BILINGUAL PUBLISHING GROUP

Journal of Atmospheric Science Research
https://journals.bilpubgroup.com/index.php/jasr

ARTICLE

Investigating the Effects of Madden-Julian Oscillation on Climate Elements of Iran (1980-2020)

Kourosh Mohammadpour[1*]***, Zahra Hejazizadeh***[1]***, Hooshang Ghaemi***[2]***, Mohammad Salighe***[1]

[1] *Department of Natural Geography, Kharazmi University, Tehran, 15447-33111, Iran*
[2] *Tehran Institute of Meteorology and Atmospheric Sciences, Tehran, 15447-33111, Iran*

ABSTRACT

The Madden-Julian Oscillation is one of the large-scale climate change patterns in the maritime tropics, with sub-seasonal time periods of 30 to 60 days affecting tropical and subtropical regions. This phenomenon can cause changes in various quantities of the atmosphere and ocean, such as pressure, sea surface temperature, and the rate of evaporation from the ocean surface in tropical regions. In this research, the effects of Madden-Julian fluctuation on the weather elements of Iran have been investigated with the aim of knowing the effects of different phases in order to improve the quality of forecasts and benefits in territorial planning. At first, the daily rainfall data of 1980-2020 were received from the National Meteorological Organization and quality controlled. Using the Wheeler and Hendon method, the two main components RMM1 and RMM2 were analyzed, based on which the amplitude of the above two components is considered as the main indicator of the intensity and weakness of this fluctuation. This index is based on the experimental orthogonal functions of the meteorological fields, including the average wind levels of 850 and 200 hectopascals and outgoing long wave radiation (OLR) between the latitudes of 20 degrees south and 20 degrees north. The clustering of the 7-day sequence with a component above 1 was used as the basis for clustering all eight phases, and by calculating the abnormality of each phase compared to its long term in the DJF time frame, the zoning of each phase was produced separately. In the end, phases 1, 2, 7, 8 were concluded as effective phases in Iran's rainfall and phases 3, 4, 5, 6 as suppressive phases of Iran's rainfall.

Keywords: Madden-Julian oscillation; Tropical convection; precipitation; Long-wave radiation; Sub-seasonal oscillation

*CORRESPONDING AUTHOR:
Kourosh Mohammadpour, Department of Natural Geography, Kharazmi University, Tehran, 15447-33111, Iran;
Email: dr.kourosh_mohammadpour@yahoo.com

ARTICLE INFO
Received: 26 December 2022 | Revised: 29 March 2023 | Accepted: 31 March 2023 | Published Online: 14 April 2023
DOI: https://doi.org/10.30564/jasr.v6i2.5351

CITATION
Mohammadpour, K., Hejazizadeh, Z., Ghaemi, H., et al., 2023. Investigating the Effects of Madden-Julian Oscillation on Climate Elements of Iran (1980-2020). Journal of Atmospheric Science Research. 6(2): 21-32. DOI: https://doi.org/10.30564/jasr.v6i2.5351

1. Introduction

Bridging the gap between spatial-temporal and climatic scales and an in-depth understanding of planetary systems is always an important challenge that the atmospheric community faces. Undoubtedly, progress in medium-range and seasonal weather forecasting and our understanding of large-scale weather patterns and the identification of specific causes of their occurrence rely on our deep understanding of the behavior of atmospheric-oceanic patterns and their relationship with each other [1]. Pressure anomalies and atmospheric and oceanic circulation patterns sometimes impose their direct and indirect effects on areas beyond the birthplace of the current [2], which is explained by the term "circulation" [3]. As we know Madden Oscillation Julian (MJO) is a distant coupling pattern and the dominant form of sub-seasonal variability in tropical and subtropical regions, which plays an important role in the atmosphere-ocean circulation system [4]. According to different theories, this phenomenon can be effective in the intraseasonal time scale in its different phases in the region of Southwest Asia, including Iran [5]. Considering the problem of water shortage in the country and the importance of planning in this area, revealing a zoning model of the various effects of this fluctuation in the country is of great importance [6]. It should be mentioned that due to the short life of knowing the effects of this fluctuation on Iran, the lack of a zoning model of the effects caused by Madden-Julian's fluctuation on Iran is felt in the scientific community of the country [7]. On the other hand, the analysis of the different phases of this fluctuation in Iran can smooth out the contradictions of theories in recent years and the results of this research can be a light for the country's macro-planning and development on the path of territorial development and sustainable development [8]. Madden-Julian Oscillation is one of the most important general atmospheric circulation phenomena in tropical regions and has been widely studied and researched in recent decades [9]. The use of this phenomenon to predict rainfall in the inter-seasonal time scale requires knowledge of its nature as well as the physical processes that occur during its evolution and distribution. This phenomenon was first discovered by Madden and Julian (1971) [10]. By spectral analysis of ground pressure data and the orbital component of the wind field from the surface of the earth to the upper levels of the atmosphere at the Canton Island station (3 degrees south and 172 degrees west), they found out the existence of a 30-60 day fluctuation in the changes of these parameters. Further research showed that such fluctuation exists in other parts of tropical regions. They considered this fluctuation to be caused by the phenomenon of convection in a large-scale orbital circulation cell moving eastward in tropical regions, which is associated with convergence at low levels of 850 hectopascals and divergence at high levels of 200 hectopascals [11]. Madden and Julian (1994) introduced this phenomenon as the strongest climatic factor in tropical regions with an inter-seasonal time scale. This phenomenon can cause variability in various parameters of the atmosphere and ocean, such as land surface pressure, wind field, cloud cover, precipitation, air temperature, sea surface temperature, and evaporation rate from the ocean surface in tropical regions [12]. In the following, some important features of this phenomenon will be discussed [13]. The inter-seasonal period of a complete MJO cycle Madden and Julian (1971) estimated the lifetime of a complete MJO cycle to be about 40-50 days using 10 years of upper atmosphere data at the Canton Island station. Then, using the data of the orbital component of the wind field at the level of 150 hPa at the Truk Island station (7 degrees south and 152 degrees east), they estimated this period to be about 22 to 79 days with an average of 45 days (Madden and Julian, 1994). The use of variability in other committees had little difference from the previous results. For example, Knutson et al. (1986) investigated the eastward propagation of OLR anomalies and obtained two events with a lifetime period of fewer than 20 days and two events with a lifetime period of more than 79 days. The lifetime period of a complete MJO oscillation is 30 to 60. It is a day that its maximum frequency is observed in about 45 days (Madden and Julian, 1994).

