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Rainfall Characteristics In Medan City With Pearson Correlation Analysis (Case Study Of February 27, 2022)

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Abstract

February is climatologically the first peak of the dry season in the North Sumatra region, but floods can still occur. This study analyzes the characteristics of rainfall patterns that occur during extreme rainfall that occurred in the Medan area on February 27, 2022 which resulted in flooding in several areas in Medan with Pearson correlation. The data used are rainfall data, satellite data, radar and other atmospheric dynamics analysis data. Based on dynamic analysis on February 27, 2022, the growth of CB clouds began at 14.00 WIB reaching its peak at 17.00 WIB where the peak temperature of the cloud reached 82.4 ° C and cloud growth lasted until 21.00 WIB, where the rain lasted long enough to cause hydrometeorological disasters (floods) to occur. The Pearson correlation coefficient method (r) used to analyze the relationship between rainfall and DMI, ENSO, SST Anomalies and SOI conditions can be seen that the dominant influence is SST Anomalies and SOI, where in February conditions that affect rainfall are ENSO with a correlation value of 0.36272 and SST Anomalies with a correlation value of 0.37548.

Keywords: Pearson correlation, rainfall, DMI, ENSO, SST Anomalies and SOI

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INTRODUCTION

Indonesia's territory which consists of 70% water and 30% land or commonly referred to as the maritime continent is one of the factors that cause the high potential for rainfall in the Indonesian region (Tjasyono & Harijono, 2012). The type of clouds in an area is closely related to the high potential for rainfall in an area where the formation of clouds and rain is due to the vertical movement of air masses in the atmosphere which is closely related to air stability. The existence of these disturbances causes significant changes in unstable air (Prawirowardoyo, 1996).

North Sumatra (Sumut) is one of the provinces in the Northern Sumatra region (Sumbagut) which is located at the coordinates of 1°-4° North latitude (LU) and 98°-100° East longitude (BT). Geographically, the North Sumatra region has unique and strategic characteristics because it is located around the equatorial line, traversed by the Bukit Barisan mountains, and flanked by two waters, namely the Malacca Strait and the Indian Ocean. For the Medan area, it is located at coordinates 3°30'- 3°43'LU and 98°35'-98°44'BT. Sumatra The equatorial pattern is characterized by the type of rainfall with a bimodial form (two rain

peaks) which usually occurs around March and October or during the equinox. The area includes the central and northern part of the island of Sumatra (Hermawan, 2010).

One of the causes of the decline in the quality of the urban environment is the occurrence of floods and puddles during the rainy season. The problem of urban flooding has yet to be solved thoroughly, and the problem tends to be even more complex. Medan City is one of the areas that experience flooding almost every year. On February 27, 2022, a flood event was recorded in Medan City. According to BNPB, the February 2022 flood was recorded as one of the worst flood disasters in Medan City. The Deli Serdang Climatology Station noted that the flood was triggered by high-intensity rain that caused river overflows in Medan city from February 27, 2022. It is interesting that February is climatologically the first dry peak in the North Sumatra region, but it turns out that floods can still occur.

From the description above, it is necessary to analyze the characteristics of the rain pattern that occurred during the extreme rain that occurred in the Medan area which resulted in flooding in several areas in Medan, this is useful to see the weather anomalies that affect extreme rain during the non-rainy season.

METHOD

In this research, the author will discuss the Medan area which is located at the coordinates of 3°30'- 3°43'LU and 98°35'-98°44'BT. This research was conducted in February 2022. The analysis was conducted on February 27, 2022 where on the following date there was an increase in rainfall which was quite high, the impact of the rainfall was the occurrence of flooding in Medan and surrounding areas.

