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Rainfall Patterns in Indonesian Provinces During El-Nino and La-Nina: FFT and Lomb Periodogram Analysis

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Abstract

Indonesia is a country affected by the El Nino and La Nina climate anomalies. The provinces of Aceh, Central Kalimantan, and Maluku are three regions representing parts of Indonesia that have a variety of rainfall distribution and climatic conditions. This research was conducted to determine the influence of the El Nino and La Nina climate anomalies on these three regions by looking at the areas that have a dominant influence due to these climate anomalies. The research used BMKG Indonesia rainfall data with a total of 16 rainfall stations and a data range of 22 years. The methods used for modeling are the Fast Fourier Transform (FFT) and Lomb Periodogram to obtain rainfall spectrum data. Then, the amplitude value was obtained, and a comparison of the data from the two methods was carried out to determine the recurrence value and the area with the highest impact due to climate anomalies. The results of data analysis according to the FFT and Lomb Periodogram showed that the highest affected area was the eastern part of Indonesia, namely Maluku Province, with the dominant frequency according to the FFT method being 5.61 years with a PSD of 7.67 mm2 and the Lomb Periodogram 6.06 years with a PSD of 18.64 mm2. Based on the average PSD value, using both FFT and Lomb Periodograms, it also shows that the influence of El Nino and La Nina is greatest in the eastern part of Indonesia; as you move towards the west, this influence decreases. The smallest influence occurred in western Indonesia. This shows that the influence of ENSO is more dominant than the influence of IODM.

Keywords: *El-Nino, La-Nina, Fast Fourier transform, Lomb periodogram*

Abstrak

Indonesia merupakan negara yang terkena dampak anomali iklim El-Nino dan La-Nina. Provinsi Aceh, Kalimantan Tengah, dan Maluku merupakan tiga wilayah mewakili wilayah Indonesia yang memiliki sebaran curah hujan dan kondisi iklim yang beragam. Penelitian ini dilakukan untuk mengetahui pengaruh anomali iklim El-Nino dan La-Nina pada ketiga wilayah tersebut dengan melihat wilayah yang mempunyai pengaruh dominan akibat anomali iklim tersebut. Penelitian tersebut menggunakan data curah hujan BMKG Indonesia dengan total 16 stasiun hujan dan rentang data 22 tahun. Metode yang digunakan untuk pemodelan adalah Fast Fourier Transform (FFT) dan Lomb Periodogram untuk memperoleh data spektrum curah hujan. Kemudian diperoleh nilai amplitudo dan dilakukan perbandingan data dari kedua metode tersebut untuk mengetahui nilai kekambuhan dan wilayah yang terkena dampak tertinggi akibat anomali iklim. Hasil analisis data menurut FFT dan Lomb Periodogram menunjukkan daerah terdampak paling tinggi adalah wilayah Indonesia bagian Timur yaitu Provinsi Maluku dengan frekuensi dominan menurut metode FFT adalah 5,61 tahun dengan PSD sebesar 7,67 mm2 dan Periodogram Lomb 6,06 tahun dengan PSD 18,64 mm2. Berdasarkan Nilai PSD rerata, baik menggunakan FFT maupun Lomb Periodogram juga menunjukkan bahwa pengaruh El Nino dan La Nina paling besar terjadi di wilayah Indonesia bagian timur, semakin ke arah barat, pengaruh ini semakin menurun. Pengaruh paling kecil terjadi di wilayah Indonesia bagian barat. Ini menunjukkan bahwa pengaruh ENSO lebih dominan dari pada pengaruh IODM.

Kata kunci: *El-Nino, La-Nina, Transformasi fast Fourier, Periodogram lomb*

Introduction

Indonesia is a tropical country with two seasons: the rainy season and summer. Each region has varying rain conditions, which influence climate diversity as well. Local influences on climate diversity cannot be ignored because Indonesia is located in the form of an archipelago and has very diverse topographic shapes, causing the influence of local conditions to be quite dominant (Athoillah et al., 2017).

The provinces of Aceh, Central Kalimantan and Maluku are three regions that represent Indonesia in the western, central and eastern parts, which have a variety of different land conditions, such as steep mountainous areas, gentle hillsides, wide land areas and flowing rivers. Due to their different geographical positions, diverse topography and the presence of vegetation, the distribution of rainfall and climatic conditions in these three regions also varies (Irwandi et al., 2018).