2. Data and method

In the implementation of the research process on the effects of Madden-Julian fluctuation on Iran's climate, in the beginning, daily data of precipitation, maximum temperature, minimum temperature and cloud cover were received from the country's meteorological organization, which only 48 stations have data due to the start of the period since 1980. The few available gaps were processed on some days. In order to reduce the error in the possible results, with the specialized software of the data bank of the National Meteorological Organization, the data sets were quality controlled and verified and finally standardized. Next, the output data of the Wheeler and Hendon model were received and processed from the Australian Government Meteorological Database (http://www.bom.gov.au) in the mentioned time period. Various indicators have been provided to check this fluctuation. The method that has been used in the stages of this research is the Wheeler and Hendon method, which has been used as a reference for all the researchers conducted, in which the two main components of RMM1 and RMM2 are analyzed based on the formula introduced by Wheeler and Hendon. The range of the above two components is considered as the main indicator.

$$\text{Amplitude} = \sqrt{\text{RMM1}^2 + \text{RMM2}^2} \tag{1}$$

This index is based on the experimental orthogonal functions of meteorological fields, including the average wind levels of 850 and 200 hectopascals and outgoing long wave radiation (OLR) between latitudes of 15 degrees south and 15 degrees north (Wheeler and Hendon, 2004). In order to emphasize the role of Madden-Julian on Iran's rainfall and remove the phenomena of less than 30 and more than 60 days, these anomalies were passed through a time-lapse filter. For this purpose, each of the anomalies on the day is presented as follows (Duchon, 1979: Jones et al., 1997):

$$y_t = \sum_{k=-n}^{n} w_k x_{t-k}$$

$$w_k = \left[\frac{\sin(2\pi f_{c2} k)}{\pi k} - \frac{\sin(2\pi f_{c1} k)}{\pi k}\right]\sigma$$

$$f_{c1} = 1/60 day^{-1}, f_{c2} = 1/30 day^{-1} \tag{2}$$

$$n = 24 \quad \sigma = \frac{\sin\left(\frac{\pi k}{n}\right)}{\left(\frac{\pi k}{n}\right)}$$

In these relations **w·k**, the weighting coefficients, f_{c1} and f_{c2} are the highest and lowest frequencies, respectively [14]. As a result, by applying these filters, phenomena whose activity period is more than 60 days and less than 30 days will be removed from the data groups. In the next step, the data of 40 years of parameters of daily precipitation, maximum temperature, minimum temperature and amount of cloudiness in each phase were clustered separately and prepared through various standardizations in Excel and Mini Tab software. Then, using Arc software GIS was concluded as zoning. In order to check the standard of phases and its effects on the climatic region of Iran, the long-term data of the phases of Madden-Julian oscillations have been considered in the clustering stage as a sequence of 7 days and more. This filter separately shows the net effects of this fluctuation on the study area, in the continuation of the purification process and application of various filters. With this condition, the number of days related to each phase in the study period is given. In this table, phases one, which is considered the birth of the Madden-Julian oscillation, have the minimum frequency and phase seven has the maximum frequency. The second part of **Table 1**, it refers to the number of consecutive periods of 7 days and more, among which phase one has the shortest period and phase 7 has the longest period [15].

Next, for the synoptic analysis of the studied meteorological quantities, the maps of the pressure fields of the earth's surface, geopotential height and wind at the standard pressure levels of each of the phases, from the daily data of the global reanalysis of the NCEP/NCAR database during the forty-year winter period (including the month December, January and February corresponding to the years 1980 to 2020) were extracted for the region of Western Europe to Central Asia. Abnormality maps of the above atmospheric patterns of each of the eight phases of the Madden-Julian Oscillation were prepared with the desired quantities. The daily rainfall data of 48 satellite stations related to the three months of December, January and February during the forty-year statistical period (1980 to 2020) were obtained from the National Meteorological Organization. The distribution of these stations in the country is shown in **Figures 1-3**. It should be noted that due to the lack of a number of stations in the country and the weakening of the quality of the graphic output of zoning, the number of processing networks was increased by using the IDW interpolation method and the resolution of the studied points increased significantly. IDW interpolation is one of the important methods whose purpose is to interpolate and determine the amount of a parameter between two measured points. This work is also done according to the neighboring points and by averaging the sample points that are located around each unknown point. The data used in this research, with a spatial separation of one degree, are related to the wind field components, geopotential height, sea level pressure, temperature and humidity for the months of December, January and February 1980 to 2020, the average maps of The NCEP/NCAR daily norms of these committees were received and produced simultaneously with the clusters of eight phases as well as the average daily data of long-wave radiation from the top of the atmosphere from 1980 to 2020 with a spatial resolution of 2.5 degrees. In order to emphasize the role of the MJO, these anomalies are passed through a 30- to 60-day Lenxos inter-pass filter with 49 weighting factors. Finally, using the RMM index, based on which the activity period of each MJO event is divided into eight different phases, the average of these anomalies in each phase has been calculated and analyzed. In the second method of the research, by implementing the MM5 numerical model, the characteristics of different MJO phases have been simulated over a region including Southwest Asia and important parts of the Indian Ocean. In this regard, to reduce and eliminate the MJO effect, the initial pattern of the horizontal wind field between latitudes of five to 15 degrees north of the target network has been changed and then the model has been implemented. The results show that in the sixth and seventh phases of the MJO, with the reduction of geopotential height anomalies of the mid-level of the atmosphere, Strengthening of moisture fluxes and hot and humid currents from the Indian Ocean, strengthening of the divergence of the current at the top and its convergence at the bottom of the atmosphere and the upward movements of the air, a noticeable increase in conditions suitable for rainfall has occurred in parts of the south and southeast of the country. On the other hand, in the third, fourth and to some extent the fifth phases of MJO, with the reverse change of all the mentioned factors, there has been a noticeable decrease in the suitable conditions for rainfall in the mentioned areas. Pearson's correlation coefficient is one of the parametric statistical tests that represent the degree of linear regression relationship between two variables, which is denoted by r, whose value varies between +1 and –1. Pearson's correlation coefficient for a statistical sample with n pairs of data [16] {display style (X_{i},Y_{i})} is defined as follows:

