Identification of forest and land fires in Sumatra Island (case study July 23, 2017)

A L Gaol[1, a] and E L Siadari[1]

[1]Indonesian State College of Meteorology Climatology and Geophysics
Jalan Perhubungan I No.5 Komplek Meteorologi Pondok Betung, Bintaro 15221, Indonesia

[a]adel.lumbangaol@gmail.com

Abstract. Forest fires are one of the phenomena which can cause negative impacts on the environment. Based on the BMKG report on July 23, 2017, there are 12 hotspots in Riau and several other provinces on the Sumatra Island, such as Jambi, Bangka Belitung and Lampung. This condition leads to a reduction of horizontal visibility as well as causing respiratory disturbance resulting from the smoke of burnt land fields. Based on this cases, further research was conducted to identify the burnt land fields using MODIS satellite imagery reflectance and vegetation index variables (NDVI) using NOAA Climate Data Record. The proccessing results indicate the presence of pixels indicated as burning field. In addition, the detection condition of smoke distribution and wind trajectory through Himawari satellite imagery processing using RGB technique in SATAID application. The wind pattern is visualized through a brown pattern on the Sumatra Island and winds moving from the east-southeast direction indicate the smoke is scattered west-northwest from the hotspot.

1. Introduction

Indonesia is one of the countries in the world that has vast tropical forests and is rich in biodiversity. Tens millions of Indonesians rely on their livelihoods from forests, either from collecting various types of forest products to meet their livelihood needs or working in the wood processing industry. Behind the resources through clearing of plantation and agricultural land by burning forests. In addition, the illegal operation of wood processing industry is believed to have destroyed Indonesia's tropical forests richness of Indonesia's tropical forests, it has a dark side. Communities with irresponsible actions undermine forest natural.

Forest fires are one of the main factors contributing to the diminishing extent of Indonesia's tropical forests. Indonesia's most frequent forest fires are on Sumatra Island include Riau, Jambi, North Sumatra and South Sumatra. Large scale combustion results in a smoke that is not easily lost throughout Sumatra and Kalimantan during each dry season.

Indonesia's forest fires become attention to the global community due to the thick smoke that spreads to other countries. The smoke caused by forest fires in Sumatra and Kalimantan which occurred in 2015 reached Singapore and made air quality worse. Hospitals and clinics were filled with people looking for treatments for various diseases related to respiratory, eye and skin diseases. Many schools, businesses and airports were closed, tourists could not visit, making the local economy condition becomes difficult.

The advancement of natural science and technological in the current period makes it easier for humans to monitor the spread of fumes and to identify spatial distribution of areas that have been burned using satellite. Research by Tjahjaningsih et al. (2005), Xie et al. (2009), Pandjaitan et al. (2015) conducted by utilizing satellite data types of geostationary orbital types such as MTSAT and Himawari 8 to monitor the spread of smoke. Further research by Cochrane (2003), Parwati et al. (2012), Suwarsono et al. (2013) and many more are done by using polar orbital satellite data such as MODIS satellites to identify areas of forest and land fires.This research aims to monitor the spread of smoke through RGB false color technique using Himawari 8 satellite data and identify areas of forest and land fires using MODIS imagery based on the NDVI value changes on Juli 23, 2017 for Sumatra Island region.

2. Methods

The data used in this research is Terra / Aqua MODIS which is the product of Lembaga Penerbangan dan Antariksa Nasional (LAPAN). The sensor resolution reaches 1 kilometer with the temporal resolution for every day. MODIS has a thermal sensor that is capable of capturing heat energy from electromagnetic waves emitted by the earth's surface, so it can be used to detect hotspots in areas of forest fires that have relatively hot temperatures compared to unburned areas [2]. MODIS Deep Blue Aerosol Angstrom Exponent is also used to determine the size of the aerosol particles. Moreover, MODIS Deep Blue Aerosol Angstrom Exponent is used to determine the state of smoke particles of an area which is then processed using the Worldview. In addition, Himawari channel 3 (0.64μm) satellite imagery, channel 4 (0.86μm), and channel 6 (2,3μm) on July 23, 2017 are used to determine the direction of smoke spread. Himawari satellite is equipped with 16 bands that can increase temporal and spatial data resolution [4]. The Himawari satellite processing uses SATAID (Satelite Animation and Interactive Diagnosis) in GMSLPD applications. The processing technique uses a combination of Red Green Blue (RGB) which is a combination of 3 primary colors, namely red, green, and blue. The RGB technique is a technique that combines 16 satellite imagery channels to generate RGB satellite imagery. The process of combining multiple satellite channels is done to produce a better image than just using a single satellite image. The steps taken in generating RGB satellite images are as follows:

