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Application Remote Sensing in Study Influence of El Niño incident in 2015/ 2016 on the Amount of Rainfall in Sarawak

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Abstract: In 2015/2016 saw the country hit by El Niño which caused drought and drought all over the country. This El Nino incident caused a decrease in the amount of rainfall due to the movement of trade air currents. Many studies have been conducted on the effects of El Niño on temperature and rainfall. However, there is a discrepancy in the findings. The study area of Sarawak experienced different natural disasters in February 2016, namely floods in South Sarawak and drought in North Sarawak. To understand this incident, researchers use rain data from remote sensing technology through Global precipitation Measurement (GPM) to provide rainfall distribution data during El Niño 2016 events. The first step to calculate the total of rainfall in a month from GPM data for gain the pattern amount rainfall during 2015/2016. The results of this study found that El Nino events caused a decrease of 20-30% during El Niño events even during the occurrence of the northeast monsoon. However, the effect of El Nino on the amount of rainwater distribution depends on the position of a district in Sarawak. The results of this study successfully show that the northern areas of Sarawak are much affected during El Nino which is important to those responsible in providing infrastructure to reduce the impact of El Niño, especially to the agricultural sector.

Keywords: El Nino, Rainfall, GPM

1. Introduction

In 2015/2016 El Niño incidents were among the worst to hit the world whose degree of strength scale was almost equal to the strength of El Niño in 1997/1998. This El Niño occurrence is often accompanied by drought and drought (Sum et al., 2018; Ricky and Oliver 2021; Awange et al., 2016; Lyra et al., 2017). Besides, the occurrence of El Niño is also the amount of rainfall below normal levels (Awange et al., 2016; Marengo et al., 2018). This decrease in the amount of rainfall will cause drought which leads to a lack of water resources. This lack of water resources will cause negative effects on social, economic, and environmental sectors (Lyra et al., 2017; Sobral et al., 2019).

Knowledge Information on drought is useful in formulating public policy and managing its effects, especially in Sarawak. Malaysia Meteorology Department (MMD) (2020) shows that moderate or strong El Niño will cause rainfall distribution in Sabah and Sarawak to be much below the time level during the Southwest monsoon (June-August) and Northeast monsoon (November-February). The impact of ENSO on mean precipitation is widely studied in different counties of the world, but comparatively few studies focus on the relationship between precipitation extremes and ENSO (Curtis et al., 2007; Zhai et al., 2007; Grimm and Tedeschi, 2009; Li et al., 2011; Villafuerte et al., 2014; Villafuerte and Mastsumoto, 2015; Lestari et al., 2016; McGree et al. 2016).

Previous studies have found that there is a difference in the effect of ENSO incidence on total rainfall. Gershunov and Barnett (1998) found that El Niño and La Niña affect heavy rainfall frequency in the United States but the effect of space is not uniform. Goddard and Dilley (2005) found that the ENSO incident had a weak effect on the amount of rainfall. Haylock et al., (2006) and Grimm and Tedeschi (2009) stated that the occurrence of ENSO affects the amount

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of rainfall. While Tangang et al., (2017) and King et al (2013) found that the occurrence of ENSO has a nonlinear effect on the amount of rainfall. McGree et al., (2016) and Lestari et al., (2016) found that ENSO incidents especially El Niño provide the effects of drought. For in Malaysia the following studies have been conducted (Tangang et al., 2017; Juneng et al. 2007; Tangang et al., 2008; Endo et al., 2009; Deni et al., 2010; Suhaila et al., 2010; Wan Zin and Jemain, 2010; Wan Zin et al., 2010; Chen et al., 2013).The climate in Southeast Asia is strongly influenced by large-scale phenomena such as the El Niño-Southern Oscillation (ENSO) (Ricky and Oliver, 2021; Moron et al., 2010) and the Madden-Julian Oscillation (MJO) (Tangang et al.). (2008; Salahuddin and Curtis, 2011).

Aldrian et al. (2003) reported that rainfall in Southeast Asian seas is sensitive to El Niño phenomena, but the northwestern region may be associated with strong monsoon activity. Robertson et al. (2011) reported that rainfall in the area is strongly influenced by MJO and cold waves, which can mutually influence and interact with weather systems in places like the Borneo Vortex, which often cause heavy rains, flash floods, and torrential rains. noisy. These studies show that rainfall in different areas is influenced by large-scale atmospheric phenomena and in-situ weather systems. Therefore, climate variability and tendencies are very different across regions and between different seasons. A large number of studies have found that rainfall in the district increases and decreases. According to the study of Lau and Wu (2007), there is a positive trend of heavy and light rainfall incidence in this district, while a negative trend of moderate rainfall incidence has emerged in this district. Aldrian and Djamil (2008) estimated that between 1955 and 2005, the rainfall ratio between the rainy season and the dry season increased. (2010) found that total rainfall and frequency of wet days have decreased, but rainfall intensity has increased in most of peninsular Malaysia.