Table 1. The number of days of phases one to eight of the Madden-Julian Oscillation under the condition of a sequence of 7 days or more (1980-2020).

phase	8	7	6	5	4	3	2	1
number of days	140	178	157	125	126	130	79	75
number of period	16	20	19	15	14	16	11	9

$$r_{xy} = \frac{(\sum x-\bar{x})(\sum y-\bar{y})}{\sqrt{\sum x^{r} \sum y^{r}}} \quad (3)$$

If the correlation coefficient is positive, the relationship between the two variables is direct, and if it is negative, the relationship between the two variables will be inverse [17]. In the next step, the studied parameters related to each of the MJO phases were extracted and prepared based on **Table 1**. Abnormality maps of the aforementioned atmospheric parameters were calculated for each of the MJO phases compared to the average of 40 years, and maps related to each phase were prepared and analyzed separately. Here it is necessary to explain the abnormality of each parameter in each of the phases (q_{an}) including the difference between the average of that parameter in each phase (q_{ph}) with a forty-year average (from 1980 to 2020) of December, January and February. It will be the same amount. If it was greater than zero, it indicates a positive abnormality, and if it was less than zero, it indicates a negative abnormality [18].

$$q_{an} = q_{ph} - q_{3mon} \quad (4)$$

According to the output of the desired models of this research, in addition to statistical and synoptic discussion and the effects of MJO phases on other atmospheric systems and external links affecting Iran's climate, at the end of the output, the obtained results are plotted in the form of zoning maps, which we will show and explain in the conclusion section. Considering the importance of analyzing the precipitation data and other desired parameters, the output of this research will be the direct and indirect effects of the Madden-Julian oscillation phases on Iran's climate elements, as well as the interaction of the surrounding atmospheric systems and the pressure and wind fields and the simultaneous phases of Madden-Julian can show a purer effect of this important atmospheric event on the water and soil area of Iran. Another part of the data and analyzed in this research is the Wheeler chart data in the format (NC) and graphical display of interest, whose indicators were evaluated and discussed during the years 1980 to 2020. We got Madden-Julian from it and the verification and the final results of the work required a lot of these data, and definitely still in all the research of the world of science, the Wheeler diagram and the OLR data are still considered to be the leading data of Madden-Julian's Oceanic Atmospheric Oscillation investigation, which is shown below in the output.

3. Discussion

As discussed in the previous section about data mining and data processing, the country's daily rainfall data was analyzed in the period from 1980 to 2020, and finally, after applying data optimization filters, the output of Iran's rainfall zoning was The use of Arc Gis software was produced separately for all eight phases, which we will discuss in the following. According to the output of the map in **Figure 1**, which shows the irregularity of Iran's rainfall in phase 1 of Madden-Julian Oscillation, the distribution of rainfall in the conditions of phase one. It can be seen with a variety of fluctuations, among which the share of rainfall and abnormality of rainfall in the southwestern and southern regions of Iran, especially The region of Fars, Hormozgan, West Kerman and Bushehr provinces is more and it is significantly distinguished from other regions of Iran. In the region of the Caspian coast, the main reason for the rainfall is different from the rainfall in other regions of Iran, and it is not discussed in this analysis. In **Figure 2**, Iran's rainfall anomaly shows in phase 2. Compared to phase 1, the precipitations are weakened and uniformly weaker in most abnormal areas. **Figure 3** shows the irregularity of Iran's rainfall in the 3rd phase of Madden-Julian Oscillation. The significance of precipitation is limited and almost local. In phase 3, there is no precipitation in Iran, and obviously, with the beginning of the positive phase of Madden-Julian Oscillation, which includes phases 3, 4, 5, and 6, the changes in precipitation in Iran are different from the negative phases (1, 2, 7, 8). Its changes relative to each other can be considered. In **Figures 4 and 5**, rainfall anomalies are still weak and spotty at the level of the country. In **Figure 6**, which represents the irregularity of Iran's rainfall in the 6th phase of Maden Julian Oscillation, rainfall can be seen in the western and southwestern regions of Iran tangent to the Zagros mountain range, where the provinces of Kurdistan, Kermanshah, Ilam, Khuzestan, Lorestan, Fars, Bushehr, Chaharmahal and Bakhtiari. It has affected Kohgiluyeh and Boyer Ahmad, Hamedan and Markazi in a clear way. In **Figure 7**, most of the rains occurred in the southern half of Iran. Sistan and Baluchistan provinces, south Kerman, Hormozgan, Bushehr, Kohgiluyeh and Boyer Ahmad, Chaharmahal and Bakhtiari, Khuzestan, Ilam, Lorestan, Fars and Bushehr are affected by the seventh phase of MJO, among which Hormozgan and Fars provinces have more anomalies than other southern provinces. In **Figure 8**, a stronger anomaly in the west, southwest and in south of Iran, it can be seen that the share of the provinces of West Hormozgan, Bushehr, Kohgiluyeh and Boyer Ahmad, Chaharmahal and Bakhtiari, Kurdistan, Kermanshah, Ilam, Khuzestan, Ilam, Lorestan, Fars and Bushehr in this anomaly is different from other provinces. The 24-hour average cloudiness maps of Iran in the 40-year period of 1980-2020 were separately averaged and produced in 8 phases, the purpose of which is to verify the effects of the Madden-Julian fluctuation on various atmospheric parameters and a more detailed analysis of the studied indicators. In this group of maps, the amount of cloudiness in the 24-hour period was checked on average, which was compared with the OLR maps and a conclusion was drawn (**Figure 9**). In the phase 1 model cloud cover can be seen in most regions of the country, which is consistent with the phase 1 precipitation maps and is a seal of approval in the verification of precipitation maps. In the phase 2 model, the amount of cloudiness in the country is more limited than in phase 1, and most of the cloudiness is seen in the northern half of Iran. In the phase 3 model, which indicates phase 3, the cloudiness is partially reduced from its previous phase and the cloudiness level of the Iranian sky is more limited. In models 4 and 5, which indicate phases 4 and 5, exactly in line with the precipitation maps of the country, the sky does not have the cloud cover caused by the Madden-Julian oscillation, and in these two phases, it is not much affected by the MJO. In model 6, which is related to phase 6, again with the change of the activity of the Julian oscillation from a positive to a negative phase, the cloudiness level has significant changes in the sky of Iran. And it is proven to be exactly in line with the precipitation maps of MJO activity in Iran in phases 6, 7 and 8. In model 8, which represents the 8th phase, cloudiness has intensified and strengthened while spreading in the sky of Iran in the western region of Iran in the provinces of Kurdistan, Kermanshah, Ilam, Hamedan, Lorestan and the western area of Alborz.

