Forest fires detection in Indonesia using satellite Himawari-8 (case study: Sumatera and Kalimantan on August-October 2015)

Fatkhuroyan*, TrinahWati and Andersen Panjaitan
Indonesia Agency for Meteorology Climatology and Geophysics
BMKG, Kemayoran, Central Jakarta, Indonesia

E-mail: fatkhuroyan@bmkg.go.id

Abstract. Forest fires in Indonesia are serious problem affecting widely in material losses, health and environment. Himawari-8 as one of meteorological satellites with high resolution 0.5 km x 0.5 km can be used for forest fire monitoring and detection. Combination between 3, 4 and 6 channels using Sataid (Satellite Animation and Interactive Diagnosis) software will visualize forest fire in the study site. Monitoring which used Himawari-8 data on August, September and October 2015 can detect the distribution of smoke and the extents of forest fire in Sumatera and Kalimantan. The result showed the extent of forest fire can be identified for anticipation in the next step.

1. Introduction

Every year forest fire inflicts smoke problem in most of province in Sumatera and Kalimantan on August to November. The impacts are seriously on environment, health and socio-economic problems [1]. The loss of forest fire in 2015 was around 16.09 million US dollars and Kalimantan Island was the most severe area affected by forest fire and smoke haze [2]. The impact of smokes were not only happened in Indonesia region, but also in neighbouring countries such as Malaysia and Singapore and this condition affects the relations between those countries. Some studies use weather and environment satellite data for smoke monitoring with polar orbital which is good in spatial resolution and have various wavelength, yet weak in temporal resolution [3,4], while the others used geostationary orbital types such as MTSAT (Meteorological Satellite) that can produce image every hour and has 5 channels [5].

Himawari-8 is a new Japanese geostationary meteorological satellite with optical sensors significantly higher in radiometric, spectral and spatial resolution than previous geostationary orbit such as MTSAT. There are 16 observation bands 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 [6,7]. Himawari-8 was launched from Japan’s Tanegashima Space Centre using an H-IIA rocket on 7 October 2014 and settled in geostationary orbit on 16 October. JMA (Japan Meteorological Agency) has operated Himawari-8 since 7 July 2015 [7]. Comparison the result of RGB (Red Green Blue) false colour image (1 visible channel and 2 near infra-red channels) between Himawari-8 and Terra-Aqua MODIS satellites with other supporting data (weather report and hotspot data) showed a similar pattern image between them.
which consist of channels combination of 3, 4 and 6 and also had corresponded to the report of smoke from weather station and hotspot data [8]. The aim of this paper is to investigate the smoke detection using Himawari-8 satellite with RGB false colour technical method which located in Sumatera and Kalimantan regions on August, September and October 2015.

2. Data and methods
Data that were used in this study are:

   a. Images of Satellite Himawari-8, channel 3,4 and 6 on August 25th, September 10th and October 19th 2015.
   b. Synoptic reports from meteorological stations
   c. Hotspot data in Sumatera and Kalimantan based on Terra-Aqua Modis satellite

The Sataid software was used to manage RGB image combination of Himawari-8 from channel 3, 4 and 6. Sataid is software developed by JMA as an application to display satellite imagery and conduct daily weather analysis including tropical cyclone monitoring. One of the core of Sataid system is GMSLPD with specialized functions for Dvorak analysis, display and overlay between satellite imagery and numerical model, use many functions such as vertical cross-sectional chart and time-series chart [9]. The method of Dvorak has been applied to Himawari-8 data set from the start of its operation. The Objective Dvorak Method is being updated to obtain maximal use from the data of new-generation geostationary satellites such as Himawari-8/9 and GOES-R [10]. RGB composite imagery is a technique to display a colour using the property of the three primary colours of light. In satellite imagery processing, RGB technique is used to combine some different channels to make an image which better result rather than only one channel [11]. The locations of the study are Sumatra Island and Kalimantan Island.