The steps taken in the research method in this study:

a. Collecting the required rainfall data in softcopy form with Microsoft Ecxel format and then grouping in February and then making a graph of rainfall patterns that occur.
b. SATAID support data to determine the amount of precipitation at the location of the incident. The method used is the interpolation method by estimating the temperature of cloud tops derived from IR Channel satellite images with the help of the GMSLPD version of SATAID Software. The use of this application is because it is an application that is easy to understand and does not require special specifications on the computer. In general, the SATAID application inputs data into memory and then displays it in the form of spatial maps or time series graphs.
c. Statistical Method (Pearson Correlation Coefficient /r)
   The Pearson correlation coefficient (r) is the most common way to measure linear correlation. It is a number between -1 and 1 that measures the strength and direction of the relationship between two variables.
   Pearson correlation coefficient formula between variables x and y :

$$r_{xy} = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\sqrt{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}\sqrt{n\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2}} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

Description:

x = independent variable value
y = dependent variable value
r = correlation coefficient value
n = number of data/samples

The strength of the relationship between the variables refers to the following criteria:

0.00 - 0.199 : Very weak correlation
0.20 - 0.399 : Weak correlation
0.40 - 0.599 : Moderate correlation
0.60 - 0.799 : Strong correlation relationship
0.80 - 1 : The correlation relationship is very strong
If the results of the correlation analysis are positive, the correlation between the variables is in the same direction, otherwise if the analysis results are negative, the correlation between the variables means the opposite.

RESULTS AND DISCUSSION

Madden Julian Oscillation (MJO) Condition

Observed in quadrant 4 (Maritime Continent) where this condition is quite contributing to the process of cloud growth in Indonesia.

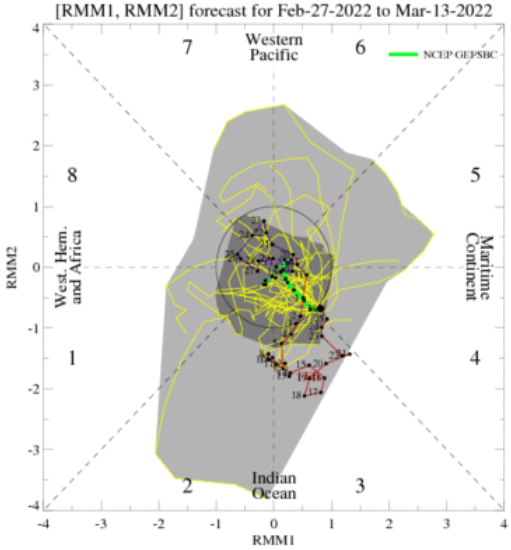

Figure 1. MJO conditions in February 2022

Dipole Mode Index (DMI) Condition

Dipole Mode Index (DMI) is -0.5 which indicates that there is a supply of water vapor from the Indian Ocean region to Western Indonesia which can increase cloud growth in Western Indonesia.

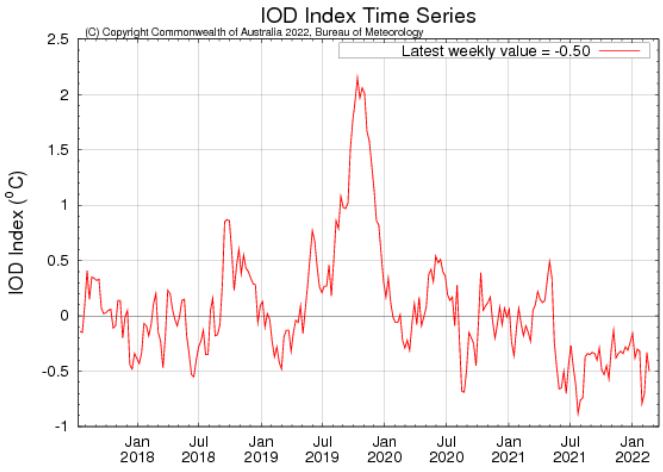

Figure 2. DMI condition in February 2022

Wind Conditions

Based on the analysis of wind conditions on February 27, 2022 at 07.00 a.m. there is a weather disturbance in the West Indian Ocean region of Sumatra, causing wind turns in the

North Sumatra region, especially Medan where such conditions can trigger the growth of rain clouds in the region.

For wind analysis at 19.00 WIB, the weather disturbance still persists in the western Indian Ocean region of Sumatra where it has become low pressure and the persistence of wind turns in the Sumatra region, especially Medan where these conditions trigger the growth of rain clouds in the Medan area.

