ASSESSMENT OF BURNED AREAS IN MATO GROSSO STATE, BRAZIL, FROM A SYSTEMATIC SAMPLE OF MEDIUM RESOLUTION SATELLITE IMAGERY

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ABSTRACT

This paper presents a method for mapping and assessing burned areas at a regional scale, using a systematic sample of medium spatial resolution satellite images (Landsat). The State of Mato Grosso, located in the Brazilian Amazon region, comprising an area of approximately 903,366 km², was selected for this study. 77 sample sites (20km × 20km in size) located at each full degree confluence of latitude and longitude were analyzed. The results showed that 52,663 km² or approximately 5.8% of the State land cover was burned in 2010. Our method produced results comparable with PanAmazonia Project data and useful for evaluating burned area products based on coarse spatial resolution imagery like MODIS or SPOT-VEGETATION.

Index Terms— Burned areas, Brazilian Amazon, Landsat TM, Sampling approach.

1. INTRODUCTION

Fires in vegetation cover play an important role in the emission of greenhouse gases and aerosols affecting the Earth's radiation balance [1]. Information on the location and extent of the areas affected by fire is necessary to assess the effects of biomass burning on atmospheric chemistry, ecosystem functioning and human health. Satellite sensor data have been used in the last decades providing a unique source of spatial information in detecting, monitoring, and characterizing fires for global environmental change research [2]. Its application for the detection and monitoring of fires from local to continental and global scales has been developed over many years, using a number of different sensors and systems such as Landsat Thematic Mapper (TM) [3], Moderate Resolution Imaging Spectroradiometer (MODIS) [4], National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) [5], SPOT-VEGETATION [6], the Meteorological Satellite Program (DMSP) satellite [7] and the Geostationary Operational Environmental Satellite (GOES) [8] (for a review at global scale see: [9]). Vegetation fires are expected to negatively impact carbon stocks, biological diversity and human health. Moreover, fires can potentially compromise the efficacy of emission reduction policies, such as activities related to Reducing Emissions from Deforestation and Degradation (REDD+) in framework of UNFCCC [10]. Vegetation fires in the Amazon basin are becoming increasingly important worldwide, not only for understanding and predicting their future environmental impacts on the Amazon biome, but also for implementing efficient climate change mitigation policies. In the Amazon, fire is widely used for the initial conversion of extensive areas of natural vegetation into agricultural fields and pasture areas, and for the subsequent maintenance of deforested areas [11, 12]. Natural fire occurrences and accidental burning are extremely rare, with the vast majority of burning events resulting from deliberate fire use [11]. In this context, the main objective of this paper is to present a method for mapping and assessing burned areas at a regional scale (Mato Grosso State), using a systematic sample of medium spatial resolution satellite images (Landsat).

2. MATERIAL AND METHOD

The study area corresponds to the Mato Grosso State, in Brazil (Figure 1), which comprises an area of approximately 903,366 km² [13]. Due to variable climate, terrain relief, precipitation patterns and length of the dry season, the State of Mato Grosso has a natural model of complex biodiversity, resulting in the different vegetation types of the Cerrado and Amazon biomes. Furthermore, Mato Grosso, located partly in the "arc of deforestation" area at the southern extent of the Brazilian Legal Amazon, is the state that has presented one of the highest annual deforestation rates [14]. Forest clearance causes, among others, habitat fragmentation, which leaves the remaining forest more vulnerable to edge effects such as fire [15]. In consequence, the fire events are likely to happen more frequently in the border of deforestation activities.

In a first step of this study we use Landsat-5 TM scenes acquired around year 2010 over Mato Grosso State for 77 sample sites (20km × 20km in size), located at each full degree confluence of latitude and longitude according to a sampling approach used at global scale for a forest cover remote sensing survey, which was developed by the European Commission's Joint Research Centre (JRC) and designed to monitor forest cover changes in the tropics (TREES Project) [16]. The method developed in our study is adapted from the method used in this global survey and is based on multi-temporal image segmentation and semi-automatic classification of Landsat imagery and followed by manual classification editing using a visual interpretation tool [17].