Suhaila et al. (2010) found that the amount of rainfall in Peninsular Malaysia, the frequency of extreme rainfall events, and rainfall intensity during the northeast season have increased. In several recent studies, various areas in Peninsular Malaysia have also reported different changes in the extreme rainfall index (Pour et al., 2014; Mayowa et al., 2015). However, the extreme rainfall index in Indonesia does not show a clear trend unless there is evidence that annual rainfall in certain areas decreases, while the ratio of rainy and dry season rainfall increases (Aldrian and Djamil, 2008). Suepa et al. (2016) Ten-year repurchase. This indicates that the climate of the Southeast Asian region differs greatly from place to place due to the characteristics and scope of different geographical and topographical locations, as well as the contrast between land and sea. Therefore, more research is needed on changes in rainfall at a local or regional scale.

The report shows that from 2001 to 2010, rainfall, especially on the Indochina Peninsula, decreased. In contrast, Caesar et al. (2011) reported that the total annual wet day rainfall increased by 22 mm every ten years, while the extreme rainy day rainfall increased by 10 mm every ten years. This indicates that the climate of the Southeast Asian region varies with geographical and topographic locations, various features, and land-sea contrast locations. Therefore, more research is needed on changes in rainfall at a local or regional scale.However, these investigations did not specifically address the issue of how precipitation trends in Sarawak were influenced by El Niño events using remote sensing technology. Technology remote sensing provides spatial information regarding the pattern of amount rainfall at Sarawak. This result may significantly important to local government namely Sarawak Disaster Management Agency gain correct and accurate location hot spot area during El Nino. This attracted the attention of researchers to map changes in rainfall distribution during the 2015/2016 El Niño incident.

2. Location of Study

This study is the entire state of Sarawak with an area of 124,450 km². Sarawak is located north of the equator between latitudes 0 ° 50 'and 5 ° N and Longitude 109 ° 36' and 115 ° 40 '. The state of Sarawak is experiencing a tropical rainforest climate with total rainfall between 3300 to 4600 mm. Daily temperatures occur at 23 ° C to 32 ° C and humidity is always high and 68%. The climate in Sarawak is strongly influenced by Madden Julian Oscillation (MJO), ENSO, and Indian Ocean Dipole (IOD) (Muhmad et al., 2018; Ricky and Oliver, 2021). Besides, the Sarawak area is also strongly influenced by monsoon incidents. North-eastern monsoon occurrences that occur in November, December, January, February, and March cause a sharp surge in total rainfall (Tangang et al., 2018, MMD, 2021). While southwest incidents in May to September cause dry season (Ricky and Oliver, 2021). The year 2016 saw floods in southern Sarawak and northern Sarawak reported drought and drought caused forest fires in the Miri city environment.

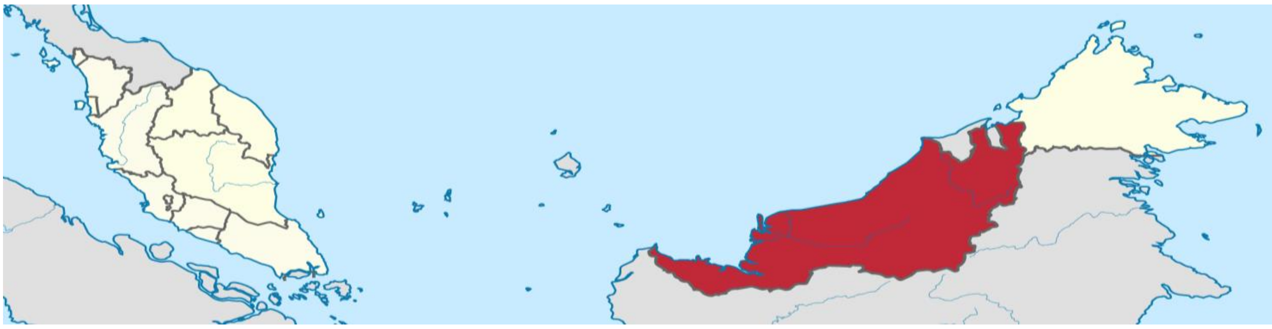

Fig. 1 - Location of study – Sarawak

Source: Google earth

3. Methodology and Data

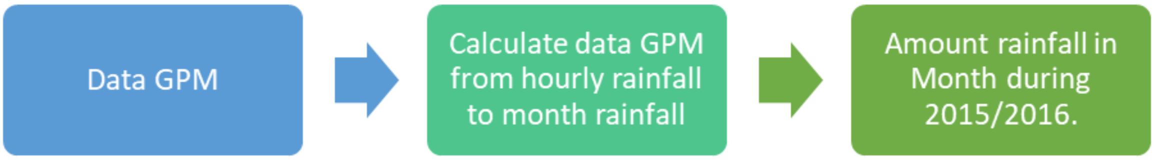

Fig. 2 - Method flow chart to achieve objective study

To achieve the objective of the study required to download data GPM from the website NASA GPM. The data GPM was in unit rainfall in an hour. The next step to calculate GPM data from hourly rainfall to monthly rainfall. Finally, the amount of rainfall during 2015/2016 was achieved. The data will represent in combo graph bar and line as discussed in chapter discussion and results.

