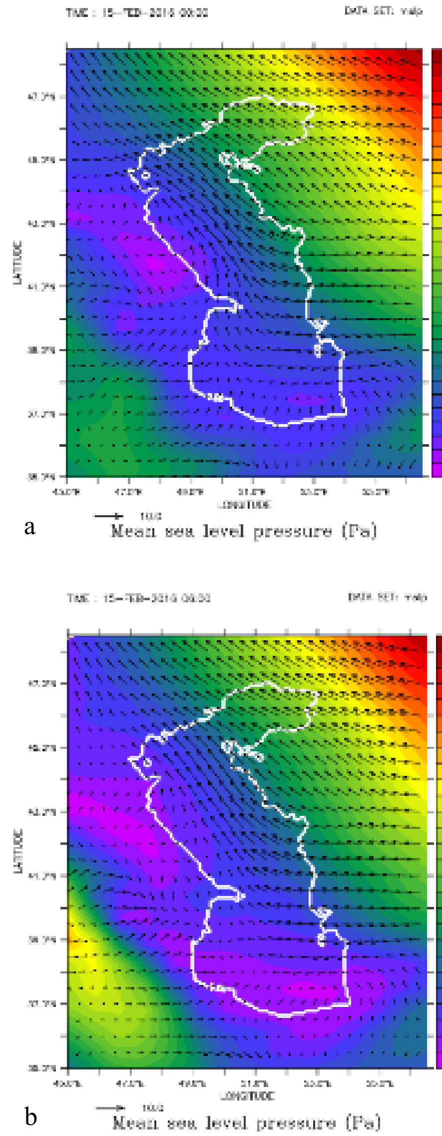
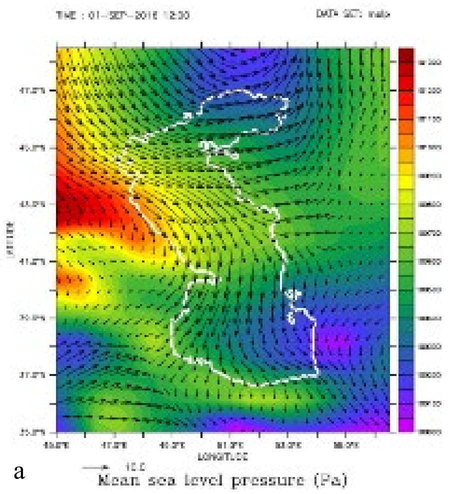
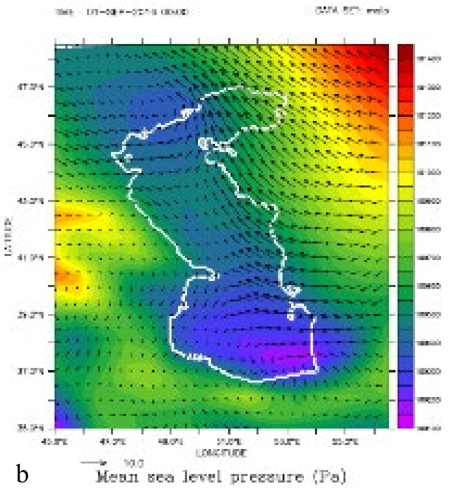


Figure 17. Atmospheric low-pressure system on February 15th, 2016

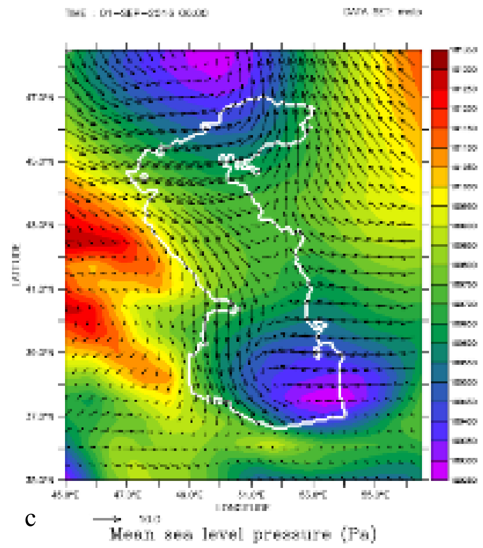
Based on Figure 17a, the atmospheric low-pressure system, as a rather strong system is moving from the west of the Caspian Sea to the middle Caspian coasts and the southern region of the southern Caspian basin. After 6 hours, at 6 o'clock, on February 15th, it affects all of the Iranian coastal regions. It is clear the changes due to the atmospheric low-pressure and the wind are 2.5 and 0.5 cm, respectively (Figure 17b).



