Utilization of MODIS data to analyze the forest/land fires frequency and distribution (case study : Central Kalimantan Province)

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Abstract. Forest/land fire often occurs in Indonesia particularly in Sumatera, Kalimantan, and Papua. This phenomenon has direct impact not only in Indonesia but also transboundary countries. To minimize this impact, remote sensing technology can be used to monitor forest/land fire using hotspot from Terra/Aqua MODIS data which good have 2 equatorial revisit times per day i.e. 10.30 a.m. for Terra and 1.30 p.m. for Aqua in near real time. The objectives of this study was to analyze the frequency and spatial distribution of hotspot in Central Kalimantan Province using Terra/Aqua MODIS. Hotspot is derived from Terra/Aqua MODIS data using algorithm which available daily in LAPAN system. Hotspot classified into three categories of confidence level i.e. low (0-30%), medium (30-80%), high (80-100%). RGB 1-2-18 were used as base map layer to analyze the spatial distribution of three hotspot categories. The result shows that there was hotspots concentrated in Kotawaringin Timur and Pulang Pisau Regency which it was burn peat hydrological unit area. Thus, peat land area that covers with shrubs, etc is hard to extinguish which relate to the frequency of hotspot. High frequency hotspot occurs in September 27th 2018 then decreasing until October 6th 2018 (10 days).

1. Introduction

The phenomenon of forest/land fires in Indonesia have significant impact not only to air quality and human health in Indonesia but also transboundary countries. As the previous case in 2015 there were six provinces encountered, such as South Sumatra, Jambi, Riau, West Kalimantan, Central Kalimantan, and South Kalimantan (bbcindonesia online, 2015). The impact of this haze was felt in North Sumatra Province, West Sumatra, as well as transboundary countries i.e Malaysia, Singapore, Thailand and the Philippines. Indonesia National Disaster Management Agency (BNPB) stated that forest/land fires in 2015 consumed 2,089,911 hectares of forest or 32x DKI Jakarta province (cnnindonesia online, 2015). Forest fires also contribute significantly to climate change, Based on data of NASA, due to forest fires in Indonesia in 2015, around 600 million tons of greenhouse gases were released into the air. That number is the same as the glass gas that released by Germany every year (Viva online, 2015). Forest/lanf fires can often become uncontrolled, leading to the destruction of large areas of forest, these fires are reported to be a major reason for the rapid degradation of the remaining rainforests in Southeast Asia (Siegert et al., 2004)

In an effort to minimize impact of forest/land fires, early information about forest/land fires is very important. Remote sensing technology can be used to provide information on forest/land fire i.e using MODIS (Moderate Resolution Imaging Spectroradiometer) images which are obtained from the Aqua and Terra satellites. Vetrita et al (2014) stated that based on field validation, MODIS data with various confidence levels provides the best data with some other data. The advantage of data from MODIS data is that it can display daily information where MODIS data has a temporal resolution of 2 times per day. Forest fire analysis is carried out by visual analysis of MODIS images and hotspots data. The research of Zubaidah (2014) showed that the percentage of MODIS FIRMS hostpot accuracy is 64%

with a commission error 18% and ommision error 18% the percentage of the accuracy of the MODIS Indofire hostpot was found at 42% with a commission error rate of 20% and ommision error of 38%. Further analysis on peatland has obtained a value of 66% hotspot Firms accuracy with a commission error of 19% and ommision error of 15%, while the Indofire hotspot was found at 46% with a commission error of 19% and ommision error of around 35%. The purpose of this study was to analyze the frequency and spatial distribution of the incidence of forest fires in Central Kalimantan Province from September 27th to October 6th 2018 by utilizing MODIS data through visual analysis of fire fumes equipped with hotspot data.

2. Methods

2.1 Study Area

This study focused on the Central Kalimantan Province, where it was one of the vulnerable area of forest/land fires. According to BNPB data, from January until June 2018, there were approximately 37 cases of forest/land fires. Total area of Central Kalimantan was 153,564,000 hectares of which 4,644,317 hectares are included in the Peat Hydrological Unit (Directorate of Peatland Damage Control, 2015). This study focused on September 27th to October 6th 2018 by considering FDRS (Fire Danger Rating Systems) data from the Remote Sensing Applications Center LAPAN. FDRS is an early warning system for forest and land fires. FDRS provides input on decisions relating to the management of forest and land fires using the weather index fire or Fire Weather Index (FWI) as a parameter (Itsnaini, 202017). FDRS data showed that Central Kalimantan Province in September 27th classified in high and extreme classespecially in the southern region. FDRS consist of FFMC (Fine Fuel Moisture Code), FWI (Fire Weather Index), ISI (Initial Spread Index), and DC (Drought Code).