3.2 Data Rainfall

Daily rainfall data is downloaded from NASA (National Aeronautics and Space Administration) at the website https://power.larc.nasa.gov/data-access-viewer/. Its research program has long supported satellite systems and research providing data vital to the study of climate and climate processes. These data include long-term climatologically averaged estimates of meteorological quantities and surface solar energy fluxes. Moreover, mean daily values of the based meteorological and solar data are provided in a time-series format. These satellite and model-based products are accurate enough to provide reliable solar and meteorological resource data over regions where surface measurements are sparse or non-existent.

3.3 Oceanic Niño Indeks (ONI)

The ONI is well established to identify events of El Niño and La Niña (Huang et al., 2016). The ONI index shows the development and intensity of El Niño or La Niña events in the Pacific Ocean. ONI is a three-month Sea Temperature (SST) anomaly in Niño region 3.4 5 ° N - 5 ° S, 120 ° - 170 ° W). The occurrence of El Niño is defined when the average value of three months at or above + 0.5 ° C anomaly, while the event of La Niña is defined as or under climate Anomaly (NOAA, 2018) −0.5 ° C (NOAA Forecast Center, 2019). ENSO value grade is classified into 5 class a Weak (with anomalies 0.5 to 0.9 SST), Medium (1.0 to 1.4), Strong (1.5 to 1.9), and Very Strong (≥ 2.0) for El Niño events and vice versa for La Niño events. Table 2 shows the ONI values for the year 2015/2016.

Table 1 - The value of ONI for Year 1997/1998 and 2015/2016 used in this study

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2015	0.6	0.6	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.4	2.5	2.6
2016	2.5	2.2	1.7	1.0	0.5	0.0	-0.3	-0.6	-0.7	-0.7	-0.7	-0.6

3.3 Global Precipitation Measurement (GPM)

GPM is a joint assignment between JAXA and NASA as well as other international space agencies to make regular observations of Earth's precipitation. It is part of NASA's Earth Systematic Missions package and works with a satellite collection to provide full global coverage. The GPM mission is a worldwide system of satellites that deliver next-generation global observations of rain and snow. Construction upon the success of the Tropical Rainfall Measuring Mission (TRMM), the GPM concept centers on the placement of observatory satellites carrying an advanced radar/radiometer system to quantity precipitation from space and assist as a reference standard to unite precipitation quantities from a gathering of research and operational satellites. Concluded improved measurements of precipitation globally, the GPM mission is helping to advance our understanding of Earth's water and energy cycles, improve predicting of extreme events that cause natural hazards and disasters, and extend current abilities in using accurate and timely information of precipitation to directly benefit society. This study will apply 24 data GPM to achieve the objective of the study.

4. Result and Discussion

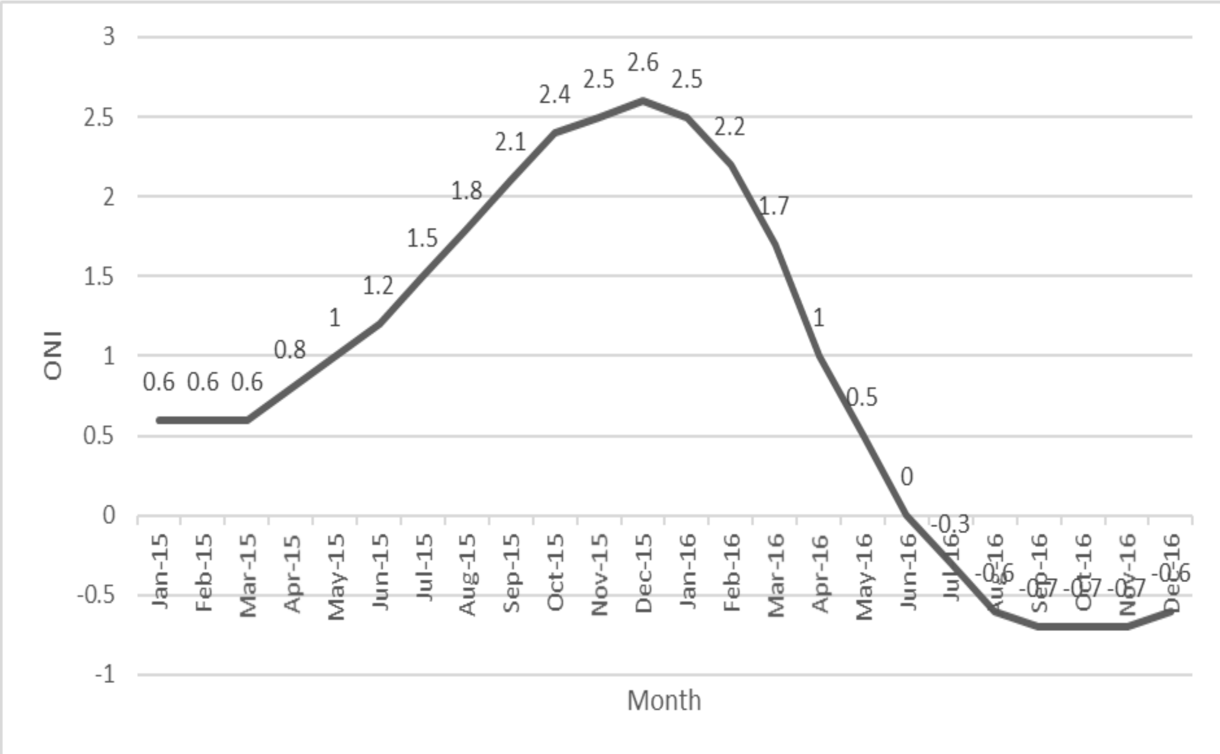

Fig. 3 - Value ONI on the year 2015/2016

This figure 3 the ONI values during the El Niño and La Niña events during the 2015/2016 events. Based on the classification from Tangang et al., (2007) if the ONI value exceeds the negative value of 0.5 is La Niña and if the ONI value exceeds the positive 0.5 is El Niño. The table below shows the classification of degrees of strength according to NOAA (2020).

