CHANGE DETECTION USING POLARIMETRIC L BAND SYNTHETIC APERTURE RADAR DATA

Mariane S. Reis, Sidnei J. S. Sant'Anna *

Brazilian National Institute for Space Research
São José dos Campos, SP – Brazil

Eliana Pantaleão

Federal University of Uberlândia
Patos de Minas, MG – Brazil

ABSTRACT

Synthetic Aperture Radar (SAR) data is very important to land cover change detection, mainly in areas of tropical forests that are constantly under cloud cover. In this study, six features extracted from two L band SAR full-polarimetric images were evaluated for region based binary change detection in a region within the Brazilian Amazon, in the years of 2006 and 2009. These features were the intensities from polarizations HH, HV and VV and the three components from Freeman-Durden polarimetric decomposition. The best results were obtained by HV intensity and the volume and double-bounce scattering components from Freeman-Durden polarimetric decomposition. Visual analysis of data indicates the volume scattering component as to better represent changes in the land cover. This feature also appears to be less sensitive to noise than the other components from the polarimetric decomposition. However, since full-polarimetric data is still limited in many areas within the Brazilian Amazon, the use of HV intensity is recommended, if only polarized data is available.

Index Terms— SAR, change detection, polarimetric decomposition, L band.

1. INTRODUCTION

The Brazilian Amazon is one of the last frontiers of economic and territorial expansion, where many changes are induced by investment programs [1]. Many remote sensing data based programs are operational for monitoring and characterizing this region, such as PRODES (Program for the Estimation of Deforestation in the Brazilian Amazon), DETER (Real Time Deforestation Monitoring System) and DETER-B, Mapping of Forest Degradation in Brazilian Amazon (DEGRAD) and the Land Use and Land Cover mapping of Deforested Areas in Legal Amazon Project (TerraClass). These programs are all based on optical data. However, this data is subjected to weather conditions, being heavily impaired by cloud cover, which is almost constant in the Brazilian Amazon. For this reason, in some periods of the year there is a lack of information in the products of the cited programs, as well as large areas classified as Not Observed (under cloud cover during the observation time).

Synthetic Aperture Radar (SAR) provides data almost independently from atmosphere conditions [2]. Therefore, many studies have been focused on detecting changes using SAR data. In this sense, it is important to determine the correct change detection method and suitable data to be used [3]. Since different features extracted from SAR data can present different information about land cover, the present study aims to evaluate six features extracted from L band SAR full-polarimetric images for detecting changes in a region within the Brazilian Amazon, using a region based binary change detection methodology.

2. MATERIALS AND METHODS

This study is focused on analyzing SAR data for detecting changes occurred between 2006 and 2009, in an area of agricultural frontier in the Brazilian Amazon. This area has approximately 290 km^2 and is located in Belterra, Pará state, as illustrated in Figure 1. This is a region of humid tropical climate that presents patches of secondary vegetation, pasture and agriculture within the forest matrix of dense forest vegetation.

Two images from Phase Array L-Band Synthetic Aperture Radar sensor (PALSAR) on board of Advanced Land Observing System (ALOS), acquired in PLR 1.1 mode (full-polarimetric in L band) were used in this study. These images date back September 05 2006 and April 28 2009. The intensities in HH, HV and VV polarizations were extracted from these images, as well as the components surface (surf), volume (vol) and double-bounce (dbl) from Freeman-Durden polarimetric decomposition. The data was projected to ground-range and geocoded to UTM WGS84 using the Sentinel-1 tool-

*Funded by CNPq grants #312753/2015-2. Special thanks to ICMBio(MMA) for SISBIO authorization #38157-2, LBA program and the Monitoramento Ambiental por Satélite no Bioma Amazônia project, process #1022114003005-MSA-BNDES.

