JURNAL GEOGRAFI
https://journal.unnes.ac.id/nju/index.php/JG

Small Fire Detection Using RGB Method of Himawari-9 and Firms Satellite Imagery (Fire Information Resource Management System) Using Viirs and Modis Satellite Imagery in Medan Marelan (Case Study: 16 November 2023)

Attiya Shakila Giananti[1*], Yahya Darmawan[2], Aditya Mulya[1]

[1]Department of Meteorology, College of Meteorology, Climatology and Geophysics, Tangerang City, Banten, Indonesia
[2]Department of Climatology, College of Meteorology, Climatology and Geophysics, Tangerang City, Banten, Indonesia

Article Info

Article History
Submitted 2025-01-16
Revised 2025-08-14
Accepted 2025-08-18

Keywords
Hotspot, Radiosonde, Fire Detection, Satellite, MODIS, VIIRS

Abstrak

Kota Medan merupakan kota dengan jumlah penduduk yang padat. Hal ini menyebabkan kawasan permukiman di Medan Marelan cenderung padat. Dampak negatifnya adalah rawan terjadi bencana kebakaran. Untuk mencegah dampak kebakaran tersebut, diperlukan pemantauan. Salah satu cara pemantauan yang dapat dilakukan adalah dengan menggunakan penginderaan jauh. Penelitian ini melakukan penginderaan jauh melalui satelit Himawari-9, MODIS, dan VIIRS. Metode yang digunakan adalah metode Red Green Blue (RGB) untuk satelit Himawari-9 dan metode Fire Information Resource Management System (FIRMS) untuk satelit MODIS dan VIIRS. Berdasarkan penelitian ini, satelit MODIS dan VIIRS lebih unggul dalam memantau kebakaran kecil yang terjadi di Medan Marelan dibandingkan dengan satelit Himawari-9. Satelit Himawari-9 lebih mampu mendeteksi awan di atas lokasi kebakaran daripada kebakaran itu sendiri. Hal ini dibuktikan dengan data radiosonde yang menyatakan bahwa kondisi atmosfer saat itu sedang tidak stabil. Dengan tambahan informasi melalui data curah hujan pada tanggal 16 November 2023 dengan kisaran 20-50 mm.

Abstract

Medan City is a city with a dense population. This causes residential areas in Medan Marelan tend to be densely packed. The negative impact is that are prone to fire disasters. To prevent the impact of these fires, monitoring is needed. Way of monitoring that can be done is using remote sensing. This research carried out remote-sensing by using the Himawari-9, MODIS, and VIIRS satellites. The method used are the Red Green Blue (RGB) method for the Himawari-9 satellite and the Fire Information Resource Management System (FIRMS) method for the MODIS and VIIRS satellites. Based on this research, the MODIS and VIIRS satellites are superior in monitoring small fires that occurred in Medan Marelan compared to the Himawari-9 satellite. The Himawari-9 satellite is more likely to detect clouds over fire locations than the fire itself. This was proven by radiosonde data which stated that atmospheric conditions at that time were moderately unstable. With additional information via rainfall data on November 16 2023 with a range of 20-50 mm.

E-mail:

p-ISSN 2549-3078 e-ISSN 2549-3094

INTRODUCTION

Medan City is a city with a dense population. From the results of the 2020 population census conducted by the Central Statistics Agency (BPS), the population of Medan City reached 2.44 million people. In detail, 1.21 million people are men and 1.22 million people are women. Spatially, Medan Deli is the sub-district with the largest population in Medan City, namely 189.32 thousand people. Its position is followed by Medan Marelan with a population of 182.52 thousand people. This does not deny that residential areas in Medan Marelan tend to be densely packed. The negative impact of dense residential locations is that they are prone to fire disasters (Tampubolon et al., 2020).

Fire disasters can be caused by extreme weather and human activities (Hidayat et al., 2019). These fires can cause potential losses that cannot be predicted financially in the form of economic losses, loss of biodiversity, ecosystem changes, and decreased air quality (Endrawati et al., 2017). To prevent the impacts that will arise, monitoring needs to be carried out early. Monitoring can be done by analyzing hotspot data by using remote sensing (Herdian et al., 2021). This is very helpful because it is difficult to access the fire location. Many researchers have monitored fire hotspots through remote sensing. However, the types of fires studied were large forest and land fires or hot spots resulting from the eruption of Mount Merapi. Therefore, in this research, monitoring small fires through remote sensing using the RGB method of Himawari-9 satellite imagery and FIRMS (Fire Information Resource Management System) was extracted based on VIIRS and MODIS satellite imagery for the Medan Marelan area.

Hot spot monitoring that is often used in Indonesia is monitoring using polar type satellites, namely the Terra, Aqua and Suomi NPP satellites (LAPAN, 2016). The Terra and Aqua satellites use the MODIS (Moderate Resolution Imaging Spectroradiometer) sensor and the Suomi NPP satellite uses the VIIRS (Visible Infrared Imaging Radiometer Suite) sensor for fire detection (Sepriando & Heru Jatmiko, 2019). The Himawari 9 satellite as a new generation of MTSAT satellite is equipped with a sensor called the Advanced Himawari Imager (AHI), which has 16 channels, namely 3 visible channels, 3 near infrared (NIR) channels and 10 Infrared (IR) channels (Pandjaitan & Panjaitan, 2018).

