EVALUATION OF C-BAND SAR DATA FROM SAREX'92: TAPAJÓS STUDY SITE

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Abstract. As part of the SAREX'92 (South American Radar Experiment), the Tapajós study site, located in Pará State, Brazil was imaged by the Canada Centre for Remote Sensing (CCRS) Convair 580 SAR system using a C-band frequency in HH and VV polarization and 3 different imaging modes (nadir, narrow and wide swath). This paper presents a preliminary analysis of this dataset. The wide swath C-band HH polarized image has been enlarged to 1:100,000 in a photograhic form for manual interpretation. This was compared with a vegetation map produced primarily from Landsat TM data and with single-band and colour composite images derived from a decomposition analysis of TM data. The SAR image shows well the topography and drainage network defining the different geomorphological units, and canopy texture differences which appear to be related to the size and maturity of the forest canopy. Areas of recent clearing of the primary forest can also be identified on the SAR image. The SAR system appears to be a source of information for monitoring tropical forest which is complementary to the Landsat Thematic Mapper.

INTRODUCTION

The large areal extent of tropical rainforest and frequent cloud cover make these areas promising candidates for management strategies which incorporate satellite radar data (ERS-1, Radarsat).

In support of the ERS-1 mission and in preparation for the launch of Radarsat, the SAREX'92 campaign provided one of thefirst opportunities for scientific study of tropical forest signatures at C-band. The airborne data collected can enable simulations of many different future satellite systems.

The purpose of this paper is to evaluate the wide swath C-HH SAR data acquired over the Tapajós study site in Pará State, Brazil. Emphasis was placed on the contribution that microwave remote sensing system may make to the existing optical remote sensing systems for monitoring tropical ecosysytem will be examined by comparing SAR and Landsat Thematic Mapper (TM) data.

SAR DATA

The SAR data over Tapajós study site was acquired on April 16, 1992 by the Convair 580 SAR System owned by the Canada Centre for Remote Sensing (CCRS). This system is a well established airborne X/C-Band SAR facility which has been used widely within North America and Europe. The full description of the SAR system and operating configuration is available elsewhere (Livingstone et al., 1988).

During SAREX'92 in Brazil the aircraft operated from an altitude of approximately 6 km using a single frequency mode (C- Band) in dual polarization (HH and VV) and 3 different imaging modes: Nadir mode - 20 km swath (incidence angles 20^{o} to 74^{o}) with 6m x 6m resolution covering 56 km length; Narrow swath mode - 18 km swath (incidence angles 45^{o} to 76^{o}) with 6m x 6m resolution covering 172 km and 60 km length; Wide swath mode - 60 km swath (incidence angles 45^{o} to 85^{o}) with 10m x 20m resolution covering 238 km length. The C-band SAR passes over the study site are shown in Figure 1.

DESCRIPTION OF THE STUDY SITE

The study site includes the Tapajós National Forest and is located near the city of Santarém in the Pará State. The Tapajós National Forest is bordered by the Cuiabá-Santarém highway to east and by Tapajós river to the west. It comprises approximately 600,000 hectares of tropical rainforest. At the border of the National Forest there are several areas which have been deforested as a result of human activity.

The soils of this area are dominantly distrophic yellow latosols with different textures, covered by a dense forest. Geomorphologically, the study site includes two areas: the "Lower Amazon Plateau (LAP)" and the "Higher Xingu-Tapajós Plateau (HXTP)".

Based on physiognomic and botanical characteristics, the LAP can be divided into two ecosystems: "Lower Plateau Ecosysytem" and "Ecosystem of the Dissected Lower Plateau". The first ecosystem occurs in an area of lowlands with low relief variance and predominantly clay-rich soil. The predominant species in this region includes: "Sucupira" (Bowdichia/Diplotropis spp), "Acariquara" (Minquartia guianensis), "Castanheira" (Bertholletia excelsa), "Cupiubas" (Groupia glabra), "Mandioqueira" (Qualea spp), and "Maçaranduba" (Manilkara huberi). The second ecosystem in the LAP consists of intensively dissected plateaus with erosion on the slopes, narrow valleys and soils with a medium texture. This

ecosystem is characterized by forests with liane and several palm trees such as "Açaí" (Euterpe pleraceae mart) and "Babaçú" (Orbignia martiana B. Rodr).

