Near Real Time Burnt Scars Monitoring using MODIS in Thailand

Veerachai Tanpipat*, Kiyoshi Honda*, and Siri Akaakara**
*Remote Sensing and GIS, School of Advanced Technologies, Asian Institute of Technology, Km 42 Phaholyothin Road, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand
**Forest Fire Control Division, National Park, Wildlife and Plant Conservation Department, Ministry of Natural Resource and Environment, Ministry of Natural Resources and Environment, Paholyothin Road, Jatujak, Bangkok 10900, Thailand;
Email: veerachai.tanpipat@ait.ac.th , honda@ait.ac.th, siri.fire@mnre.go.th

Abstract

A new methodology to detect forest fire burnt scars at near real time using MODIS (Moderate-resolution Imaging Spectroradiometer) data is presented here with a goal of introducing a new and improved capability to detect forest fire burnt scars in Thailand. This new technology is expected to increase the efficiency and effectiveness of the forest fire tackling resources distribution and management of the country.

Using MODIS data in burnt scars detection has two major advantages - high availability of data and high resolution per performance ratio.

Results prove the near real time algorithm suitable and working well in order to monitor the forest fire dynamic movement. The algorithm is based on the threshold separated linear equation of burnt and un-burnt. A ground truth experiment confirms the burnt and un-burnt areas characteristics (temperature and NDVI). A threshold line on a scatter plot of Band 1 and Band 2 is determined to separate the burnt from un-burnt pixels. The different threshold values of NDVI and temperature use to identify pixels' anomaly, abnormal low NDVI and high temperature. The overlay (superimpose) method is used to verify burnt pixels.

Since forest fire is a dynamic phenomenon, MODIS burnt scars information is suiting well to fill in the missing temporal information of LANDSAT for the forest fire control managing strategy in Thailand. This study was conducted in the Huai-Kha-Kaeng (HKK) Wildlife Sanctuary, Thailand

1. Introduction

1.1 Background

Thailand has two dominant vegetation types, Evergreen and Deciduous Forests. The Evergreen Forest is composed of a great proportion of the non-leaf shedding species and covered about 40% of the total forested area. On the other hand, the Deciduous Forest, which covers the remaining 60%, comprised of species with leafless periods. Forest fires in Thailand occur annually during the dry season from early December to early May with their peak in March. Most Fires in Thailand are classified as surface fires. They mainly take place in Deciduous Forest (Dry Dipterocarp and Mixed Deciduous). In certain extremely dry areas, double burning in the same season is also common. These surface fires consume surface litters, other loose debris on the forest floor and small vegetations. Other types of fire (crown and underground) are not common to the forests of this region. According to the official statistics collected by the Forest Fire Control Division, a very insignificantly small numbers of naturally caused fires were recorded, so human is the main cause. Causes of forest fires are related to activities of those who live in the rural areas - gathering of forest non-timber products, agricultural debris burning, and carelessness (Akaakara 1999 and 2001 and Plodpail et al 1987).

1.2 Statement of the Problem

The mapping of forest fires in Thailand only targeted burnt sites using the LANDSAT TM data. A combination of Bands 7-4-2 is used in the visual interpretation where the cartographers' trace and some characteristics such as shape, pattern, color, site, and association in a burnt region (Ongsomwang 1999-2002) are also employed. Using LANDSAT TM for a burnt area mapping, however, has several limitations. The non-frequent 16-day revisiting time of the satellite is a little bit too long to monitor the progress of forest fires. In addition, the images will be purchased after the forest fire season is over hence it is impractical to monitor forest fires interactively. Therefore, the multi-temporal remote sensing data with MODIS available today promises an attractive alternative to explore for the near real time forest fire management. MODIS has a revisit period of 1-2 days with additional 250 m spatial resolution in the visible and near infrared range, which is essential in the burnt scars detection (Justice et al 1998 and 1999).

1.3 Objectives and Scope

The objective of this study is to develop an alternative and a more effective approach– a "near real time burnt scars detection" methodology using MODIS data - in forest fire detection and management in Thailand. To realize this goal, field experiments have been performed to characterize thermal and NDVI profiles of burnt and un-burnt area. This information together with the data from MODIS, have been analyzed. The outcome is used as a bench reference in determining, predicting and distinguishing the burnt and un-burnt pixels in HKK Wildlife Sanctuary.

2. Methodology

2.1 Description of the Study Area

The study was conducted in Western Thailand within the World Heritage HKK Wildlife Sanctuary (see Figure 1) in Utaitani province. HKK is comprised of corners of four provinces - , Suphanburi, Utaitani, Kanchanaburi, and Tak - with the total coverage area of 2,574 km^2. The center of the study area is at the Forest Fire Control Region 1 Center 1.

