21st International Conference Man and Working Environment
SEMSIE
Safety Engineering & Management - Science, Industry, Education

REVIEW PAPER

DOI: 10.46793/SEMSIE25.095J

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COMPARATIVE ANALYSIS OF DATA SOURCES FOR WILDFIRE MONITORING SYSTEMS

Abstract: *Monitoring wildfire data is essential for risk management and decision-making, given that they seriously threaten ecosystems, economies and human communities. The paper analyzes data on wildfires in the Republic of Serbia obtained from the European Forest Fire Information System (EFFIS), the Global Wildfire Information System (GWIS), and the Statistical Office of the Republic of Serbia. The results show significant differences in the reported number of fires and the burned area, indicating the need for integration of various data sources to obtain a more accurate insight into fire activity. By comparing the methodologies and operational principles of EFFIS and GWIS, this paper provides an overview of their differences, advantages, and limitations. Understanding these differences can contribute to improving wildfire prevention and response both in Serbia and globally. The importance of monitoring different data sources was emphasized to gain a more precise insight into the frequency and spread of fires, as well as to establish a basis for more effective prevention. The monitoring and analysis of this data can contribute to a better understanding of the causes and dynamics of wildfires, with the aim of improving forecasting and timely response.*

Keywords: wildfires, EFFIS, GWIS, number of fires, burned area.

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INTRODUCTION

Monitoring wildfires is of great significance, given that they pose a growing threat to human safety, ecosystem preservation, and the regional economy. In addition, wildfires emit greenhouse gases and affect local air quality. On a global scale, more than 200,000 wildfires occur annually, burning a total area of 3.5 to 4.5 million square kilometers (Hua & Shao, 2017). These effects are exacerbated by climate change, which reduces the moisture content in vegetation, creating favorable conditions for wildfires to ignite. Fire seasons are becoming increasingly longer, wildfires are emerging in areas where they were previously uncommon, and the average fire size is also growing (Artés et al., 2019).

Early and reliable detection and monitoring of wildfires are essential for minimizing potential damage and the costs associated with fire suppression (Hua & Shao, 2017). This process entails not only the identification and characterization of active fire locations, but also the continuous tracking of wildfires throughout their life cycle – including the evaluation of pre-fire fuel conditions and the assessment of post-fire impacts on vegetation, climate, and air quality (Chen et al., 2024).

Historically, wildfire monitoring relied on lookout towers and aerial reconnaissance; however, these methods were limited in their ability to provide continuous observation at continental or global scales. The advent of remote sensing technology, marked by the launch of the first Landsat satellite in the 1970s, enabled early detection and mapping of wildfires (Chen et al., 2024).

Today, systems such as the European Forest Fire Information System (EFFIS), Global Wildfire Information System (GWIS), and Fire Information for Resource Management System (FIRMS) are most commonly used. These platforms enable near real-time active fire data, mapping of affected areas, and the retrieval of various datasets for further analysis.

The European Commission's Joint Research Centre manages both GWIS and EFFIS, platforms that redistribute and visualize hotspot data from Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS), originally provided by FIRMS, along with other fire-related datasets such as fire weather forecasts and burned area statistics. These systems offer fire-related insights at the global level (GWIS) and for the European Union and neighboring countries (EFFIS). Similar to FIRMS, both GWIS and EFFIS generate updated spatial data products on an hourly basis, depending on the availability of data from MODIS and VIIRS (Hope et al., 2024).

This paper will focus on the EFFIS and GWIS systems, examining their similarities, differences, and capabilities. For comparison, wildfire data available for the Republic of Serbia from 2019 to 2023 will be used.

EUROPEAN FOREST FIRE INFORMATION SYSTEM (EFFIS)

The European Forest Fire Information System was created by the European Commission (EC) in partnership with national fire administrations to assist those responsible for forest fire protection in the EU and neighbouring countries, and to offer the EC and the European Parliament consistent data on forest fires across Europe. In 2015, EFFIS was integrated as one of the elements of the Emergency Management Services within the EU Copernicus program. Specific applications available through EFFIS include the Current Situation Viewer, Current Statistics Portal, Firenews, Long-term fire weather forecast and Wildfire Risk Viewer (European Forest Fire Information System [EFFIS], n.d.).

