EVALUATION OF FOREST FIRE ON NA NGOI COMMUNE, KY SON, NGHE AN USING SENTINEL 2A AND LANDSAT-8 OPERATIONAL LAND IMAGER (OLI) SPECTRAL INDICES

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Abstract

Forest fire occurred on March 16-20, 2016 at Na Ngoi commune, Ky Son, Nghe An caused a huge of damages. The fire spread out over 10 km with more than 100 hectares of destroyed forest. This study presents the preliminary results of the assessment of spectral indices to evaluate the burn severity of the Na Ngoi fires. These spectral indices were computed using the Sentinel-2 and Landsat 8 OLI imagery acquired on pre-fire and post-fire dates, including Normalized Difference Vegetation Index (NDVI), Normalized Burn Ratio (NBR), differenced NDVI, differenced NBR, relative differenced NBR, Relativized Burn Ratio. Based on the burn severity of the previous studies, the dNDVI and RBR generated from Sentinel-2 and Landsat-8 OLI data were used for classifying four classes consisting of low, moderate, high and very high burn level. In addition, the surface temperature map extracted from the Landsat-8 image acquired on March 20, 2016 indicates that the area has a very high surface temperature corresponding to the high burn level. The burn severity maps in Na Ngoi, Ky Son, Nghe An established by remote sensing method contribute to forest fire control and forest management in the western part of Nghe An province.

Introduction

The identification of changes in both quantity and quality of post-fire forest for forest management and protection in order to know the effects of forest fire on the extent of space and time (Morgan et al., 2014). The literature reviews including the Normalized Burn Ratio (NBR), differenced normalized burn rates (dNBR), Relative differenced normalized burn rates (RDNBR), Relativized Burn Ratio (RBR) are the most suitable for estimating burn severity (Veraverbeke et al., 2010). The dNDVI value is often used to establish the burn severity map of forest fire area (Clark and McKinley, 2011) and predict the risk of forest fire as well as the burn severity that can occur in the United States (Holden et al., 2009).

Landsat data with 30 m spatial resolution and the Sentinel-2 data (Fernández-Manso et al., 2016) are widely used to establish the burn severity map. The standardization and evaluation of spectral indices and adaptation of sensors to specific areas is still necessary to examine the strong correlation between field data and remote sensing results (Picotte and Robertson, 2011).

The specific objectives aim (a) to evaluate the content of the original spectrum channels and the indicators of both sensors to distinguish between affected and non-affected forest areas due to burning, (b) to determine the optimum spectral indices for each sensor for estimating burn severity based on the survey results and (c) to establish and validate of burn severity maps for each sensor based on the thresholds specific corresponding spectrum indices.

Data and methods

Table 1. Sentinel-2 and Landsat-8 data for the study area

Satellite	Sensor	Row/Path	Acquired date	Spatial resolution (m)
Sentinel-2	MSI	-	11/03/2016	10, 20, 60
Sentinel-2	MSI	-	01/04/2016	10, 20, 60
Landsat-8	OLI	127/047	13/03/2016	15, 30, 100
Landsat-8	OLI	128/046	20/03/2016	15, 30, 100
Landsat-8	OLI	128/046	05/04/2016	15, 30, 100

