Analyzing Climate Anomalies Effect to Rainfall Data on Lampung Province

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Abstract. Lampung Province is one of Indonesia granary. Which are easily affected by climate anomalies, like floods and drought. To understand how climate anomalies affected Rainfall data on Lampung Province, research to determine the effect has to be conducted. The purposes of this research are to determine what type of climate anomalies affect rainfall on Lampung Province the most, to analyze recurrence rainfall data which affected by climate anomalies. The method in this climate anomalies analysis is a Lomb Periodogram. The result of this research are Lomb Periodogram dominant frequencies recurrences are Kotabumi 4,063 years, Maritim 5,0513 years, Masgar 6,5735 years and Radin Inten 2 3,82 years. Conclusion of this analysis is according to Lomb Periodogram result Lampung Province affected by two types of climate anomalies. Kotabumi, Maritim and Masgar are affected by El Nino and La Nina with 4,063 – 6,5735 years recurrences while Radin Inten 2 affected by Dipole Mode with 3,82 years recurrences.

Keywords: Climate, El Nino, La Nina, Dipole Mode, Lomb Periodogram.

1 Introduction

Indonesia is a tropical country, Indonesia just have 2 seasons, summer and rainy. Because of that, Indonesia is greatly affected by climate anomalies, such as ENSO and Dipole Mode. Climate anomalies affected rainfall in Indonesia. Climate anomalies is one of the causes of natural disasters in Indonesia therefore influence of climate anomalies is considered important for the possibility of natural disasters such as droughts, floods, landslides and others. Apart from that, this climate anomaly is also the root cause of 50% of civil conflicts that occur in tropical countries [1]. The natural disasters that occurred in Indonesia did not only affect the security sector but also affected the economic, food and also higher possibility of conflict between residents.

ENSO is one of the climate anomaly phenomena. ENSO consists of 2 climate anomalies that is El Nino and La Nina. ENSO is a global marine atmospheric phenomenon which has the implication that Indonesia seas are colder during El Nino events and warmer

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during La Nina events [2]. El Nino is a caused by rising temperatures in the central and eastern Pacific Ocean, while La Nina is the opposite of El Nino, it is decreasing temperatures in the central and eastern Pacific Ocean. The 2 types of climate anomaly above have different consequences. For El Nino it causes a decrease in the possibility of rain in the tropics, while for La Nina it results in an increase in the possibility of rain in the tropics. This influence can cause droughts and floods in the tropics due to the affected rainfall.

IODM is a natural phenomenon that also occurs in Indonesia. Dipole Mode is a change that occurs in the Indian Ocean and some parts of Sumatra. This phenomenon is caused by differences in temperature anomaly on the east coast of Africa and the west coast of Sumatra. The Indian Ocean Dipole Mode is considered to have more influence on the western part of Indonesia, so it is important to know about the influence that occurred in Indonesia [3].

Lampung is one of rice granary areas in Indonesia. Lampung's yield in 2021 is 2,472 tons. Rice yields in Lampung province are affected by climate anomalies. Several areas in Lampung during El Nino conditions experienced a failures crop yield. And natural disasters such as droughts, floods and landslides are more vulnerable to climate anomaly conditions than in normal year.

Lomb Periodogram is a method that can be used to calculate data repetition. This method is used for time series data, so this method is considered suitable for analyzing time series or anomalies that occur in rainfall data in Lampung province. The Lomb periodogram has no limitations in the amount of data, both small and large data scales. However, lomb periodogram method is predictive mathematically so the possibility of changing variables in the field will greatly affect the analysis.

In the future, extreme climate events such as floods and droughts are expected to occur more frequently with greater intensity and duration [4]. In order to reduce the impact of natural disasters, several disaster mitigation efforts have been carried out, especially in the Lampung area. However, disaster mitigation efforts are considered not optimized both the location affected by the disaster and the estimated time. In a disaster caused by a climate anomaly, the disaster mitigation carried out is considered unable to anticipate the consequences, because the detail about estimated time and estimated location cannot be determined before disasters occur, so in an effort to determine affected area and also the estimated time, an analysis effect of the climate anomaly is carried out on rainfall data in Lampung province.

Objectives of this study were to analyse what types of climate anomalies affect each area in Lampung province, analyse the areas most affected by climate anomalies in Lampung province and analyse the year of recurrence of climate anomalies in each area in Lampung province.

