Evaluation of Wildfire Duration Time Over Asia using MTSAT and MODIS

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Abstract

In this study, we present an approach to evaluate a wildfire duration time. An-hourly MTSAT imagery is quite powerful to obtain the duration time of rapid fire events such as a grass land fire that cannot be detected with the frequency of MODIS. Research areas are evergreen needleleaf forest in Far-east Russia and evergreen broadleaf forest in Sumatra. Our approach is based on a model that the temperature of the pixel becomes higher than the non-fire pixels if there is some wildfire in the pixel. As a result, it is found that fire duration time is detected by comparing the fire pixel which contains hotspots with a non-fire pixel around it. This technique is useful to detect wildfire duration time even land coverage is evergreen needleleaf forests or evergreen broadleaf forests. We can conclude that an-hourly based monitoring provides us with a sufficient time resolution and plays an important role to monitor wild fire duration time despite a lower spatial resolution in 4 kilometer than that of MODIS in 1 kilometer.

Key Words: Sentinel Asia, Web-GIS, Wild Fire Detection, Hotspots Detection Algorithm, MOD14, Peat Bog Fire

1. Introduction

1.1 Background

Serious wildfire occurs in Asia so frequently. It causes not only threads for inhabitants but also global warming or smog problem for neighbor countries (UNDP, 2001). Most of wild fires occur in hardly accessible places. Therefore, remote sensing is one of very useful tools to find or evaluate the wild fire.

There are many researches to get better information of wildfires. For example, methods of finding wildfire hotspots using high time resolution data such as MODIS (Kaufman et al., 1997), AVHRR (Li et al., 2000) and detection of burning area using high spatial resolution data such as Landsat TM, SPOT HRV, Terra ASTER (Takeuchi et al., 2005). At the current situation, however, despite the advent of satellite imagery and the growing significance of fires to understand a condition of global forests, no reliable global statistics are available for a wildfire duration time. More information about duration time of wildfires would be needed so far.

MTSAT have thermal infrared sensor in spite of spatial resolution is 4km. By using MTSAT, we can analyze hourly features of wildfires (JMA, 2003). Before MTSAT launched, there is no way to clarify the feature of duration time of wildfires. Clarification of duration time of wildfire contributes to the evaluation of carbon dynamics change studies such as CO_2 emissions by wildfires (Ito, 2005).

1.2 Objective

The objectives of this research are as follows.

- To evaluate relation between a scale of burning area and spatial resolution by comparing ASTER, MODIS, and MTSAT which spatial resolution is different each other.
- To clarify the feature of duration time using MTSAT data Myanmar, far east Russia, and Sumatra.

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2. Methodology

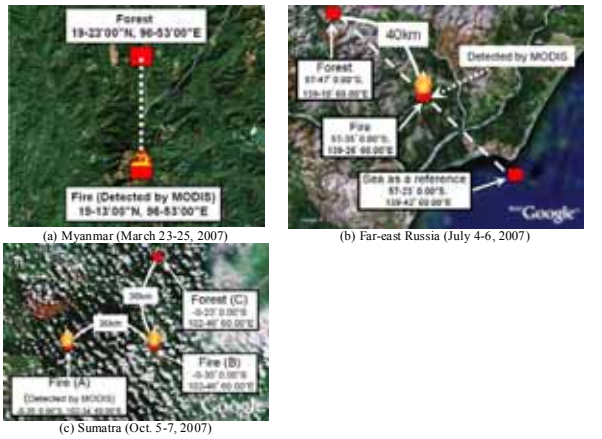
2.1 Wildfire duration time estimation model used in this study

Figure 1 shows the flowchart of wildfire duration time estimation with MTSAT. This research consists of two parts; comparison of burnt area delineation with ASTER, MODIS and MTSAT, the other is the evaluation of wildfire duration time using MTSAT data.

Firstly, three study areas were determined supplemented by hotspot data with MODIS. Secondly, a bunch of satellite dataset was created including ASTER, MODIS and MTSAT with different spatial resolutions 90m, 1km and 4km respectively. They were used to delineate burnt areas and were carried out by using web-based processing systems (http://webmodis.iis.u-tokyo.ac.jp, http://webgms.iis.u-tokyo.ac.jp). Finally, wildfire duration time was estimated with 72-hours time series behaviors of MTSAT thermal infrared imagery by comparing a fire pixel with a non-fire pixel.