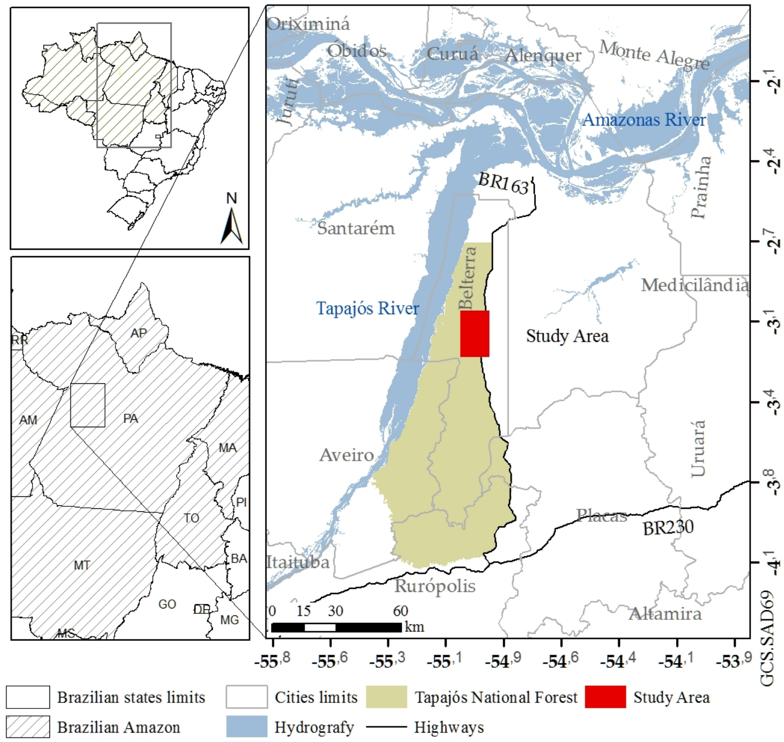

Fig. 1. Study area, with geographical references.

box software, and resampled to square pixels of 3 m by nearest neighbor interpolation.

Change detection was conducted in a region based approach. Firstly, the three intensity channels for each date were segmented using MultiSeg [4], with the following configuration: 4 levels, similarity=20, estimated number of looks=4.5, confidence=0.99 and minimum area=100. The two resulting segmented images were then superposed so each segment represents an homogeneous region in both 2006 and 2009 data. Regions with less than 100 pixels were grouped with those that shared the longest border. Change detection was performed based on this segmented image and each one of the six SAR features (three intensities and three components from Freeman-Durden polarimetric decomposition) of each date. Firstly, the mean value of pixels in each segment is calculated for each date. If the mean value of a given segment in both dates differs beyond a certain percentage threshold, this segment is labeled as Change. Otherwise, the segment is labeled as Non-Change. This methodology was previously used by [5] to perform change detection on the same region and ALOS/PALSAR data in dual-polarized amplitude data, with good results.

Studies as [5, 6, 7] had previously identified ten main land cover classes in the study area (as defined by [6]):

- Bare Agricultural Soil (BS): agricultural areas that at the sensing time presented bare soil;
- Idle Agricultural Area (IA): fallow annual agriculture areas, that presents herbs in green or senescent state;
- Cultivated Area (CA): culture being cultivated in the area at the sensing time;
- Clean Pasture (CP): pasture areas, covered by gramineaes, in which invasive shrub plants can be found in less than 15% of the feature;
- Overgrown Pasture (PA): pasture areas in which invasive shrub plants are present in more than 15% of the feature;
- Initial Secondary Vegetation (SV1): areas of secondary vegetation (grown after completely razing the natural forest) formed predominantly by herbaceous vegetation and shrubs;
- Intermediate Secondary Vegetation (SV2): areas of secondary vegetation composed mainly by shrubs and small trees;
- Advanced Secondary Vegetation (SV3): areas of secondary vegetation, composed by trees with

mean height of 20 m, with presence of emergent trees and, to a lesser extent, shrubs and herbaceous vegetation;

- Modified Forest (MF): forested areas modified by logging and/or fire;
- Mature Forest (MA): well structured, climax forests, with small to none evidence of alteration.