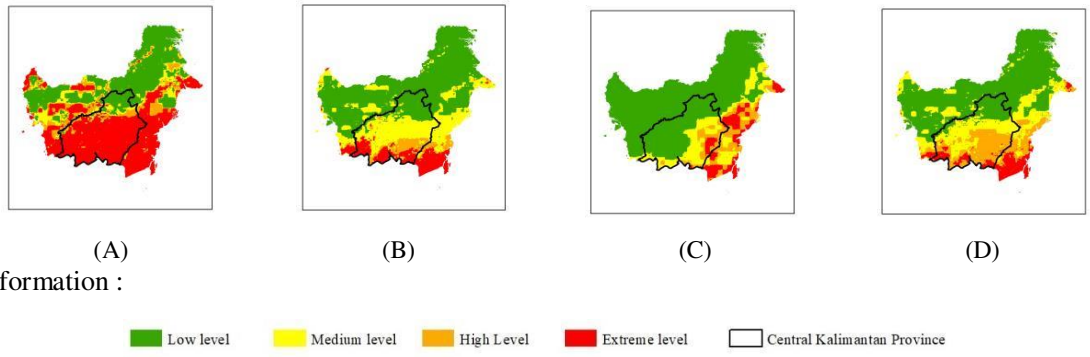


Figure 1. (A) FFMC, (B) ISI, DC (C), (D) FWI
FDRS Central Kalimantan Province
(Source :*http://spbn.pusfatja.lapan.go.id/maps/927)*

2.2 Hotspot Data

MODIS data can used to analyze forest/land fires using hotspot data which indicates high temperature in an area. To produce hotspots from MODIS data, there are 7 spectrums of waves electromagnetic is used, i.e thermal spectrum 4 µm, 11 µm and 12 µm, and spectrum reflectance 0.65 µm, 0.86 µm and 2.1 µm which are used to minimize cloud disturbance, sunshine reflection on the sea (sun glint), coastal areas, and forest clearing. MODIS band that used to analyze hotpots i.e band 1 (0.65 µm), band 2 (0.86 µm), band 7 (21 µm), band 21 (4.0 µm), band 22 (4.0 µm), band 31 (11.0 µm) and band 32 (12.0 µm) (Giglio et al 2016). Then the data is processed using certain algorithms to produce hotspot information. The following is the band used to obtain hotspot data from MODIS Imagery :

Table 1. The Band Used to Produce Hotspot Data from MODIS Imagery

Band	Central Wavelength (μm)	Usability
1	0.65	Minimize the error of detection due to reflection of sun glint, coast, and clouds.
2	0.86	Minimizing errors due to sun glint and coastal conditions.
7	21	Minimizing errors due to sun glint and coastal conditions.
21	4	Is a channel that has a high range for fire detection.
22	4	Is a channel that has a low range for fire detection.
31	11	For fire detection and minimizing errors of detection from clouds and forest clearing
32	12	To minimize detection errors due to clouds.

(Source : Giglio *et al* 2016)

The Indonesia National Aeronautics and Space Agency (LAPAN) has utilized the algorithm to produce hotspot data, the data can be accessed on Modis Catalog website (http://modis-catalog.lapan.go.id/). Giglio (2015) in MODIS *Active Fire Product User's Guide* classified confidence level into 3 types :

Table 2. Confidence Level Classification of Hotspot from MODIS Imagery

Confidence Level	Classification	Action
0%-30%	Low	Important to noticed
30%-80%	Medium	Alert
80%-100%	High	Immadiate response

It is important to note that the number of hotspot not showing the number of occurrences forest/land fires but indicate occurrences of forest/land fires. The indicators of forest/land fires is :

- Hotspots that clustered, large enough offorest/land fires are not detected as only one hotspot because the heat effect spreads, so if the hotspot is clustered then it can be ascertained that there was forest/land fires.
- Hotspots accompanied by smoke. In analyzing hotspots as markers of forest/landfires, it is also necessary to look at RGB combination of band 1, band 2, and band 18.
- Hotspot points occur repeatedly, so there is a possibility of fires in the area. (Deputy for Remote Sensing LAPAN, 2016).

then to get a visual display of forest and land fires can be done with a combination of RGB combination of band 1-2-18, the band data is obtained from Modis Catalog Website (http://modis-catalog.lapan.go.id/). Combination of RGB bands 1-2-18 and hotspot data is then used to identify forest/land fires.