Table 2 - Strength Degree Scale Based on ONI

Strength Degree	El Niño	La Niña
Low	0.5 until 0.9	-0.5 until -0.9
Moderate	1 until 1.4	-1 until -1.4
Strong	1.5 until 1.9	-1.5 until -1.9
Very strong	≥2	≥-2

According to the ONI, the El Niño events started in March 2015 where the value of ONI 0.8 and continues to increase to a peak in December 2015 which 2.6 value of ONI. The ONI values started to decline in Jan 2016 until May 2016 to become neutral.

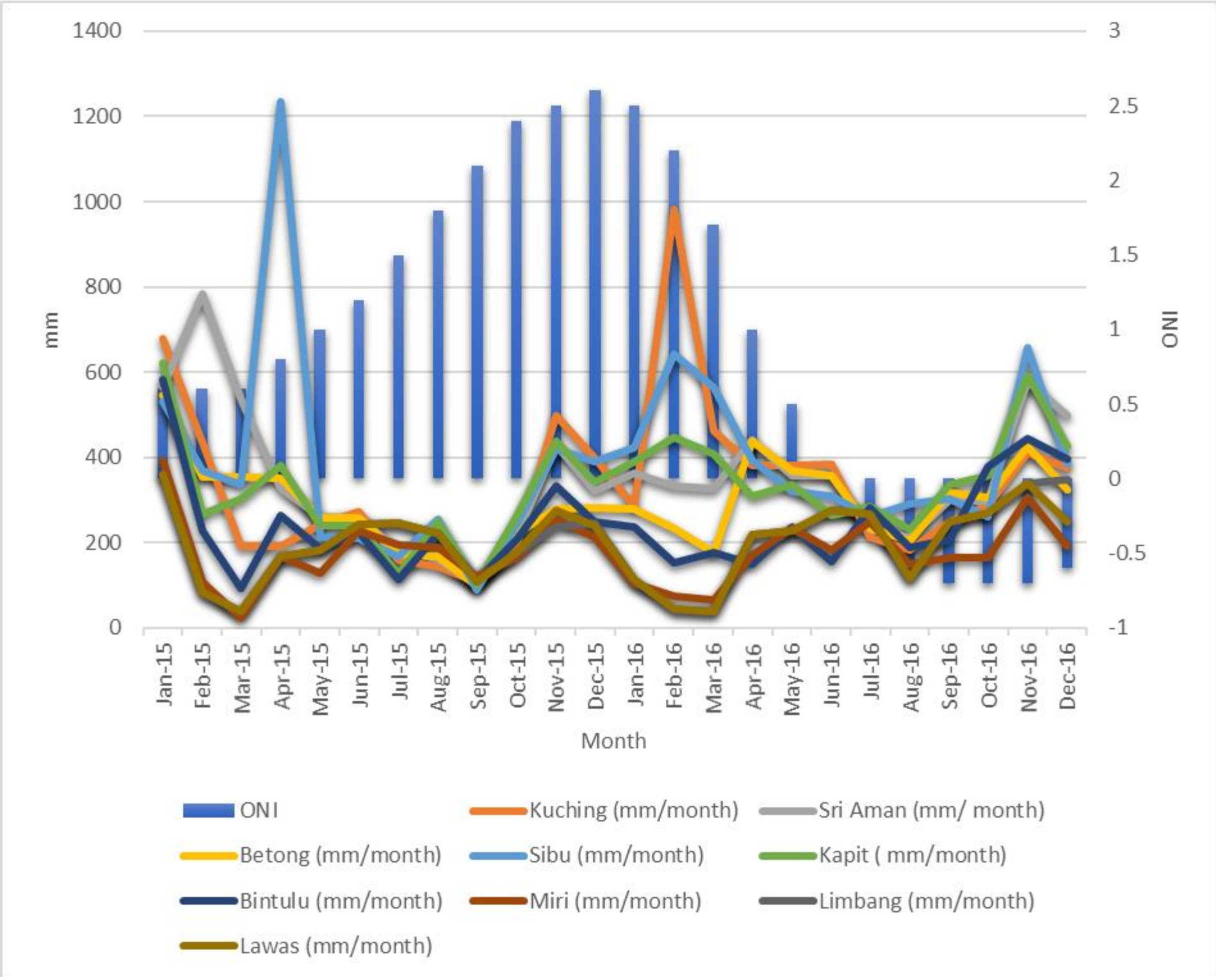

Fig. 4 - ONI Value and the total monthly rainfall

Figure 4 shows the ONI value and the total monthly rainfall for each part in Sarawak. Overall, the occurrence of El Niño affects the value of the monthly amount during the northeast monsoon season. This northeast season results in higher total rainfall values than usual. The northeast season occurs from November to March (MMD, 2021). The occurrence of this northeast monsoon causes the amount of monthly rainfall to be higher than during the southwest season and the transition period or intermediate of both seasons.

