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Study of the Madden-Julian Oscillation (MJO) Scheme in South Sulawesi Province

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Abstract

The Madden-Julian Oscillation (MJO) is a phenomenon of the propagation of oscillatory waves that move eastward to the earth with a repetition time of 30-90 days and the impact is very strongly felt in low-latitude areas, near the equator and occurs for the first time in the Indian Ocean and moves eastward between 100 latitude and 100 latitude. MJO is closely related to an increase in excessive rainfall during the rainy season and even the dry season in Indonesia. This research was conducted with the aim of analyzing the effect of the rainfall parameter on MJO and the scheme for the emergence of MJO in South Sulawesi Province, through empirical methods with statistical calculations, based on MJO data in the form of MJO amplitude index values and daily rainfall data for South Sulawesi Province. MJO data was taken from BoM while rainfall data was obtained from NASA TRMM 3B42RT with a time range from 2010 to 2019. Both data were filtered for MJO focusing on phases 2 and 3 (Indian Ocean) and 4 and 5 (Indonesian Maritime Continent) and then analyzed the correlation with sensitivity analysis by simple linear regression, and data plotted on a graph for each year. South Sulawesi Province is one in Indonesia which is located in the southern part of Sulawesi Island. Astronomically, South Sulawesi is located at 0°12' - 8° South Latitude and 116°48' - 122°36' East Longitude. Its geographical location is in the middle of the Indonesian Maritime Continent (BMI), there is a strong positive dominant correlation effect in the province of South Sulawesi with an r of 0.712. This means that the rainfall parameter in South Sulawesi Province can have a strengthening influence on the MJO. Based on the graphical scheme of the emergence of MJO in the province of South Sulawesi, there was an increase in rainfall during phases 4 and 5 which occurred for eight days. In addition, the influence of ENSO and IOD can strengthen MJO or even trigger MJO and still cause excessive rainfall which is influenced by these global factors, besides that local factors also affect rainfall such as monsoon winds and topographical conditions that are different in each province. So not all of the rainfall that occurs is caused by MJO activity.

Keywords: Madden-Julian Oscillation; rainfall; South Sulawesi Province

1. Preliminary

The territory of Indonesia is known as the Indonesian Maritime Continent (BMI) or better known as the Indonesia Maritime Continent (IMC), which is surrounded 75% by sea and only about 25% consists of land, and has a very strategic location, which is flanked by two large continents (Asia). and Australia) and the two great oceans (Pacific and Indian). Conditions in which the role of the land (islands) and the surrounding ocean have a major influence on climate variations, atmospheric and marine anomalies on local and global scales. This area is thought to be a place for heat storage in the form of sensible heat and latent heat for the formation of rain clouds such as cumulonimbus. South Sulawesi Province is one of the provinces whose geographical location is in the middle of the maritime continent of Indonesia.

One of the global phenomena that affect Indonesia's weather and climate is the Madden Julian Oscillation (MJO). According to Madden & Jullian (1971), MJO is the dominant oscillation model of variability in the tropics. The impact of MJO is very strong in low latitudes, near the equator, and occurs for the first time in the Indian Ocean with an eastward movement between 100º LU and 100º LS. The MJO can be characterized as an eastward “pulse” of clouds and precipitation near the equator that usually repeats every 30 to 60 days producing the main intra-seasonal fluctuations that explain the variations in weather in the tropics. The MJO affects the entire troposphere in the tropics but is even more pronounced in the Indian Ocean and in the western Pacific Ocean. MJO includes variations in wind, sea surface temperature (SST), cloudiness and rainfall and can trigger the ENSO phenomenon which is well known as a single signal from intraseasonal variations in Earth's climate.

The MJO phenomenon can be the cause of high-intensity rain events in several regions in Indonesia and sea level rise. This impact can cause natural disasters such as floods and landslides. It is realized that it is not easy to detect when and where the dominant MJO activity occurs. Referring to the problems above, a research was carried out on the characteristics and schemes for the appearance of MJO (Madden Julian Oscillation) in the archipelago, which would then be set forth in the form of research writing with the title Study of the Scheme for the emergence of MJO in the archipelago.