The map of burned areas for year 2010 derived from MODIS data from PanAmazonia and Amazonica Projects [18] is used as reference information to assess the results of our approach. The approach used by PanAmazonia project is based on INPE's PRODES digital method [19], consisting in image segmentation of fraction images derived from Landsat TM and using a non-supervised classification per region algorithm followed by manual image editing to minimize misclassifications [20].

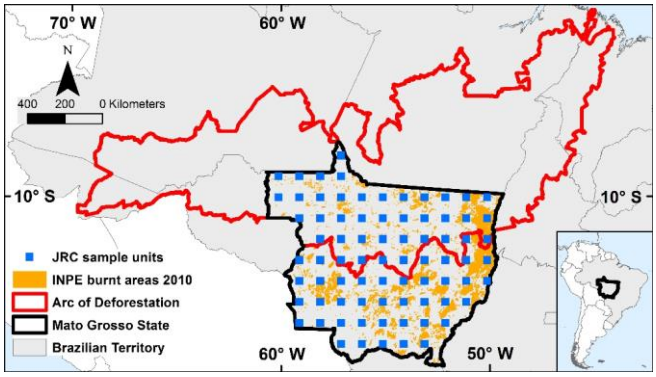

Figure 1. Location of the study area: State of Mato Grosso.

3. RESULTS

The first assessment for the Mato Grosso State for the year 2010 resulted in 1,603.67 km^2 of burned areas or approximately 0.2% of the Mato Grosso State area. Then the preliminary results show a much lower amount of burned areas when compared to the burned area estimate for year 2010 from PanAmazonia and Amazonica Projects [18]. This result should be interpreted considering that the Landsat images that we used for mapping burned areas over the 77 sample sites encompass an "epoch" which includes year 2009 (37 sample sites), year 2010 (17 sample sites) and year 2011 (23 sample sites) imagery. Moreover, the Landsat imagery was originally selected for another purpose (estimating forest cover change) and consequently acquired as 'best' cloud-free available image [21] between April to September of each of the three years while most of the fires occurs at the end of the short dry season (mainly in September). However, for the sample sites which show some burned areas (Figure 2), i.e. 26 sample sites among the full sample of 77 sites, our burned area mapping results show a reasonable agreement with the PanAmazonia maps.

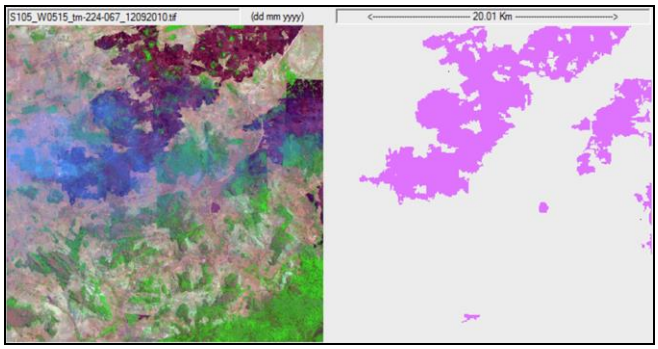

Figure 2. Example of one of the sampling site showing burned area (in pink).

It can be observed in the PanAmazonia data that most of the burning during the year 2010 occurred in August and September (17% and 70% of total burned areas respectively).

Therefore, to improve the assessment of burned areas from Landsat imagery through our proposed method, a more consistent and exhaustive set of Landsat imagery was selected to cover the time period August to October 2010 for the sites where burned areas were detected in the PanAmazonia maps. The analysis of this new dataset resulted in 52,663 km² of burned areas or approximately 5.8% of the State area. Our burned area mapping results show a reasonable agreement with the PanAmazonia Project [18] results, when considering the estimation for September 2010 (7.4% of the State area), when the majority of the burned occurred (67% of the total) and which is compatible with the majority of image dates of the new TM dataset used in our research.

4. CONCLUSIONS

The method described in this paper has the potentiality to be used for estimating burned areas at regional scale using medium spatial resolution data. This information is critical for regional and global environmental studies and for efforts to control such burning in the future. The results demonstrated that Landsat data are important sources of timely information for mapping burned areas and can be used at the regional level in Brazilian Amazonia. Our method can also be used in the future for evaluating burned area products based on coarse spatial resolution imagery like MODIS or SPOT-VEGETATION.

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