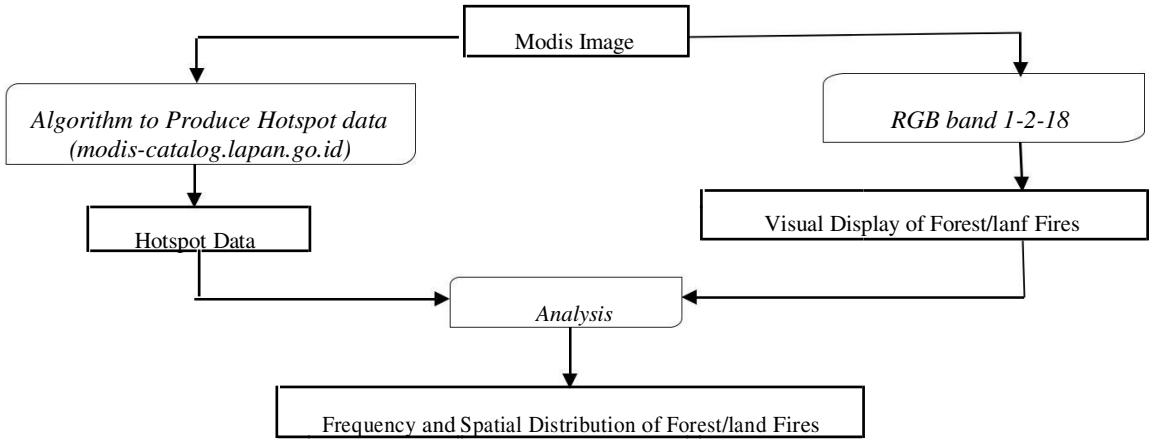


Figure 2. Research Flow Diagram

3. Result and Discussion

3.1 Hotspot Frequency

Terra satellite recording in the Central Kalimantan Province is at 10.30 a.mand Aqua satellite 01.30 p.m in near real time, daytime hotspot data from Aqua Satellite is generally more extensive than the hotspot data from Terra satellite. Based on the results of the study, there are fluctuating daily frequency of the hotspot data in Central Kalimantan Province which most of hotspot data classified as medium class and high class in confidence classification.

Table 3. Daily Hotspot Data from Aqua/Terra MODIS Image
Central Kalimantan Province
September 27th – October 6th 2018

Date	Confidence Level			Total
	Low (0-30%)	Medium (30-80%)	High (80-100%)	
September 27th 2018	16	165	109	290
28 September 2018	3	41	20	64
29 September 2018	10	82	54	146
30 September 2018	4	46	13	63
01 October 2018	0	16	5	21
02 October 2018	3	39	19	61
03 October 2018	0	4	0	4
04 October 2018	8	156	79	243
05 October 2018	0	3	0	3
06 October 2018	0	20	17	37

The highest number of hotspots occurred on September 27th and decreased the following day until October 3rd with some increased in number on September 29th. Then there was an increase in the number again on October 4th.

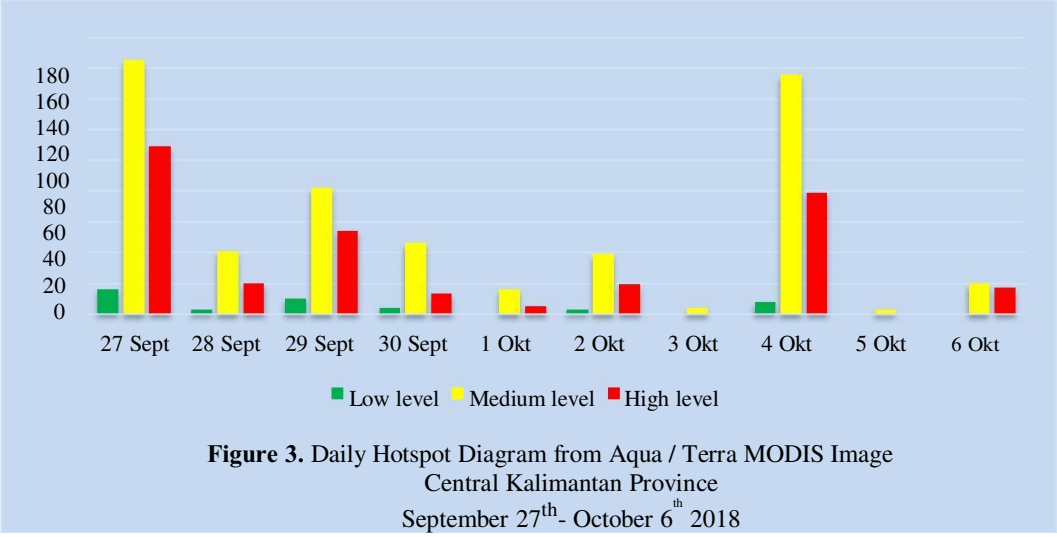


Figure 3. Daily Hotspot Diagram from Aqua / Terra MODIS Image
Central Kalimantan Province
September 27th- October 6th 2018

