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Determining synoptic patterns in atmospheric middle level of effective daily precipitation in Zayanderood basin

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Abstract

Changes and fluctuations of rainfall in Zayanderod catchment can severely affect the survival and development in the central Iran. In this study, we have analyzed the synoptic patterns of precipitation with more than ten millimeters as effective precipitation for the preparation of water supply in central Iran. For this purpose, a database of daily rainfall over ten mm was formed in the basin from 1987 to 2011and the days were selected in which that at least two stations reported the rainfall of more than ten millimeters. Then geopotential height maps of 500htp level of 211 rainy days with more than ten millimeters were derived from a database search. Factor analysis and hierarchical cluster analysis were used for the classification of geopotential height maps. Based on the factor analysis undetected output, 211 days of maps were summarized in 8 factors. Then days were grouped based on the factor loadings using hierarchical clustering. Thus the division of maps into four groups had the highest correlation within the group and variance had the highest between-group. The results also showed that the deep trough pattern of the Northwest to Southeast and North East to South deep trough pattern were, respectively, the main patterns established over ten millimeters of rainfall in the basin.

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Introduction

The Zayanderood basin is an important inner basin in Iran and the only permanent river flowing in it. The Zayanderood River is of great importance to the economic development of Isfahan province and the neighboring provinces. The scarcity of water in the river basin in recent years has become a major issue that has overshadowed all aspects of the development with social and economic consequences, nationally and internationally. Successive droughts in recent years and the need to supply water to other parts of the basin margins have shown that the need to plan for optimum utilization of water resources in the basin is more than ever necessary. Careful planning and proper management of Basin water resources require knowledge of all mechanisms affecting the reliability of water supply in the basin. One of these cases is the effective rainfall as it could lead to the provision of safe water in the basin. Undoubtedly, by understanding the governing system of air and precipitation patterns in the previous cases, we can better plan water resources to help.

Although the determination of mechanisms contributing to precipitation in Zayanderood basin is very important, there are few studies in this regard. However, we can refer to the study conducted by Lashkari *et al* (2012) who analyzed heavy rains from the synoptic perspective in Isfahan province. In comparison, it can be said in the first place, their work focused on major rainfalls of more than 30mm. second, the geographic domain of his work was Isfahan province, so it was different from our geographic area and types of precipitation involved. Furthermore, although some of our results are consistent with those Lashkari and colleagues (e.g., positive advection effect of East side facing West-wind trough in West Iran), based on our results, subtropical Jet-Stream is more effective in creating rainfall in Zayanderood basin. Also, Masah Bovani and Morid (2005) analyzed the effects of climate change on Zayanderood River from the perspective of statistical methods, but they had no synoptic analyses. Their results showed a decrease in the rainfall of 10 and 16%, and an increase in temperature, 4.6 and 3.2 degrees, respectively. Based on these, scenarios A2 and B2 were projected.

This study is intended to identify synoptic patterns of rainfall river basin, the origin and the properties of these patterns. This could be in the planning process to facilitate optimal utilization of water resources in the basin. On the other hand, understanding the ruling system and describing the frequency of occurrence of each of the Synoptic conditions could pave the way for finding similar patterns in the future. However, we should mention other studies that have had a synoptic approach, especially in Iran. For example, Khoshhal and colleagues (2009) identified the origin and direction of moisture heavy rains in Bushehr province. In their study, the precipitation more than 100mm was selected. Their results showed that water resource heavy rains were from tropical East Africa, Indian Ocean, Arabian Sea and Gulf of Aden, Red Sea, Persian Gulf and the Oman Sea. Masodian and Mohammadi (2010) studied precipitation of heavy rains in October, 2000 and analyzed them from the synoptic point of view. The analysis revealed a pattern of high-pressure sea level. Pressure maps in Europe - Iraq caused the low pressure to high pressure gradient over the region and influenced the rain. The influence of subtropical and polar fronts merged was very considerable on Cyprus, with a major impact on the occurrence of rainfall.