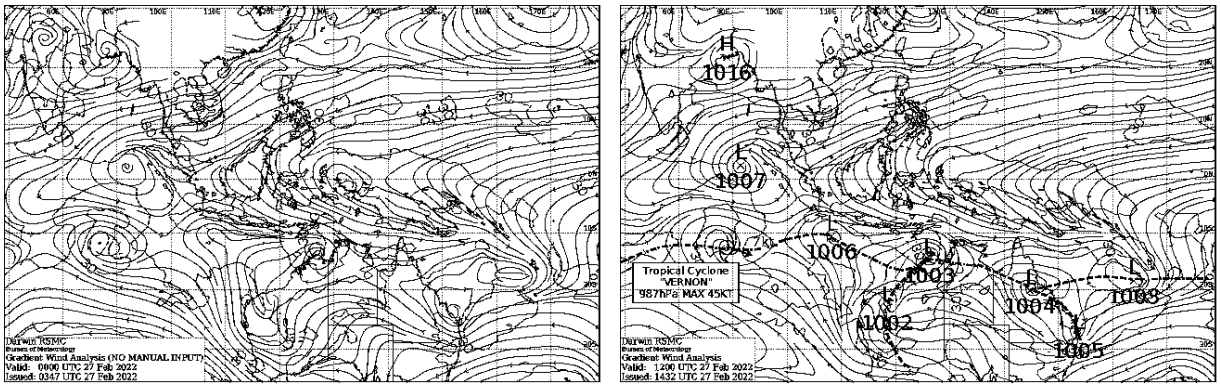

Figure 3. Wind analysis conditions on February 27, 2022 at 07:00 and 19:00 WIB

Air Lability Conditions

From the sounding results at 07:00 a.m. on February 27, 2022 where the K-Index, Total-total Index and SWEAT values are at a moderate level, which indicates the potential for rain accompanied by moderate thunder.

From the sounding results at 7:00 p.m. on February 27, 2023 the K-index and SWEAT values are quite strong, these conditions indicate that rain accompanied by thunderstorms has occurred.

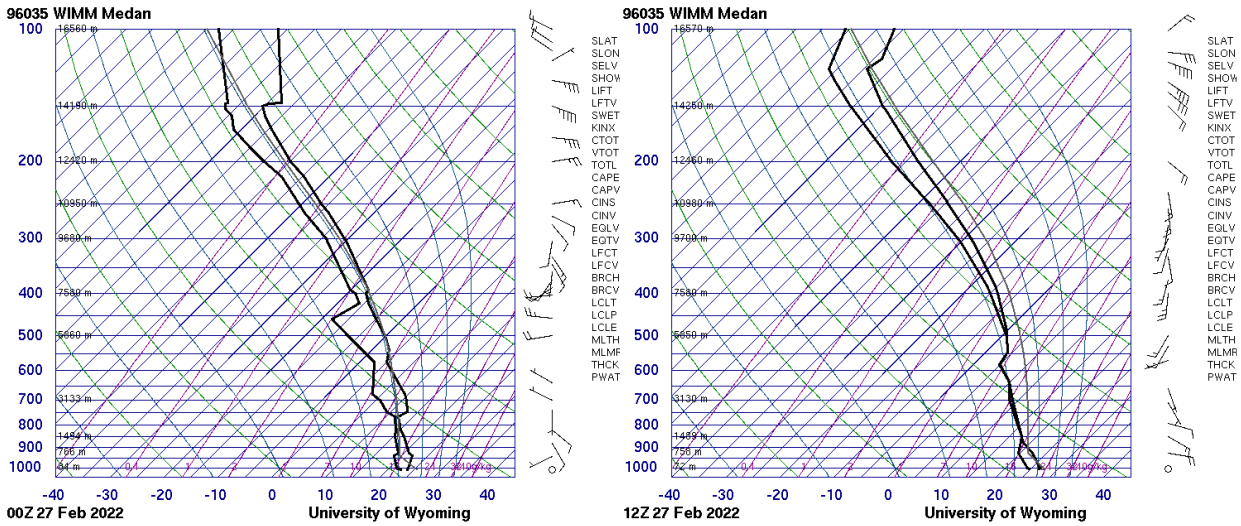

Figure 4. Air Lability Index on February 27, 2022 at 07:00 and 19:00 WIB

Satellite Image

From the observation of satellite imagery using the GMSLPD version of the SATAID application on the IR channel, it can be seen that there is cloud cover starting at 14.00 where the peak of clouds in the Medan area occurs at 17.00 WIB until 21.00 WIB. Where from the observation of satellite imagery clouds containing rain occurred at around 17.00 pm.

