# A WebGIS Base Information System for Monitoring Wildfire Using Suomi-NPP (VIIRS) Satellite in Phare Province, Thailand

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**Abstract**

This paper is present a real-time wildfire monitoring service that exploits Suomi-NPP (VIIRS) satellite to detect hotspots and monitoring the evolution of fire fronts. The service makes heavy use of VIIRS for hotspots on national forest, forest conservation in Phare province, northern part of Thailand. GIS technology is ideally suited as a tool for the demonstration of data derived from continuous monitoring of locations and use to support and deliver information to environmental managers and public. The highest of active fire detection was 943 hotspots located in national forest (a total of 1,374 hotspots) from 15/03/2019 to 15/04/2019. Combined with GeoServer, PostgreSQL/PostGIS, it extends the WebGIS capabilities in providing real-time data from the monitoring activities. Therefore, there is a growing need of WebGIS for easy and fast distribution, sharing, displaying and processing of spatial information which in turn helps in decision making for various natural resources-based application.

**Keywords**: Wildfire, WebGIS, GIS, Suomi-NPP (VIIRS) satellite, Active fire detection, Phare province

## Introduction

Global warming has been one of the main concerns of the period. The reasons of this problem are the green-house gases. Due to the manmade mistakes the carbon dioxide ($CO_2$) emission has reached highest of its level in recent years. Wildfire, fog and deforestation have contributed in increasing the $CO_2$ emission to the atmosphere. Almost every summer, February to April of northern part of Thailand, massive forest wildfires break out in several areas, leaving behind severe destruction in forested and agricultural land, infrastructure and private property, and losses of human lives. When it comes to wildfire management, Geographic Information System (GIS) provides accurate and comprehensive information to analyse, visualize, and prioritize values at risk, such as housing developments, utility infrastructure, wildlife, and natural or cultural resources (Kallimani, Chandra, Vyas, & Kallimani, 2014). GIS technology is ideally suited as a tool for the presentation of data derived from continuous monitoring of locations and used to support and deliver information to environmental managers and the public (Amiruddin, 2016).

GIS technology has been developed in such a way that spatial information is stored and efficiently retrieved and modelling issues are appropriately embedded to support decision making and operational needs. The added value of GIS technology usage in managing crisis evens is directly connected to the profits expected from the exploitation of such technologies designed for supporting decision making related to the geographical space, especially in the case of the operational field that intensely needs to make important decision of spatial nature (Vakalis, Sarimveis, Kiranoudis, Alexandridis, & Bafas, 2004).

The VIIRS (Visible Infrared Imaging Radiometer Suite) sensor on the S-NPP (Suomi National Polar-orbiting Partnership) satellite combined fire-sensitive channels, including a dual-gain high-saturation temperature 4 μm channel, enabling active fire detection and characterization. The active fire product, based on the 750 m moderate resolution “M” bands of VIIRS, is one of the standard operational products generated by the interface data processing segment of the S-NPP ground system. The product builds on an earlier “Collection 4” version of the algorithm used for processing MODIS (Moderate Resolution Imaging Spectroradiometer) data. Following postlaunch quality assessments and corrections in the input VIIRS sensor data record data processing, an initial low detection bias was removed. The product achieved beta quality in April 2012. Daily spurious detections along-scan lines were also significantly reduced as a result of further processing improvements in October 2012. Daily spurious detections along-scan lines were also significantly reduced as a result of further processing improvements in October 2012. Direct product comparison with MODIS over 4 months of data in 2013 has shown that VIIRS producers about 26% more detections than MODIS within the central 3 pixel VIIRS aggregation zone of about $\pm 31^{\circ}$ scan angle range and 70% more detections outside of the zone, mainly as a result of the superior VIIRS scanning and sampling characteristics. Further development is in progress to ensure high-quality VIIRS fire products that continue the MODIS data record and better serve the user community by delivering a full image classification product and fire radiative power retrievals (Csiszar et al., 2013).

