Forest fires hotspot detection in Indonesia using Himawari-8 satellite data

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Abstract. Forest fires in Indonesia have been going on for years, which are common in the dry season. This prominent global phenomenon that has a significant impact on a variety of environment, ecosystem, climate functions and structures, furthermore it can produce smoke that is dangerous for health. During 2016, most hotspots in Indonesia occurred in JAS months (July, August, September). To enhance the capabilities of hotspot monitoring, this paper examined the Himawari-8 satellite data to detect the forest fires hotspot in Indonesia. The method used RGB (Red, Green, Blue) technique to combine Himawari-8 satellite data channel 4, 6, 7, and 13. This study was conducted in July, August, and September 2017. Monitoring which used Himawari-8 satellite data could detect forest fires hotspot in Sumatra, Kalimantan, East Nusa Tenggara, and Papua. The result shows that the sites of forest fires can be identified with the new combination of those data and can be seen as an image with the red pattern which indicates the forest fires hotspot. In addition, the verification will be determined so that the accuracy level can be accounted for.

1. Introduction

Recently, the forest fires in Indonesia are driven by a complex set of issues. The forest fires could happen naturally or from human activities [6]. Every year forest fires inflict smoke problem in most of provinces in Indonesia, mostly in Sumatera and Kalimantan. Indonesia's disaster mitigation agency (BNPB) has warned an escalating threat of forest fires during the dry season from July to September, while hot spots have already detected in some provinces which causes choking smoke. The impacts are seriously on environment, health and socio-economic problems [9]. For example, Indonesia suffered some of its worst forest fires in 2015, hitting mainly the island of Sumatra and Kalimantan, the Indonesian portion of Borneo island. The World Bank, citing government data, said that 2.6 million hectares of land in Indonesia burned between June and October 2015, causing US$16 billion of estimated economic damage.

Some studies use weather and environment satellite data for smoke monitoring and detection with polar orbital that is good in spatial resolution and has various wavelength. In addition, some use geostationary orbital types such as MTSAT which has 5 channels and can produce image every hour. As we know, Himawari-8 is a Japanese geostationary meteorological satellite which has 16 observation bands with 0.5 or 1 km spatial resolution for visible and near-infrared bands and 2 km for
infrared bands. By using this, Himawari-8 can produce image around 10 minutes to identify the changing weather phenomena. JMA (Japan Meteorological Agency) has operated Himawari-8 since July 2015. And then SATAID (Satellite Animation and Interactive Diagnosis) is a software developed by JMA (Japan Meteorological Agency) that serves to display binary data from MTSAT satellite into an image or image. SATAID has long been used as an operational tool in JMA for daily weather analysis. However, having Himawari-8 satellite as the new generation of MTSAT satellites, the SATAID is also used for processing satellite data that has 16 channels to generate RGB imagery [10]. The aim of this paper by using 4 channels with different background properties of those channels determined can represent the sites of forest fire in some regions of Indonesia. Those will be helped by RGB false colour technical method in order to get red-sign in imagery as the sites of forest fires. Another advance from this paper, for meteorologist or researchers can utilize these 16 channels of Himawari-8 to identify or track another changing weather phenomena based on their background properties of those channels.

2. Materials and Methods

The research used two types of data:

a. Himawari-8 satellite data channels 4, 6, 7, and 13, taken from BMKG satellite central database. Those data were combined to detect the forest fires hotspot. The satellite imagery was processed by using SATAID application.


This research utilized Himawari 8 satellite data which was processed using SATAID GMSLPD application to generate RGB satellite image combinations from channels 4, 6, 7, and 13. The method used in this study is RGB technique. RGB (Red, Green, Blue) is a technique of displaying images in a way combining three primary colours (red, green, and blue) [4] [11]. Combination of those 3 primary colours produce derived colours (secondary colour) yellow, magenta, cyan, brown, black and white. In image data processing satellite, RGB techniques were used to combine several long channels different waves to get an image product that contains information that is better than that obtained from the image of 1 channel. As for composition to display, RGB satellite images are as follows:

3. Results and Discussion

3.1 Case studies of hotspot detection

Hotspot detection using Himawari-8 satellite data based on RGB technique can be done near real time, since the Himawari-8 satellite image has a temporal resolution of up to 10 minutes. Thus, the satellite data which are available and updated every 10 minutes can be used for continuous monitoring of hotspots in Indonesian tropical rain forest area. Compared with MODIS Terra/Aqua satellite imagery which has only a day temporal resolution, it can only detect hotspots once a day in Indonesian territory. Of the time resolution, the Himawari-8 satellite is much better than the Terra/Aqua MODIS satellite, especially for hotspot detection in Indonesia.

The detection of hotspots is based on the thermal anomalies captured by the Himawari-8 satellite. This study discussed several cases of hotspot detection in several regions in Indonesia. However, as samples are only displayed at certain hours when the hotspots appear quite clear. In addition, with the same RGB combination with hotspots, there is also a Himawari-8 satellite image that can detect smoke mixed with cloud cover over hotspot areas.
Using the RGB technique in the Himawari-8 satellite image, the hotspots would appear as red signs. The red color indicates the intensity of the hotspot, and vice versa. Meanwhile, the smoke would be seen as a cyan colored area (green bluish). The increasing color of cyan indicates an increasing thickness of smoke, and vice versa. Here are some cases of hotspot detection in some regions of Indonesia in July, August, and September 2017.

