The Effect of El Niño Southern Oscillation (ENSO) on Rainfall and Correlation with Consecutive Dry Days (CDD) in Palembang City

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Abstract. El Niño Southern Oscillation (ENSO) `is an event where the increase in sea surface temperature becomes unnatural. Stronger events where the sea surface temperature anomaly becomes large, then this disrupts local fish and bird populations. The ENSO phenomenon also affects rainfall in several parts of Indonesia. In this study, an analysis of the effect of the ENSO phenomenon on rainfall in Pelambang City from 2000 to 2020 was carried out and the correlation between Consecutive Dry Days (CDD) and Rainfall in Palembang City for the last 20 years. ENSO data and rainfall data as well as CDD and rainfall data were analyzed using a simple linear regression method. In addition, a correlation analysis was also carried out between the Niño 3.4 and SOI indices with rainfall at two stations, namely Palembang Climatology Station and Sultan Mahmud Badaruddin II Meteorological Station to determine how much influence the ENSO phenomenon has on rainfall in the Palembang City area. The results of the analysis show that the effect of ENSO on rainfall at each station in general is almost not influenced by El Niño and La Niña, this is presumably due to the location of Palembang City which is in the Munsonal area. Monsoon areas are characterized by a unimodial type of rainfall (one peak of the rainy season) where in June, July and August the dry season occurs, while December, January and February are wet months. The remaining six months are a transitional or transitional period (three months of transition from the dry season to the rainy season and three months of transition from the rainy season to the dry season.

INTRODUCTION

Indonesia is a maritime country traversed by the equator, located between the continents of Asia and Australia and between the Indian Ocean and the Pacific Ocean. Indonesia has a tropical climate which is divided into two seasons, namely the rainy season and the dry season. The rainy season occurs between October-March with a peak around December-February caused by the Asian cold monsoon (Saji & Vinayachandran, 1999). While the dry season occurs between April-September with a peak around June-August due to the Australian monsoon. Although the rainy and dry seasons occur periodically, the amount of rainfall for each region of Indonesia is not always the same (Lestari et al., 2016). This condition shows that rainfall in the territory of Indonesia is not only formed by monsoons, but there are equatorial rainfall patterns and local rainfall patterns. One of the weather phenomena that affect rainfall conditions is ENSO (Adikusumo, 2008; Bunga Rahayu, 2019). The ENSO phenomenon or southern oscillation is a movement that occurs in the atmosphere and oceans due to the dynamic interaction between the atmosphere and the oceans in the equatorial Pacific Ocean. The interaction between the atmosphere and the ocean is indicated by an increase or decrease in sea surface temperature that exceeds its climatological temperature (long-term average temperature of about 30 years) causing anomalies (deviations) (Karundeng, 2013; Robial et al., 2016). If the positive anomaly that occurs means the sea surface temperature is warmer than usual, then an El Niño occurs. On the other hand, if a negative anomaly occurs, it means that the temperature is colder than normal, so La Niña occurs. There are interesting findings revealing the relationship between the Asian summer moonson and ENSO. Several researchers have obtained a fairly good understanding of the relationship between these two phenomena, including (Agusta et al., 2013; Hermawan, 2010; Sipayung et al., 2007). They concluded that the summer Asian moonson was negatively correlated with ENSO, namely the El Niño phenomenon. That is, if the Asian summer moonson index rises, the El Niño weakens.

ENSO is a weather phenomenon that occurs in the Pacific Ocean that can affect the global climate. ENSO consists of two phases, namely a hot phase during El Niño and a cold phase during La Niña. El Niño is an event of increasing sea surface temperature in the Central and Eastern equatorial Pacific Ocean, causing surface air pressure in Darwin to be higher than in Tahiti (William J. Emery and Richard E. Thomson, 2016). Meanwhile, La Niña is the cold phase of the Central and Eastern Pacific Ocean marked by the warming of the sea surface temperature in the Western Pacific so that some areas experience high rainfall intensity. In general, the effect of La Niña on rainfall in Indonesia moves dynamically, where at the beginning it only occurred in parts of Indonesia, namely the southern and eastern parts of Indonesia. In a previous study conducted by (Glisan et al., 2016). It was reported that ENSO and Dipole Mode had no effect on rainfall in Ketapang with the correlation value of the Niño 3.4 index data on rainfall of -0.18, while the correlation value of the Dipole Mode Index data was -0,12 (Cavazos, 2000; I. Iskandar, 2010). The effect of ENSO and DM patterns on rainfall shows that the El Niño phase tends to be low. However, during the positive DM phase, the rainfall in Palembang City tends to be high. Meanwhile, when the La Niña and DM phases are negative, rainfall tends to increase. Considering the magnitude of the influence of ENSO as a global phenomenon that can affect the weather, it is necessary to conduct a study related to the occurrence of El Niño and La Niña phenomena in the Palembang City area which has a monsoon rainfall pattern, to see how much influence the ENSO phenomenon has so that it can complement previous research (I. Iskandar et al., 2008).