1. Displaying data of Himawari satellite imagery in 3, 4 and 6 channels processed through GMSLPD SATAID application on July 23, 2017.
2. Activate on the gray panel and make RGB color combination settings. The processing of three satellite image channels starts from a three-channel arrangement as a red image with a gamma value of 1.80, a green image through channel 4 with a gamma value of 1.00 and channel 6 satellite imagery as a blue image with a 3.00 gamma value.
3. Storage via bitmap in .png or .jpg format. This data is analyzed soon to determine the distribution of smoke indicated by a bright yellow or brownish image.

The visualization of the smoke trajectory is performed by overlaying the GS model data to the previously displayed satellite imagery. The data which has been overlay is processed by activating the NWP panel to generate direction data and wind speed at surface layer through wind panels. Trajectory data of the smoke distribution will be displayed through the menu system on the brightness level window. The activated menu is vert 5 (traj) menu which is pressed at the same time with the Ctrl key on the keyboard. The direction of the distribution of the smoke trajectory will be shown starting from the starting point of the distribution and then continuing along the direction of the wind that has been visualized by the NWP model.

The next data used in this study is NDVI (Normalized Difference Vegetation Index) which is an index that represents the various spectral of vegetation [7]. This data retrieves from the NOAA Climate Data Record (National Oceanic and Atmospheric Administration) using AVHRR (Advanced Very High Resolution Radiometer) by detecting surface reflectance. NDVI has a resolution of 0.05^{o} x 0.05^{o} used to measure the greenishness of vegetation specifically in Sumatra Island on July 23, 2017.

3. Results and Discussion

3.1. Synoptic Observation Product

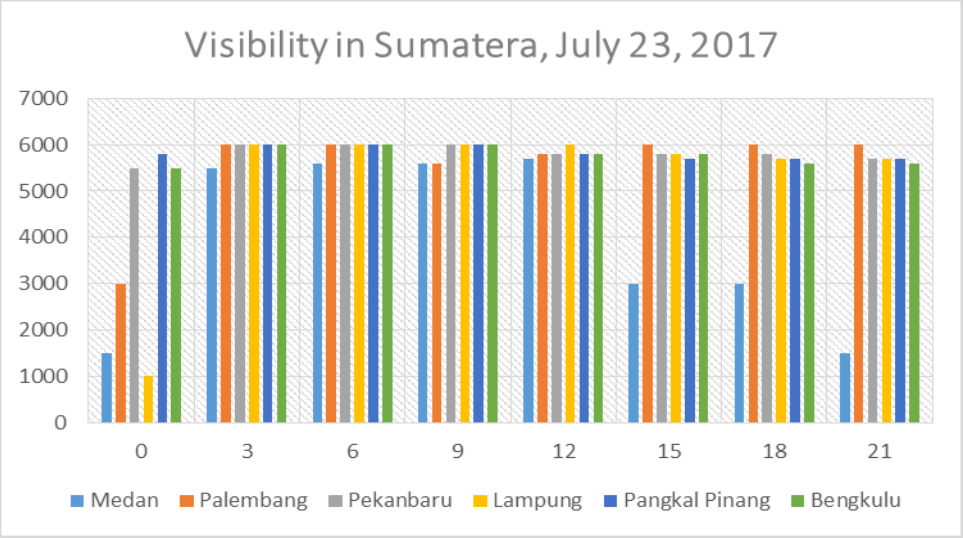


Figure 1. Visibility condition recorded at selected meteorological stations on Sumatra Island on July 23, 2017.

Figure 1 shows the visibility conditions observed by selected meteorological stations in the Sumatra Island on July 23, 2017. The data show the average visibility conditions in some areas in the Sumatra Island ranged from 5000 to 6000 meters. This indicates that there is still a blur of air conditions in some areas caused by the spread of smoke from forest and land fires. The average condition of visibility is quite low in the region of North Sumatra Province. Although visibility conditions do not interfere with aviation transport routes, this condition is sufficient to indicate a lack of horizontal visibility due to the blurring of smoke from the hotspot detected in the Sumatra Island.