3.2 Distributin of Forest/Land Fires

Base on an analysis of forest/land fire indicators there are forest and land fires in several locations. Some points are in the same location continuously for several days, this is due to forest/land fires occurring on peat land, so the fire lasts a long time.

Table 4. Forest/Land Fires Based on Forest/Land Fires Indicators Using MODIS Image
Central Kalimantan Province
September 27th – October 6th 2018

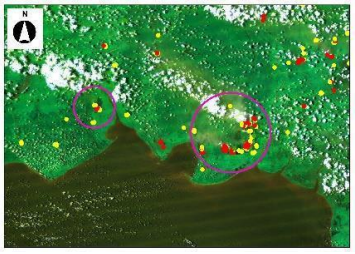
Date	Time	Satellite	Longitude	Latitude	Regency	Confidence
September 27th 2018 at 09.55 a.m						
9/27/2018	09.55	Terra	113.313988	-2.592333	Katingan	90
9/27/2018	09.56	Terra	114.622108	-2.545527	Barito Selatan	73
9/27/2018	09.57	Terra	114.004860	-3.026157	Pulang Pisau	100
9/27/2018	09.58	Terra	113.841797	-3.221791	Pulang Pisau	100
September 27th 2018 at 12.46 WIB						
9/27/2018	12.46	Aqua	113.827110	-3.213700	Pulang Pisau	100
9/27/2018	12.46	Aqua	113.882156	-3.225609	Pulang Pisau	100
9/27/2018	12.46	Aqua	113.991943	-3.200390	Pulang Pisau	100
9/27/2018	12.46	Aqua	113.997169	-3.035089	Pulang Pisau	100
9/27/2018	12.46	Aqua	114.366028	-2.576918	Kapuas	100
9/27/2018	12.46	Aqua	112.886627	-2.916742	Kotawaringin Timur	100
9/27/2018	12.46	Aqua	113.569366	-0.714748	Gunung Mas	100
September 28th 2018 at 13.30 WIB						
9/28/2018	13.30	Aqua	112.363266	-2.710428	Seruyan	86
9/28/2018	13.30	Aqua	112.892723	-2.913026	Kotawaringin Timur	100
9/28/2018	13.30	Aqua	114.003563	-3.047861	Pulang Pisau	100