The system is structured into modules that cover all phases of the fire cycle: the pre-fire phase, which supports fire prevention and preparedness; the active fire phase; and the post-fire phase, which focuses on evaluating the impact of forest fires – including land cover damage, atmospheric emissions, soil degradation, and erosion. In addition to these modules, the European Forest Fire Database stores data contributed by EFFIS network members, currently encompassing 43 countries across Europe, North Africa, and the Middle East (Monteiro et al., 2013).

The system features several key modules that support this process, starting from the pre-fire phase (EFFIS):

1) Fire Danger Assessment;
2) Rapid Damage Assessment, which involves:
    - Active fire detection;
    - Fire severity assessment;
    - Land cover damage assessment;
3) Emissions Assessment and Smoke Dispersion;
4) Potential Soil Loss Assessment;
5) Vegetation Regeneration.

The first two modules, Fire Danger Assessment and Rapid Damage Assessment, are available in near-real time through the Current Situation Viewer application.

As mentioned, for active fire detection, EFFIS uses satellite sensors MODIS and VIIRS.

The MODIS sensor is located on the TERRA satellite (originally known as EOS AM-1) and the AQUA satellite (originally known as EOS PM-1). The orbit of the TERRA satellite around Earth is timed so that it passes from north to south over the equator in the morning. In contrast, AQUA passes from south to north over the equator in the afternoon. This arrangement ensures that the same area of the Earth is observed both in the morning and in the afternoon, allowing for the monitoring of changes throughout the day. MODIS detects a wide spectrum of electromagnetic energy and performs measurements at three spatial resolutions: 200, 500, and 1000 meters (Modis_brochure, n.d.). The spatial resolution of the active fire detection pixel from MODIS is 1 km (EFFIS).

The VIIRS 375m thermal anomalies/active fire product provides data from the VIIRS sensor aboard the joint NASA/NOAA Suomi National Polar-orbiting Partnership (Suomi NPP) and NOAA-20 satellites. The 375 m data complements MODIS fire detection. Both MODIS and VIIRS products demonstrate strong consistency in detecting hotspots. However, the enhanced spatial resolution of the VIIRS 375 m data product offers better detection of smaller fires and more precise mapping of large fire boundaries. Additionally, this product performs better at night. As a result, it is highly suitable for fire management applications, such as real-time alert systems, and scientific research requiring more accurate fire mapping (NASA Earthdata, n.d.).

EFFIS locates wildfires based on so-called thermal anomalies they produce. Using algorithms, the temperature of the potential fire is compared to the temperature of the surrounding land. If the temperature difference exceeds a predefined threshold, the potential fire is confirmed as an active fire or "hot spot". To reduce false alarms and exclude active fires that are not classified as wildfires (such as agricultural burnings), EFFIS displays only a filtered selection of hotspots detected by FIRMS. This filtering is based on a knowledge-based algorithm that considers factors like nearby land cover types, proximity to urban and artificial areas, and the confidence level of each hotspot. Using the identify feature tool, users can access key information for each active fire, including its geographic coordinates, administrative location (commune and province), and the predominant land cover type affected (EFFIS).

In addition to this information, EFFIS also provides data on the number of fires and the burned area for a given time period. Table 1 presents these data for the Republic of Serbia for the period from 2019 to 2023.

Table 1. *Burned area (ha) and number of fires in Serbia (2019-2025) (EFFIS)*

Year	Burned area (ha)	Number of fires
2019	15763	103
2020	9385	90
2021	7006	61
2022	11508	104
2023	2312	23

The highest number of fires was recorded in 2022 (104), while the largest burned area occurred in 2019, amounting to 15,763 ha. In contrast, the lowest number of fires was reported in 2023 (23), which also had the smallest burned area, amounting to 2,312 ha.

For the monitoring of burned areas, EFFIS utilizes a combination of high spatial resolution data – primarily MODIS at 250 m, along with Sentinel-2 imagery (at 10

– 20 m resolution), enabling more detailed analysis of fire-affected regions. MODIS captures the perimeters of burned areas for fires approximately 30 hectares or larger. Since 2018, the integration of Sentinel-2 imagery has allowed for the mapping of smaller fires (under 30 hectares) and the refinement of final fire perimeters initially delineated using MODIS 250 m imagery (EFFIS, Copernicus Atmosphere Monitoring Service, 2024).