2 Research Methodology

2.1 Research sites.

In this study the Lampung area become focus of the study, for the analysis in this study used rain station data sourced from the Meteorology and Geophysics Agency. Where in Lampung province four rain stations were used, namely the Masgar, Maritim, Radin Inten 2 and Kotabumi rain stations. The locations that are the focus of this research are as follows:

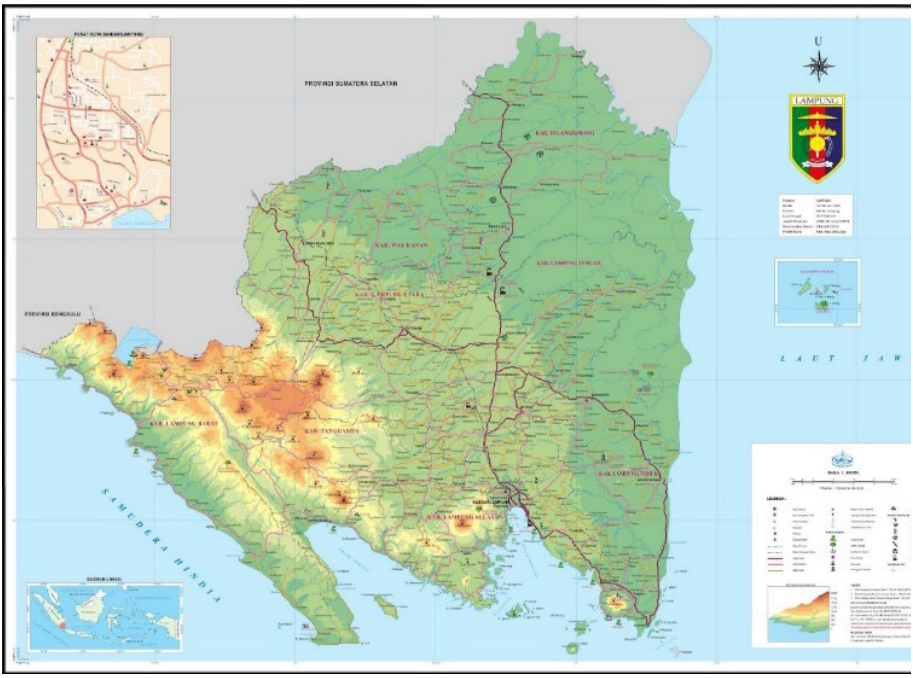

Fig. 1. Research Sites.

2.2 Data collection

This Research using secondary data, the rainfall data obtained from the Indonesian Meteorological and Geophysics Agency. Namely high rainfall data at 4 stations in Lampung, namely Masgar, Maritim, Kotabumi and Radin Inten 2 stations. For the data period used is high rainfall data from 1999 - 2018.

2.3 Spectral method Lomb periodogram

Lomb Periodogram analysis used to determine the frequency of rainfall and see the effect of climate anomalies. This method can see rainfall data anomalies and see the repetition of these anomalies with analysis based on rainfall data time series. The advantage of this method is that it does not require a large amount of time series data so that small-scale data can be analysed using the Lomb periodogram method. The following is a function of the analysis of the Lomb periodogram [5-7]:

$$P(f) = \frac{1}{4.\pi.s^2}\left\{\frac{|\sum_{i=1}^{n}(x-\bar{x})\ cos\ \omega(t_i-\tau)|^2}{\sum_{i=1}^{n} cos^2\omega(t_i-\tau)} + \frac{|\sum_{i=1}^{n}(x-\bar{x}) sin\ \omega(t_i-\tau)|^2}{\sum_{i=1}^{n} sin^2\omega(t_i-\tau)}\right\} \quad (1)$$

P (f) = Periodogram
$\bar{x}$ = Average rainfall data
x = Rainfall data
t = Time
ω = Frequency

3 Results and discussion

The results of the spectral method were obtained from 4 rain stations in Lampung province. And the results are obtained by analysing rainfall data to obtain rainfall patterns from the analysis of the Lomb Periodogram.

3.1 Normalizing rainfall data

Normalizing rainfall data is to ensure that the rainfall data used in the analysis is valid data. Lomb periodogram analysis also requires data in the form of time series without missing data, so complete rainfall data is needed. The BMKG rainfall data has drawbacks in its use, the BMKG rainfall data has a lot of missing data and also empty dates so Normalizing Rainfall data should be done. Data normalization is carried out by replacing unmeasured data and also unrecorded dates with a value of 0. The bmkg.exe program made with Force 3.0 is used in the data normalization process. The appearance of the bmkg.exe program is as follows:

Fig. 2. User Interface bmkg.exe.

From the analysis results obtained good time series rain data and can be used in further Lomb periodogram spectral analysis.