Consecutive Dry Days (CDD) or the longest consecutive day without rain is one of the important extreme rain parameters recommended by the Expert Team on Climate Change Detection and Indices (ETCDDI) to provide an overview of climatic conditions in an area, especially related to information on climate change and drought. that happened (Dewanti et al., 2018; Harrison, 1998). This CDD is defined as the maximum number of consecutive days without rain or with rainfall in a day less than 1 mm. Previous CDD studies in Indonesia have been carried out using rain observation point data to determine the characteristics of extreme rain associated with global climate anomalies such as El Nio. This information is very important in efforts to develop a drought early warning system, especially in food centers because it has a major influence on rice crop productivity (Handoko et al., 2019; Hermon, 2014). Another option is the use of Climate Hazards Group Infrared Precipitation with Station data (CHIRPS), which is a grid-shaped assimilation data product that is built based on rain stations on land and involves three different types of information such as global climatological data, satellite estimates and results from observations of rain gauges. This CHIRPS data has been validated and used in previous studies, especially studies related to rainfall and drought variability. El Niño is one of the ocean-atmosphere phenomena that has an impact on global climate anomalies (Baeda et al., 2019). There are two types of El Niño, namely the conventional El Niño which is a sea-atmosphere anomaly interaction in the eastern tropical Pacific region that extends to the middle and El Niño Modoki which is concentrated in the central tropical Pacific so that it is often called the Central Pacific El Niño. These two types of El Niño have different characteristics and impacts in all parts of the world such as South America, South Africa and Australia. Another atmosphere-sea interaction in the form of the Indian Ocean Dipole (IOD) in the Indian Ocean region which forms a paired pattern between the east and west also has an influence on climatic conditions in other regions. IOD events are generally assessed for their impact on rainfall and temperature variability, as well as drought (Zhan et al., 2017).

METHOD

This research was conducted in Palembang City with 2 research stations, namely the Palembang City Climatology Station and the Sultan Mahmud Badaruddin II Meteorological Station. The map of Palembang City can be seen in the following figure. The data used in this study are Niño 3.4 index data and Consecutive Dry Days (CDD) data on a monthly scale (NOAA: https://www.fisheries.noaa.gov/resources/data). CDD data on a monthly scale (BOM: http://www.bom.gov.au/) and rainfall data from the BMKG Palembang City for the period 2000 to 2020. The method used in this study is a simple linear regression method to determine the correlation coefficient and the coefficient of determination. Simple linear regression method was used to determine the effect of one independent variable on one dependent variable, CDD data and observational rainfall data were processed using a simple linear regression method and Niño 3.4 index data on the same rainfall data were processed using the same method. The general form of a simple linear regression equation is expressed in equation 1(Gibson et al., 2017),

$$Y = a + bX \quad (1)$$

Where X is the independent variable or predictor (CDD data and Niño index 3.4), Y is the dependent variable or response (rainfall data), a is a constant and b is a regression coefficient parameter (slope); the magnitude of the response generated by the predictor (Harrison, 1998). Where X is the independent variable or predictor (CDD data and Niño index 3.4), Y is the dependent variable or response (rainfall data), It is a constant and b is a regression coefficient parameter (slope); the magnitude of the response generated by the predictor. Correlation analysis was used to determine the close relationship between the two variables between ENSO and rainfall (Hafizhurrahman et al., 2015). Correlation analysis was carried out twice, namely between CDD on rainfall and the Niño 3.4 index on rainfall. The correlation equation used can be seen in equation (2) (Pourasghar et al., 2012).

$$r_{xy} = \frac{1}{N-1}\sum_{i=1}^{N}\frac{(xi-x)-(yi-y)}{s_x s_y} \quad (2)$$

Where X is the independent variable (CDD data and Niño index 3.4), Y is the dependent variable (rainfall observation data) and n is the amount of data in a year. The correlation value (r) ranges from 1 to -1. While the direction is expressed in the form of positive (+) which indicates a directly proportional relationship or in the same direction and negative (-) indicates an inversely proportional relationship. The closer the value to 1 or -1 means the relationship between the two variables is very strong. The level of relationship or correlation can be seen in Table 1 (Chonghua Yin, 1994; M. R. Iskandar, 2014).

