Forest fire experiment toward the detection of forest fires using RS - Thermal and reflectance environment change observation at ground level -

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I. Abstract

In this forest fire experiment, the ThermoViewer was set up on the platform built on a tree and observed the temperature change, before, during and after the fire. The fire experiment had been carried out not only the day of the forest fire experiment but also continued for four months after the forest fire had been gone. The results from the experiment showed that the temperature difference is significant in the afternoon; therefore, afternoon satellite passing is better and suitable time for active forest fires and burnt scars detection; moreover, after 83 days, the burnt and un-burnt vegetation become almost the same condition, fully regenerated and the temperature difference become nearly 0° Celsius, so there is not enough temperature different between burnt and un-burnt vegetation for current sensors to distinguish the difference anymore.

II. Introduction

Forest fires in Thailand occur annually during the dry season from December to May, with the most occurrences in February and March. Monitoring and Mapping of fire are important to manage and control forest fire. Unfortunately, forest fires in Thailand are nearly 100 percent human caused, so it is very difficult to prevent.

The forest fires can be classified into 3 types as follows. The first is a surface fire, which always occurs in Dry Dipterocarp Forest, Mixed Deciduous Forest, and other type of Evergreen forest such as Forest Plantation, Dry Evergreen Forest, and Hill Evergreen Forest or even in some parts of the Tropical Rain Forest. These surface fires consume surface litter, other loose debris on the forest floor and small vegetations. The second is a crown fire, which always occurs in Pine Plantations in the northern region of the country. The third is an underground fire, which occurs only in the Swamp Peat Forest in the southern region of the country. The third type can be classified further to underground-underground and underground-surface-underground. The later two types of forest fire are rarely occurring in Thailand, thus we decided to target the type of surface fire mainly Dry Dipterocarp Forest in Huai-Kha-Khaeng Wildlife Sanctuary, Uthaitani, in this study.

Royal Forest Department (RFD) is operationally developing fire scars maps using LANDSAT TM annually since 1999, which is very useful to summarize and record the country's forest fire history. On the other hand, the near real time update is not yet practiced since forest fire maps are being produced by using LANDSAT TM images (30m resolution) with revisiting time of 16 days.

Asian Center on Research on Remote Sensing (ACRoRS) has been receiving Moderate Resolution Imaging Spectroradiometer (MODIS) data on board TERRA satellite since May 2001; thus, using MODIS data, near real time update of forest fire maps is possible. Although its resolution is rather low such as 250m, 500m, and 1km, its 1 or 2 days (revisiting time) temporal coverage has an advantage for near real time monitoring.

Although MODIS observes the area every 1 or 2 days, the observation of one area is only in a second. So authors set our target to develop a methodology to detect not only active forest fires but to detect burnt scars using thermal and near infrared information as well. Therefore authors have decided to look at the temperature and near infrared reflectance environment change caused by forest fires at ground level, which will be linked to satellite data by using the 3 main equipments which are ThermoViewer, ThermoGun, and Multi-spectrometer.

There are two results that can be concluded from this study. The first is that the afternoon temperature difference between burnt and un-burnt area can be detected by a thermal sensor within 80 days after forest fires. The second is that the reflectance value of vegetations will drop right after the fire and start to increase and reach its healthy condition around 80 days after.

III. Study Area

The World Heritage Huai-Kha-Khaeng Wildlife Sanctuary in Uthaitani province, Thailand, was chosen for the study since it always has many forest fires every year; furthermore, it is the most important part of the most valuable esthetics Western Forest of Thailand. It consists part of 4 provinces, Suphan-Buri, Uthaitani, Kanchanaburi, and Tak with the total coverage of 2,574 sqkm (1,737,587 rais). The study area is at the E540527, N1724917 MODIS 1000m pixel within the sanctuary.

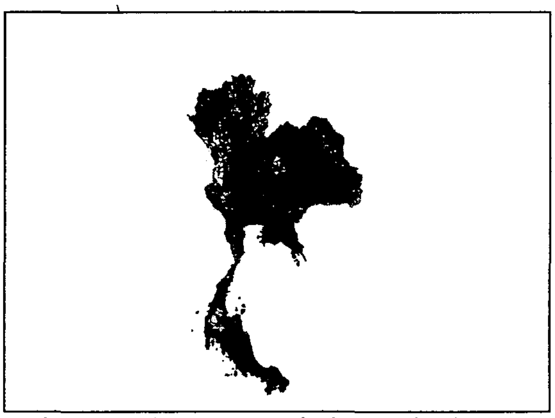

Figure 1: The green area is the Uthaitani Province where the experiment was conducted and data were collected.