Extreme climate phenomena that result in hydrometeorological disasters, such as drought and floods in Indonesia, are influenced by the El Nino and La Nina climate phenomena (Surmaini & Faqih, 2016; Purnamasari et al., 2021). In recent years, this phenomenon has become more frequent, both in terms of intensity and frequency, while there is also a tendency for changes in world climate patterns due to global warming, and it is still ongoing (Laimeheriwa et al., 2019; Kaimuddin, 2000; Boer et al., 2003; Laimeheriwa, 2002). According. According to observations, El Nino and La Nina occur again every 2 to 7 years (Luo, 2001) and can last for 12 to 15 months (Ismiati, 2022).

The El Nino climate anomaly phenomenon is generally characterized by the potential for rain to fall and air temperatures to rise. In contrast, La Nina is characterized by the potential for rainfall to be above normal (Irawan, 2016). Several previous studies examined the El Nino and La Nina climate phenomena, which influence changes in the occurrence of solar activity (Fendeková et al., 2014). There is also research that observes the relationship between this climate anomaly and rainfall, solar radiation, and wind speed (Mohammadi & Goudarzi, 2018). Then, researchers also observed the relationship between the anomalous El Nino and La Nina climate phenomena and an increase in the stress threshold of birds living on the Galapagos Islands Islands (Wingfield et al., 2018). This proves that the climate anomaly phenomenon or climate deviation of El Nino and La Nina influences all the activities of living things and climate transitions that exist in nature (Suripin & Kurniani, 2016). The recurrence or frequency of rainfall events in recent years is also still a hot topic for research by hydrologists and related disciplines (Nugraheni & Zakaria, 2023). In determining the influence caused by this phenomenon, the Fast Fourier Transform (FFT) method (Noya et al., 2014) and the Lomb Periodogram (VanderPlas, 2018; Thong et al., 2004) were used to determine the increase and decrease in rainfall, which produces a spectrum shape for the rainfall. So, the data that has been generated is then analysed to find out the areas that are most affected by El Nino and La Nina.

The ability to accurately predict the anomalous climate phenomena El Nino and La Nina is very useful in planning all human activities and supporting efforts to reduce disaster risks such as floods, storms, high waves, landslides, and also the droughts they cause (Efendi & Purwandani, 2013). Based on this background, this research was conducted to analyze the magnitude of the influence of the recurring El Nino and La Nina climate phenomena on rainfall in western, central, and eastern Indonesia. In which regions the influence of El Niño and La Nina is greater and smaller? If the rainfall anomaly is greater in the eastern part compared to the western part of Indonesia, it means that the influence of ENSO is more dominant than the influence of the Indian Ocean Dipole Mode (IODM), and vice versa. Apart from that, it is hoped that the results of this research can be used as a reference for further research.

Material and Methods

The research locations are the provinces in Indonesia which represent the western, central and eastern regions of Indonesia. The western region of Indonesia took research locations in Aceh Province, the central region in Central Kalimantan Province and the eastern region in Maluku Province with a total of 16 rainfall stations. Aceh Province is located at 2°-6° N and 95°-98° E. It takes 5 rainfall stations, namely Tjut Nyak Dhien Meulaboh Meteorological Station, Sultan Iskandar Muda Meteorological Station, Malikussaleh Meteorological Station, Cut Bau Maimun Saleh Meteorological Station and Indrapuri Climatological Station. Central Kalimantan Province is located at 0°46ʾ N - 3°33ʾ South Latitude and 110°51ʾ - 115°50ʾ E. It also takes 5 rainfall stations, namely Tjilik Riwut Meteorological Station, Iskandar Meteorological Station, H. Asan Meteorological Station, Beringin Meteorological Station and Meteorological Station Sanggu. Meanwhile, Maluku Province is located at 3°0ʾ N - 3°40ʾ South Latitude and 123°50ʾ - 129°50ʾ E. It takes 6 rainfall stations, namely Namlea Meteorological Station, Kuffar Meteorological Station, Karel Sadsuitubun Meteorological Station, Bandaneira Meteorological

Station, Amahai Meteorological Station and Maluku Climatology as presented in Figure 1,

Figure 1. Map of the Provinces of Aceh (Western Indonesia), Central Kalimantan (Central Indonesia) and Maluku (Eastern Indonesia).