9/28/2018	13.30	Aqua	113.987305	-3.108525	Pulang Pisau	90
9/28/2018	13.30	Aqua	113.875534	-3.173480	Pulang Pisau	91
9/28/2018	13.30	Aqua	114.700485	-0.404997	Murung Raya	81
September 29th 2018 pada 09.43 WIB						
9/29/2018	09.43	Terra	112.875084	-3.014459	Kotawaringin Timur	97
9/29/2018	09.43	Terra	114.031288	-2.275664	Palangka Raya	90
9/29/2018	09.43	Terra	114.761261	-2.641791	Kapuas	94
9/29/2018	09.43	Terra	113.955452	-2.991885	Pulang Pisau	100
9/29/2018	09.43	Terra	114.018684	-3.020075	Pulang Pisau	94
9/29/2018	09.43	Terra	113.981827	-3.097248	Pulang Pisau	100
9/29/2018	09.43	Terra	114.016624	-3.213359	Pulang Pisau	99
9/29/2018	09.43	Terra	113.803352	-3.153434	Pulang Pisau	84
September 29th 2018 pada 12.34 WIB						
9/29/2018	12.34	Aqua	112.869209	-3.011262	Kotawaringin Timur	91
9/29/2018	12.34	Aqua	112.892303	-2.930338	Kotawaringin Timur	88
9/29/2018	12.34	Aqua	113.856705	-3.145370	Pulang Pisau	100
9/29/2018	12.34	Aqua	114.020576	-3.214178	Pulang Pisau	89
9/29/2018	12.34	Aqua	114.015144	-3.031702	Pulang Pisau	91
9/29/2018	12.34	Aqua	114.413841	-2.481152	Kapuas	70
September 30th 2018 pada 10.26 WIB						
9/30/2018	10.26	Terra	114.003937	-3.156706	Pulang Pisau	55
9/30/2018	10.26	Terra	113.435829	-1.958531	Katingan	71
September 30th 2018 pada 13.17 WIB						
9/30/2018	13.17	Aqua	112.867966	-2.998992	Kotawaringin Timur	94
9/30/2018	13.17	Aqua	112.888214	-2.939001	Kotawaringin Timur	93
9/30/2018	13.17	Aqua	113.752075	-3.223514	Pulang Pisau	91
9/30/2018	13.17	Aqua	114.015312	-3.214895	Pulang Pisau	88
9/30/2018	13.17	Aqua	114.000183	-3.161659	Pulang Pisau	89
9/30/2018	13.17	Aqua	113.967957	-3.100604	Pulang Pisau	87
9/30/2018	13.17	Aqua	114.059822	-3.124371	Pulang Pisau	42
9/30/2018	13.17	Aqua	113.962868	-2.996229	Pulang Pisau	90
October 1st 2018 at 09.30 a.m						
10/1/2018	09.30	Terra	113.859344	-3.141144	Pulang Pisau	95
10/1/2018	09.30	Terra	113.969055	-3.089191	Pulang Pisau	89
October 2nd 2018 at 10.12 a.m						
10/2/2018	10.12	Terra	113.880959	-3.251491	Pulang Pisau	94
10/2/2018	10.12	Terra	114.063805	-3.016094	Pulang Pisau	84
October 2nd 2018 at 01.05 a.m						
10/2/2018	13.05	Aqua	111.952690	-3.461575	Seruyan	89
10/2/2018	13.05	Aqua	112.841408	-3.076896	Kotawaringin Timur	94
10/2/2018	13.05	Aqua	112.867561	-2.971042	Kotawaringin Timur	100
10/2/2018	13.05	Aqua	113.867249	-3.233211	Pulang Pisau	98
10/2/2018	13.05	Aqua	113.959717	-3.210057	Pulang Pisau	95
October 3rd 2018 at 09.17 a.m						

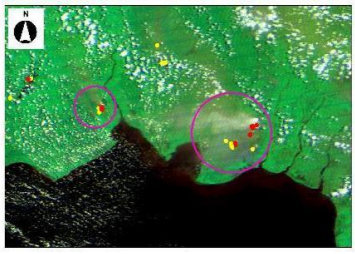
10/3/2018	09.17	Terra	112.869781	-2.966804	Kotawaringin Timur	74
10/3/2018	09.17	Terra	114.065918	-3.010835	Pulang Pisau	47
October 4th 2018 at 10.00 a.m						
10/4/2018	10.00	Terra	113.805481	-3.135988	Pulang Pisau	90
10/4/2018	10.00	Terra	113.944321	-3.094931	Pulang Pisau	100
10/4/2018	10.00	Terra	113.949989	-3.054620	Pulang Pisau	97
October 5th 2018 at 00.40 p.m						
10/6/2018	12.40	Aqua	114.276962	-0.773253	Marung Raya	83
10/6/2018	12.40	Aqua	115.237373	-1.144433	Barito Utara	92
10/6/2018	12.40	Aqua	115.286652	-1.263811	Barito Utara	88

3.3 Concentration of Forest/land Fires

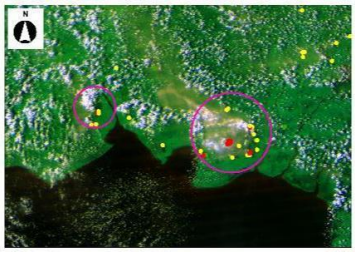
Based on the data above, the hotspot location on September 27th, September 29th and October 4th spread in Central Kalimantan Province area and there were several points of concentration of hotspots where and continued, several points i.e in Pulang Pisau Regency and East Kotawaringin Regency. From visual appearance RGB 1-2-18 MODIS image can be observed forest/land fires both at the point of Pulang Pisau Regency and Kotawaringin Timur Regency where fires in Pulang Pisau Regency are greater than in Kotawaringin Timur Regency. The following is a visual display of temporal forest/land fires located in Pulang Pisau Regency.