IV. Data Collection

Three main equipments were used to collect ground truth data. The ThermoViewer (Diagram 1 and Fig. 2) was used to collect data until it broke down in very hot weather condition late April. There was no natural effect to the ThermoViewer.

There are a few natural factors while using a ThermoGun (Fig. 3) to collect temperature data. The environmental conditions such as wind, cloud, and precipitation can directly influence temperature values of vegetations. Those factors can reduce temperature rapidly within a few seconds. In order to reduce such temperature uncertainty, the average temperature mode had used to collect data. Moreover, walking around while ThermoGun was on for a few minutes to cover 30 by 30 m was followed.

In order to measure vegetation reflection values, the Multi-spectrometer (Fig. 4) was used and there were a few natural factors such as sunlight, cloud, and wind which could change the measure values slightly; therefore, many measurements were done and then use the average numbers.

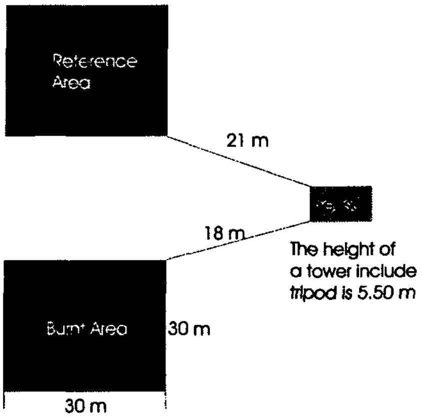

Diagram 1: The outline of the fire experiment setup

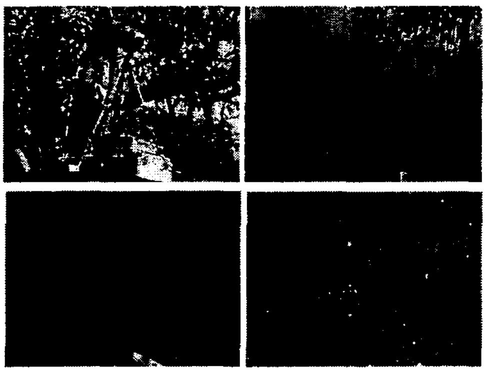
Figure 2: The ThermoViewer setup and the fire experiment

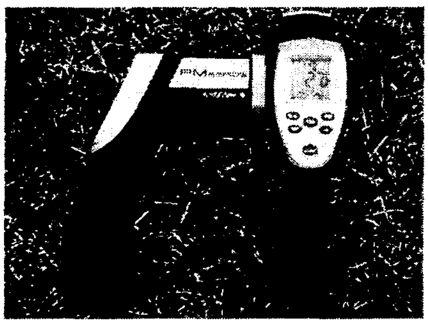
Figure 3: ThermoGun

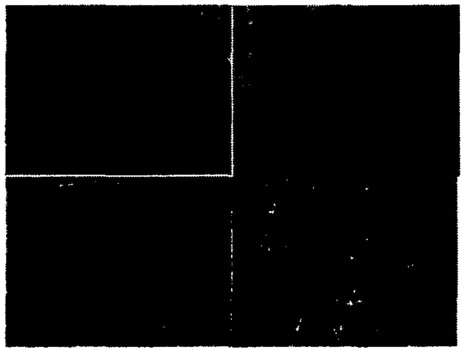
Figure 4: The Multispectrometer

a) Equipments' specifications

1. ThermoViewer

JOEL JTG 6300, Made in Japan, Input power AC 100 V, Temperature detection range -20 ~ 184 C, 5 FOV (H x V); FOV 25: 25 x 23 ; FOV 20: 20 x 18.5 ; FOV 15: 15 x 14 ; FOV 10: 10 x 9 ; FOV 5: 5 x .7 ; Accuracy 1 °Celsius.

