FIRE-HOTSPOT INFORMATION SYSTEM FROM MULTI-RESOLUTION REMOTE SENSING DATA FOR EARLY DETECTION OF FOREST FIRES

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ABSTRACT: The Fire-Hotspot Information System namely version 2.0 for early detection of forest fires is now available at LAPAN Indonesia, which is an update from the previous version. Until now, forest fires still occur frequently in Indonesia and even routinely every year. The Fire-Hotspot Information System through the Website and Android has been developed by LAPAN since 2015. Currently this system has used remote sensing satellite data from several satellites such as TERRA, AQUA, SNPP, NOAA-20 and Landsat-8 with related sensors MODIS, VIIRS and OLI. The data processing system uses a global algorithm to derive hotpot information from remote sensing satellite data. After obtaining fire-hotspot information, it is then sent to the database by adding administrative boundary information and masking the data with persistent fire information to reduce detection errors due to bright objects, roofs, mountain craters, etc. The final process is clustering, in which each adjacent hotspot will be used as 1 fire-hotspot information to represent 1 fire event. The clustering method is very useful for large fire events detected by remote sensing satellites with medium resolution (30 m) because the Fire-hotspot data in the form of pixels will have a large number of fire-hotspots which will become 1 fire hotspot cluster. On average, the loading time for version 2.0 can also be 9.65 times faster than version 1.0. The process of masking fire-hotspot data can reduce the number of fire-hotspot pixels by 47.77% in Januari to September 2020. Meanwhile, the clustering method will decrease by 67.25% compare to total number of hotspot in version 1.0. The LAPAN Fire-Hotspot Information System version 2 has been able to improve detection of forest fires by reducing detection errors and improving the correlation between the number of fire hotspots and the number of fire events.

1. INTRODUCTION

Forest/land fires are disasters that occur every year in Indonesia. The incidence of forest fires has a large impact from various aspects, even in 2015 the loss was estimated at up to USD 16 billion, which is twice the loss due to the Aceh tsunami (Septianingrum, 2018). The incidence of forest and land fires can affect air quality, even fires in Sumatra can affect air quality in Malaysia (Show & Chang, 2016). In general, this disaster has a direct impact on the destruction of forest ecosystems, economic losses as well as health and transportation problems caused by the smoke it produces.

Forest/land fire monitoring efforts using remote sensing satellite data have been developed and operated by the Indonesian National Aeronautics and Space Agency (LAPAN) since long time. Currently, the data used to monitor hotspots are satellite data from Terra/Moderate-resolution Imaging Spectroradiometer (MODIS), Aqua/MODIS, Suomi National Polar-orbiting Partnership (S-NPP)/Visible Infrared. Imaging Radiometer Suite (VIIRS). NOAA-20/VIIRS and Landsat-8/Operational Land Imager (OLI). With the rapid development of information technology today, it is possible to disseminate information more quickly and efficiently.

This research aims to develop a hotspot information system from remote sensing satellite data for early detection of forest/land fires in Indonesia. Currently, LAPAN has provided a hotspot information system version 1.0, the system that will be produced will be referred to as version 2.0 which is an improvement over the previous version.

2. DATA AND METHOD

2.1 Data

The data used are low and medium resolution remote sensing satellite data acquired by the LAPAN Ground Stations. Remote sensing satellite data used are TERRA/MODIS, AQUA/MODIS, SNPP/VIIRS NOAA-20/VIIRS and LANDSAT-8/OLI. The data used is data that was acquired from 1 January to 30 September 2020.

