Study of atmosphere dynamics in the event of very heavy rain causing flood in Supadio International Airport Pontianak using WRF-ARW Model and Himawari-8 Satellite Imagery (Case study: November 11, 2017)

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Abstract. On November 11, 2017, extreme weather in the form of very heavy rain has occurred in Pontianak. Based on surface observations data from Supadio Meteorological Station, the amount of rainfall reached 187.4 mm/day and caused flooding in several areas in Pontianak. As a result, a number of flights were cancelled on November 12, 2017 due to flooding in the airport runway. This study aims to examine the causes of very heavy rain using the WRF-ARW model and the results of Himawari-8 satellite images which are processed using Python Programming.

Based on the output of the WRF-ARW model with the resolution 3 km, it shows some weather parameters that have potential for bad weather in Pontianak, namely the existence of shear line in West Kalimantan and the eddy circulation in this region which can trigger convective cloud accumulation in Pontianak, the wet RH in the 850-500 mb layer ranges from 70-90%, the CAPE ranges from 1000-2000 J/kg, and the air pressure decreases between 03.00 UTC until 06.00 UTC with a 1.7 mb tendency. In addition, the results of the Himawari-8 Satellite Image show that the cloud peak temperature is very low at -75.8°C at 08.33 UTC. Therefore, based on the WRF-ARW and Himawari-8 Satellite results, those support the occurrence of very heavy rain in Pontianak.

1. Introduction

On November 11, 2017, a very heavy rain occurred in Pontianak, based on surface observation data from Supadio Meteorological Station, the amount of rainfall reached 187.4 mm/day, with rain peaks between 06-09 UTC reaching 166 mm. As a result, the runway at Supadio International Airport was flooded and a number of flights were cancelled on November 12, 2017.

Weather phenomena that used in understanding atmospheric dynamics can be seen in the patterns of air pressure, wind patterns, tropical disturbances and local influences [1]. Therefore, the weather phenomenon in the form of very heavy rain in this study, will be reviewed and analyzed with the wind patterns, air pressure and local influences (RH, CAPE and cloud conditions at the time of very heavy rain) based on the output of WRF-ARW numerical models and Himawari-8 satellite images [2], to find out the cause of very heavy rain.
advantages of using WRF-ARW model and Himawari-8 satellite on this study. Based on the problems above, this study aims to examine the causes of very heavy rain using the WRF-ARW model and the results of Himawari-8 satellite images which are processed using Python Programming.

2. Research Area

![Figure 1. Map of the research area](image)

The area or location on this research is Kabupaten Pontianak which shown in Figure 1, especially in Supadio International Airport, which located on 0.1467338 S and 109.4021559 E.

3. Research Data and Methods

3.1 Research data

3.1.1 Final Analysis (FNL) data. FNL data as a model input data of WRF-ARW that obtained from https://rda.ucar.edu. FNL data that used in this research is the data for 24 hours on November 11, 2017, with the resolution 0.25° x 0.25°.

3.1.2 Infrared (IR) channel of Himawari-8 satellite data. The data was obtained from ftp://202.90.199.

3.1.3 Rainfall data on November 11, 2017. The data was obtained from surface observation data from Supadio Meteorological Station in Pontianak.

Those data above will be used to analysis the cause of very heavy rain that causing flood in Pontianak, especially in Supadio International Airport.

3.2 Research Method

The research method in this study is to analysis descriptively the WRF-ARW model output, the output is processed with GrADS (The Grid Analysis and Display System). Furthermore, cloud top temperature will be analysed based on IR channel Himawari-8 satellite data. WRF model that used in this study is WRF V3.9.1.1 with the WSM-3 parameterization scheme (Table 1). Meanwhile, IR channel Himawari-
8 satellite data will be processed with Python programming to obtain cloud top temperature value on November 11, 2017.

