Identification of Mesoscale Convective Complex (MCC) phenomenon with image of Himawari 8 Satellite and WRF ARW Model on Bangka Island (Case Study: 7-8 February 2016)

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Abstract. Based on monitoring on 7th and 8th February 2016 there has been a flood that occurred due to heavy rainfall in a long time in some areas of Bangka Island. Mesoscale Convective Complex (MCC) is one type of Mesoscale Convective System (MCS). Previous research on MCC mentions that MCC can cause heavy rain for a long time. This study aims to identify the phenomenon of MCC in Bangka Island both in the satellite imagery and the output of the model. In addition, this study was also conducted to determine the effect of MCC on the weather conditions in Bangka Island. The study area in this research is Bangka Island with Pangkalpinang Meteorological Station as the centre of research. The data used in this research are FNL (Final Analysis) data from http://rda.ucar.edu/, Satellite Image of Himawari-8 IR1 Channel from BMKG, and meteorological observation data (synoptic and radiosonde) from Pangkalpinang Meteorological Station. The FNL data is simulated using the WRF-ARW model, verified using observation data and then visualized using GrADS. The results of the analysis of Himawari-8 satellite image data showed that two MCCs occurred on 7th and 8th February 2016 on Bangka Island and the MCC was nocturnal, which appeared at night which then continued until extinction in the morning the next day. In a peak cloud temperature review with the coordinates of Pangkalpinang Meteorological Station (-2.163 N 106.137 E) when 1st MCC and 2nd MCC events ranged from -60 °C to -80 °C. The result of WRF-ARW model output analysis shows that MCC area has high humidity value and positive vertical velocity value which indicates the potential of heavy rain for a long time.

Keywords: MCC, Himawari 8, Satellite, WRF ARW

1. Introduction
Indonesia lies geographically on the equator which certainly has a great potential impact on atmospheric physical conditions during extreme weather events, especially as the Mesoscale Convective Complex (MCC) phenomenon. Extreme weather is a situation in a place at a certain time on a short time scale and is extreme [1]. One of the factors that influence the occurrence of extreme weather is the occurrence
of irregularities or the so-called weather anomalies both on a global scale, regional, and local. Mesoscale Convective Complex (MCC) is a combination of Cumulonimbus clouds that are marked by a small shear and a large Convective Available Potential Energy (CAPE), and has a duration of > 6 h (heavy rain ± 3 hours) rainfall and a large area with an index CAPE stability ≥ 1750 J / kg [2]. Weather Research Forecasting (WRF) is a mesoscale weather model created for analysis and forecasting of atmospheric conditions. WRF can model atmospheric conditions in a region so that it can assist in calculating meteorological events better [3]. On 07 and 08 February 2016 there was heavy rain lasting for a long time in Bangka Island and covered a large area causing floods to occur in some areas. In the event of heavy rain is due to the growth of convective clouds that are active over the area of Bangka Island, especially the northern fluctuation that has a very wide range of areas, so that a collection of convective clouds that collide over the area of Pulau Bangka is a Mesoscale Convective Complex (MCC) if analyzed through GMSLPD. The magnitude of the impact caused this incident interesting to be studied using WRF ARW model.

The data used in this research are:
1. Himawari 8 satellite data on 07-08 February 2016 Infrared (IR1) channel with 10 minutes resolution with data extension. Z and NetCDF.
2. WRF-ARW model input data using Final Data (FNL) data on February 07, 2016 and 08 February 2016 obtained from http://rda.ucar.edu website with a spatial resolution of 5 km, 2m grid resolution and resolution temporal 1 hour.
3. 3-hour rainfall data from observation of Pangkal Pinang Meteorological Station on 07-09 February 2016.

