THE POTENCIAL FOR OPERATIONAL MONITORING OF SELECTIVELY LOGGED FOREST USING VEGETATION INDEX IN THE BRAZILIAN AMAZON

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ABSTRACT

This work presents a approach for monitoring forest degradation in the Brazilian Amazon using a multi-temporal dataset of Landsat-8 imagery. We use a Normalized Burned Ratio (NBR) for detecting selective logging in two differents areas in the Brazilian Amazon, Acre State and the Roraima State. The proposed approach can be used for monitoring forest degradation to availability the vegetation indice using the proposed method and facilitating the implementation of action of forest protection in the Brazilian Amazon.

Key words — forest degradation, selective logging, Brazilian Amazon, change detection, NBR.

1. INTRODUCTION

After the recent stabilization of the deforestation rate in the Brazilian Amazon and an accomplished decrease of the deforestation rate by 75% between 2004 and 2017, the Brazilian government faces new challenges in complying with the national climate change legislation, establishing a maximum annual deforestation rate of 3,904 km² by 2020 and, in consequence, a reduction of carbon emissions from land use change. Recent studies have shown that human-induced forest degradation, due to selective logging and forest fires, can significantly reduce the forest conservation value and carbon stocks[1]. To reach the commitments made during COP-21 of reducing greenhouse gas emissions by 37% by 2025 and 43% by 2030, Brazil needs to tackle forest degradation. Forest degradation is not only a process of changing the state of the primary forest [2], [3] in addition e.g. selective logging also changes the carbon balance in the Brazilian Amazon, accounting for 33,3% of carbon emission in years without extreme droughts [4].

In the context of incentive mechanisms such as REDD+ (Reduction of Emissions from Deforestation and Forest Degradation and the role of forest conservation, sustainable management of forests and enhancement of forest carbon stocks), the long-term reduction of biomass due to anthropogenic activities in remaining primary forests is the most prominent aspect of forest degradation. The Brazilian Amazon Forest Degradation Project (DEGRAD) is a system for forest monitoring, developed by the Brazilian Institute for Space Research (INPE) that has been mapping degraded forest areas using visual interpretation of enhanced color composite Landsat imagery images. Another monitoring system is the near real-time deforestation detection system DETER-B, designed as an early warning system in support the surveillance and control of deforestation. DETER-B maps the occurrence of clear cutting and forest degradation and sends detected areas as GIS layers to the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) and other public environmental institutions, which are responsible for deforestation surveillance and law enforcement. The DETER-B system uses images from the WFI sensors, CBERS-4 satellite (Sino-Brazilian Satellite of Earth Resources) and AWiFS, from the IRS (Indian Remote Sensing Satellite) satellite, with 64 m and 56 m spatial resolution, respectively, and with a 5 days repetition rate. The method is based on visual interpretation of fraction images derived from on the basis of the linear spectral mixture model[5]. Alternatively, there is a multitude of approaches by Spectral Mixture Analysis (SMA) and analysis of single bands or various vegetation indices (VI) using different medium to high resolution satellite imagery, such as Landsat and Sentinel-2, that allow for detecting signs of forest disturbances at low or no data costs [6]–[10], [14].

New data processing technologies can improve the capacity for assessing forest degradation. The Google Earth Engine (GEE), for example, is a geospatial data processing platform, based on a cloud computing infrastructure providing geospatial data and algorithms that can easily be accessed and edited with the Application Programming Interface (API) [11]. This tool enables the mapping of large areas using time series of multiple sensors without the need of data download, storage and processing requiring high computation capacity. So, in this study with GEE we analyze the potential for operational monitoring using an approach based on a self-referenced Normalized Burn Ratio (NBR) [12] index with Landsat-8 imagery for the detection of selectively logged forest in Acre and Roraima state. The objective is to offer a new source for assessing and evaluate forest degradation data.

2. MATERIAL AND METHODS

2.1. Study Area, Satellite and Auxiliary Data

The study areas correspond to two a Landsat-8 scences located in Acre State (Landsat path/row 002/066) and located in Roraima State (Landsat path/row 231/060) in the Brazilian Amazon (Figure 1). We consider all existing top-of-atmosphere (ToA) ortho-rectified Landsat-8 images (spatial resolution 30 m) available in the GEE archive for the period from 1 July to 31 October for the years 2010, 2011 and 2015 in the State of Acre, corresponding to the existing field data in the area. Due to the same reason (existing field data) we selected all Landsat-8 available from 1 January 2016 to 31 March 2018 for Roraima State, covering most of the logging season in the area.

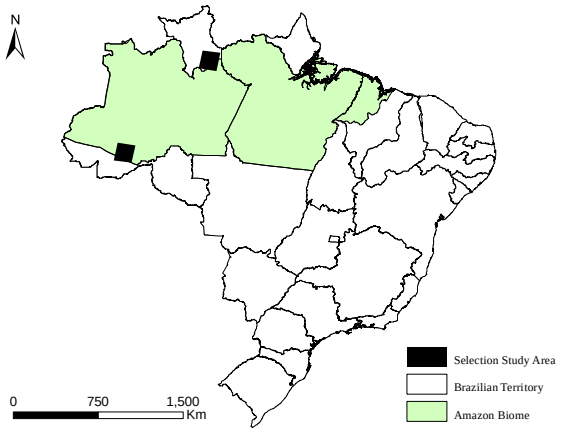

Figure 1. Location of the study area.

