MAPPING AND MONITORING BURNED AREA/VEGETATION CLEAR-CUT IN RIAU OF SUMATRA FROM TIME SERIES OF SENTINEL-1 DATA

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ABSTRACT: Remote sensing techniques provide a useful tool for land and forest fire monitoring and the damage assessment. Accurate and up to date information on areas affected by fire are crucial to estimate aerosols and gaseous emissions for modelling climate variability, pollutant transport and air quality. Satellite data are used to detect the fire burned areas and most of the mapping approaches are based on optical data. However, due to the frequent cloud cover in Sumatra, SAR data with its cloud and thick haze penetrating ability are useful for detecting vegetation clearance associated with fire. The main objective of this study is to detect the spatial distribution and temporal variation of fire burned area in the Province of Riau, Sumatra with time series of Sentinel-1 SAR data. We use the dual-polarized C-Band SAR data acquired every 12 days during the dry season from February to March in 2019 to perform change detection analysis. The SAR batch pre-processing was first performed for each acquired image which mainly include radiometric calibration, multi-looking (2X2), speckle filtering and range doppler terrain correction. To deal with SAR speckle effects, the object-based change detection method was used to derive the burned area change map. The multispectral optical imagery (Sentinel-2, Landsat-8, SPOT and planet) were used to validate the created burn scar change map. The produced map clearly shows the spatial and temporal distribution for the burned area during the fire season. The results show that most of the fire burned area located near the coastal region. This study presented an approach for change detection analysis and the burned area mapping. The produced map provides an up to date information for the study area and can be used to update the land use/land cover map and for the damage assessment.

1. INTRODUCTION

The satellite imagery provide valuable information for fire monitoring and the burn scar mapping. The synoptic view and repeat observations from satellite data make it possible to operationally monitor the remote actively fire burning regions. The multispectral optical data have been widely used for fire monitoring and the burn scar mapping. However, data acquisition is frequently affected by cloud cover in the tropical region such as Sumatra in Indonesia. And the dense fire smoke plumes often covered part of the burned area. To overcome these limitations, the synthetic aperture radar (SAR) data has also been used for the burn scar mapping due to the cloud and smoke penetrating ability.

Indonesia experiences the world's 2nd highest deforestation rate. Our study site shown in Figure 1 is located at the Province of Riau, Sumatra. Riau has two dry seasons a year, February-March and June-September. Land and forest fire occurred every year during the dry season in Sumatra. The main land cover/land use type in the study area include peat swamp forest, oil palm/acacia

plantations, natural forest, scrubland and small holder plantation/agriculture mosaic. To obtain the accurate and timely information for areal extent and temporal trends of vegetation cover loss will aid for the fire disaster management.

Figure 1. Location Map of the Study Site (Riau Province, Indonesia).

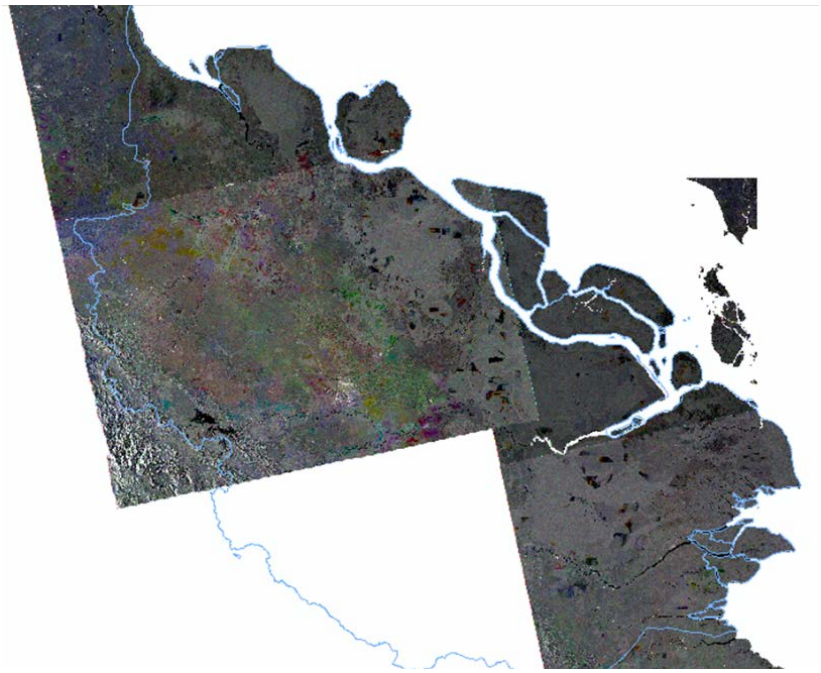
The main objective of this study is to detect the spatial distribution and temporal variation of the fire burned and vegetation cleared area during the dry season in the Province of Riau, Sumatra with time series of Sentinel-1data.