Table 1. Interpretation of Correlation coefficient

Value of r (correlation)	**Description**
0,00-0,199	Very Low
0,20-0,399	low
0,40-0,599	Moderate
0,60-0,799	High
0,80-1,00	Very High

RESULT AND DISCUSSION

This section will explain the results of the analysis of the relationship between CDD and the Niño 3.4 index with rainfall at several observation stations in Palembang City, namely Palembang Climatology Station and Sultan Mahmud Badarudin II Meteorological Station. ENSO data represented by the Niño 3.4 index and drought data are Consecutive Dry Days (CDD) with rainfall can be seen in Figures 1 to 4. In general, the relationship between rainfall and ENSO at two stations in Palembang City from 2000 to 2020 has a low correlation with correlation values ranging from 0.03. This means that the rainfall in Palembang City is not too affected by the ENSO phenomenon. The picture is presented in Figure 1.

Data from the combined analysis of ENSO (Niño 3.4 index and Consecutive Dry Days (CDD)) with rainfall at the Climatology Station of Palembang City are shown sequentially in Figures 1 to 4. It can be seen in Figure 1 that in 2018 there was an increase in rainfall which coincided with the phenomenon of El Niño is strong. Should an area be affected by El Niño, there will be a dry season, so it is known that the influence of the pressure gradient between Tahiti-Darwin is not too large. Meanwhile, when the La Niña phenomenon occurred in 2010, rainfall at the Kota Climatology Station Palembang has increased, but still has a very low correlation level of 0.03. It can be said that rainfall at the Climatology Station of Palembang City is not too influenced by the value of the Niño Index 3.4. These results can be represented by the Figure 2.