2.2 Study area

Figure 2 shows study area which is determined by fire spots data by MODIS, vegetation map by Boston University, and visual judgments from Google earth. Considering difference of size and vegetation, following three areas are selected; evergreen broadleaf forest in Myanmar (March 23rd in 2007, 96-53'E, 19-13'N), evergreen needleleaf forest in far-east Russia (July 4th in 2007, 139-26'E, 57-33'N), and evergreen broadleaf forest in Sumatra (Oct. 5th in 2006, 102-43'E, 0-43'S).



(a) Myanmar (March 23-25, 2007) (b) Far-east Russia (July 4-6, 2007)

(c) Sumatra (Oct. 5-7, 2007)

Figure 2: Area of interest in this study including Myanmar, Far-east Russia and Sumatra.

3. Results

3.1 Comparison of burnt area delineation with ASTER, MODIS and MTSAT

Figure 3 shows thermal infrared imagery of ASTER, MODIS and MTSAT. The area of interest is 8x8 km2 corresponding to 4 pixels of MTSAT. Figure 2-(a) shows ASTER channel 14 imagery. A histogram of ASTER channel 14 shown in Figure 3-(a) was used to determine a threshold between fire pixels and non-fire pixels, and binary image was created as shown in Figure 3-(b). The extracted fire-affected area is shown in white colors in the center of the image and area was estimated 1.5 km2. As a comparison, MODIS channel 31 image is shown in Figure 3-(c) over the same area. Spatial distribution of MODIS has consistency with that of ASTER. MTSAT channel 1 image shown in Figure 3-(d) shows a fairy good results compared with ASTER and MODIS as

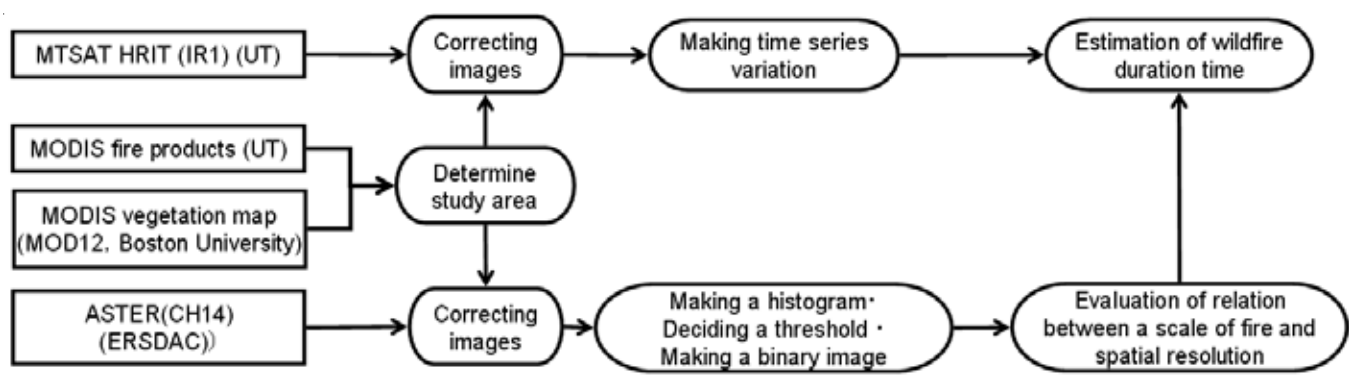


Figure 1: Flowchart of wildfire duration time estimation using MTSAT.

well. A fire affected pixel shown in an upper left highlighted in white color has 3K higher than the other three non-fire pixels. It was found that this fire event with the size of 1.5 km2 is detected by 4km MTSAT thermal infrared imagery.

