SATELLITE ANALYSIS TO DETECT BURNT AREA OF FOREST FIRE IN KAMAISHI, TOHOKU 2017

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INTRODUCTION

Annually fire occurrence in forest and field has been reported in Japan with an average of 1635 cases from 2010 to 2014 with average value of loss annually approximately 576 million yen (Fire and Disaster Management Agency and Statistics Bureau, Ministry of Internal Affairs and Communications). A large fire broke out in Kamaishi on 8 May 2017 and suppressed on 22 May 2017. Fig. 1 shows the estimated total burned area (in red) which was 413 hectares, larger than the total burned area in whole Japan for 2016, 384 hectare.

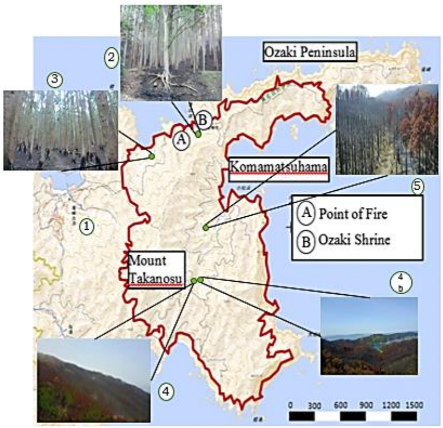

Fig. 1. Area affected by fire drawn based on information from Kamaishi Forestry Association

Satellites are used worldwide to detect forest fire and as a tool in fire management. Himawari-8 and Terra launched in 2015 and 1999 offers spatial resolution up to 500 meters and 250 meters respectively and temporal resolution of every 10 minutes of Japan and every one and two days respectively while Landsat-8 launched in 2013 offers spatial resolution up to 30 meter with more than 650 scenes a day. Information on burnt area can be used for calculation cost of damage and estimation of pyrogenic gaseous and aerosol emissions (Giglio et al. 2009).

This study aims to detect burnt area in Kamaishi post fire using surface temperature/brightness temperature and NDVI from Himawari-8, Terra, and Landsat-8 and validating the analysis through ground truth using five locations with different burned severity and one unaffected forest as shown in. Fig. 1.

WEATHER OVERVIEW

Prior to May 2017, precipitation in Tohoku region was low in winter and this dry condition continued into spring. Records of Automated Meteorological Data Acquisition System (AMeDAS) from January to April 2017 showed low total precipitation for Kamaishi compared to other area (Fig. 2(a)) and 60% lower precipitation from normal year (Fig. 2(b)) (Touge et al. 2018). On 7th May, a dry warning report was issued for the northern Kanto, Chubu, Chugoku and Tohoku region.

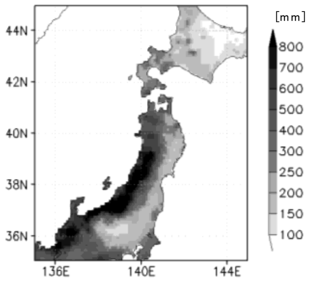

Fig. 2(a) Total precipitation

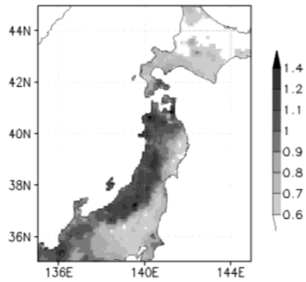

Fig. 2(b) Ratio of total precipitation from normal year

Strong wind was recorded in late April to early May. The maximum wind speed, 14m/s recorded by Kamaishi Observatory Station on 8 May 2017 was the highest for May 2017. Fig. 3 shows the hourly average of wind speed at 12 to 13 o'clock when the fire occurred (Touge et al. 2018).

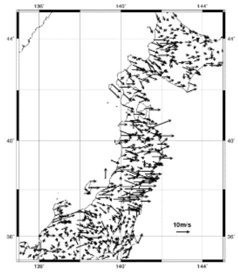

Fig.3 Hourly average wind speed and direction

METHODOLOGY

A field investigation in Kamaishi was made to collect ground truth such as location, stem-bark char height and its direction, diameter and height of trees which were used in this study. 750 observation data points were collected and the direction of stem-bark char were drawn as shown in Fig. 4.

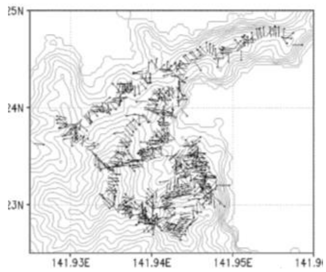

Fig.4 Direction of stem-bark char

Brightness and surface temperature were used in detecting burnt area. Land surface temperature of Landsat-8 was calculated from At-Satellite Brightness Temperature expressed by the Eq. (1) and Eq. (2) (Weng et al. 2004).