The peak temperature of the cloud in the Medan area at 17.00 pm was 82.4 ° C (Figure 4.5a(c)), where the peak temperature of the cloud indicates that the Medan area has met the criteria for rain clouds and the chances of CB (Cumulunimbus) clouds are getting bigger, from the graph of the peak temperature of the cloud it can be seen that the peak

temperature of the cloud begins to decrease but the cloud growth still persists which indicates that the rain still persists.

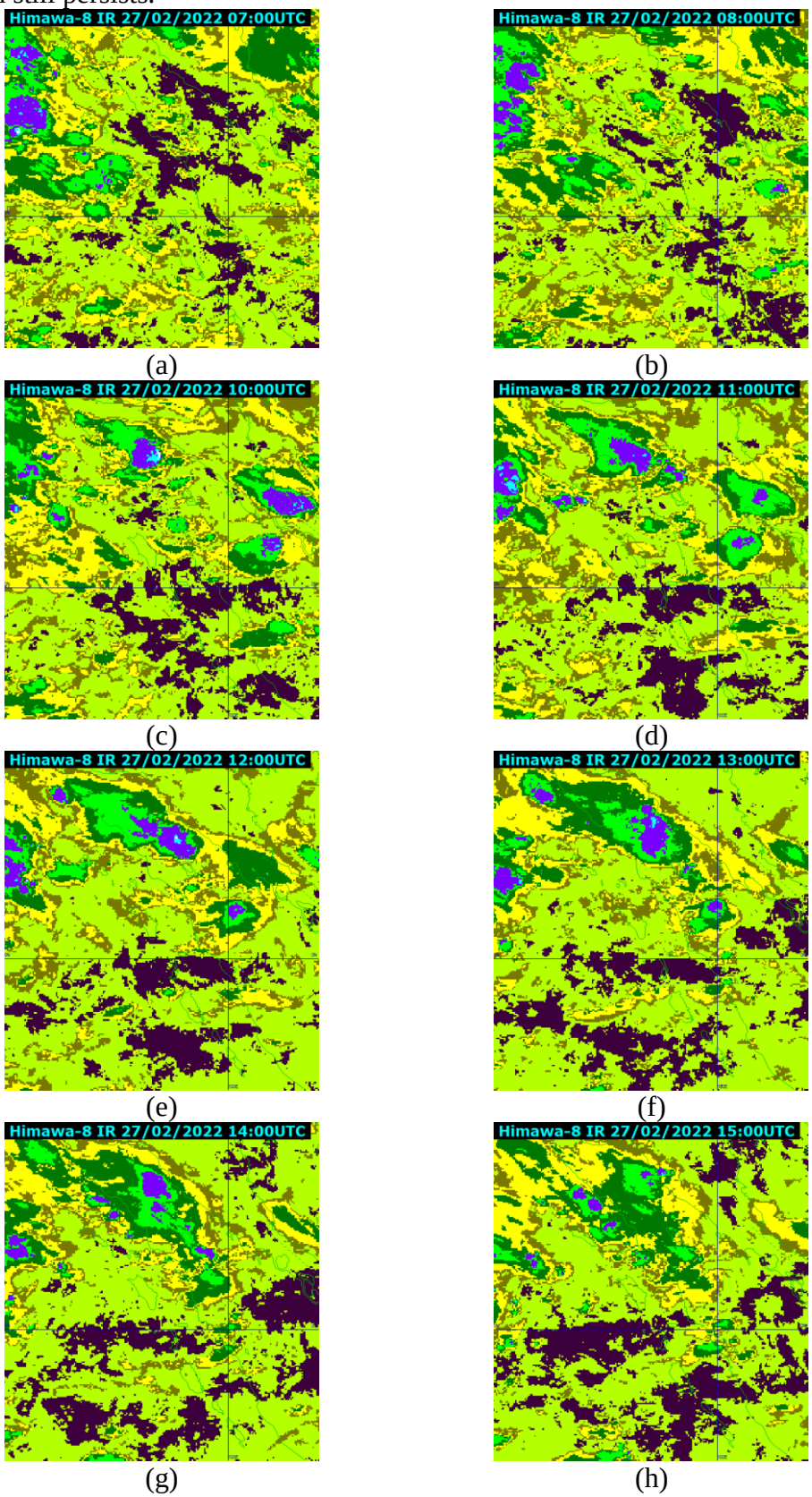

Figure 5. IR Satellite Image of February 27, 2022 (a). at 2:00 p.m., (b). at 3:00 p.m., (c). at 4:00 p.m., (d). at 5:00 p.m., (e). at 6:00 p.m., (f). at 7:00 p.m., (g). at 8:00 p.m., (h). at 9:00 p.m.

Figure 6. Cloud Peak Temperature Graph