2.2 Framework of the Study

The development of a near real time burnt scars detection algorithm was founded on a corresponding relationship between the ground truth characteristics (fire experiment) and the analysis of remote sensing (MODIS) data of forest fires. During the field works, a fire was conducted to gather salient information on changes of the surrounding environmental conditions between the burnt areas and un-burnt ones (see section 2.4). Subsequently, the MODIS data were processed and analyzed to derive for a threshold equation so that burnt and un-burnt pixels can be identified. The near real time burnt scars detection algorithm was derived upon a linear separated equation. To determine, if it is a burnt or un-burnt pixel, the threshold equation and values are employed (see section 2.5).

2.3 Data

Two sets of data were collected and used in this study: (i) ground data and (ii) remote sensing data. The ground data included the fire experiment, the 2002 forest fire locations report where the forest fire fighters operated both ground and aerial works from the Forest Fire Control Office. The remote sensing data included three LANDSAT 7 ETM+ images taken on 16 February, 4 March, and 5 April 2002, obtained from the Geo-Informatics and Space Technology Development Agency (GISTDA). In addition, there were six other MODIS scenes collected on 9 February, 16 February, 11 March, 29 March, 21 April, and 9 May 2002, which were obtained from the ground-receiving terminal at Asian Institute of Technology (AIT). The LANDSAT data together with the ground information were used as benchmarks in the accuracy assessment of the results from the newly developed near real time burnt scars detection algorithm.

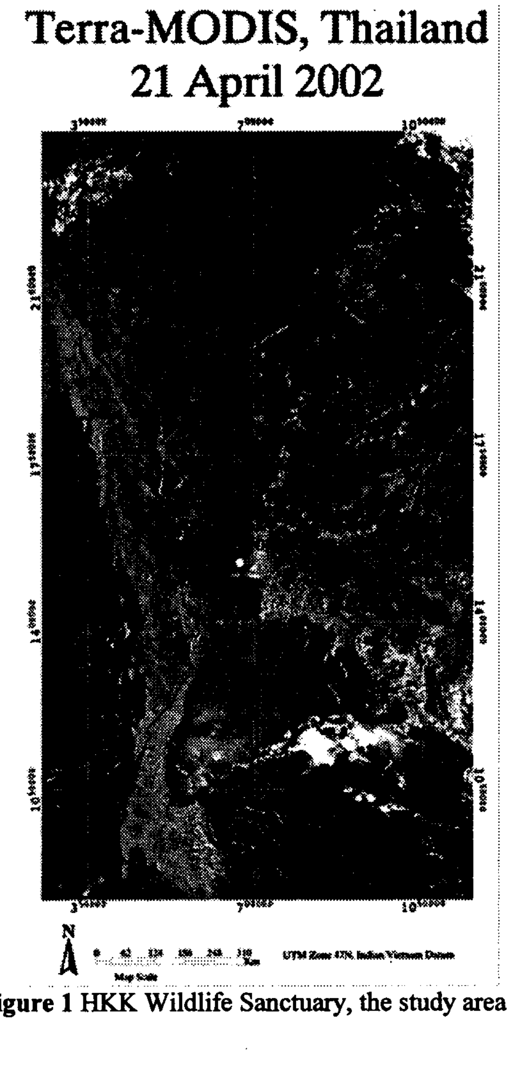

Figure 1 HKK Wildlife Sanctuary, the study area

2.4 Fire Experiment

2.4.1 General Description

The purpose of this fire experiment is to study changes in the environmental conditions of burnt and un-burnt areas, which are pre-requisite information in the development of the near real time burnt scars detection algorithm. The data collection (changes of temperature and NDVI caused by forest fires at ground level) began on 10 February 2002 and continued until 9 May 2002.

2.4.2 Instruments

Three main equipments were used in the fire experiment (i) ThermoViewer, (ii) ThermoGun, and (iii) Multi-spectrometer. The ThermoViewer was used to observe the thermal profile (space and time) of the experimental forest fire. The ThermoGun was used to record a temperature at a specific point in time during the experiment. The Multi-spectrometer was used to collect NDVI values. To minimize the fluctuation in the data caused by environmental factors, several readings have been done and the average values were used in the analyses.

3. Results and Discussion

3.1 Fire Experiment

This section discusses outcomes of the forest fire experiment conducted inside the HKK Wildlife Sanctuary during the fire season of 2002. The environmental changes occurred during and after the fire were observed. The recorded observation was then compared with MODIS data.

3.1.1 Temperature Change

Some salient observations have been noted on temperature. During the fire, temperature rises. After the fire, temperature drops slowly. The burnt area maintains a higher temperature compared to the un-burnt one during day time. The difference is sustained. The temperature difference peaks in the afternoon, ~ 7 degrees the day after the burnt and after 28 days, it is ~ 6 degrees. The maximum temperature difference in the morning is ~ 5 degrees. The temperature difference continues until the first heavy rain arrives, in this study it was the 26th April 2002. Then vegetation starts to grow quickly. After the rain, the vegetation covers of the burnt areas have higher moisture than the un-burnt areas where dry vegetation remained. As a result, the temperature of the un-burnt areas is higher than that in the burnt areas. Full vegetation recovers within 2 to 3 weeks. This distinctive characteristic implies that burnt scars could be detected through out the dry season if it is big enough. The analyzed results strongly suggested the best window for detecting the temperature change is in the afternoon, as the afternoon gives longer time for the burnt area to expose to sun light. The important character that can be concluded is that the MODIS' temperature difference of burnt and un-burnt shows difference after the fire occurred where the ground truth fire experiment temperature difference also shows the same behavior.