The process of burned area detection in EFFIS involves comparing satellite imagery of the affected region before and after the wildfire. For this purpose, the so-called Normalized Burn Ratio (NBR) is used. NBR is commonly applied and is calculated based on satellite imagery to support the identification of burned areas. Specifically, the difference in NBR values (dNBR) between the two images is used to detect changes on the Earth's surface. The dNBR is calculated by subtracting the post-fire NBR value from the pre-fire NBR value, as shown in Equation 1 (Suárez-Fernández et al., 2024).

$$dNBR = NBR_{prefire} - NBR_{postfire} \quad (1)$$

The purpose of calculating dNBR is to assess fire severity (Arisanty et al., 2022). Positive dNBR values indicate burned areas, with higher values corresponding to more severe vegetation damage (Copernicus Atmosphere Monitoring Service, 2024; Suárez-Fernández et al., 2024).

The dNBR index also provides information on post-fire vegetation dynamics, so negative dNBR values indicate vegetation regeneration following a fire (Llorens et al., 2021).

The process of mapping burned areas within the EFFIS system is based on a semi-automatic procedure. Initial fire mapping is carried out using a combination of spectral band thresholds and auxiliary information, such as data from the CORINE Land Cover database, active fire detection products from MODIS and VIIRS sensors, and fire news applications. After the initial detection, the fire maps are visually verified and corrected using imagery from MODIS and Sentinel-2 satellites (EFFIS).

GLOBAL WILDFIRE INFORMATION SYSTEM (GWIS)

The Global Wildfire Information System (GWIS) is a collaborative initiative under the Group on Earth Observation (GEO) and the Copernicus Work Programs. It aims to provide comprehensive and up-to-date wildfire monitoring, assessment, and forecasting on a global scale. GWIS integrates existing regional and national information sources to offer a comprehensive global assessment of fire regimes and their impacts. GWIS builds on the ongoing activities of the EFFIS, the Global Terrestrial Observing System (GTOS), Global Observation of Forest Cover – Global Observation of Land Dynamics (GOFC-GOLD), Fire Implementation Team (GOFC Fire IT), and the associated Regional Networks. It complements global wildfire information–gathering initiatives by integrating and enhancing existing activities. Currently, GWIS is made of five applications (Global Wildfire Information System [GWIS], n.d.): Current Situation Viewer, Current Statistics Portal, Country Profile, Long-term fire weather forecast and Data & Services.

GWIS operates in a similar manner to EFFIS, with the primary distinction being that EFFIS is focused on Europe, whereas GWIS is a global system. However, although both platforms utilize MODIS and VIIRS data, discrepancies in the number of recorded fires and burned areas may occur. Table 2 presents data on the number of fires and burned areas in the Republic of Serbia, as reported by GWIS, for the same time period from 2019 to 2023.

Table 2. *Burned area (ha) and number of fires in Serbia (2019-2025) (GWIS)*

Year	Burned area (ha)	Number of fires
2019	171753	568
2020	28824	141
2021	34886	155
2022	26587	133
2023	31211	132

A clear discrepancy exists between the data on the number of fires and burned areas in the Republic of Serbia reported by EFFIS and GWIS. These differences can be attributed to the use of different methodologies for fire mapping. The EFFIS methodology for Near-Real-Time (NRT) identification of fire events incorporates MODIS 250 m and Sentinel-2 imagery, which means that the number of fires corresponds to the number of burned areas mapped by EFFIS. In contrast, the GWIS methodology is based on the spatial-temporal clustering of thermal anomalies detected by MODIS and VIIRS. Fires mapped in GWIS may include deliberately ignited fires for vegetation management purposes, which helps explain the discrepancies in the number of fires identified by EFFIS and GWIS (GWIS).

The data available in GWIS are derived according to the GlobFire methodology, which uses the MODIS burned area product (MCD64A1) to define fire events and calculate burned areas for each event. This product integrates satellite imagery from both Terra and Aqua platforms with thermal anomaly data, and delivers pixel-level information on burn extent and data quality. GWIS GlobFire data are not available in real time, as the underlying MCD64A1 product typically requires about two months for processing and release. Additionally, the recorded start and end dates of fire events are subject to a temporal uncertainty of several days (GWIS).