2.2 METHOD

The hotspot information system built is an end to end system from ground stations to websites and android mobile. The entire system developed has been able to run automatically from the time the data is received at the ground station until the presentation for the user. The presentation system provided is the website, android application and services such as file transfer Protocol (FTP) and Aplication Programmng Interface (API). The complete system is depicted in Figure 1. (Indradjad, Sunarmodo, Salyasari, & Pratiknyo, 2019)

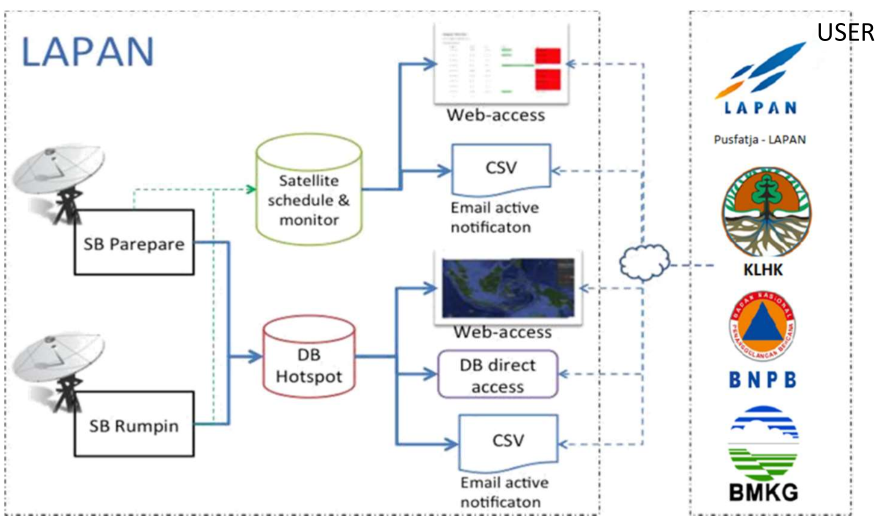


Figure 1 Hotspot Information System

Figure 2 explains how the hotspot information system data flowchart used in version 1.0. The Hotspot processing section is the part that will process hotspot information from the satellite raw data received at the earth station. The hotspot processing system at this stage really depends on the type of satellite sensor used (Indradjad et al., 2019). In the MODIS sensor the data processing software used is MODIS Data processing level 1b and mod 14 using IMAPP Virtual Appliance ver.2 (using C6) from Wisconsin University (Huang et al., 2016) (Giglio, Schroeder, & Justice, 2016) ,ll,e3e. In VIIRS Sensor the data processing software used is VIIRS data processing using Active Fires software from Community Software Processing Package (CSPP) (Gustiandi & Indradjad, 2013) (Huang et al., 2016)(Schroeder, Oliva, Giglio, & Csiszar, 2014). In OLI Sensor the data processing software used is from Software from NOAA (Schroeder et al., 2016). After Hotspot processing part is Hotspot ingesting in this part will input Hotspot data in csv file from standard satellite processing to the database. In this part before importing data into database, the hotspot data is adding administration boundary such as province, district and sub-district. Database that is used in version 1.0 is mysql. After data in the database in can be shown in website, android application and services such as FTP and API.

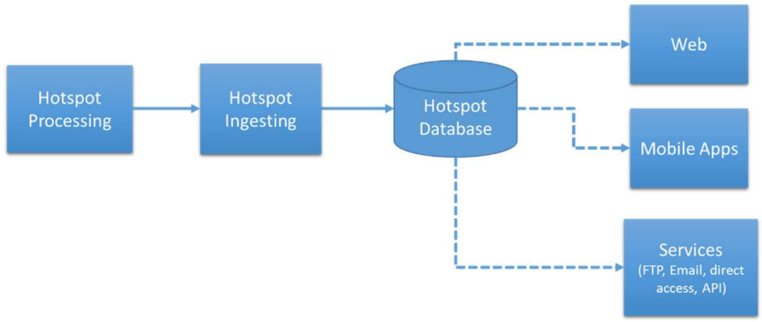


Figure 2 Hotspot Information System Flowchart Version 1.0

Figure 3 shows the flowchart of the system to be built which will be referred to as the hotspot information system version 2.0. The difference that exists in the version 2.0 hotspot information system is that there are parts that do not exist in version 1.0, namely flowcharts in image processing. This section functions to display an RGB heat intensity image which will show a red color on the resulting hotspot information. Current RGB Heat intensity images can only be displayed on the website. In the flowchart image processing, image processing satellite data into RGB and input it to the image database. The image database used is Postgresql, then it can be used as a service map.