Monitoring on this satellite utilizes the combination of several channels to produce RGB (Red, Green, Blue) products (Kushardono, 2012). VIIRS consists of sixteen moderate resolution channels (M-Bands) ranging from M1 to M16, one Day/Night Band (DNB) channel, and five high resolution imagery channels (I-Bands), namely I1 to I5 (Baugh, 2014). MODIS has 36 channels covering the wavelength range 0.4- 14.2 μm including Visible (VIS), Near Infrared (NIR), Short and Middle-Wavelength Infrared (SMIR), and Long-Wavelength Infrared (LWIR) (NASA's Earth Observing System, 2002).

Reporting from the news suarasumut.id and medantribun, a used tire warehouse fire occurred in Medan Marelan on November 16 2023 with thick black smoke rising high. The fire occurred at 14.00 and 4 hours later, the fire still had not been extinguished. The area around the tire storage area was also affected. The aim of this research is to utilize data from different satellites to monitor hot spots for used tire warehouse fires.

METHODS

The method used is the RGB method which utilizes Himawari-9 satellite image data and the NASA FIRMS method which utilizes VIIRS and MODIS (Terra and Aqua) satellite data. The RGB used is RGB Ash and RGB Natural Fire Color. The research location is Medan Marelan, North Sumatra with a case study dated November 16 2023. The following are details of the data and applications used in data processing:

- Himawari-9 Advanced Himawari Imaginer (AHI) satellite imagery as the main data. This data is processed in the SATAID (Satellite Animation and Interactive Diagnosis) application which has been radiometrically and geometrically corrected (Sepriando & Heru Jatmiko, 2019). The data taken is data on channels 3, 4, 6, 7, 11, 13, and 15 with a time range of 7 to 10 UTC.

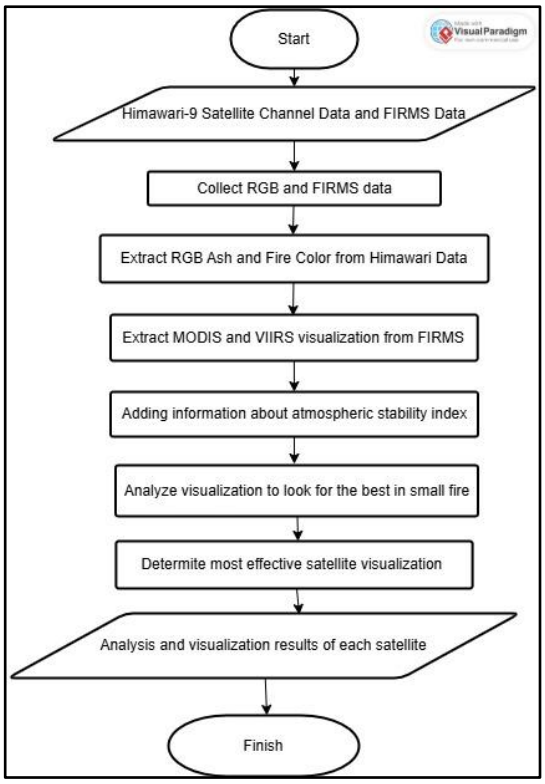


Figure 1. Research Flowchart

Table 1. Himawari-9 Canal Spesification

Wave length [µm]	Himawari-9		
	Band number	Spatial resolution at SSP [km]	Central wave length [µm]
			AHI-9 (Himawari-9)
0.47	1	1	0.47059
0.51	2	1	0.50993
0.64	3	0.5	0.63972
0.86	4	1	0.85668
1.6	5	2	1.6065
2.3	6	2	2.2570
3.9	7	2	3.8289
6.2	8	2	6.2479
6.9	9	2	6.9555
7.3	10	2	7.3437
8.6	11	2	8.5936
9.6	12	2	9.6274
10.4	13	2	10.4074
11.2	14	2	11.2080
12.4	15	2	12.3648
13.3	16	2	13.3107

- MODIS and VIIRS hotspot data were obtained from NASA's FIRMS page (https://firms.modaps.eosdis.nasa.gov/download/) as comparative data. This page is equipped with tools in the form of coordinates, location, time, satellite type, sensor type, area, and the type of map you want to use. This data is also processed using Google Earth Engine.
- BMKG daily hot spot distribution map and diagram as a comparison of hot spots and the GSMap (Global Satellite Mapping of Precipitation) map processed by BMKG based on JAXA (Japan Aerospace Exploration Agency) data as precipitation data.
- MODIS and VIIRS True Color images obtained from NASA's Earthdata page (https://worldview.earthdata.nasa.gov).
- Radiosonde data from the Kualanamu Class I Meteorological Station 00 UTC. This data was obtained using the RAOB 5.7 application.

