A DUAL-FREQUENCY SAR MOSAIC OF THE AMAZON

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1. INTRODUCTION

The development and availability of accurate landcover information is critical to the ecological science questions [Cerri, et al., 1995; Hall, et al., 1995], such as defining the rate and extent of deforestation within the Amazon. This need can only be met by techniques that are sensitive to phenomena at the scale of the landscape patch and can be efficiently applied in a consistent fashion over very large regions. For example, estimation of Amazonia's carbon budget will require a large-scale mosaic of the location and spatial extent of land-cover types, forest regrowth biomass, and selective logging. Vegetation type and surface condition exert control over carbon and trace gas fluxes. Estimates of the biotic carbon pool are also important since carbon accumulation rates vary not only with vegetation types but with successional stage and management practices as well. Both the extent and carbon accumulation rates of regenerating tropical forest are poorly known. If the ages of forest disturbance can be established (i.e., from the Landsat time series), then the SAR-derived estimates of aboveground biomass can be used to estimate annual sequestering of carbon. Though these data were acquired at higher resolution, it is possible to use this data to map land-cover, biomass and selective logging at a spatial scale of 100-m for the Amazon basin.

2. TECHNICAL APPROACH AND METHODOLOGY

Our specific objectives are to use archival orbital imaging radar data to produce (1) land-cover classifications, (2) forest regrowth aboveground biomass estimation and (3) estimates of the areal extent of selective logging. All of these products hinge on production of a calibrated mosaic of SAR data, in this case from RADARSAT and JERS. The JERS and Radarsat data were acquired during two sampling periods in 1995 and 1996. We have used in-house computer codes in order to geometrically and readiometrically correct the data and accurately place each pixel. The raster map so generated is consistent with the JERS mosaic produced many years ago that provided for geometric correction only [Siqueira, et al., 2000].

In order to use data from two different satellites, the data must be co-registered to each other, and ideally to a map as well. This is due to the unique terrain-induced distortions that are caused by the different viewing geometries of the two sensors. Hence, rubber-sheeting techniques for geometric correction face difficult, if not impossible task. Our current process uses in-house orthorectification software to accomplish this, and it has worked very well. To make this process practical for use with hundreds or thousands of separate SAR images requires the orbital correction phase fo the process to automated. This is because the satellite orbit that is provided with the data is never accurate enough for use in orthorectification. Improved orbital information is available from NORAD, and we have incorporated ideas and codes made available to us from the JPL team that worked on the previous JERS mosaic. This enables us to correct the orbit of the satellite and so produce a much more accurate orthoretified image. Unfortunately this process only worked well with the RADARSAT data. The JERS data seemed to have a random clock error that placed the satellite incorrectly along the orbital path, and hence the image was up to 20 Km off in ground position. How we dealt with this is detailed later.

The JERS mosaic developed here uses a data set of some 1500 image scenes that were collected over the Amazon region in South America by the JERS-1 L-band SAR operated by the Japanese Space Agency (NASDA) as part of the Global Rainforest Mapping project (GRFM), and provided to us by NASA. The JERS data set is unique because the 25 m resolution data extending over some 8 million Km^2 was collected within a relatively short time period over two seasons, low-flood (September/October 1995) and high-flood(May/June 1996). See Figure 1. The RADARSAT mosaic uses several hundred scansar images collected at C-band.