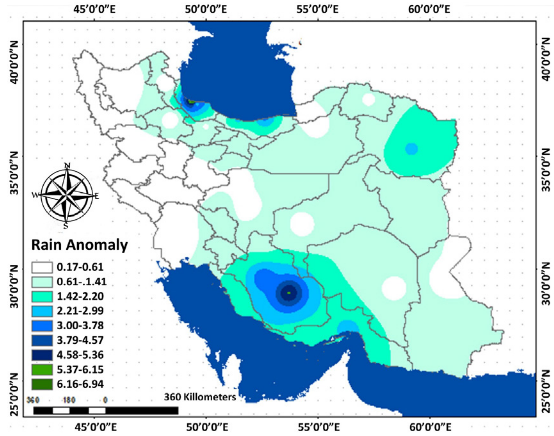

Figure 1. Iran's rainfall anomaly map in phase 1 of Madden-Julian Oscillation.

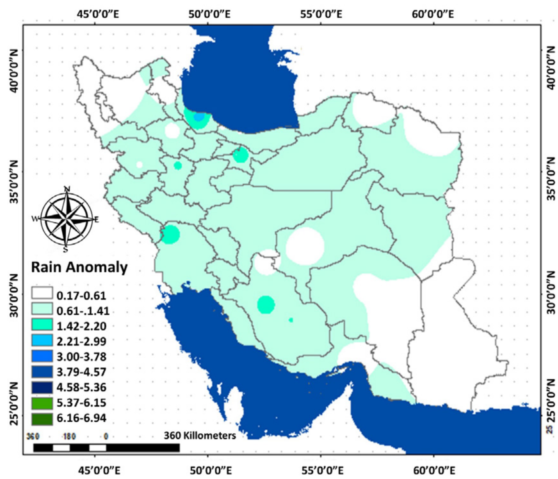

Figure 2. Iran's rainfall anomaly map in phase 2 of Madden-Julian Oscillation.

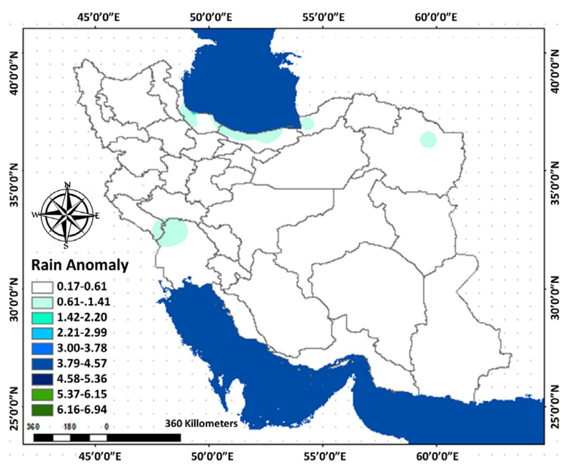

Figure 3. Iran's rainfall anomaly map in phase 3 of Madden-Julian Oscillation.

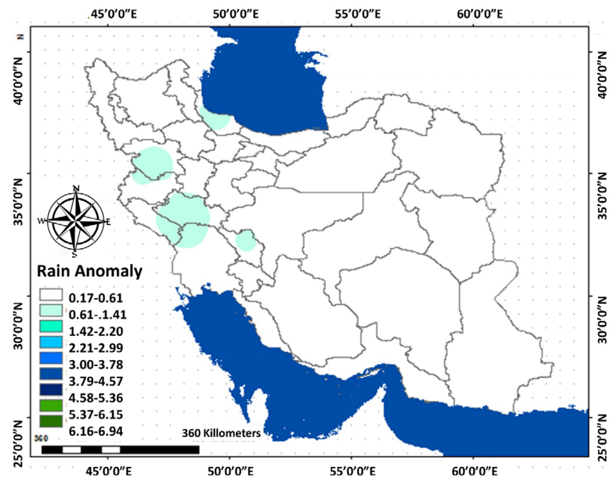

Figure 4. Iran's rainfall anomaly map in phase 4 of Madden-Julian Oscillation.

