OBJECT BASED DETECTION OF MULTISCALE CHANGES IN BRAZILIAN SAVANNAH USING SAR IMAGERY

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1. INTRODUCTION

Savannah-like and woody vegetation in the Brazilian's Biome called Cerrado have been considered some of the most endangered ecosystems in the world, despite the stronger emphasis given to the "charismatic" Amazon forest. Threaten is relatively more eminent due to the existence of fertile soils and suitable terrain relief within the Cerrado, which makes it attractive for agricultural activities [1]. Less than 3% of the Cerrado Biome is currently protected under National parks or nature conservation areas [2]. Finally and most alarming are the estimates that more than 80% of the Biome has already been completely cleared out or irreversibly degraded due to anthropogenic activities [3]. In spite of this well-known critical situation, illegal vegetation removal is still taking place indiscriminately and some figures suggest that, unless effective monitoring and law enforcement efforts are urgently implemented, the Brazilian savannah might disappear in less than 25 years [2].

Changes taking place within the Cerrado Biome present a multiscale nature. They range from a few hectares, deforested for charcoal production, to thousands of hectares affected by single fire events every year. Hence, an effective monitoring system should be able to deal with this variability related to the size of changed areas. This fact has important implication for the design of appropriate analysis chains and for the selection of suitable input datasets.

A few efforts in Brazil have tackled operational monitoring of savannah areas with remote sensing. Carvalho and Scolforo [4] have been using Landsat data to detect savannah removal in southeastern Brazil since 2003 on a biyearly basis. Modis data has been used in the work of Sano and Ferreira [5] for monitoring the savannah of central Brazil. Cloud cover seriously limits both mentioned monitoring systems in terms of updating frequency, and a search for alternative data sets to overcome this limitation has been considered. Another important aspect refers to automation. The Cerrado Biome covers approximately 200 million hectares (23% of the Brazilian territory), demanding automation within the monitoring procedure in order to be practical and executable in due time.

Thus, the objective of this study is to evaluate the suitability of weather independent SAR data and object based multiscale image analysis in an attempt to overcome the limitations described above and provide some degree of automation within the framework of ongoing initiatives for monitoring the Cerrado Biome via remote sensing.

2. STUDY SITE AND DATA

An area in the North of Minas Gerais State (Figure 1) was selected for developing the proposed approach. Site selection was guided by the availability of extensive field data provided by the State Forest Institute (IEF) of Minas Gerais concerning illegal deforestation and wild fires for this area. The site is also within one of the largest contiguous remnant of savannah in the Cerrado Biome, which reinforce its importance as a priority area for implementing effective monitoring systems.

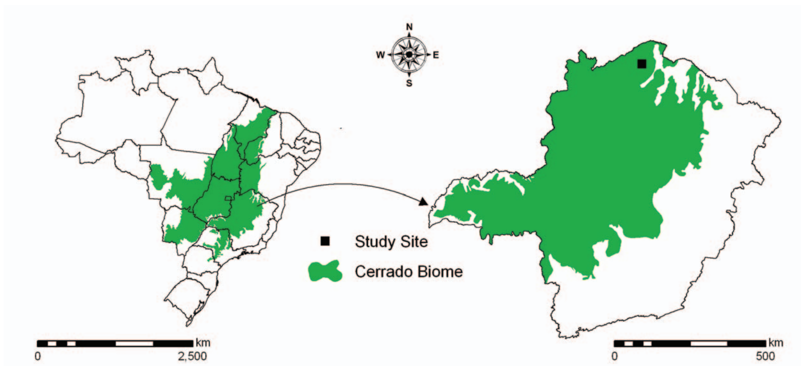

Figure 1. Location of the study site within Minas Gerais, Brazil.

Alos-Palsar processing Level 1.5 images acquired in 2007 and 2009 were used as inputs to the change detection procedure. Validation was carried out using field measured polygons delineating wild fire affected areas, clear cuts, and areas subject to biomass decrease due to selective logging.

3. METHODS

The Palsar images were converted from amplitude data format to normalized radar cross section (σ^0) [6]:

$$\sigma^0 = 10 \log_{10} [DN^2] + CF, \quad (1)$$

where DN is the digital number, CF is a constant calibration factor, and CF = -83.0 dB.

Multidate image comparison was performed by the standard procedure used in SAR change detection known as the log-ratio image [7].

The core methodology consisted of submitting the log-ratio image to a multiresoluiton wavelet transform. Multiresolution transforms applied to change detection have been originally proposed by Carvalho et al. [8] and further developed in studies carried out by Bovolo and Bruzone [9] and De Grandi et al. [10] showing promising results in terms of detection accuracy, noise reduction, and detail preservation.