2. Portable GPS

Garmin's GPS III Plus Personal Navigator with 12 channels receiver from a constellation of 24 GPS satellites, Made in Taiwan

3. Portable Multi-spectrometer

ABE SEKKEI Model 2703, Made in Japan, Aperture 2 and 10 degree, Powered by 9 volt dry battery, 17 Wavelength in nm range from 400 to 1050; 400, 425, 450, 475, 500, 525, 550, 575, 600, 625, 650, 675, 700, 750, 850, 950, and 1050

4. Portable Electric Generator

SH1000DX Sawafuji Electric, Honda Engine AC 220 V, fuel gasoline (petrol) Rated output 750 VA, Max output 850 VA, Made in Japan

5. UPS 500VA, (220 V/50 Hz, in and output),

6. Auto Voltage Regulator SLIDEUP
7. ThermoGun's Specification

Yokokawa M&C Corporation, Model: PM132A, Temperature Range: -42 – 610 °Celsius, Wavelength: 8 ~ 14 μm, Accuracy: 0.1 °Celsius.

V. Methodology

The first step is finalizing all collected ground truth for a clear and better picture. The second is processing data from ThermoViewer by ThermoWin software and retrieve average temperature in °Celsius from the ground cover extent within the processed images. The third is arranging and combining the temperature data from ThermoWin with ThermoGun. The fourth is converting data collected by Multi-spectrometer to the 'Reflectance % Factor' values by using $R_i = 10^{(vi-v0)}$; where R_i is Reflectance % factor, V_i is Object Reading Values, and V_0 is Whiteboard Reading Values.

VI. Results and Discussions

1. Temperature environmental change

a. During the fire, temperature goes up (Fig. 5), the image captured by ThermoViewer can be seen in Fig. 8 and 9.

b. After the fire, temperature goes down slowly.

c. The burnt area keeps higher temperature comparing to un-burnt area during day time. The difference continues (Fig. 6).

d. By Comparing to un-burnt area, temperature is higher during day time. However, the temperature becomes the same in the mornings and in the evening.

e. The temperature difference becomes the maximum in the afternoon, which is approximately 7 degrees after 30 days and started to drop (Fig. 7).

f. Difference continues until the first rain came then vegetation started to grow up (Fig. 7).

g. After the rain, temperature difference becomes negative because the vegetation covers of the burnt are quicker fully recovered than the un-burnt and the new fresh vegetations at the burnt area contain higher moisture than the un-burnt area where there is still dry vegetation remained among the regenerated one (Fig. 7).

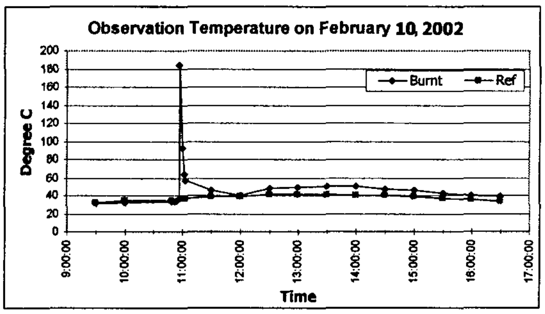

Figure 5: The temperature during the forest fire experiment

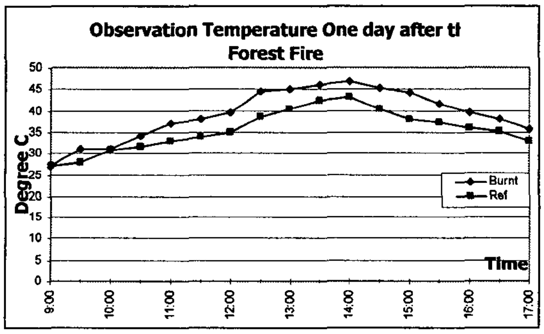

Figure 6: The Observation Temperature a day after the forest fire occurred

(Burnt-Ref: Temperature Difference between Burnt Area and Un-burnt reference Area)

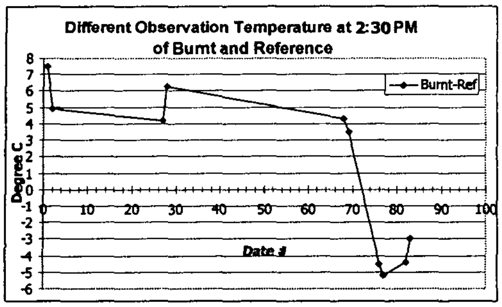

Figure 7: The temperature different at 2:30 PM as a Julie Day Calendar.

2. Reflectance environmental change

The processed images can be seen below in Fig. 8 and 9. In Fig. 8, active fire is shown in the red tone and in Fig. 9 the same active fire is exaggerated up vertically, so it could be seen in 3D view alike.

