Analysis of Impact of Tropical Cyclone Blance on Rainfall at Kupang Region Based on Atmospheric Condition and Satellite Imagery

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Abstract. The Tropical Depression previously identified on March 3, 2017, at Arafuru Sea has grown to Tropical Cyclone Blance on March 5, 2017. The existence of Tropical Cyclone Blance gave impacts like increasing rainfall for some regions in Indonesia until March 7, 2017, such as Kupang. The increase of rainfall cannot be separated from the atmospheric dynamics related to convection processes and the formation of clouds. Analysis of weather parameters is made such as vorticity to observe vertical motion over the study area, vertical velocity to see the speed of lift force in the atmosphere, wind to see patterns of air mass distribution and rainfall to see the increase of rainfall compared to several days before the cyclone. Analysis of satellite imagery data is used as supporting analysis to see clouds imagery and movement direction of the cyclone. The results of weather parameters analysis show strong vorticity and lift force of air mass support the growth of Cumulonimbus clouds, cyclonic patterns on wind streamline and significant increase of rainfall compared to previous days. The results of satellite imagery analysis show the convective clouds over Kupang and surrounding areas when this phenomena and cyclone pattern moved down from Arafuru Sea towards the western part of Australia.

Keywords: Rainfall, Vorticity, Vertical Velocity, Streamline

1. Introduction

A tropical cyclone is a form of extreme weather disorder that begins the emergence of a low-pressure center over the ocean that triggers the process of convection and the formation of clouds intensively. Generally, the formation of tropical cyclones is effective in latitudes above 10° north latitude and southern latitudes (Haryani and Zubaidah, 2012). Approximately 65% of tropical cyclones are formed in the region between 10° and 20° of the equator. Tjasyono in Suryantoro (2008) reveals that there are some necessary conditions (geographical and climatological conditions) in the formation of tropical cyclones, i.e., sea surface temperature is quite hot (> 26°C). Coriolis parameters must be greater than the minimum value found in the surrounding latitude 5° northern and southern hemispheres, and the presence of vertical wind shear is weak in the thick troposphere.
Tjasyono, (2004) mentions the growth of tropical storms in general divided into three stages. The birth stage is characterized by the arrangement of clouds and storm lines relating to the motion of the wind disturbance. In the adult stage, characterized by a strong circulation with symmetrical conditions and regular cloud patterns with cyclone eyes that have low pressure. The dead stage is characterized by the widening of the circulation so that its size and shape become less symmetrical. In the northern hemisphere, the average age of tropical cyclones is 6 days and 5 days in the southern hemisphere (Asrianti et al., 2013).

This research aims to determine the impact of tropical cyclone Blance formed on March 5, 2017, which was previously identified as a low-pressure center in the Arafuru Sea to change the pattern and intensity of rainfall in Kupang region on 5 - 7 March 2017.

2. Methods
The data used in this research is observation data in the form of rainfall from Kupang Meteorological Station to see the fluctuation of rainfall in Kupang area before until the time of the cyclone. In this study we also uses weather parameter data taken from ECMWF (European Center for Medium-Range Weather Forecast) with a resolution of 0.25x0.25 for selected layers, in the form of streamline data to see the wind patterns and air mass distribution generated by the occurrence of cyclones so as to affect weather conditions in the Kupang region, parameter of vorticity to see the existence of vertical air movement that raises the mass of air and vertical velocity to see the speed of lifted air masses, as well as using IR satellite channel data taken from BMKG. The method used in this research is a descriptive analytic method of the results of the processed data parameters before until the cyclone in Kupang region especially on March 5-7, 2017. For observation data, time series graph is used to see the fluctuation of rainfall. While the weather parameter data is processed by using GrADS software (The Grid Analysis and Display System) and satellite data is processed by using software GMSPLD / SATAID (Satellite Animation and Interactive Diagnosis).

3. RESULTS AND DISCUSSION
3.1. Analysis of Vorticity
Based on Figure. 1, parts A1-B1-C1, A2-B2-C2, A3-B3-C3 sequently shows layers of vortices of 850 hpa, 700 hpa and 500 hpa on March 5-7, 2017. Seen from A1 until C3, the vortices are relatively negative between $-1e^{-05}$ to $-3e^{05}$ although in A1 and C1, the value still shows positive which indicates on March 5, 2017, has not been yet too affected of the cyclone. These results show strong vortices with negative values in the southern hemisphere, thus indicating the presence of a strong enough air mass increase on the 3 dates up to 500 hpa layer.

