Tomographic measurements of boreal forest with Synthetic Aperture Radar

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INTRODUCTION

Polarimetric interferometry [1] is an innovative Synthetic Aperture Radar (SAR) imaging and image processing technique, which provides new information about the target and opens up new application areas. The polarimetric interferometry provides means to measure the relative height of a scattering centre at different polarizations. In combination with scattering models, it can provide eg. 3D information about vegetation and enables certain types of tomographic imaging.

In this work we give a short overview of a technique called Polarization Coherence Tomography (PCT) [2]. The PCT allows estimation of the vertical scattering function of the forest canopy. We show how the PCT results can be improved with ancillary forest height measurements provided by HUTSCAT scatterometer or LIDAR.

MATERIAL AND METHODS

The SAR data used in our study was collected during the FINSAR campaign [3], carried out in autumn 2003 in Finland over a boreal forest test site. The main instruments of the campaign were E-SAR and HUTSCAT ranging scatterometer. German E-SAR collected five L-band (1.3 GHz) repeat pass fully polarimetric images (5 m, 10 m, 12 m and 0 m baselines) and an X-band (9.6 GHz) single-pass single-pol (VV) interferometric image pair. The LIDAR scanning over part of the FINSAR test site was conducted by Finnish Geodetic Institute on 12 July 2005 using Optech ALTM 3100 scanner, providing 3-4 pts/m^2 point density on the object. Accurate Digital Surface Model (DSM) and the canopy height model (CHM) were derived from LIDAR measurement [4].

The PCT method estimates the vertical scattering function inside the media by using Fourier-Legendre polynomial expansion, when interferometric coherence on boundaries and media properties are known. In case of forest the calculation requires additionally for coherence value good estimates for ground phase and tree height. Usually these values are received by Random Volume over Ground (RVoG) model inversion [1] for the same SAR data. However, this approach is susceptible for propagating errors as the same interferometric SAR image is used both for initialization and calculation of the tomogram. The RVoG model inversion requires also fully polarimetric interferometric SAR measurement, which is not necessary for PCT.

In our study we derive ground phase and tree height initial values from an independent source, namely from LIDAR and HUTSCAT measurements. We show that this gives more stabile tomographic profiles and allows the use of the PCT also for single polarization SAR interferometry, when the RVoG inversion is not feasible.

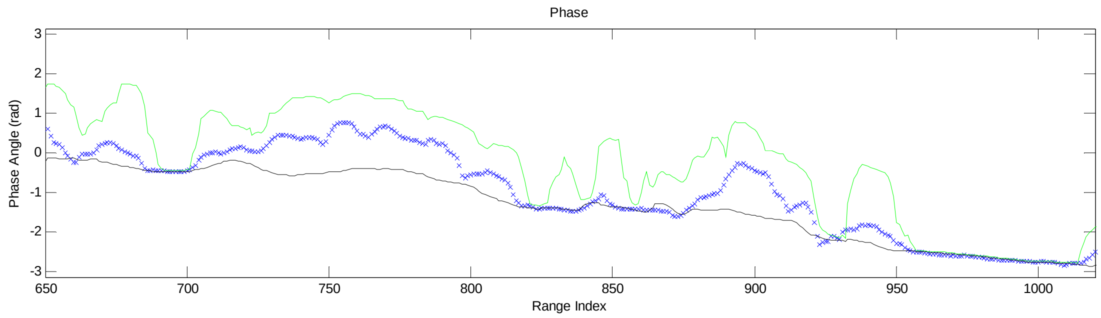

Figure 1: The vertical height of X-band scattering centre phase (blue crosses) and estimates for LIDAR derived ground phase (black line) and treetop phase (green line).

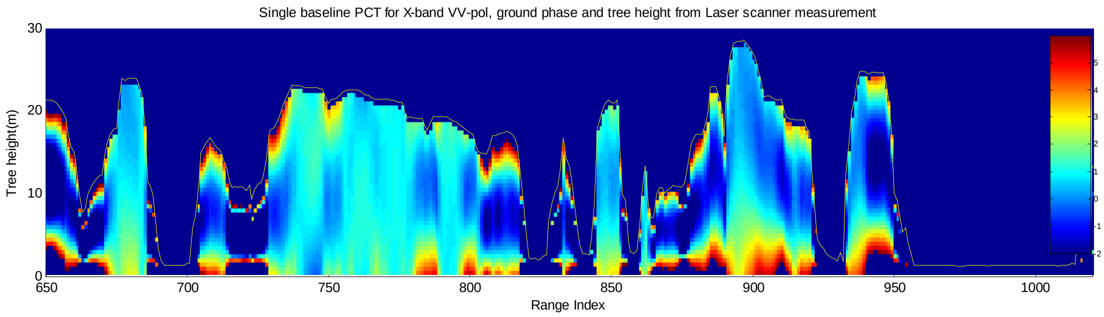

Figure 2: PCT profile for single baseline X-band VV polarization measurement formed with the help of LIDAR measurement. Colors scale on the right; blue – weak and red – strong reflection. X-axis denotes the SAR range index and y-axis is the tree height.

RESULTS AND CONCLUSIONS

Figure 1 shows the vertical height of the X-band scattering centre phase along a forest transect with respect to LIDAR derived ground and treetop phase. Figure 2 shows a coherence tomogram of the forest transect, formed with the help of LIDAR measurements. Without LIDAR measurements the tomogram calculation would not be possible. Different forest types appear correctly as different vertical scattering profiles. In sparse forest (Figure 1, on the right) scattering has high values on the ground, whereas in dense forest the scattering function is more steady throughout the forest canopy.

The LIDAR and HUTSCAT measurements contain much less noise in tree height measurement than the estimates given by the RVoG model inversion. Therefore, use of these measurements as initial values for PCT yields significantly less noisy tomographic scattering profiles for forest. Use of ancillary measurements allows to application of the PCT method also to single-polarized interferometry, when tree height and ground phase initial values cannot be derived by the RVoG model inversion.

References

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