In the present study, change is defined as any segment that presented one of these classes on 2006 and another one in 2009. Samples of Change and Non-Change areas were collected on the images and used to evaluate the accuracy of maps obtained using varied percentage thresholds and each SAR feature. The Detection rate and the False Alarm rate were calculated using these samples and compared to form ROC (Receiver Operating Characteristic) plots, used to evaluate the performance of SAR features.

3. RESULTS

The ROC curves for the six SAR features are presented in Figure 2. In ROC curves, curves with higher Detection rate (tendency to the upper corner) and lower False Alarm rate (tendency to the left corner) indicate the best features for change detection. As can be seen in Figure 2, the best results were obtained by HV intensity, vol and dbl. HV intensity and the vol component were both able to achieve a very high Detection rate with the smallest False Alarm rate. The dbl component from polarimetric decomposition, however, could achieve a very small False Alarm value, with relatively good Detection rate. These three SAR features, along the calculated difference in percentage of the mean values of such features, are illustrated in Figure 3.

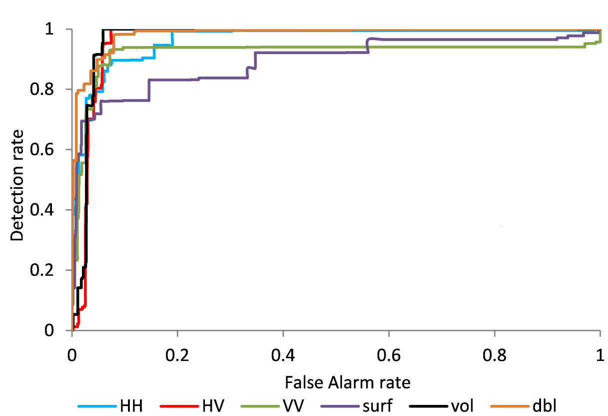

Fig. 2. ROC curves. HH=Intensity HH, HV=Intensity HV, VV= Intensity VV, surf=Surface scattering,vol= Volume scattering and dbl= Double-bounce scattering.

In Figure 3, it is possible to observe high differences in percentage values in agricultural and pasture areas for the intensity in HV polarization (dark areas in the SAR features). This result was expected, due to changes in the land cover regarding land use and management practices. However, it means that changes in the forest itself (brighter areas of SAR features) may be more difficult to detect using this data. Based on the visual analysis of Figure 3, it appears the volume scattering component is the most suitable one to analyze changes in the land cover. Compared to the double-bounce scattering component, volume also appears to be less influenced by noise.