It is also important to note that the definition of a fire event differs between GlobFire and EFFIS. In EFFIS, the same burned area originating from two separate ignition sources is classified as two distinct fire events. In contrast, GlobFire treats it as a single event if two fires remain active within a five-day period and their burned areas overlap or are contiguous (Artés et al., 2019).

Table 3 summarizes the key methodological differences between EFFIS and GWIS.

Table 3. *Comparison of EFFIS and GWIS Wildfire Monitoring Systems*

Characteristic	EFFIS	GWIS
Geographic scope	Europe, Mediterranean region	Global
Active fire detection	MODIS (1 km), VIIRS (375 m)	MODIS (1 km), VIIRS (375 m)
Burnt Areas	MODIS 250 m + Sentinel-2 Imagery	MODIS MCD64A1
Burnt Area Mapping Method	Semi-automatic classification with visual verification	Fully automatic processing from MCD64A1 burned area product
Update Frequency	Near-real time (daily for active fires, verified weekly)	Seasonal/global updates (not real-time)
Validation Process	Yes – visual inspection and manual correction	No – fully automated
Fire Event Definition	Two ignition points = two fires, even if areas merge	Merged areas within 5 days = one fire
Minimum Fire Size Mapped	~30 ha (due to filtering and validation threshold)	<10 ha possible (high sensitivity, no filtering)

These differences in methodology, approach, and objectives between the two systems contribute significantly to the discrepancies in the reported number of fires and the total estimated burned area. Therefore, data from EFFIS and GWIS should be interpreted in light of their respective frameworks and limitations.

ANALYSIS OF WILDFIRE DATA FROM EFFIS, GWIS, AND THE STATISTICAL OFFICE OF SERBIA

In addition to the data provided by EFFIS and GWIS, official statistics on the number of wildfires and burned areas should also be taken into account.

For the sake of comparison, data from the Statistical Office of the Republic of Serbia on the number of fires and burned areas for the period 2019 to 2023 are also presented.

According to the Statistical Yearbook of the Republic of Serbia (2024), the total forested area in the Republic of Serbia amounts to 2,854,956 hectares. Of this, 42% (1,191,466 ha) is under state ownership, while 58% is privately owned. Furthermore, the Statistical Office of the Republic of Serbia reports that a total of 159 wildfires were recorded in both state-owned and privately owned forests during the period from 2019 to the end of 2023 (Gavrilović, 2024).

In comparison, EFFIS data indicate a total of 381 fires during the same period, while GWIS reports a significantly higher number – 1129 fire events.

The data on the number of wildfires and the burned area, as reported by the Statistical Office of the Republic of Serbia for the specified period, are presented in Table 4.

Table 4. *Burned area (ha) and number of fires in Serbia (2019-2023) (*Statistical Office of the Republic of Serbia*)*

Year	Burned area (ha)	Number of fires
2019	1079	41
2020	196	26
2021	834	34
2022	423	45
2023	192	13

For the purpose of data comparison, Figures 1 and 2 present the number of wildfires and the burned area in Serbia, as reported by EFFIS, GWIS, and the Statistical Office of the Republic of Serbia for the period 2019 – 2023.

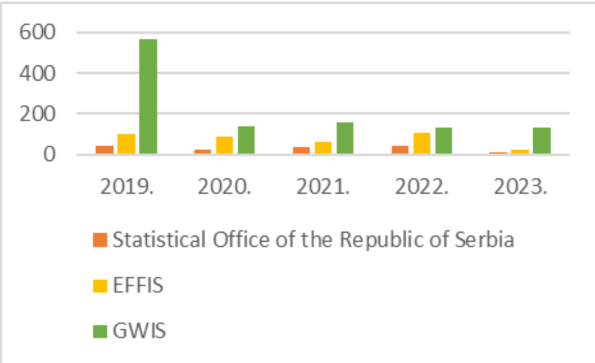

Figure 1. *Number of fires (Statistical Office of the Republic of Serbia, EFFIS, GWIS)*

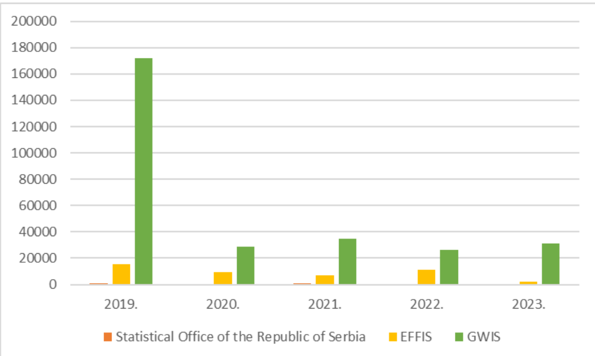

Figure 2. *Burned area (ha) (Statistical Office of the Republic of Serbia, EFFIS, GWIS)*