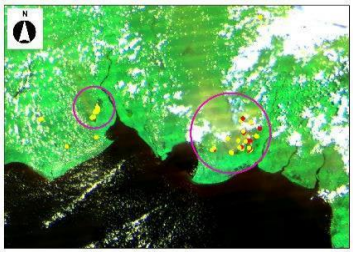
(September 27th, at 00.46 p.m)



(September 28th, at 00.30 p.m)

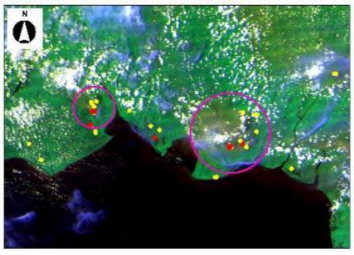


(September 29th, at 00.34 p.m)

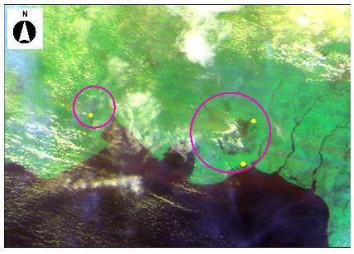


(September 30th, at 01.17 p.m)

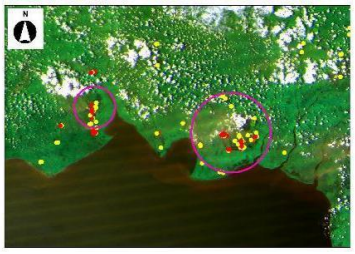
(October 1st, at 09.30 a.m)



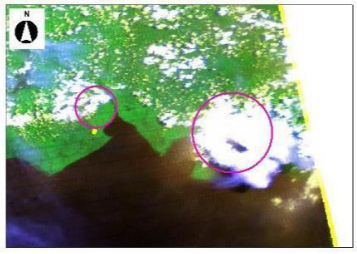
(October 2nd, at 01.05 p.m)



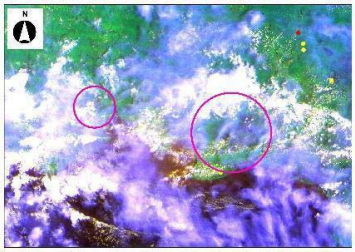
(October 3rd, at 09.17 a.m)



(October 4th, at 00.52 p.m)



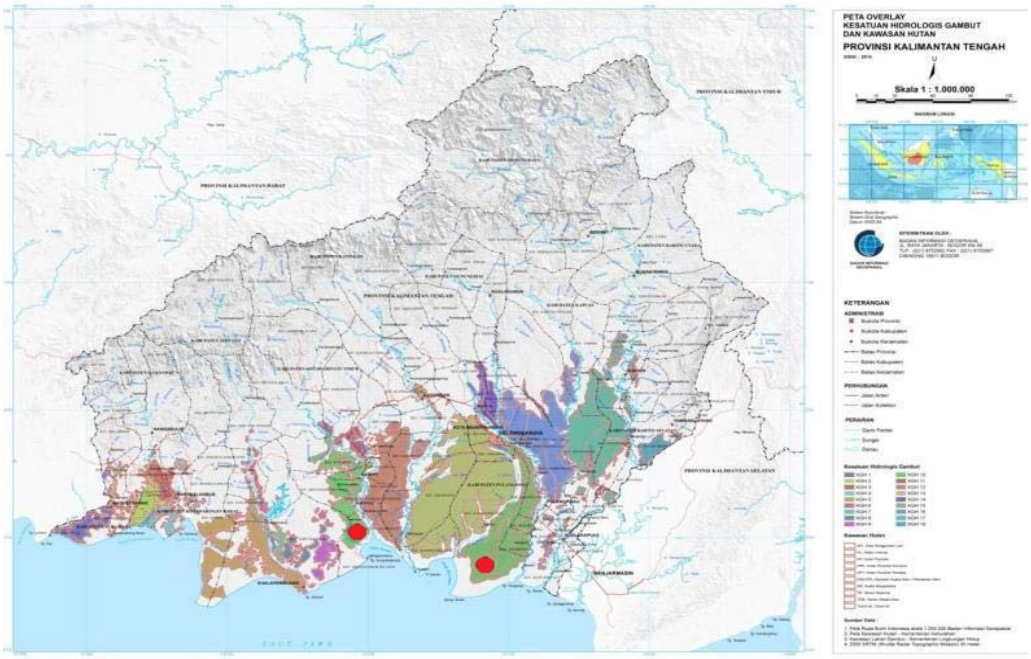
(October 5th, at 01.34 p.m)



(October 6th, at 09.49 a.m)

Figure 4. Time Series Display of RGB Images 1-2-18 and Hotspot Data on Forest/land Fires in Kotawaringin Timur Regency and Pulang Pisau Regency

Forest/land fires in Kotawaringin Timur Regency and Pulang Pisau Regency have decreased since September 27th, until on October 3rd only the remaining smoke of forest/land fires is visible but on October 4th, forest/land fires appear to reappear with high frequency, until finally decreasing until October 6th there were no hotspots or forest/land fire fumes from MODIS data recording. This phenomenon indicates that forest/land fires occur on peatland, where fire burns not only on the surface but reaches deeper ground so that it is not detected by MODIS image recording.