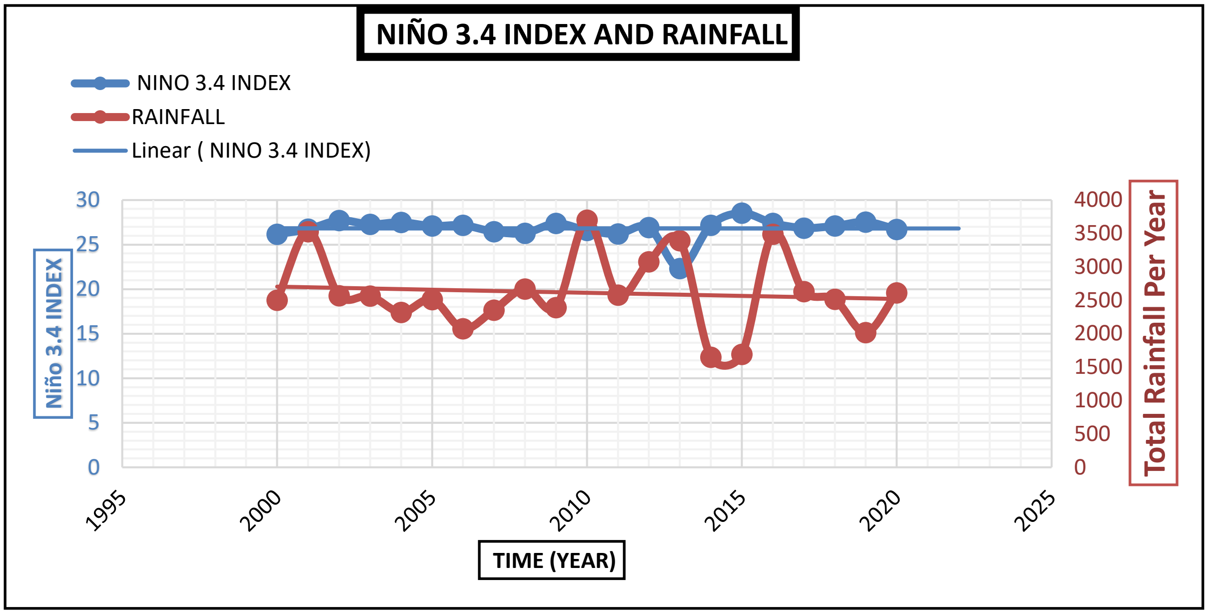

Figure 1 Graph of Rainfall with Niño Index 3.4

Figure 2 shows the linear equations of the Niño 3.4 Index and Bulk. The information obtained from this equation is that the Niño 3.4 index can be said to have no significant effect on rainfall in the city of Palembang. With a significant level value of 0.03. This is due to the area of the city of Palembang. In the graph it can also be seen that in 2015 there was a very extreme decrease in total rainfall with a value of only reaching 1694 mm at year in 2015. The opposite happened to the Niño 3.4 index which had a fairly high value of 28.4. This shows that in 2015 there was an extreme El Niño phenomenon that resulted in drought in Palembang City almost throughout the year, namely a decrease in rain intensity starting from June 2015 to December 2015.

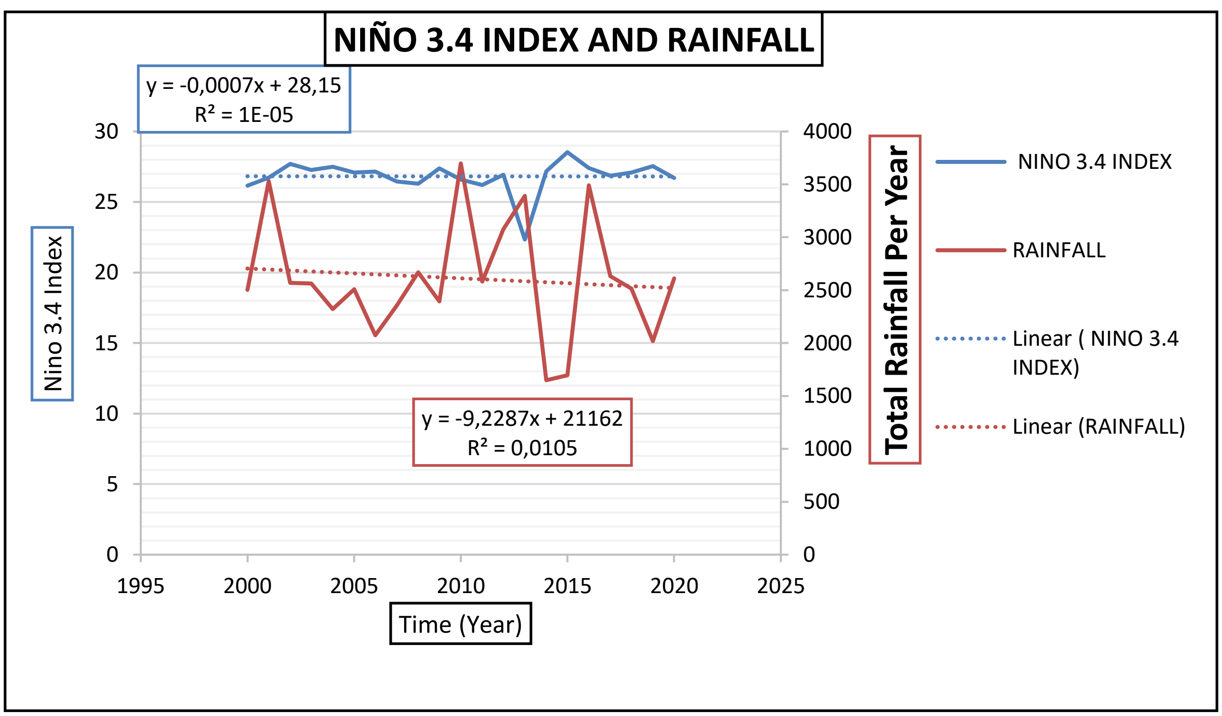

Figure 2 Linearity of the Niño 3.4 Index and Rainfal

This of course resulted in drought in Palembang City and Land and peat forest fires were inevitable in 2015. Based on data from the Palembang City Disaster Management Agency in 2015, forest and peatland fires were quite extensive. The smoke disaster is very disturbing community activities comprehensively and covers all areas of life of the people of Palembang city. Public health was a public concern at that time and the community's economic activities were quite disrupted due to the smoke disaster that occurred in 2015 (IPCC, 2018; Siswanto et al., 2015, 2016).