The discrepancies in the number of wildfires and the burned area during the 2019 – 2023 period can be attributed to the fact that the official data provided by the Statistical Office of the Republic of Serbia likely include only reported fires or those that required firefighting intervention. On the other hand, EFFIS and GWIS detect wildfires based on thermal anomalies, which may also capture smaller fires such as agricultural burns, waste burning, and similar activities.

Another limitation affecting the reliability of burned area and active fire data is the fact that most currently operational Earth Observation (EO) sensors are not specifically designed for wildfire monitoring. For example, active fires may be falsely detected due to highly reflective surfaces that mimic the thermal signature of fires by reflecting sunlight. Regarding burned areas, rapid vegetation regrowth in certain ecosystems (such as grasslands and croplands) can obscure recent fire evidence. Additionally, it is particularly challenging to develop algorithms that perform well at the global scale due to regional differences in vegetation, climate, and fire behavior (Chen et al., 2024).

CONCLUSION

The comparison of wildfire monitoring systems, EFFIS and GWIS, based on available data on the number of fires and burned areas in the Republic of Serbia for the period 2019–2023, revealed significant discrepancies between the two systems. These differences can be attributed to several factors. First, the systems rely on different satellite data sources. Specifically, for burned area estimation, EFFIS utilizes MODIS 250 m and Sentinel-2 imagery, whereas GWIS relies on the MODIS MCD64A1 product. In addition to differences in sensors, the data processing methodologies also vary. The EFFIS process is semi-automated and includes visual verification, which contributes to higher mapping accuracy but may result in underestimation of the total burned area. In contrast, GWIS employs a fully automated algorithm that can more easily detect very small fires, though it lacks precision in delineating their spatial extent.

These differences are also evident in the detection of active fires. GWIS applies spatial-temporal clustering of thermal anomalies to identify fires, often recording a higher number of events, as each thermal anomaly is treated as a potential fire. In contrast, EFFIS filters detected thermal anomalies and supplements them with additional information, such as news reports and field observations.

The discrepancies between the two systems—including differences in the definition of a "fire" and the criteria for grouping fire events – highlight the importance of careful interpretation of these data. To ensure reliable use of the data for research, decision-making, and risk management, it is essential to understand both the strengths and limitations of each system, as well as the potential for their complementarity.

To improve the accuracy of wildfire detection and analysis, combining data from multiple sources is recommended. Furthermore, integrating satellite-based observations with ground reports and official national statistics can enhance the credibility of analyses. Continued improvement of automatic burned area classification algorithms, along with harmonization of definitions and methodologies between systems, represent key steps toward greater data accuracy and comparability.

ACKNOWLEDGEMENTS

This paper is supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia under agreement № 451-03-136/2025-03/200148, Goal SD 15, with the University of Niš, Faculty of Occupational Safety.

REFERENCES

Arisanty, D., Feindhi Ramadhan, M., Angriani, P., Muhaimin, M., Nur Saputra, A., Puji Hastuti, K., & Rosadi, D. (2022). Utilizing Sentinel-2 Data for Mapping Burned Areas in Banjarbaru Wetlands, South Kalimantan Province. International Journal of Forestry Research, 2022. https://doi.org/10.1155/2022/7936392

Artés, T., Oom, D., de Rigo, D., Durrant, T. H., Maianti, P., Libertà, G., & San-Miguel-Ayanz, J. (2019). A global wildfire dataset for the analysis of fire regimes and fire behaviour. Scientific Data, 6(1). https://doi.org/10.1038/s41597-019-0312-2

Chen, Y., Morton, D. C., & Randerson, J. T. (2024). Remote sensing for wildfire monitoring: Insights into burned area, emissions, and fire dynamics. In One Earth (Vol. 7, Issue 6, pp. 1022–1028). Cell Press. https://doi.org/10.1016/j.oneear.2024.05.014