3.2. Terra/Aqua LAPAN Product

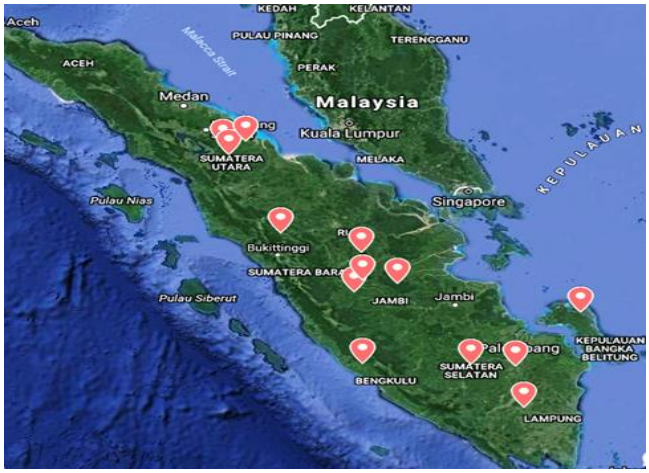


Figure 2. The Terra / Aqua MODIS product results show the pattern of hot spot spreading in Sumatra on July 23, 2017.

From the observation of visual appearance of Terra / Aqua MODIS product based on LAPAN observation with a confidence rate of more than or equal to 80% (≥ 80%) shows hot spots in some areas such as Medan, Riau, Bangka Belitung, South Sumatra and Lampung on July 23, 2017. Hot spots that are spread along Sumatra Island is marked by red dots. Based on forest and land fires data from Direktorat Pengendalian Kebakaran Hutan dan Lahan, there are at least 15 hot spots in Indonesia

with 13 dominant hot spots located in Sumatra with the most hot spots detection in North Sumatra Province for 3 hot spots, which is in Asahan and Toba Samosir City.

3.3. MODIS Deep Blue Aerosol Angstrom Product

The smoke distribution conditions can be detected with the MODIS Deep Blue Aerosol Angstrom. Exponent product. Small exponential values of less than 1.00 (<1.00) show the optical dominance of coarse particles, such as dust, whereas an exponent value greater than 1.00 (> 1.00) indicates the optical dominance of fine particles, such as smoke. The blue color shows the exponent value ranging from 1.50 to 1.80. This indicates that there are fine particles of smoke in the region of Sumatra Island. Visual observation shows the dominance of smoke in the northern and western Sumatra. The smoke conditions covering the islands of Sumatra particularly in western and northern part of Sumatra Island indicate the potential for low visibility in the region due to the disruption of the smoke particle distribution.

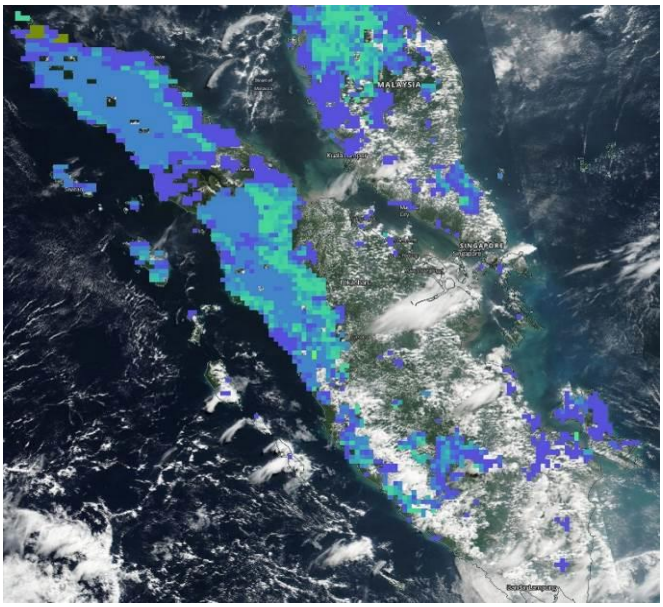
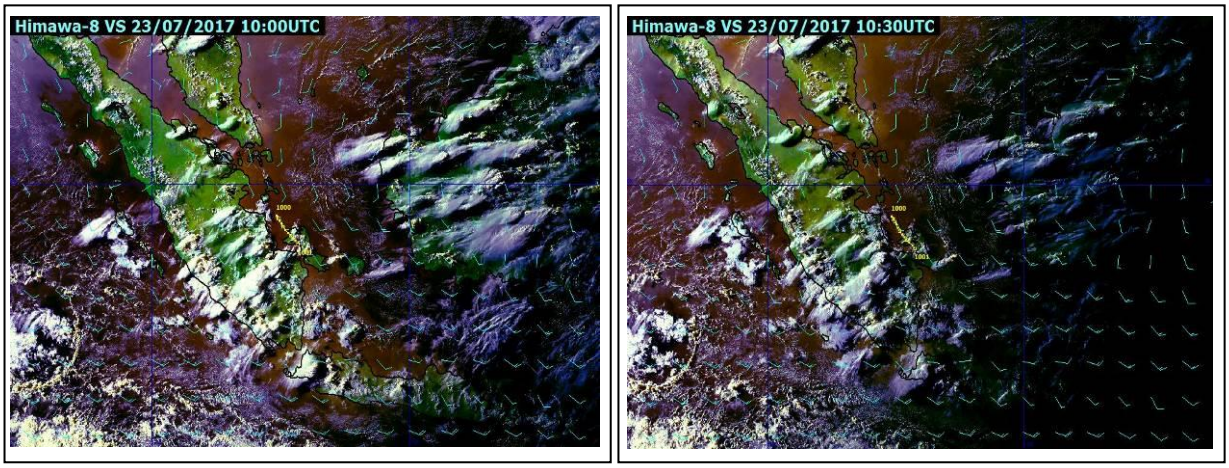