WebGIS is the integrated product of GIS and internet technologies; in WebGIS, the internet technologies are connected with GIS in order to take advantage of their special characteristics, such as easy usability, use of the GIS data such as input, adjustment, manipulation, analysis, and output of geographical information and to bring out related service on the internet (Miao & Yuan, 2013). This paper presents a real-time wildfire monitoring service that exploits Suomi-NPP satellite to detect hotspots and monitoring the evolution of fire fronts in Phare province, northern part of Thailand. The entire system has been implemented using Free and Open Source Software (FOSS) and Open Geospatial Standards.

## Methods and Materials

The study area was conducted at the Phare province, northern part of Thailand (Figure 1).

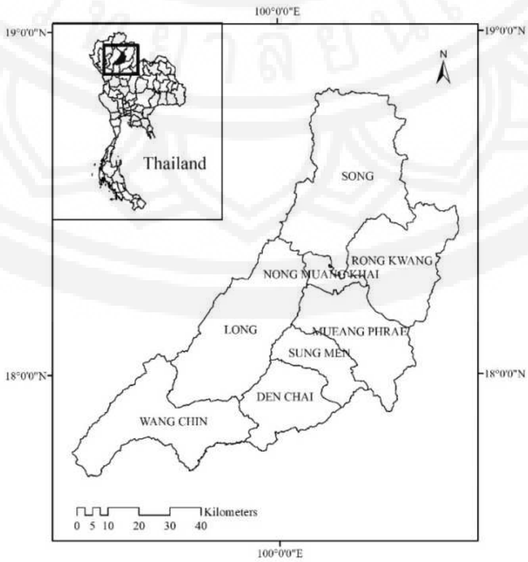



**Figure 1** The study area, Phare province

Phare province comprises 8 districts, 78 sub-districts. The province covers an area of 6,474 square kilometer with geographical location between 18°00’ N to 19°00’ N and 100°00’ E to 100°15’ E. It is mostly covered with agriculture and forest area, with an approximate elevation of 155 meters about mean sea level.

Implementation of the WebGIS base information system for monitoring wildfire using Suomi-NPP (VIIRS) satellite consist of the software used and details of item software version. The WebGIS was designed and developed with a user-friendly main interface. The development of applications and tools is shown in table 1.

**Table 1** The development of applications and tool

| **Software and Hardware** | **Requirements** |
|---|---|
| Server | Cloud Server |
| Operating System Server | Ubuntu Server |
| Web Server | Apache2 |
| | PHP5 |
| Application Server | Apache Tomcat |
| | MapServer |
| | GeoServer2.9 |
| Database Server | PostgreSQL |
| Spatial Database | PostGIS2.0 |
| User Interface | OpenLayers 2.13 GeoExt and ExtJS |
| | jQuery Mobile |
| | Java for android |
| Client Web Browser | Chrome, Firefox, Internet Explorer, Safari |

The server side provides access to geospatial data and performs online spatial requests such as find, spatial query, measure, and closeness analysis based on requests made by from user. The main components of the WebGIS was presented in Figure 2. To respond to the need of remote spatial data management, WebGIS analytical tools to process geospatial data manipulation are used in many services and organizations. In this paper, the WebGIS is implemented using GeoServer and GeoWebCache to interact with the spatial database on a desktop. HTML, PHP and JavaScript are used to develop the user-friendly interface. The system allows the client GIS to update and edit spatial data via desktop GIS.