The second geomorphological unit (HXTP) is characterized by dense tropical forest with trees having a high commercial value such as "Castanheira", "Andiroba" (Carapa guianensis), "Louro-canela" (Licania canela Meis-Sn), "Cumarú" (Dipteryx odorata), "Guaruba branca" (Vochysia guianensis Aubl), "Cedro" (Cedrela odorata), "Maçaranduba"(Malnikara huberi), etc.

The datasets including information from topography, soil, and vegetation maps are available from the research project developed by INPE in collaboration with IBAMA and FUNATURA (Hernandez Filho, 1992)

PRELIMINARY ANALYSIS OF C-BAND SAR DATA

Wide swath C-band SAR HH polarized images were analyzed. These images have been enlarged to 1:100,000 scale for manual interpretation. They were compared with images produced from a Landsat Thematic Mapper (TM) scene obtained in August, 1988. The preliminary analysis consisted of the identification of large relief features reported by RADAMBRASIL. The Lower Amazon Plateau (LAP) and the Higher Xingu-Tapajós Plateau (HXTP) can be easily identified in this data set. Also, the two ecosystems described for LAP can be separated based on the visual topography and texture of these images.

Removal of primary forest can be identified by the difference of tree height as shown at the eastern border of the National Forest. As the forest regenerates, the contrast between primary forest and secondary forest decreases. The radar images seem to be more sensitive to early stages of regeneration than the Thematic Mapper images, whereas the TM continues to show distinct differences in areas where it is difficult to distinguish between primary and secondary forest with the radar image.The difference between the overgrown rubber tree plantation at Belterra and primary forest in the HXTP ecosystem can be identified analysing the difference in visual texture and shape, i.e., the secondary forest presents a smooth texture and geometrical shape due to the human activities. Newer clear cuts within the secondary forest are very well outlined in this SAR image. Inside the primary forest within the National Forest, some areas of old regrowth can be identified and delineated as a form of "canopy topography" where the canopy of the secondary forest is more irregular in height and has not attained the same height as the surrounding primary forest.

In the LAP area, the SAR images show some long shadows due to the shallow incidence angle which mask some information.

A comparison between the SAR image and vegetation classes compiled by (Hernanfez Filho, 1992), shows good

general agreement between the vegetation class boundaries and geomorphological boundaries clearly visible on the SAR image. In some cases it is apparent that a single vegetation class could be subdivided into two or three classes based on the geomorphology interpretable from the radar image. The fine texture of the SAR image appears to provide some information on the size and maturity of the primary forest canopy: slightly coarser textures appear related to areas with larger, older trees. In one case there was a change in the fine texture visible on radar image which did not correspond to a change in vegetation class on the map, suggesting a vegetation difference which has not been mapped.

The SAR image was also compared with images made by a spectral decomposition technique (Simabukuro and Smith, 1991) from the six reflective bands of the TM image. Three components were derived: soil fraction, vegetation fraction, and shadow fraction. These were produced as individual black and white images and as a colour composite, with blue assigned to shadow fraction, green assigned to soil fraction, and red assigned to vegetation fraction. It is apparent that the radar image and the colour composite image have complementary information, with the colour composite contributing information on the type and amount of vegetation cover, and the radar contributing information on the topographic expression. In comparing the individual components with the radar image, it was apparent that there is also considerable topographic information in the shadow fraction component. However, the topographic expression of the radar image is easier to interpret because the gray tones in the radar image are dominated by topography (except at the finest resolution, where texture becomes important), while the shadow fraction image also contains considerable information about the vegetation cover. A suitable combination of the radar and decomposition images should be pursued.

CONCLUSION

The preliminary analysis of wide swath C-SAR HH polarized images acquired over the Tapajós study site shows the potential this dataset for differentiating geomorphological units, and for showing recent clearing of the primary forest. Through topographic and textural information, it appears to provide information useful in further refining generalized vegetation cover information. The SAR images appear to provide information which is very complementary to the vegetation cover information available from the Thematic Mapper. Combinations of TM and SAR data suitable for visual interpretation should be pursued.

