Identification of The Influence of Long Winter Season in 2017 – 2018 to the Forming of Strong Northerly Cold Surge over West Indonesia

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Abstract. This study identifies the characteristic of strong Northerly Cold Surge (NCS) over West Indonesia in the period from November 2017 until April 2018. Usually the NCS occurs in the DJF period that indicates the rainy season that usually goes to trigger some severe weather in Indonesia. The severe weather accompanying the intense northerly cold surge often brings more major disruptions that often trigger natural disasters like floods and landslides to the affected regions in West Indonesia. Descriptive and statistical methods are used in this study by classifying the intensity of NCS in November 2017 until April 2018. The real-time data from Ogimet Weather Information Service, GSMAp Satellite, and restudy data from National Centers for Environmental Prediction (NCEP) are used to determine the 925 millibar meridional wind, relative humidity in 1000, 925, 850, and 700 millibar, mean sea level pressure, and rainfall estimation to identify the passage of NCS in West Indonesia region. The long winter season in 2017 – 2018 triggered the NCS to stay active even it comes to March and April 2018. It is proven by the natural disaster that comes from consecutive intense rainfall like floods and landslides that still intensively occurred in the March until April 2018 in West Indonesia.

Keywords : GSMAp, Northerly Cold Surge, meridional wind, landslides.

1. Introduction
The region of Indonesia is located geographically between two major continents (Asia and Australia) and two oceans (Indian and Pacific), this geographic position gives a huge impact to the weather dynamics in Indonesia [1]. That is why the weather dynamics in Indonesia are mostly influenced by monsoon. Monsoon is triggered by the surplus-deficit of energy between Asia and Australia. When the Asian monsoon that brings a very moist air masses occurs and passes above Indonesian continent, it could trigger the forming of convective clouds become more intense, that mostly lead to more intense rainfall (rainy season). Another hand, when the Australian monsoon that bring dryer air masses occurs and passes above Indonesian continent, it could reduce the concentration of air moisture, that means on that moment a number of convective clouds could be reduced. This deficit of convective clouds would lead into dry season in some region in Indonesia.

When it comes to the winter season in Northern Hemisphere in the South China Sea, usually a huge mass of cold air is pounded from Asia that originally comes from the isolated cold region in Siberia. This condition called Northerly Cold Surge (NCS) [2]. Despite the monsoon, the NCS is also has a significant impact on the weather dynamics in Indonesia, especially in West Indonesia. The huge cold
air mass pounds the warm air mass in West Indonesia, that forces the warm air mass to lift and leads to the forming of convective clouds that responsible to some intense rainfall events that occur in that region.

In the period between 2017-2018, the winter season in Northern Hemisphere expands until the end of April 2018 [3, 4, 5]. The unusual condition of winter season in 2017-2018 like the increasing of winter storms over Northern Hemisphere to affect aerodrome closed for certain airports in big city of the United States of America and Canada in Northern America Continent, and the freezing water Niagara for the first time during the last 50 years could be additional condition from coolest than normal and it might longer than usual based upon public information and collecting the global climatic chart from National Climate Centers under coordination from the World Meteorological Organization (WMO) [2]. This cold condition could expand over European Countries and North Asian Continent. With the expansion of the winter season, it suspected to be a big factor to the more intense energy of NCS that passes West Indonesia region.

The aim of this research is to identify the impact of the long winter season in 2017-2018 to the forming of strong NCS over Indonesia. We are using some major factors to determine the NCS in West Indonesia: the difference of mean sea level pressure of Gushi-Hongkong in November 2017 until April 2018, 925 millibar meridional wind (V component), 1000, 925, 850, and 700 millibar relative humidity and surface rainfall estimation in South China Sea and West Indonesia region (25˚N to -10˚S and 95˚E to 122.5˚E) in November 2017 until April 2018 to determine the passage of the NCS and its impact over West Indonesia.

