Analyzing the Circulation Patterns Affecting Rain Showers in the Mountainous Regions of Iran

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Extended abstract

1. Introduction

Rainfall is the most significant phenomenon or feature of the environment. The factors causing rainfall have been the subject of numerous studies. Both the rainy or very dry years have considerable impact on the quality of humans' living environments. Rainfall occurs when there is enough moisture as an effective factor. Both of these conditions are provided through circulation patterns of the atmosphere. The purpose of the present study is to identify the circulation patterns and factors causing rain showers in the mountainous regions of Iran (i.e. Southern Alborz and Eastern Zagros mountain range); moreover, it is attempted to explain how they are formed, during which period of the year they could evolve more significantly, and at what times they occur in the region, along with their similarities and differences.

2. Theoretical Framework

Given the breadth and considerable socioeconomic significance of the region being studied (i.e., Southern Alborz and Eastern Zagros mountain range) it is necessary to identify the circulation patterns causing such damaging rain showers. To this end, the occurrence of this phenomenon could be predicted by observing the commencement of the sequences of patterns leading to torrential rain showers at least one or two days beforehand. In this case, there would be enough time to make necessary preparations.

3. Methodology

In this study, the circulatory synoptic approach to environment was used; in this regard, first the statistics and data on the climate codes of past and present in

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stations including codes 80 to 99 related to showers or heavy rainfalls accompanied by lightning were extracted from 50 synoptic stations in the region of the study during a 30-year period (1985-2014). Next, the days of occurrence (code 80-99) were identified followed by the days with rain showers among the entire statistical data which had been observed in at least 50% of the stations of the region; ultimately, 80 days of rain showers were identified. Then, clustering approach was used on data in order to identify circulation patterns causing such showers based on Euclidean distances and integrate it with Ward's method in SPSS. It was carried out according to the elevation data at 700 hectopascal level of these days, which is the best level for demonstrating how rain showers are formed. Furthermore, data on the vertical speed (omega) and components of orbital, meridional and vorticity winds obtained from clustering patterns at 10-80° E and 10-70° N with a spatial resolution of 2.5×2.5 degrees were provided. In the end, the related maps were drawn and analyzed in Surfer and GrADS softwares.

4. Results and Discussion

According to the findings obtained from principal components analysis, seven primary components constituting 80% of total data diffraction were selected so as to indicate climate circulation patterns. Given 80 days representing the entire days being studied (19333 days) in 50 synoptic stations during a 30-year period (1985-2014), 7 clusters (circulation patterns) causing rain showers were identified through the aforementioned method as well as conducting cluster analysis with Euclidean distances based on data at the level of 700 hectopascal using Ward's integration method. Drawing conclusions on the analysis of seven clusters at the region of the study showed the presence of drought in the western part of the region as well as blocking and cut-off low at the level of 700 hectopascals, low-pressure systems in Saudi Arabia and Eastern Iran and a high-pressure system at the northern part of the region, and dominant synoptic phenomena during days of rain showers at the region.

5. Conclusion and Suggestions

Examining the patterns of climate's upper levels in the region studied shows that the highest volume of rainfall occurs when systems are formed as blocking, while the high-altitude subtropical center moves toward more southern latitudes. Given the analysis of drawn synoptic patterns, according to the data of level 700 hectopascals, in general, it must be pointed out that among the obtained patterns from clustering the aforementioned level data, the highest number of days with rain shower occurrences in the region follows the cut-off low pattern of the Black Sea as well as the deep drought of North-Western Iran; these patterns have been formed mainly during Spring (March, April, and May). The highest amount of rainfall in this pattern has occurred in the Western and North Western of the region. The examination of this pattern demonstrated the presence of a deep and strong closed low-altitude center on the Black Sea. While this low altitude contour gradient center in the region moves, it paves the way for the formation and expansion of baroclinic waves in the eastern regions of the trough. As the low altitude center