2. Literature Review

Atmospheric oscillation is an atmospheric phenomenon that occurs due to the inequality of solar energy received at the earth's surface. Several types of atmospheric oscillations are known, including the intra/sub-seasonal oscillation or the Madden Julia Oscillation (ISO/MJO), which is a sub-seasonal oscillation. Other atmospheric phenomena are the southern annual oscillation (SAO) which is a semi-annual or monsoonal atmospheric oscillation, the annual oscillation (AO) with a one-year oscillation period, the Quasi Biennial Oscillation (QBO) and the El Nino Southern Oscillation (ENSO) phenomenon with an oscillation period 3-7 years [1].

2.1 Madden-Julian Oscillation (MJO)

Indonesia as an archipelagic country has many islands, and the sea is the dominant part of the land. Where almost 2/3 of it is filled with water, and the rest is by land/islands, with a coastline length of around 81,000 km and consisting of approximately 17,508 islands, both large and small islands, so this area is the only area that has the most convection. currently active. This is also what causes this area to get wet almost every year due to the intensity of the rainfall it produces. As a result, this region is susceptible to various global weather or climate phenomena, particularly the Madden Julian Oscillation (MJO) phenomenon.

According to Madden & Julian [2], MJO is a dominant oscillation model of variability in the tropics. Oscillation is a periodic variation over time from a measurement result. The impact of MJO is very strong in low latitudes, near the equator, and occurs for the first time in the Indian Ocean with an eastward movement between 100º LU and 100º LS. MJO is manifested on a time scale between 30-60 days through large-scale anomaly patterns of atmospheric circulation and strong convection that propagates from the western part of Indonesia (Indian Ocean) to the east (Pacific Ocean) with an average speed of 5 m/sec. The area traversed by the MJO will experience an increase in sea surface temperature along with the passage of sea currents to the east which will have an impact on the high evaporation of sea water. Zang [3] explains that there is a vertical movement of water vapor and forms several rain cloud clusters with a speed of 5-10 m/s [4]. This cloud contains a lot of water and has a return period of 30 to 90 days, which means that in that time range there will be an increase in rain in the areas it passes through.

MJO was first discovered in 1971 by Dr Roland Madden and Dr Paul Julian of the US NCAR (National Center for Atmospheric Research), when they were studying wind patterns and tropical pressure. They observed a regular oscillation of winds between Singapore and Canton Island in the West Central Equatorial Pacific.

MJO weather disturbances such as clouds, rain, wind and pressure which move eastwards, cross the tropics and return to their starting point. MJO in the active phase has a correlation with the occurrence of high rainfall intensity to the area it passes. MJO also has a significant effect on monsoons, such as affecting the time of onset of monsoons, also disrupting the active phase and the monsoon break phase.

2.2 Characteristics of MJO

According to Madden and Jullian [2], MJO events are characterized by eastward propagation of tropical areas that are experiencing increased pressure, especially in the Indian Ocean and the Pacific Ocean. Rainfall anomalies often occur in the Indian Ocean which then spreads eastward in warm tropical waters, to be precise in the western and central Pacific. When the ocean waters are cold in the East Pacific region, rainfall patterns in the Pacific region diminish, but will occur more frequently around the tropical waters of the Atlantic and Africa. Along with the variations in tropical precipitation, there are different patterns and circulation of the atmosphere in the tropics and subtropics. These variations occur almost all over the world with the highest intensity in the eastern hemisphere.

The following description is adapted from Madden and Julian [2], which is then simplified by Gottschalck et al [5]. A vertical section of the MJO at the equator showing rainfall, wind speed and direction as well as sea surface temperature (SST) when the MJO moves eastward from the Indian Ocean to the Pacific Ocean around the tropics.

According to Higgins and Shi [6], MJO has eight phases every one oscillation period. When MJO is active, there is a significant increase in wind speed at an altitude of 850 hPa. Typical conditions for the eight different stages of the MJO cycle the various oscillations that propagate from the Indian Ocean through the Pacific Ocean and into the western hemisphere (Fig. 2) show potential rainfall, wind speed and direction of 850 hPa, and sea level pressure between November to April.