Copernicus Emergency Management Service. (n.d.). About EFFIS. European Forest Fire Information System (EFFIS). https://forest-fire.emergency.copernicus.eu/about-effis

Copernicus Emergency Management Service. (n.d.). Active fire detection. European Forest Fire Information System (EFFIS). https://forest-fire.emergency.copernicus.eu/about-effis/technical-background/active-fire-detection

Copernicus Emergency Management Service. (n.d.). Rapid damage assessment. European Forest Fire Information System (EFFIS). https://forest-fire.emergency.copernicus.eu/about-effis/technical-background/rapid-damage-assessment

Gavrilović, D. (Ed.). (2024). Statistical Yearbook of the Republic of Serbia, 2024. Statistical Office of the Republic of Serbia. https://www.stat.gov.rs/sr-cyrl/publikacije/publication/?p=15984&tip=2

Hope, E. S., McFayden, C. B., de Jong, M. C., Crowley, M. A., Johnston, J. M., Davies, D. K., Olsina, O., Hewson, J., San-Miguel-Ayanz, J., Ferrari, D., & Sloane, M. (2024). Exploring the use of satellite Earth observation active wildland fire hotspot data via open access web platforms. International Journal of Digital Earth, 17(1). https://doi.org/10.1080/17538947.2024.2420821

Hua, L., & Shao, G. (2017). The progress of operational forest fire monitoring with infrared remote sensing. Journal of Forestry Research, 28(2), 215–229. https://doi.org/10.1007/s11676-016-0361-8

Joint Research Centre. (n.d.). Active fire detection. Global Wildfire Information System (GWIS). https://gwis.jrc.ec.europa.eu/about-gwis/technical-background/active-fire-detection

Joint Research Centre. (n.d.). Burnt areas. Global Wildfire Information System (GWIS).

https://gwis.jrc.ec.europa.eu/about-gwis/technicalackground/burnt-areas

Llorens, R., Sobrino, J. A., Fernández, C., Fernández-Alonso, J. M., & Vega, J. A. (2021). A methodology to estimate forest fires burned areas and burn severity degrees using Sentinel-2 data. Application to the October 2017 fires in the Iberian Peninsula. International Journal of Applied Earth Observation and Geoinformation, 95. https://doi.org/10.1016/j.jag.2020.102243

Modis_brochure. (n.d.). NASA's Earth Observing System.

Monteiro, A., Corti, P., San Miguel-Ayanz, J., Miranda, A. I., & Borrego, C. (2013). The EFFIS forest fire atmospheric emission model: Application to a major fire event in Portugal. Atmospheric Environment, 84, 355–362. https://doi.org/10.1016/j.atmosenv.2013.11.059

NASA Earthdata. (n.d.). VIIRS I-Band 375 m Active Fire Data. NASA. https://www.earthdata.nasa.gov/data/instruments/viirs/viirs-i-band-375-m-active-fire-data

NASA. (n.d.). Active fire data. Fire Information for Resource Management System (FIRMS). https://firms.modaps.eosdis.nasa.gov/active_fire/

Statistical Office of the Republic of Serbia. (2020). Damages to forests, 2019 (Statistical Release SU10, No. 140).

Statistical Office of the Republic of Serbia. (2021). Damages to forests, 2020 (Statistical Release SU10, No. 137).

Statistical Office of the Republic of Serbia. (2022). Damages to forests, 2021 (Statistical Release SU10, No. 138).

Statistical Office of the Republic of Serbia. (2023). Damages to forests, 2022 (Statistical Release SU10, No. 147).

Statitical Office of the Republic of Serbia. (2024). Damages to forests, 2023 (Statistical Release SU10, No. 147).

Suárez-Fernández, G. E., Martínez-Sánchez, J., & Arias, P. (2024). Assessment of vegetation indices for mapping burned areas using a deep learning method and a comprehensive forest fire dataset from Landsat collection. Advances in Space Research. https://doi.org/10.1016/j.asr.2024.12.001

Zhang, P., Hu, X., Ban, Y., Nascetti, A., & Gong, M. (2024). Assessing Sentinel-2, Sentinel-1, and ALOS-2 PALSAR-2 Data for Large-Scale Wildfire-Burned Area Mapping: Insights from the 2017–2019 Canada Wildfires. Remote Sensing, 16(3). https://doi.org/10.3390/rs16030556