The CDD index became the attention of researchers in 2015, how much influence it had on the Niño Index that occurred at that time. Below is a graph showing the CDD Index and the Niño 3.4 Index. In Figure 3, the CDD index value data is presented with the Niño Index 3.4. From these data, it is found that during the La Niña phenomenon in 2010, rainfall has increased with the correlation value between rainfall and the Niño 3.4 index of 0.026. The influence of La Niña on rainfall in Indonesia moves dynamically where at the beginning it only occurred in some parts of Indonesia, namely the southern part and continued to move dynamically throughout Indonesia to the eastern part of Indonesia. This is because the intensity of El Niño and La Niña strength is not always the same every time it occurs, depending on the magnitude of the deviation of sea surface temperature resulting in changes in air pressure over Darwin-Tahiti. In accordance with the data in Figure 3, it is found that the Niño 3.4 index value does not have a significant effect on the CDD value in the Palembang City Region.

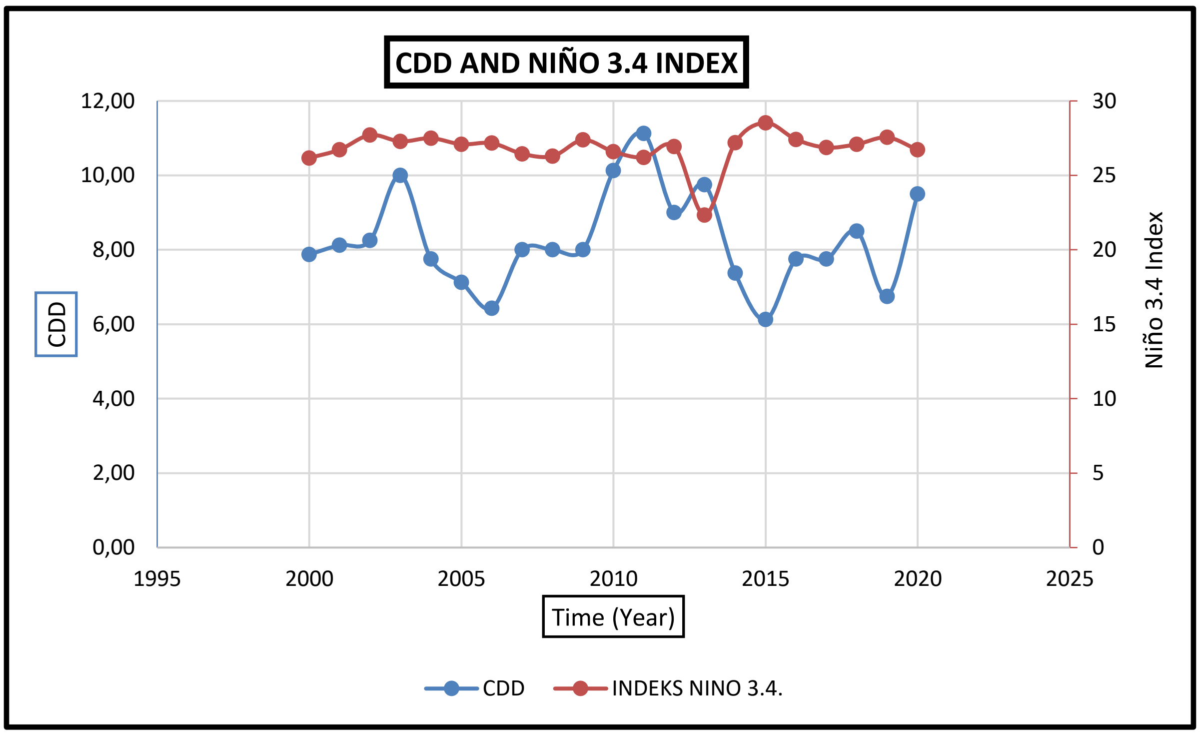

Figure 3 CDD and Niño 3.4 Index from 2000-2020

This is in line with research conducted by (Ben Arther Molle, 2020; Dewanti et al., 2018; Hafizhurrahman et al., 2015; Sari, 2016; Tukidi, 2010) which states that the southern part of Sumatra, including the city of Palembang, is in the monsoon area, where the area is an area of rainfall in Indonesia influenced by monsoons which are driven by monsoons. the presence of high pressure cells and low pressure cells in Asia and Australia continents alternately. In December-January-February (DJF) in the Northern Hemisphere, winter occurs as a result of high pressure cells occurring on the Asian continent, while in the Southern Hemisphere it is summer at the same time, resulting in low pressure cells on the Australian continent (Swenson & Grotjahn, 2019). Because there is a difference in air pressure on the two continents, during the DJF period the wind blows from high pressure in Asia to low pressure in Australia, this wind is called the West Monsoon or Northwest Monsoon.