Baaqydh and colleagues (2012) studied 39 daily precipitations greater than 7 mm in a period of 6 years in the GorganRoud Atrak basin and analyzed them from the synoptic point of view. Based on this analysis, six synoptic patterns at ground level and 500 mg were diagnosed. The surface pattern, in contrast with a relatively strong high pressure center in the West or North West and low-pressure center in the eastern borders of Iran, was evident in 500 with landing on Iran. Asakereh and colleagues (2012) conducted a synoptic analysis of heavy rainfalls received daily in Gilan. For this purpose, the rainfalls during 77 days were selected and sea level pressure was classified by correlation Lund method and the five models were found at the end. This suggested that the patterns formed on the North West high pressure of Black Sea, northern Russia, North West Europe Norwegian Sea, North Sea and West Sea Black Sea – Mediterranean were similar to the system impact of heavy rains in the province of Gillan. Khosravi and colleagues (2012) studied the dominant type of Sistan air Synoptic. For this purpose, 14 climatic variables were used during a period of 10,825 days. Their results showed that the component temperature, humidity, wind and precipitation would explain a total of 87% of the diffraction data as the most important component of the climate influence in SISTAN was identified. Based on cluster analysis, six types of weather could affect the Sistan province. Hvnyka Claus *Et al* (2006) surveyed Heavy rainfall regions of the Alps from the synoptic method view point. He called it the air of an autumn trough extending the type mentioned due to heavy rainfall in the south-western Europe as the Alpine region. Statistical results showed the position of the trough-like in the north-south belt of middle level and toward the south, between the Pyrenees and the Mediterranean. North Africa experienced the increase of rain. Orographic significant impact was found on the West, thereby enhancing the potential volubility in the upper echelons of the Western Alps. P. R.. Rakhcha and P. R.. Pysharvty (1996) studied daily 5000 rainfall stations in India during monsoon rainfall to estimate the incidence of heavy rainfall. According to the annual heavy rains, heavy rains continued for a time of two or three days, and the highest hourly rainfall was determined. D. K. Pyzamanys *Et al* (2005) studied the major characteristic of the climate Synoptic conditions as associated with showery activity during June and August in Thessaloniki (northern Greece). They concluded that the most important factor in the occurrence of atmospheric activity was the aligned passage of cold air usually derived from the polar region. The results showed that a warm, humid weather continuing around the clock prior to the occurrence of thunder and lightning in northern Greece entered the inner regions of the Balkan Peninsula and the northern cold treats. This led to the creation of a lightning storm. Aqdyvs Rymaks *Et al* (2011) surveyed the immediate changes in extreme precipitation in Lithuania within the period of 2008-1961. Positive trends in some cases were identified. Atmospheric circulation processes were derived using Hoes and Brzvsky classification for the large-scale circulation figures. More than a third of heavy precipitation events (37%) occurred when there was atmospheric circulation in the Orbital. The location in a central part of cyclone over Lithuania, at the time being 27 percent, led to heavy rainfall. M. Laura Batooli *Et al* (2009) studied geopotential height anomaly at levels of 100 and 500mb in order to identify the type of Synoptic weather in southern America and its relationship with precipitation in the center of agricultural production in Argentina. Their initial classification results showed seven patterns for 1000 and five patterns for level 500mb. Arthur gevorgyan (2013) studied the main types of processes in synoptic circulation causing heavy rainfall in Armenia. He determined this using the classification Lamb and recognized seven types of circulation causing heavy rainfall in Armenia. The results showed that the method of Lamb was significant for the diagnosis of atmospheric pattern based on sea level pressure. Given the previous research and the emphasis on the important effect of middle and top level of atmosphere on precipitation in median Latitudes (Perry and Andrew J. Roger M. Carlton, 2001), the aim of this study was to determine the balance between the atmosphere synoptic patterns and rainfall in Zayanderood basin. This is because identification of these patterns can help forecast the occurrence of effective precipitation in this area.

