

Integration of Multi-Sensor Data to Characterize Amazon River Floodplain Habitats

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ABSTRACT

This paper reports on the integration of multi-sensor data to characterize floodplain habitats in the lower reach of the Amazon River. The study area is located between the Tapajós river mouth and the Xingu River mouth. Three data sets are available for this study: C-band ScanSAR wide mode RADARSAT images, L-band SAR JERS-1 images and TM/Landsat images. The RADARSAT C-band image enhanced floodplain boundaries and hydrodynamic differences between Tapajós and Xingu rivers. JERS-1 L-band image improved the detection of recent clear cut areas allowing the update of deforested areas especially where the cloud cover prevent the acquisition of optical data as TM. As the shade fraction image derived from TM data also enhances deforested areas, the combination of JERS-1 and TM shade fraction are an optimal data set to estimate the increment of deforested areas.

INTRODUCTION

In the last three decades, the Brazilian Amazon region has been submitted to state programs to foster its economical integration to the country. Therefore, the Amazon population increased specially in the floodplains. The Amazon floodplain has reach soils that can support food production.

Sediment carrying floods seasonally enriches the floodplain soil. Hence the floodplain farming, ranching and fisheries increased and it is now a threat to the environmental stability. The area covered by the Amazon River and its tributaries is estimated in 250,000 square km most of which is completely unknown. RADAM project was the first comprehensive effort to map the entire Amazon floodplain using X-band Side-Looking Airborne Radar data in the 70's. The results of the RADAM project show clearly that the use of remote sensing techniques is the only viable way to cope with complexity and dimension of such a region. This paper reports on the integration of multi-sensor data to characterize floodplain habitats in the lower reach of the Amazon River.

STUDY AREA

The study area is located between the Tapajós river mouth and the Xingu river mouth. This area represents the transition zone between the Medium and Lower Amazon [1]. This area is an intricate mosaic of interconnected ecosystems, including rainforests, floodplain forest, igapó forest, savannas, wetlands [2]. It also includes rivers and lakes with different types of water. This region also displays system subjected to growing tidal influence Tapajós River towards Xingu River [1].

REMOTE SENSING DATA ANALYSIS

The images from Landsat, RADARSAT and JERS-1 were first geo-referenced using a 100 meters pixel spacing. The linear mixing model [3] was applied to the Landsat TM mosaic using channels 3, 4, and 5 generating three fraction images: vegetation, soil, and shade. These images are formed by the proportion values of these components inside of each pixel. The vegetation fraction image is similar to the well known vegetation index images such as Normalized Difference Vegetation Index (NDVI) as showed in [4].

The soil fraction image highlights the bare soil areas while shade fraction image differentiates the forested and non forested areas (including recent clear cuts, pasture, agriculture and forest regrowth areas) as presented in [5]. The Principal Component Analysis (PCA) algorithm was applied to RADARSAT and JERS-1 SAR data. The first Principal Component image highlights the water bodies on the scene while the second Principal Component image shows the difference among different land cover types.

The set of 11 different images were used as input for a channel selection algorithm taking into account known ground classes as follows: water, macrophyte beds, forest, agricultural and urban land use. The five best sets of data were then used to run an unsupervised classification "K-Means algorithm".

RESULTS

The RADARSAT C-band image shows the boundaries of floodplain areas and the difference between the Tapajós and Xingu rivers regarding hydrodynamic aspects (Fig 1).

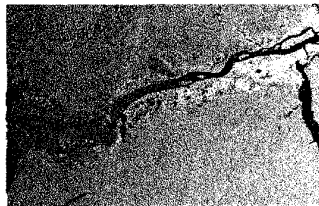


Fig. 1 – RADARSAT image.

The JERS-1 L-band image detects the recent clear cuts areas allowing to update the estimate of deforested areas especially where the cloud cover prevent the acquisition of optical data (Fig. 2).

The combination of JERS-1 and the TM shade fraction images highlights the increments of deforested and regenerated areas (Fig. 3). This figure shows the Southeast portion of the study area.

The variation of water bodies can be evaluated comparing the First Principal Component image derived from satellite SAR data and the shade fraction image (Fig. 4).



