DETECTION OF 2015 INDONESIAN PEAT FIRES BY ADVANCED HIMAWARI-8 IMAGER (AHI)

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ABSTRACT: In recent years, large-scale forest fires increased in many countries. It is necessary to find the position of forest fire, hence various satellite data are used to enable early detection of forest fires.

Himawari 8, a Japanese weather satellite, was launched in October 2014 and became fully operational in July 2015. The instrument aboard Himawari 8 is a 16 channel multispectral imager and include the band for using to search fires, and produces images every 10 mins. Then the time-resolution of Himawari 8 is high enough to detect the forest fire more rapidly. But the spatial resolution is not so high to compare with the existing satellite data. So it is necessary to confirm the sensitivity to discover forest fires of Himawari 8.

Hence we selected Palangkaraya, the southern side of the island of Kalimantan (Borneo), Indonesia. From September to October 2015, there were large-scale forest fires. So we collected the Landsat 8 data and estimated the fire area, burnt area, and forest area. Then we selected corresponding pixel of Advanced Himawari-8 Imager (AHI) and compared these 2 data. As a result, we found that the special ability of fire detection is not so clear but we could distinguish the change of the fire area and process of the extinguishment of a fire.

1. INTRODUCTION

In recent years, large-scale forest fires occur frequently. There are some papers about the relationship between climate change and wildfire potential (Liu et al., 2013) (Jolly et al., 2015), so it is expected that forest fires will be increased with global warming (IPCC, 2014) then it is thought that the technique of early detection of forest fires will become more important.

For the purpose of the early detection of forest fires, from the 80's, several satellites have been used to detect the forest fires (Cahoon et al., 1994) (Rauste et al., 1997) (Boles & Verbyla, 1999). For early detection of the forest fire, it is necessary to use the satellite with the high resolution of time, but generally, the time resolution of satellite images are high, the spatial resolution tends to be low. So we must confirm the sensitivity of fire detection of the satellite images.

In this study, we used Himawari 8, a Japanese weather satellite, was launched in October 2014 and became fully operational in July 2015. The instrument aboard Himawari 8 is a 16 channel multispectral imager to capture visible light and infrared images and include the band for using to search fires. Advanced Himawari Imager (AHI) can produce images every 10 mins then the time-resolution is high enough, so it seems to be useful to detect the forest fire more rapidly. But the spatial resolution is 2km and is not so high to compare with the existing satellite data, for example, MODIS data.

Hence we want to investigate the AHI's detecting sensitivity of forest fire. Then we selected the place that we could confirm the forest fire area by using other satellite data and check the characteristics of AHI sensors.

2. STUDY AREA AND DATA

We selected the study area in Indonesia. From September to October 2015, many large-scale forest fires occur in Indonesia. In order to confirm the forest fire area, we selected the Landsat 8 data. Hence we selected the area that are existed the Landsat 8 images with a little influence of the cloud. Under this condition, we selected the area of Palangkaraya, the capital of the Indonesian province Central Kalimantan and Katingan and Pulang Pisau Regencies, which comprise the Central Kalimantan Province on the island of Kalimantan (Borneo), Indonesia (Figure 1).

The spectral characteristics of 16 band multispectral imager of AHI is showed in Table 1. For investigating the detecting ability of the forest fire, we selected the band 7 and 13 of AHI, mid-infrared and thermal bands, that are suitable to detect the fires (San-Miguel-Ayanz and Ravail. 2005). We chose the 2015/10/22 Landsat 8 image as the data to confirm the fire area and the AHI data from 2015/10/19 to 2015/10/26.