Materials and methods

The research method is an inductive and a synoptic method of environmental circulation .The work is summarized as follows:

Data's

1. Daily rainfall data of synoptic, climatology and rain gauge stations within the period of 1986-2011 were collected. Dailies rainfalls in the basin stations were grouped and days were recorded in which rainfalls of at least 10 mm in two stations had been recorded. At the end of 211 days, this was done.
2. Data files at different levels of the atmosphere were collected from the site map, www.cru.uea.ac.uk /, and the database of geopotential height 500mb was formed at the same time period. Various data, including geopotential height in all years, was in text format at this site. Then text data were changed to computable data as geographical frame latitude(X) , longitude (Y) and geopotential height (Z) in the range longitude of zero to 80 degrees in the East and in the range latitude of 10 to 70 degrees in the North for 365 or (366) days of year or (leap year).
3. Geopotential height data of days with more than 10 mm of precipitation was filtered to get the selected days of the year. Thus, data from 211 days in 825 nodes with 2.5×2.5 ° geographical dimension of the matrix (211 days×825 nodes geographically) were formed.

Methods

Factor analysis was used to classify the rainfall patterns. Factor analysis finds a specific relationship between many variables and establishes a theoretical model and suggests them in terms of a smaller number of dimensions or structures called factor (Mansurfar 2009: 255). The advantage of this method is that it also reduces the number of variables, and the initial value of the variance (diffraction or variation) remains in the original data (Alijani 1996: 180). Because the goal was to extract air patterns, Partial Components Analysis (PCA) method without rotation method for classification was used. State of S (Component Loading Matrix) (Roger at all 2001: 82) was used for pattern classification and zoning maps and partials components analysis method without rotation could explain the greater part of the variations in the data (Yarnal 1989: 102). By using hierarchical clustering based on factor loadings, 8 factors were extracted, days map were grouped and the maps patterns were derived too. The Ward method clustering for the determination of the clusters and the Square of the Standard Euclidean Distance were used to determine the distance between the clusters. In the Ward method, we first calculated the mean of the variables within each cluster and then Square of the Euclidean Distance of mean clusters for every observed was calculated. This distance was the sum of all observations. At each step, two clusters were combined that had the smallest increase in the sum of squared distances from the cluster (Goldaste *et al* 1997: 380). Geographical location of Zayanderod basin is shown in Fig 1.

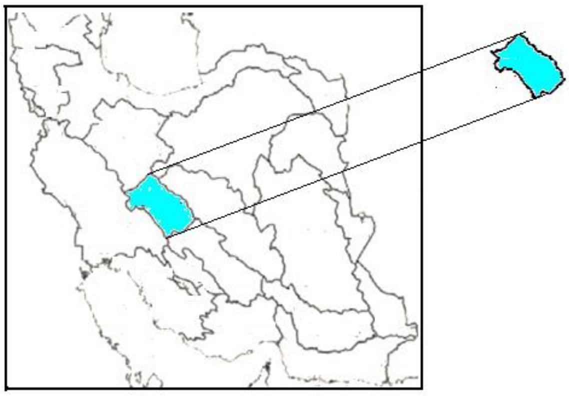

Fig. 1. Geographic location of the Zayanderood basin on other water basins in Iran

Results and discussion

Groping

Considering the high number of maps, we used factor analysis to classify the rainfall patterns. Thus, 211 days were summarized in 8 factors. The first factor alone would explain 84.6 percent variations in the data and a total of 8 factors could explain 97.1 percent of variations in the data. Hierarchical clustering based on factor loadings of 8 factors was also used to classify days pattern. The cluster was determined based on the highest in-group correlation and highest between-group variance.

Therefore, by dividing the days into four groups, the maximum correlation within a group and the highest diffraction between groups were obtained. Thus, these four patterns of rainfall were detected to cause river basin rainfall of more than 10 mm. In fig. 2, extraction and determination of clusters have been shown.