We calculated the NBR (Equation 1) for each single Landsat-8 scene, with NIR and SWIR2 referring to Landsat-8 band 5 (0.85-0.88 µm) and band 7 (2.11-2.29 µm), respectively. Recent openings in the canopy cover (even on sub-pixel scale) can be detected using the NBR.

$$NBR = \frac{NIR - SWIR_2}{NIR + SWIR_2} \quad (1)$$

For the detection of changes in forest canopy, indicating processes of forest degradation, we calculate the difference (Δ) of a modified Normalized Burn Ratio (rNBR) index. The forest disturbance mapping with a ΔNBR approach consist in: cloud computing with Java Scrip on the specific time periods covered by the GEE Landsat archive through a change detection approach between two consecutive years , In addition, a 'self-referencing' step was introduced to normalize the NBR values within each year (creating rNBR values), largely eliminating illumination/topography effects, and thus maximizing inter-annual comparability [12]. (Equation 2).

$$\Delta\text{rNBR} = rNBR_{self-ref_{t1}} - rNBR_{self-ref_{t2}} \quad (2)$$

The forest degradation monitoring is therefore based on a change detection analysis of forest crown cover over time, differentiating selective logging activities from naturally open canopy cover. The thresholds applied to the ΔrNBR value, based on Landsat image analysis, is 0.036, in order to separate disturbance from non-disturbance, following the proposal by [13].

3. RESULTS AND DISCUSSION

The ΔNBR results are visually compared to each year in the area of selective logging located in the Acre State occurred in different years in the period from 2009 to 2015. The dynamics of forest degradation in this region of the Amazon shows that the forest is capable of regenerating rapidly. The ΔNBR detects the stratification and severity of the damage caused by the extraction of trees, opening of roads and landings.

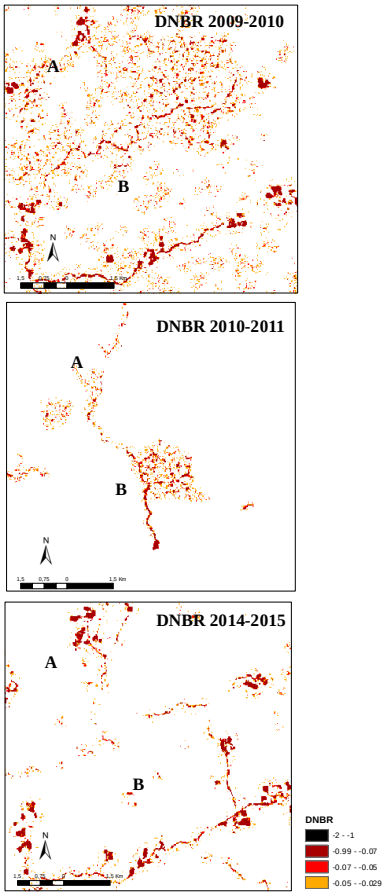

Figure 2. ΔNBR result (30 meters) with areas indicating the selective logging in the Acre State.

In the state of Roraima, logging is historically practiced in the dry period, between November and March. The NBR results from 2017 to 2018 demonstrate that selective logging was identified by the method. A visual comparison shows similar patterns in two areas, but depending on the definition of forest degradation (e.g. biomass loss over certain period of time), because the selective logging in the Acre State shows this study is by forest management, while the area in Roraima State is caused by illegal logging. So, it is very important to differentiate the areas authorized to carry out the monitoring forest degradation and to apply a masking "legal logging".

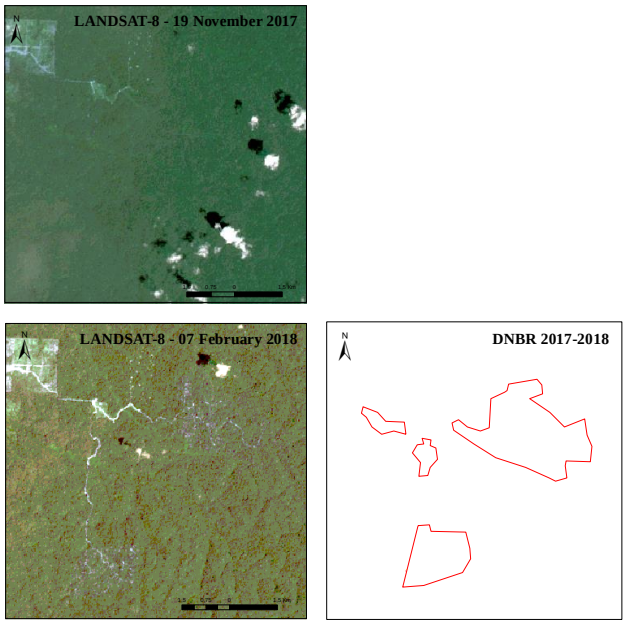

Figure 3. ΔNBR result (30 meters) with areas indicating the selective logging in the Roraima State.

Figure 4. Selective logging in the Roraima State.

4. CONCLUSIONS

Selective logging is an important activity for forest economy in Brazil, which can be performed under legal frameworks and sustainable practices. Therefore, it is crucial for the country to improve its measures and data on forest degradation to evaluate its progress in national and international climate change commitments. The results that we have achieved indicate that is possible to offer an improvement in the tools for monitoring forest degradation of the large-scale in the Amazon.

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