In the second part of version 2.0, namely the hotspot processing flowchart which looks as if it is the same as version 1.0. The hotspot processing block does use the same standard processing that was used in version 1.0. The difference occurred in the ingesting hotspot block. In the ingesting hotspot block, hotspot masking is initiated in the persistent fire information area, after that the clustering process is carried out. After both processes the hotspot data will be sent to the hotspot database. In the hotspot database there are 2 tables, namely for hotspots that are per pixel without clustering and hotspot clustering, so that these two methods can be displayed on the website.

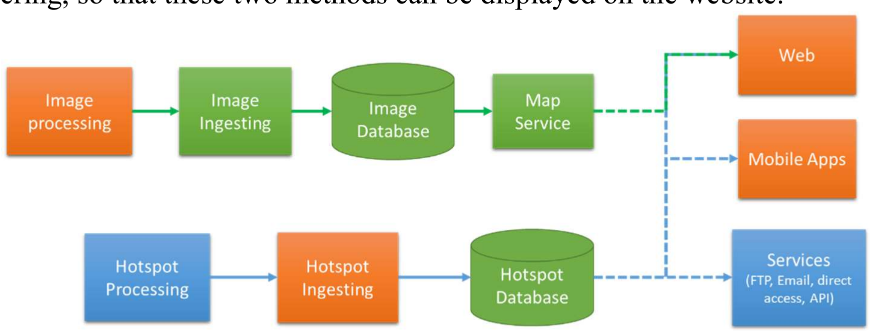


Figure 3 Hotspot Information System Flowchart Version 2.0

Figure 4 shows how the clustering method is carried out to unite adjacent hotspots. The clustering method used is to make it easier to identify the number of hotspots, especially at a medium resolution of 30 m. The clustering method is done by creating a hotspot on adjacent pixels into 1 hotspot cluster, with the following conditions:

- Clustering is done per satellite per time
- The cluster center point is determined by the coincide pixel coordinate average method
- Adjoining pixels when 2 adjacent points have a distance of n, which depends on the type of satellite sensor

  3x30m (Landsat8)

  1.5x375m (Snpp, Noaa20)

  1.5x1km (Aqua, Terra)
- The confidence level value is a round of the cluster member's confidence level pixel value
- The administrative location is the mode location (the location of the majority of member pixels)
- Cluster radius is the root of the number (c) area of pixel cluster members (a) -> √ (c.a)

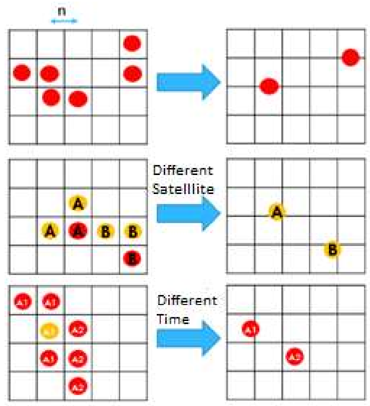


Figure 4 Clustering Method

3. RESULTS AND DISCUSSION

3.1 Results

Hotspot Information System version 2.0 can be accessed at the link http://lowres-catalog.lapan.go.id This system has the following features:

1. Selection of existing areas of Indonesia, 34 Provinces and search to the sub-district level
2. Time options available are 24 hours, 48 hours, the last 72 hours and a certain time period.
3. Options for the level of confidence that exist are at least low, medium and high confidence levels
4. Choice of methods, namely pixel and hotspot cluster.
5. There is an option to display RGB Heat Intensity.

The website shown at Figure 5., it is the initial view of the hotspot information system website