The rainfall data used in this research is secondary data obtained from the Indonesian BMKG (Meteorology, Climatology and Geophysics Agency) ground data station. The data used is data with a time span of 22 years, namely from 1998 to 2019 which was downloaded from the official BMKG website which can be accessed via dataonline.bmkg.go.id.

Analysis Method. In this study, a comparative analysis of peak events was carried out between the FFT method and the Lomb Periodogram method. Before analysing using these two methods, the data obtained was subjected to a data quality test which included converting rainfall data into data series, analysing missing rainfall data using Inversed Square Distance and testing the consistency of rainfall data. Rainfall Data Estimation Using Inversed Square Distance. Missing data or gaps in data at a rain gauge post at a certain time can be filled with the help of data available from rain gauge posts in the vicinity at the same time (Yogafanny & Legono, 2022). In this research, the Inversed Square Distance method is used, assuming that the rainfall data is affected by the distance between rainfall stations. The method is presented in Eq. (1) as follows,

$$Px = \frac{\frac{1}{(dXA)^2}P_A + \frac{1}{(dXB)^2}P_B + \frac{1}{(dXC)^2}P_C}{\frac{1}{(dXA)^2} + \frac{1}{(dXB)^2} + \frac{1}{(dXC)^2}} \qquad (1)$$

Where P_x is lost rainfall, P_A, P_B, P_C are rainfall at stations A,B,C. *dXA*, *dXB*, *dXC* are distance between stations A,B,C.

Test Consistency. Consistency testing is a test of the correctness of data in the field which is not influenced by errors during measurement and is described by the actual situation (Suhartanto et al., 2019). In testing the consistency of hydrological data, several methods are usually used such as the RAPS (Rescaled Adjusted Partial Sums) Method and the Multiple Mass Curve Method (Pirnia et al., 2019).

Spectral Method (Fast Fourier Transform). This FFT method aims to convert rainfall data from the time domain or data series into rainfall data in the frequency domain (Zakaria & Sumiharni, 2022). This method is presented in the form of a Fourier Transformation as presented in Eq. (2) as follows (Cooley & Tukey, 1965):

$$P\,(f_m) = \frac{\Delta t}{2\sqrt{\pi}} \sum_{n=\frac{-N}{2}}^{n=\frac{+N}{2}} p(t_n).\,e^{\frac{-2.\pi.i}{M}.m.n} \qquad (2)$$

Where f_m is rainfall in frequency series, P(f_m) is data in the frequency domain, t_n is time series variable, namely the length of the Nth data. $p(t_n)$ is rainfall series data in the time domain.

In its initial development, this method was less attractive because the transformation required a long time, so this method was considered less effective. After several years of research, this spectral method developed to be more efficient so that faster calculations were obtained. The use of this method became more widespread after the discovery and development of the FFT or Fast Fourier Transform calculation method (Zakaria et al., 2023) . This frequency analysis calculation method has been developed with the help of a program called FTRANS (Zakaria, 2008) to determine the frequency of periodic rainfall models.

$$P\,(f) = \frac{1}{4.\pi.s^2}\left\{\frac{\left[\sum_{i=1}^{n}(x_i-\bar{x})\cos\omega(t_i-\tau)\right]^2}{\sum_{i=1}^{n}\cos^2\omega(t_i-\tau)} + \frac{\left[\sum_{i=1}^{n}(x_i-\bar{x})\sin\omega(t_i-\tau)\right]^2}{\sum_{i=1}^{n}\sin^2\omega(t_i-\tau)}\right\} \qquad (3)$$

with τ is defined as Eq. (4),

$$tan(2\omega\tau) = \frac{\sum_{i=1}^{n}sin(2\omega t_i)}{\sum_{i=1}^{n}cos(2\omega t_i)} \qquad (4)$$

Where $P(f)$ is periodogram, $\bar{x}$ is average rainfall height, x is rainfall height, t is time, ω is frequency.

The Lomb Periodogram method is a method that can also be used to determine the frequency or recurrence of a data series such as daily rainfall data where the occurrence times are not the same time step. This method can be presented in Eq. (3) (Zakaria, 2011; Thong et al., 2004). The Lomb Periodogram method (Eq. (3) and Eq. (4)) is usually used by researchers or experts in the medical and astronomical fields. This method can also be used in the field of civil engineering, which uses data series. Just like FFT, this method also produces rainfall data in the frequency domain P(f).