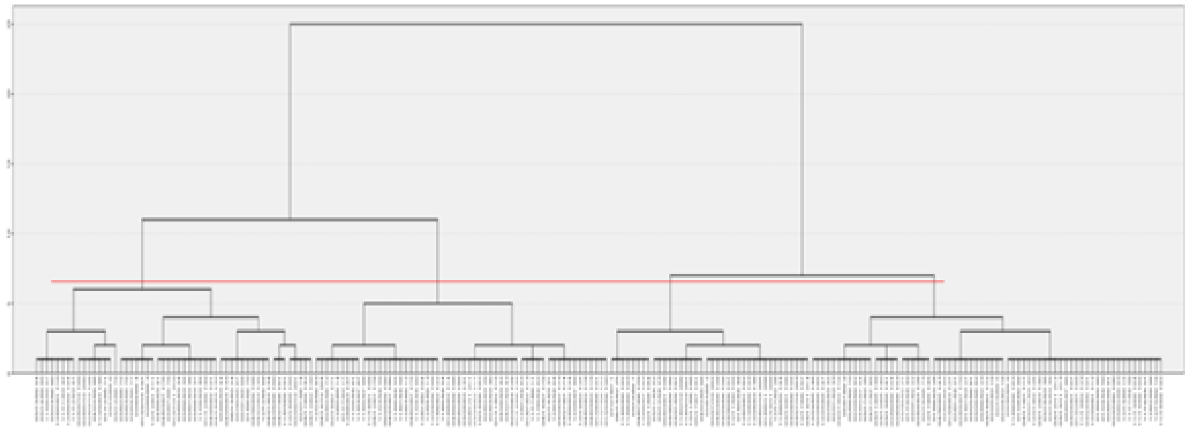

Fig. 2. Dendrogram grouping of geopotential height maps of rainy days based on factors loading of 8 extracted factors.

The results of group precipitation patterns are summarized in Table 1. According to this table, the highest frequency of precipitation was observed in pattern (4), where 31.3% of days of precipitation had rainfalls more than 10mm. The lowest frequency was related to Type 3 that included just 17.7% of the days. One of the main items on the occurrence of heavy rainfall was the gradient of pressure (altitude). Due to the steep elevation changes, most established patterns of rainfall over 10 mm were patterns 4 and 2 and then patterns 3 and 1, respectively. The correlation between mean pressure gradient and pressure patterns was R= -0.71, significant at 0.01 percent level. Therefore, the pressure gradient increase was accompanied with decreasing pressure values that could cause the heavy rainfall in the catchment. The results showed that in days with most pressure gradient, rainfall was increased significantly.

Table 1. Synoptic patterns of rainfalls more than 10mm in Zayanderood basin.

	Frequency	Percentage of Frequency	Day representative of a Pattern	Corr-Coef of Typical Day in any Patterns	Interclass Corr-Coef of any Pattern	Ave. of height gradient
Syn_Pattern. 1	52	24.6	12/18/2009	0.906	0.847	196.4
Syn_Pattern. 2	56	26.5	12/04/1989	0.941	0.909	239.4
Syn_Pattern. 3	36	17.1	01/09/2011	0.947	0.911	223.2
Syn_Pattern. 4	67	31.8	05/07/1989	0.947	0.914	246.4
	211	100				

Patterns

In all patterns, air advection on the Zayanderod basin was the main factor behind precipitation of more than 10mm. The arrangement of the lines in the height of 500mb in all types of cargo was completely different. After grouping the map days, mean maps were calculated for each model and for each pattern, mean maps were drawn. Although the elevation lines on the map mean were very soft, these maps represented a property every day, so they could be considered as a pattern map of any group.

Pattern. 1 Low pressure pattern in the Eastern Europe: In this pattern, a low pressure area in the Eastern Europe and the North West Black Sea was formed. T1-Mean maps as maps representing the average pattern 1 and the Day on December 18, 2009 are shown in Fig 1. Typical day of any pattern has been selected based on highest Coef-Corr of a day with other days.