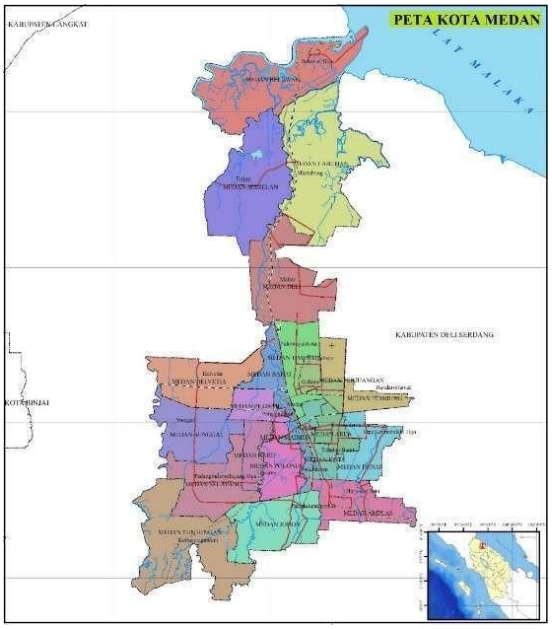


Figure 2. Map of Medan City (Source: peta-hd.com)

RESULT AND DISCUSSION

1. RGB Ash

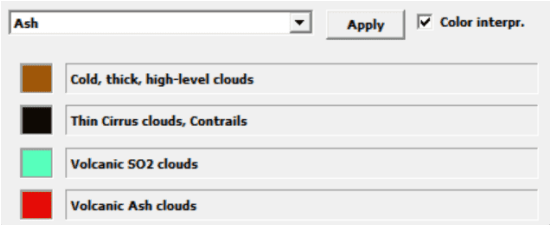
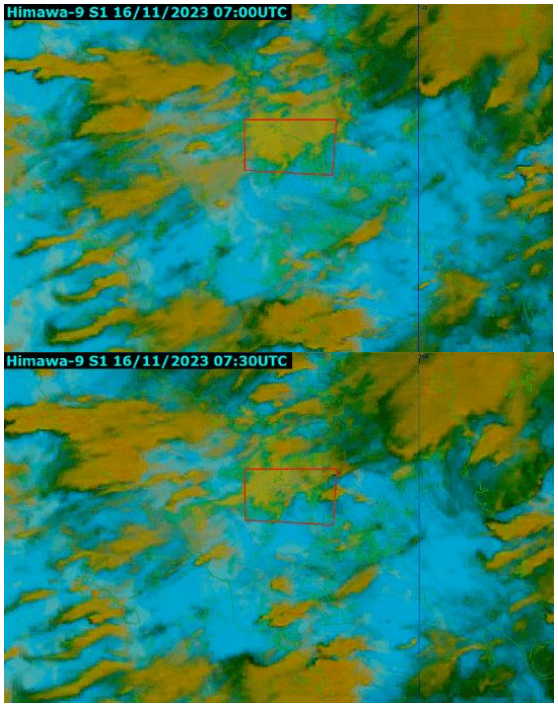


Figure 3. Interpretation of RGB Ash Color



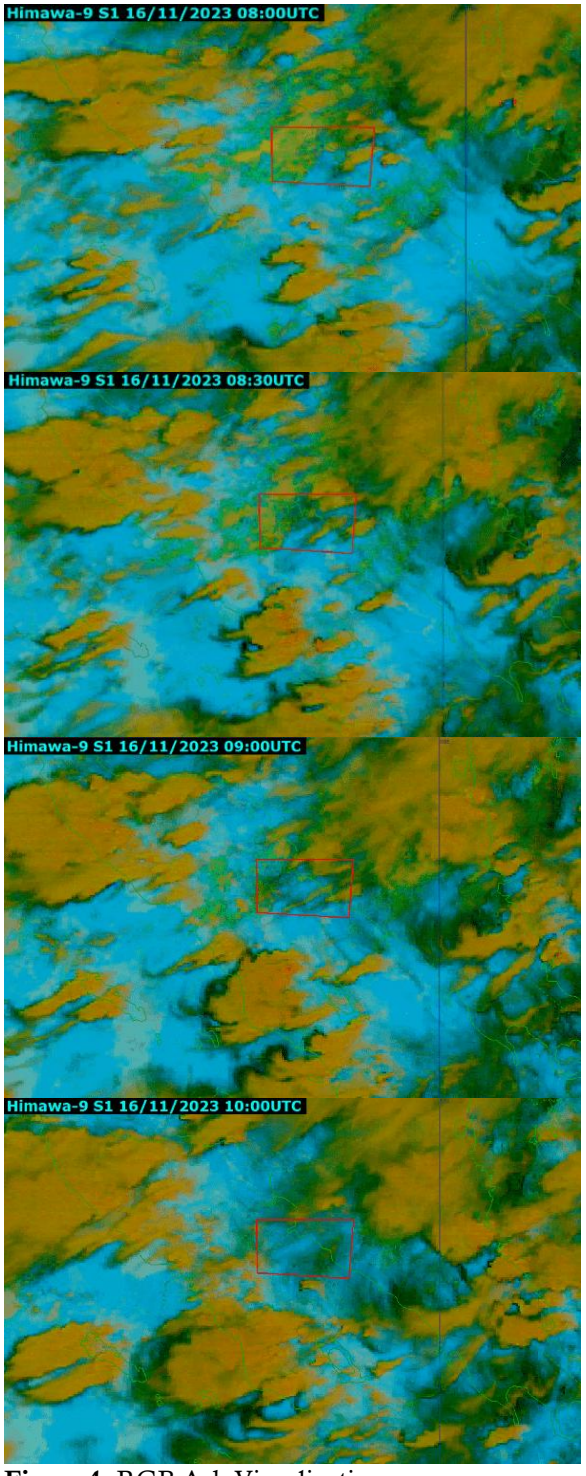


Figure 4. RGB Ash Visualization

Based on the RGB Ash visualization of the Himawari-9 satellite in Figure 3, it tends to be brownish with a little black. This means in Figure 2 that in this area there are high cold and thick clouds (brown) and there are also high thin cirrus type clouds (black). At 07.30 UTC (14.30 WIB), a reddish dot was seen which could be interpreted as a cloud of ash or thick smoke. However, this is still subjective because it is very difficult to interpret objects based only on one small point.