3.2. Analysis of Vertical Velocity
It is an upward movement due to a mechanical process (not thermodynamic), where a positive valu(+) indicates no vertical upward movement. While the negative value (-) indicates a vertical upward movement (Zakir, 2010). Based on figure 2, the value of vortices either on March 5, March 6 or March 7, 2017 shows a negative value of speed. On March 5, 2017, vertical velocity in the region of Kupang is indicated by a value between -0.1 to -0.15 and on March 6, 2017 vertical velocity in the region of Kupang is indicated by a value between -0.3 to -0.35 which each of both is at an altitude of 850, so indicates that at this altitude enables the formation of Cumulonimbus clouds. Likewise on March 7, 2017, the value of vertical velocity is valued with a value of between -0.15 to -0.2 at an altitude of 850mb where at that height, this energy has been able to allow the air mass lifted so as to form Cumulonimbus clouds.
Figure 1. Vorticity sequently (from left-right) from 850 hpa, 700 hpa, and 500 hpa on March 6-7, 2017

Figure 2. Vertical Velocity in 850 hpa layer sequently on March 5-7, 2017
3.3. Analysis of Surface Wind

![Figure 3. Surface Wind Pattern on March 6 - 7, 2017 around Kupang and surrounding areas](image)

Based on figure 3 on the surface layer, the cyclone pattern that has formed was previously originated from the Arafuru Sea which has moved to the southeastern region of Kupang on March 5, 2017, March 6, 2017, until March 7, 2017, has reached to the western part of Australia. The air mass coming from the west forms a convergence pattern around the southern part of Kupang. The air mass that moves in this pattern typically slows down the speed so that it triggers a lot of air masses gathered in the area. This has the potential to affect large parts of Kupang in the presence of an increase in convection activity and thus the potential for the growth of convective clouds such as Cumulonimbus clouds.

3.4. Analysis of Rainfall Data

| Dates          | Number of rainfall |
|----------------|--------------------|
| March 3, 2017  | No Rain            |
| March 4, 2017  | No Rain            |
| March 5, 2017  | 12.0 mm            |
| March 6, 2017  | 15.5 mm            |
| March 7, 2017  | 20.8 mm            |

An increase rainfall indicates an increase of convective clouds, as shown in table 1. Based on the table, there is an increase in rainfall between March 3, 2017, until March 7, 2017, in the Kupang region. On March 3-4, 2017, there was no occurrence of rain events that occurred on that day, followed by the incident on March 5, 2017, with a measured amount of 12.0 mm. On the next day, rainfall increased to 15.5 mm and increased on March 7, 2017, to 20.8 mm. This significant increase in the value of rainfall indicates that the impact brought by the presence of this tropical cyclone “Blance” is sufficient to affect convection activity over the Kupang region resulting in the growth of convective clouds which produces rain such Cumulus and Cumulonimbus.

3.5. Analysis of Satellite Imagery

Based on the Figure 4, originated from a Tropical Depression located on Arafuru Sea on March 3, 2017. The Tropical Depression was identified as a 1-day continuous growth and growth on March 4, 2017. Until March 5, 2017, the Tropical Depression has grown into a Tropical Bluff Cyclone that continues to experience movement and growth until it reaches its mature stage at 18:00 UTC on the same day. On March 6, 2017, Tropical Cyclones began to experience a weakening stage until on March 7, 2017 the Tropical Cyclone was slowly extinct. From the time of the Tropical Depression to the Tropical Cyclone Blance, the direction of the movement is from the Arafuru sea descending towards the southwest past Kupang and ending in western Australia.
Figure 4. HIMAWARI-8 Satellite Imagery of Tropical Cyclone “Blance” motion every 6 hours on March 5-7, 2017
4. Conclusion

The presence of tropical cyclone "Blance" gave impacts such as significant increase of rainfall in Kupang region from March 5, 2017, to March 7, 2017, based on the observation data, where on March 3-4, 2017 there has been no rain event since it was still a Tropical Depression and not yet approaching Kupang. The parameters that run into change as impacts of the occurrence of cyclones which resulted an increase rainfall are vorticity that shows a negative value (strong vortices in the southern hemisphere) which indicates a strong lifting of air masses over Kupang, vertical velocity with a negative value on 850 hpa layer indicates the occurrence of upward vertical movement in the southern hemisphere with a strong enough energy which enabled to occur the growth of convective clouds, convergence pattern that causes the buildup of air masses resulting an increase of convection activity, and the movement of tropical cyclone "Blance" which previously located in the Arafuru Sea declined southwestward across the Kupang region and finally stopped in west of Australia.

5. References

[1] Haryani NS, Zubaidah A 2012 Dinamika Siklon Tropis di Asia Tenggara Menggunakan Data Penginderaan Jauh. (Widya, 29 Vol 324) p 54-58
[2] Suryantoro A 2008 Siklon Tropis di Selatan dan Barat Daya Indonesia dari Pemantauan Satelit TRMM dan Kemungkinan Kaitannya dengan Gelombang Tinggi dan Putting Beliung (Majalah Sains dan Teknologi Dirgantara Vol 3 chapter 1) p 21-32
[3] Tjasyono BHK. 2004. Klimatologi. (Bandung: Institut Teknologi Bandung)
[4] Zakir, A., Khotimah, M.K., dan Sulistia, W., 2010 Prespektif Operasional Cuaca Tropis (Jakarta: BMKG)