(cut-off low) is closed, the movement of Western systems over the Iranian mountainous region is slowed down and rainfall continues. On the other hand, the western and north-eastern parts of the region under investigation are influenced by the 1025 hectopascal high pressure of Western Europe in this pattern while the eastern parts of the region are affected by the low-pressure center. The presence of a strong ridge in the Northern Mediterranean Sea as well as a deep scot-off low in the Eastern Black Sea have strengthened baroclinic waves at the lower level of the atmosphere; consequently, considering the proper convergence in low levels, suitable conditions for ascension and positive vorticity, divergence at upper levels of the atmosphere, and desirable rain showers (more than 40 mm) have been observed, particularly, in the north-eastern parts of the region. In this pattern, humidity transfer has occurred in the north-eastern and eastern parts of the region over the Caspian Sea, through high-pressure tabs. In addition, the role of the cyclonic movement of south-eastern systems in transferring and enhancing the humidity of the Arabian Sea and the Persian Gulf cannot be overlooked. According to the 7 synoptic patterns formed in this clustering, the southern and south-western low-pressure systems are of substantial importance in offering convergence among low levels and rain showers. Rainfalls occur in high volumes when systems appear as cut-off low or deep and strong low-altitude centers in the upper layers of the atmosphere. Furthermore, the presence of a strong ridge in Western Europe and the subsidence of cold weather from high latitudes have enforced pass pression center at low levels while its tabs have led to the northern streams and the injection of Caspian humidity to the western parts of the region under investigation.

Keywords: Rain showers, Circulation patterns, Principal Component Analysis and Clustering, Iran's mountainous regions

References (in Persian)

1. Alijani, B. (2009). *Eghlimshenasi synoptik* [Synoptic climatology]. Tehran, Iran: SAMT.
2. Azizi, G., & Samadi, Z. (2007). Tahlil olguye sinoptiki seyel 28 mehrmah 1382 ostanhaye gilan va mazandaran [The analysis of synoptic patterns of flooding in October 20, 2003 in Golestan and Mazandaran provinces]. *Geographical Research, 39*(8), 61-74.
3. Barati, G., Badagh Jamali, J., & Maleki, N. (2013). Naghsh vacharkhandeha dar rokhdad bareshyahe sangin dahehaye akhir gharb iran [The role of anticyclone in the occurrence of recent heavy rains in western Iran]. *Physical Geography Research Quarterly, 40*(88), 85-98.
4. Dargahian, F., Alijani, B., & Mohammadi, H. (2014). Barasi sinoptiki olguhaye feshar mortabet ba bloking moaser bar rokhdad bareshhaye modavem va sangin iran [A synoptic study of blockings causing heavy and continuous rains in Iran]. *Geography and Environmental Hazards, 3*(10), 155-173.
5. Fatahi, A., & Razie, T. (2009). Olguhaye gardesh javi ruzane ba ruye iran [The patterns of daily atmospheric circulation in Iran]. *Geographical Research, 24*(2), 45-60.