3.1.1. 24 July 2017

Figure 2. (a) Hotspot (red signs) and smoke (cyan) in Sumatra on 24 July 2017 at 08.30 UTC; (b) BMKG MODIS hotspot map on 24 July 2017 00-21 UTC
Figure 2a shows the Himawari-8 satellite image that has been processed by RGB technique on July 24, 2017 at 08.30 UTC in Sumatra region. The hotspots detected on satellite imagery are seen as red signs. Namely, around the Aceh region, there are several hotspots (yellow and red circles). The presence of hotspots can be an early indicator of forest fires, where many of Sumatra's areas are vulnerable to burning peatlands. In the image can also be seen the spread of smoke (red circle) around the western Aceh region colored cyan (green bluish). Visible smoke spreads around the hotspots area and leads to the northeast. This is the advantage of the combination of RGB Satellite Himawari-8 in this study, not only to detect hotspots, but also to detect the spread of forest fire smoke. Whereas, Figure 2b is a BMKG hotspots map which shows hotspots detection using MODIS Terra/Aqua satellite, accumulated from 00-21 UTC. From the Figure 2, it can be stated that the result of hotspot detection in Aceh region with Himawari-8 satellite image indicates the same location as MODIS satellite hotspot distribution map.

3.1.2. 31 July 2017.

Figure 3a shows the Himawari-8 satellite image that has been processed by RGB technique on July 31, 2017 at 06.00 UTC in Kalimantan region. The hotspots detected on satellite imagery are seen as red signs. Namely, around the area of West Kalimantan, there are some hotspots (yellow circle) which the intensity is strong enough because the red dot appears very clear. The presence of hotspots can be an early indicator of forest fires, where Kalimantan has also a lot of areas of vulnerable peat soil. Figure 3b is a hotspot map of BMKG hotspots detected using MODIS Terra/Aqua satellite, accumulated from 00-21 UTC. From the Figure 3, it can be stated that the result of hotspot detection in West Kalimantan with Himawari-8 satellite image indicates the same location as MODIS satellite hotspot distribution map.

Figure 3. (a) Hotspot in Kalimantan on 31 July 2017 at 06.00 UTC; (b) BMKG MODIS hotspot map on 31 July 2017 00-21 UTC
3.1.3. 21 August 2017

Figure 4. (a) Hotspot in Merauke, Papua on 21 August 2017 at 07.00 UTC

Figure 4a shows the Himawari-8 satellite image that has been processed by RGB technique on 21 August 2017 at 07.00 UTC in Papua region. The hotspots detected on satellite imagery are seen as red signs. Namely, in Merauke, Papua, there are several hotspots (yellow circle). The presence of hotspots can be an early indicator of forest fires, where Papua is dominated by vulnerable forest land. In the image can also be seen the spread of smoke (red circle) around the Merauke region colored cyan (green bluish). Visible smoke spreads around the hotspots area and heading south. Figure 4b is a hotspot map of BMKG hotspots whose detection used MODIS Terra / Aqua satellite, accumulated from 00-21 UTC. From the Figure 4, it can be stated that the result of hotspot detection in Papua region especially in Merauke with Himawari-8 satellite image indicates the same location as map of hotspots of MODIS satellite distribution.

3.1.4. 14 September 2017

Figure 5. (a) Hotspot in Nusa Tenggara on 14 September 2017 at 07.00 UTC; (b) BMKG MODIS hotspot map on 14 September 2017 00-21 UTC
Figure 5a shows the Himawari-8 satellite image that has been processed by RGB technique on September 14, 2017 at 07:00 UTC in Nusa Tenggara region. The hotspots detected on satellite imagery are seen as red signs. That is around the area of NTB, and part of NTT there are some hotspots (yellow circle). The presence of hotspots can be an early indicator of forest fires. Meanwhile, Figure 5b is a hotspots map of BMKG hotspots detection using MODIS Terra/Aqua satellite, accumulated from 00-21 UTC. From the Figure 5, it can be stated that the result of hotspot detection in Nusa Tenggara using Himawari-8 satellite image indicates the same location as MODIS satellite hotspots distribution map.

3.2 Discussion

The principle of hotspot detection using Himawari-8 satellite data is based on thermal anomalies using infrared channels that are sensitive to solar components, especially I4S channels. The channel can sense optimally if there is radiation of the sun to the earth. Once tested, the detection of hotspots with the technique RGB satellite Himawari-8 by using channels 4, 6, 7, and 13 has limitations. Hotspot detection results will be optimally used during the daytime or when there is still radiation of the sun to the earth. Meanwhile, for the detection of hotspots at nighttime by using a combination of RGB in this study cannot give clear results. Satellite imagery processed by RGB technique at night appears all red as seen in Figure 6, so it cannot be used for hotspot detection in Indonesian region at nighttime. This is the weakness of RGB technique of Himawari-8 satellite image in this research.

In addition, the result of hotspot detection using Himawari-8 satellite in this study is still limited to determine hotspot locations, but not yet able to categorize hotspots according to their belief level as in MODIS Terra / Aqua satellite. However, the intensity of hotspots can be known.

Figure 6. Himawari-8 satellite RGB image in Papua on 24 July 2017 at 08.30 UTC (19.30 LT)
4. Conclusion

It can be drawn to a conclusion based on case studies of this research in Indonesia especially in Sumatra, Kalimantan, Nusa Tenggara, and Papua in July, August, and September 2017. The data of Himawari-8 satellite channels 4, 6, 7, and 13 processed using RGB (Red, Green, Blue) techniques produce images that can be utilized to detect hotspots visible as red signs that have the potential to cause forest fires and to detect the resulting smoke in the form of color distribution cyan (green bluish). The combination of RGB can be used during the daytime, while at nighttime it cannot be used optimally because the satellite channel is used in connection with the presence of sun exposure. Threshold limit to indicate hotspots ranges above 0.05. Visually, the results of hotspot detection using the Himawari-8 satellite show relatively similar results to MODIS Terra / Aqua satellite detection.

References