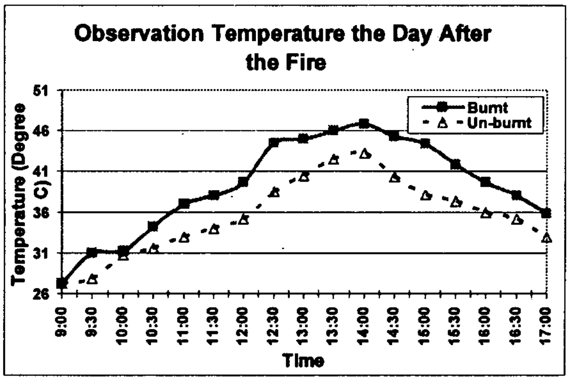

Figure 2 The Observation Temperature one day after the forest fire occurred.

3.1.2 NDVI Change

After the burning on the 10 February 2002, the NDVI value reduced (0.06, close to zero), then, regenerated to 0.48 on 8 May 2002. The analyses suggested that the NDVI value of burnt pixels is smaller than the un-burnt.

3.2. MODIS Burnt Scars Detection

This part of the study explored a near real time burnt scars detection algorithm using the information obtained from the fire experiment comparing to MODIS data. First the temperature and NDVI profiles for burnt and un-burnt areas from the fire experiment were analyzed. Next the threshold of Band 1 and 2 was determined. The value was used in deciding if the MODIS pixel was burnt or un-burnt.

3.2.1 The Temperature and NDVI

The time profiles of temperature and NDVI appear that the experimental results conform well to the MODIS information. The burnt temperature is higher (abnormal high) than the un-burnt and the burnt NDVI is smaller (abnormal low) than un-burnt.

3.2.2 Band 1 and Band 2 Scatter Diagram

This part of the study aims to determine a threshold equation for the distinction between burnt and un-burnt pixels in a MODIS image. The following results are derived from the MODIS data of the burnt and un-burnt experimental areas, the forest fire reports and the LANDSAT images used to support and confirm the MODIS burnt and un-burnt pixels.

A scatter plot of Band 1 and Band 2 of selected MODIS data was plotted. A clear separation between burnt and un-burnt pixels is observed in the graph. The separation line is defined as Band 2 = 3212 + 1.277* (Band 1).

3.2.3 Near Real Time Burnt Scars Detection

The near real time burnt scars detection algorithm was developed using threshold equation and values were each results will be overlaid (superimposed) to confirm if the areas are burnt. The procedure was applied in multi-temporal MODIS data. Results are shown in Figure 3.

3.2.4 Accuracy Assessment

The MODIS burnt pixels based on the burnt scars detection algorithm were validated using burnt area maps of the LANDSAT images (Ongsomwang et al, 1999-2002), field forest fire fighting report and the helicopter fire locations report (HKK Forest Fire Report, 2002). It is evident that the burnt scars detection from MODIS and LANDSAT TM conformed well in term of dynamic movement characteristics of forest fire. In addition, detection of the accumulated burnt areas between MODIS and LANDSAT are highly comparable.

4 Conclusions and Recommendations

The fire experiment results concluded that the morning NDVI and temperature differences can be used to detect the burnt scars movement where temperature difference between the burnt and un-burnt areas could be detected until the first heavy rain starts. The NDVI value of vegetations drops right after the fire and starts to rise again and quickly recovers after the first heavy rain. In addition, the outcome of this study suggested that the detection by using MODIS will be better when adding the afternoon acquisition, this study conducted before the Aqua was launched, but it should be further investigated.

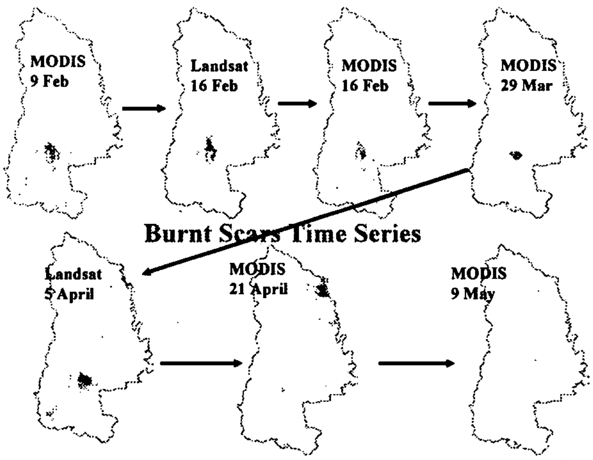

Figure 3 Time series burnt scars map of LANDSAT TM and MODIS to show the dynamic movement of forest fire

This method has great potential for improving significantly the monitoring of the burnt scars movements and the forest fire activities, which consequently, it will facilitate better management of the forest resources of the country.

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