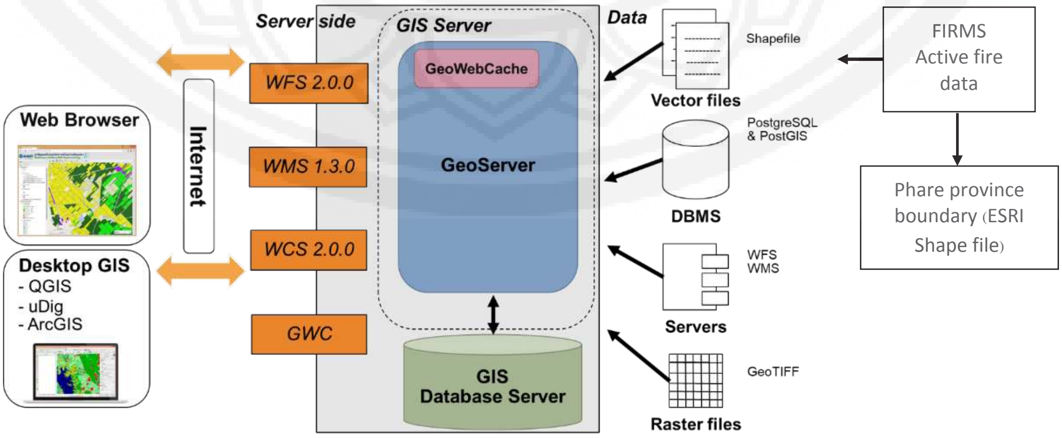



**Figure 2** Architecture of WebGIS

The advances in Free and Open Source Solutions for Geoinformatics (FOSS4G) provide an alternative approach to geospatial software development. FOSS4G has become popular as a practical alternative for develops and users and has been successfully used in many applications. The FOSS4G software stack comprises of system software, data processing tools, data delivery and user interface tools for both desktop and web-based environment (Choosumrong, Raghavan, Jeefoo, & Vaddadi, 2016). The VIIRS sensor was designed to operate with a specific pixel aggregation scheme that impacts fire detection through the resulting spatial sampling, and to some extent, also the radiometric signal. Actual radiometric measurements are made by native resolution pixels, having approximate pixel sizes of 750 m x 250 m at nadir for moderate resolution M bands (for "imagery" resolution I bands the pixel lateral dimensions are half of those of the M bands). Between nadir view and a scan angle of 31.58°, three native resolution pixels are aggregated into a single nominal pixel. Between 31.58° and 44.6°, two native resolution pixels are aggregated, and beyond the 44.6° scan angle single native resolution pixels constitute a nominal pixel. As a result, the along-scan growth of pixel size is significantly reduced compared to sensors without a similar aggregation scheme, such as MODIS or AVHRR (Wolfe et al., 2013). While for the later sensors fire detection capabilities significantly degrade for off-nadir views; the aggregation switchover angles, the lower limits for detectable fire temperature and area also change more significantly at those angles.

The primary VIIRS data input for active fire detection and characterization is the moderate resolution M13 channel, which encompasses the spectral region between 3.973 µm and 4.128 µm. M13 is a dynamically controlled dual-gain band, which was specifically designed for hot target detection and characterization, with nominal saturation temperatures of 343 K and 634 K and at high and low gain settings, respectively.

The secondary band in the VIIRS fire detection algorithm used to characterize background thermal conditions is M15 at 10.263-11.263 µm. This is a single-gain band, which is subject to the same pixel aggregation scheme described above. However, contrary to the M13 channel, the M15 data are aggregated onboard the spacecraft before being relayed to the ground station; therefore, native resolution, unaggregated data are unavailable (Csiszar et al., 2013). In this research was introduced a new VIIRS active fire detection, which is driven primarily by the 375 m middle and thermal infrared imagery data. The VIIRS active fire data is received from FIRMS active fire web site of NASA (https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms/viirs-i-band-active-fire-data). Furthermore, WebGIS is screening only Phare province, Thailand.

## Results and Discussion

This section describes the capabilities of the proposed application in terms of the services developed, as well as the implications in monitoring wildfire tasks. Figure 3 was shown the main VIIRS active fire detection WebGIS page of all the wildfire hotspot during 15/03/2019 to 15/04/2019 (30 days) in Phare province. When the user opens the WebGIS, all the wildfire hotspot locations are retrieves hotspot from the FIRMS active fire web site by automatically and displayed on the map as green, orange and purple fire points over base Google Map. The wildfire hotspot locations were represented three color types consist of 1) green fire point is national forest, 2) orange fire point is conservation forest, and 3) purple fire point is national forest or conservation forest respectively.