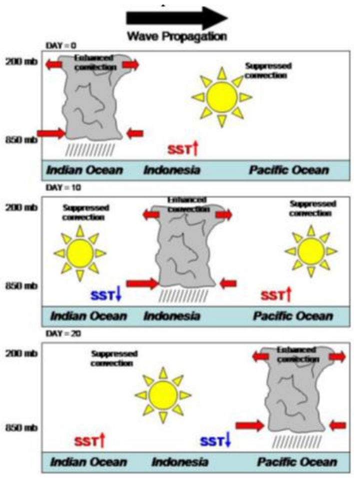

Figure 1. MJO propagation [5]

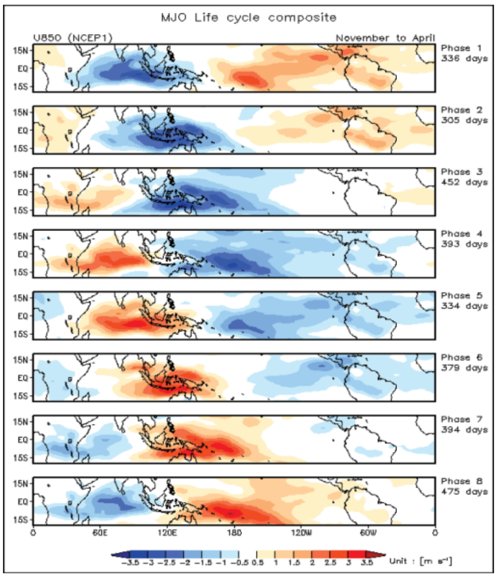

Figure 2. MJO phase [5]

MJO consists of 2 phases, namely the convective rainfall phase and the decreasing rainfall phase. MJO identification can be performed using RMM (Real-time Multivariate) 1 and 2 index data. RMM1 and RMM2 convective phase locations based on geography can be seen in 8 phases (Fig. 3). MJO has these eight phases in completing one oscillation period starting from the western Indian Ocean or eastern Africa. These phases are as follows:

1. Phase 1 in Afrika (21°BB- 60°BT)
2. Phase 2 in the western Indian Ocean (60° East - 80° East).
3. Phase 3 in the Eastern Indian Ocean (80° East - 100° East).
4. Phase 4 in western Indonesia (100° East - 120° East).
5. Phase 5 in Eastern Indonesia (120° East -140° East).
6. Phase 6 in the West Pacific region (140° East - 160° East).
7. Phase 7 in the East Pacific Region (160°E - 180°E).
8. Phase 8 of the convection zone in the Eastern Pacific ((180° - 160° W).

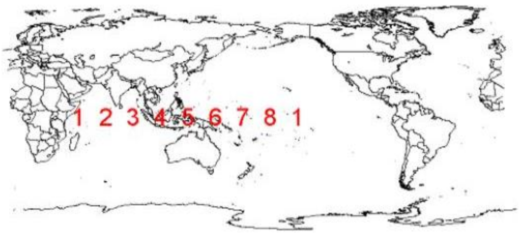

Figure 3. MJO phase position [7]

The MJO phase diagram depicts the development of the MJO through its distinct phases, which generally coincide with locations along the equator around the world. RMM1 and RMM2 are mathematical methods that combine the amount of cloud and wind in the upper and lower levels of the atmosphere to give a measure of the strength and location of the MJO. When the index is inside the central circle, the MJO is considered weak, meaning that it is difficult to distinguish using the RMM method. Outside of this circle the index is stronger and will usually move in a counterclockwise direction as the MJO moves from west to east. For convenience, we define 8 different MJO phases in this diagram. Depiction in index RMM1 and RMM2 as follows:

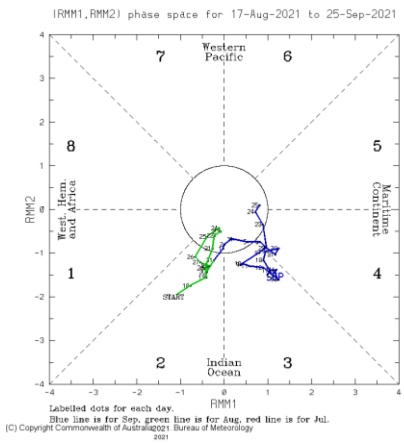

Figure 4. MJO phase diagram for the August-September 2021 period

How to detect MJO can also be done with the Hovmoller diagram (Fig. 5). The diagram depicts all the average values in one longitude/latitude column by placing these values on one axis while the other axis represents the time dimension. MJO propagation can be detected using this diagram through the vertical axis describes time while the horizontal axis describes longitude. MJO can also be detected through several atmospheric variables such as OLR (Outgoing

Longwave Radiation) and wind where these variables have strong oscillations during the active phase.

