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Comparing helicopter-borne profiling radar with airborne laser scanner data for forest structure estimation.

Livia Piermattei (1), Markus Hollaus (1), Norbert Pfeifer (1), Yuwei Chen (2), Mika Karjalainen (2), Teemu Hakala (2), Juha Hyyppä (2), and Wolfgang Wagner (1)

(1) Department of Geodesy and Geoinformation, TU Wien, Austria (livia.piermattei@geo.tuwien.ac.at), (2) Department of Remote Sensing and photogrammetry, Geospatial Reserach Institute FGI, the National Land Survey of Finland, Finland

Forests are complex ecosystems that show substantial variation with respect to climate, management regime, stand history, disturbance, and needs of local communities. The dynamic processes of growth and disturbance are reflected in the structural components of forests that include the canopy vertical structure and geometry (e.g. size, height, and form), tree position and species diversity. Current remote-sensing systems to measure forest structural attributes include passive optical sensors and active sensors. The technological capabilities of active remote sensing like the ability to penetrate the vegetation and provide information about its vertical structure has promoted an extensive use of LiDAR (Light Detection And Ranging) and radar (RAdio Detection And Ranging) system over the last 20 years. LiDAR measurements from aircraft (airborne laser scanning, ALS) currently represents the primary data source for three-dimensional information on forest vertical structure. Contrary, despite the potential of radar remote sensing, their use is not yet established in forest monitoring. In order to better understand the interaction of pulsed radar with the forest canopy, and to increase the feasibility of this system, the Finnish Geospatial Research Institute has developed a helicopter-borne profiling radar system, called TomoRadar. TomoRadar is capable of recording a canopy-penetrating profile of forests. To georeference the radar measurements the system was equipped with a global navigation satellite system and an inertial measurement unit with a centimeter level accuracy of the flight trajectory. The TomoRadar operates at Ku-band, (wave lengths $\lambda \sim 1.5$cm) with two separated parabolic antennas providing co- and cross-polarization modes. The purpose of this work is to investigate the capability of the TomoRadar system, for estimating the forest vertical profile, terrain topography and tree height. We analysed 600 m TomoRadar crosspolarized (i.e. horizontal – vertical) profile, acquired in October 2016 over a boreal test site in Evo, Finland. The intensity of the reflected backscatter energy was used to measure the height canopy distribution within an individual footprint. As the intensity of the backscatter energy from the ground is exceeding the intensity from vegetation, the estimation of canopy height and the forest structure were based on i) a threshold between canopy and ground and ii) a peak analysis of the backscattering profile. ALS data collected simultaneously was used to validate the TomoRadar results (i.e. canopy height) and to obtain elevation ground truth. The first results show a high agreement between ALS and TomoRadar derived canopy heights. The derived knowledge about the energy distribution within the canopy height profile leads to an increased understanding of the interactions between the radar signal and the forest canopy and will support optimization of future radar systems with respect to forest structure observation.