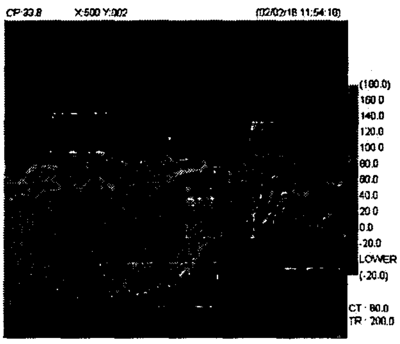

Figure 8: The image captured by ThermoViewer while conducting the experiment on February 10, 2002 along with the official prescribe burning at Huai-Kha-Kaeng Wildlife Sanctuary.

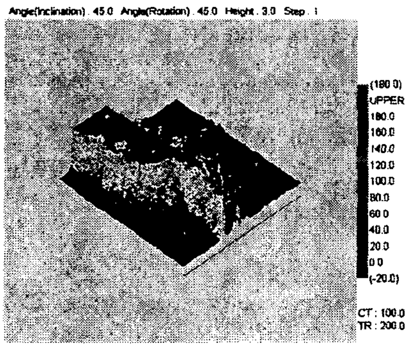

Figure 9: The different look at the same processed image of Figure 8.

There is also an important evident of vegetation recovery which caused the temperature after burnt to be negative. Spectral reflectance change measuring by a multi-spectrometer which can be seen in Fig. 10 indicates that the after burnt vegetative condition drops then starts to regenerate again. The 850 nm measurement was selected because it is the closest to 250m MODIS Band 2 (841-876 nm) which represents a near infrared range for the sensor. The reason that the burnt vegetation reflects low % of NIR is because as mentioned in (1.f) above.

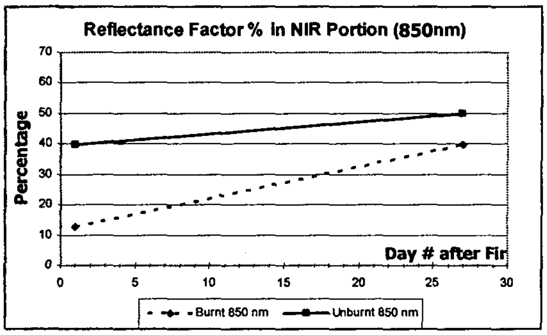

Figure 10: The Reflectance % Factor of vegetation measured by the Multi-spectrometer over 83 days since the vegetation got burnt.

The important characteristic that can be identified here is that the un-burnt (Reference area) vegetations have temperature a little bit higher than the burnt vegetation after 80 days. The point worst to mention here is that after the first heavy rain, vegetation cover grows very quickly. From my observation, after 5 days of the first heavy rain, full vegetation regeneration will be recovered within 2 to 3 weeks. The result from this natural phenomenon is that surrounding temperature is higher than the burnt and un-burnt vegetations. This is the reverse temperature different characteristics detected by a portable thermal sensor since burnt vegetations usually contain higher temperature than the un-burnt vegetations. This significant characteristic can be notified as the end of the detection of forest fire burnt scars by a satellite since a current space-borne sensor cannot distinguish the different temperature and vegetation reflectance between the burnt and un-burnt vegetations anymore.

From the result, authors can say that the afternoon will be the best time for detecting temperature environment change since the temperature different between the burnt and un-burnt is significant in the afternoon. The average value of the first 60 days is 5 ° Celsius with the peak at 7 °Celsius. The current MODIS is on board TERRA satellite observes the earth around 11 AM (morning satellite). NASA just launched AQUA satellite which has the same MODIS sensor on board on 2:55 AM PDT May 4, 2002 from Vandenberg Air Force Base, CA USA.

The observation time of MODIS / AQUA is around 1:30 pm at nadir (afternoon satellite), thus MODIS/AQUA would be more suitable for detecting fire scars at near real time basis in Thailand.

Future Plan

The remote sensing data of MODIS and LANDSAT TM are being processed and analyzed to develop algorithms for detection of active forest fires and fire scars. After getting those satellites processed results, links will be made in order to show that the results form the field experiment can improve the usage of quicker temporal satellite remote sensing to improve the typical LANDSAT 16 days revisit cycle of active forest fire detection and burnt scars products.

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References

[1] Akaakasa, Siri, 2001, *Forest Fire Control in Thailand*, Forest Fire Control Office, Royal Forest Department, Thailand, 2-5.

[2] MODIS Website http://modis.gsfc.nasa.gov