2. Data and Methods
2.1. Data
We are using the daily mean sea level pressure of Gushi-Hongkong data in November 2017 until April 2018 from Ogimet Weather Information Service; 925 millibar restudy meridional wind (V component) data in South China Sea and West Indonesia region (25˚N to -10˚S and 95˚E to 122.5˚E) in November 2017 until April 2018 from National Centers of Environment Prediction (NCEP) with 2.5˚ × 2.5˚ data resolution; 1000, 925, 850, and 700 millibar relative humidity data in South China Sea and West Indonesia region (25˚N to -10˚S and 95˚E to 122.5˚E) in November 2017 until April 2018 from National Centers of Environment Prediction (NCEP) with 2.5˚ × 2.5˚ data resolution; and rainfall estimation data in South China Sea and West Indonesia region (25˚N to -10˚S and 95˚E to 122.5˚E) in November 2017 until April 2018 from Global Satellite Mapping of Precipitation (GSMaP) with 2.5˚ × 2.5˚ data resolution.

Figure 1. Research domain to determine the NCS in South China Sea and West Indonesia region (25˚N to -10˚S and 95˚E to 122.5˚E).
2.2. Method
The method used in the research is descriptive. The emergence of NCS from Siberia is identified from the cold surge index (the difference of mean sea level between Gushi and Hongkong), and then it would be classified in the range of weak (10.0 – 12.9 millibar), moderate (13.0 – 14.9 millibar), and strong (> 15 millibar) indexes [6]. The transport of cold surge from Siberia to South China Sea and finally would come to West Indonesia region can be identified from the meridional wind (V component) study, it would take at least 24 to 72 hours for the cold surge to come to West Indonesia region [6]. The passage of cold surge in West Indonesia would affect the increasing amount of air moisture (relative humidity) from the usual condition that would provide more chances to the forming of convective clouds (that could lead to hydro-meteorological hazards like floods and landslides). The relative humidity study in 1000, 925, 850, and 700 millibar is the key to identify the surplus of air moisture that could be determined as the trigger to the forming of convective clouds in the West Indonesia region when the NCS comes. The dynamics of moisture distribution in the research domain would be compared with the mapping of near real-time daily rainfall data based from GSMaP Satellite to strengthen the evidence of the increasing of the convective clouds formation in the research domain.

3. Result and Discussion
3.1. NCS Index Study (Gushi-Hongkong)
According to the mean sea level pressure difference between Gushi-Hongkong within 24 hours, the indication of NCS is determined when the difference of the pressure is equal or more than 10 millibar that implemented to the NCS index that shown on Figure 2 and 3 [7].

![Figure 2. Daily NCS index on November 2017 – January 2018.](image)

![Figure 3. Daily NCS index on February 2018 – April 2018.](image)
On Figure 2 and 3 we can see 8 cases of NCS occurred on November 2017, the month when the Asian Monsoon passes over Indonesia, then 10 cases of NCS occurred on December 2017, and 11 cases of NCS in January 2018. In February 2018 the amount of NCS cases started to decrease to 3 cases and it slightly increased to 4 cases in March 2018 and decreased again in April 2018 with 2 NCS cases. The result of the study is well-corresponded with recent research by Winarso and Prayuda, 2017 [8].

According to [6], in November 2017 there were 5 weak NCS, 1 moderate NCS and 2 strong NCS. In December 2017, there were 9 weak NCS and 1 moderate NCS. In January 2018, there were 5 weak NCS, 4 moderate NCS and 2 strong NCS. In February 2018, there were 3 weak NCS. In March 2018, there were 3 weak NCS and 1 moderate NCS. In April 2018, there were 2 weak NCS.

3.2. Meridional Wind Study

The significant pressure difference between Gushi and Hongkong causing an air that flows from high-pressure area to the low-pressure. The presence of cold advection that brought by the air flow causes the NCS. The NCS can also be identified by analyzing the 925 mb meridional wind [6, 9]. The 925 mb meridional wind is eligible to use for the study because on this level there is no interference to the air flow that caused by surface obstacles (mountains, buildings, etc.) [6].

Based on data study, on November 4th, 2017 the NCS passed Hongkong with the meridional wind speed on the range of 5 – 15 m/s from 15 N – 20 N down to the south, but there has not been any propagation to western Indonesia. This is identified with the meridional wind upon western Indonesia still went to the north with a speed of 0 – 5 m/s. On November 5th, 2017, the surge began to appear to the south with speed of 0 – 5 m/s reaching western Indonesia, especially in most parts of Kalimantan, but there was still a force of the wind towards the north in Indonesian waters (Malacca Strait and Strait Java). The NCS reached the territory of west Indonesia within 48 hours. On November 6th, 2017, the wind that carrying cold water vapor reached almost over all-region in western Indonesia.