Table 1. WRF-ARW Configuration Model in this study

| Konfiguration       | Domain 1 | Domain 2 | Domain 3 |
|---------------------|----------|----------|----------|
| Centre-lat          | 0,053°   |          |          |
| Centre-lon          | 110,46°  |          |          |
| e_we                | 50       | 70       | 91       |
| e_sn                | 36       | 55       | 91       |
| Spatial Resolution  | 27 km    | 9 km     | 3 km     |
| Parameterisation    | WSM-3 (WRF Single Moment-3) |          |          |
| Time step           | 162      |          |          |

4. Result and Discussion

4.1. Wind Pattern Analysis

Based on the results of WRF-ARW output in the form of streamline and wind vectors, wind patterns show a fairly sharp shearline at 07-09 UTC (Figure 2). Streamline that shows the most tight and sharp shearline is shown at 08 UTC, which triggers the cumulation of convective clouds in Pontianak and supports the occurrence of very heavy rain. Similarly for wind vectors, there is a pattern of shearline with a speed of around 5-8 knots (Figure 3). Based on supported data from bom.gov.au, there is eddy circulation in the Kalimantan region at 12 UTC (Figure 4), and affects wind circulation in West Kalimantan. Therefore, the wind pattern on 11 November 2017 supports the occurrence of very heavy rain in Pontianak.
Figure 2. Streamline in Pontianak that shown in red circle which obtained from the output of WRF-ARW model (a, b, c)
4.2 Relative Humidity

Rain occurs between 06-09 UTC and 21-00 UTC. Therefore, relative humidity will be analyzed based on the occurrence of the rain. Based on the results of the vertical cross section for relative humidity at layers 850-500 mb at Supadio International Airport, humidity for 06-09 UTC at 850 mb ranges from 70-95%. At the 700 mb layer, relative humidity ranges from 70-85% and at 500 mb layer, relative humidity ranges from 65-70%. Meanwhile, relative humidity at 21-00 UTC, shows that the humidity is very wet and ranges from 75-95% for layers 850-500 mb. Based on the results of relative humidity at
06-09 UTC and 21-00 UTC above, relative humidity shows a fairly wet value up to 500 mb, and supporting the growth of convective clouds that cause very heavy rain on November 11, 2017.

**Figure 5. RH in Supadio International Airport which obtain from WRF-ARW model**

### 4.3 CAPE (Convective Available Potential Energy)

Based on the output of the WRF-ARW model, the CAPE value is between 1000-2000 J/kg at 07-09 UTC. The CAPE value signifies moderate (medium) level instability. Middle / moderate level instability in the atmosphere indicates that the atmosphere is quite labile and supports the growth of convective clouds that causing very heavy rain in Pontianak [5].
4.4 Air Pressure
Based on the output of the WRF-ARW model, air pressure at 06 UTC decreases with air pressure at 03 UTC with a tendency of 1.7 mb. The air pressure drastically decreased at 06 UTC which indicated the potential for bad weather. Low air pressure indicates a high air temperature, which triggers evaporation and supports the growth of convective clouds in Pontianak. Therefore, air pressure contributes to influencing bad weather in the form of very heavy rain.

4.5 Himawari-8 Satellite Imagery
Based on the results of Infrared (IR) channel of Himawari-8 satellite data with coordinates at Supadio International Airport, it is clear that the top cloud temperature is very low and cold at 8.33 UTC or 500 minutes with top cloud temperature around -75.8°C. This indicates that Cb clouds are mature and ready to supply very heavy rainfall in Pontianak, especially at Supadio International Airport.
Figure 8. Infrared (IR) channel of Himawari-8 satellite data that shown in red circle which processing with Python programming

| Weather Elements         | Disturbance                              |
|--------------------------|------------------------------------------|
| Wind Pattern             | Tight shearline and eddy circulation     |
| Relative Humidity (RH)   | Wet RH up to 500 mb                      |
| CAPE value               | Adequately high CAPE value               |
| Air Pressure             | Drastic reduction of air pressure        |
| Himawari-8 Satellite     | A very low and cold top temperature of a cloud |

5. Conclusion
The very heavy rain in Pontianak is occurred because of several weather element with each disturbance. The WRF-ARW V3.9.1.1 model with the WSM-3 parameterization scheme produces several weather parameters that can support and explain the occurrence of very heavy rain in Pontianak, especially flooding at Supadio International Airport such as wind patter, relative humidity, CAPE Value, air pressure, and temperature. Those factors have different characteristic of disturbance that leads to very heavy rain.

6. Reference
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