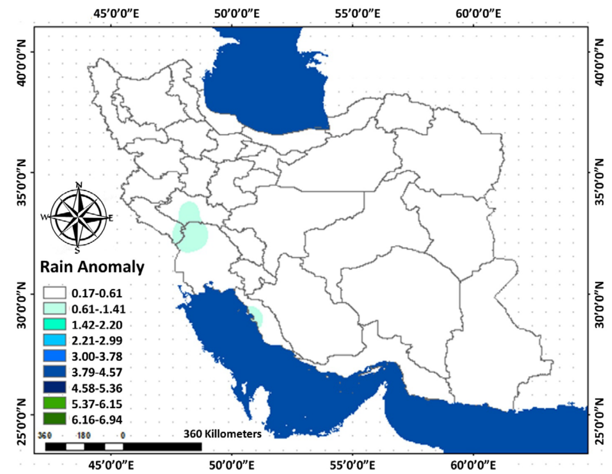

Figure 5. Iran's rainfall anomaly map in phase 5 of Madden-Julian Oscillation.

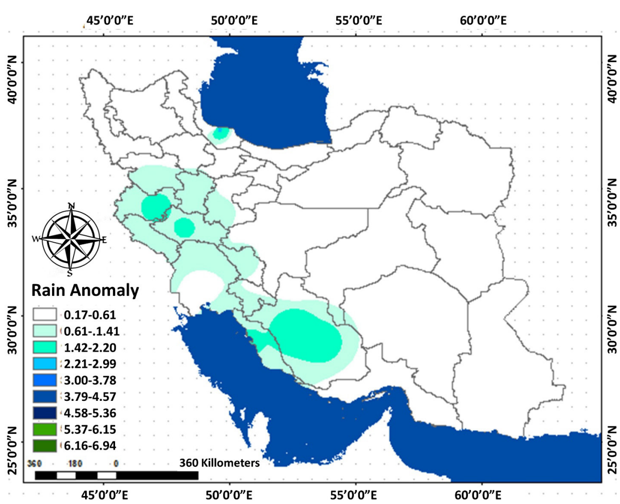

Figure 6. Iran's rainfall anomaly map in phase 6 of Madden-Julian Oscillation.

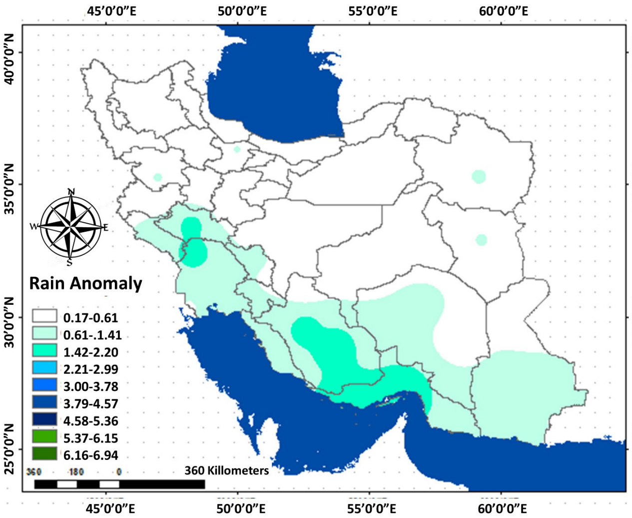

Figure 7. Iran's rainfall anomaly map in phase 7 of Madden-Julian Oscillation.

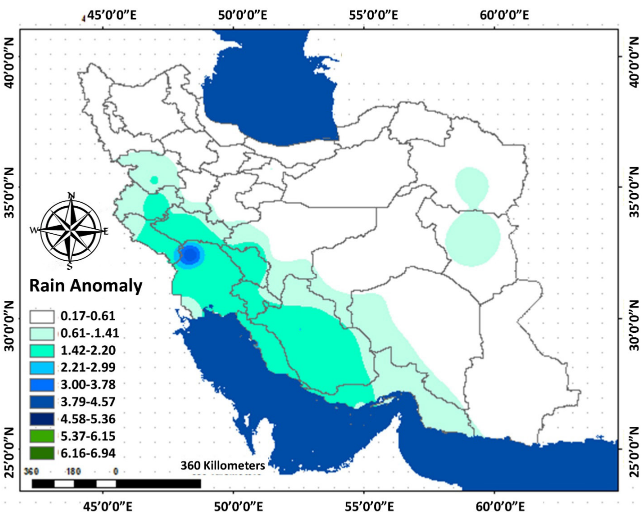

Figure 8. Iran's rainfall anomaly map in phase 8 of Madden-Julian Oscillation.

Interpretation of the mutual effects of the currents and the eight phases of the MJO

In this part of the article, we intend to interpret the mutual effects of jet streams and the eight phases of MJO, which is one of the most important factors of rainfall anomalies in the region. **Figure 10** shows the long-term average of the orbital wind component at the level of 200 m bar for DJF months from 1980 to 2020. In these maps, Iran is located between the two rivers of Asia and North Africa. And the connection and discontinuity between these two rivers can have a very important effect on Iran's rainfall [19].

During the occurrence of positive phases and when convection takes place in the region of Indonesia, the occurrence of abnormal events at the peak of convection with the divergence and anomalies of the upper levels winds cause the connection and continuity of the Asian and North African jets [20]. Due to the importance of the entry and exit of the rivers, which have positive and negative convection effects, these conditions can have a great effect on the behavior of phase precipitation in the region of Iran. In these situations, when the jets are connected to each other discretely or continuously. The impact of the behavior of the jets and the effects caused by them are weakened or strengthened. As can be seen in **Figure 11**, the different phases of Madden-Julian have an effect on the wind field of the upper atmosphere and as a result on the winds and their behavior.