In the present study we employed multiresolution analysis within the so-called Geographic Object-Based Image Analysis approach [11] to automatically detect objects representing land cover changes. The log-ratio image was transformed into a multiresolution representation with seven scale levels using the algorithm "à trous" [12]:

$$I_{LR\,k} = \sum_{k} a_{Jk}\phi_{Jk}(t) + \sum_{j=1}^{J}\sum_{k} d_{jk} w_{jk}(t), \tag{2}$$

where a represents the pixel at position k in the J^{th} approximation of the log-ration image, d is the pixel at position k in the detail image at scale level j, and ϕ and w are, respectively, the scaling and wavelet functions used at the corresponding position k and scale level j.

Detection of objects representing land cover changes was performed using local maxima detection in the wavelet product domain (Figure 2), which is generated by the position-wise product of wavelet detail images.

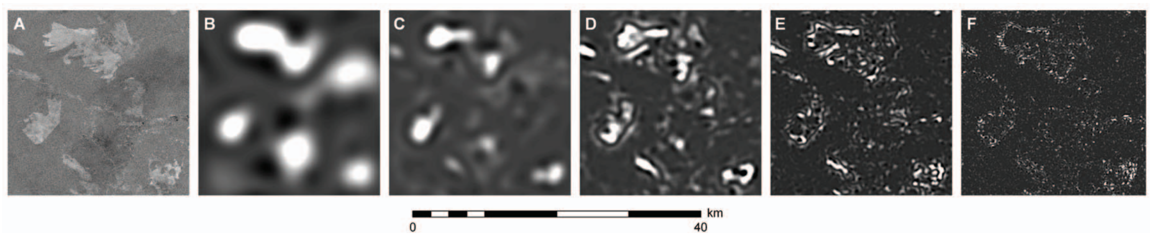

Figure 2. Log-ratio image (A), product of scale 6x7 (B), 5x6 (C), 4x5 (D), 3x4 (E), and 2x3 (F).

4. PRELIMINARY RESULTS

Image objects representing land cover changes were effectively detected using the proposed multiscale approach. The product of wavelet scales 1 and 2 contains mainly noise and were completely excluded from further analysis. Large objects tend to appear at large scale levels where noise and small structures are smoothed out making the detection process very easy. As we move across scale levels, smaller objects start to appear maintaining the same desirable noise reduction characteristic, as illustrated in Figure 3B. A preliminary validation was carried out using the change polygons provided by the State Forest Institute (IEF). The validation polygons were classified in three size classes (small, medium, and large) to verify the algorithm performance for multiscale change detection. All medium and large changed objects, as well as the majority of the small objects (Figure 3), were automatically pinpointed using local maxima detection applied to the multiscale product domain. Misregistration effects and very small polygons that approach the image resolution could not be detected due to noise reduction provided by the multiscale transform.

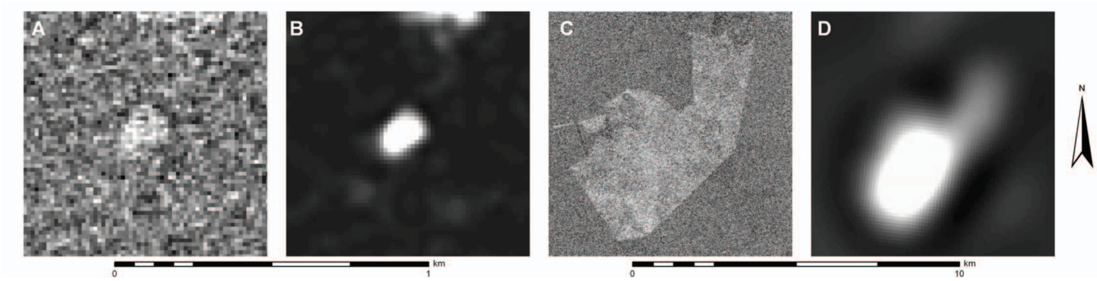

Figure 3. Small change object in the original Palsar image (A) detected in the product of scale 2x3 (B). Large change object (C) detected in the product of scale 5x6 (D).

5. CONCLUSION

A procedure for detection of image objects that represent change in SAR data has been developed and demonstrated in an area of tropical savannah in Minas Gerais, Brazil. We conclude that the use of SAR images for change detection within the monitoring framework currently implemented by the State Forest Institute of Minas Gerais is feasible and might provide information in areas frequently covered by clouds. The procedure is fully automated without the need of any user interaction. Further research is being conducted to extend the use of multiscale wavelet products for automatic edge detection and object segmentation focusing on areas where significant changes have been detected with the procedure presented in this paper.

6. REFERENCES

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