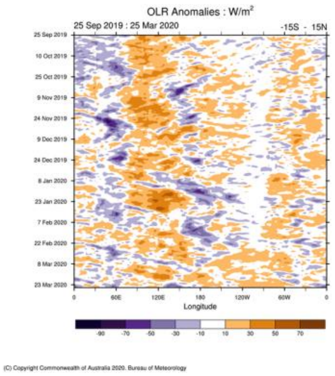

Figure 5. An example of an OLR anomaly Hovmoller diagram

The structure of the surface and upper atmosphere of the MJO when the increasing convective phase (rain and storms) is centered on the Indian Ocean and the decreasing convective phase on the Pacific Ocean. Horizontal arrows pointing left represent easterly winds and arrows pointing right represent westerly winds. The system moves in pairs to the east and eventually circles back to its point of origin. In the convective phase increasing surface winds meet, air is pushed up. Above the atmosphere the winds reverse, the increased air movement in the atmosphere tends to increase condensation and precipitation. When the winds decrease, it tends to decrease rainfall.

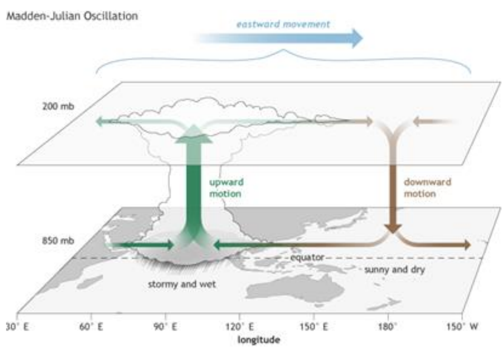

Figure 6. MJO movement and structure

2.3 Rain (Precipitation)

Precipitation is the fall of water from the atmosphere to the earth's surface which can be in the form of rain, snow, fog, dew, and hail. In the tropics rain makes the biggest contribution so it is often rain that is considered precipitation [8]. Meanwhile, according to Sosrodarsono in Triatmodjo [8] precipitation is the general name of steam that condenses and falls to the ground in a series of hydrological cycle processes, usually the amount is always expressed by the depth of precipitation (mm). If the water vapor that falls is in liquid form it is called rain (rainfall) and if it is in solid form it is called snow (snow).

The earth's atmosphere contains water vapor, although the amount of water vapor is very small compared to other gases in the atmosphere, it is the most important source of fresh water for life on earth. Water is in the air in the form of water vapor gas), liquid (water droplets), and ice crystals. This collection of water grains and ice crystals has a very fine size (2-40 microns in diameter) forming clouds that float in the air, clouds are formed as a result of cooling from wet air moving upwards. The cooling process occurs because the air temperature decreases adiabatically with increasing altitude. Dust particles, salt crystals, and ice crystals floating in the air can serve as condensation nuclei which can speed up the cooling process, thus there are two important conditions for rain to occur, namely the air mass must contain enough water vapor and the air mass must rise upwards in such a way that it becomes cold [8].

The amount of rain that falls on the surface of the earth is expressed in terms of water depth (usually mm), which is assumed to be evenly distributed throughout the catchment area. Rain intensity is the amount of rainfall in a unit of time, which is usually expressed in mm/hour, mm/day, mm/month and so on, which is then called hourly rain, daily rain, weekly rain, monthly rain and so on [8].

According to Sosrodarsono in Triatmodjo [8] explains that rainfall does not increase in proportion to time. If the duration of time is longer, the addition of rainfall is smaller than the addition of time, because rain can decrease or stop as shown in Table 1. Rain duration is rain calculated from the time it starts to rain until it stops raining, which is usually expressed in hours. Average rain intensity is the ratio between rain depth and rain duration. Rainfall distribution as a function of time that describes variations in rain depth, can be expressed in a discrete or continuous form which is referred to as a hydrograph, namely a histogram of rain depth or rain intensity.