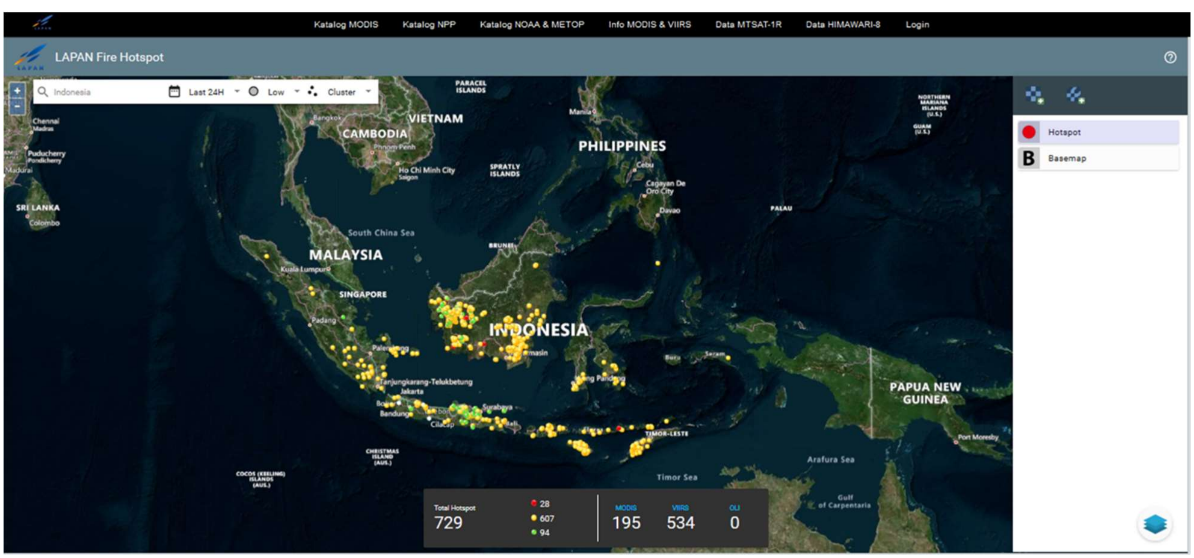


Figure 5 Website Hotspot Informstion System

RGB Heat Intesity overlay is use image data from selected band from satellite Image which is used for generate hotspot information. RGB heat intensity also available for time series satellite image. The RGB overlay used is as follows:

1. Projection using the Nearest Neighbor method, EPSG: 4326
2. It is possible that there is a shift in the pixel raster compared to the hotspot position
3. Always refer to the hotspot position when there is a difference
4. Until now, the available raster type is Heat Intensity which is an RGB combination of:

Landsat 8 (7, 5, 2), Noaa20, Snpp (I4, I2, I1), Aqua, Terra (22, 2, 1)

5. Raster heat intensity is only a description of the heat level with an RGB (3 band) composite, it could be that the red color on the raster does not indicate a hotspot, or vice versa. Because the hotspot determination is also based on the surrounding pixel value
6. The raster is only available for daytime acquisition times

Time series raster overlay example show in figure 6.

Figure 6 Image Overlay on the website

Besides being accessible through the website, the hotspot information system can also be accessed via Android by using the Play Store with the following link: http://bit.ly/LAPANFireHotspot. The appearance of the android application can be seen in figure 7. The data used in the android application is hotspot information only with the cluster method, and there is no option to change other methods, besides that the android application still cannot display image overlay data.