In this study Himawari 8 satellite data with the initial extension. Z processed using the application (SATAID). Satellite Interaction and Interactive Diagnosis (SATAID) to display cloud time temperature time series, while NetCDF data will be processed using Grid Analysis and Display System (GrADS) software to display cloud images with IR1 channels that use cloud top temperature to determine cloud type. NC data is extracted from the convert Z data using sataid2nc.exe application via Command Prompt. After satellite data is used also input data model WRF-ARW form FNL data used to know the values of physical parameters that cannot be known only by using satellite data. In this domain selection is used domain with the location of the center at the Station Meteorology Class I PangkalPinang with coordinates -2.163 N 106,137 E. The results of the WRF-ARW running model are then processed using GrADS data to display streamline, cloud fraction, vertical velocity, based on observation center point at
1. PangkalPinang Meteorological Station. In addition to these data are also used additional data supporting observation data of rainfall 3 hours from PangkalPinang Meteorological Station.

2. Material and Method

In this study, the authors adopted a research journal conducted by (Putri, R J A, et al) [4]. That is by using parameterization scheme which has been tested in Mesoscale Convective System (MCS) simulation in Nabire region, Papua. As we know that Indonesia has a unique atmosphere in every atmosphere in each region, the authors try to simulate it also with the WRF model on the physical condition of the atmosphere when MCC occurs on the island of Bangka.

This research is focused on location in Bangka Island with coordinate point position at Pangkalpinang Meteorological Station with coordinate -2,163 N 106.137 E. Based on Pangkalpinang Meteorological data in 1998, the climate in Bangka Regency is a tropical climate of type A with rainfall of 107.6 to 343.7 mm per month, and in further study according to Schmidt-Ferguson, in 1999 the variation of rainfall to be between 70, 10 to 384.50 mm per month, so that the physical condition of the weather in Bangka Island is very much certainly influenced by wind circulation.

Weather Research and Forecasting-Advanced Research (WRF-ARW) version 3.8.1 is used in this study [5, 6, 7]. Used two domains with one-way nesting (Figure 2). Horizontal 18 and 6 grid spacing for both running processes in WRF-ARW. The outermost domain covers most of the islands of Sumatra, Kalimantan, and Java, while the deepest domain (domain 2) is centred on the Pangkalpinang meteorological station. The grid resolution for both domains is 5 m and 2 m respectively. The physical options used in this study are summarized in Table 1.

| Physical Schematic of WRF-ARW Model | Model WRF-ARW Area | Domain 1 (D01) | Domain 2 (D02) |
|------------------------------------|---------------------|----------------|----------------|
| Resolution                         | 18 km               | 6 km           |
| Mikrofisis                         | Lin et al.          | Lin et al.     |
| Short Wave Radiation               | Dudhia              | Dudhia         |
| Long Wave Radiation                | RRTM                | RRTM           |
| Land Surface                       | Noah LSM            | Noah LSM       |
| Planetary Boundary Layer           | YSU scheme          | YSU scheme     |
| Cumulus Parameterization           | Kain-Fritsch        | Kain-Fritsch   |
3. Result

The results of cloud classification on Infrared satellite channel images obtained from Himawari-8 satellite show that at the time of heavy rainfall on 07 and 08 February 2016 in Bangka Island area is covered by cloud with very wide coverage with cloud top temperature reaching $<-80\,\text{°C}$ twice. After analysis using GMSLPD software, it is known that the cloud cover is a Mesoscale Convective Complex (MCC). This is indicated that the cause of heavy rain in the area of Bangka Island is caused by clusters of convective clouds or called 1st MCC and 2nd MCC which each have a lifespan of more than 6 hours.

Figure 3. Cloud Image with Infrared Channel
Figure 4. a) Cloud fraction in vertical profile from 00-23 UTC on February 7, 2016 shows clearly the percentage at layer 1000 mb to 100 mb; b) Cloud fraction in vertical profile from 00-23 UTC on February 8, 2016 shows clearly the percentage at layer 1000 mb to 100 mb.

Figure 4 is the result of the Cloud Fraction output (%) of the WRF-ARW centred on the coordinates of the location of the Pangkalpinang meteorological station. In the Cloud Fraction shown in the vertical profile where if we examine at 21 UTC on 07 and 08 February 2016 it clearly shows a pattern that supports MCC formation by marking the percentage value of Cloud Fraction reaching 1% value range meaning to indicate that cloud cover at the layer is thick. Seen to have a significant difference from 07 to 08 February 2016 clearly on 08 February cloud fraction has been formed on the lower layer of 900 mb.