Results and Discussions

Before being used, rainfall data sourced from BMKG was still in the form of data series with many empty days. To transform gaps in rainfall data, the short program is used so that the process of filling in empty days and unrecorded data can be processed more quickly. Then, before the analysis was carried out using the FFT and Lomb Periodogram methods, the rainfall data was tested for data consistency. From the results of the consistency test, it was found that the data were consistent with high correlation values. The results obtained based on this test are stable, so it can be concluded that the data is homogeneous and can be used for further analysis.

Table 1. Correlation coefficient at each rainfall station

No	Province	Rainfall Station	Correlation
1	Aceh	Tjut Nyak Dhien Meulaboh	0.9985
		Sultan Iskandar Muda	0.9927
		Malikussaleh	0.9984
		Cut Bau Maimun Saleh	0.9974
		Indrapuri	0.9995
2	Central Kalimantan	Tjilik Riwut	0.9977
		Iskandar	0.9910
		H. Asan	0.9933
		Beringin	0.9974
		Sanggu	0.9951
3	Maluku	Namlea	0.9909
		Kuffar	0.9979
		Karel Sadsuitubun	0.9961
		Bandaneira	0.9982
		Amahai	0.9910
		Sanggu	0.9984

Then, based on the research data in the form of daily rainfall data series and using Eq. (2) which is presented using the FFT method, a test is produced in the form of a daily rainfall spectrum from 1998-2019 and it can be seen which values are dominant and in how many years they arise. The result value is expressed in the form of ω which is then converted into a period per year and the amplitude value which is then converted into PSD (Power Spectral Density) to clarify which values are dominant and which are not dominant as presented in Figures 2, 3, and 4.

In the analysis using FFT, several dominant frequencies were found, namely the dominant frequency that occurs once a year and the dominant frequency that occurs in various variations of yearly recurrence. Research analysis shows that the dominant return period for rainfall data occurs once a year or what is usually called the annual oscillation. Previous research stated that the annual oscillation arises due to the direction of the monsoon wind which changes once a year (Yuggotomo & Ihwan, 2014) . Figures 2, 3, and 4 generated a result as presented in Table 2.

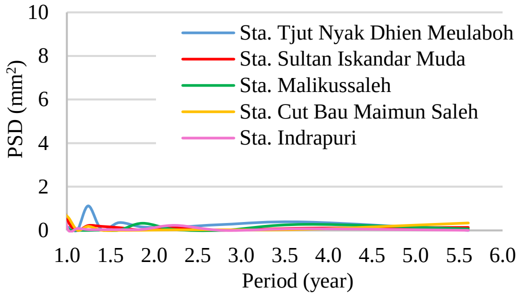

Figure 2. Rainfall spectrum over 1-year FFT Method (Western Indonesia).

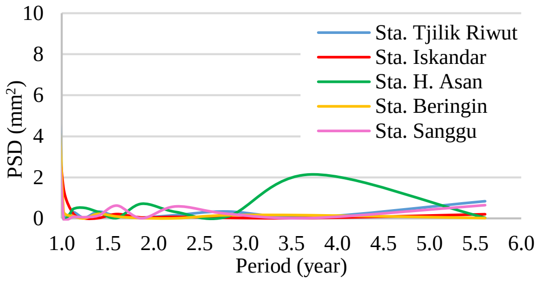

Figure 3. Rainfall spectrum over 1-year FFT Method (Central Indonesia).

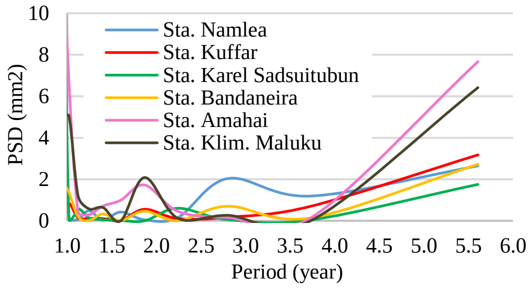

Figure 4. Rainfall spectrum over 1-year FFT Method (Eastern Indonesia).