During the 2015/2016 El Niño incident, it was found that the rainfall value was lower than normal. Monthly rainfall was found to decrease from November 2015 to March 2016 even during the northeast monsoon season. This study found that El Niño 2015/2016 causes the influence of the northeast monsoon which brings reduced rainfall or slows down the occurrence of the northeast monsoon. The effects of the northeast monsoon began to appear in February 2016 which found the value of total rainfall increased. However, the effect of El Niño on monthly rainfall varies according to the position of certain parts of Sarawak. Attention to the graph above also gets the ONI value affecting the amount of monthly rainfall. The location factor of a place affects the amount of monthly rainfall distribution. A map of the average hourly rainfall distribution will illuminate in-depth.

Referring to figure 5 the places found on the hourly rainfall map in 2015 areas in northern Sarawak such as Miri, Limbang, Lawas, Baram, and Marudi which are affected every time the contents of the lowest hourly rain show the red and yellow occurrences. El Niño 2015. Refers to the map of areas that are said to be affected in January, February, March, April, May, July, and December 2015. While the special areas of rain that are represented by blue are Kuching, Serian, Sri Aman, Kapit, and Belaga special in January, February, March, April, June, July November, and December 2015. For central Sarawak which means Sibu, Selangau, Sarikei, Betong, and coastal areas such as Mukah and Balingian during the influence of moderate El Niño events which in the month January and February, the affected areas will be reduced to special areas of high and moderate rainfall in April, May, June, August, September, October, November and December 2015.