In this model, a low pressure system strengthened European area with a wide geographical distribution and depth of its trough made the performance of low pressure be extended to areas of the Middle East and Iran. Wave advection tabs in the west wind swept up the humidity from the Mediterranean and Red Sea, leading to precipitation in Zayanderood basin. The low pressure strengthened that formed in the West Europe due to the size of the entire wide areas from the Eastern Europe and the Middle East region, Iran and Zayanderod basin. Representative of this pattern can be daily rainfall stations in Fereidoonshahr, Najaf Abad, Varzaneh, Kabootarabad, Isfahan and the Zarinshahr with 18.1, 16.6, 12.8, 21.8, 25 and 33.3mm. In this model, the average daily rainfall was 23.4mm, which was the third pattern of rainfall with more than 10mm.

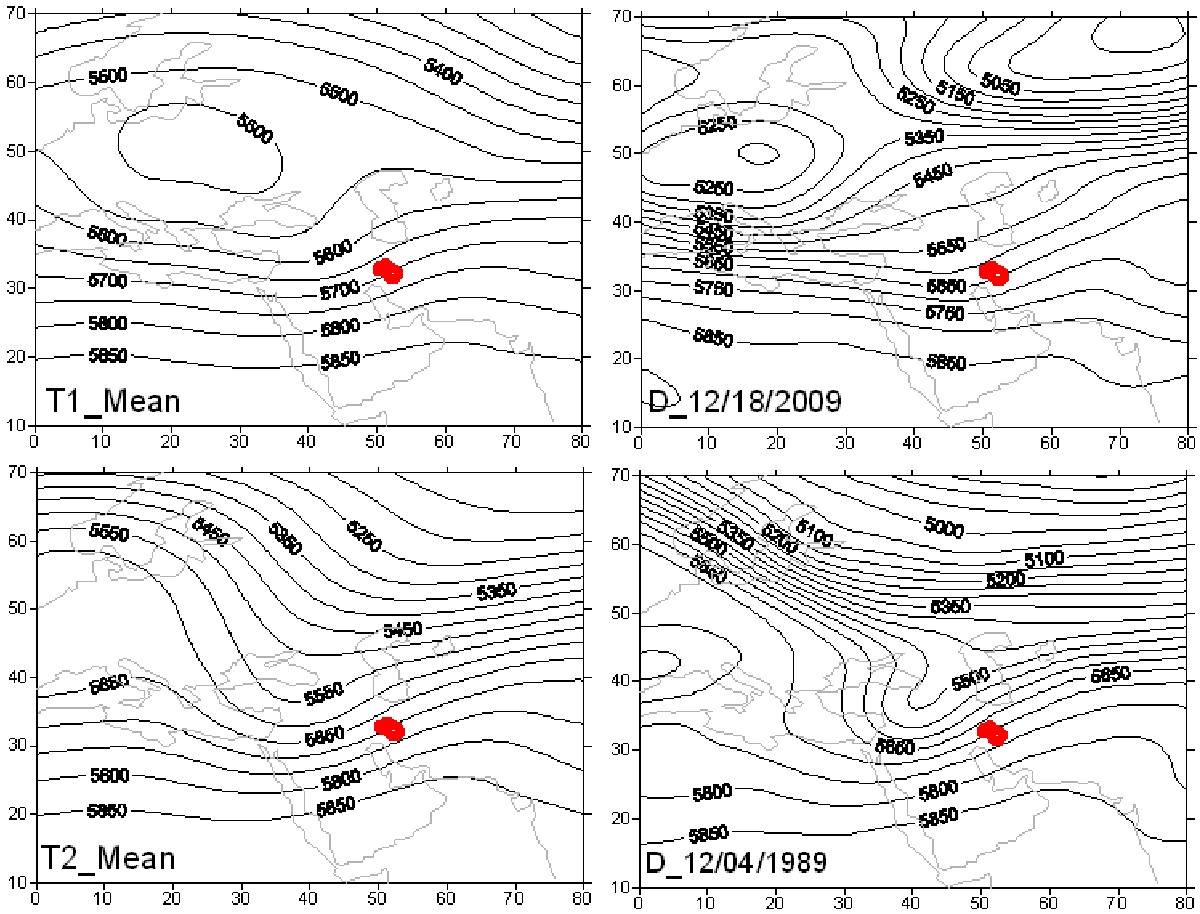

Fig. 2. Patterns 1 and 2 from the four atmospheric patterns at a level of 500 mb. On the left at the top/ at the bottom, the map mean geopotential height lines of patterns 1 and 2 have been shown. On the right at the top/ at the bottom the typical day belonging to pattern.1 and 2 has been displayed. Zayanderod basin can be identified in the center by red solid line.

Pattern. 2 The trough pattern curved towards the South West: In this model, due to the greater severity advection vorticity, intensity and rainfall were greater than those in pattern 1. As this pattern can be seen in the average map (Fig. 2 lower left), in this model, the trough was deeper and advection of air on the river basin was more severe and therefore, it was expected to have more and more intense rainfalls. Curves towards the South-West trough increased the depth of western winds and sharply raised adiabatic in front of the wave. Elevation gradient in this model was more than that in Models 1 and 3, thereby resulting in more active agent dynamics of atmosphere. As a result, when the front of deeper trough was on the Zayanderood basin, the rainfall would be more in this basin. Representative of this in the model could be on December 4, 1989, when rainfall stations located in East Isfahan Province Owners and Koohrang showed precipitation of 28, 33, 59 and 141.8 mm, respectively. This model, with an average rainfall of 28.4mm per day in the second pattern, caused the precipitation of 10mm.