Figure 5. a) Velocity vertical in vertical profile from 00-23 UTC on February 7, 2016 shows clearly the percentage at layer 1000 mb to 100 mb; b) Velocity vertical in vertical profile from 00-23 UTC on February 8, 2016 shows clearly the percentage at layer 1000 mb to 100 mb.

Figure 5 shows velocity vertical during growth, development, and decay of MCC. If the vertical velocity (in units Pa / s) is positive, it indicates there is a movement of the air mass rising vertically to
form clouds. Conversely, if a negative vertical velocity indicates there is a decreasing air mass movement. The increasing value indicates the speed of the air mass movement. In the vertical velocity, it is seen that if the UTC 21 hour of reference to the WRF results do not show as clear as that produced by the Himawari 8 satellite image of the IR channel which of course has an upwardly uplifting air masses, the results of this WRF model show that Velocity vertical which is shown to indicate the existence of a moving upward air mass on February 07, 2016 at 03 UTC with a value of 0.3 Pa/s, while on February 08, 2016 in the 5th range of UTC with a value reaching 0.9 Pa/s.

Figure 6. Streamline at 15:00 UTC and 21:00 UTC on 07 and 08 February 2016

Streamline results shown from the WRF model were obtained at 6 hours before the peak occurred 1st MCC and 2nd MCC. On 07 February 2016 at 15 UTC and 21 UTC there is a pattern with shear flow followed by a weak wind speed ranging from 1.9 Kt and 2.4 Kt resulting in a buildup of air masses supporting cloud growth, while on February 08, 2016 at 15 UTC and 21 UTC there is a clear pattern over Pangkalpinang area that formed anticyclonic pattern with the lowest wind speed ranged from 2.2 Kt and 1.8 Kt.

Table 2. Rainfall Data from February 7 to February 09, 2016 at PangkalPinang Meteorological Station

| Date/Hr (UTC) | 03  | 06  | 09  | 12  | 15  | 18  | 21  | 24  | TOTAL |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 7             | 6.8mm | 1.5mm | 5.2mm | 0.1mm | 15.6mm | 13.1mm | 40.9mm | 31.7mm | 114.9mm |
| 8             | 4.5mm | 53.8mm | 56.5mm | 47.3mm | 1.3mm | 1.1mm | 3.4mm | 16.0mm | 183.9mm |
| 9             | 22.8mm | 0.8mm | TTU | 0 | 0 | 0 | 0 | 0 | 23.6mm |

Based on Table 1 it can be seen that the rainfall based on observation observation at the Class I PangkalPinang Meteorological Station shows the amount of rainfall intensity recorded for every three
hours according to Universal Time Center (UTC) time system, starting at 00:00 UTC (07.00 WIB) until 00.00 UTC (07.00WIB) the following day. On February 07, 2016 in one day the measured rainfall reached 114.9 mm, then on February 08, 2016 measured rainfall in one day measured to reach 183.9 mm. After February 08, rain falls to a halt on February 09, 2016 which is marked by rainfall at 09.00 UTC (16.00WIB) shows (Unmeasured) TTU. According to BMKG (2010), rainfall intensity ≥ 100 mm per day can be classified as rainy conditions when it is very dense.

Can be seen in Figure 2 the cloud top temperature at the point of coordinate location of Meteorological Station PangkalPinang when the MCC saw time series graph is reaching -60 °C to -80 °C. From the temperature has been indicated that the clouds have gone through the tropopause layer indicating in MCC there is Cumulonimbus cloud in the mature phase.

4. Conclusions

Based on the result of research, it can be concluded that the existence of MCC can by using the image of Himawari 8 satellite to see the type and pattern of cloud distribution formed, and time series of cloud temperature has shown good approach and according to the pattern, but if viewed from WRF-ARW model result the WRF model is still lacking especially in showing the suitability of the pattern of the Himawari 8 satellite imagery results in helping identify MCCs by looking at the cloud distribution patterns as well as the value of cloud-value of other physical parameters.

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