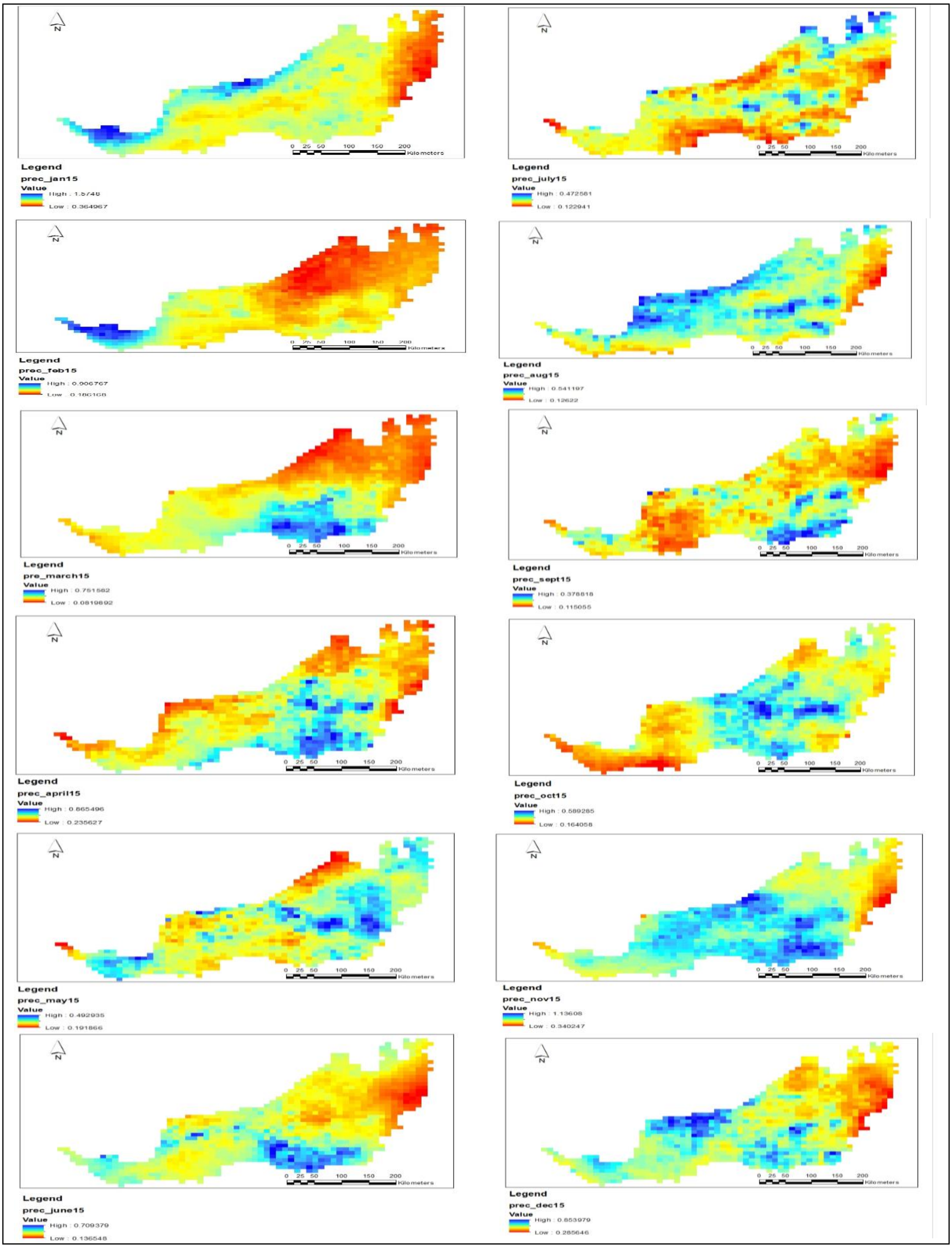

Fig. 5 - Map of hourly rainfall in 2015

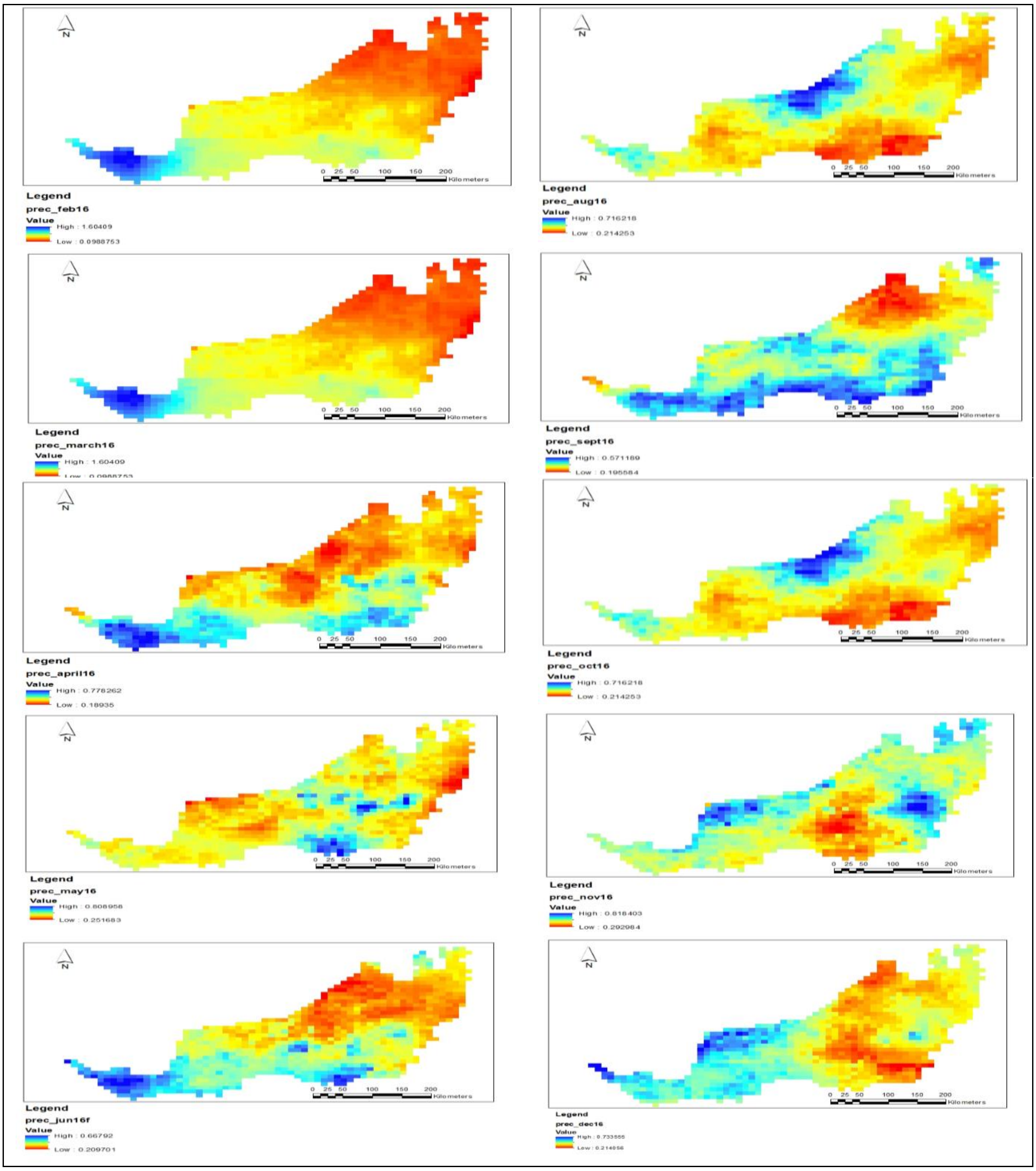

Fig. 6 - Map of hourly rainfall in 2016

Referring to figure 6 the places found on the hourly rainfall map in 2016 areas in northern Sarawak such as Miri, Limbang, Lawas, Baram, and Marudi which are affected every time the contents of the lowest hourly rain show the red and orange occurrences of El Niño 2016. The pattern of the map of hourly rainfall in 2016 found an almost similar pattern to the map of hourly rainfall in 2015. Refers to the map of areas that are said to be affected in January, February, March, April, May, July, and December 2016. While the special areas of rain that are represented by blue are Kuching, Serian, Sri Aman, Kapit, and Belaga special in January, February, March, April, June, July November, and December 2016. For central Sarawak which means Sibu, Selangau, Sarikei, Betong, and coastal areas such as Mukah and Balingian during the influence of moderate El Niño events which in the month January and February, the affected areas will be reduced to special areas of high and moderate rainfall in April, May, June, August, September, October, November and December 2016.