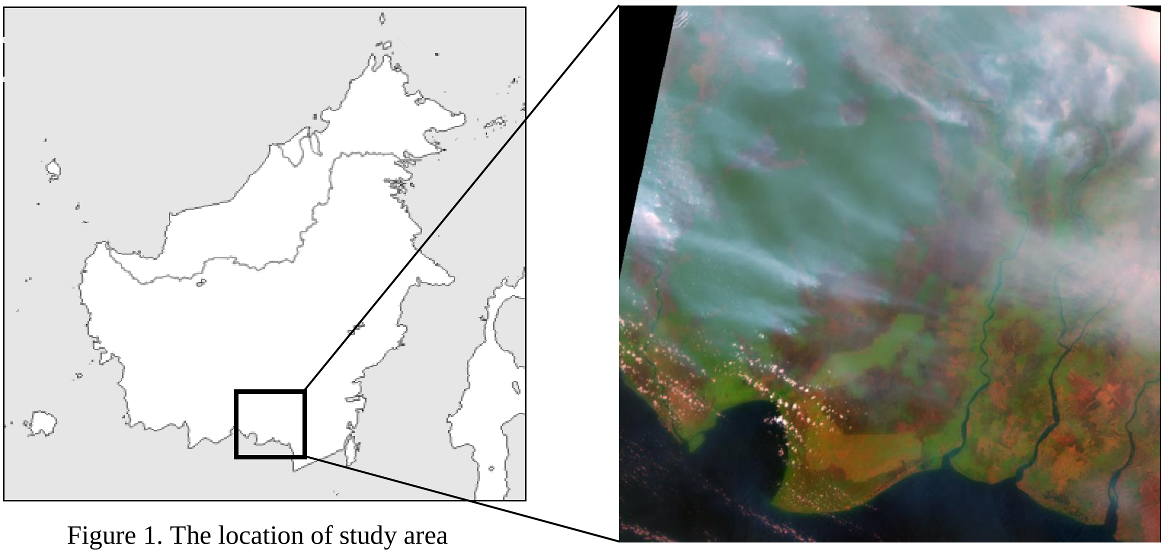

Figure 1. The location of study area

Right image: Landsat8 20151022 RGB=band6, 5, 4

Table 1. Spectral characteristics of AHI

Band number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
horizontal resolution (km)	1	1	0.5	1	2	2	2	2	2	2	2	2	2	2	2	2
wave length (μm)	0.47	0.51	0.64	0.86	1.6	2.3	3.9	6.2	6.9	7.3	8.6	9.6	10.4	11.2	12.4	13.3

3. METHOD

According to the flowchart, we estimated the forest fire area by using the Landsat data (Figure 2). We couldn't find the fire pixels because of the thick smoke. Hence we used band 10 of TIRS (Thermal Infrared sensor) in order to select the fire area.

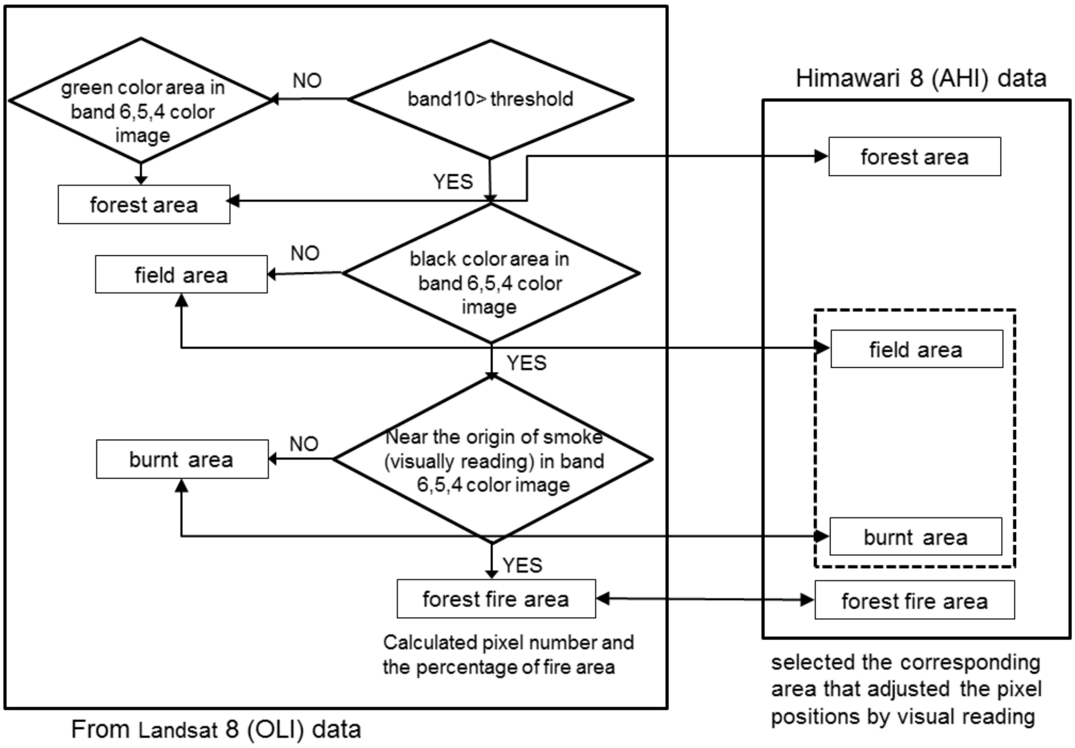

Figure 2. Flowchart for selecting samples of 3 types of ground.