Figure 3 shows how wildfire hotspot location is higher in the national forest (green fire point) and total of fire point during 30 days from 15/03/2019 to 15/04/2019 is 1,374 hotspots of wildfire. For example, fire detection service icons represent hotspots, which mark areas that a high probability of fire.

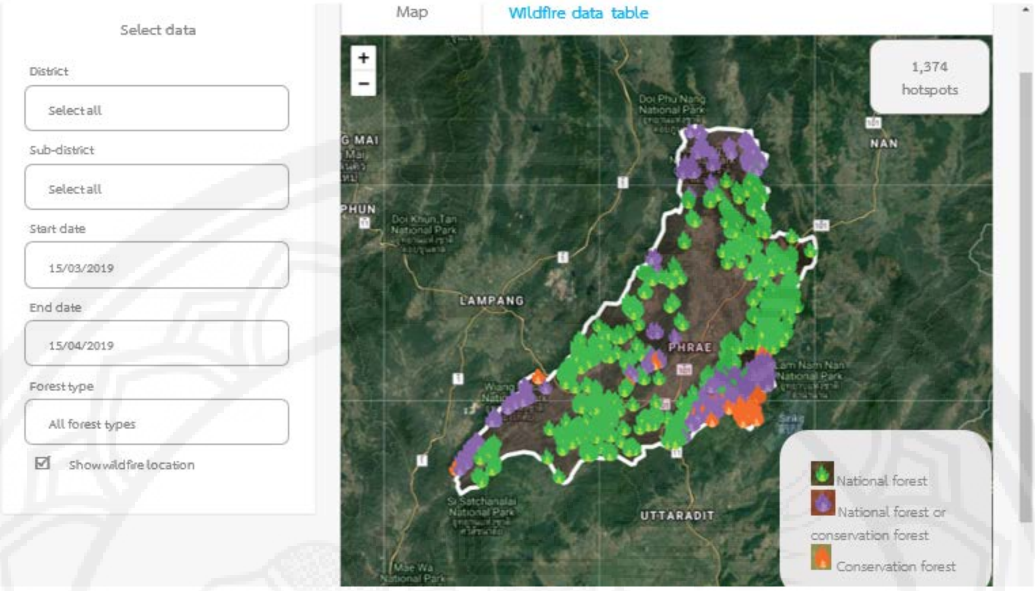



**Figure 3** User interface of the WebGIS monitoring wildfire client application with filtering options

The users select data including district, sub-district, date start, date end and forest types (figure 4). The WebGIS is automatically shown hotspots directly.

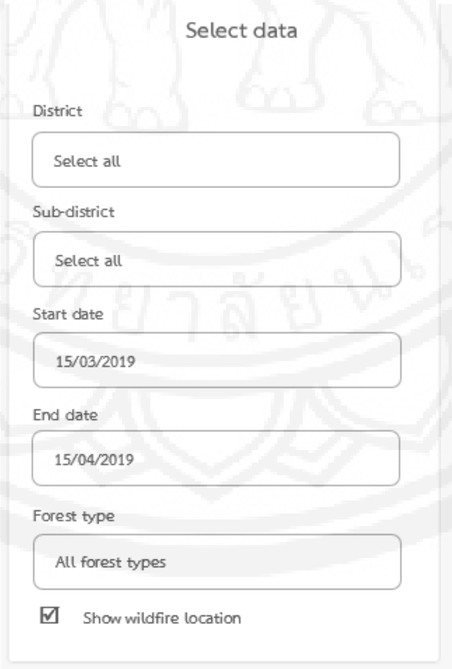



**Figure 4** Select data interface

From figure 5-7, it can be concluded that the highest of active fire detection was national forest (943 hotspots, green fire icon), secondary was national forest or conservation forest (373 hotspots, purple fire icon) and the last was conservation forest (58 hotspots, orange fire icon) respectively.