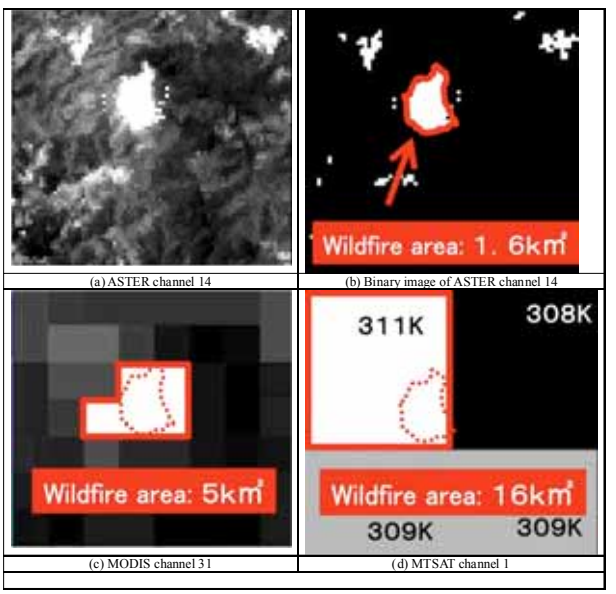


Figure 3: Thermal infrared imagery of ASTER, MODIS and MTSAT. The area of interest is 8x8 km2 corresponding to 4 pixels of MTSAT. Brighter color indicates high brightness temperatures.

3.2 Estimation of wildfire duration time using MTSAT

3.2.1 Myanmar

Figure 2-(a) shows the location of intensive wildfire hotspot in Myanmar. Figure 4-(a) shows time series variation of the land surface temperature from MTSAT (channel1, 10.5um) from March 23rd to 25th in 2007. The hotspot was detected in March 23rd, the first day of the series, by MODIS fire product. Time series variation from MTSAT shows that temperatures of fire pixels transit higher than that of non-fire pixels. The biggest difference is 2K at 14:00 in local time. The difference of temperatures between fire pixels and non-fire pixels were gone during nighttime. From this result, even though spatial resolution of MTSAT is poorer than that of MODIS, time series variation of a thermal infrared channel of MTSAT show significant difference to detect fire pixels because time resolution is more frequently.

3.2.2 Far-east Russia

Figure 2-(b) shows locations of target pixels of time series variation on evergreen needle leaf forests in Russia. Figure 4-(b) shows time series variation of the land surface temperature from MTSAT (channel1, 10 m) from July 3rd to 5th in 2007. The time when the wildfire was detected by MODIS fire products is July 4th and July 5th. As the figure shows, both of a fire pixel and a non-fire pixel show a similar time series variation in July 3rd. However, the fire pixel displays different behavior from normal pixels in July 4th and July 5th. At the peak of the graph, the fire pixel shows about 3K higher temperatures than the non-fire pixel in July 5th. From this information, the wildfire duration time is 10 hour in July 4th and 12 hour in July 5th.

3.2.3 Sumatra

Figure 2-(c) shows locations of target pixels of time series variation on evergreen broadleaf forests in Sumatra. Figure 4-(c) shows time series variation of the land surface temperature from MTSAT (channel1, 10 m) from Oct. 5th to 7th in 2006. The time when the wildfire was detected by MODIS fire product is Oct.5th and Oct. 6th at fire pixels A and B. As the figure shows, the peak of the time series variation at fire pixels A and B on Oct. 5th and Oct. 6th is higher than a non-fire pixel C. From this figure, duration time of wildfire is 14 hours in Oct. 5th and 9 hours in Oct. 6th. At Oct. 7th, both of the land surface temperature in pixel A, B, and C change in the almost same way, so we estimate there is no wildfire in these pixels.

4. Conclusion and future works

In this research, we have presented two types of research. Firstly we compare burnt area delineation with ASTER, MODIS and MTSAT that spatial resolution is different each other. Secondly, we estimate duration time of three wildfires by using time series variation of MTSAT comparing fire pixels and non-fire pixels.

Our accomplishments are following three things.

- Thermal infrared imagery of ASTER, MODIS, and MTSAT shows consistent spatial distribution.
- MTSAT can be used to detect intensive wildfire that a an area is about 1.5 km2 in this survey, even though spatial resolution of MTSAT is 4km meanwhile that of ASTER is 90m.
- Duration time of intensive wildfire can be estimated at an hourly basis by visual judgment of fire pixels and non-fire pixels.

In the future research, we have to consider following three things.

- Importance of precise geometric correction
  - MTSAT imagery have around 4 km geometric errors
  - Manual geometric correction are applied scene

by scene

- Lower availability of ASTER data
  - Cloud coverage is crucial to find fine ASTER imagery which capture hotspots
  - The same sypes of sensors should be combined; Landsat, SPOT, ALOS, IKONOS *etc.*
- Validation of wildfire duration time
  - Duration time estimation in nighttime is more difficult than that in daytime.