The SAR System appears to be a promising source of information for monitoring tropical ecosystems where cloud cover has restricted data acquisition by optical sensor systems.

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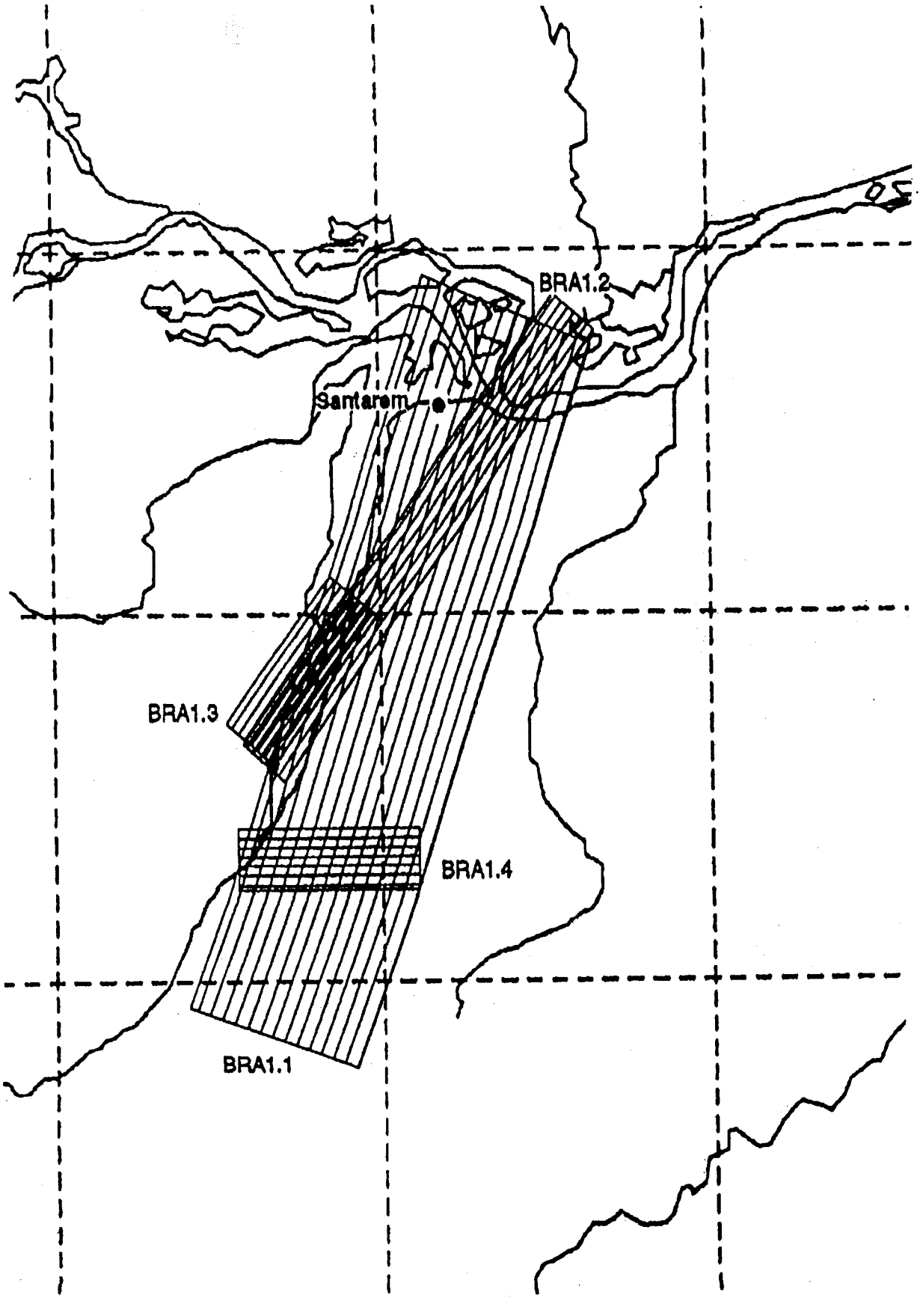

Figure 1. Radar coverage of Tapajós Study Site