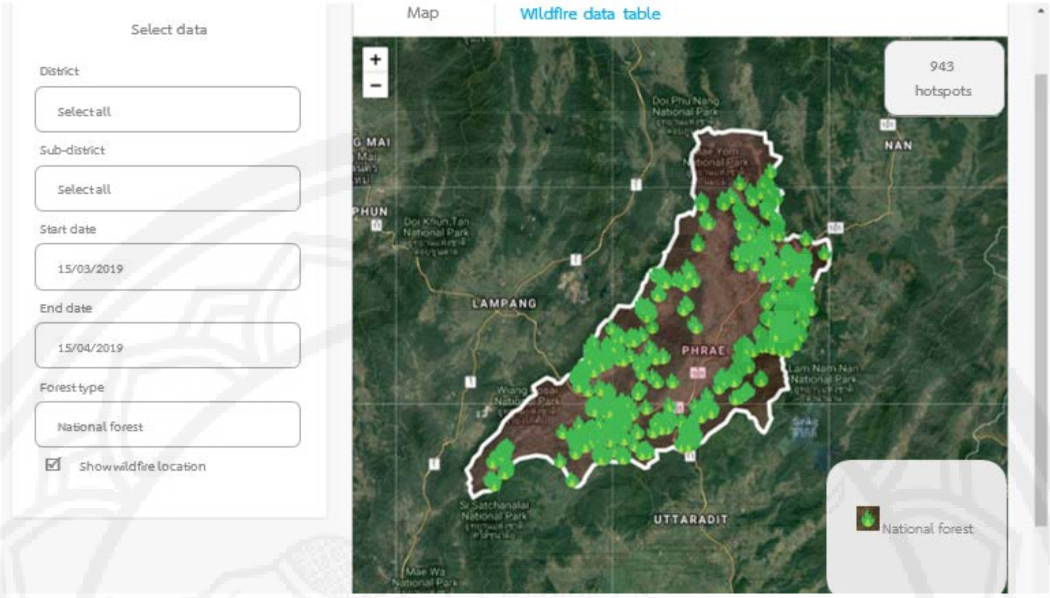



**Figure 5** The wildfire hotspot location in national forest (green)

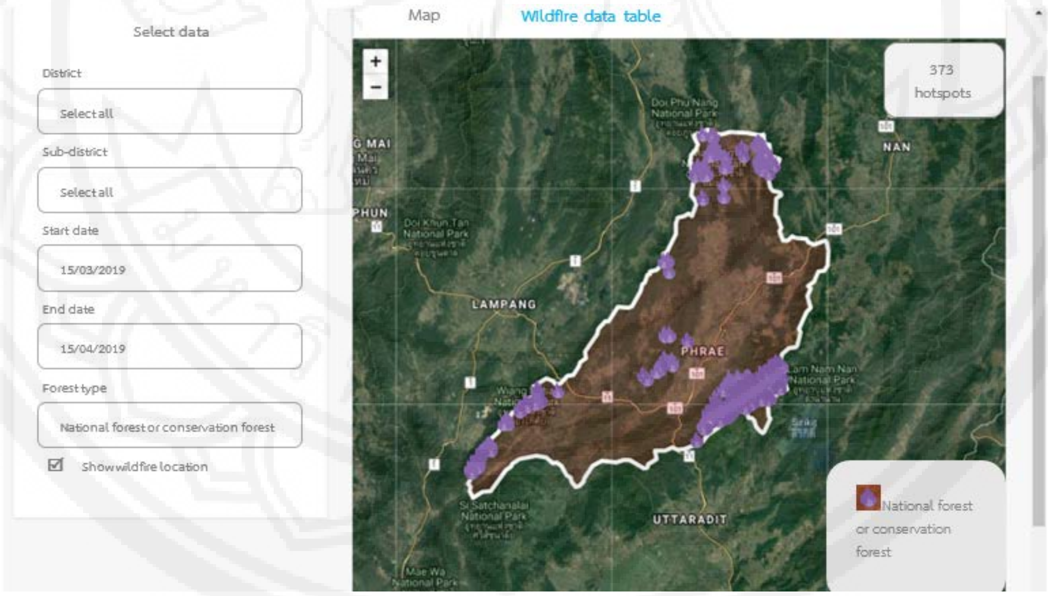



**Figure 6** The wildfire hotspot location in