Table 1. Rain conditions and rain intensity [8]

Rain Condition	**Rain intensity**	
	1 hour	**24 hours**
Very light rain	<1	<5
Light rain	1-5	5-20
Normal rain	5-10	20-50
Heavy rain	10-20	50-100
Raining really hard	>20	>100

3. Research Methods

The study area in this study is South Sulawesi Province, one of the provinces in Indonesia, which is located in the southern part of Sulawesi Island. Astronomically, South Sulawesi is located at 0°12' - 8° South Latitude and 116°48' - 122°36' East Longitude. This province is bordered by Central Sulawesi and West Sulawesi in the north, the Gulf of

Bone and Southeast Sulawesi in the east, the Makassar Strait in the west and the Flores Sea in the south, and its geographical location is in the middle of the Indonesian Maritime Continent (BMI).

The data needed in this study are daily rainfall data (precipitation) for South Sulawesi Province downloaded via the official website of NASA based on TRMM (Tropical Rainfall Measuring Mission) satellite observation type 3B42RT version 7 and the MJO index with daily temporal resolution downloaded via the official BoM website. , with each time range 01/01/2010-31/12/2019. In solving the problem for this research, several methods are needed, namely: Filtering data, MJO data consists of the RMM1&2 index, amplitude and phase is the MJO index developed by the Bureau of Meteorology (BoM) to identify the date and number of MJO events.

This research focuses on phases 2, 3, 4 and 5 that occur in the Indian Ocean (phase 2 and 3) and the Indonesian Maritime Continent (phase 4 and 5) and where the MJO phase spreads around BMI and affects convective activity in BMI. MJO data and daily rainfall data for each province are put together in data tabulations according to the time series with the 2010-2019 range, and filtered focusing on MJO data, namely phases 2, 3, 4 and 5.

Sensitivity analysis with simple linear regression, simple regression based on the functional and causal relationship of one independent variable with one dependent variable. In this study, simple linear regression was carried out with rainfall data as the independent variable (X) and MJO index data in the form of amplitude as the dependent variable (Y). the two variables were analyzed for correlation to test one independent variable against the dependent variable using Microsoft Excel software with Anova (Data Analysis Tools-Regression). The correlation value or the high and low degree of relationship of the two variables can be analyzed from the value of the correlation coefficient (r) obtained. If the correlation coefficient value is close to a positive number 1, then there is a close positive relationship, and vice versa if the correlation coefficient value is close to a negative number (-) 1, then there is a close negative relationship. Meanwhile, if the correlation coefficient value is close to 0 (zero), then the relationship between the two variables is weak or not close. According to Sugiyono [9], the interpretation of the strong correlation is as follows:

Table 2. Interpretation of correlation coefficient [9]

Coefficient Intervals	Relationship Level
0.00 – 0.19	Very low
0.20 – 0.39	Low
0.40 – 0.59	Currently
0.60 – 0.79	Strong
0.80 – 1.00	Very strong

4. Results

4.1 The Effect of Rainfall Parameters on the Madden-Julian Oscillation (MJO) in South Sulawesi Province

Rain is one of the most frequently studied climate elements in Indonesia because it has a very high level of diversity both in time and place. This situation is caused by the position of Indonesia which is passed by the equator and is located between two continents and two oceans. The influence of the topography and geographic location of an area can be the main cause of weather changes in large-scale patterns [10].

Table 3. The correlation coefficient of rainfall with the MJO amplitude of South Sulawesi Province 2010-2019 year

Years	Rainfall (mm) Average	Average MJO Amplitude	Correlation Coefficient (r)
2010	9.264	1.061	
2011	6.465	1.138	
2012	5.752	1.182	
2013	8.360	1.093	
2014	5.75	1.137	0.712
2015	5.114	1.259	
2016	8.237	1.069	
2017	6.374	1.172	
2018	6.242	1.400	
2019	4.931	1.352	

The collected daily rainfall data for each Province of South Sulawesi and the Madden Julian Oscillation (MJO) for 10 years will be analyzed for correlation to determine the percentage of influence between the daily rainfall variables on the MJO variable in the form of amplitudes using a simple linear regression method. Daily rainfall data for each province with MJO data are made in the form of a tabulation for the 2010-2019 timeframe, which is filtered first by focusing on MJO phases 2, 3, 4 and 5. These phases occur in the Indian Ocean region and the Indonesian Maritime Continent as well as in when MJO is active in phases 2, 3, 4 and 5 it affects the strength of convection activity in BMI (Indonesian Maritime Continent). From the results of this screening, daily rainfall data is then averaged each month, then the 12 monthly average data per year are averaged to obtain an annual average. And for MJO data in the form of MJO amplitude according to daily rainfall data for an average (average) per year. Sensitivity analysis with simple linear regression of the two variables to see the relationship or effect of rainfall with the MJO index in the form of amplitude. A positive correlation value is a positive correlation (directly proportional), while a negative correlation value is a negative correlation (inversely proportional).