Fig. 2 – JERS-1 L Band SAR image.

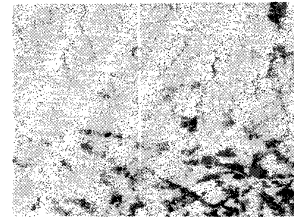


Fig. 3 - JERS-1 L Band SAR (Magenta), Shade Fraction (Green). Increment of Deforestation (Dark green) and Regeneration (Dark magenta) areas.

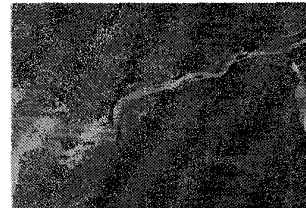


Fig. 4 – PC1 (Green); Soil Fraction (Magenta).

The tree best channels selected to discriminate among ground classes were TM3, TM4 and TM5. Fig. 5 shows the classification results. It can be observed that, in spite of the statistical results, this composition is unable to discriminate between flooded forest and the Terra Firme Forest (all in green). It also shows misclassification between floodplain grasslands and urban and agricultural land uses.

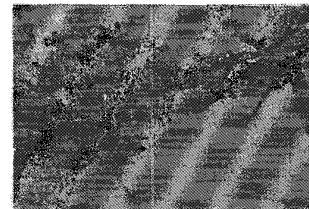


Fig 5 – Unsupervised classification of TM3, TM4, and TM5.

If L-band is added to the three best channels, the classification results are even worse as shown in Fig. 6.

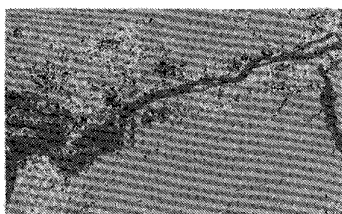


Fig 6 – Classification results using L band, TM3, TM4, and TM5 bands.

The use of the multi frequency (L and C band), and multispectral TM data (bands 3, 4 and 5) improves the discrimination of the floodplain habitats (Fig. 7). It can be observed that the floodplain vegetation (yellow) is discriminated from the “terra firme” forest in most of the “varzea”. The area covered by floodplain grasses subjected to tide effects is also discriminated (pink). Therefore, the inclusion of C band, improves the discrimination between floodplain grasslands and agricultural and urban land use areas.

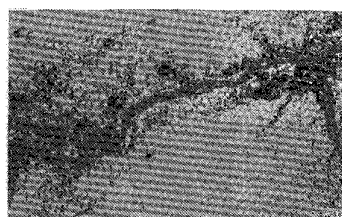


Fig. 7 – Classification result using TM bands, JERS-1 L band and RADARSAT C band.

Fig. 8 shows that the removal of TM3 from the previous data set reduces the discrimination between the different types of floodplain vegetation, but highlights the flooded areas (pink), mainly where herbaceous vegetation is dominant.

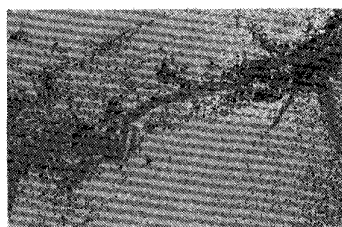


Fig. 8 - Classification result using TM4 and TM5 bands, JERS-1 L band and RADARSAT C band.

Fig. 9 shows the classification results using the PC1 and the three fraction images. The classification results are similar to the previous data set, except that in this case, recent clear cuts are mixed with the floodplain vegetation (pink).

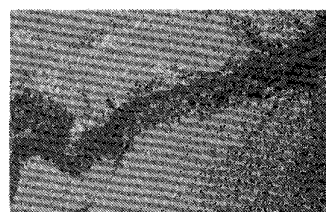


Fig. 9 – Classification results using PC1 and vegetation, soil and shade fraction images.

CONCLUSION

The RADARSAT C-band image enhanced the floodplain boundaries and hydrodynamic differences between Tapajós and Xingu rivers. JERS-1 L-band image improved the detection of recent clear cut areas. The integration of Landsat TM (original and fraction images), RADARSAT and JERS-1 data showed to be a useful tool to characterize floodplain habitats in the lower reach of the Amazon River.

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