Utilization of Red-Green-Blue (RGB) modification composite for nighttime convective cloud monitoring over North Sumatra region

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Abstract. Located between the Indian Ocean and the Malacca Strait, also the presence of the Bukit Barisan Mountains cause high convective activity in the North Sumatra region. The Himawari-8 satellite has 16 atmospheric observation channels that allow for observations of the convective system growth phase. The Red-Green-Blue (RGB) composite method is used to display a variety of satellite image composite information. The nocturnal convective system that often forms in the coastal areas of Sumatra causes heavy rains. A nocturnal convective system observation method is needed to publish early warning information on extreme weather. This research was conducted to observe the nocturnal convective system during heavy rain events in the North Sumatra region using a modification of RGB composite. This research used the Himawari-8 satellite data, Column Max (CMAX) products of Medan weather radar data, and Global Satellite Mapping of Precipitation (GSMaP) rainfall estimation data. Comparison of RGB modified products with Night Microphysics RGB products and CMAX weather radar products, as well as time-series rainfall analysis. The results showed that the RGB modification product could capture the beginning of the convective system's growth, development, and spatial movement. The convective cloud distribution pattern corresponds to the area of heavy rain. There is a slight difference in cloud growth area between the satellite and radar products indicated the parallax error from the satellite image.

Keywords: RGB composite, Himawari-8, convective cloud

1. Introduction

Indonesia Maritime Continent (IMC) was a very active convective area in which the cloud formation fluctuates seasonally or annually [1]. The weather satellite is a remote sensing technology used to monitor cloud conditions. Satellite observing the surface and atmosphere of the Earth from space by using electromagnetic radiation [2]. Himawari-8 satellite was observing visible to infrared radiation from the Earth. So, it needed to understand electromagnetic radiation and its interaction with the atmosphere.

Himawari-8 is a geostationary weather satellite operated by the Japan Meteorological Agency (JMA) which since 7th July 2015 replacing the MTSAT-2 satellite [2]. Himawari-8 has 16 channels consisting of 3 visible (VIS) channels, 3 near-infrared (NIR) channels, and 16 infrared (IR) channels. Some of the improvements on Himawari-8 difference from MTSAT-2 are the spatial resolution was 2
2. Data and Methods

This research was conducted by taking the case study of the heavy rainfall event in the North Sumatra region, i.e. 17th June and 14th September 2020. Heavy rain was the indicator of the convective system formation [1,6,15]. This research used the Himawari-8 satellite data, the Coloumn Max (CMAx) products of Medan weather radar data, and Global Satellite Mapping of Precipitation (GSMaP) rainfall estimation data. The Himawari-8 data used in the sataid (.Z) format, consisted of 16 bands every 10 minutes. The Himawari-8 data obtained from BMKG, i.e. geometric and radiometric corrected level 1B data which contains the Brightness Temperature value for the IR bands and the reflectance value for the VIS bands. The 16 bands of Himawari-8 characteristics are shown in Table 1 below.
Table 1. Himawari-8 Imager (AHI; Advanced Himawari Imager) [2]

| Band           | Spatial Resolution | Central Wavelength | Physical Properties                      |
|----------------|--------------------|--------------------|------------------------------------------|
| 1              | Visible (VIS)      | 1 km               | 0.47 μm                                  | vegetation, aerosol |
| 2              |                    |                    | 0.51 μm                                  | vegetation, aerosol |
| 3              |                    | 0.5 km             | 0.64 μm                                  | vegetation, low cloud, fog |
| 4              | Near-Infrared (NIR)| 1 km               | 0.86 μm                                  | vegetation, aerosol |
| 5              |                    | 2 km               | 1.6 μm                                   | cloud phase          |
| 6              |                    |                    | 2.3 μm                                   | particle size        |
| 7              |                    | 3.9 μm             |                                          | low cloud, fog, forest live |
| 8              |                    | 6.2 μm             |                                          | mid-and upper-level moisture |
| 9              |                    | 6.9 μm             |                                          | mid-level moisture   |
| 10             |                    | 7.3 μm             |                                          | mid-and lower-level moisture |
| 11             |                    | 8.6 μm             |                                          | cloud phase, SO₂     |
| 12             | Infrared (IR)      | 2 km               | 9.6 μm                                   | ozone content        |
| 13             |                    |                    | 10.4 μm                                  | cloud imagery, information of top cloud |
| 14             |                    | 11.2 μm            |                                          | cloud imagery, sea surface temperature |
| 15             |                    | 12.4 μm            |                                          | cloud imagery, sea surface temperature |
| 16             |                    |                    | 13.3 μm                                  | cloud top height, CO₂ |