After that, we selected the corresponding area from Himawari data. We couldn't separate burnt area and field area in AHI data because the resolution of AHI is too low to separate these 2 area, so we included these 2 types into 1 type, field area. There are displacement between Landsat and Himawari image. So we had to adjust the position of these two images by visual reading.
Then from these set of data, we investigated the ability of fire detection of AHI. At first we want to investigate the spatial sensitivity of AHI. The spatial resolution of Landsat is 30m and that of band 7 and 13 of AHI are 2km. Then we counted the band 10 of TIRS in the corresponding area of AHI pixel and calculated the ratio of fire area, and compared that and temperature that calculated from pixel value of AHI.
Next we traced the change of each pixel value for 7 days and investigated the ability to detect the change of surface condition, i.e. extinguishment of a fire and outbreak of fire. We picked up the sample pixels from 3 types area; fire area, forest area, and new burnt area (field area) from band 7 and band 13 and investigated which is the suitable band to detect these changes.
And we checked the change of the pixel value for each type of the ground surface and found the characteristics that separate the fire area from other types of ground surface.

3. RESULT AND DISCUSSTION

At first, we checked the relationship between the estimated ratio of fire area from Landsat and temperature estimated from AHI value (Figure 3).

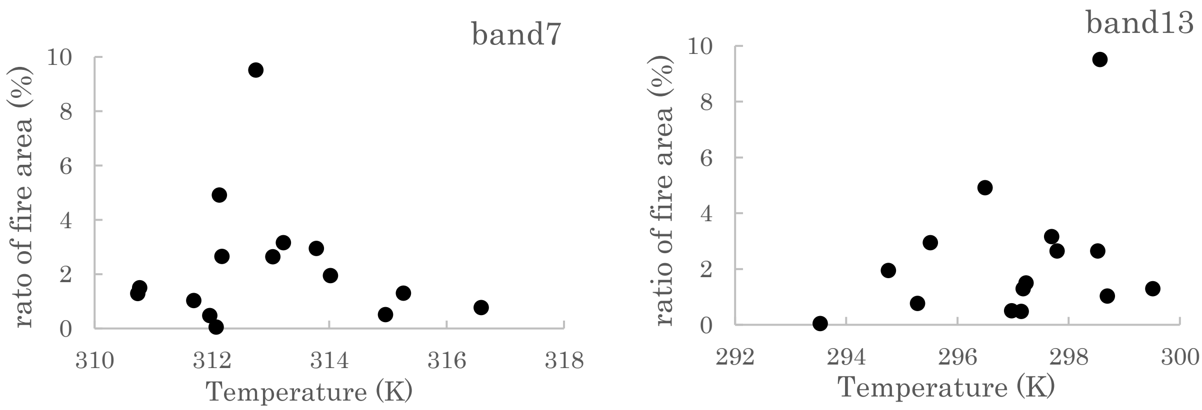

Figure 3. Relationship between temperatures estimated from AHI and ratio of fire area by

Then we found that there are no relationship between those 2 values.
So next we selected the samples of 3 types of ground surface and traced the change of the values for 7 days (Figure 4)