Information :

Central Kalimantan Province
Concentration of Forest/land Fires at Pulang Pisau Regency and Kotawaringi Timur Regency

Figure 5. Peatland Hydrological Unit Map in Central Kalimantan Province and Location of Forest/Land Fires that Occurs in Pulang Pisau Regency and Kotawaringin Timur Regency (Source : Geosapatial Information Agency in Suwarno, 2017)

Based on the data above, there are locations continuous forest/land fires is on peatland hidrological unit of Kotawaringin Timur Regency and Pulang Pisau Regency. The area of peat land in

Kotawaringin Timur Regency is 361,835 hectare, consisting of very shallow peat area of 19,385 hectare, shallow peat 103,517 hectare, medium peat 88,923 hectare, peat in 129,799 hectare, and very deep peat 20,211 hectare (Wahyunto, 2005), while Regency Pulang Pisau amounted to 64% of 899,700 hectare in the form of peat land (Government of Pulang Pisau Regency, 2015), the condition of peatlands was alarming due to agricultural activities, expansion of plantations and transmigration settlements, in 2016 the population growth of Kotawaringin Timur Regency is 2.37% (BPS Kotawaringin Timur Regency, 2017) while Pulang Pisau Regency is 0.51% (Pulang Pisau Regency BPS, 2017) population growth in Kotawaringin Timur and Pulang Pisau Regency due to the transmigration program, due to increasing population caused changes in land use from forests to settlements, human activities in changing landuse often ignored existing environmental conditions, often clearing forests by burning because it is considered the most effective, besides that the construction of facilities such as irrigation also causes the volume of water stored in peatlands to be reduced so that it is vulnerable to forest fire. In the other side, FDRS value in Kotawaringin Timur Regency and Pulang Pisau Regency on September 27th - October 6th, 2018 is in high to extreme category in majority.