2. RGB Natural Fire Color

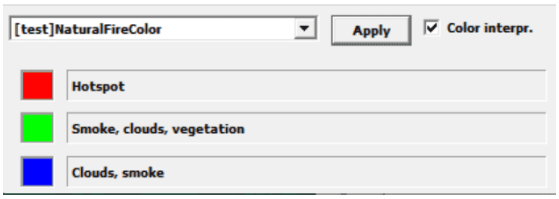
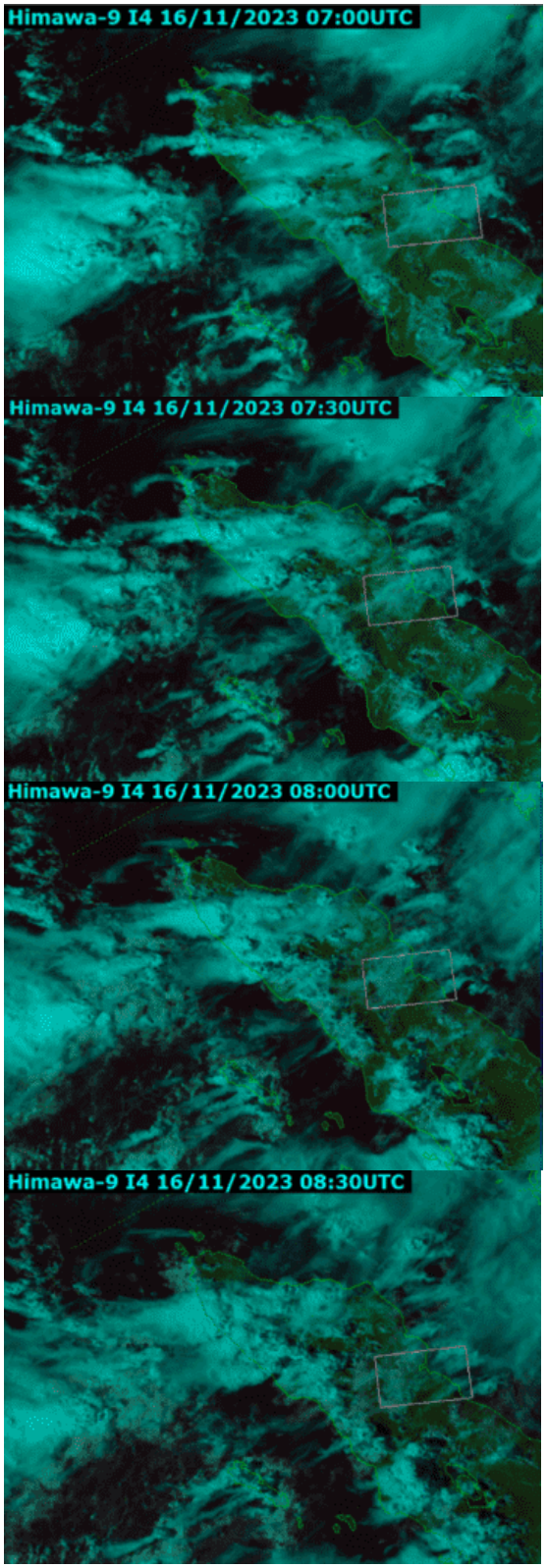


Figure 5. Interpretation of RGB Natural Fire Color



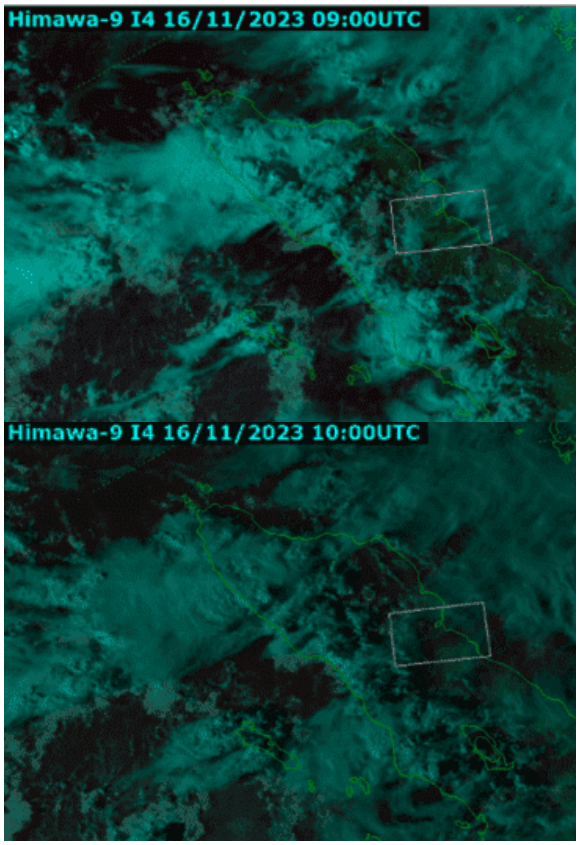
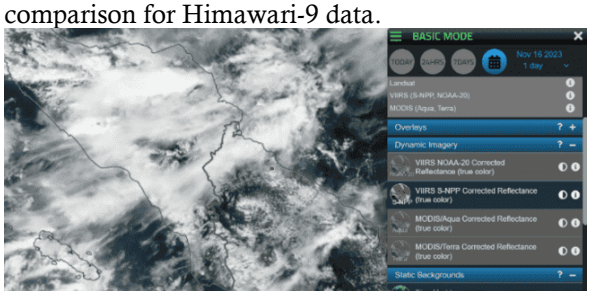