June-July-August (JJA) occurs on the contrary, there is low pressure in Asia and high pressure cells in Australia, so during the JJA period the wind blows from high pressure in the Australian continent to low pressure in Asia, this wind is called the East Monsoon or Monsoon Southeast. This causes that the most influential thing on climate change in the monsoon region is the difference in cell pressure on two continents, namely the Asian continent and the Australian continent. The influence caused by the dynamics of the Ocean or Pacific Ocean that triggers the ENSO phenomenon is very small in impact on seasonal changes in the Monsoon Region.

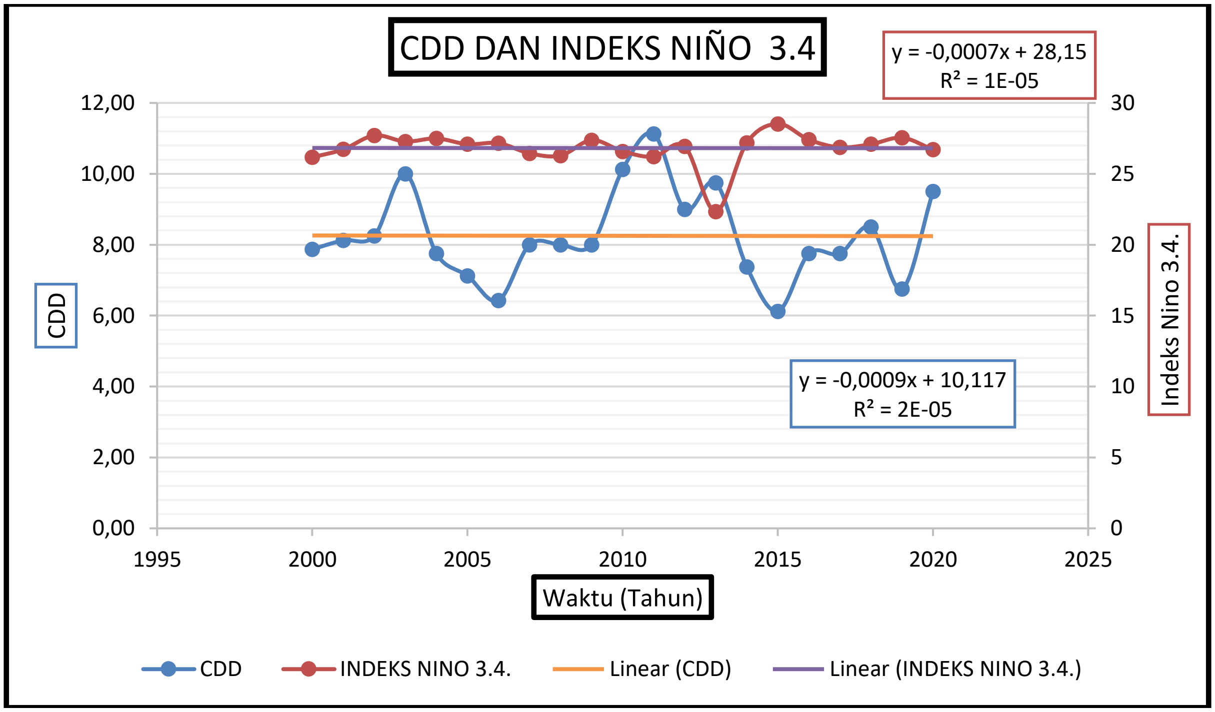

Figure 4 Linearity of the CDD and Rainfall

CONCLUSION

From the calculation of the correlation between the Niño 3.4 and Rainfall index and the Niño 3.4 index and CDD value on rainfall from 2000 to 2020, it can be concluded that the rainfall in Palembang City is almost not influenced by the ENSO phenomenon. Rainfall in Palembang City is not affected during the El Nio phase. The increase in rainfall during the La Nia phenomenon can be expected because of the location of Palembang City which is in a monsoon area which has a unimodial rainfall distribution (one peak of the rainy season) caused by differences in air/atmosphere pressure cells between the two continents, namely the Asian continent. and the Australian continent.Figures, tables, and equations must be inserted in the text and may not be grouped at the end of the paper. Important: A miscount of figures, tables, or equations may result in revisions. Please double check the numbering of these elements before you submit your paper to your proceedings editor.

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