Rainfall in Indonesia is generally influenced by the phenomenon of atmospheric circulation on a global, regional and local scale. One of the global phenomena that affect Indonesia's weather and climate is the Madden Julian Oscillation (MJO) [11].

The effect of daily rainfall in South Sulawesi Province on the MJO amplitude during phases 2, 3, 4 and 5 has an r (correlation coefficient) of 0.712 with a percentage effect of 71.2% and a coefficient value of 1.560 and a coefficient value of -0.056 b. With r of 0.712, the influence of daily rainfall in South Sulawesi Province on the MJO amplitude during phases 2, 3, 4 and 5 has a strong influence in a directly proportional (positive) pattern, which means that the influence of daily rainfall in South Sulawesi Province has a strengthening effect on MJO that spread in the province. The linear regression equation for daily rainfall in South Sulawesi Province with MJO amplitude is:

$$Y = 1{,}560 - 0{,}056X \qquad (1)$$

4.2 Scheme for the Emergence of the Madden-Julian Oscillation (MJO) in South Sulawesi Province

Madden-Julian Oscillation (MJO) is the dominant phenomenon in the equatorial region with periods of oscillation ranging from 30 to 70 days due to the influence of convection clouds that form over the Indian Ocean (west of Indonesia) then move eastward along the equator [12]. Rainfall in Indonesia is generally influenced by the phenomenon of atmospheric circulation on a global, regional and local scale, one of which is MJO. MJO is an atmospheric wave phenomenon that moves from the west (Indian Ocean) to the east and can increase the rainfall it passes through. The results of the analysis of the latest atmospheric dynamics conditions indicate that there is MJO activity over Indonesia, which is a cloud cluster with the potential for rain. The MJO phenomenon greatly affects global weather and climate.

The MJO appearance scheme in research is focused on increasing or decreasing rainfall intensity to determine the impact of MJO on a province, both when MJO activity is strong or weak. The rainfall of the Indonesian Maritime Continent is influenced by various weather/climatic factors, both global and local so that it can be daily. Apart from global climate factors such as MJO, other global climate factors are El Nino-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), Inter-Tropical Convergenze Zone (ITCZ). In addition, regional scale climatic factors such as monsoons, tropical cyclones, and convergence areas also affect the climate conditions in these areas. On a local scale, cloud growth and rain are influenced by natural conditions such as land, sea and topography of the area.

To find out the scheme for the emergence of the MJO, the phases of the MJO movement that are focused on in this study are in phases 2, 3, 4 and 5. Phases 2 and 3 are the Indian Ocean and 4 and 5 are the Maritime Continents. This phase is used to determine the location of active MJO movement (wet mode) or inactive MJO (dry mode). Using MJO index data which consists of Real Time Multivariate MJO (RMM1 and RMM2) and an amplitude > 1 can indicate active MJO. As well as rainfall data for 10 years for each province, it is synchronized with MJO index data which is then filtered by phases 2, 3, 4 and 5. With visualization using a graph of the relationship between amplitude and rainfall along with MJO phases to find out where MJO occurs, this graph serves to determine how is the rainfall when MJO is active and the dominant phase.

The influence of the geographical location of an area can be the main cause of weather changes in large-scale patterns. Rainfall variations that occur in an area can describe the variety of atmospheric oscillations that occur in that region [13].

South Sulawesi is a province in Indonesia which is located in the southern part of Sulawesi Island. Astronomically, South Sulawesi is located at 0°12' - 8° South Latitude and 116°48' - 122°36' East Longitude. This province is bordered by Central Sulawesi and West Sulawesi in the north, the Gulf of Bone and Southeast Sulawesi in the east, the Makassar Strait in the west and the Flores Sea in the south, as well as its geographical location in the middle of the Indonesian Maritime Continent (BMI).