3.2 Spectral method Lomb periodogram

Spectral analysis was carried out by analysing rainfall data in the form of time series from several stations in Lampung province, namely Kotabumi rain station, Masgar rain station, Radin Inten 2 rain station and Maritim rain station. In this analysis, a program was created to support this analysis to minimize errors in the Lomb periodogram analysis and quicker process. The display program used is as follows:

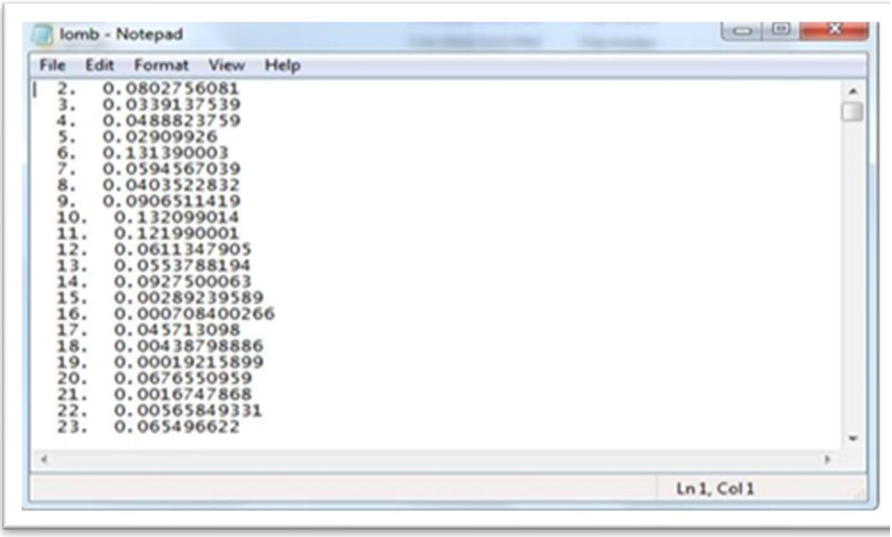

Fig. 3. Lomb periodogram analysis.

The next process of this analysis are the amplitude results of each rainfall data generated by the Lomb periodogram analysis, so that samples from the results of the slow periodogram analysis can be seen in the following table:

Table 1. Lomb periodogram result sample.

T (day)	Amplitude (A)	T (year)	A^2 (PSD)
2	0.002111397	0.005475702	0.00000446
3	0.126732153	0.008213552	0.01606104
4	0.146042521	0.010951403	0.02132842
5	0.072067684	0.013689254	0.00519375
6	0.080160357	0.016427105	0.00642568
7	0.002236515	0.019164956	0.00000500
8	0.005598139	0.021902806	0.00003134
9	0.208840799	0.024640657	0.04361448
10	0.204317597	0.027378508	0.04174568

The results of the Lomb periodogram are in the form of days and the frequency amplitude. The results of this analysis are transformed into units of years, because in viewing an influential climate anomaly we use repetition with units of years. The amplitude results are transformed into a squared amplitude so that the amplitude affected by the climate anomaly can be clearly seen in the graphics of the frequency.

From the results obtained from Lomb Periodogram and the transformation results, a frequency graph of each rain station in Lampung province can be produced as follows:

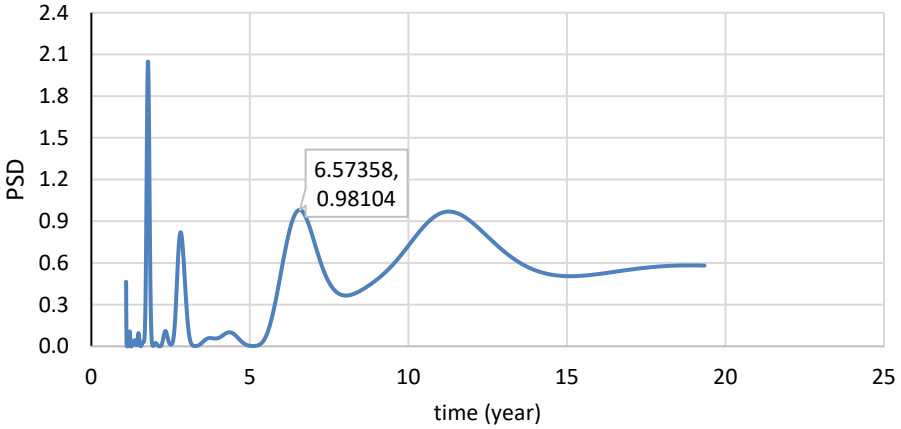

Fig. 4. Lomb periodogram result graphic on Masgar rainfall station.