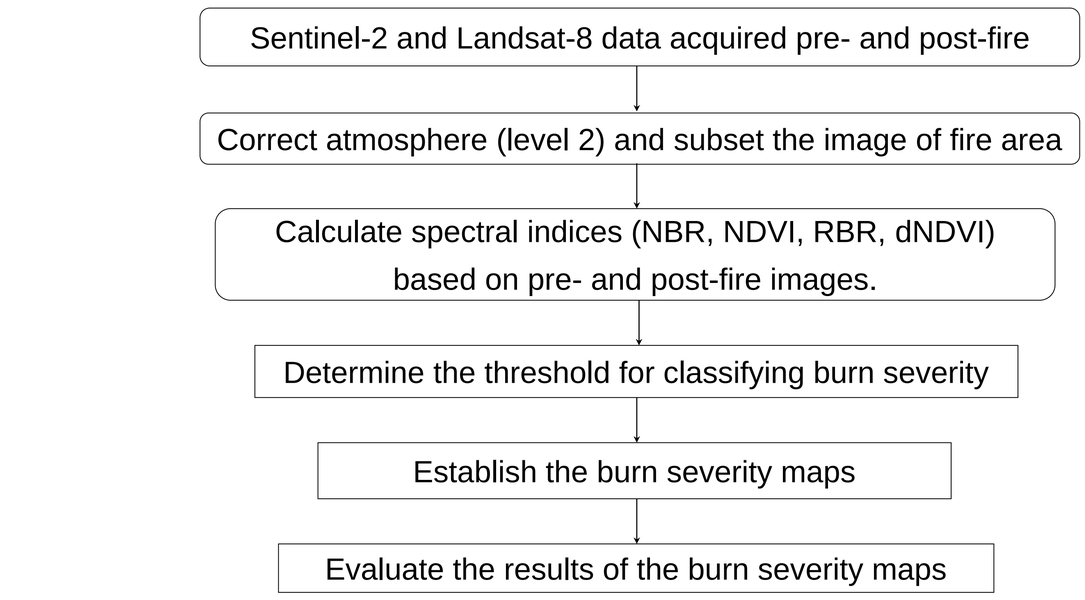

Figure 1. Experimental procedure for establishing burn severity maps

Results and discussion

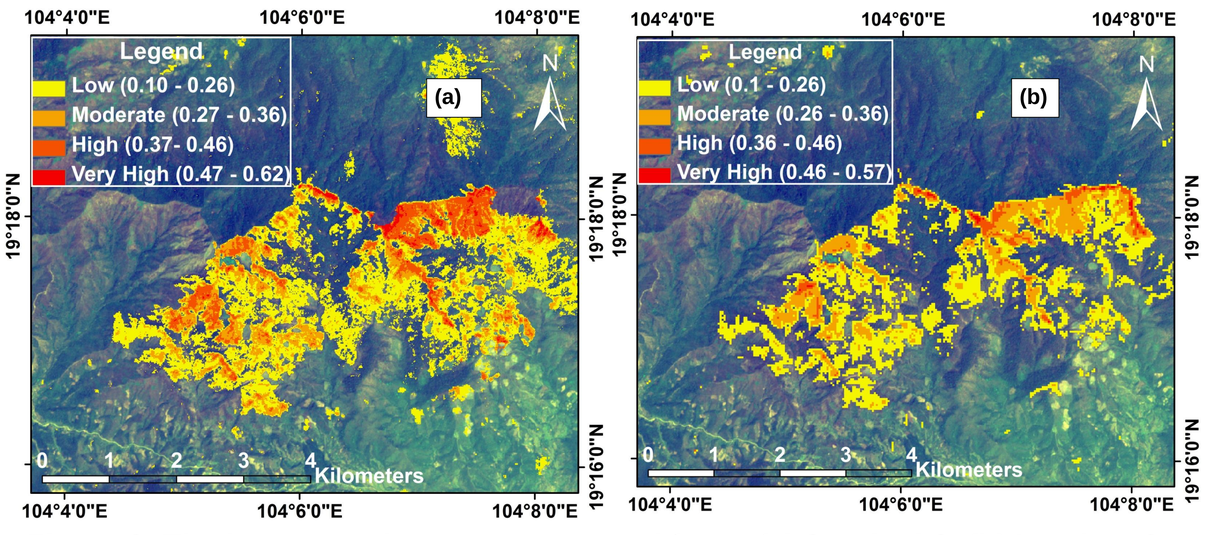

Figure 2. The burn severity maps generated from: (a) Sentinel-2, (b) Landsat-8

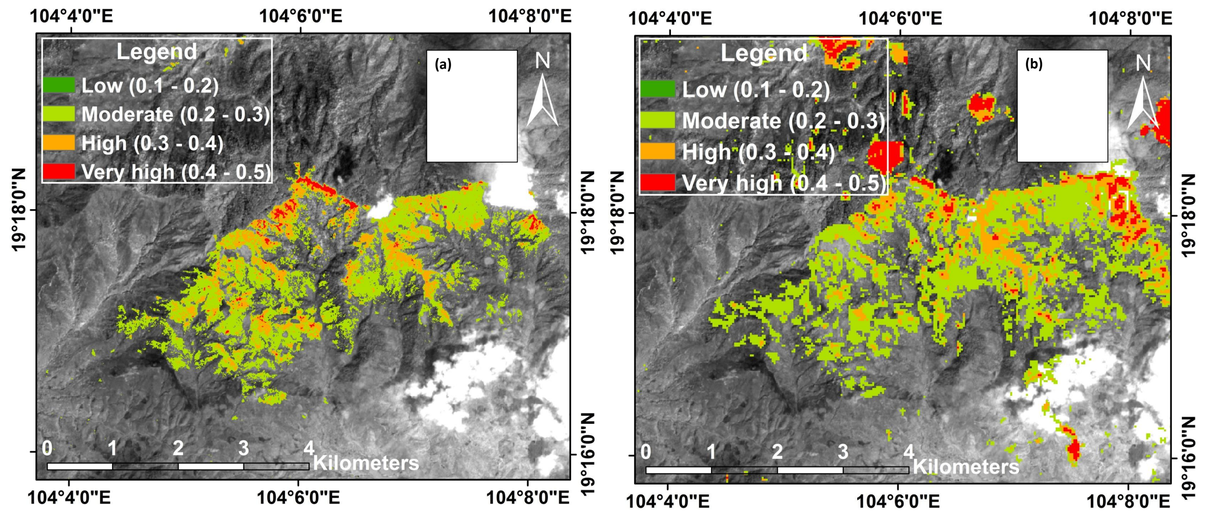

Figure 3. NDVI change maps generated from: (a) Sentinel-2, (b) Landsat-8

Table 2. Evaluation results of burn severity maps

Sentinel-2			*Landsat-8*		
Burn severity	*User (%)*	*Producer (%)*	*Burn severity*	*User (%)*	*Producer (%)*
Low	86.17	83.29	Low	80.21	91.32
Moderate	56.23	65.18	Moderate	55.78	56.45
High	67.12	53.24	High	86.85	51.68
Very High	75.96	84.31	Very High	65.14	89.92
Total error	73.24%		Total error	71.17%	
Kappa	0.69		Kappa	66.13	

The accuracy of the low burn class on the two burn severity maps is very high (over 80%). However, the accuracy of the moderate burn class on the two maps is very low (less than 60%). The difference of accuracy between the two burn severity maps can be explained by the difference in the spectral bandwidth used to compute the spectral indices. The total error and Kappa are a little difference between two burn severity maps generated from Sentinel-2 and Landsat-8 data types.

The results of the dNDVI values of the pre- and post-fire images of the Sentinel-2 and Landsat-8 images are nearly similar. It also indicates that the dNDVI change is very high near top of mountain in which the elevation is about 2000m corresponding which had very high burn. In addition, moderate and low burn areas correspond to moderate and low dNDVI classes.