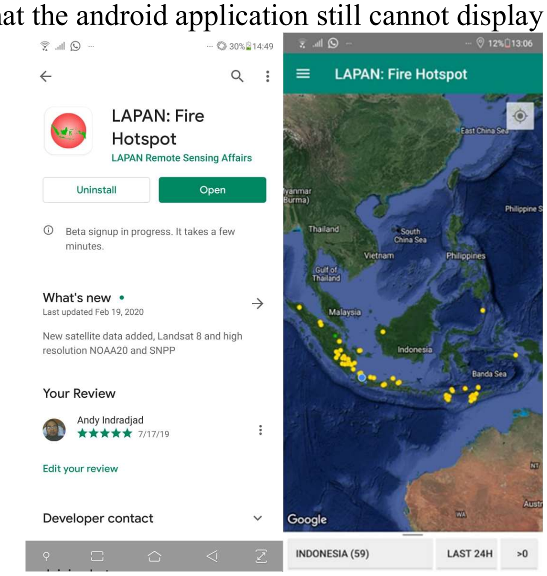
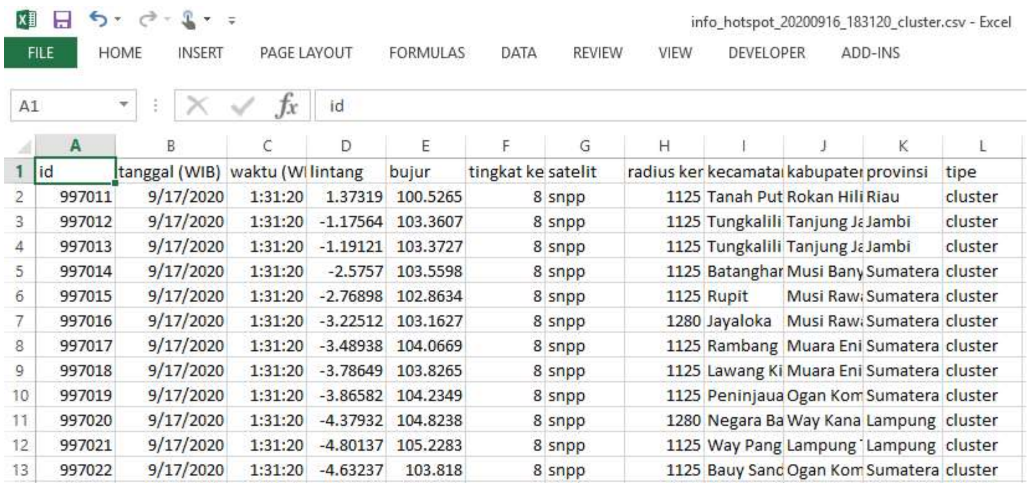


Figure 7 LAPAN Fire Hotspot Android Application

Another product of this hotspot information system version 2.0 is that the hotspot data can be downloaded in the form of csv (comma separated value) file format. This format can be opened using Microsoft Excel software as shown in Figure 8. The file is equipped with a header at the top to show the existing columns. The header fields provide information such as Id, date and time, Latitude and longitude, level of confidence, radius of possibility, administrative limit, method used. The radius of possible is three times of spatial resolution of the satellite sensor, if the radius is likely to be more than 3 times the resolution of the satellite it means the data comes from 2 or more hotspots using the cluster method. The confidence levels are low, medium and high which are coded with 7, 8, and 9. And the time is in Western Indonesian Standard Time (WIB).



	A	B	C	D	E	F	G	H	I	J	K	L
1	id	tanggal (WIB)	waktu (WI	lintang	bujur	tingkat ke	satelit	radius ker	kecamatai	kabupater	provinsi	tipe
2	997011	9/17/2020	1:31:20	1.37319	100.5265	8	snpp	1125	Tanah Put	Rokan Hili	Riau	cluster
3	997012	9/17/2020	1:31:20	-1.17564	103.3607	8	snpp	1125	Tungkalili	Tanjung Ja	Jambi	cluster
4	997013	9/17/2020	1:31:20	-1.19121	103.3727	8	snpp	1125	Tungkalili	Tanjung Ja	Jambi	cluster
5	997014	9/17/2020	1:31:20	-2.5757	103.5598	8	snpp	1125	Batanghar	Musi Bany	Sumatera	cluster
6	997015	9/17/2020	1:31:20	-2.76898	102.8634	8	snpp	1125	Rupit	Musi Rawa	Sumatera	cluster
7	997016	9/17/2020	1:31:20	-3.22512	103.1627	8	snpp	1280	Jayaloka	Musi Rawa	Sumatera	cluster
8	997017	9/17/2020	1:31:20	-3.48938	104.0669	8	snpp	1125	Rambang	Muara Eni	Sumatera	cluster
9	997018	9/17/2020	1:31:20	-3.78649	103.8265	8	snpp	1125	Lawang Ki	Muara Eni	Sumatera	cluster
10	997019	9/17/2020	1:31:20	-3.86582	104.2349	8	snpp	1125	Peninjaua	Ogan Kom	Sumatera	cluster
11	997020	9/17/2020	1:31:20	-4.37932	104.8238	8	snpp	1280	Negara Ba	Way Kana	Lampung	cluster
12	997021	9/17/2020	1:31:20	-4.80137	105.2283	8	snpp	1125	Way Pang	Lampung	Lampung	cluster
13	997022	9/17/2020	1:31:20	-4.63237	103.818	8	snpp	1125	Bauy Sand	Ogan Kom	Sumatera	cluster