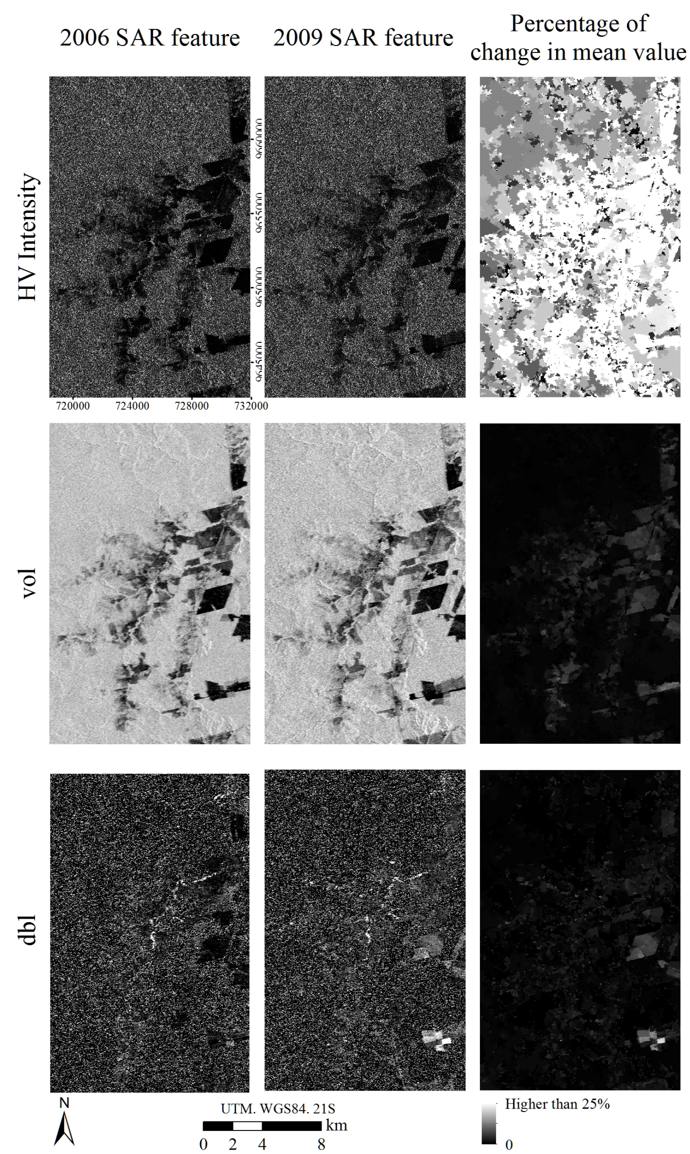

Fig. 3. SAR features from both dates and percentage of change in mean values. HV=Intensity HV, vol= Volume scattering and dbl= Double-bounce scattering.

4. FINAL CONSIDERATIONS

This study evaluated six band L SAR features for binary change detection in a region within the Brazilian Amazon. HV intensity and the volume and double-bounce scattering components from Freeman-Durden polarimetric decomposition presented the best results. In special, the volume scattering component appears to better represent both small and drastic changes in the land cover and is less sensitive to noise than the other components from the polarimetric decomposition. However, it is important to highlight that full-polarimetric data is still limited in many areas within the Brazilian Amazon, and so the use of HV intensity may be very interesting, if only polarized data is available, such as Fine Bean Dual mode images of ALOS/PALSAR and ALOS/PALSAR2 sensors. Using the data in intensity is also simpler than applying polarimetric decomposition. Future works should include the use of other SAR data and other methods for polarimetric decomposition. More detailed reference data for change detection should also be obtained and analyzed, in order to further evaluate the potential of such data for change detection in Amazon.

5. REFERENCES

[1] N.A. Mello, *Políticas públicas territoriais na Amazônia brasileira*, Ph.D. thesis, Universidade de São Paulo 2002, 2002, These de doctorat dirigée par Musset, Alain et Costa, Wanderley Messias da Géographie Paris 10 2002.

[2] W.R. Paradella, A.R. Santos, P. Veneziani, and E.S.P. Cunha, "Radares imageadores nas geociências," *Revista Brasileira de Cartografia*, vol. 1, no. 57, pp. 56–62, 2005.

[3] D. Lu, G. Li, and E. Moran, "Current situation and needs of change detection techniques," *International Journal of Image and Data Fusion*, vol. 5, no. 1, pp. 13–38, 2014.

[4] M.A. Sousa Jr., "Segmentação multi-níveis e multimodelos para imagens radar e ópticas," M.S. thesis, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, 2005.

[5] M. S. Reis and S. J. S. Sant'Anna, "Analysis of binary land cover change detection methods using optical and radar data," in *2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*, July 2015, pp. 4236–4239.

[6] M.S. Reis, L.V. Dutra, S.J.S. Sant'Anna, and M.I.S. Escada, "Examining multi-legend change detection in amazon with pixel and region based methods," *Remote Sensing*, In press.

[7] M.S. Reis, "Detecção de mudanças de uso e cobertura da terra utilizando dados óticos e de micro-ondas em uma região da amazônia brasileira," M.S. thesis, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, 2014.