Figure 3. The results of MODIS Deep Blue Aerosol Angstrom Exponent product show pattern of smoke distribution in Sumatra on July 23, 2017.

3.4. Himawari Product using RGB Method



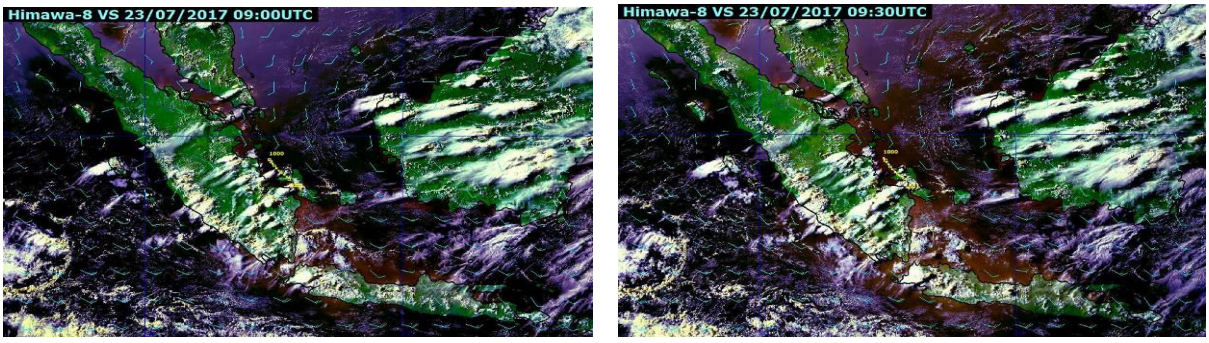
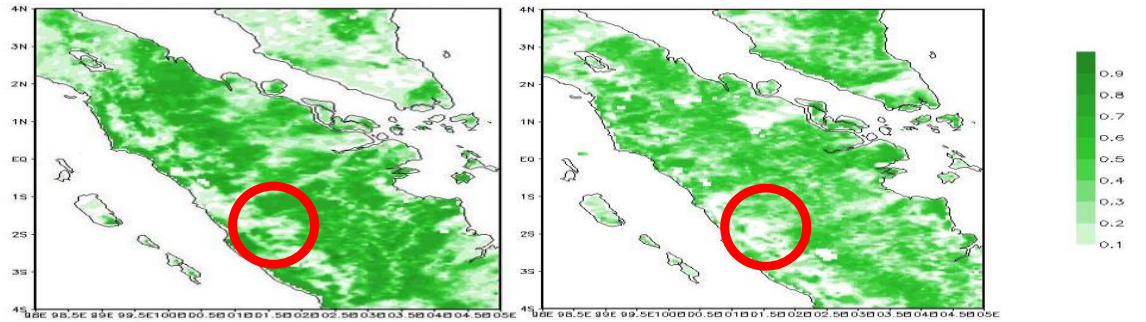


Figure 4. The results of Himawari satellite products show the distribution of smoke along Sumatra shown by the brownish color on July 23, 2017.