national forest or conservation forest (purple)

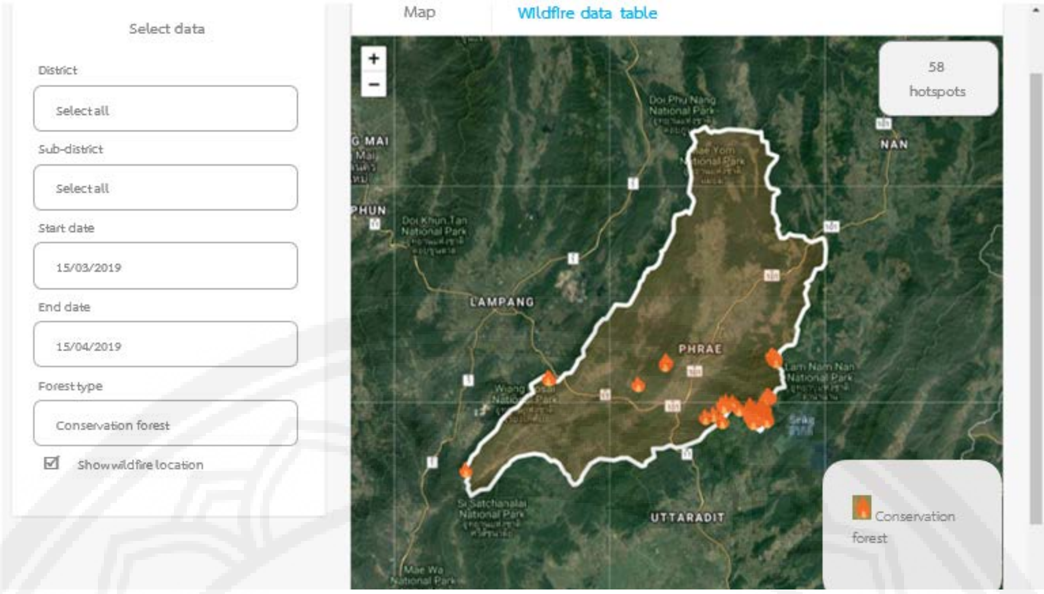



**Figure 7** The wildfire hotspot location in conservation forest (orange)

Map | Wildfire data table

SEARCH:

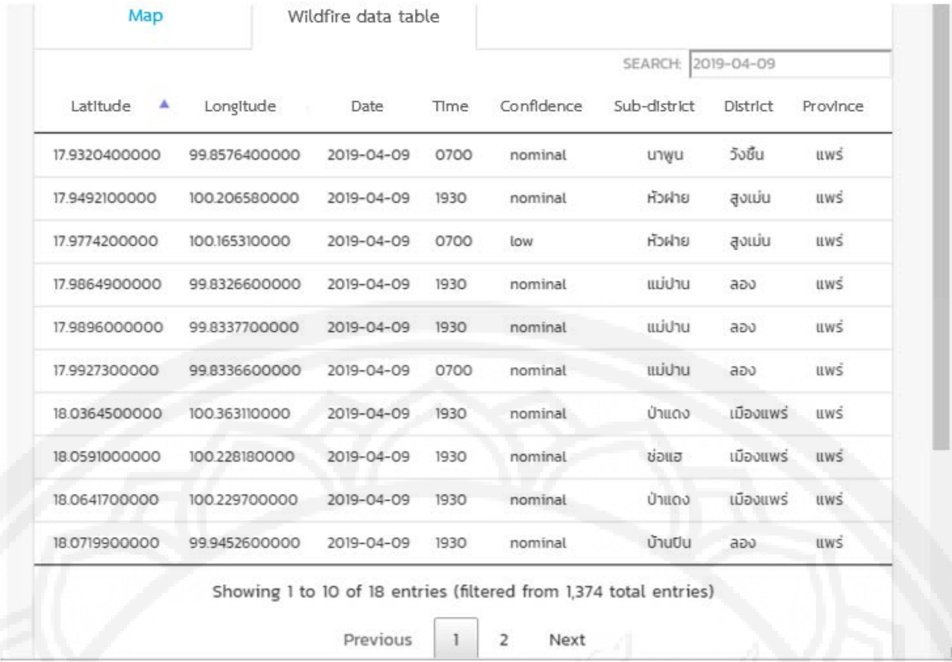
| Latitude | Longitude | Date | Time | Confidence | Sub-district | District | Province |
|---|---|---|---|---|---|---|---|
| 17.7323200000 | 99.4585500000 | 2019-04-15 | 1918 | nominal | สรอย | วังชิ้น | แพร่ |
| 17.7439300000 | 99.4631700000 | 2019-04-02 | 1818 | nominal | สรอย | วังชิ้น | แพร่ |
| 17.7443500000 | 99.4594700000 | 2019-04-02 | 1818 | nominal | สรอย | วังชิ้น | แพร่ |
| 17.7446500000 | 99.4556000000 | 2019-04-01 | 1836 | nominal | สรอย | วังชิ้น | แพร่ |
| 17.7452700000 | 99.7126100000 | 2019-03-16 | 1836 | nominal | นาพูน | วังชิ้น | แพร่ |
| 17.7453400000 | 99.4504300000 | 2019-04-01 | 1836 | nominal | สรอย | วังชิ้น | แพร่ |
| 17.7460300000 | 99.4596300000 | 2019-04-02 | 1818 | nominal | สรอย | วังชิ้น | แพร่ |
| 17.7460400000 | 99.4452400000 | 2019-04-01 | 1836 | nominal | สรอย | วังชิ้น | แพร่ |
| 17.7498600000 | 99.4456400000 | 2019-04-01 | 1836 | nominal | สรอย | วังชิ้น | แพร่ |
| 17.7690200000 | 99.3742600000 | 2019-03-21 | 1848 | nominal | สรอย | วังชิ้น | แพร่ |

Showing 1 to 10 of 1,374 entries

Previous 1 2 3 4 5 ... 138 Next

**Figure 8** Screenshot of the Suomi-NPP database table

Figure 8 is presented the field description consist of coordinate (latitude/longitude), date of hotspot detected, time, confidential, sub-district, district and province, totally 1,374 entries from 15/03/2019 to 15/14/2019.



Map | Wildfire data table

SEARCH: 2019-04-09

| Latitude | Longitude | Date | Time | Confidence | Sub-district | District | Province |
|---|---|---|---|---|---|---|---|
| 17.9320400000 | 99.8576400000 | 2019-04-09 | 0700 | nominal | นาพูน | วังชิ้น | แพร่ |
| 17.9492100000 | 100.206580000 | 2019-04-09 | 1930 | nominal | หัวฝาย | สูงเม่น | แพร่ |
| 17.9774200000 | 100.165310000 | 2019-04-09 | 0700 | low | หัวฝาย | สูงเม่น | แพร่ |
| 17.9864900000 | 99.8326600000 | 2019-04-09 | 1930 | nominal | แม่ปาน | ลอง | แพร่ |
| 17.9896000000 | 99.8337700000 | 2019-04-09 | 1930 | nominal | แม่ปาน | ลอง | แพร่ |
| 17.9927300000 | 99.8336600000 | 2019-04-09 | 0700 | nominal | แม่ปาน | ลอง | แพร่ |
| 18.0364500000 | 100.363110000 | 2019-04-09 | 1930 | nominal | ป่าแดง | เมืองแพร่ | แพร่ |
| 18.0591000000 | 100.228180000 | 2019-04-09 | 1930 | nominal | ช่อแฮ | เมืองแพร่ | แพร่ |
| 18.0641700000 | 100.229700000 | 2019-04-09 | 1930 | nominal | ป่าแดง | เมืองแพร่ | แพร่ |
| 18.0719900000 | 99.9452600000 | 2019-04-09 | 1930 | nominal | บ้านปิน | ลอง | แพร่ |