Keywords: Forest fire, surface temperature, NDVI, Himawari-8, Terra, Landsat-8
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$$T = \frac{T_b}{\left[1 + \left(\lambda \times \frac{T_b}{c_2}\right) \times ln(e)\right]} \quad (1)$$

$$c_2 = h \times \left(\frac{c}{s}\right) \quad (2)$$

Where T is land surface temperature, T_b is At-Satellite Brightness Temperature, λ is wavelength of emitted radiance, c_2 is 1.4388×10^{-2} m K, h is Planck's constant, 6.626×10^{-34} J s, c is velocity of light 2.998×10^{8} m/s, s is Boltzmann constant, 1.38×10^{-23} J/K and e is emissivity.

NDVI were used in detecting burnt area by analyzing the changes of vegetation pre and post fire. Then images and time series of brightness/surface temperatures and NDVI from these satellites were analyze pre-and post-fire.

RESULTS

Image Analysis

Fig. 5(a) shows Himawari-8 can detect the brightness temperature but its low spatial resolution reduces its ability to map out burned area. Due to this, no time series was made for it. Terra could detect the surface temperature but during the period of fire, no data were acquired due to contamination of cloud cover and only overpasses the area twice daily.

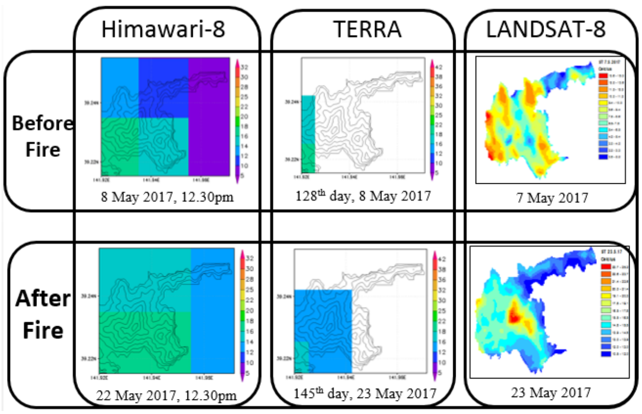

Fig. 5(a) Image of brightness and surface temperature

Fig. 5(b) shows NDVI from both satellites also did not map burned out area clearly. However, surface temperature and NDVI from Landsat-8 can map out burnt area clearly.

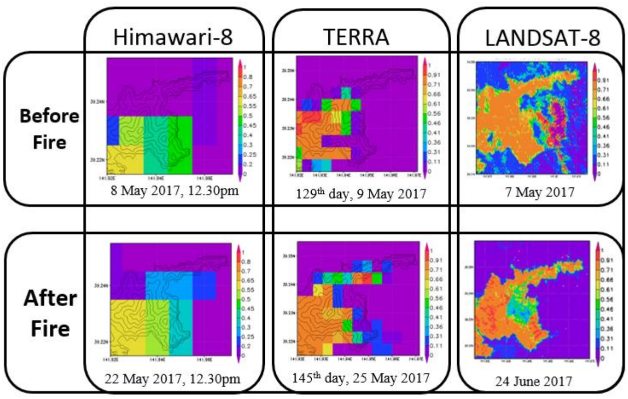

Fig. 5(b) Image of NDVI

Time Series

The image analysis of brightness and surface temperature were not satisfactory as the NDVI and no ground truth on surface temperature was collected. Therefore no discussion on time series of surface temperature are made.

Time series of NDVI from Landsat-8 has better distribution in Fig. 6(a) than Terra in Fig. 6(b) for different points selected due to its 30 meters resolution.

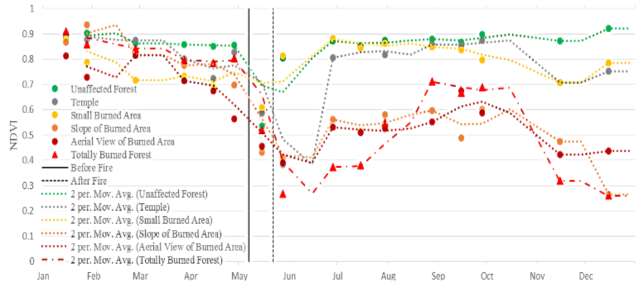

Fig. 6(a) NDVI of Landsat-8 for six points

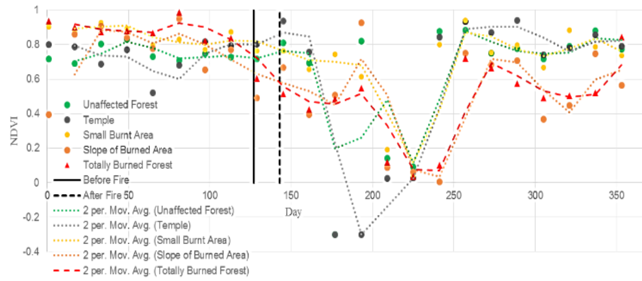

Fig. 6(b) NDVI of Terra for five points

CONCLUSIONS

Time series and images from Landsat-8 showed better NDVI distribution for different points selected and can map out burned area more precise than Terra and Himawari-8. It has the potential to be used in future study on burn severity of an area as it relates directly to vegetation change. Detection of burnt area post fire using satellites with higher spatial resolution is more advantageous than higher temporal resolution.

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