6. Gandomkar, A. (2012). Modiriat bohran voghue seyl dar shahr esfahan ba estefade az samanehaye javi [The crisis management of flooding in Isfahan using the atmospheric weather system]. *Geographical Research, 27*(105), 115-128.
7. Javanmard, S., & Asiai, M. (2005). *Farhang estelahat havashenasi va eghlim shenasi [A dictionary of meteorology and climatology]*. Mashhad, Iran: Sokhan Gostar.
8. Khoshhal Dastjerdi, J. (1998). *Tahlil va erae model hamdidi climatology baraye bareshhaye bish az sad milimetr dar savahel daryaye khazar* [Analyzing and presenting the model of synoptic climatology for rainfall of over 100 mm in the coasts of the Caspian Sea] (Unpublished doctoral dissertation). Tarbiat Modares University, Tehran, Iran.
9. Masoompour Samakosh, J., Miri, M., & Rahimi, M. (2016). Vakavi amari-hamdidi tufanhaye tondari savahel jonubi iran [A statistical-synoptic analysis of thunderstorms in the Southern Coasts of Iran]. *Journal of the Earth and Space Physics, 42*(3), 697-708.
10. Masoompour Samakosh, J., Miri, M., Zolfaghari, H., & Yarmohammadi, D. (2013). Tain sahm bareshyahe hamrafti shahr tabriz bar asas shakheshaye napayedari [Determining the convectional rainfall proportion in Tabriz following the instability indices]. *Journal of Applied Research in Geographical Sciences, 31*, 227-225.
11. Mofidi, A., Zarin, A., & Janbaz Ghobadi, G. (2007). Tain olguye hamdidi bareshhaye shadid va hadi paize dar savahel jonubi daryaye khazar [Determining the synoptic pattern of autumn heavy and extreme rains in the southern coasts of the Caspian Sea]. *Journal of the Earth and Space Physics, 33*(3), 131-154.
12. Omidvar, K. (2011). *Mokhaterat tabiei* [Natural disasters]. Yazd, Iran: Yazd University Press.
13. Omidvar, K. (2013). *Ab va havashenasi hamdidi* [Synoptic meteorology]. Yazd, Iran: Yazd University Press.
14. Omidvar, K., Hassan Beigi, S., & Rahimi, K. (2013, May). *Tahlil sinoptiki bareshhaye sangin paziezi tehran* [A synoptic analysis of autumn heavy rain in Tehran]. Paper presented at the First National Conference on Climatology of Iran, Kerman, Iran.
15. Omidvar, K., Mahmoudabadi, M., & Safarpour, F. (2015). Barasi va tahlil hamdidi bareshyahe sangin bahman 1389 dar manategh jonubi va markazi iran [A synoptic analysis of heavy rains in February 2011 in southern and central regions of Iran]. *Journal of Geography and Planning, 19*(51), 21-39.
16. Salehi, H., Saneinejad, H., & Mousavi Baygi, M. (2014). Barasi shakheshaye napayedari hengam voghue padidehaye ab va havaye mokhareb dar mashhad [Analysis of instability indices during severe weathers in Mashhad]. *Geography and Environmental Hazards, 3*(9), 113-123.
17. Zare Neyestanak, M. (2015, November). *Tahlil hamdidi baresh shadid monjar be seyl 1394.4.28 ostanhaye terhran and alborz* [A synoptic study of heavy rains caused flooding in July 19, 2015 in Tehran and Alborz provinces]. Paper

presented at the First National Conference on Water Crisis and its Management, Yazd, Iran.

References (in English)

1. Chen, C.-S., Lin, Y.-L., Peng, W. C., & Liu, C.-L. (2010). Investigation of a heavy rainfall event over southwestern Taiwan associated with a sub-synoptic cyclone during the 2003 Mei-Yu season. *Atmospheric Research, 95*(2), 235-254.
2. Hoerling, M., Eischeid, J., Perlwitz, J., Quan, X.-W., Wolter, K., & Cheng, L. (2016). Characterizing recent trends in U.S. heavy precipitation. *Journal of Climate, 29*(7), 2313-2332.
3. Kašpar, M., & Müller, M. (2010). Variants of synoptic-scale patterns inducing heavy rains in the Czech Republic. *Physics and Chemistry of the Earth, Parts A/B/C, 35*(9), 477-483.
4. Keim, B. D. (1996). Spatial, synoptic, and seasonal patterns of heavy rainfall in the southeastern United States. *Physical Geography, 17*(4), 313-328.
5. Tramblay, Y., Neppel, L., & Najib, K. (2010, September). *Heavy rainfall events in the Languedoc region (France): Relationships with synoptic patterns and frequency analysis*. Paper presented at the 12th Plinius Conference on Mediterranean Storms, Corfu Island, Greece.
6. Yonetani, T. (1982). Increase in number of days with heavy precipitation in Tokyo urban area. *Journal of Applied Meteorology, 21*(10), 1466-1471.

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