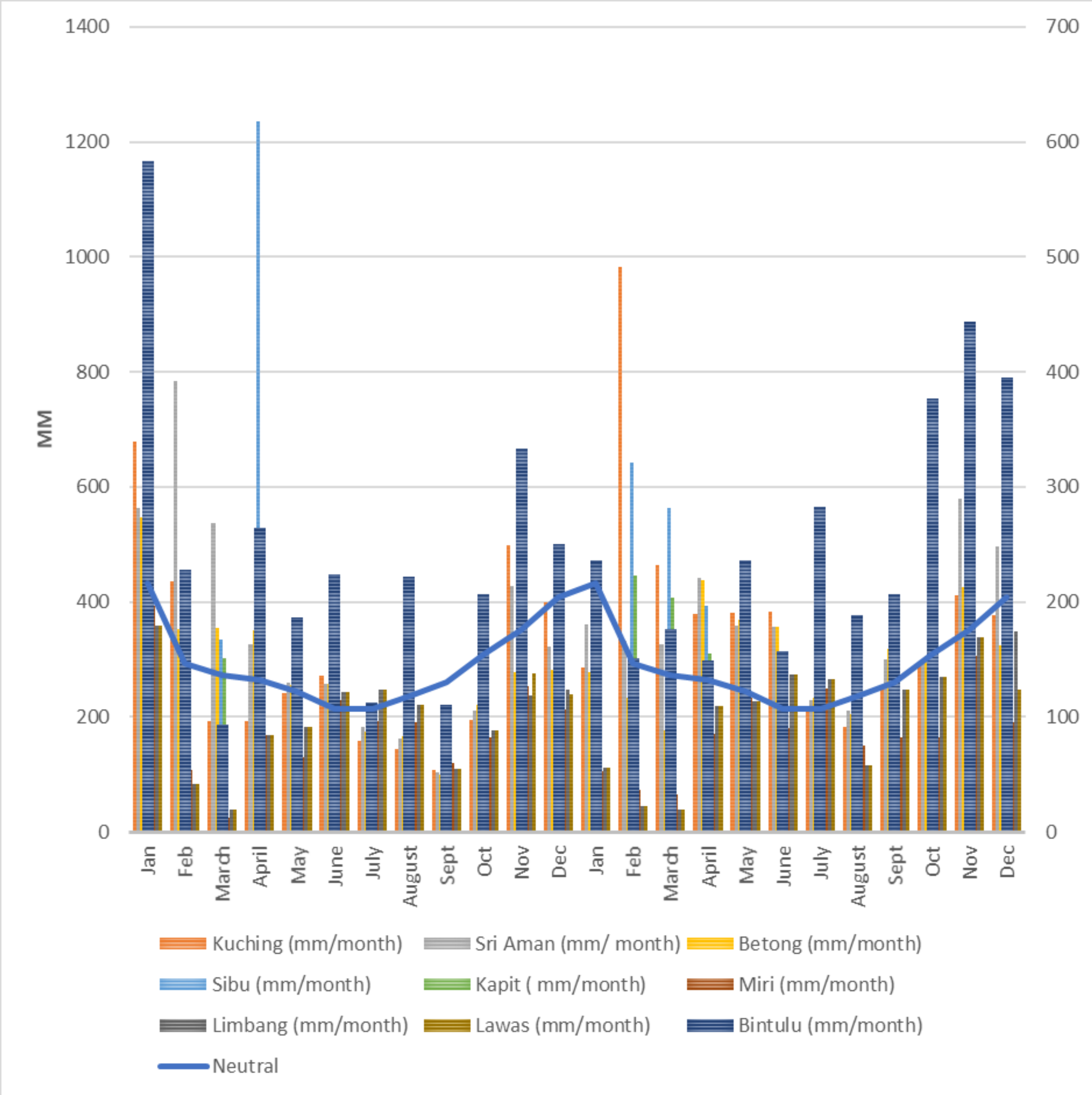

Fig. 7 - Value of rainfall during neutral and El Niño

Figure 7 shows a comparison of the amount of monthly rainfall at the neutral time with the amount of monthly rainfall during El Niño 2015/2016. The part that gets the amount of rainfall below the normal level since the ONI value of 0.5 in April 2016 until May 2016 in the northern part of Sarawak such as Miri, Limbang, and Lawas. These three parts consistently find the value of total rainwater below normal levels compared to other parts. In September 2015 and October 2015 where the ONI value of 1.8 caused all parts of Sarawak to be below normal levels. An in-depth description of the impact of the El Niño event on the total monthly rainfall changes will be explained in the next paragraph.