Figure 6. RGB Natural Fire Color Visualization

Not much different from the previous RGB, in Figure 5, the RGB Natural Fire Color visualization does not show any hot spots at the Medan Marelan location. The RGB tends to display cloud cover in the area which is marked with a bluish green color. There is no red color which is interpreted as a hotspot (hot spot) at all in the specified time period. So, RGB is difficult to interpret small fires, especially when there is cloud cover over that location.

3. FIRMS

Validation of the hotspots used Ministry of Forestry data also showed that there were quite a lot of fires in the field that were not detected as hotspots. FIRMS data with various confidence levels provides the highest level of accuracy compared to other data sources (Vetrita et al., 2014). Therefore, this study uses FIRMS data as a comparison for Himawari-9 data.



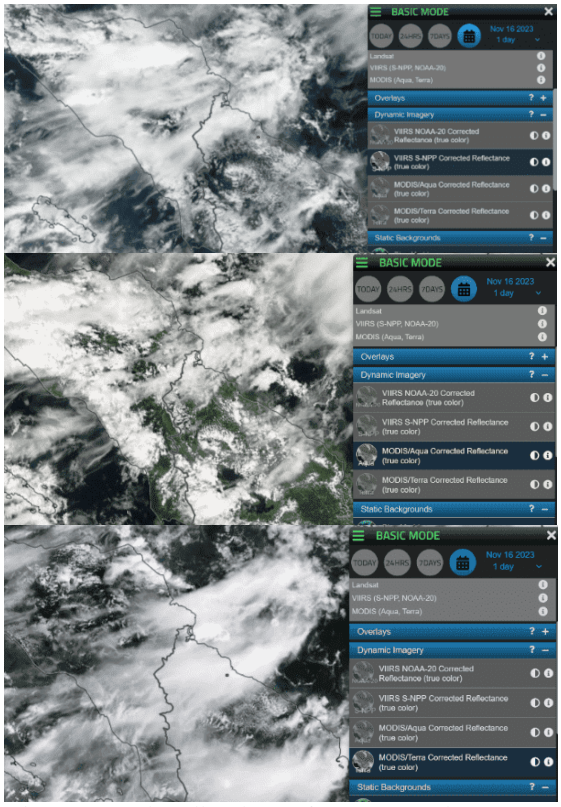


Figure 7. Visualization of VIIRS and MODIS FIRMS

Figure 8. Visualization of FIRMS Hot Spots

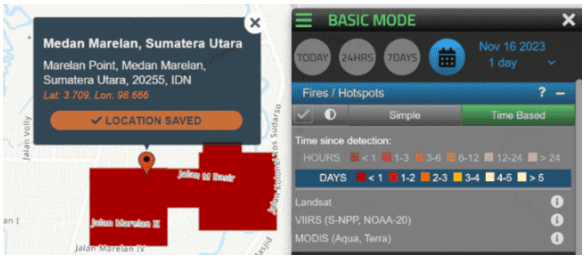


Figure 9. Location and Time of Fire (in days)

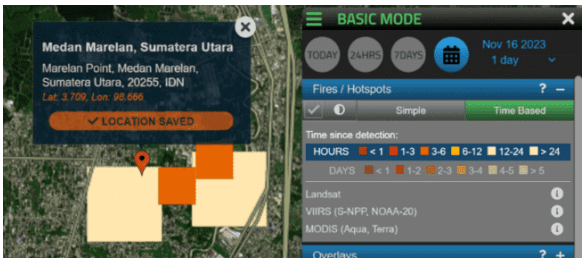


Figure 10. Location and Time of Fire (in hours)

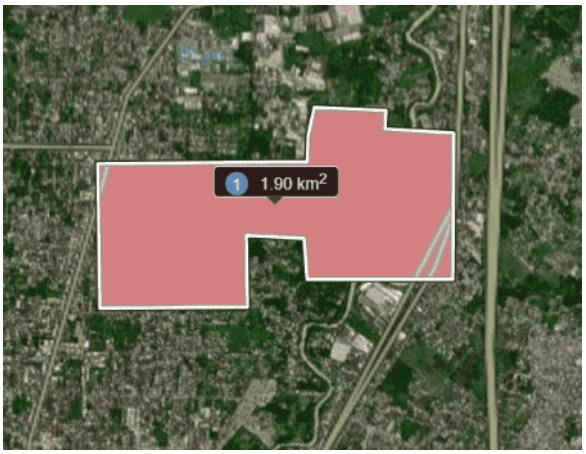


Figure 11. Hot Spot Distribution Area

Based on Figures 6 and 7, on November 16 2023 in Medan Marelan, there are hot spots marked in red based on both MODIS FIRMS and VIIRS FIRMS data. After enlarging the image, the results obtained more clearly interpret the distribution of hot spots compared to the Himawari-9 satellite data visualization. FIRMS is also able to determine the location, time range, and extent of distribution of fire hotspots in the area (Figures 8, 9 and 10). This greatly simplifies the remote monitoring process. The fire incident lasted for 1 day with a time span of 3-12 hours covering approximately around 2 km radius from the point of occurrence.

