COMPARISON OF L- AND P-BAND BIOMASS RETRIEVALS BASED ON BACKSCATTER FROM THE BIOSAR CAMPAIGNS

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1. INTRODUCTION

The current interest in radar remote sensing of forests using L- and P-band SAR is very strong. For P-band, the interest is to a large extent driven by the European Space Agency's (ESA's) Candidate Earth Explorer Mission, BIOMASS, which is a P-band Synthetic Aperture Radar (SAR) mission for forest monitoring [1]. For L-band, the fully polarimetric radar system PALSAR now orbits the globe, successfully delivering high quality SAR images of the earth's surface [2]. The need to map properties of forests around the world is high, since forest play an important role in the global carbon cycle, a role which presently is not well understood. In this context ESA has initiated two experiments with the aim to assess whether forest properties (biomass, tree height etc.) can be retrieved from SAR data, with emphasis on P-band data. The experiments, named BioSAR-1 2007 and BioSAR-2 2008, included SAR data acquisitions from two test sites in Sweden. The datasets allow analyses based on radar backscatter, polarimetric measures, polInSAR and tomography. This paper will focus on a comparison between L- and P-band data with respect to biomass retrieval from backscatter intensity. Effects of polarization and topography will be studied, as well as temporal stability of the signals.

2. EXPERIMET DESCRIPTION

The first BioSAR experiment was conducted during the spring 2007, and was a joint collaboration between ESA, the German Aerospace Center (DLR), FOI, Chalmers and SLU. A detailed experiment description can be found in [3]. On three occasions, spanning a period of nearly three months, the Remningstorp test site in southern Sweden was imaged by DLR's Experimental SAR (E-SAR) system. Multiple baselines were flown, allowing both polInSAR and tomography to be performed on the dataset. For P-band, data from a secondary track was collected. This track was chosen so that the forest stands of interest corresponded to steep incidence angles, simulating the geometry of a space borne system. *In-situ* data were available from several datasets, collected and updated during the period 2004-2007. A 4 km by 1 km large area was mapped by high density (~30 pulses/m^2) lidar data, using the laser scanning system TopEye S/N 425 mounted on a SE-JFT helicopter. The lidar data was combined with *in-situ* data to create a biomass map of the area covered by lidar data.

In the second experiment, carried out during the fall 2008, the Krycklan test site in northern Sweden was imaged by the E-SAR system. This test site is undulating, in contrast to Remningstorp which is fairly flat. For BioSAR-2 experiment all data were collected during a period of one week. P-, L- and X-band data were collected. To be able to study effect of ground topography, several tracks with different headings were flown. During the fall 2008 more than 30 forest stands, all larger than 0.5 ha, where inventoried in the field. An additional *in-situ* dataset, consisting of a systematic grid on measurement plots, was also collected during the second half of 2008. A large part of the test site was covered by lidar data with a pulse density slightly less than for the corresponding data from 2007.

3. METHODS

Backscattering coefficients in gamma-naught format were extracted for a set of forest stands. Biomass as well as other properties (tree height, ground slope, tree species etc.) was estimated for each stand using *in-situ* and/or lidar data. The relationship between biomass and backscatter was then investigated by means of statistical regression analysis. Semi empirical or empirical regression models were used and the performance of biomass estimation using different frequencies and polarizations were investigated. Emphasis is placed on the comparison between L- and P-band, and on the effect of ground topography. For the study of topographic effects data from the Krycklan test site is the most suitable, since this area has significant topographic variations and SAR data have been collected from multiple headings. The Remningstorp test site is fairly flat.

4. RESULTS

Preliminary results from the BioSAR-1 campaign show that both cross polarized (HV) and HH-polarized data are dependent on biomass for both L- and P-band. For L-band it was found that a nonlinear water cloud model (WCM) was suitable to describe the relation between backscatter and biomass. The backscatter saturated for high biomass values. For HV the adjusted coefficient of determination (R^2) was found to be between 0.47 and 0.65, where the highest values were obtained for data from May 2, 2007 and the lowest for data collected March 9, 2007. The corresponding values for HH were between 0.36 – 0.57. For P-band, the signal did not saturate over the range of measured biomasses, and a linear regression model could be used. R^2 was found to be 0.63-0.65 for HV and 0.64-0.68 for HH. In the full paper, the results will be further analyzed, and biomass retrieval algorithms will be tested and evaluated. Results from the BioSAR-2 campaign will also be presented. The effect on biomass retrieval of additional variables will be studied and of special interest is the effect of topography. This will be analyzed using data from BioSAR-2, since the Krycklan test site is more topographic then Remningstorp, and several headings were flown in the second campaign. The results will be discussed, and conclusions will be drawn regarding the performance of biomass estimation algorithms using L- and P-band SAR backscatter.

5. REFERECES

[1] P. Cliddhold (ed.), *ESA SP-1313/2 Candidate Earth Explorer Core Missions- Reports for Assessment: BIOMASS*, ESA Communications Production Office, Noordwijk, Netherlands, 2008.

[2] A. Rosenqvist, M. Shimada, N. Ito and M. Watanabe, "ALOS PALSAR: A pathfinder Mission for Global-Scale Monitoring of the Environment," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 45, pp. 3307-3316, 2007.

[3] I. Hajnsek, R. Scheiber, L. Ulander, A. Gustavsson, G. Sandberg, S. Tebaldini, et. al. *BIOSAR 2007 Technical Assistance for the Development of Airborne SAR and Geophysical Measurements during the BioSAR 2007 Experiment: Final Report without Synthesis,* European Space Agency, 2008.