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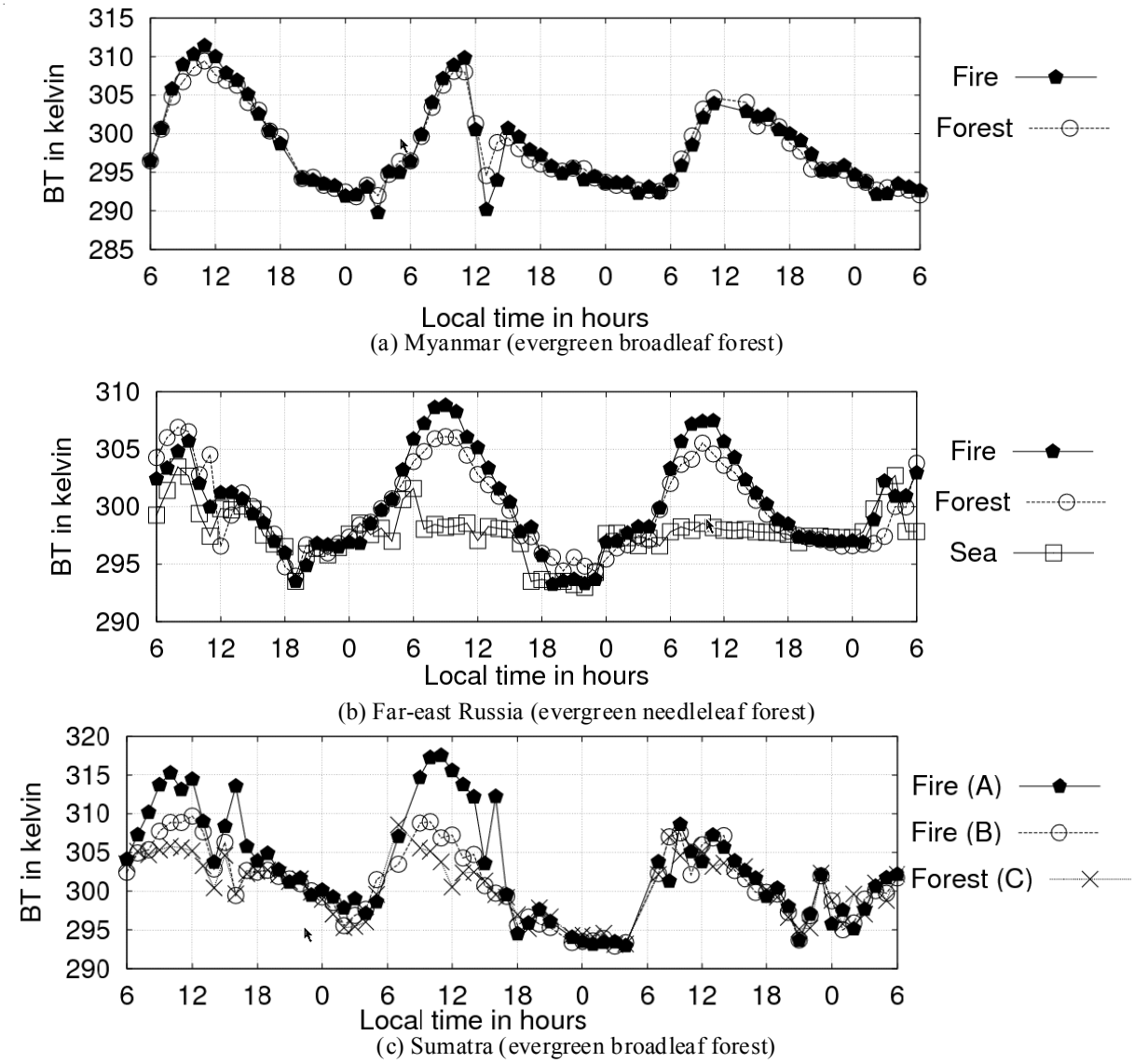

(a) Myanmar (evergreen broadleaf forest)

(b) Far-east Russia (evergreen needleleaf forest)

(c) Sumatra (evergreen broadleaf forest)

Figure 4: Time series variation of MTSAT thermal infrared imageries (channel 1 10.5um).

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