Based on the BMKG hot spot distribution map source in Figure 11, there were no hot spots that occurred on November 16 2023 in North Sumatra Province. The diagram in Figure 12 also shows that from 7 November to 16 November 2023 no hot spots were detected in the North Sumatra region. This is in line with Vetrita, 2014 who said that there are still many fire incidents that are not detected. One of the factors that causes fire incidents to not be detected using remote

sensing is weather conditions in the form of cloud cover.

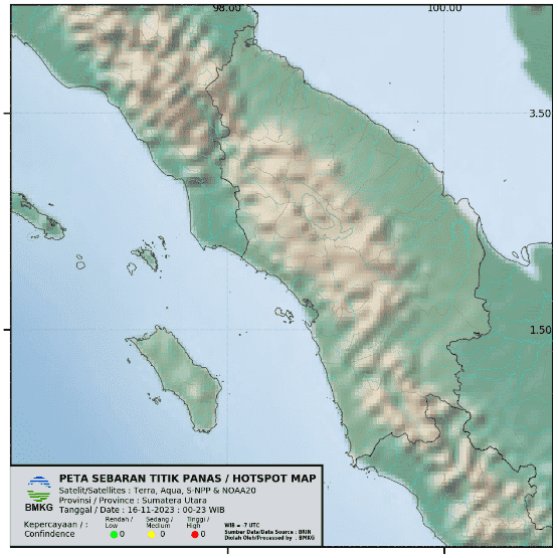


Figure 12. Map of Hot Spot Distribution of North Sumatra (Source: BMKG)

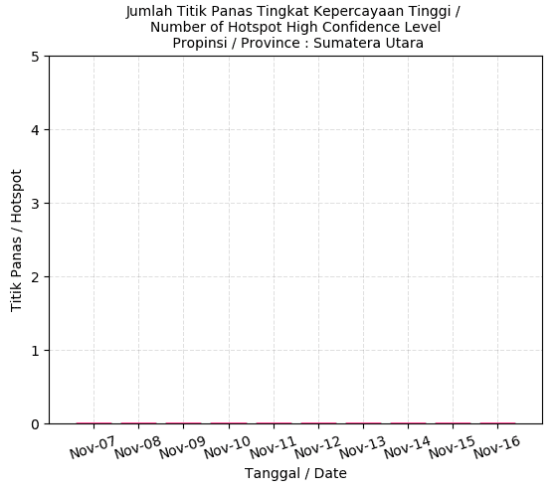


Figure 13. Diagram of the Number of Hot Spots in North Sumatra

4. Air Stability Index

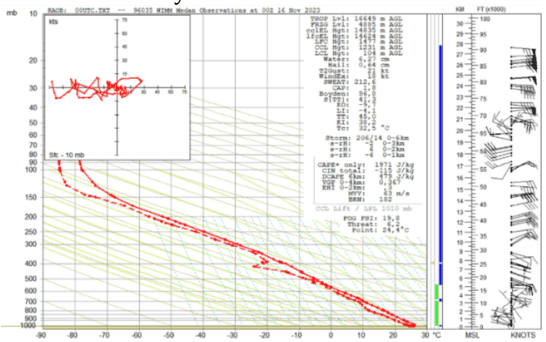


Figure 14. Kualanamu Class I Meteorological Station radiosonde 16 November 2023 00 UTC

Table 2. Atmospheric Stability Index (Source: AWS and The Universal Rawinsode Observation Program (RAOB))

Indeks	Storm's potensial		
	Weak	Moderate	Strong
LI	>-3	<-3, >-5	<-5
SI	>4	4 - -4	<-4
KI	<25	25-35	>35
TT	<45	45-55	>55
SWEAT	<300	300-600	>600
CAPE	<1000	1000-2500	>2500

Radiosonde is a tool that can measure the distribution of temperature, humidity and pressure from the surface up to a height of 30 km (Fatimah Zahroh et al., 2017). Radiosonde observations in Indonesia are carried out twice a day, namely at 00 and 12 UTC. Radiosondes can be useful for determining the process of convective cloud formation and predicting potential thunder storm events through the atmospheric stability index (Syaifullah, 2011). Radiosonde data can also be used to determine cloud base height through the CCL (Convective Condensation Level), LCL (Lifting Condensation Level) and LFC (Level of Free Convection) indices.

CCL is the height of the cloud base produced by air parcels rising from the surface caused by buoyancy due to heating, while LFC is the layer formed when the temperature of the air parcel being lifted is the same as the dew point temperature through convection temperature. LCL is the level of an air parcel that becomes saturated after experiencing dry adiabatic lift. The LCL level is also used to identify cloud base height (Ferdiansyah, 2012). The LCL and LFC values that can indicate the occurrence of a storm are at an altitude of 832 m - 1361 m (Davies, 2004). The LFC height between 686 m - 763 m and the LCL height between 361 m - 679 m will also indicate very heavy rain (Kim & Lee, 2006).

