Detection of mesoscale convective complexes using multispectral RGB technique of Himawari-8 (Case Study: Jakarta, 20 February 2017)

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Abstract. Mesoscale Convective Complexes (MCC) is a well organized convective cloud that has big size and long lifetime. The aim of the study is to detect and to monitor the development of MCC around Jakarta on 20th February 2017 using satellite Himawari-8. This study uses the analyzing method of the infrared channel and multispectral imagery RGB Technique to monitor the development of radiative, morphology and cloud position which describe the cloud top microphysics, structure and movement of the MCC. On 20th February 2017, the result from Himawari-8 shows that there are many dense-clouds with small ice particle and cloud top temperature could be < -50°C which can be seen as red and yellow dot colour by RGB Technique. The MCC caused a severe storm at Jakarta and its surrounding area.

1. Introduction
Mesoscale convective complexes is a well-organized convective cloud that has a big size and long lifetime. The concept of MCC have been introduced in 1980 that has cloud shield with continuously low IR temperature ≤ -32°C with area ≥100,000 km² and has interior cold cloud region with temperature ≤ -52°C with area 50,000 km² [1]. The MCC also has the shape of the cloud with eccentricity ≥ 0.7 at time maximum extent and it can affect the severe weather [1,2]. Recently, the operational numerical weather-prediction model is not sufficient to represent the MCC and to forecast of such system is still difficult [3], mainly based on real-time observation and knowledge concerning the environmental conditions which are favourable for MCC triggering [4]. A possible way to improve MCC prediction is by multi-parametric tools and conceptual models based on average behaviour of several parameters coming from different observation such as satellite, images and model output fields [5].

Himawari-8 is a new Japanese geostationary meteorological satellite operated since July 7th 2015 with optical sensors significantly higher in temporal and spatial resolution than previous geostationary orbit such as MTSAT-2 [6]. There are 16 observation channels with 0.5 or 1 km spatial resolution for visible and near-infrared bands and 2 km for infrared bands. The shortened revisit times around 10 minutes for full disk provide new levels of capacity for identification and tracking of rapidly changing weather phenomena and for the derivation of quantitative products [7]. There are still a few previous studies about MCC at Maritime Continent. The spatial and temporal MCC over Indonesia was studied for 5 years (2001-2005) and concluded that MCC was frequently happened at Java Sea during March-April-May (MAM) and December-January-February (DJF) [8]. The MCC over the Maritime Continent have large lightning densities, while MCC in the oceanic convergence zones are more connected and have proportionately larger strati form rain fractions [9]. The aim of this study is to
2. Data and methods

Himawari-8 satellite imagery was used for studying the structure and development of the MCC on 20th - 21st February 2017 and observation rainfall data from 13 stations in Sumatra and Java on 19th – 21st February 2017 for rainfall data verification. The locations of rain gauges sites is presented in Figure 1.

![Figure 1](image_url)

**Figure 1.** The Locations of rain gauge sites (red dots).

IR black body temperature ($T_{BB}$), derived from ten minutes data of Himawari-8 since Feb 20th 2017 10.00 UTC until Feb 21st 2017 03.00 UTC were used to identify and monitor the development the MCC and their physical characteristics based on Maddox (1980) as shown in table 1.

| Physical Characteristics | Size: A – Cloud shield with continuously low IR temperature $\leq -32^\circ$C must have an area $\geq 100\ 000\ km^2$ | B – Interior cloud could region with temperature $\leq -52^\circ$C must have an area $\geq 50\ 000\ km^2$ |
|--------------------------|-------------------------------------------------|-------------------------------------------------|
| **Initiate:**            | Size definitions A and B are first satisfied     |                                                 |
| **Duration:**            | Size definition A and B must be met for a period $\geq 6\ h$ |                                                 |
| **Maximum Extent:**      | Continuous cold could shield (IR temperature $\leq -32^\circ$C) reaches maximum size |                                                 |
| **Shape:**               | Eccentricity (minor axis/ major axis) $\geq 0.7$ at time of maximum extent |                                                 |
| **Terminate:**           | Size definition A and B no longer satisfied       |                                                 |

Studies of MCC structures and propagation using Himawari-8 Satellite consist of detection and monitoring of convective cloud cell use Infrared channel in order to monitor time evolution of
radiative, morphology and location of clouds. It also describe cloud top microphysics, structure, growth and the movement of MCC.

Multispectral Himawari-8 imagery analysis of RGB (Red Green Blue) technical analysis [10] using SATAID software [11] for visualization of Himawari-8 data have conducted for investigating the organization and cloud top microphysics of every MCC cycle phase. Red colour is displayed by compositing the differentiation of channel 12.3µm minus 10.4µm, green colour is from differentiation of channel 10.4µm minus 3.9µm and blue colour is from channel 10.4µm [12,13]. This RGB is effective to distinguish clouds with high cloud top (Cumulonimbus) and fog or low-level clouds because the difference of 3.9µm is included at this scheme.

