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Spatializing national forest inventories in mountainous terrain by use of airborne laser scanner data

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Traditionally, national forest inventories (NFI) combine field measurements collected at selected sampling locations to provide statistical measures at the regional to national level. For example, for the Austrian NFI, samples are collected at regular time intervals over a 3.89 km spaced grid. The statistical measures obtained in this way are therefore only representative for relatively large areas and might loose their viability when employed at a local scale for smaller administrative units. This might particularly be the case in mountainous terrain where due to topography heterogeneity of stands is rule rather than exception. Mapping such small scale variations requires downscaling techniques based on spatially distributed information sources such as remote sensing imagery or aerial photographs.

Airborne laser scanning (ALS) is one of the most promising techniques for area-wide mapping of NFI attributes. Due to the fact that ALS data provides information about the horizontal and vertical structure of the canopy, a quantitative assessment of forest parameters such as tree height and stem volume is possible. While ALS is already operationally deployed for large-area forest inventories in Scandinavian countries, its application in alpine regions is lacking behind due to technological challenges of ALS

operations in such environments, the complicated data processing involved, and the required robustness of estimation algorithms.

The objective of this presentation is to evaluate the performance of an empirical approach for ALS-based mapping of stem volume, when applied to a large mountainous area. The study area covers the entire Vorarlberg province of Austria, which comprises around 97.000 ha of forest. The ALS data were acquired in the framework of a commercial district-wide terrain mapping project and were acquired during several winter- and summer flight-campaigns. Laser point density varied between 1 and 4 points/m^2 while pre-processing of the ALS data was performed with state-of-the-art methods and commercially available software packages. The empirical model describes stem volume as a linear function of canopy volume, which is defined by the volume between the terrain surface and the canopy surface derived from the first-echo laser hits. In a first step, the stem volume model was calibrated with Austrian NFI data of Vorarlberg independent of tree species. This provided an R^2 of 0.79 and a relative standard deviation (rSD) of residuals derived from cross-validation of 30.2%. Calibrating the model separately for conifer dominated sample plots further increased the achieved accuracies (R^2 = 0.83; rSD = 27.4%). Based on the calibrated model a stem volume map is generated for the entire province. This product will be validated with independent inventory data of the forest administration Stand Montafon Forstfonds.

The presented work is part of the project “Downscaling of forest inventory data by means of airborne laser scanning methods”, financed by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. As all involved data sources are in operational use, it is ensured that the results obtained in this study are relevant for forest and environment policy and practical applications.