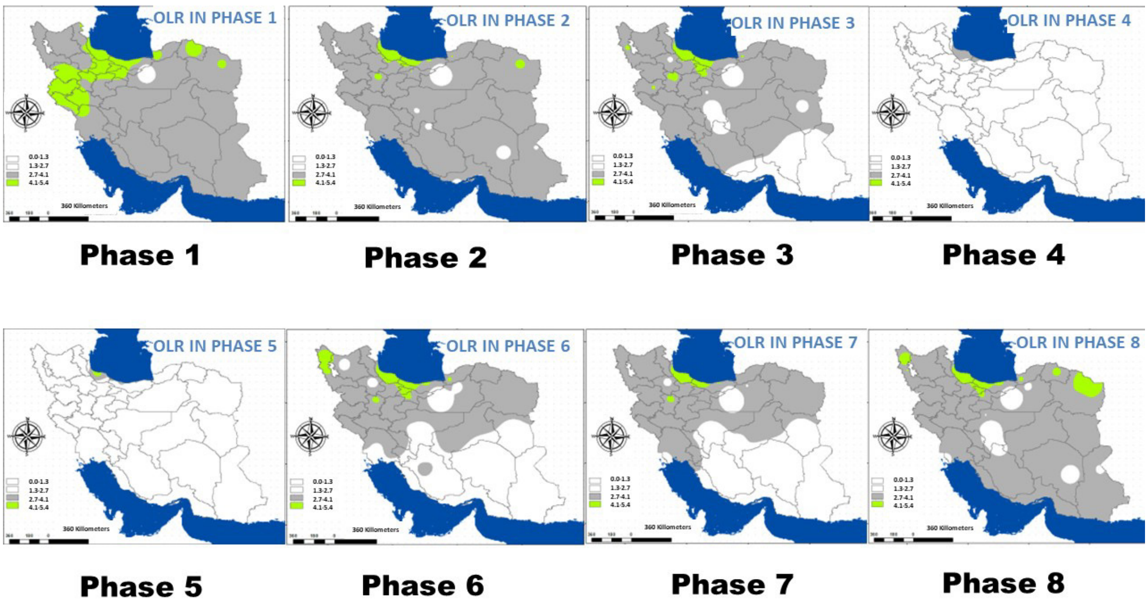

Figure 9. Clouds map of Iran during Madden-Julian oscillation phases (1980-2020).

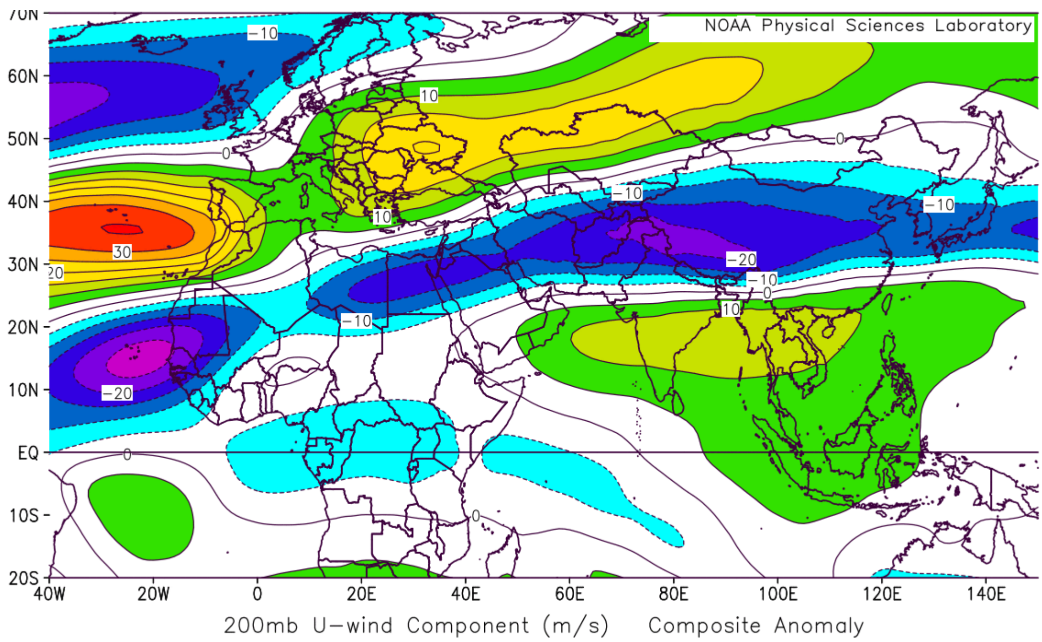

Figure 10. Long-term anomaly (between 1980 and 2020) of wind orbital component at 200 hPa level for DJF months and subtropical jet stream climatic position and average wind orbital component in the positive phases of MJO. (NOAA Physical Scinces Laboratory).