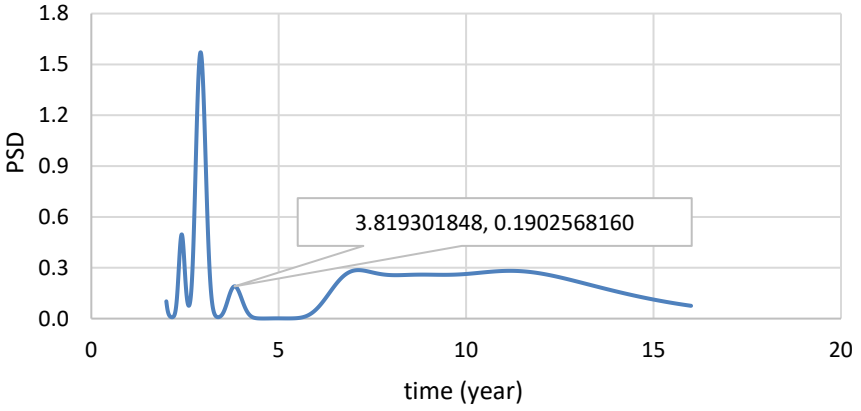

Fig. 5. Lomb periodogram result graphic on Radin Inten 2 rainfall station.

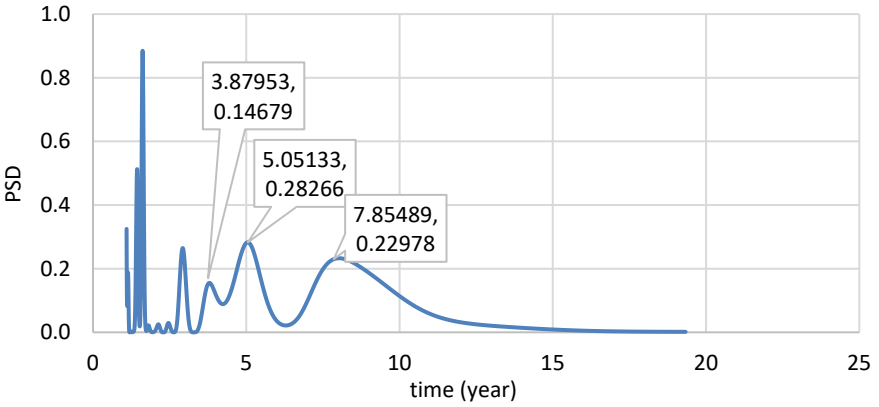

Fig. 6. Lomb periodogram result graphic on Maritim rainfall station.

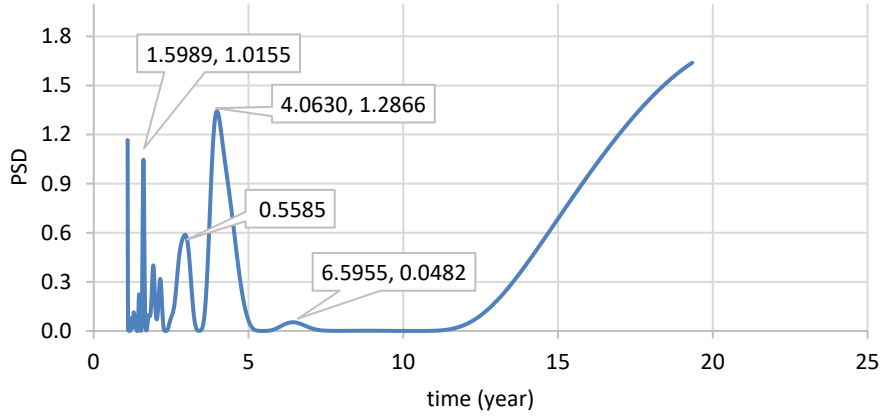

Fig. 7. Lomb periodogram result graphic on Kotabumi rainfall station.

From the results of the Lomb periodogram analysis, the dominant frequency of each station is obtained. Dominant frequency affected by the climate anomaly is a dominant frequency at 4 – 7 years for ENSO and 2 – 4 years for IODM so that the dominant frequency values are obtained in the following table:

Table 2. Lomb periodogram dominant frequencies.

Station	Year	Amplitude
Kotabumi	4.0630	1.28661
Maritim	5.0513	0.28266
Masgar	6.5736	0.98104
Radin Inten 2	3.8200	0.19026

The results from the four rain stations in Lampung province it was stated that Kotabumi, Maritime, Masgar were affected by the ENSO climate anomaly and Radin Inten was affected by the IODM climate anomaly.

4 Conclusion

Based on the lomb periodogram analysis the conclusions that can be drawn are Area in Lampung province that is most affected by climate anomalies ENSO is Kotabumi with highest Amplitude 1,287 with 4,063 years recurrence. And according to Lomb Periodogram result Lampung Province affected by two types climate anomalies. Kotabumi affected by El Nino with 4,0630 years recurrence, Maritim affected by El Nino with 5,05133 years recurrence and Masgar affected by El Nino with 6,57358 years recurrence affected by El Nino and La Nina with 4,063 - 6,5735 years recurrences while Radin Inten 2 affected by Dipole Mode with 3,82 years recurrences.

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