The activation of NCS on November 7th, 2017 strengthened the spread of NCS until November 10th, 2017 as shown in green color on Figure 4. On November 18th, 2017 a strong NCS and followed by a weak NCS for the next 2 days strengthening the head south wind over west Indonesia. This consecutive surge makes the propagation period spent only 24 hours to pass the west Indonesia region. After this case, weak to moderate NCS occurred consecutively until the end of the month that caused the wind towards the equator to reach 5 – 10 m/s pulled to the west of Sumatra and southern Java (shown on Figure 5) and the wind rose to a maximum of 15 m/s on November 26th – 28th, 2017 over western Sumatra.

![Figure 4. Meridional wind approached the equator.](image1)

![Figure 5. Meridional wind strengthened and pulled to the West Sumatra.](image2)
The active weak NCS still occurred on December 1st, 2017 with the surge reaching the South China Sea with meridional wind speed of 5 – 10 m/s but weakening to 0 – 5 m/s when it reached the south of the equator. The NCS was blowing constantly until December 4th, 2017. On December 13th, 2017 an active weak NCS consecutively occurred, this occurrence strengthened the head south wind until the end of December 2017 with the meridional wind speed of 15 – 20 m/s in South China Sea (Figure 6) and 5 – 15 m/s in the west Indonesia (Figure 7).

![Figure 6. Meridional wind with wind speed of 15 – 20 m/s over South China Sea.](image)

![Figure 7. Meridional wind with wind speed of 5 – 15 m/s over west Indonesia.](image)

On January 2018, the frequency of NCS reached its highest peak. The increasing frequency of NCS was supported by the Asian Monsoon is still active above Indonesia. This condition allows the NCS to have a larger influence on the weather dynamics especially over west Indonesia region.

![Figure 8. Meridional wind on January 12th, 2018.](image)

![Figure 9. Meridional wind on January 31st, 2018.](image)

On the first 3 days of January 2018, the winds with a speed of 5 – 10 m/s reached South China Sea and then the surge reached west Indonesia with a speed of 0 – 5 m/s. While on January 9th, 2018 the surge has reached the South China Sea and west Indonesia with an average meridional wind speed of 5
- 10 m/s due to the previous active NCS moderate intensity that occurred in those regions. The average wind speed strengthens for the next 3 days with average meridional wind speed of 10 – 20 m/s in the South China Sea. Meanwhile in the north of the equator reaches 5 – 15 m/s and south of the equator reaches 5 – 10 m/s as shown in Figure 8. However, on January 13th, 2018 the speed weakened to 5 – 10 m/s in the South China Sea and western Indonesia, this condition lasts until January 19th, 2018. On January 23rd, 2018 until January 29th, 2018 the active NCS occurred again with weak to strong intensity, the active NCS reaches South China Sea for 72 hours with meridional wind speed of 5 – 10 m/s and 0 – 5 m/s in west Indonesia (Figure 9).

Due to the active influence of NCS on January 31st, 2018 it makes the NCS stay active on February 3 and 4, 2018. This condition increased the meridional wind speed to 10 – 15 m/s in the South China Sea and it lasts until February 9, 2018 with meridional wind speed decreased to 5 – 10 m/s with the narrowing of the affected area (see Figure 10 and 11). On February 10, 2018 the weak NCS has activated again so that it re-establishes the wind speed to become stronger in the South China Sea and Indonesian territory with average meridional wind speed of 5 – 15 m/s with 48 hours of propagation time. The effect of the surge lasted until the end of February with an average meridional wind speed of 0 – 5 m/s, this condition was allegedly due to the synoptic conditions of the South China Sea which supported its effects to last for days.

![Figure 10. Meridional wind on February 5th, 2018.](image)

![Figure 11. Meridional wind on February 9th, 2018 with the narrowing of the affected area.](image)

On March 9th, 2018, the NCS has activated again and it took 72 hours propagation time (Figure 12) with an average meridional wind speed of 10 – 15 m/s in the South China Sea and 0 – 10 m/s in west Indonesia. The NCS in the area lasted until March 14th, 2018 with weaker wind speed (0 – 5 m/s). On March 20, 2018 the NCS was active and reached the South China sea for 24 hours with meridional wind speed of 5 – 10 m/s and in west Indonesia with a speed of 0 – 5 m/s with some intensity fluctuation until the end of the month.