Based on the 00 UTC rason data of the Kualanamu Meteorological Station, the LCL, CCL and LFC values are 104 m, 1231 m, 1477 m respectively. This could potentially cause precipitation. This data also shows an atmospheric stability index with the potential for moderate hurricanes. So, if atmospheric conditions allow, precipitation can occur.

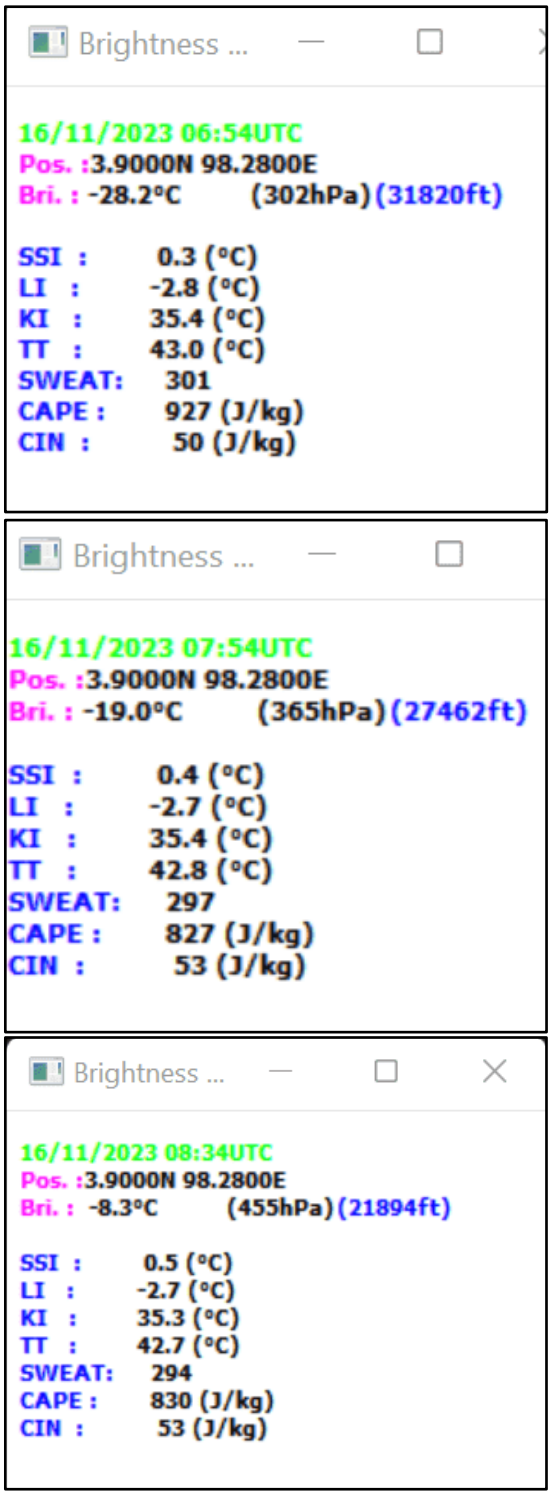


Figure 15. Himawari-9 Satellite Air Stability Index

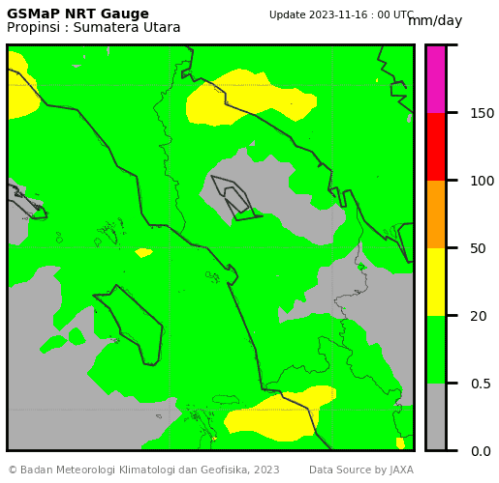


Figure 16. Daily North Sumatra Precipitation 16 November 2023

Based on data at 7 UTC in Figure 14, it is known that the potential for storms can occur with moderate intensity. As time goes by, the potential for storms decreases to weak intensity. This is proven by precipitation data that it rains around 20-50 mm/day. According to the Meteorology, Climatology and Geophysics Agency (BMKG), this can be classified as moderate intensity rain. If linked back to monitoring hot spots, small fires are difficult to detect if atmospheric conditions are unstable. This is because satellites tend to interpret objects above the fire location, but are not yet able to penetrate cloud cover. However, FIRMS is quite capable of interpreting small fires compared to other sources.

CONCLUSION

The tire warehouse fire that occurred in Medan Marelan on November 16 2023 can be detected and monitored via remote sensing. NASA's FIRMS method is more effective than other sources because some satellite images have not been able to penetrate the cloud cover at the location of the incident. This was proven based on RGB Ash and Natural Fire Color visualizations and validated using radiosonde data regarding the atmospheric stability index at the time of the incident. The RGB can only detect tall, thick clouds rather than hot spots. So, in monitoring hot spots, especially detecting small fires, FIRMS is superior. However, data validation must still be carried out so that the data obtained is appropriate.

REFERENCES

Baugh, K. (2014). *Nightfire: Using The Viirs Nighttime M-Bands To Detect And Characterize Combustion Sources*.

