BOREAL FOREST BIOMASS CLASSIFICATION WITH TANDEM-X

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Boreal forests contain roughly 1/3 of the total Earth's forest biomass. Due to the vastness and remoteness of this area, satellite imagery is needed to extend and update boreal forest biomass data. 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 (mainly distinguishing between Forest and Non Forest). Quantitative classifications of the boreal forest biomass are necessary to estimate global carbon rates and dynamics. In the SIBERIA project [1], 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 structures and therefore can be used to improve and extend boreal forest biomass classifications. The TDX mission provides a global acquisition in the operational DEM generation mode covering the entire boreal region, although only in one polarization (HH) [2].

Forest height can be estimated from the interferometric coherence (using the Random Volume over Ground model (RVoG)) [3]. The interferometric coherence, in case of TDX comprises two main decorrelation contributions, volume and noise decorrelations (in the operational bistatic mode the temporal decorrelation can be assumed equal to 1) [2]. 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 under the assumption of an exponential backscattering function with a constant shape factor. A performance analysis will show the impact of this assumption on the biomass classification.

Forest biomass is estimated from forest height using a height-to-biomass allometric equation. The accuracy of the allometric function is maximum for forests characterized by homogenous structural conditions, like in the boreal region, but it is reduced for forests with highly diverse structures, or forests affected by disturbances. The impact of the height-to-biomass allometry accuracy in the biomass classification performance will be also analyzed.

Two test-sites have been evaluated in this study: Krycklan located in middle Sweden, a boreal forest site with a hilly topography; and Remningstorp in southern Sweden, a hemi-boreal forest over a rather flat terrain. High resolution LiDAR data, acquired in 2007 over these sites, are used to validate the biomass

classification results and the European thematic classification CORINE is used to illustrate the potential of biomass classifications for the improvement of existing thematic classifications.

The boreal forest biomass classification obtained from TDX DEM standard acquisition data shows a good agreement with the validation biomass maps. A performance analysis accounting for both sources of deviation (height and allometry induced errors) shows an optimum number of 4 biomass classes with a confidence interval of 95%. In our test sites the defined four biomass classes result in the following ranges: <10, 10-50, 50-150, >150 Mg/ha. The height estimation accuracy lies within a range of +/- 10% and a shows correlation factor of 70%, allowing biomass estimations within a range of +/- 25% and a correlation of 54%. Finally, it will be shown that the obtained biomass classification maps can improve thematic mapping in forested areas, like CORINE, and is able to discriminate between different biomass levels within defined CORINE classes in the boreal forests.

The improvement of the biomass classification after combining acquisitions with different baseline configurations (more and narrower biomass classes) and the influence of seasonality in the classification performance will be discussed.

[1] W. Wagner et al., “Large-scale mapping of boreal forest in SIBERIA using ERS tandem coherence and JERS backscatter data”, Remote Sensing of Environment, vol. 85, pp. 125-144, 2003.

[2] G. Krieger, A. Moreira, H. Fiedler, I. Hajnsek, M. Werner, M. Younis, and M. Zink, “TanDEM-X: A Satellite Formation for High-Resolution SAR Interferometry”, IEEE Transactions on Geoscience and Remote Sensing, vol. 45, no. 11, pp. 3317- 3341, 2007.

[3] K. P. Papathanassiou, and S. R. Cloude, ‘‘Single-baseline Polarimetric SAR Interferometry’’, IEEE Transactions on Geoscience and Remote Sensing, vol. 39, no. 11, pp. 2352-2363, 2001.