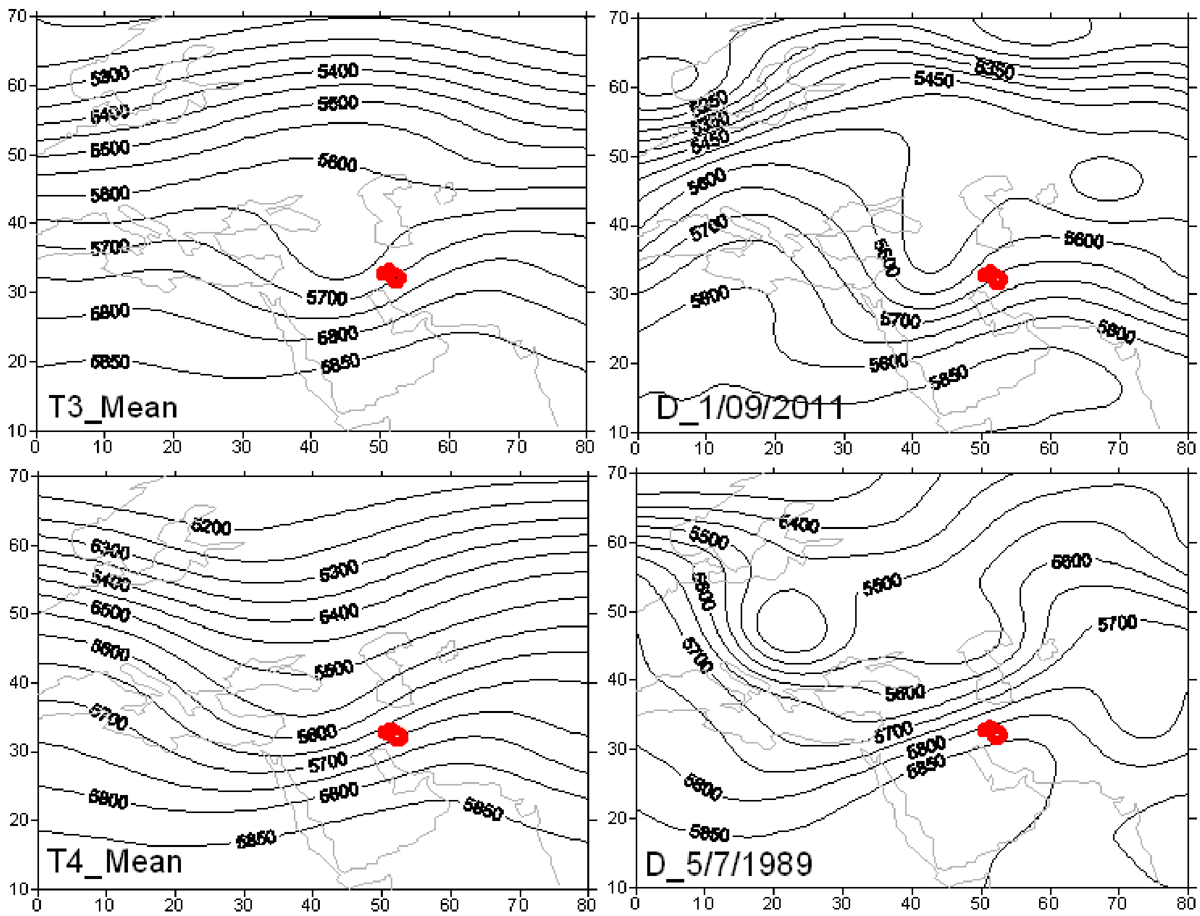

Fig. 3. As in fig. 2, patterns 3 and 4 of the four atmospheric patterns at the level of 500mb have been shown

Pattern. 3 Low pressure pattern in Mediterranean: In this model, the cause of more than ten mm rainfall was low pressure formed on the Mediterranean and in the East towards substantial rainfall, it led to rainfall on Zayanderod basin. This model showed the general consensus of many researchers who called it the low dynamic pressures, also known as Cyclone Mediterranean. Front immunogenicity and cyclone were formed over the Mediterranean region due to the formation of such a system. The underlying cause of more than 10mm of rainfall in this pattern was located on the Mediterranean basin Zayanderod with the low pressure center. Due to the low width of this model as compared to others, it predicted less rainfall intensity. Unlike many researchers who believe that this model is the original occurrence of rainfall in

Iran, Only 17% of days with precipitation greater than 10mm were affected by this pattern. On January 9, 1988 a case of this model in Kohrang, Isfahan and Kabutarabad stations recorded 33.5, 10.5 and 14mm of rainfall. However, the lowest average rainfall 19.1 mm was in this model.

Pattern. 4 Deep trough pattern in North West - South East of the West: the reason for the precipitation in this model was the low pressure area formed in Europe and in their motion cyclonic suctions, the Red and the Persian Gulf moisture and lots of rain came down in Zayanderood basin. On May 7, 1989, a case of of this model in Kohrang and Daran stations was recorded, with 64.1 and 15.5 mm rainfall. The average rainfall in the days of this pattern was 29.1 mm, which was the highest average rainfall in all patterns. Generally, the extent of the cyclone system over the passage of these systems can influence the amount and intensity of precipitation. So, the typical pattern of low pressure developed in Europe played a more effective role in causing rainfall than ten millimeters in Zayanderod basin. In Mediterranean systems, regardless of low pressure center closer to the river basin, the amount and intensity of rainfall over the basin were higher.