2. DATA AND METHODOLOGY

The Sentinel-1 satellites C-band synthetic aperture radar (SAR) images acquired from February 5 to March 30 in 2019 were used for the vegetation clearance detection. The image products were downloaded from the ESA website.

We use the dual-polarized (VV and VH) C-Band SAR data acquired every 12 days , total 20 images during the fire season to perform change detection analysis. The SAR batch pre-processing was first performed for each acquired image using the Sentinel-1 SNAP toolbox (Zuhlke et al. 2015), which include the apply orbit file, the radiometric calibration to Sigma0, multi-looking (2X2), speckle filtering (refined Lee), range doppler terrain correction using 30m SRTM elevation data and conversion of intensity to decibel (dB) value. The preprocessed imagery used for the change detection is shown in Figure 2

The SAR backscatter is sensitive to vegetative structure and moisture content changes through the dielectric constant. C-band SAR with its cloud-penetrating ability is effective at detecting vegetation disturbance events associated with fires and has been used for the burn scar mapping or vegetation cleared land mapping.



Imagery shown on the left above : Image shown on the above right:

Figure 2. The Processed Imagery Used for the Change Detection.

To deal with the SAR speckle effect, we choose the object-based change detection method for the burned area extraction. The object-based image analysis (OBIA) method (Blaschke, 2010; Benz et al., 2004) was used for the change detection in this study using the eCognition software.

First, the multiresolution segmentation algorism (Baatz and Schäpe, 2000; Trimble eCognition, 2015) was used for feature extraction that is a bottom-up region-merging technique, the smaller image objects with similar spectral and spatial characteristics were merged into larger objects in an iterative optimization procedure based on the defined scale, shape and compactness parameters. We defined these three parameters as 3, 0.1 and 0.5 respectively based on the data type and our requirement. The relatively homogeneous and semantically significant objects were generated for further analysis.

Second, each segment object was assigned a pre-defined thematic class label based on the membership rule. The colour, shape and contextual information of the segmented objects were utilised to develop the rule sets for the change detection. Compared to the VV-polarized band, the processed cross-polarized (HV) backscatter found to be generally more sensitive to the vegetation clearance/biomass change in the study area.

The multispectral optical imagery (Sentinel-2, Landsat-8, SPOT6 and planet) were used for evaluating the change detection results. The pre-fire land use/land cover map and the peat layer map are also used to analyse the burned area.

3. RESULTS AND DISCUSSION

The change map is created to identify the spatial distribution and temporal variation of the vegetation cleared area in the study site. The results shows that most of the burned area/vegetation clear-cut are on islands or near the coastal region. Figure 3 and Figure 4 show the change map in two sub regions where fires burned in relative large areas. The image shown in red and yellow are the vegetation cleared area. The map legends are shown in Figure 3 and Figure 4.

Figure 3 shows the island of Rupat and the coastal area, the vegetation clearance from Feb 10 to March 6 is shown in red and the clearance from March 06 to March 30 is shown in yellow.

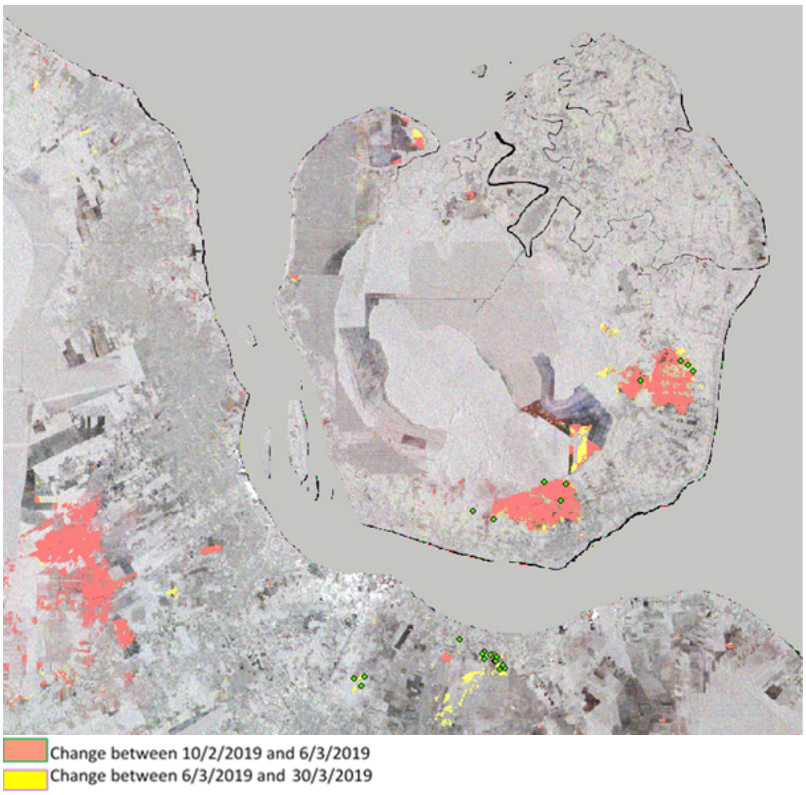


Figure 3. Change Map (Feb 10, 2019~Mar 30, 2019)

The islands (Bengkalis, Pedang, Tebingtinggi, Rangsang, Mendol) in Figure 4 show more burned area. The area marked in purple rectangle in Figure 4 is the Island of Rangsang, The vegetation cleared from Feb 5 to March 1 is shown in red and the vegetation clearance during March 01 ~ March 25 is shown in yellow.