Based on Fig. 7, rainfall in South Sulawesi during 2010-2019 experienced an insignificant increase and decrease in rainfall, and based on Fig. 7 in the form of a visualization of the MJO graph with rainfall in South Sulawesi, the rainfall that occurs is light rainfall with an intensity of 5-20 mm / day to normal rainfall with an intensity of 20-50 mm / day. South Sulawesi's rainfall is very likely to be influenced by the MJO which is located close to the equator, and this oscillation is very strongly felt in low latitude areas, near the equator and occurs for the first time in the Indian Ocean and moves eastward between 100 and 100 latitude. LS [14]. In addition to global factors that affect the weather and climate of South Sulawesi, local factors also affect rainfall in South Sulawesi such as the Asian monsoon winds, these winds will cause an increase in the mass of wet air with a confluence pattern from the Java Sea to Sulawesi.

Figure 7. the MJO relationship to rainfall in South Sulawesi Province in 2010-2019

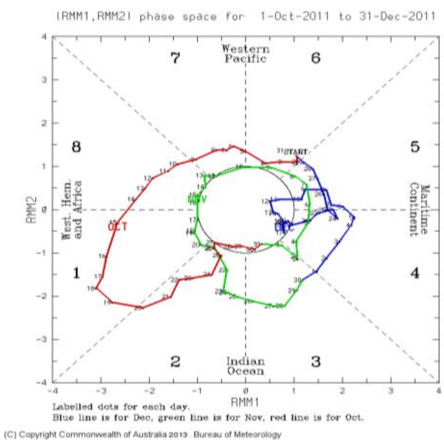

Figure 8. MJO phase diagram for the October-December 2011 period

As seen in Fig. 8, the propagation of MJO in December is represented by the blue line circled, MJO which spreads from phase 4 to phase 5 outside the circle which shows strong MJO activity so that it has the effect of increasing rainfall that MJO passes during phases 4 and 5. This strong MJO effect lasts for 8 days, starting with light rain with an intensity of 5-20 mm/day then increasing to normal rainfall with an intensity of 20-50 mm/day during phase 4 then MJO spreads to phase 5, rainfall increased rainfall which is classified as normal rainfall with an intensity of 20-50 mm/day. And rainfall decreases when MJO activity is weak with an amplitude <1 when MJO spreads in phase 5. This increases the meeting of air masses and supports the activity of convective cloud growth which has the potential for normal to heavy rain.

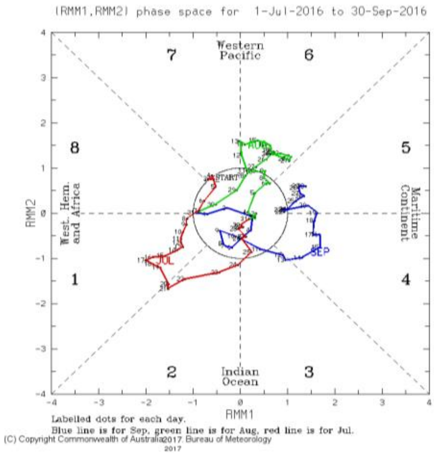

Figure 9. MJO phase diagram for the July-September 2016 period

Based on Fig. 9, September is represented by a blue line that spreads in phases 4 and 5 with strong MJO activity because it spreads outside the circle. And in 2016 September was the dry season in South Sulawesi, but there was light rain with an intensity of 15 mm/day to normal rain with an intensity of 23 mm/day with strong MJO activity with an amplitude > 1 which lasted for 4 days when MJO spread in the phase 5, this is a negative anomaly that occurs due to disturbances in the dynamics of the atmosphere where there is a role for the interaction between the ocean and the atmosphere, one of which is the MJO. With the strong MJO activity, creating a meeting of air masses (convergence) that is able to increase and support the activity of convective cloud growth which has the potential to cause normal to heavy rain, apart from that there are other factors in the form of sea surface temperature in the waters of the southern Makassar Strait and its surroundings. which is warm enough which will also contribute to accelerated growth of rain clouds.

The dominant MJO propagation in phases 4 and 5 which is in the Indonesian Maritime Continent (BMI) affects South Sulawesi because the MJO oscillation has a very strong impact in low latitudes (near the equator). This causes the MJO phenomenon to significantly affect rainfall in South Sulawesi.