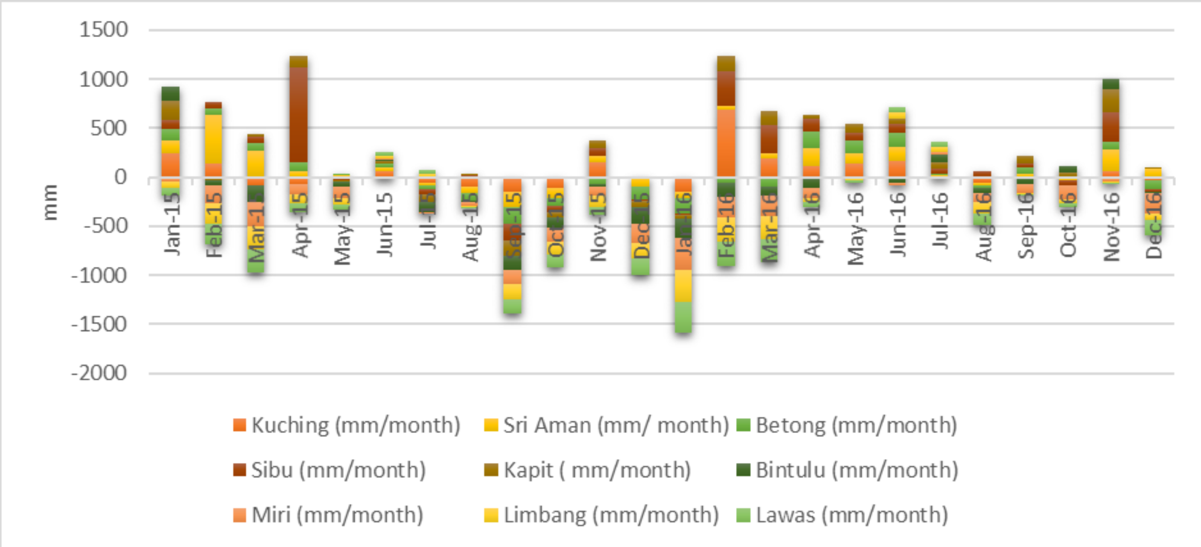

Fig. 8 - Value Rainfall Change during 2015/2016

Referring to figure 8 in May, September, and November, El Niño events caused monthly rainfall in all parts of Sarawak. The northern parts of Sarawak Miri, Limbang, and Lawas have consistently experienced a reduction from July 2015 to April 2016. Bandar Sibu, Kapit, and Kuching increased rainfall June 2015, November 2015, February 2016 to July 2016. In April 2015 there was an increase in rainfall monthly by 970 mm and Kuching city also increased by 690 mm in February 2016. An increase of 690 mm saw major flooding in Kuching city (National Flood Forecast and Warning Center Water Resources and Hydrology Management Division Department of Irrigation and Drainage, Malaysia, 2018). Almost 90% of case of the floods at Sarawak in 2016 occurred between January-February 2016 and October - December 2016. In general, the causes of floods are as follows because heavy rain collides with high tide air, prolonged heavy rains, and river overflow, and heavy rain and drainage/drainage system problems.

Of the 45 flood cases used, 53% (24 cases) occurred between January-February 2016 and 36% (16 cases) occurred between October-December 2016 different in each division cause of extreme rainfall during that time. The area's most frequently hit by floods during 2016 are the Kuching, Sibu, and Limbang parts each of the 10 floods. Followed by the Samarahan and Sri Aman divisions which also each displayed 5 cases of floods. February 2016 saw the state of Sarawak hit by the flood disaster in Kuching city and the drought in Miri the distance between the two cities was 950 km. December 2015 was the culmination of the El Niño incident and began to decline for the next month. Apart from the fact that the northern position of Sarawak is closer to the Pacific Ocean, the effects of El Niño are still influential compared to the Kuching city area. The floods in February 2016 were due to monsoon incidents and the intensity of the effects of the El Niño incident began to decrease in the position of Kuching city. This explains clearly that the effect of El Niño occurrence on the amount of rainfall is varied according to position (Tangang et al., 2017). Bernama (2009) newspaper reported that there were eight divisions in Sarawak severely affected during the El Niño incident specifically on the coast in northern Sarawak. Besides, the latest evidence reports in 2016 changes occurred two different natural disasters drought in northern Sarawak and floods in January and February 2016 in southern Sarawak.

5. Conclusion

The El Niño incident in 2015/2016 was the worst recorded ever to hit Sarawak from the lack of rainfall that occurs in almost the whole of Sarawak. The results of the study illustrate the occurrence of El Niño and La Niña that occurred in the Pacific Ocean affected the rainfall distribution in Sarawak. The existence of the El Niño phase (either at strong, medium, or weak levels) will cause Sarawak to experience a dry state of probability as much as 20-30%. The results of this study can help responsible parties such as the government and non-governmental organizations to identify and find solutions and early planning before the peak of the El Niño phenomenon. This study is expected to provide an overview comprehensive on the influence of El Niño and monsoon events and their impact on the distribution and amount of rainfall received by our country. Negative implications of hot and dry weather events or droughts associated with El Niño and monsoon events that occur simultaneously will have an effect that can disrupt community activities from the comfort of temperature and hydration but will affect agriculture as well as industry. Planning by local authorities in preparation for a drought prolonged in the future may be able to relieve the situation faced by countries in the climate of climate change that the world is experiencing. The El Niño event was great in 2015 and 2016 has also had a severe impact on Malaysia. Forest events which burn due to hot and dry weather in Indonesia has crossed the country's border when the haze covered most of Malaysia's airspace at the time (Sum et al., 2018; Mahmud, 2018) and detrimental to the health of local people (Sum et al., 2013, Mahmud, 2018).

6. Acknowledgement

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