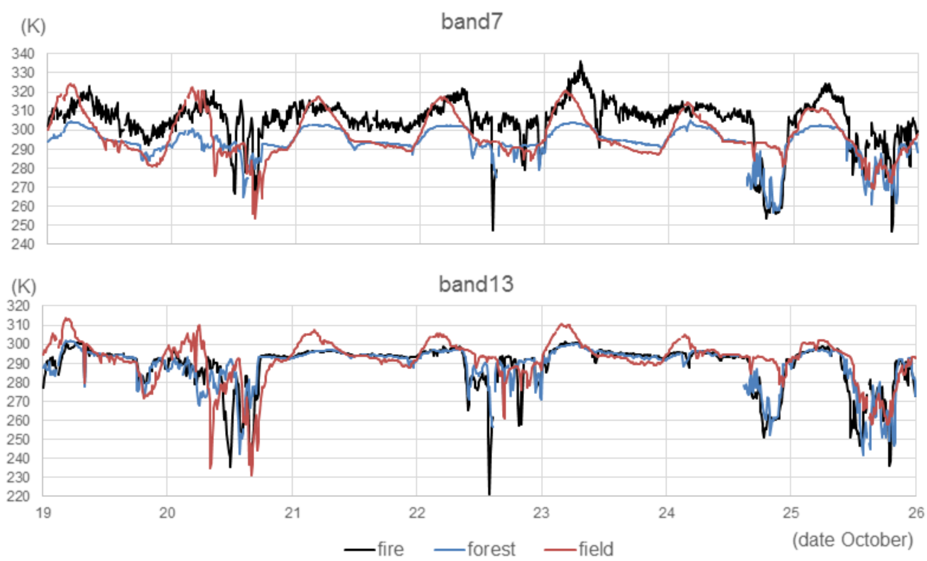

Figure 4.result of compared the value of band 7 and band13 for 7 days.

From these graphs, we found that band 7 is more suitable to detect the fire area than band 13. Except the influence of the cloud, band 7 value of the fire area are always higher than that of the forest area. But also we found that we couldn't separate the fire area by only using the threshold value, because sometimes the value of field area are higher than that of fire area in the daytime. So we must find other factors to detect the fire area. From the graph of band7, we found that the graphs of forest area and field area are changed very smoothly. On the contrary, the graph of fire area is different for each area, and changed with short-term fluctuations. So we assumed that not only the rise in the band 7 value but also the short-term fluctuations is the characteristics of the fire.

In order to establish this assumption, we checked the trace graph of each fire areas and compared the trace graph of forest area. From the sample areas we found 3 trace line, 1 was selected from forest area and 2 were selected from different fire area. In order to examine the range of fluctuations, we used the moving average method, and defined;

μ_{tm} mean = mean (X_t), ($t = tm-30 \sim tm+30$), Xt: temperature that calculated from band 7.

$D_{tm} = \text{abs} |X_{tm} - \mu_{tm}|$:

We regarded D_{tm} as the difference by the short-term fluctuations. So we calculated μ_{tm} and D_{tm}, and also calibration error of the AH sensor, using the value of radiometric calibration accuracy (0.42%; AHI-8 performance test results) , and compared 3 set of trace graphs (Figure 5).