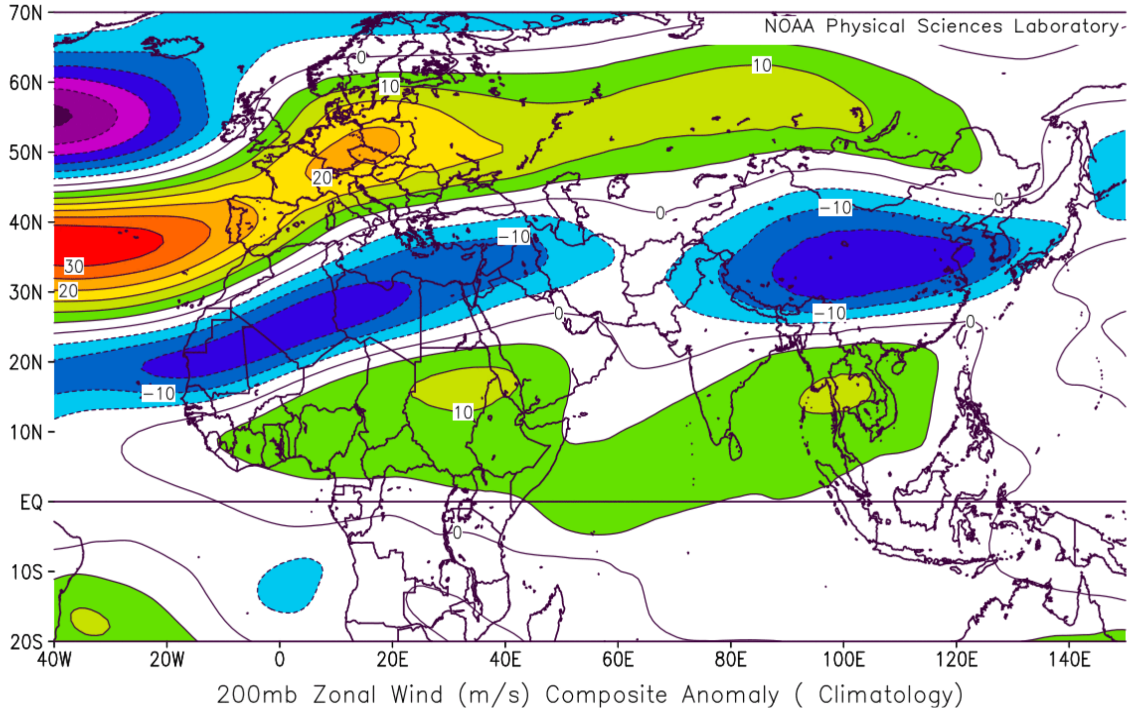

Figure 11. Long-term anomaly (between 1980 and 2020) of wind orbital component at 200 hPa level for DJF months and subtropical jet stream climate position and mean wind orbital component in the negative phases MJO. (NOAA Physical Scinces Laboratory).

The analysis of the anomaly of the meridional wind component at the level of 200 m bar (**Figure 9**) fully confirms that during the occurrence of positive phases of the MJO, the North African anomaly in the exit region of the jet and the wind fields in this region caused the jet to expand to the Indian region. The final connection of these two rivers has brought about this issue, which will cause Iran to leave the area of influence of the North African jet stream and the unstable conditions in Iran will disappear, in which we are witnessing a calm and stable pattern in Iran's air. But on the contrary, as **Figure 10** shows, when the anomalies of the upper atmosphere and the winds of this region are disturbed by convection in the negative phases of Madden-Julian, Iran is again located in the exit region of the North African Wind. It becomes favorable for the occurrence of precipitation in Iran, and in the conditions of the presence of precipitation systems, we will witness the strengthening of their precipitation behavior in Iran.

4. Conclusions

Phases with a sequence of 7 days and a component above 1 were used as the basis for clustering all eight phases, and by calculating the abnormality of each phase compared to its long duration in the DJF time frame and by passing the data through the 30-60 day intermediate filter, zoning each phase was produced in latitude 25 to 40 degrees north and longitude 44 to 63 east. With the investigations carried out and the output of the models and finally the production of zoning related to Iran's rainfall anomalies in the eight phases of the MJO, the country's daily rainfall data were analyzed in the period from 1980 to 2021, which finally after applying data optimization filters, Iran's precipitation zoning output using Arc Gis software were produced separately for all eight phases. According to the outputs, the distribution of rainfall in the conditions of phase one can be seen with a variety of fluctuations, among which the share of rainfall and rainfall anomalies is greater in the southwestern and southern regions of Iran, especially in the regions of Fars, Hormozgan, West Kerman and Bushehr provinces. It is significantly different from other regions of Iran. In the region of the Caspian coast, the main reason for the rainfall is different from the rainfall in other regions of Iran, and it is not discussed in this analysis. Iran's rainfall anomaly in phase 2 has weakened compared to phase 1 rainfall, and it can be felt that the anomaly is weaker in most areas. Iran's rainfall anomaly in phase 3 of Madden-Julian Oscillation has shown, we have significantly limited rainfall and almost locally. In phase 3, there is no rainfall in Iran, and obviously, with the beginning of the positive phase of the Madden-Julian Oscillation, which includes phases 3, 4, 5, and 6, the changes in precipitation in Iran are different from the negative phases 1, 2, 7, and 8, and their changes can be considered in relation to each other. Eliminating the boundary between spatial-temporal scales and a deeper understanding of distant planetary systems is always an important challenge that the scientific community is facing. Undoubtedly, progress in medium-range and seasonal weather forecasting and our understanding of large-scale weather patterns and the identification of specific causes of their occurrence rely on our deep understanding of the behavior of atmospheric-oceanic patterns and their relationship with each other. Based on the direction of this research, the investigation of precipitation anomalies associated with the eight phases of MJO during the period of December, January and February 1980 to 2020 showed that the precipitation behavior of each of these phases is different from each other. These abnormalities are variable in each phase. At the end of this research, the results were obtained that the effect of MJO on Iran's rainfall is clear and according to the filters applied in this research, it can be concluded with a high percentage of confidence that this phenomenon is formed in the west of the Indian Ocean and towards the east. It is most active in the Indonesian region (phase 5) and weakens and gradually subsides in the middle of the Pacific Ocean (phase 8). The existence of strong and negative anomalies of the long wave radiation of the OLR output from the top of the atmosphere in the MJO convection zone. These anomalies are mainly due to the fact that in the convection zone, very huge convective clouds are formed and spread, whose peaks extend to the east and have weak long-wave radiation, which is evident in the path of OLR images. The presence of two rotating cells at the 850 hpa level on both sides of the equator and around the convection zone. These two cells in the convection zone cause the convergence of western winds, and the eastern winds located in front of the convection zone also help to strengthen this convergence [6]. Based on the results, it seems that the effects of the MJO include the regions of Iran, which is the result of the interaction between the MJO and other large-scale atmospheric circulations, especially the North Atlantic Oscillation (NAO) [4]. This fluctuation in phases 1, 2, 7, and 8 is clearly effective in some areas of Iran, and in phases 3, 4, 5, and 6, which are known as positive phases, it has a debilitating effect and rainfall is significantly limited. Considering the problem of water shortage in the country and the importance of planning in this area, it is very important to reveal the zoning pattern of the various effects of this fluctuation in the country. To complete these results, the frequency of dry and wet periods with positive and negative phase events respectively MJO is correlated. Thus, in the positive phase, the possibility of drought and in the negative phase of MJO is more likely to occur periodically. Finally, it can be concluded that Madden-Julian Oscillation indirectly and in the form of an intensifying and modulating engine has an effect on Iran's climate elements such as precipitation, humidity, cloudiness, wind and drought, and each of its phases in different ways in the water and Iran's weather are influential. Considering the outstanding research of this research on the effects of the Julian Oscillation on Iran, it was tried to examine the effects as purely as possible and the effects of other systems were removed from it, and this result was achieved to a high extent. In the end, it is hoped that the analysis of different phases and zoning produced by this research will be a light for the country's macro-planning and development in the direction of territorial improvement and sustainable development.