Showing 1 to 10 of 18 entries (filtered from 1,374 total entries)

Previous 1 2 Next

**Figure 9** Search function

Search function is useful for user to searching for information such as date, coordinate latitude/longitude, sub-district and district. Figure 9 was demonstrated the utilization of the system for monitoring and evaluation of scenarios for active fire detection in 2019-04-09 date and then the system is automatically shown the results 18 entries of all. The system is easily customizable for other situations.

## Conclusion

VIIRS is a cross-track scanning radiometer sensor that measures reflected and emitted radiation from the Earth-atmosphere system in 22 spectral bands, crossing from 412-12,050 nm. It also features dual gain bands which allow a greater dynamic range while retaining high SNR (signal-to-noise ratio) at low radiance values making the bands usable for ocean, atmospheric and land applications (Cao, Deluccia, Xiong, Wolfe, & Weng, 2013; Jackson, Liu, Laszlo, & Kondragunta, 2013). VIIRS offers single-angle observation and does not measure polarization. It has a wide swath (approximately 3000 km), which allows it to fully sample the Earth every day. An on-board pixel trimming algorithm eliminates redundant views of the same Earth scenes, which mitigates the “bowtie” effect at swath edges (Cao et al., 2013). In addition, the pixel combination and geometric strategy decreases the growth of the pixel sizes toward the swath edge. VIIRS pixel ground-projected instantaneous field of view (GIFOV) grows by approximately a factor of 4 from nadir to edge of scan, in contrast to the eightfold increase of the MODIS GIFOV. VIIRS has three types of bands: imagery bands, moderate resolution bands (M-bands), and the day-night band. The spatial resolution of a VIIRS observation depends on the VIIRS bands used (Cao et al., 2013).

The VIIRS enhanced spatial sampling, which eliminates coverage gaps over lower latitudes and minimizes pixel size increase with scan angle, provided consistent daily fire mapping performance of fires lasting several days. Our initial data quality assessment indicated high level of agreement between VIIRS 375 m fire detection data and near-coincident higher resolution airborne and Landsat-8 reference data sets. The classification of pixels into two main classes, namely nominal and low confidence groups, helped distinct confirmed fire-affected pixels from ambiguous pixels more likely associated with false alarms and marginal burning (Schroeder, Oliva, Giglio, & Csiszar, 2013).

This research introduces a new VIIRS active fire detection in Phare province, northern part of Thailand, which is driven primarily by the 375 m middle and thermal infrared imagery data. The advances in FOSS4G provide an alternative approach to geospatial software development. So, there is a growing need of WebGIS for easy and fast distribution, sharing, displaying and processing of spatial information which in turn helps in decision making for various natural resources-based application. The system is easily customizable for other situations. In future it would be important to have select data by village location. Some ancillary findings of the study such as wildfire hotspot locations were represented three color types consist of 1) green fire point is national forest, 2) orange fire point is conservation forest, and 3) purple fire point is national forest or conservation forest in that order. WebGIS base information system for monitoring wildfire using Suomi-NPP (VIIRS) satellite is also an interesting outcome of the study. The methodology is based on notions on general principles of information technology and has the potential for application for other disaster.

## Acknowledgments

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