Conclusions

Zayanderod basin plays an important role in supplying water in the central region of Iran. Review of weather maps in the middle level of atmosphere (500mb) showed the underlying cause of precipitation of more than ten millimeters in Zayanderod basin, thus modeling the low pressure system that emphasized the breadth and depth of functionality. Existence of a trough deep in the western Iran was the cause of rainfalls more than ten millimeters in Zayanderod basin. So, from the four patterns of occurrence of rainfalls of more than ten millimeters, three models, 1, 2 and 4, due to geographical spread of low pressure systems and a model (model 3), emphasized the location and placement of the passage Basin pluvial systems. The results obtained by Lashkari and colleagues (2012) on the heavy rainfall in the province also indicated that in all models, the positive vorticity advection in the North East, Saudi Arabia and the Persian Gulf at sea level and at the level of 500 mg predicted severe and widespread rainfall over the study area. The advection could result from exposure in the West to the East-West trough winds, and heavy rains causing the river to move to the basin. According to Khoshhal *et al* (2012), low dynamic pressure, which is from Eastern Europe and the Mediterranean, can lead to heavy rains in Iran (the Bushehr province). Synoptic patterns of heavy rainfall in Bushehr province were consistent with some of the models presented in this study. Model 3 emphasized the position of the low pressure system over the Mediterranean. Consensus, for example, was studied by Khoshhal *et al* (2012), Lashkari and colleagues (2012) and Atai (2008). The height gradient showed that the cause for more than 10mm of rainfall average was threshold pressure gradient of at least 196.4htp which was aligned along the axis of land in western Iran.