3. Results and Discussion

3.1 August 25th 2015
The observation of Himawari-8 imagery has revisit time every 10 minutes. However, in this paper the imagery was taken only at 0600 UTC as samples to monitor the spread of smokes from forest fire. The observation using Sataid GMSLPD as seen on Fig 1.a and Fig 1.b on August 25th 2015 0600 UTC showed smoke of forest fire area with brown colour [12][13] in Sumatera (Riau and South Sumatera provinces) and Kalimantan (Central Kalimantan Province).

![Figure 1. Himawari-8 Imagery at August 25th 0600 UTC for forest fire area in (a) Sumatra (b) Kalimantan](image-url)
In order to endorse the result from RGB false colour analysis, supporting data from hotspot data of Sumatera and Kalimantan on August 25th also provided at Fig 2, the figure showed that most of area which the same area as brown colour in Fig 1.a and Fig 1.b have many hotspots as the signals of forest fire.

The hotspot data showed that the burning area are not exactly the same with the brown colour on the imagery, wind direction played a role in the spread of smoke (Table 1). Wind direction from weather stations in Pekanbaru, Rengat and Palembang for Sumatera were dominated from south and southeast, so that the spread of smoke tend toward northwest of Sumatera. While wind direction in Kalimantan was dominated from southeast and east (Palangkaraya, Pangkalan Bun and Sampit), so the smokes spread toward central and west of Kalimantan. Smoke visibility also was reported from weather stations in Sumatera and Kalimantan as seen on Table 1.

Table 1. Weather Condition on August 25th 2015

| Station Name      | Weather Condition | Wind Direction |
|-------------------|-------------------|----------------|
| PekanBaru         | Smoke             | South          |
| Rengat            | Smoke             | Southeast      |
| Palembang         | Smoke             | Southeast      |
| Palangkaraya      | Smoke             | East           |
| Pangkalan Bun     | Smoke             | Southeast      |
| MuaraTeweh        | Smoke             | Calm           |
| Sampit            | Smoke             | Southeast      |
3.2 September 10\textsuperscript{th} 2015

The smoke on September 10\textsuperscript{th} as seen at Fig 3.a and Fig 3.b showed that at 0600 UTC, the locations of hotspot in Sumatera were the same as the smoke and wind direction dominated calm (Table 2), while in Kalimantan the hotspots mostly located in all region (West, Central and South of Kalimantan Provinces) but the brown colour intensively located in central Kalimantan. Wind direction in Kalimantan was dominated from east. Weather stations reported the smoke visibility as seen on Table 2.

![Himawari-8 Imagery at September 10\textsuperscript{th} 06 00 UTC for forest fire area in (a) Sumatra (b) Kalimantan](image)

**Figure 3.** Himawari-8 Imagery at September 10\textsuperscript{th} 06 00 UTC for forest fire area in (a) Sumatra (b) Kalimantan

![Hotspot area, September 10\textsuperscript{th}](image)

**Figure 4:** Hotspot area, September 10\textsuperscript{th}

source: BMKG

In order to endorse the result from RGB false colour analysis, supporting data from hotspot data of Sumatera and Kalimantan on September 10\textsuperscript{th} also provided at Fig 2, the figure showed that most of area which the same area as brown colour in Fig 3.a and Fig 3.b have many hotspots as the signals of forest fire.

The hotspot data showed that the burning area are not exactly the same with the brown colour on the imagery, wind direction played a role in the spread of smoke (Table 2). Wind direction from weather stations in Pekanbaru, Rengat and Palembang for Sumatera were dominated by calm, so that the spread of smoke tend to stay calm. While wind direction in Kalimantan was dominated from east (Palangkaraya, Pangkalan Bun and Sampit), so that the spread of smoke was toward west of Kalimantan. Smoke visibility also was reported from weather stations in Sumatera and Kalimantan as seen on Table 2.
### Table 2. Weather Condition on September 10th 2015

| Station Name | Weather Condition | Wind Direction |
|--------------|-------------------|----------------|
| Pekanbaru    | Smoke             | Calm           |
| Rengat       | Smoke             | Calm           |
| Palembang    | Smoke             | East           |
| Palangkaraya | Smoke             | East           |
| Pangkalan Bun| Smoke             | East           |
| Muara Teweh  | Smoke             | Calm           |
| Sampit       | Smoke             | East           |