The Asian Monsoon usually occurred on the December-January-February (DJF) period that usually accompanied by NCS in some certain condition.[10] But in the period of 2017 – 2018 the NCS remains active until April 2018. It could be proved by on April 1st, 2018 the propagation of NCS was still active in the South China Sea and the north of the equator with the meridional wind speed average between 10 – 15 m/s and in the south of the equator 0 – 5 m/s (Figure 13). On April 6th, 2018 the NCS appeared to be active with weak intensity. The propagation took 24 hours to come over in west Indonesia with the average meridional wind speed 0 – 10 m/s (Figure 14). The condition consecutively occurred until April 9th, 2018. On April 24th, 2018 the NCS spotted to be active but the propagation did not reach the region of The South China Sea and West Indonesia.
3.3. Relative Humidity and Surface Rainfall Study

The availability of water vapor is closely related to cloud formation. The availability of a lot of water vapor and an increase in unstable air parcels causes the air mass to continue to move up and carry moisture. The height achieved is associated with the formation of convective clouds that rise high and have the chance to cause sudden heavy rainfall [11]. From several flight paths through Cumulus clouds, it was found that on the outside of the cloud, air usually has a relative humidity between 95% and 100%, then swoops down as low as 70% near the ends of the clouds where turbulent mixing is responsible for the entry of dry air from outside the cloud. In the deeper parts of the cloud, relative humidity is found which is 100% to 107% [12].
Table 1. Relative humidity in west Indonesia on November 2017 – April 2018

| Year | Month | Date | 1000 mb | 925 mb | 850 mb | 700 mb |
|------|-------|------|---------|--------|--------|--------|
| 2017 | November | 4 | 80-100 | 70-90 | 70-90 | 60-100 |
|      |        | 7 | 80-100 | 70-90 | 80-100 | 70-100 |
|      |        | 11 | 80-100 | 70-90 | 80-90 | 70-90 |
|      |        | 18 | 80-100 | 80-90 | 80-100 | 50-80 |
|      |        | 19 | 80-100 | 80-90 | 80-90 | 70-90 |
|      |        | 20 | 80-100 | 70-90 | 80-90 | 70-90 |
|      |        | 29 | 80-100 | 80-100 | 80-100 | 70-90 |
|      |        | 30 | 80-100 | 80-100 | 70-90 | 60-90 |
|      | December | 1 | 80-100 | 80-100 | 80-100 | 60-90 |
|      |        | 4 | 80-100 | 80-100 | 70-90 | 60-90 |
|      |        | 5 | 80-100 | 70-90 | 70-90 | 60-90 |
|      |        | 8 | 80-100 | 70-90 | 70-90 | 70-90 |
|      |        | 13 | 80-100 | 80-100 | 80-100 | 70-100 |
|      |        | 14 | 80-100 | 70-90 | 70-90 | 60-90 |
|      |        | 15 | 80-100 | 70-90 | 70-90 | 50-80 |
|      |        | 16 | 80-100 | 70-90 | 70-90 | 50-90 |
|      |        | 17 | 70-100 | 70-90 | 70-90 | 60-90 |
|      |        | 19 | 80-100 | 80-100 | 70-90 | 60-90 |
|      | January | 4 | 90-100 | 70-90 | 70-90 | 60-90 |
|      |        | 5 | 90-100 | 70-90 | 60-90 | 60-90 |
|      |        | 6 | 90-100 | 60-90 | 60-90 | 50-90 |
|      |        | 8 | 90-100 | 70-90 | 70-90 | 70-90 |
|      |        | 23 | 90-100 | 80-100 | 70-90 | 60-90 |
|      |        | 24 | 90-100 | 80-100 | 70-90 | 60-90 |
|      |        | 25 | 90-100 | 70-90 | 60-80 | 50-80 |
|      |        | 26 | 90-100 | 60-90 | 60-80 | 40-80 |
|      |        | 27 | 80-100 | 60-80 | 60-80 | 40-80 |
|      |        | 28 | 80-100 | 60-80 | 60-80 | 40-80 |
|      |        | 29 | 80-100 | 60-90 | 60-80 | 40-80 |
| 2018 | February | 3 | 80-100 | 70-90 | 60-90 | 70-100 |
|      |        | 4 | 80-100 | 80-100 | 70-100 | 70-100 |
|      |        | 10 | 70-90 | 60-80 | 70-90 | 60-90 |
|      | March | 5 | 80-100 | 70-90 | 80-100 | 70-100 |
|      |        | 6 | 80-100 | 70-90 | 80-100 | 70-100 |
|      |        | 16 | 80-100 | 60-80 | 80-100 | 40-80 |
|      |        | 20 | 80-100 | 60-80 | 70-90 | 60-90 |
|      | April | 6 | 80-100 | 70-90 | 70-90 | 60-100 |
|      |        | 24 | 80-100 | 70-90 | 70-100 | 60-100 |
Based on the relative humidity data that has been processed, the relative humidity in the period between November 2017 until April 2018 is relatively high on the average of 70 – 90% on each layer. The surplus of water vapor in the atmosphere would make the production of convective clouds increased that usually leads to intense rainfall. It could be proven by the study from the surface rainfall study that shows the distribution of rainfall on the period from November 2017 to April 2018 with the estimation in west Indonesia is around 5 – 35 mm/day on November 2017. While on December 2017 the rainfall estimation is on between 5 – 25 mm/day but in some areas in the west coast of Sumatra the rainfall estimation reached 20 – 35 mm/day. In January 2018 the rainfall estimation is between 5 – 25 mm/day. On February 2018 the rainfall estimation is between 0 – 15 mm/day.