Rainfall Data

Based on the rainfall data of BBMKG Region I Medan data for 15 (fifteen) years, namely 2008-2022, it can be seen from the graph that in February 2022 is a fairly high rainfall for 15 years, amounting to 359.8 mm, where in February for Medan city it enters the dry season. Judging from the graph for 15 years the rainfall in Medan city has increased.

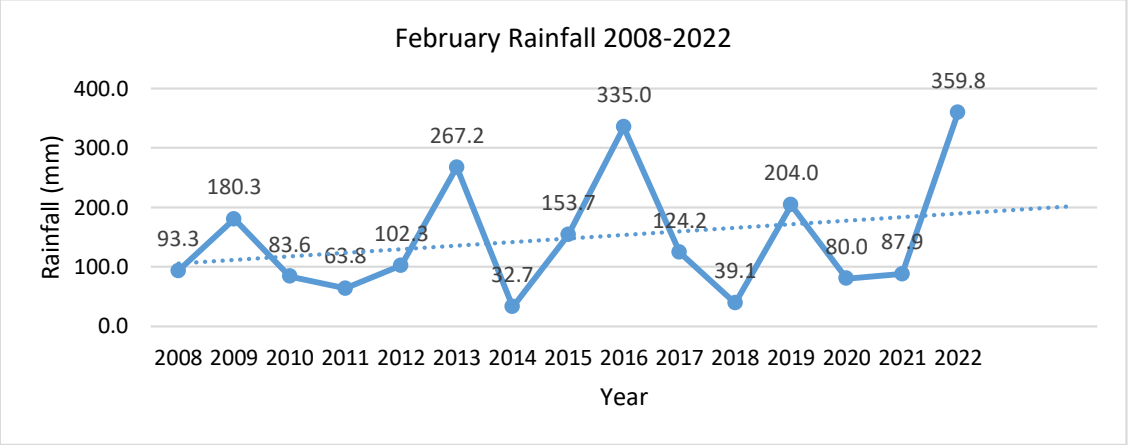

Figure 7. February Rainfall Chart 2008-2022

Meanwhile, based on the daily rainfall data for February 2022, it can be seen that the significant rainfall on February 27, 2023, which amounted to 128 mm in one day, has occurred quite extreme rain where rain occurs almost all day, resulting in hydrometeorological disasters (floods) in the Medan city area.

