ANALYSIS OF GEOSAR, DUAL-BAND, INSAR DATA FOR PERUVIAN FOREST

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1. ABSTRACT

GeoSAR collects X-Band (VV, 9.7GHz), and P-Band, (HH, 0.35GHZ) interferometric synthetic aperture radar (SAR) data in single-passes, over swaths of width ~11km, that may extend to several hundred kilometres, and from which are derived digital elevation models (DEMs) [1]. The system comprises four X-band and four P-band antennae mounted permanently on a Gulfstream-II jet aircraft, permitting simultaneous port and starboard acquisition, and includes a nadir-looking LiDAR used primarily for high-density ground control. LiDAR data points are filtered and those associated with bare surfaces provide control in the DEM generation process, and data for quality control. Use of calibration targets and LiDAR control, plus an acquisition scheme with high redundancy, permits the generation of accurate DEMs, with typically a 1m RMSE error associated with the X-band DEM at 5m posting.

Notionally scattering at X-band arises predominantly from direct returns in the “upper” canopy. In contrast, P-band HH returns are more strongly influenced by ground-volume interactions. So the X-band VV interferometric phase centre appears high in the canopy, whilst the P-band HH phase centre lies close to the ground. The difference in X-band and P-band DEM heights therefore yields a surrogate vegetation height, h_{XP}, which has been used in the retrieval of biomass for areas of tropical forest when combined with the P-band HH backscattering coefficient [2, 3]. By virtue of design, GeoSAR has a wide-area mapping capability, and this, combined with the sensitivity of the observations to forest height, make the system suited to the estimation and monitoring of forest biomass on a wide scale.

Biomass recovery for high biomass tropical forest is most sensitive to the interferometric height difference, which is related through allometric equations to tree heights and diameters, which in turn are correlated. Thus knowledge of the correlation of Dual-Band, Interferometric SAR (DBInSAR) height differences with tree heights is of fundamental importance. In July, 2009 (during IGARSS09) GeoSAR was used to collect DBInSAR data over a pilot project area in Madre de Dios, Peru. The area contained a large number of forest validation plots, including areas critical for establishment of REDD projects: Manu National Park, a Conservation Corridor linking protected areas in the lowlands with montane protected areas and encompassing the deforestation frontier of the Interoceanic Highway, and The Puerto Maldonado and Bauaja-Sonene areas, with high immigration and deforestation pressures. Some of the project area, over 200km wide, is shown in the image mosaic in figure 1:

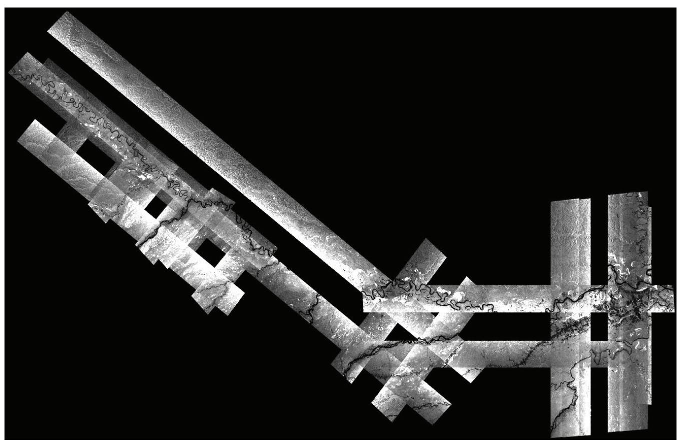

Figure 1. Mosaic of P-band swaths in the project area.

One of the goals of the collection was to develop a map of above-ground forest biomass over three sample sites in the Peruvian Amazon using GeoSAR data and provide an accuracy assessment of the methodology. We will present the results of comparisons of LiDAR and X-band interferometric SAR heights, and indicate how LiDAR data have been used to adjust the X-band InSAR height, in order to improve the correlation between DBInSAR canopy height estimates and ground data available for the test areas. We describe the process by which local canopy mean height is estimated using object-oriented image analysis, and assess the improvement in mean height accuracy associated with differing levels of image segmentation. Finally, we model the quantitative effects of terrain slope on the ground-volume scattering ratio, and show how this quantity affects the P-band HH interferometric phase centre height. We use this model to determine the effects of terrain slope on the recovered interferometric vegetation height estimates, and show how this information can be used to improve the mean canopy height estimate obtained from GeoSAR, DBInSAR data.

2. REFERENCES

[1] A K Wheeler, and S Hensley, *The GeoSAR airborne mapping system*, Record of the IEEE 2000 International Radar Conference, 2000, Page(s):831 – 835.

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