References

Alijani B. 2006. Synoptic climatology, SAMT, Tehran, Second Edition.

Artur gevorgyan, 2013. Main types of synoptic processes and circulation types generating heavy precipitation event in Armenia, Meteorol Atmos Phys,Voll. **122**, pp.91-102.

Asakereh H, Khoshraftar R, Sotodeh F. 2012. Analysis of heavy rain the day of September in connection with the Synoptic patterns in Gilan Province (2005-1976), Research in Geography, No. **80**, 51 -66.

Atai H, 2008. Identification and analysis of atmospheric circulation patterns in the middle level of rainy year, Geographical Research, No. **90**.

Baqydh M, Entezari A. Alimardani F. 2012. Synoptic analysis of precipitation in GorganRoud and

Atrak basin (rainfall inclusive 39), Geography and Development, No. **26**, 113-124.

Pissimanis DK, Notaridou VA, Spyrou CK. 2006. On the main characteristics of synoptic weather conditions associated with thunderstorm activity during the months of July and August in the city of Thessaloniki (Northern Greece), Theor. Appl. Climatol. **83**, 153–167 .

Egidijus Rimkus, Justas Kaˇzys, Ar unas Bukantis, Aleksandras Krotovas, 2011. Temporal variation of extreme precipitation events in Lithuania, OCEANOLOGIA, **53** (1-TI), pp. 259–277.

Fredrick K. Lutgens, Edward J. Tarbuck, 2004. The Atmosphere, An Introduction to Meteorology, Pearson Education. Ninth Edition

Howard B. Bluestein, 1993. Synoptic-Dynamic Meteorology Midlatitudes, Oxford University Press Vol. 11.

Khosravi M, Nazari M. 2012. Synoptic study of prevailing weather types in Sistan region (station Zabul). Research in Geography, No. **81**, 39-62.

Khoshhal J, Khosravi M, Nazari. 2009. Identify sources and pathways of rain and heavy moisture Bushehr. Geography and Development, No. **16,** 7-28.

Klaus P. Hoinka, Cornelia Schwierz, Olivia Martius. 2006. Synoptic-scale weather patterns during Alpine heavy rain events. Q. J. R. Meteorol. Soc. **132**, pp. 2853–2860

Lashkari H, Ghaemi H, Hodjati Z. Amini M. 2012. Synoptic analysis of heavy rains in the province, Research Geography. No. **4**, 99-116.

Laura Bettolli M, Olga Penalba C, Walter Vargas M. 2010. Synoptic weather types in the south of South America and their relationship to daily rainfall in the core crop-producing region in Argentina, Australian Meteorological and Oceanographic Journal **60** pp.37-48

Massahbovani A, Morid S. 2005. Effects of climate change on river flow. Science and Technology of Agriculture and Natural Resources, No. **4**, 17-27.

Masoudian SA. 2006, Synoptic climatology and its application in environmental studies. authored by Brent Yarnal, Isfahan University.

Mohammad B, Masoudian A. 2010. Synoptic analysis of heavy rainfall (Case Study November 1994). Geography and Development, No. **19**, 47-70.

Mnsurfar K. 2009. Advanced statistical methods with computer programs, Tehran University, third edition

Rakhecha PR, Pisharoty PR. 1996. Heavy rainfall and monsoon: point and spatial distribution, Curent Science, Vol. **71**, No. 30.