A map of the land surface temperature at the time of fire on March 20, 2016 (Figure 4) was established from the Landsat-8 thermal infrared band according to the method proposed by (Jeevalakshmi. D. et al., 2017). This map shows that regions with very high surface temperatures (greater than 36 C^0) are relatively coincident with areas with very high burn levels on the burn severity map.

Very high levels of fires occur in areas with an elevation of between 1500m and 2000m and widespread within 4km due to firefighting encountered by complex terrain (Figure 2) and overlay thicky layer of forest on the area. In addition, rudimentary fire techniques and manual fire extinguishers are also the reason lead to the extent fire in large areas during the five days.

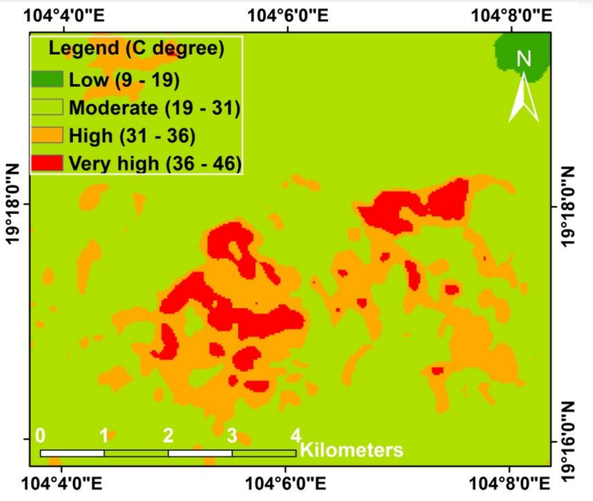

Figure 4. The surface temperature on 20 March 2016 generated from Landsat-8 data

Summaries

In this study, two Sentinel-2 and three Landsat-8 data acquired on pre- and post-fire were used to establish burn severity maps based on the NBR values generated from satellite image and additional data. The overall error of burn severity maps is 73.24% and 71.17% respectively for Sentinel-2 and Landsat-8 data. The low burn class is the highest precision (more than 80%).

The two maps of the dNDVI rate between pre- and post-fire for both Sentinel-2 and Landsat-8 data match with the given burn severity maps. Apart from the temperature surface map generated from the 10th chanel of the Landsat-8 occurred at the same time of forest fire indicate that the high temperature (greater than 36 C^0) corresponded to the area of the high burn level of burn severity maps.

Acknowledgments

The authors would like to thank European Space Agency for providing Sentinel-2 data. The Landsat-8 data and the burn data generated the VIIRS and MODIS 6C data and DEM of the study area were provided by USGS.