The RGB composite technique is used to present information using the concept of a colour image that comes from the combination of 3 main colours of light, i.e. red, green, and blue. The combination of the 3 primary colours produced secondary colours such as yellow, magenta, cyan, brown, black, and white [2,16] as shown in Figure 1 below.

![Figure 1. Colour composition in the concept of RGB images](image)

The concept of RGB images has been used in remote-sensing satellite image processing. RGB technique serves to display more than one information obtained from each satellite wavelength channel into one view. The final colour display comes from each channel or channel combination of satellite wavelengths that are entered in the Red, Green, and Blue colour components. WMO has recommended...
about 9 RGB composite schemes that can be used to display combined information in the field of meteorology using weather satellite imagery data, including Natural Colour RGB, Airmass RGB, Night Microphysics RGB, Day Convective Storms RGB, and Differential Water Vapor RGB [2,16].

One of the RGB composite schemes that can be used to monitor cloud and weather conditions at night-time is the Night Microphysics RGB composite scheme. This scheme is metanalysis in the night-time which is a combination of Red (B15-B13), Green (B13-B07), and Blue (B13) components. Table 2 and Figure 2 below show the Brightness Temperature value settings used in the Night Microphysics RGB scheme and their interpretation.

Table 2. The setting of the Brightness Temperature value for the Night Microphysics RGB [2]

| Colour   | Himawari-8 bands | Gamma | Standard          | Tropical          |
|----------|------------------|-------|-------------------|-------------------|
| Red      | IR12.0 – IR10.8  | 1.0   | -4 to +2 K        | -4 to +2 K        |
| Green    | IR10.8 – IR3.9   | 1.0 to 1.3 | 0 to +10 K   | 0 to +5 K        |
| Blue     | IR10.8           | 1.0   | 243 to 293 K      | 273 to 300 K      |

Figure 2. The composition of Night Microphysics RGB composite colour along with the resulting physical information [17]

In this study, the RGB modification scheme was used based on the research result of Panjaitan et al. [12] as follows (Table 3).

Table 3. The setting of the Brightness Temperature value for the modification RGB scheme [12]

| Colour | Himawari-8 Bands | Gamma |
|--------|------------------|-------|
| Red    | IR10.4 – WV6.2   | 1.0   |
| Green  | IR3.9 – IR10.4   | 1.5   |
| Blue   | IR10.4 – IR12.4  | 1.0   |

The processing of the composite scheme in this study was carried out using SATAID GMSLPD version 3.3.0.1 from JMA. This software can directly process level 1B data from the Himawari-8 satellite into 9 RGB composites, including Night Microphysics RGB and RGB modification [3].
3. Results and Discussions

3.1. Case study on 17 June 2020

The following is the product image of modified RGB (Figure 3), Night Microphysics RGB (Figure 4), and weather radar (Figure 5) at the time of the nocturnal convective system event on 17th June 2020 over the North Sumatra region.

![Figure 3. Product images of modified RGB on 17th June 2020](image-url)
In the case of 17th June 2020, based on weather radar images it was shown that convective activity on the east coast of North Sumatra began to form at 13.20 UTC with a reflectivity value of 30-55 dBZ (Figure 5). At 16.00 UTC, the hitting convective cloud cluster expanded, until it disintegrated at 23.00 UTC.

The convective cloud distribution pattern shown by the RGB modification product shows the same pattern as the weather radar. It can be seen from the satellite image of the RGB modification product that convective activity around the Bukit Barisan mountains began to form at around 13:10 UTC. However, the convective clouds that form are inconsistent and last long. At 16.00 UTC, a new convective cloud cluster was formed around the east coast of North Sumatra (Figure 3). At 17.00 UTC, a new convective cloud cluster was formed on the east coast of North Sumatra. At 18.10 UTC, the first convective cloud cluster began to decay, while the growth of the second convective cloud cluster...
increased. At 20.00 UTC, a third convective cloud cluster was formed on the east coast of North Sumatra. At 23.00 UTC, it was seen that the second convective cloud cluster began to decay, while the third convective cloud cluster experienced growth and moved north-eastward towards the waters of the Malacca Strait.