Conflict of Interest

There is no conflict of interest.

References

[1] Hejazizade Begum, Zahra. Sadaqat, Mehdi. 2018. Digital tracking of cyclones in the Middle East during the cold period of the year: natural geography researches (former geographical researches), 41st fall of 2018, number 69. (in Persian)
DOI: http://ensani.ir/fa/article/226106/

[2] Alamzadeh, Sh., Ahmadi Gievi, F., Mohbalhajeh, A. R., and Nasrasafhani, M. A. 1392. Statistical-dynamical analysis of the mutual effects of NAO and MJO. Geophysical Journal, 64-80 (in Persian)
DOI: https://www.ijgeophysics.ir/article_39526.html

[3] Quaid Amini Asadabadi, H., and Nazemalsadat, M. J. 1391. Evaluation of Madden-Julian Oscillations on the occurrence of daily rainfall in Sistan and Baluchistan and Fars Provinces: Ab and Khak Journal, 1383-1372, 6. (in Persian)
DOI: https://jsw.um.ac.ir/article_36596.html

[4] Nasr Isfahani, M., Ahmadi Givi, F., 1389. Effect of Indian Ocean Convection on Some Meteorological Committees in Southwest Asia. Proceedings of the 14th Iran Geophysical Conference, Institute of Geophysics. (in Persian)
DOI: https://journals.ut.ac.ir/article_70987.html

[5] Abadi, R.S., Soori, M., 2017. A study of the impacts of the MJO on atmospheric circulations and winter precipitation in Iran. Iranian Journal of Geophysics, 11(1), 49-65. (in Persian)
DOI: https://www.ijgeophysics.ir/article_46715.html#ar_info_pnl_cite

[6] Ahmadi Givi, Farhang and Mohib al-Hajjah, Ahmadi Givi, Farhang and Mohib al-Hajjah, Alireza and Ghazanfari, Abolqasem, 2008, Studying the distribution of humidity and precipitation over Iran in the winter of 2006 and its possible relationship with the circulation in the Indian Ocean. (in Persian)
DOI: https://civilica.com/doc/72702/

[7] Barlow, M., Wheeler, M., Lyon, B., et al., 2005. Modulation of daily precipitation over southwest Asia by the Madden-Julian Oscillation. Monthly Weather Review. 133, 3579-3594.

[8] Bond, N.A., Vecchi, G.A., 2003. The influence of the Madden-Julian oscillation on precipitation in Oregon and Washington. Weather and Forecasting. 18, 600-613.

[9] Cassou, C., 2008. Intraseasonal interaction between the Madden-Julian Oscillation and the North Atlantic Oscillation. Nature. 455, 523-527.

[10] Henderson, S.A., Maloney, E.D., Barnes, E.A., 2016. The influence of the Madden-Julian Oscillation on northern hemisphere winter blocking. Journal of Climate. 29, 4597-4616.

[11] Jones, C., 2000. Occurrence of extreme precipitation events in California and relationships with the Madden-Julian Oscillation. Journal of Climate. 13, 3576-3587.

[12] Jones, C., Waliser, D.E., Lau, K.M., et al., 2004. Global occurrences of extreme precipitation and the Madden-Julian Oscillation: Observations and predictability. Journal of Climate. 17, 4575-4589.

[13] Jones, C., Carvalho, L.M.V., 2010. Spatial intensity variations in extreme precipitation in the contiguous United States and the Madden-Julian Oscillation. Journal of Climate. 25(14), 4898-4913.

[14] Johnson, N.C., Collins, D.C., Feldstein, S.B., et al., 2014. Skillful wintertime north American temperature forecasts out to 4 weeks based on the State of ENSO and the MJO. Weather and Forecasting. 13, 23-38.

[15] Hendon, H.H., Salby, M.L., 1994. The life cycle of the Madden-Julian Oscillation. Journal of the Atmospheric Sciences. 51, 2225-2237.

[16] Kalnay, E., Kanamitsu, M., Kistler, R., et al., 1996. The NCEP/NCAR 40-year reanalysis project. Bulletin of the American Meteorological Society. 77(3), 437-472.

[17] Lin, H., Brunet, G., Derome, J., 2009. An observed connection between the North Atlantic Oscillation and the Madden-Julian oscillation. Journal of Climate. 22, 364-380.

[18] Lin, H., Brunet, G., Mo, R., 2010. Impact of the Madden-Julian Oscillation on wintertime precipitation in Canada. Monthly Weather Review. 138, 3822-3839.

[19] Madden, R.A., Julian, P.R., 1972. Description of global-scale circulation cells in the tropics with a 40-50 day period. Journal of the Atmospheric Sciences. 29, 1109-1123.

[20] Climate Plotting and Analysis Tools [Internet] [cited 2023 Mar 27]. Available from: https://psl.noaa.gov/data/getpage/