Furthermore, it can be seen from the results of the analysis using the FFT method that in Aceh Province the dominant recurrence value is 3.7381 annually with a PSD value of 0.38 mm² at the Tjut Nyak Dhien Meulaboh station, Central Kalimantan Province (Central Indonesia) is 3.7381 annually with a PSD value of 2.14 mm² at H. Asan station and Maluku Province is 5.6071 annually with a PSD value of 7.67 mm² at Amahai station.

It can be seen from the analysis that the cycle of rainfall recurrence is in the period 2.24 years to 5.61 years, this shows that rainfall in the three provinces is affected by the ENSO phase or El Nino and La Nina climate deviations with strong recurrence and showing the highest spectral energy the same is on a 2–7-year cycle (Ismiati, 2022; Luo, 2001).

Table 2. Comparison of peak rainfall events (amplitudes) using the FFT method.

No	Province	Rainfall Station	2.2428 yearly	2.8036 yearly	3.7381 yearly	5.6071 yearly
1	Aceh	Tjut Nyak Dhien Meulaboh	0.15	0.27	0.38	0.00
		Sultan Iskandar Muda	0.13	0.01	0.10	0.14
		Malikussaleh	0.04	0.01	0.28	0.07
		Cut Bau Maimun Saleh	0.03	0.03	0.05	0.34
		Indrapuri	0.23	0.00	0.08	0.00
		average	0.1193			
2	Central Kalimantan	Tjilik Riwut	0.16	0.34	0.06	0.84
		Iskandar	0.07	0.03	0.02	0.20
		H. Asan	0.31	0.09	2.14	0.03
		Beringin	0.01	0.15	0.15	0.02
		Sanggu	0.58	0.22	0.02	0.65
		average	0.2900			
3	Maluku	Namlea	0.16	2.04	1.19	2.65
		Kuffar	0.11	0.17	0.71	3.17
		Karel Sadsuitubun	0.60	0.06	0.04	1.75
		Bandaneira	0.00	0.70	0.15	2.72
		Amahai	0.45	0.16	0.15	7.67
		Sanggu	0.12	0.26	0.02	6.42
		average	0.3939			

This is in accordance with previous research which states that ENSO events tend to increase in terms of frequency of events, duration of events and level of climate deviation (Irawan, 2016).

On average, the Power Spectral Density (PSD) of rainfall in the Maluku region is 0.3939, it is the greatest compared to PSD of the Kalimantan region is about 0.2900, it is becaused of the Maluku region is closer to the area where ENSO occurs, namely in the sea surface in the Pacific Ocean, on the west coast of Ecuador and Peru. And the PSD of rainfall in the Kalimantan region is greater than the PSD of rainfall in the Aceh region is about 0.1193. This indicated that the influence of El-Nino and La Nina is more dominant compared to the Indian Ocean Dipole Mode (IODM).

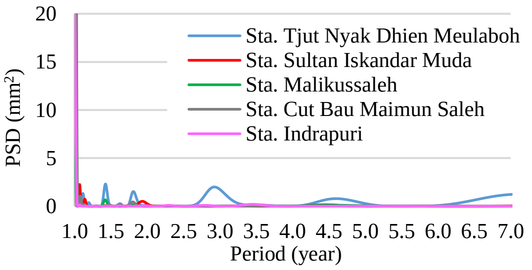

Figure 5. Rainfall spectrum over 1 year Lomb Periodogram Method (Aceh Province-Western Indonesia).

Meanwhile, just like FFT, analysis using the Lomb Periodogram method was also carried out to determine the recurrence and periods of El Nino and La Nina climate anomalies. Apart from data comparison, using this method also has the advantage of detecting values with a smaller probability of repetition so that the amplitude value can be seen in more detail. If the FFT method produces period values in angles, then the Lomb Periodogram method produces period values directly in days which are then converted into years and amplitude values which are converted into PSD.

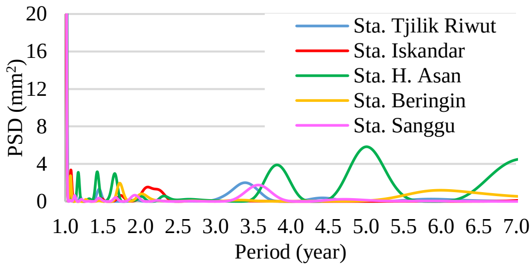

Figure 6. Rainfall spectrum over 1 year Lomb Periodogram Method (Central Kalimantan Province - Central Indonesia).