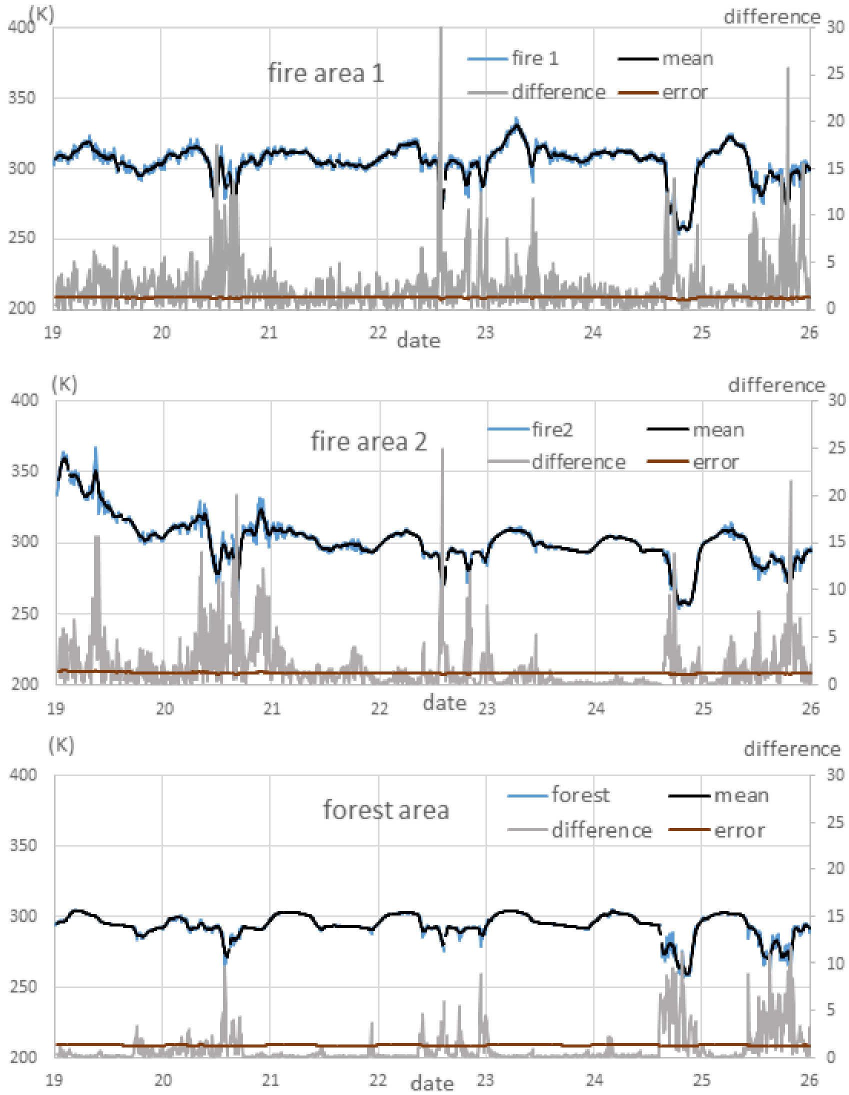

Figure 5. Temperature, μ_{tm}, D_{tm}, and calibration error

From Figure. 5, we confirmed that the D_{tm} of forest area is small enough in comparison with calibration error, unless the area was under the influence of the cloud. On the other hand, the range of D_{tm} of fire area 1 is bigger than the calibration error during seven days. The range of D_{tm} of fire area 2 is also big between 19 to middle of 22 in October, but after the middle of 22, the range become small as trace line got closer to that of forest area. So we concluded that the short-term fluctuations is one of the characteristics of the fire area.

Finally, we traced the big forest fire area for 7 days and investigated the change of the value of band 7 (Figure 6_1). On October 19, we could estimate that there were big fire in study area, by using band7, 6, 5 of AHI color composit image.
Then we traced the change of band 7 of these 12 pixels (Figure 6_2).