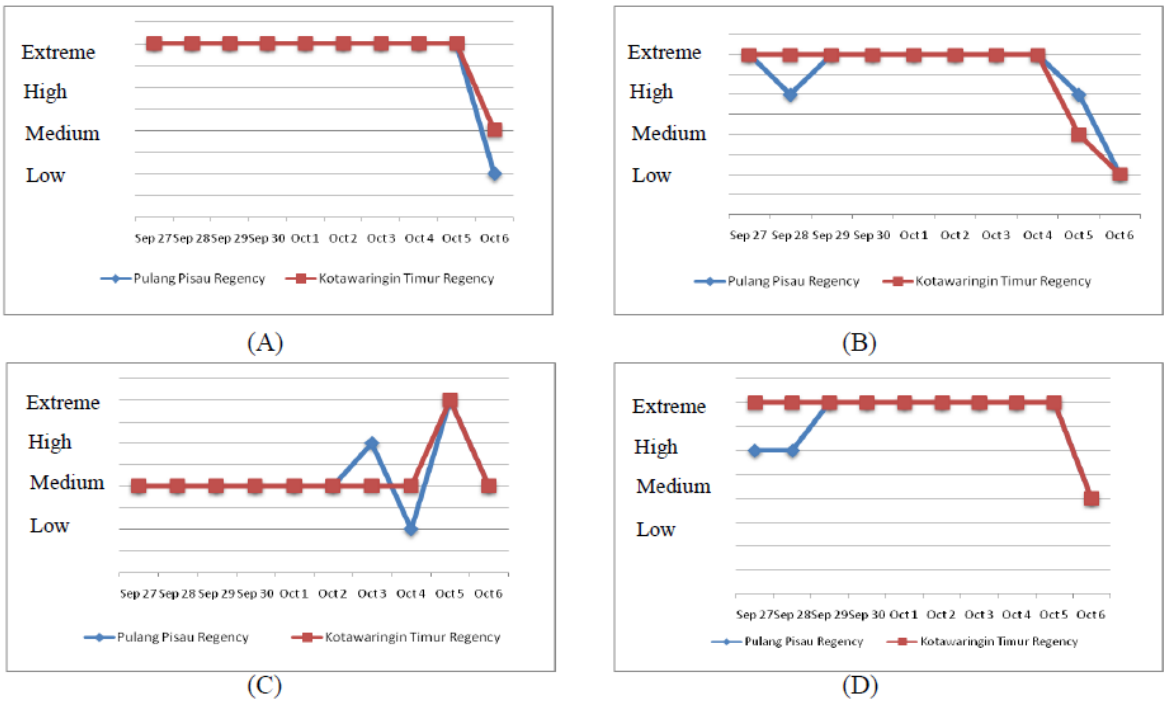


Figure 6. FFMC (A), ISI (B), DC (C) and FWI (D)
FDRS Kotawaringin Timur Regency and Pulang Pisau Regency
Central Kalimantan Province
September 27th –October 6th 2018
(Source : http://spbn.pusfatja.lapan.go.id/maps/927)

The high FFMC value fromSeptember 27th to October 5th shows that the area is classified as "extreme" which shows relatively dry burnt material which caused by the dry season and can also be caused by human activities so that they are flammable, on the October 6th declined at the "low" level to Pulang Pisau Regency and “medium” level to Kotawaringin Timur Regency, this could be due to the presence of clouds and rain on that date so that the relational burnt material was wetter than the

previous date. The ISI value on September 27th to October 4th which is classified as "high" to "extreme" shows the high spread of fire, this indicates that the fires that continue to occur have the potential to enlarge, the decline in value on October 5th can be caused by weather, which in the fashionable image is identified the presence of thick clouds. DC values are an indicator of the potential for fire to flare in a forest/land fire and the potential for smog to occur. DC values on 27th September to October 2nd are relatively stable in the "medium" category, there are fluctuations in DC values caused by fires, when the fire of forest fires decreases, it can leave burning coals, especially on peatlands. The FWI value shows the effect of weather on forest fuels and forest fires. on September 27th to October 5th the value of FWI is "high" to "extreme", this can be seen from the absence of clouds on that date, on October 6 the value of FWI dropped due to the influence of the weather

3.3 Obstacles

MODIS imagery from Aqua/Terra satellite recordings can be used to monitor forest/land fires, especially in Indonesia which has a tropical climate and land conditions in the form of peatlands with a fairly good temporal resolution, namely 2 times in 1 day. The obstacle in utilizing MODIS data is in determining the location of the fire, spatial resolution of MODIS Image is1km x 1 km, for the edge area, the spatial resolution can be 2 km x 2 km, so the location error can reach a maximum of 2 km. The coordinates of the hotspot/hotspot are the midpoints of the MODIS Terra/Aqua satellite image. The source of the fire identified as a hotspot can be in the area of the satellite pixel.

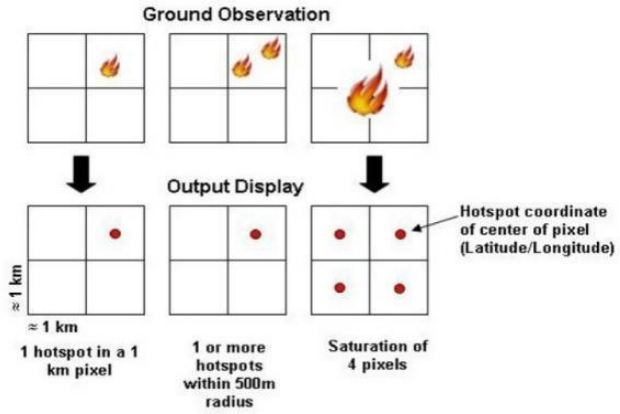


Figure 7. Illustration of Land Fire Using Remote Sensing Data
(Source: Giglio *et al* 2003)

Another obstacle is to obtain MODIS Figure data, it takes about 30 minutes of recording time due to data processing by the server. In this study only using data processing operations through software, field surveys are needed to validate forest/land fires.

4. Conclusion

Utilization of MODIS data in observing forest/land fires shows a pattern of spreading hotspots and at some points there is a concentration of hotspots, this concentration indicates forest/land fires, visual analysis of forest/land fire fumes and concentrations of continuous hotspots can also be used as a reference to determine forest fires. Concentration of fires is in Kotawaringin Timur Regency and Pulang Pisau Regency, fires in the area of the Kotawaringin Timur and Pulang Pisau Regency showed burning land in the form of peatlands with land cover i.e shrubs, the condition of peatlands caused fires to be extinguished because they burned to the ground, with at least 7 weather conditions and land cover days to extinguish fires on the surface based on analysis of peak frequency on September 27th and decreasing until October 3rd, the increase in frequency on October 4th indicates the possibility of fires occurring in the peat soil propagating back to the surface.

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