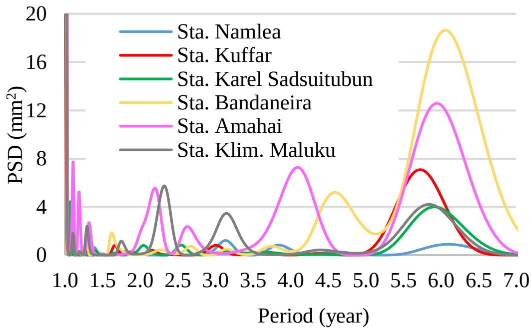

Figure 7. Rainfall spectrum over 1 Year Lomb Periodogram Method (Maluku Province).

In this analysis, Figures 5, 6, and 7 resulted, and the same 16 stations were used as the FFT method but produced different dominant recurrences. So, it is estimated that there are differences that were not detected in the FFT method but were detected in the Lomb Periodogram method. From Figures 5, 6, and 7 produced a result as presented in Table 3. The results of calculations from the Lomb Periodogram show that the dominant recurrence in Aceh Province is 2.0 - 4.5 years, in Central Kalimantan Province it is 2.1-6.0 years and Maluku Province is 2.3 - 6.1 years. It is estimated that rainfall with this recurrence is influenced by the natural phenomena El Nino and La Nina (Ismiati, 2022).

Based on the peak comparison results using the Lomb Periodogram method, it can be stated that the area that is more affected by the El Nino and La Nina phenomena in Aceh Province is the Tjut Nyak Dhien Meulaboh station with a recurrence value of 2.9213 per year and a PSD of 2.008 mm², in Central Kalimantan Province at the station H. Asan with an annual recurrence value of 5.0103 and a PSD of 5.837 mm² and Maluku Province is the Bandaneira station with an annual recurrence value of 6.0561 and a PSD of 18.64 mm². Observation results show that the influence of the El Nino and La Nina phenomena is not the same from one region to another. Each region, whether in Aceh Province, Central Kalimantan or Maluku Province, does not experience the same magnitude of deviation phenomena, therefore regions that have a greater influence of climate deviations have a greater risk of disasters occurring than regions that have a smaller influence of climate deviations.

From the use of the two analytical methods that have been carried out in the three provinces representing western Indonesia, namely Aceh Province, central Indonesia, namely Central Kalimantan Province and eastern Indonesia, namely Maluku Province, it can be concluded that the most dominant impacts are both located in Maluku Province, while the smallest impact was in Aceh Province. This proves that the areas most vulnerable to climate change are small islands (Laimeheriwa et al., 2019).

Using the Lomb Periodogram method, on average, PSD of rainfall in the Maluku region is about 8.207. It is also the greatest compared to the Kalimantan region with the PSD is about 2.465. Because the Maluku region is closer to the area where ENSO occurs, namely in the sea surface in the Pacific Ocean, on the west coast of Ecuador and Peru. The PSD of rainfall in the Kalimantan region is greater than the PSD of rainfall in the Aceh region, where PSD in Aceh is about 0.526. This also indicates that the influence of El Nino and La Nina is more dominant compared to the Indian Ocean Dipole Mode (IODM).

According to the geographical conditions of Maluku Province, it is clear that the region consists of small islands and there are seascapes around them. Administratively, Maluku Province borders several regions, namely the northern part borders the Seram Sea, the southern part borders the Indian Ocean and the Arafura Sea, the eastern part borders West Papua Province and the western part borders the Banda Sea.

Table 3. Comparison of peak rainfall events (amplitudes) using the Lomb Periodogram method.

No	Province	Rainfall Station	Period (yearly)	PSD
1	Aceh	Tjut Nyak Dhien Meulaboh	2.9213	2.008
		Sultan Iskandar Muda	2.0014	0.247
		Malikussaleh	4.5010	0.121
		Cut Bau Maimun Saleh	3.5236	0.050
		Indrapuri	3.4497	0.203
		average		0.526
2	Kalimantan Tengah	Tjilik Riwut	3.3949	2.003
		Iskandar	2.0999	1.537
		H. Asan	5.0103	5.837
		Beringin	5.9959	1.197
		Sanggu	3.5702	1.753
		average		2.465
3	Maluku	Namlea	3.1348	1.210
		Kuffar	5.7221	7.081
		Karel Sadsuitubun	5.9110	3.991
		Bandaneira	6.0561	18.64
		Amahai	5.9439	12.58
		Sanggu	2.3217	5.741
		average		8.207

Table 4. Comparison of the analysis results of the FFT and Lomb Periodogram methods.