5. Conclusion

The results of the study of the influence of the daily rainfall parameter with MJO using amplitude index values with a focus on MJO phases at 2, 3, 4 and 5 during 2010-2019 in South Sulawesi Province obtained a correlation value (r) of 0.712, which means the effect of daily rainfall The South Sulawesi Province has a strong influence on the MJO amplitude during phases 2, 3, 4 and 5 in a directly proportional (positive) pattern, which means that the influence of daily rainfall in South Sulawesi Province has a strengthening effect on the MJO that spreads in the province. Based on the research results of the MJO emergence scheme in South Sulawesi Province, the dominant MJO appeared in phases 4 and 5 which caused normal rain that occurred for 8 days. The influence of positive ENSO and IOD can affect MJO which propagates at the equator. So that ENSO and IOD can strengthen the MJO or even weaken the MJO and still cause excessive rainfall which is influenced by these global factors, besides that local factors also affect rainfall such as monsoon winds and topographical conditions that are different for each province. So not all of the rainfall that occurs is caused by MJO activity.

References

[1] A. Arista, Asrul, and S. Nugroho, "Analisis Variasi Curah Hujan Harian Untuk Menentukan Ragam Osilasi Atmosfer di Kota Padang," *Pillar Phys.*, vol. 1, pp. 34–43, 2013.

[2] R. A. Madden and P. Jjulian, "Detection of a 40±50 day oscillation in the zonal wind in the tropical Pacific," *J Atmos Sci*, vol. 28, pp. 702–708, 1971.

[3] D. Handayani, Asrul, and S. Nugroho, "Analisis Angin Zonal dan Outgoing Longwave Radiation untuk Inisialisasi Kemunculan Fenomena Madden Julian Oscillation (MJO) di Kota Padang," *Pillar Phys.*, vol. 8, pp. 9–16, 2016.

[4] B. Tjasjono, *Meteorologi Terapan*. Bandung: ITB, 2008.

[5] J. Gottschalck, V. Kousky, W. Higgins, and M. L. 'Heureux, "Summary of Madden Julian Oscillation," USA, 2005.

[6] W. Higgins and W. Shi, "Intercomparison of the Principal Modes of Interannual and Intraseasonal Variability of the North American monsoon system," *J, Clim.*, vol. 14, pp. 403–417, 2001.

[7] S. L. M., *Physics Of The Atmosphere and Climate*. Macquarie University: Cambridge University Press, 1996.

[8] B. Triatmodjo, *Hidrologi Terapan*. Yogyakarta: Beta Offset, 2008.

[9] Sugiyono, *Statistika Untuk Penelitian*, Cetakan Ke. Bandung: Alfabeta, 2007.

[10] N. Tallamma, N. Ihsan, and A. J. Patandean, "Analisis Pengaruh Madden Julian Oscillation (MJO) terhadap Curah Hujan di Kota Makassar," *J. Sains Dan Pendidik. Fis.*, vol. 12, no. 3, pp. 324–329, 2016.

[11] E. Hermawan, L. Evana, and S. Effendy, "Pengembangan Model Prediksi Madden Julian Oscillation (Mjo) Berbasis Pada Hasil Analisis Data Real Time Multivariate Mjo (Rmm1 Dan Rmm2)," *J. Agromet*, vol. 22, pp. 144–159, 2008.

[12] E. Hermawan, "Analisis Struktur Vertikal MJO Terkait Dengan Aktivitas Super Cloud Clusters (SCCs) di Kawasan Barat Indonesia," *J. Sains Dirgant.*, vol. 8, pp. 25–42, 2010.

[13] D. D. Lestari, I. D. Faryuni, and A. A. Kushadiwijayanto, "Respons Curah Hujan Terhadap Fenomena Madden Jullian Oscillation (MJO) di Pontianak," *Prism. Fis.*, vol. 7, no. 2, pp. 108–114, 2019.

[14] S. Yana, A. Ihwan, M. I. Jumarang, and Apriansyah, "Analisis Pengaruh Madden Julian Oscillation, Anual Oscillation, ENSO dan Dipole Mode Terhadap Curah Hujan di Kabupaten Kapuas Hulu," *J. Prism. Fis.*, vol. II, no. 2, pp. 31–34, 2014.