Davies, J. M. (2004). *Total Cape, Low-Level Cape, And Lfc In Significant Tornado Events With Relatively High Lcl Heights*. Http://Members.Cox.Net/Jdavies1

Endrawati, Purwanto, J., Nugroho, S., & S, R. A. (2017). Identifikasi Areal Bekas Kebakaran Hutan Dan Lahan Menggunakan Analisis Semi Otomatis Citra Satelit Landsat (Identification Of Forest And Land Burnt Scar Area Using Semi Automatic Analysis Of Landsat Sattelite Imagery) E. *Seminar Nasional Geomatika 2017: Inovasi Teknologi Penyediaan Informasi Geospasial Untuk Pembangunan Berkelanjutan*, 237–282. Https://Modis-Catalog.Lapan.Go.Id/Monitoring

Fatimah Zahroh, N., Wayan Srimani Puspa Dewi, N., Harsanti, D., Besar Teknologi Modifikasi Cuaca -Bppt, B., Ir Mohammad Soebagio, G., Kawasan Puspiptek, G., Selatan, T., Studi Klimatologi Terapan, P., & Pertanian Bogor, I. (2017). The Use Of Atmospheric Instability Indices To Predict Thunderstorm Event On Peak Wet Season Condition In 2016. *Jurnal Sains & Teknologi Modifikasi Cuaca*, *18*(1), 9–15.

Ferdiansyah, A. (2012). Potensi Parameter Keluaran Raob (Rawinsonde Observation Programs) Sebagai Indikator Kunci Dalam Analisis Curah Hujan. In *Skripsi. Fakultas Mipa: Institut Pertanian Bogor.* Institut Pertanian Bogor .

Herdian, A., Boreel, A., & Loppies, R. (2021). Tingkat Kerawanan Kebakaran Hutan Dan Lahan Menggunakan Sistem Informasi Geografis (Sig) Di Kota Ambon (Studi Kasus Di Jazirah Leitimur Selatan). *Jurnal Hutan Pulau-Pulau Kecil*, *5*(1), 1–13. Https://Doi.Org/10.30598/Jhppk.2021.5.1.1

Hidayat, T., Priyatna, M., Sutanto Ahmad, Khudri, A. Al, & Khomarudin Rokhis. (2019). Informasi Sebaran Titik Panas Berbasis Webgis Untuk Pemantauan Kebakaran Hutan Dan Lahan Di Indonesia Hotspot Distribution Based On Webgis For Forest And Land Fire Monitoring In Indonesia. *Jurnal Teknologi Lingkungan*, *20*(1). Http://Pycsw.Org

Kim, H. Woo, & Lee, D. K. (2006). An Observational Study Of Mesoscale Convective Systems With Heavy Rainfall Over The Korean Peninsula. *American Meteorological Society*, *21*, 125–148.

Kushardono, D. (2012). Kajian Satelit Penginderaan Jauh Cuaca Generasi Baru Himawari 8 Dan 9. *Pusat Teknologi Dan Data Penginderaan Jauh Lembaga Penerbangan Dan Antariksa Nasional*, *3*(5), 41–49.

Lapan. (2016). *Panduan Teknis Informasi Titik Panas (Hotspot) Kebakaran Hutan/Lahan* (Vol. 1).

Nasa's Earth Observing System. (2002). *Modis Moderate Resolution Imaging Spectroradiometer*.

Pandjaitan, B. S., & Panjaitan, A. (2018). Pemanfaatan Data Satelit Cuaca Generasi Baru Himawari 8 Untuk Mendeteksi Asap Akibat Kebakaran Hutan Dan Lahan Di Wilayah Indonesia (Studi Kasus: Kebakaran Hutan Dan Lahan Di Pulau Sumatera Dan Kalimantan Pada Bulan September 2015). *Seminar Nasional Penginderaan Jauh*. Https://Doi.Org/10.13140/Rg.2.2.27568.05120

Sepriando, A., & Heru Jatmiko, R. (2019). Deteksi Kebakaran Hutan Dan Lahan Menggunakan Citra Satelit Himawari-8 Di Kalimantan Tengah Forest And Land

Fires Detection Using Himawari-8 Satellite Imagery In Central Kalimantan. In *Jurnal Sains & Teknologi Modifikasi Cuaca* (Vol. 20, Issue 2). Https://Worldview.Earthdata.Nasa.Gov

Syaifullah, D. (2011). Potensi Atmosfer Dalam Pembentukan Awan Konvektif Pada Pelaksanaan Teknologi Modifikasi Cuaca Di Das Kotopanjang Dan Das Singkarak 2010. *Jurnal Sains & Teknologi Modifikasi Cuaca*, *12*(1), 9–16.

Tampubolon, M. V., Tambunan, L., & Agirachman, F. A. (2020). Studi Literatur Pencegahan Bahaya Kebakaran Pada Pemukiman Masyarakat Suku Baduy Dan Penerapannya. *Arsitektura*, *18*(2), 351. Https://Doi.Org/10.20961/Arst.V18i2.44957

Vetrita, Y., Zubaidah, A., Priyatna, M., & Sukowati, K. D. A. (2014). Validasi Hotspot Di Wilayah Rawan Kebakaran Hutan 2012: Kasus Lahan Gambut Dan Kebakarn Kecil. *Seminar Nasional Penginderaan Jauh*, 491. Https://Earthdata.Nasa.Gov/Data/Near-Real-Time-Data/Firms