a



b



c

Figure 18. Atmospheric low-pressure system on September 1st, 2016

Based on Figure 18a, the atmospheric low-pressure is being created at the southeast of the Caspian Sea. This system is moving with the velocity and direction of 2.6 m/s and 25.5 degree, respectively, to the eastern coasts of the southern Caspian basin. At the same time, another atmospheric low-pressure system at the north of the northern Caspian basin is being created (Figure 18b), which vanishes after 6 hours; the atmospheric low-pressure system in the southeast of the southern Caspian basin is egressing from the eastern coasts of this basin (Figure 18c).

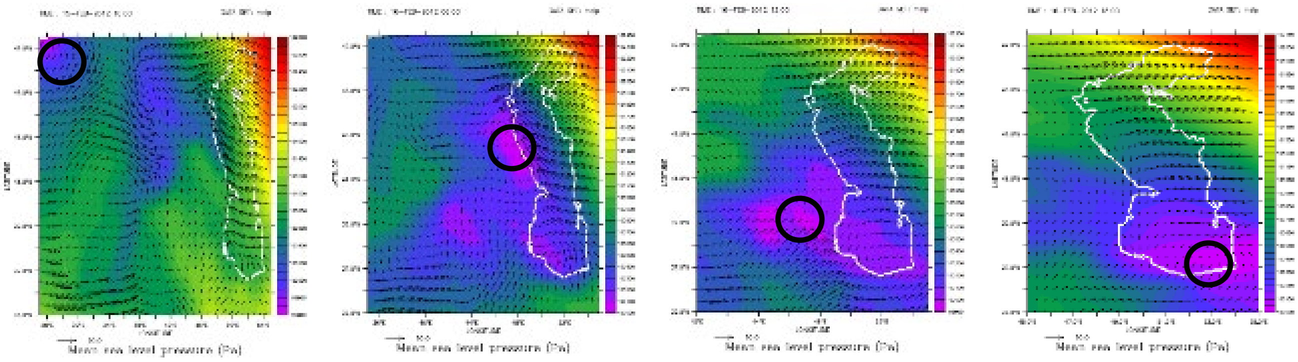


Figure 19. Atmospheric low-pressure tracing, February 15th-16th, 2012

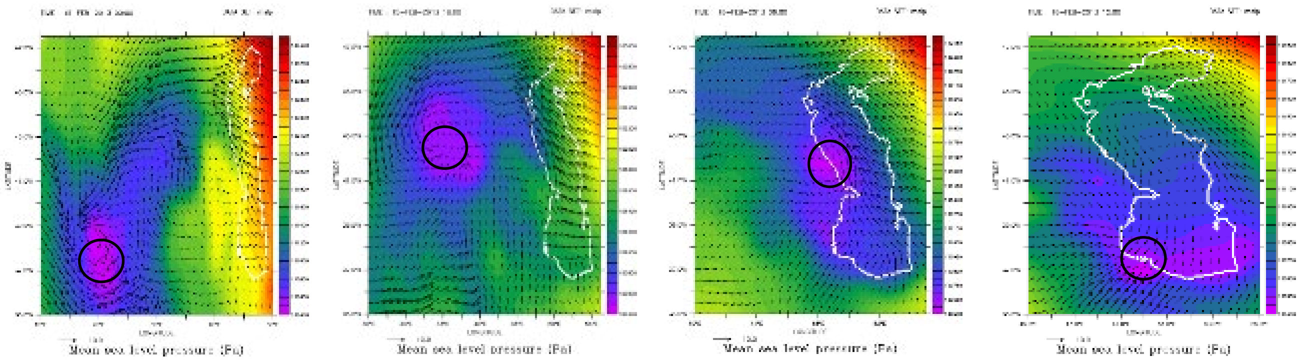


Figure. 20. Atmospheric low-pressure tracing, February, 15th-16th, 2013

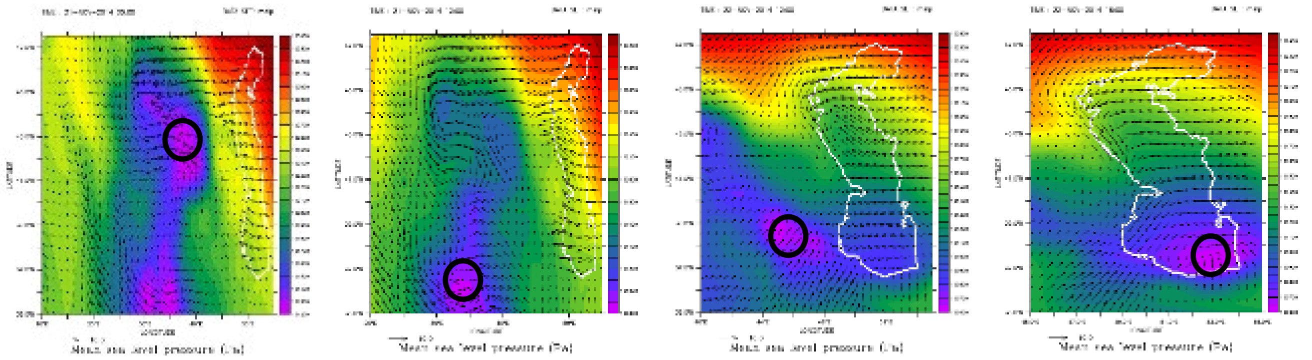


Figure 21. Atmospheric low-pressure tracing, November, 21st-22nd, 2014

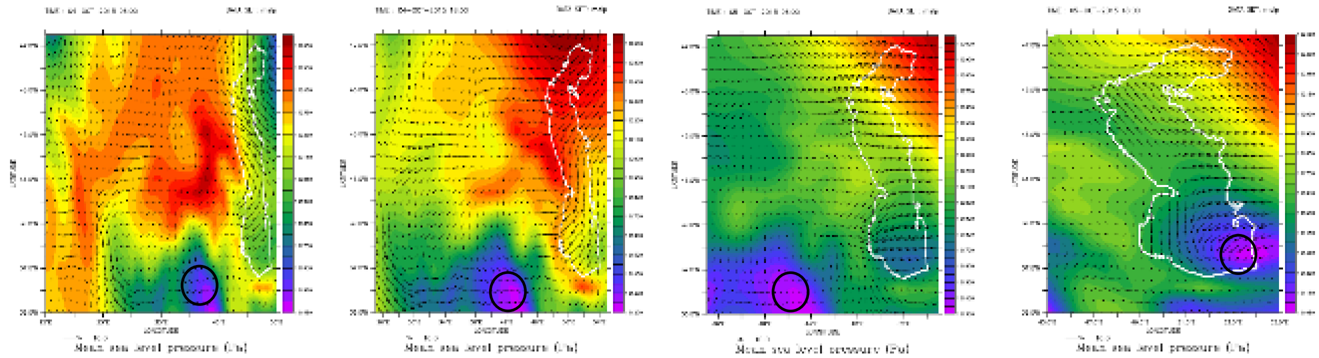


Figure. 22. Atmospheric low-pressure tracing, October, 4th-5th, 2015

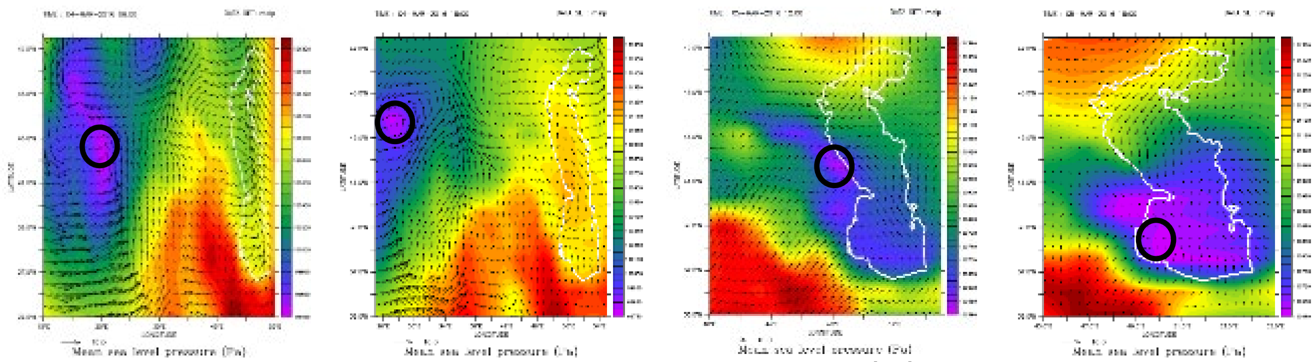


Figure 23. Atmospheric low-pressure tracing, March 4th-5th, 2016

Figures 19-23 show tracing of atmospheric low-pressure from 2012 to 2016 for various months, respectively. According to these Figures, it is observable that in most of these years, the source of the atmospheric low-pressure creation is from the southwest and the west of the Caspian Sea. After some hours, most of the atmospheric low-pressure systems egress from