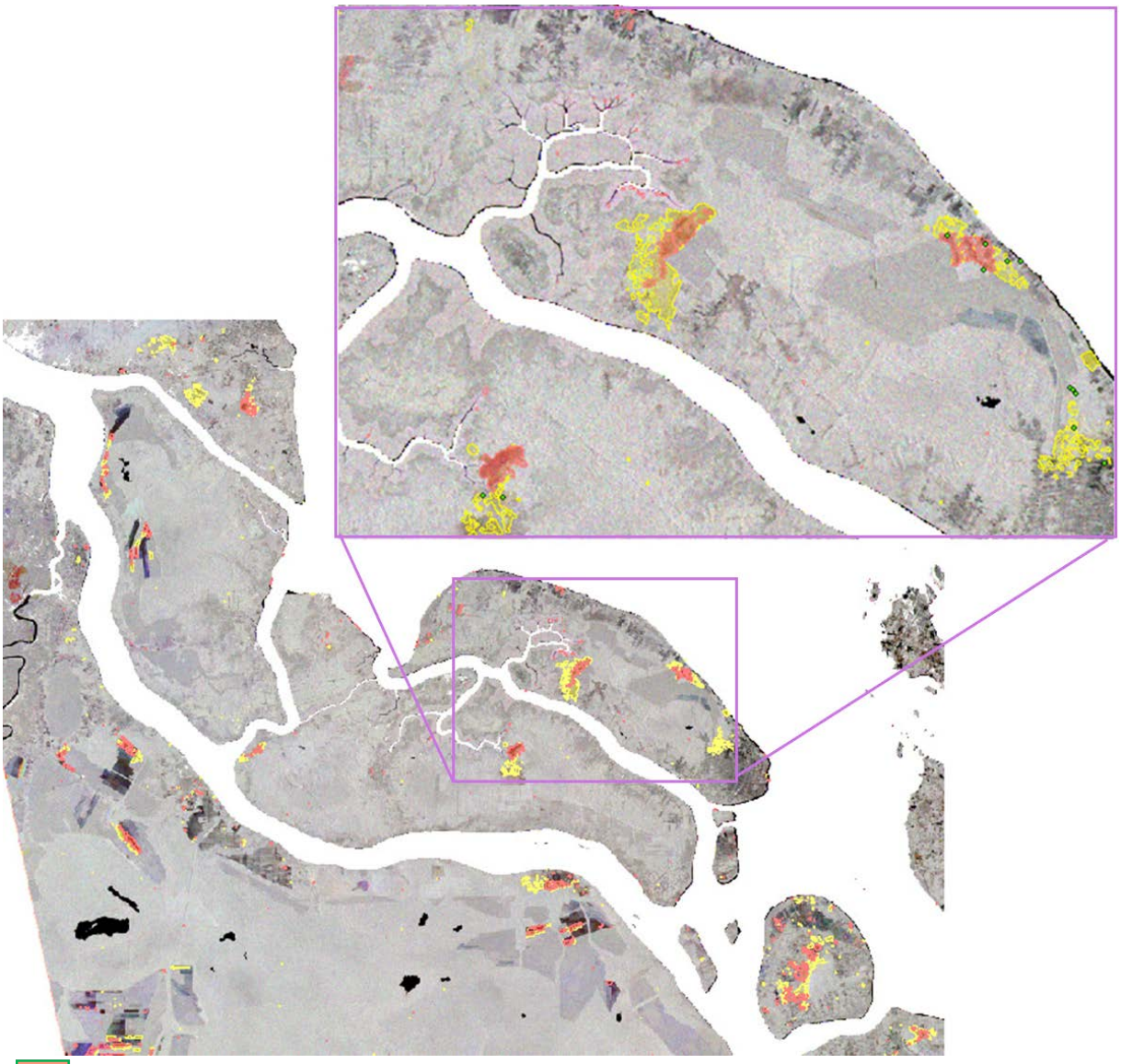


Figure3.The Change map (Feb 5, 2019~Mar 25, 2019)

4. CONCLUSION

This study presented an approach for burned area/vegetation clearance mapping and the time series change detection analysis. The produced change map derived from the Sentinel-1 SAR data provides an up to date information for the study area which can be used to update the land use/land cover map and for the damage assessment. The method can be used in areas where persistent cloud cover or dense smoke plums prevent the extraction of burnt area information using conventional multispectral approaches.

5. ACKNOWLEDGMENT

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6. REFERENCES

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