POLARIMETRIC SAR INTERFEROMETRY FOR FOREST APPLICATIONS AT P-BAND: POTENTIALS AND CHALLENGES

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ABSTRACT

A number of techniques and algorithms for forest parameter estimation from lower frequency (multi-baseline) SAR interferometry (InSAR) and the coherent combination of polarimetry with interferometry (Pol-InSAR) based on the variation of the complex interferometric coherence with baseline and/or polarisation. Examples include forest height and structural retrieval using a two-layer coherent model inversion or Polarisation Coherence Tomography (PCT).

Pol-InSAR techniques for forest parameter retrieval are based on physical modelling of the coherent radar signal scattered from a 3-D vegetation layer. The coherence is then related to the vertical variation of radar backscatter (referred to also as vertical structure function F(z). At low frequencies, there is significant penetration of vegetation and this function varies with vegetation type and density. Hence, the shape and limiting bounds of the structure function F(z) are key parameters that can be related to physical forest parameters. An important special case of the structure function is the exponential profile which, when combined with a Dirac delta function for the surface contribution, forms the basis for two widely used models, the Random-Volume-over-Ground (RVoG) model and the Interferometric Water Cloud (IWC) model. The RVoG model is used to estimate forest height (hv) from the observed complex coherence by inversion of a 2-layer coherent model.

In this paper we discuss the performance Pol-InSAR techniques for forest parameter retrieval at P-band. We investigate both, physical as well as technical challenges.

Differences in the physical interaction at P-band may have to be accounted in the implementation of the algorithms. The vegetation extinction coefficient and penetration depth degreases with decreasing frequency modifying F(z). For volumes that consist of scatterers with different sizes and orientation distributions the differential extinction (i.e. expressing the change of extinction with polarisation) may changes with frequency as a concequence of the change of the effective scatterers. In the case of combined ground and volume scattering in addition to the extinction also the ground scattering amplitude is a function of frequency enforcing the variation of the interferometric coherence with frequency. Finally, fact that the volume scattering elements as well as the ground scattering contribution changes with frequency makes the effect of temporal decorrelation also frequency dependent. In general P-band is characterised by a higher temporal stability than any higher frequency.

On the other side, the International Telecommunication Union (ITU) allocates the system bandwidth at P-band to 6 MHz at 432-438 MHz. We discuss the implication of this limitation with respect to Pol-InSAR forest parameter estimation techniques projected onto the satellite mission system configuration and mission operation scenario. The impact of system parameters (bandwidth and NESZ, SAAR), and operation scenario (temporal baseline and ionospheric effects) is evaluated and a performance analysis with respect to forest parameter estimation is performed and discussed.

The performance analyses is supported and validated by E-SAR Pol-InSAR simulation data and allometric data acquired in the frame of the BioSAR and the Indrex campaign. In order to support the future satellite mission, the E-SAR airborne radar campaigns carried out over the boreal forest in southern Sweden on 2007 and the tropical forest in Indonesia on 2004. These campaign’s data set have been simulated to investigate the impact of system parameters and operation scenario in space.