



Abstract

Title: Polarimetric data for tropical forest monitoring. Studies at the Colombian Amazon

Author: M.J. Quiñones Fernandez

Date: 4 November, 2002

An urgent need exists for accurate data on the actual tropical forest extent, deforestation, forest structure, regeneration and diversity. The availability of accurate land cover maps and tropical forest type maps, and the possibility to update these maps frequently, is of great importance for the development and success of monitoring systems. For areas like the Amazon the use of optical remote sensing systems as the source of information, is impeded by the permanent presence of clouds that affect the interpretation and the accuracy of the algorithms for classification and map production. The capabilities of radar systems to acquire cloud free images and the penetration of the radar waves into the forest canopy make radar systems suitable for monitoring activities and provide additional and complementary data to optical remote sensing systems. Information regarding forest structure, forest biomass, and vegetation cover and flooding can be associated with radar images because of the typical wave-object interaction properties of the radar systems.

In this thesis new algorithms for the classification of radar images and the production of accurate maps are presented. The production of specific maps is studied by applying the developed algorithms to two different study areas in the Colombian Amazon. The first site, San José del Guaviare, is a colonisation area with active deforestation activities and dynamic land cover change. The second area is a pristine natural forest with high diversity of landscapes.

A detailed statistical description of the polarimetric AirSAR data is made in terms of backscatter (gamma values), polarimetric phase difference and polarimetric correlation. This approach allows a better interpretation of physical backscatter mechanisms important for interpretation of images in relation to ground parameters. Theoretical cumulative probability density distributions (pdf) are used to describe the mean field values and the standard deviation for a class. A Gaussian distribution is used to describe the field average gamma values; a circular Gaussian distribution is used to describe the field average HH-VV phase difference and a Beta distribution is used to describe the field average HH-VV phase correlation. The accuracy of the estimation of the field-averaged values depends on the level of speckle, i.e. number of independent looks. This effect is included in the calculation of the pdf's and therefore can be simulated.

For the Guaviare site the classification algorithm is used to assess the AirSAR data in the production of a land cover type map. Classification accuracies are calculated for different combinations of bands and level of speckle. An accuracy of 98.7% was calculated for a map when combining L-HV and P-RR polarisations. Confusion between classes are studied to evaluate the use of radar bands for monitoring activities, e.g. loss of forest or detection of new deforested areas. In addition a biomass map is created by using the empirical relationship between the combination of the same radar bands and the biomass estimations from 28 plots as measured in the field. The agreement of the biomass map with the land cover map is used to evaluate the biomass classification.

For the Araracuara site the classification algorithm is used to assess the use of polarimetric data for forest structural type mapping and indirect forest biophysical characterisation. 23 field-measured plots used for forest structural characterisation are used to assess the accuracy of the classification. A new SAR derived legend is more suitable for the SAR map allowing better physical interpretation of results. A method based on iterated conditional modes is introduced to create maps from the classified radar images, increasing in most of the cases the accuracy of the classification. The structural type map with 15 classes can be classified with accuracies ranging from 68% to 94% depending on the classification and the mapping approach. The relationship between forest structure and polarimetric signal properties is studied in detail by using a new decomposition of polarimetric coherence, based on a simple physical description of the wave-object interactions. The accuracy of the complex coherence is described using the complex Wishart distribution. In addition for the same area, a biomass map is created using the previous structural type characterisation as the basis for the classification, overcoming problems as the well know radar signal saturation.

The possibilities and restrictions of creating biomass maps with AirSAR polarimetric images are deeply investigated. Two different approaches are proposed depending on the terrain conditions. A theoretical exploration on the physical limits for radar biomass inversion is made by using a new interface model, called LIFEFORM that describes the layered tropical forest in terms of scatterers. The UTARTCAN scattering model is used to analyse the effect of flooding, forest structure and terrain roughness in the biomass inversion.