Boreal forest biomass classification with TanDEM-X standard DEM acquisitions

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Boreal forests contain 1/3 of the Earth's forest biomass. Due to their vastness and remoteness, satellite imagery is needed for global boreal forest biomass monitoring. The main existing Remote Sensing data are based on optical systems which are limited to qualitative classifications and generally result in an insufficient number of forest classes (Forest/Non Forest). In the SIBERIA project, a radar approach, based on ERS/JERS backscattering and ERS interferometric coherence, was used to generate a land cover classification with three forest biomass classes (sensitive up to 81 Mg/ha) showing the potential of synthetic aperture radar (SAR) to map boreal forest biomass. Now, the TanDEM-X (TDX) mission offers again interferometric coherence measurements. X-band interferometric coherence is sensitive to forest structure and can therefore be used to improve boreal forest biomass classifications. The TDX mission provides a global coverage in the operational DEM in one polarization (HH). Forest height can be estimated from the interferometric coherence (using the Random Volume over Ground model (RVoG)). The interferometric coherence, in case of TDX comprises two main decorrelation contributions, volume and noise decorrelations. Noise decorrelation is calculated from the antenna pattern and corrected from the data. Thus, volume coherence can be assumed to be the only contribution to the interferometric coherence and forest height can be directly estimated from it. With one polarization only a simplified height estimation is possible assuming an exponential backscattering function with a constant shape factor. A performance analysis will show the impact of this assumption on the biomass classification. The possibility of using a second baseline is also analyzed. An extra baseline allows the estimation of the volume shape factor, improving the estimation sensitivity and the number of biomass classes. Effects in the estimation of the volume shape factor when combining DEM acquisitions from summer and winter need to be considered. Forest biomass is estimated from forest height using a height-to-biomass allometric equation. The accuracy of the allometric function is highest for forests characterized by homogenous structural conditions, like in the boreal region, but it is reduced for forests with highly diverse structures, or forests under disturbances. The impact of the allometry in the biomass classification performance is also analyzed. Two test-sites are evaluated here: Krycklan in middle Sweden, and Remningstorp in southern Sweden. High resolution LiDAR data (2007) and the European thematic classification CORINE are used to validate the biomass classification results. At the time of this study two bistatic acquisitions acquired in the standard DEM mode, in winter, and two experimental acquisitions, in summer, were available. Further work with only standard DEM acquisitions will be done once these data are available. The boreal forest biomass classification obtained from TDX shows a good agreement with the validation biomass maps. Height estimation is the critical step in the biomass estimation with a correlation factor of 84% in Krycklan and 77% in Remningstorp and a standard deviation below 10%. A performance analysis accounting for both sources of deviation (height and allometry induced errors) shows with a 95% confidence interval an optimum number of 4 biomass classes for a single baseline case and of 5 for the dual baseline. In our test sites the defined classes for the single baseline were the following: 150 Mg/ha; and for the dual baseline: 250 Mg/ha. Longer baselines are more sensitive to biomass than shorter baselines, but if the baseline is too long saturation effects will appear. Finally, it will be shown that TDX boreal biomass classification maps can improve thematic mapping in forested areas, like CORINE, and are able to discriminate between different biomass levels within defined CORINE classes.