With the extension of the winter season in the Northern Hemispher, the NCS occurred until early April 2018, NCS in March was identified on March 5th, 2018 with moderate intensity, followed on March 6th, 2018 with weak intensity. On March 5th, 2018 the relative humidity in the South China Sea of the 1000 mb layer was 90 – 100% and continued to expand to Natuna waters on March 6th, 2018, on March 8th – 11th, 2018 the relative humidity increased to 80 – 90%, on March 12th – 14th, 2018 humidity increased to 90 – 100% and extends to Kalimantan and Sumatra; at layer 925 mb the relative humidity is on 60 – 80%, then on March 9th, 2018 relative humidity increased to 80 – 90% in the South China Sea, and extended to Kalimantan, southern Sumatra and parts of Java until March 12th, 2018; layer 850 mb humidity 70 – 90%, but on March 7th – 10th, 2018 it drops to reach 40 – 60%, then rises with variations of 60 – 90% on March 12th, 2018; the 700 mb layer of relative humidity varies between 40 – 70% and decreases up to 20 – 50% until March 11th, 2018, and on March 12th, 2018 the humidity rises again to 40 – 70%. On this period the rainfall estimation is between 0 – 20 mm/day.

NCS in April was identified on April 6th, 2018 with a weak intensity. Relative humidity in the South China Sea at layer of 100 mb was 80 – 100%, and rising on April 10th, 2018 reached 90 – 100%, and then dropped to 80 – 90% on April 16th, 2018; at layers of 925 mb 50 – 80% relative humidity, increases with 80 – 100% variation on April 8th – 9th, 2018, and drops to 70 – 90% on April 10th, 2018; in the 850 mb layer the relative humidity varies between 40 – 70%, rises on April 8th, 2018 to 60 – 100%, and goes down again on April 10th, 2018 with relative humidity variations of 60 – 80%; while at the 700 mb layer the humidity reaches 30 – 50% going to April 9th, 2018 then rises to 40 – 70%. On this period the rainfall estimation is between 0 – 20 mm/day.

4. Conclusion
Based on the study, the NCS period in 2017 – 2018 has been expanded until early April 2018 due to the unusual winter season in the 2017 – 2018 that also expanded until April 2018 in the Northern Hemisphere. The extended passage of NCS dominantly affected the atmosphere dynamics over West Indonesia. It proven by the huge number of water vapor brought by meridional wind (NCS) that still spreading widely from north equator to the West Indonesia even though it comes to March – April period that in the normal condition on that period the water vapor concentration should be decreased due to the dry air from Australia that should flows from south equator started to pass over West Indonesia (Australian Monsoon).

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