Topographic effects in P-band polarimetric SAR of boreal forests

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Forestry is a major land application of satellite remote sensing. Optical satellites are still dominating but synthetic aperture radar (SAR) is emerging with several promising concepts. One of the more promising is based on low radar frequencies to provide penetration through the canopy and scattering from the larger structural elements. The BIOMASS mission [1], which was recently selected as the European Space Agency's seventh Earth Explorer, is based on this concept. The instrument is a P-band (435 MHz) polarimetric SAR and one primary objective is to produce global maps of above-ground dry biomass on a 200 m grid with an RMSE of 20%.

Early approaches of estimating biomass from P-band SAR data often used HV-polarisation, which showed highest dynamic range and best linear regression results. However, it has been observed that single-polarisation estimates generally have limited accuracy due to effects of varying structure, ground topography and moisture conditions. For example, "double-bounce" scattering between the ground and tree structural elements becomes prominent at lower radar frequencies. This effect can be observed in multiple images from different aspect angles in topographic areas. It is strongest in high-resolution HH data where the backscatter from tree trunks on sloping ground changes significantly with aspect angle. A physical-optics model has been developed and used to predict the influence of topography on HH P-band backscatter [2].

Mutiple polarisations provide significantly improved results, in particular when combined with a digital elevation model (DEM) of the ground surface. Different approaches have been used to select training and validation data. For a global mission like BIOMASS, it is important to develop estimation algorithms which can be used for broad forest classes. Training and validation data should be strictly separated, and both should be collected to represent a broad range of expected conditions (biome, structure, topography, moisture). A recent study separated training and validation data by more than 700 km. Up to four observables where used in linear regression models to estimate model parameters in one area and validate the model in the other area. A single polarization model gave a RMSE of 84%, three polarisations gave 38%, and three polarisations together with ground slope gave 24%.

In this paper, we present new results based on an airborne SAR experiment conducted in 2010. The experiment was designed to include three flight headings, i.e. 178°, 199° and 270°, in order to study the effect of topography for different aspect angles. The topography in the test area is generally small with ground elevation varying between 120 m and 145 m above sea level. However, the ground slope can locally be rather large. Results show that there is only a small difference between the SAR images for headings 178° and 199°. Significant differences occur for heading 270°, however, which clearly can be related to the ground slope effect. Perhaps most surprising is that significant topographic effects are also present in the VH-polarised data.

References

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