#### 3.3 October 19th 2015

The spread of smoke on October 19th 0530 UTC as seen on Fig 5.a and Fig 5.b showed that the location of smoke in Sumatera were the same as the hotspots because wind direction mostly calm (Pekanbaru and Rengat on Table 3). The spread of smoke in Kalimantan mostly in central and eastern part of Kalimantan, while hotspots were located in Central, South and East Kalimantan, mostly wind direction were calm.

![Figure 5. Himawari-8 Imagery at October 19th 0530 UTC for forest fire area in (a) Sumatra (b) Kalimantan](image)

**Figure 5.** Himawari-8 Imagery at October 19th 0530 UTC for forest fire area in (a) Sumatra (b) Kalimantan

**Figure 6:** Hotspot area, Oct 19th

source: BMKG
In order to endorse the result from RGB false colour analysis, supporting data from hotspot data of Sumatera and Kalimantan on October 19\textsuperscript{th} also provided at Fig 6, the figure showed that most of area which the same area as brown colour in Fig 5.a and Fig 5.b have many hotspots as the signals of forest fire.

The hotspot data showed that the burning area are not exactly the same with the brown colour on the imagery, wind direction played a role in the spread of smoke (Table 3). Wind direction from weather stations in Jambi and Palembang for Sumatera were dominated from southeast, so that the spread of smoke tend toward northwest of Sumatera. While wind direction in Kalimantan dominated from east (Palangkaraya and Sampit), so that the spread of smoke toward central and west of Kalimantan. Smoke visibility also were reported from weather stations in Sumatera and Kalimantan as seen on Table 3.

| Station Name    | Weather Condition | Wind Direction |
|-----------------|-------------------|----------------|
| PekanBaru       | Smoke             | Calm           |
| Rengat          | Smoke             | Calm           |
| Palembang       | Smoke             | Southeast      |
| Jambi           | Smoke             | Southeast      |
| Palangkaraya    | Smoke             | East           |
| pangkalan Bun   | Smoke             | Calm           |
| MuaraTeweh      | Smoke             | Calm           |
| Sampit          | Smoke             | East           |
| pontianak       | Smoke             | Calm           |

The smokes from forest fire on August, September and October 2015 using RGB technical method could be displayed properly with Himawari-8 especially for areas that were not covered with cloud. The brown colour pattern on RGB false colour imagery of Himawari-8 indicated the smoke from forest fire and land [12][13]. The analysis also supported by the smoke visibility reported from weather stations around the location and hotspots location map resulted from MODIS satellites. However, the location of smoke did not always the same as hotspots because the influence of wind direction. The brown colour as indicator of smoke is the combination of three channels namely channel 3 with the wavelength of 0.64\(\mu m\) (interval between 0.2 – 0.55 \(\mu m\)) as red component, channel 4 with the wavelength of 0.86 \(\mu m\) (interval between 0.3 – 0.55 \(\mu m\)) as green component and channel 6 with the wavelength of 2.3 \(\mu m\) (interval between 0.04 – 0.21 \(\mu m\)) as blue component.

4. Conclusions
It can be concluded that Himawari-8 has advantages in temporal resolution which can revisit every 10 minutes, spatial resolution until 0.5 km and spectral resolution with 16 channels. This indicates that RGB technical method can be applied for forest fire smoke detection. Then the spread of forest fire smoke can be monitoring for anticipation purposes. The limitations of Himawari-8 satellite in smoke detection according to this study that it has passive sensor that very dependent on the reflection of solar radiance. So, it can only monitor the forest fire during day-time. The more brown colour detected the thicker of the smoke, and vice versa. Therefore, supporting instrumentation observation such as LIDAR (Light Detection and Ranging) observation can be obtained in order to complete the smoke condition monitoring.
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