No	Method (Impact)	Province	Stastion	PSD	Period (yearly)
1	FFT max	Aceh	Tjut Nyak Dhien Meulaboh	0.38	3.74
		Central Kalimantan	H. Asan	2.14	3.74
		Maluku	Amahai	7.67	5.61
2	FFT min	Aceh	Indrapuri	0.00	2.80
		Central Kalimantan	Beringin	0.01	2.24
		Maluku	Bandaneira	0.00	2.24
3	Lomb max	Aceh	Tjut Nyak Dhien Meulaboh	2.01	2.92
		Central Kalimantan	H. Asan	5.84	5.01
		Maluku	Bandaneira	18.6	6.06
4	Lomb min	Aceh	Cut Bau Maimun Saleh	0.05	3.52
		Central Kalimantan	Beringin	1.20	6.00
		Maluku	Namlea	1.21	3.13

Based on its location, it is automatically influenced by climate deviation phenomena, thereby influencing rainfall fluctuations in Maluku Province. This results in the assumption that rainfall in the Maluku region is influenced by the ocean and forms the weather system in the region. Previous research states that the climate in Indonesia is consistently tropical and is located between two continents and two seasons (Sipayung, et al., 1995), while the weather system is too complex and the variety of topography in Indonesia plays a role in determining the high rainfall (Gustari, 2009).

Currently, there is controversy among researchers regarding global warming, which can increase the incidence of El Nino and La Nina climate deviations because various climates depend on several conditions, several climate models have shown that El Nino and La Nina will become stronger and occur more frequently with there is global warming. Changes in the amplitude of El Nino and La Nina depend on the model used to study them. Several studies show that various types of El Nino or ENSO events are variations that occur naturally in the Pacific Ocean (Yeh & Kirtman, 2007).

The results indicate that the climate anomaly phenomena El Nino and La Nina are natural phenomena that occur in Pacific waters, which strongly affect sea surface temperature and rainfall conditions in Indonesia rather than the Indian Ocean Diploe Mode (IODM). If the influence of IODM is greater, the PSD values in western Indonesia will be greater than the PSD values in eastern Indonesia. The further east you go, the influence of IODM decreases (Liu & Duan, 2017).

The results obtained using the FFT method compared with the results from the Lomb Periodogram. Table 4 shows a comparison result between the FFT (Fast Fourier Transform) and Lomb Periodogram methods. It shows the value of the recurrence period or frequency of rainfall, which has the most dominant influence according to BMKG rainfall data. The eastern region of Indonesia, namely Maluku Province has the highest influence based on the FFT method, namely at 5. 61 years with a PSD of 7.67 mm^2 and based on the Lomb Periodogram method, namely at 6.06 years with a PSD of 18.64 mm^2. Table 4 also shows that the Lomb Periodogram method provides a higher PSD compared to the FFT method.

Conclusion

Based on the research that has been carried out, the results show that the magnitude of the influence of the ENSO or El Nino and La Nina climate phenomena in an area can be predicted early. By using the FFT (Fast Fourier Transform) and Lomb Periodogram methods, it can be concluded that the value of the recurrence period or frequency of rainfall, which has the most dominant influence according to BMKG rainfall data, is in the eastern region of Indonesia. This recurrence is a repetition of rainfall that occurs due to the impact of the climate deviation phenomena of El Nino and La Nina.

The PSD average values show that the impact of El Nino and La Nina on the Maluku region is stronger than that of the Kalimantan region. El Nino and La Nina in the Kalimantan region are stronger than in the Aceh region. This change in PSD values shows that the effect of El Niño and La Nina or ENSO is more dominant than the effect of IODM in rainfall data from Indonesia.

Recommendation

In this research, several suggestions must be considered for further research, namely: (1). It is necessary to carry out research with a longer number of years of research to get better results, and

(2). Some missing rainfall data may interfere with the analysis results so it is hoped that research can be carried out with better data.

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