3. Results and Discussion

Life-cycle of MCC will be shown by sequential infrared image (10.8µm) with blue cloud-shield and red interior cold cloud-shield and by multispectral imagery from a combination of some channels [10]. There are eight steps of MCC life-cycle, which consists of MCC-12h, pre-MCC, Initiation, Growth, Mature, Decay, Dissipation and post-MCC [14]. The development of MCC was started at 20th Feb 2017 10 UTC with the development of many embedded cumulonimbus clouds around west of Lampung and Bengkulu along the Indian Ocean (Fig. 2a). At 13 UTC, it reached initiate condition (Fig. 2b) which had interior cold-cloud region ≥ 50,000 km² (red colour) and cloud shield ≥ 100,000 km² (blue colour) in Lampung until the Indian Ocean. The MCC had growth bigger and cover all Lampung area (Fig. 2c) then it reached mature condition while it cover all Lampung area, some part of South Sumatera, Bengkulu, the Indian Ocean until the Sunda Strait (Fig.2d) at 18 UTC. The MCC decayed in the following day at 21st Feb 2017 01 UTC (Fig. 2e) when it extended across the Sunda Strait, the Indian Ocean, Banten, and Jakarta. It caused heavy rainfall and floods. In the end, The MCC dissipated at 03 UTC in the morning (Fig. 2f).
Figure 2. (a) Pre-MCC (b) Initial (c) Growth (d) Mature (e) Decay (f) Dissipation using IR channel.
The development of the MCC since Pre-MCC phase until dissipation phase also can be monitoring very well using multi-spectral night microphysics RGB as seen as in fig. 3(a-f). From multispectral imagery, it was clearly seen that there were cold-thick-high level clouds which displayed in red colour over Lampung, the Sunda Strait and the Indian Ocean during growth phase. Moreover, grey colour over the Java Sea, northern part of Jakarta indicated low-level cloud (Fig. 3c). Cold-thick clouds with ice particles in the top of high cloud with temperature at the top could be reach $<-50^\circ\text{C}$ with small ice particles and cause storm severity were displayed by yellow dot red colour during mature phase of the MCC(Fig. 3d). Cold and thick high-level clouds still stayed during decay and dissipation phase which caused heavy rainfall at western part of Java and Jakarta.

Table 2 and Table 3 represent the amount of observation rainfall from rain gauges in Sumatra and Java. On 19 February 2017, the rainfall which more than 50 mm is only in Serang, Banten, while on 20 February 2017, the heavy rain almost happened in Lampung (Masgar, Maritim Lampung and Raden Inten II), Banten (Pondok Betung, Serang and Cengkareng) and Jakarta (Tanjung Priok and Kemayoran). According to Indonesian National Board for Disaster Management (BNPB), on 20 February 2017 the flood because of heavy rain happened at 54 point in Jakarta and surrounding, the inundation recorded from 10 cm until 150 cm. The flood also happened in some part of Tangerang Banten (Pondok Ranji) on February 20, 2017. While in Bandar Lampung (Capital city of Lampung Province), the flood happened on 21 February 2017 with the inundation recorded 50 cm until 80 cm [15].

![Figure 3. (a) Pre-MCC (b) Initial (c) Growth (d) Mature (e) Decay (f) Dissipation using Night Microphysics RGB.](image-url)
Table 2. The rainfall in Sumatra (Bengkulu and Lampung) in mm/day.

| Date      | Fatmawati | Baai | Kepahiyang | Masgar | Maritim Lampung | Raden inten II | Kotabumi |
|-----------|-----------|------|------------|--------|-----------------|----------------|----------|
| 19-02-2017| 17        | 7    | 1          | 6      | 1               | 10             | 7        |
| 20-02-2017| 30        | 43   | 15         | 107    | 81              | 88             | 4        |
| 21-02-2017| 5         | 6    | 8          | 5      | 6               | 27             |          |

Table 3. The rainfall in Java (Banten and Jakarta) in mm/day.

| Date      | Pondok betung | Serang | Curug | Cengkareng | Tanjung | Priok | Kemayoran |
|-----------|---------------|--------|-------|------------|---------|-------|-----------|
| 19-02-2017| 11            | 55     | 3     | 16         | 21      | 9     |           |
| 20-02-2017| 93            | 50     | 33    | 73         | 116     | 180   |           |
| 21-02-2017| 11            | 3      | 13    | 10         | 12      | 11    |           |

4. Conclusions

Himawari-8 imagery is able to detect and monitor the development, structure, growth and movement of the MCC on 20 th February 2017. Multispectral imagery also revealed the organization, cloud top microphysics every phase of the MCC’s life cycle appropriately and attractively in order to give better early warning about extreme rainfall and flood disaster. The MCC on 20 February 2017 has caused storm and heavy rains in Jakarta and Lampung causing flood and inundations in some locations on 20-21 February 2017, even though the inundation is also due to the poor drainage of the cities.

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