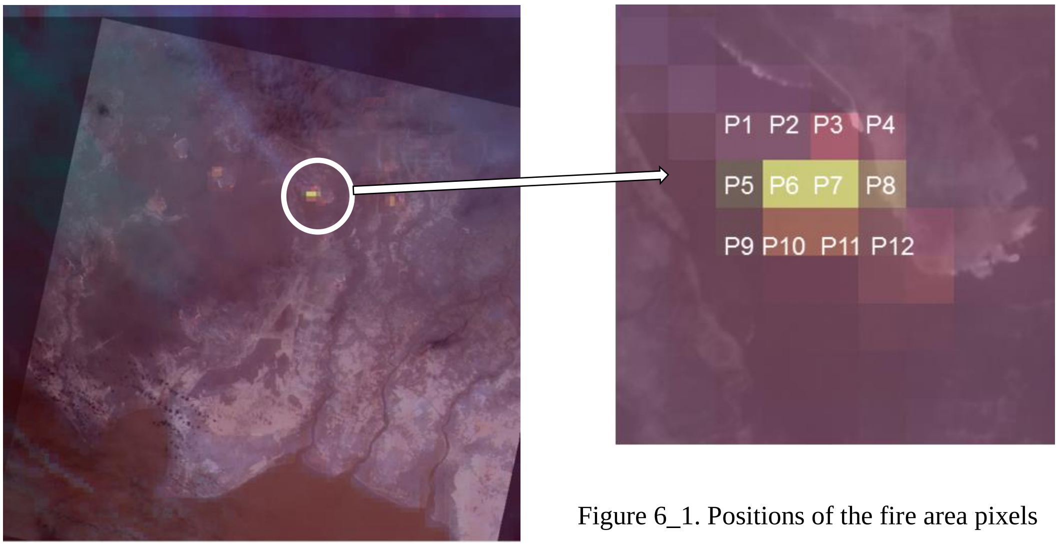

Figure 6_1. Positions of the fire area pixels

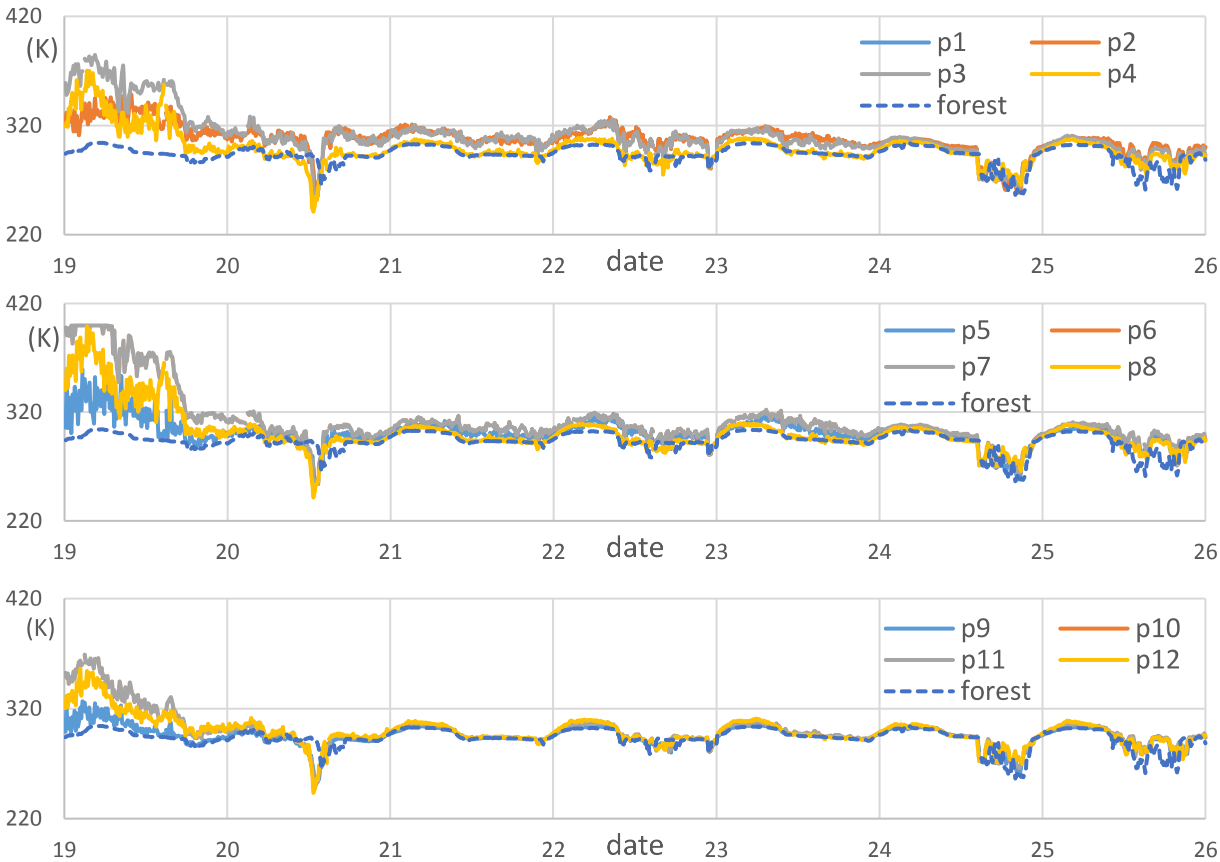

Figure 6_2. Trace line that shows the change of the 12 pixels

From these graphs, we could find that the fire of south row was extinguished in first 2 days. And in first day, the influence of fire was significant in the middle row, but after second day, the influence of fire was bigger in the north row. Both of north and middle rows, p4 and p8, the pixel in the east column, escaped the influence of fire at first. As a result, we could assume that the fire area moved to north-west direction.

4. CONCLUSION

We investigated the ability of fire detection of AHI, and found that it is possible to grasp the change of fire area. But for the early detection of the fire by AHI, there are more problems. So next step, we want to confirm that the change of early stage of fire are reflected to AHI value. In this study we couldn't find the relationship between size of fire area and estimated temperature of AHI, and we also found that the temperatures estimated from band 7 may change in short time span so it is necessary to consider the influence when we confirm the spatial sensitivity of AHI sensor. But if we can find the time point to detect the fire by AHI and confirm the size of the fire area at that time by other information, we will be able to know the spatial sensitivity indirectly.

And using these result, there is some possibility to estimate the speed of moving fire. For this purpose, we need at least 2 images to check the burned area. By combining the information of expansion of the fire and ground truth data, it is possible to get more detailed information for reduction of fire damage.

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