the western coasts of the mid Caspian Sea to the Caspian Sea basin and their destination is mostly the east and the southeast of the southern Caspian basin. In 2016, based on Figure 23, it is observable that the source of low-pressure system is the northwest of the Caspian Sea (high latitude). However, like other years, it enters from the west of the middle Caspian basin to the Caspian Sea.

4. Conclusion

In this research, parameters such as number of seasonal atmospheric low pressure, place of atmospheric low pressure, source and trace of atmospheric cyclones and effects of the atmospheric low pressure and wind on the sea surface level were analyzed. The results of this research show that the atmospheric low pressure mostly occurs in spring and autumn. Also, atmospheric cyclones mostly occur in the southern coasts of the southern Caspian basin. However, the eastern coasts are mostly affected by low pressure phenomenon due to being flat. Investigations on tracing of the atmospheric low pressure shows that in most of these years the source of the creation of atmospheric low pressure is observed to be from the western south and the west of the Caspian Sea. After a few hours, most of the atmospheric low-pressure systems enter from the eastern coasts of the middle Caspian basin to the Caspian Sea basin and their destination is mostly the east and the southeast of the southern Caspian basin. In 2016, it is observed that the source of the atmospheric low pressure is from the northwest of the Caspian Sea (high latitude) but similar to other years, it enters to the middle Caspian from the west of the Caspian Sea. This research studies the effects of wind and the atmospheric low pressure on the sea level in the Caspian Sea in stations such as Bandar-e Anzali, Amirabad and

Fereydunkenar. According to Table 1, it is clear that in 2013, in Bandar-e Anzali Station, the atmospheric low pressure has had a significant effect on the sea level. The Figures related to the atmospheric low pressure show that wind direction is from the coasts to the sea on May 16th. In 2015, it is observable that in the east of the southern Caspian basin (Amirabad Station) and in the west of this basin (Bandar-e Anzali Station), the wind has the most significant effect. In the east of this basin, the direction of the wind is from the coasts to the sea and the low-pressure center is close to Amirabad Station reflecting that the atmospheric low-pressure effect is more than the wind effect in this region. At the west of the basin, the atmospheric low-pressure centers are a bit farther than Bandar-e Anzali Station and the wind direction is from the sea to the coasts and causes mass transition. In this basin, the sea level also increases due to the collision between the bed and waves. Therefore, it is concluded that during the years 2013 and 2016, the low pressure and during the year 2015, the wind has the most significant effect on the sea level. The maximum velocity of the atmospheric cyclone movement from 2012 to 2016 is 10.17, 7.96, 44.7, 16.7 and 2.6 m/s, respectively.

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