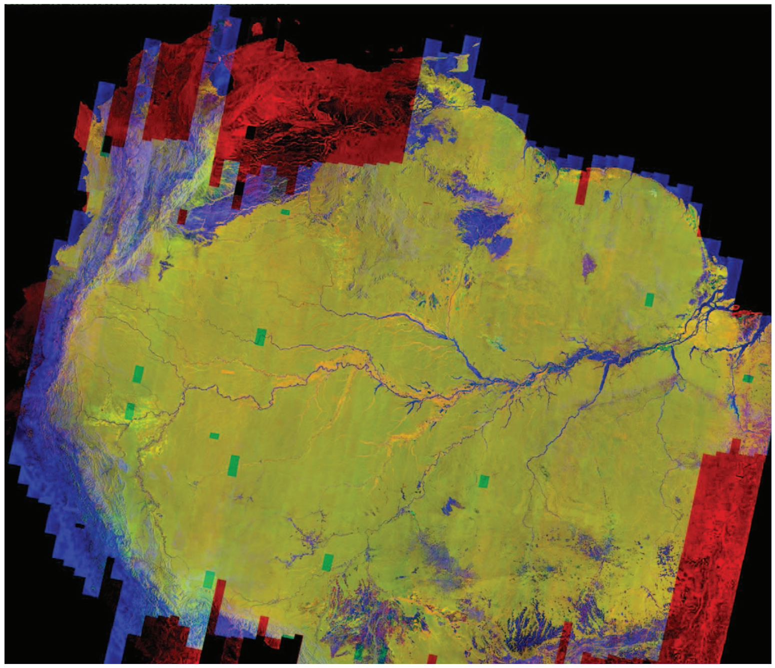


Fig. 1. Two-season coverage of the Amazon basin. In this image, high-flood backscatter is encoded in the red channel, low-flood backscatter yellow and low-flood texture the blue channel. Using this simple encoding, open water, savanna, mountains and development show up as blue, forest as light green, flooding as pink, and missing high-flood scenes as green.[Siqueira, et al., 2000]

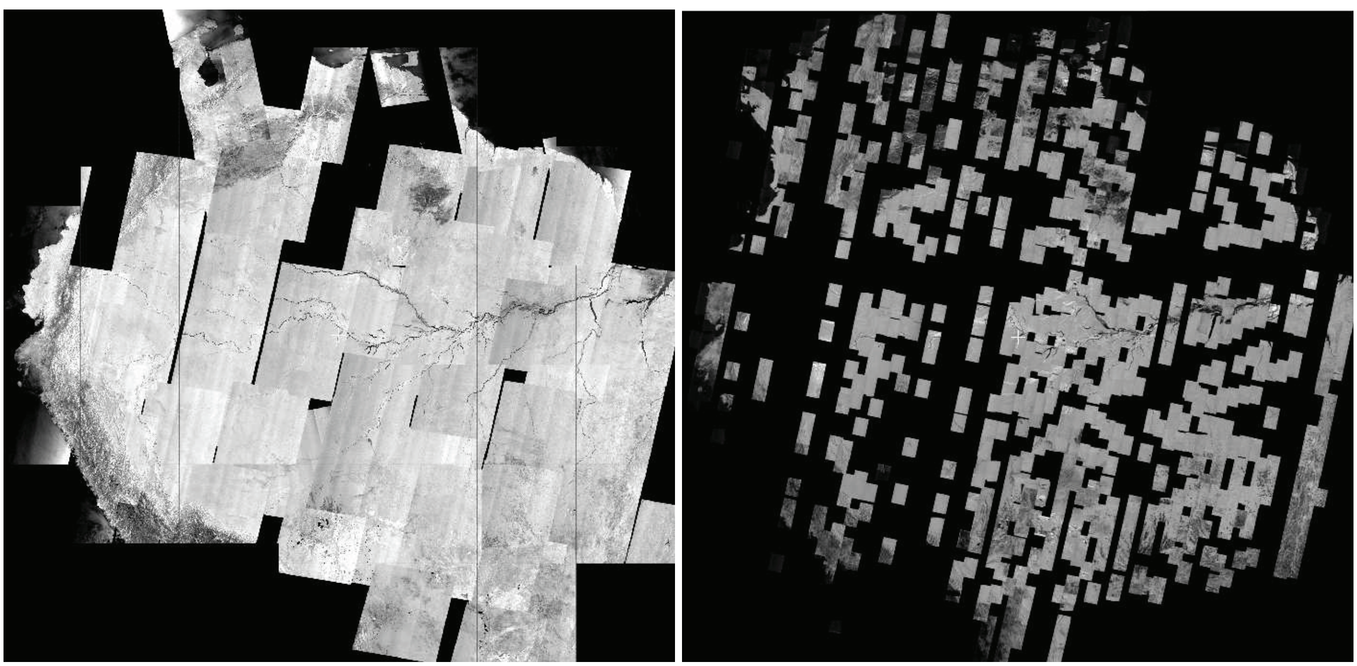
The process of coregistration by JPL of the 1500 scenes within a season and coregistration of the between season mosaics was accomplished by using a least-squares minimization approach to solving for small rotation and shifts to the scene locations induced by inaccuracies in the orbital knowledge of the satellite and distortions of the imagery due to regional topography [Siqueira et al., 2000]. Without taking into account topography, the removal of these geometric distortions via the rotation and shift corrections is able to increase the cartographic accuracy of the radar imagery from 1 km accuracy to better than 400 m with a near-perfect registration between seasons. Still, there remain small geometric distortions induced by the local topography and radiometric effects that need to be removed to make the data more accessible to the general user and amenable to further basin-wide studies.