Figure 8 Hotspot Information in csv format

3.2 Discussion

The hotspot information system created is a system that runs automatically since data is received at the ground station, this has been possible since the first version (Indradjad et al., 2019). Improvements made in version 2.0 also include the information system on the website that is able to handle larger number of hotspot data and is also able to display more quickly. The hotspot information system website is currently capable of displaying all data from January 1, 2020 to September 30, 2020. Website version 1.0 will cause the browser to crash if it displays hotspots around +/- 30000 hotspots, making it difficult to display the number of hotspots in 1 month at peak fire. The performance of this version 2.0 website is faster than version 1.0, especially if it displays a larger number of hotspots. This can be seen in table 1 which shows the loading time of the website per month in seconds. From table 1 it can be seen that in August and September the performance of version 2 was 13.2 and 19.5 times faster than version 1.0. On average, from January to September, it is 9.65 times faster than version 1.0.

Table 1 Website Loading time

Month	V1 (s)	V2 (s)	V1/V2 (s)
January	8.2	1	8.2
February	8.2	1.1	7.5
March	12.7	1.4	9.1
April	10.6	1.2	8.8
May	7	1.2	5.8
June	9.9	1.5	6.6
July	15.5	1.9	8.2
August	67.4	5.1	13.2
September	95.6	4.9	19.5

Hotspot information system version 2.0 has masking areas that are often wrongly detected as fires, such as residential areas, factories, refineries, volcanic craters and others. With masking in these areas, it will reduce detection errors in persistent fire areas (Schroeder et al., 2016). The hotspot information system version 2.0 has a smaller number of hotspots than version 1.0, this is because version 2.0 has reduced the possibility of error detection in the above areas. Apart from masking version 2.0, it also uses the cluster method which can be useful for better counting the number of hotspots. Comparison of the number of hotspots generated every month from version 1.0 (V1) and version 2.0 with the Pixel method (V2P) and version 2.0 with the Cluster method (V2C) can be seen in table 2.Table 2 can be seen at the peak of fires in August and September The number of hotspots in version 2.0 can be reduced by 64.14% and 77.49% compared to version 1.0. This is when compared to the cluster version, but when compared in pixel terms, it is 42.46% and 65.39%. Overall, the number of hotspots with masking in version 2.0 can reduce detection errors by 47.77% and by adding the cluster method, the number of hotspots is 67.25% less than the number of hotspots in version 1.0. Thus, the number of hotspots is expected to get closer to the number of fires, especially if using 30 m medium resolution data such as Landsat-8.

Table 2 Number of Hotspot

Month	**V1**	**V2P**	**V2C**	**V1P to V2P (%)**	**V1P to V2C (%)**
January	8663	6053	4032	30.13	53.46
February	8020	6416	3779	20.00	52.88
March	12692	10932	5280	13.87	58.40
April	9838	8096	4798	17.71	51.23
May	6924	4789	3408	30.83	50.78
June	10391	7074	4712	31.92	54.65
July	17587	14149	9170	19.55	47.86
August	88282	50798	31661	42.46	64.14
September	133312	46135	30007	65.39	77.49
TOTAL	**295709**	**154442**	**96847**	**47.77**	**67.25**

4. CONCLUSION

Hotspot information system version 2.0 can be built with better performance than version 1.0, with an average performance of 9.65 times faster than version 1.0 in the period January to September 2020.

The process of masking fire-hotspot data can reduce the number of fire-hotspot pixels by 47.77% in Januari to September 2020. Meanwhile, the clustering method will decrease by 67.25% compare to total number of hotspot in version 1.0. The LAPAN Fire-Hotspot Information System version 2 has been able to improve detection of forest fires by reducing detection errors and improving the correlation between the number of fire hotspots and the number of fire events.

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