MODELING IMPACTS OF ENVIORNMENTAL CONDITIONS AND VARIABILITY OF FOREST ARCHITECTURE ON POLARIMETRIC INTERFEROMETRIC MEASUREMENTS OF FOREST HEIGHT

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ABSTRACT

Variability in canopy architecture and composition are significant characteristics of forest structure that carry information about forest succession, health, and past disturbances. Environmental variables, such as moisture, temperature, and seasonality impact the forest function and can determine site-specific conditions that differentiate forest structure. It is predicted that forest architecture, composition, and environmental variables interact with microwave scattering of forest canopies and can cause uncertainty in the estimation of forest structure and biomass. In this paper, we model the impacts of structural heterogeneity and environmental variables on Pol-InSAR measurements of forest height. The main goal of this study is to examine how future planned radar interferometric missions by ESA (BIOMASS) and NASA (DESDynl) can provide measurements of forest structure and biomass unambiguously and repeatedly on a global scale.

We present a new three-dimensional forest scattering model to simulate the Pol-InSAR measurements at L-band frequency and with a fixed baseline. The model treats the forest as a layer of discrete random medium with a diffuse upper boundary over a rough ground interface. The scatterers in the layer are modeled as forest components (leaves, branches, and stems) using dielectric thin disks and cylinders of different size and orientation. The Distorted Born Approximation (DBA) has been used to treat the scattering of electromagnetic waves through the random medium and to analytically formulate the interferometric complex fields at different polarizations. The contribution of three dominant mechanisms of volume, volume-ground interaction, and ground scattering were explicitly modeled in Pol-InSAR coherence and phase.

We present model simulations for forests with the same height and extinction coefficient but different canopy architecture such as leaf and branch orientations, vertical distribution, and gap statistics using realistic forest structure data acquired from ground measurements in temperate and tropical forests. We further examine changes in environmental variables such as soil and vegetation moisture as a result of changes in precipitation and temperature. The sensitivity of the model to these variables will be quantified and will be evaluated in terms of potential uncertainties in the estimation of forest height or biomass from Pol-InSAR measurements. The results will be discussed in the context of future NASA and ESA missions and the recommendations to reduce the uncertainties will be provided.

Keywords: Pol-InSAR, Polarimetric SAR, Interferometry, Radar, Forest Biomass, Forest Height, Scattering Model, Environmental Variable, Forest Architecture

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