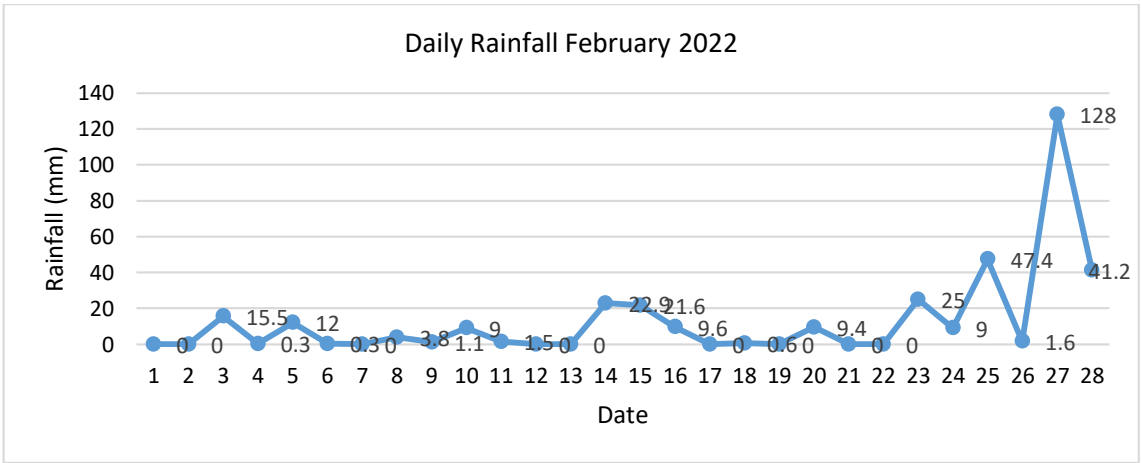

Figure 8. Graph of February Daily Rainfall in 2022

Pearson Correlation Coefficient (r)

The rainfall phenomenon in Medan City has a correlation relationship with DMI, ENSO, SST Anomaly and SOI from 2008 to 2022 (Table 4.7). It can be seen in the table for January that the positive value is SST anomaly, for February the global conditions that moderately affect rainfall are ENSO and SST Anomaly, for March the DMI correlation value moderately affects rainfall, for April the correlation that moderately affects rainfall is ENSO and SST Anomaly, in May the correlation that moderately affects ENSO and SST Anomalies, in June the correlation that affects is DMI, for July and August the correlation that moderately affects is SOI, in September the correlation that affects is ENSO, for October that affects is DMI, in November the SOI correlation is moderately affecting and in December the correlation is less affecting rainfall conditions.

Table 1. Pearson Correlation Coefficient (r) between Rainfall and DMI Index, ENSO, SST Anomaly and SOI (2008-2022)

Month	Pearson Correlation Coefficient (r)			
	DMI	**ENSO**	**Anomali SST**	**SOI**
Januari	-0,03834	-0,04489	0,24643	0,05619
Februari	-0,21078	0,36272	0,37548	-0,23991
Maret	0,50728	-0,30816	-0,09981	0,16870
April	-0,21078	0,36272	0,37548	-0,39605
Mei	0,26311	0,49123	0,56045	0,32296
Juni	0,36379	-0,20653	0,02593	-0,36263
Juli	0,23585	0,16740	0,10404	0,55147
Agustus	-0,50334	-0,51103	0,22644	0,43568
September	-0,21078	0,36272	-0,21078	-0,04235
Oktober	0,45113	0,11608	-0,11062	-0,13488
November	-0,18655	-0,02793	0,19379	0,27443
Desember	-0,05820	-0,30281	-0,39065	0,06026

CONCLUSION

Based on the research, it can be concluded that on February 27, 2022 the supply of water vapor from the Indian Ocean region to western Indonesia is quite significant, from the wind analysis there is a weather disturbance in the form of Low Pressure in the West Indian Ocean region of Sumatra causing wind turns in the southeast Sumatra region, especially Medan and supported by a fairly unstable air mass, CB cloud growth began at 14. 00 WIB reached its peak at 17.00 WIB where the cloud top temperature reached 82.4 ° C and cloud growth lasted until 21.00 WIB, where the rain lasted long enough to cause hydrometeorological disasters (floods) to occur.

The Pearson correlation coefficient (r) method used to analyze the relationship between rainfall and DMI, ENSO, SST and SOI conditions, it can be seen that the dominant influence is SST and SOI anomalies. The results showed that each month the weather disturbances that affect rainfall are different. For February, the conditions that affect rainfall are ENSO with a correlation value of 0.36272 and SST Anomaly with a correlation value of 0.37548.

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