Compared to the Night Microphysics RBG product, the RGB modification product shows the same cloud distribution pattern (Figure 3 and Figure 4). The satellite image of the RGB modification product looks better able to show the embryo of convective cloud growth. This information is urgently needed to issue the early warnings information of extreme weather.

The spatial map of rainfall shows that heavy rainfall began to be observed on the east coast of North Sumatra at 18.00 UTC or 01.00 LT, which is around 10-26 mm (Figure 6). Based on the convective cloud growth time series shown by the RGB modified satellite image, the area of heavy rain is slightly shifted from the growth area of the first convective cloud cluster. Based on the accumulated rainfall data on 17th June 2020, it can be seen that there are three areas of heavy rainfall (> 50 mm) which coincide with the growth areas of three convective cloud clusters, where you can see the second convective cloud cluster giving the highest rainfall.

3.2. Case study on 14th September 2020

The following is a display of modified RGB product images (Figure 7), Night Microphysics RGB (Figure 8), and weather radar (Figure 9) during the nocturnal convective system incident on 14th September 2020 over the North Sumatra region.
Figure 7. Product images of modified RGB on 14th September 2020

Figure 8. Product images of Night Microphysics RGB on 14th September 2020
It can see the difference in the colour of the convective cloud clusters in the satellite image of the RGB modification product as shown in figure 7. Convective cloud clusters that form during the day can be detected by the RGB modification product, even though the colour is different from the convective cloud clusters at night. In the case of 14th September 2020, based on weather radar images it was shown that convective activity on the east coast of North Sumatra began to form at 08.00 UTC with a reflectivity value of 30-55 dBZ. In figure 9, the embryo of this convective cloud continues to grow and is seen forming a convex cloud formation at 10:00 UTC. This convective cloud cluster that formed on the east coast of North Sumatra is seen starting to decay starting at 21.30 UTC.

The growth pattern and movement of convective clouds that formed on the east coast of North Sumatra on 14th September 2020 can be captured by both Night Microphysics RGB and modified RGB products (Figure 7 and Figure 8). Convective cloud clusters that have formed move northeast towards the waters of the Malacca Strait. At around 17.00 UTC, several points of convective activity were seen forming on the east coast of North Sumatra. This convective cloud cluster on the east coast of North Sumatra has been seen decaying since 21.30 UTC, as shown in the radar image in figure 9. The product images of modified RGB show the same pattern as the Night Microphysics RGB product. RGB modification products have advantages in detecting the embryo of the convective clusters that are formed compared to Night Microphysics RGB products.

The maps of spatial rainfall in figure 10 show that heavy rainfall began to be observed on the east coast of North Sumatra at 11.00 UTC or 18.00 LT, which is around 6-22 mm. Based on the
accumulated rainfall data on 14th September 2020, it can be seen that there are two areas of heavy rainfall (> 50 mm) that coincide with the growth areas of three convective cloud clusters.

4. Conclusions

Based on the research results, there are convective cloud characters as shown by the classification results of RGB modification using Himawari-8 data. Modified RGB products can show areas of severe weather clouds clearly and similarly to weather radar. The RGB technique allows the delivery of multispectral information for a more optimal display, while at the same time maintaining the pattern and texture of cloud and surface features as well as continuity in the time domain. So that this technique can be used for the operational needs of weather forecasting (nowcasting).

The modification of RGB composite for night-time convective cloud monitoring was able to detect the initial appearance of a convective cloud, its growth phase up to the decay period, and the movement of the convective cloud. It can be seen that there is a pattern equation between the convective cloud distribution from satellite imagery and the spatial distribution of rainfall from GSMaP. Compared with the CMAX product from weather radar, there is a difference in the location of the convective cloud with that shown by the satellite imagery. This indicates the weakness of satellite parallax which needs to be studied further.

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