The processing results from the satellite image view using the RGB method show the presence of brownish-colored lump that can be indicated as the distribution of smoke covering the Sumatra region. Spreading smoke from forest and land fires began to appear at around 09:00 UTC and detected in the south of Sumatra island. The distribution of smoke gradually increased and at 10:00 UTC showed the conditions of smoke that has spread in almost Sumatra. In addition, the island of Java is also detected that there is a spread of smoke that indicates there are a number of hotspots in the region.

The result of GS data shows the condition of the direction dan windspeed which is in surface layer and moving from the South East-South direction. It also supports the formation of trajectories of smoke marked by yellow line. Based on the results of the smoke trajectory show that the surface wind conditions in Sumatra is generally moving from south east-south direction to the northwest-north direction. The direction of wind movement can potentially bring smoke from forest and landfires to the north-west direction. The result of RGB image of Himawari satellite indicates the suitability with the particle smoke distribution condition through MODIS image and dominantly detected in the northern region of Sumatra.

3.5. NDVI (Normalized Difference Vegetation Index) Product



(a) **(b)**

Figure 5. The results of the NDVI satellite products show changes in vegetation cover in Sumatra, **(a)** before forest and land fires and **(b)** during forest and land fires marked by red circles.

Based on NDVI image analysis by NOAA, a change of vegetation cover is identified which can be seen from Figure 5. The condition before the forest and land fire incident is shown in Figure 5a. The vegetation cover index is above 0.6 (> 0.6). However, in the event of forest and land fires on July 23, 2017 (Figure 5b), a reduction vegetation cover identified by the value under 0.6 (<0.6). This shows that there is a decline in the vegetation index induced by forest and land fires in Sumatra.

4. Conclusion

From the analysis of Terra/Aqua MODIS by LAPAN shows there are 13 hot spots in the region of Sumatra Island. In addition, the condition of smoke distribution through MODIS Deep Blue Aerosol Angstrom Exponent dominates in the western and northern parts of Sumatra Island. This condition is also supported by the results of the trajectory of the surface layer wind moving towards the northwest-north direction which has the potential to spread smoke to that direction. The condition of smoke distribution in Sumatra Island began to appear at 09.00 UTC and at 10:00 UTC the distribution of smoke was detected almost around Sumatra Island. The analysis results of the Himawari satellite imagery is also strengthened by weather reports from several Meteorological Stations in Sumatra Island. In addition, the results of NDVI vegetation index analysis show the changes in vegetation cover during the forest and land fire at some points in Sumatra Island.

References

[1] Adinugroho Wahyu C et al 2005 *Panduan Pengendalian Kebakaran Hutan dan Lahan Gambut* (Bogor: Wetlands International – Indonesia Programme)
[2] Anggraini N dan Bambang T 2011 Kajian Dampak Perubahan Iklim terhadap Kebakaran Hutan dan Deforestrasi di Provinsi Kalimantan Barat *J. Penginderaaan Jauh Pengolahan Data Citra Digit.* **8** 11
[3] FWI/GFW 2001 *Keadaan Hutan Indonesia* (Bogor, Indonesia: Forest Watch Indonesia dan Washington D.C.: Global Forest Watch)
[4] Kushardono D 2012 Kajian Satelit Penginderaan Jauh Cuaca Generasi Baru Himawari 8 dan 9. *Majalah Inderaja* **3 (5)** 41
[5] Pandjaitan B, Septian, dan Andersen P 2015 *Pros. Sem. Nas. Penginderaan Jauh* p 636
[6] Rani N A 2017 *Pros.Sem. Nas. Fis. Apl. (SENFA 2016)* vol II Maret 2017 pp 79-84
[7] Rouse JW, Haas R H, Schell J A, and Deering D W 1974 Monitoring Vegetation Systems in the Great Plains with ERTS *Third Earth Resources Technology Satellite–1 Symp. Vol. 1: Technical Presentations, NASA SP-351* (Washington, D.C.: NASA) eds S.C. Freden, E.P. Mercanti, and M. Becker pp 309-317
[8] Shimizu A The Basis of RGB Image Composites Presentation of Analysis Division Meteorological Satellite Center Japan Meteorological Agency