SAR backscatter return is sensitive to the slope of the terrain for two reasons: (1) Surfaces, and targets in general, become more reflective as the angle of incidence and the angle of return become equal. This pattern generally follows a cosine, or cosine squared law, and is not as pronounced an affect as the second reason, (2) The physical ground area which lies within a single range resolution element [van Zyl et al., 1993]. Typically, for calculating backscatter power, we assume a flat surface, laying at some orientation (the incidence angle) with respect to the instrument. As the surface becomes oriented in a perpendicular direction to the incidence angle, the total area contained within the range resolution cell increases, and so proportionally does the backscatter power. Knowledge of the terrain through a digital elevation map (DEM) could in principal be used for eliminating this affect by taking into account the intercepted area for each resolution element in the output image.

At present, the best available DEM for the Amazon region is that made available from the SRTM mission in 2000, at 90 meter postings (see: http://srtm.usgs.gov). Using the correct orbit, and this highly-accurate DEM data enables us to automatically orthorectify all the RADARSAT data. The JERS data needed another step in order to account for the errors in the onboard clock. This step used a correlation algorithm to slide each JERS image along the orbital path, and hence along the pre-existing JERS mosaic from years ago. The offset needed for high-correlation was used to calculate a new orbital time for the image, and the remaining steps of the orthorectification process could continue.

3. RESULTS

The mosaics have both been generated. Fig. 2(a) shows the RADARSAT mosaic. There are a few holes that we would like to fill in the near future. Fig. 2(b) shows the JERS mosaic. There are many holes. This is due in part to two causes: (1) some of the orginal data was unavailable, and so we planned to order more to fill in the holes once the holes were identified, and (2) some of the scenes did not correlate well with the JPL JERS mosaic, and so were not placed. Future work will address these issues in order to generate a more complete mosaic. In the interim, Fig. 3 shows the mosaic using the orginal JERS mosaic in red with the RADARSAT data overlayed in green and blue. Already one can see interesting features where the two bands are providing information on land cover that neither one alone could provide.



(a) (b)

Fig. 2. (a) RADARSAT mosaic. (b) JERS mosaic.

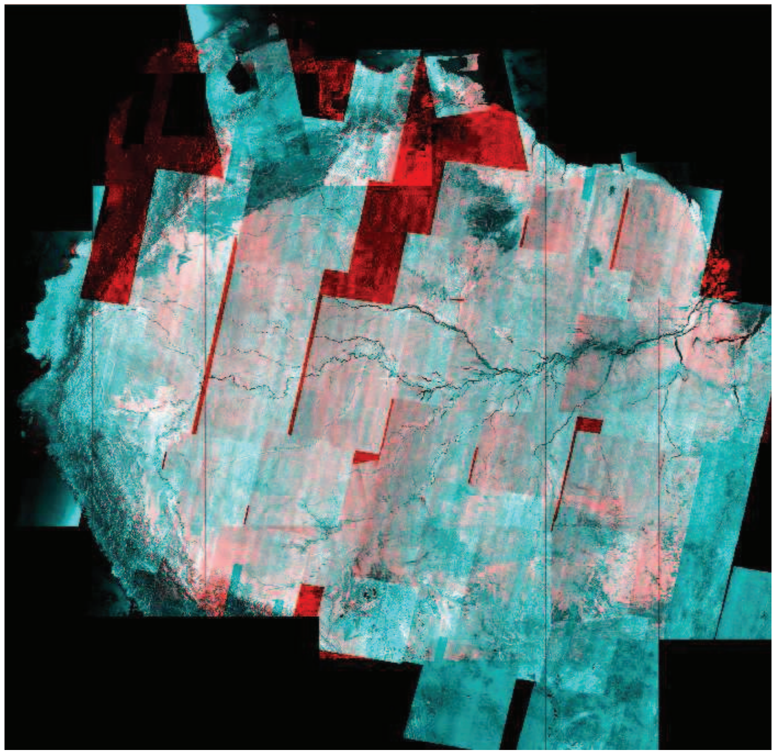


Fig. 3. The RADARSAT mosaic combined with the original JPL JERS mosaic.

4. REFERENCES

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