Using airborne LiDAR and Landsat data to derive biomass at regional scale in the Canadian northern boreal forest

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Abstract

Aboveground biomass information of the northern boreal forests of Canada is required to report on the state of Canada's forests. This information need is being partly met through the recent completion of a satellite land cover map over the forested areas of Canada, an initiative of the Earth Observation for Sustainable Development of Forests (EOSD) project supported by the Canadian Space Agency. Within the EOSD framework, a biomass mapping strategy based on the integration of field and multi-sensor / multi-resolution satellite data has been developed. It includes a biomass mapping method that has been tested successfully for coniferous forests over three northern pilot regions. This method estimates biomass using optical high spatial resolution imagery (HSRI), such as QuickBird, providing surrogate sampling plots (SSP) to compensate for the lack of forest inventories. HSRI-derived SSP are subsequently scaled across a Landsat mosaic using the kNN algorithm for regional mapping purposes. However, HSRI shows significant spectral limitations to estimate biomass for all northern boreal cover types as well as sampling design issues for large-scale implementation.

In this paper, we consider profiling airborne lidar data as a newer and viable alternative to HSRI data due to the strong potential to estimate biomass operationally for a wide variety of cover types over long stretches of northern boreal forests. We describe a lidar-based biomass mapping method and present preliminary results obtained over a northern pilot region in Quebec. This region is covered by a normalized mosaic of 11 Landsat scenes and includes hundreds of ground sampling plots (GSP). We used the portion of the NASA PALS (Portable Airborne Lidar System) data set crossing the pilot region, made of four long transects containing over 4 million PALS lidar pulses acquired at a nominal post spacing of 0.25 m. The PALS data set was acquired in 2005 within the NASA Québec Carbon Lidar Project (QCLP).

First, biomass is derived from PALS transect data to provide SSP. Quadratic mean height (QMH) is extracted from PALS data within contiguous 30m cells along the PALS transects. Biomass is estimated across these cells using QMH as a predictor of biomass through regression equations developed using GSP within the QCLP project. Few hundreds of these 30m biomass cells are used in a sampling process to generate SSP. Second, lidar-derived SSP are scaled across the normalized mosaic of Landsat TM/ETM data using the kNN algorithm used operationally for inventory applications in Sweden and Finland. Finally error estimates (bias and RMSE) are obtained through cross-validation using SSP or directly from GSP.

We present preliminary results mainly for the dominating coniferous black spruce forests. At local level, good estimates of biomass were achieved using PALS data with R^2 up to 60 % and RMSE down to 14.2 t/ha depending on the QMH-biomass equation used. At regional level, R^2 better than 50% and RMSE around 25-30 t/ha were obtained using kNN algorithm driven by

lidar-derived SSP. Errors were slightly higher than using the HRSI-based method but were still satisfactory towards implementation. We also present the potential of the lidar-based method in deciduous and mixed stands. Finally we discuss the overall merits and drawbacks of the lidar-based vs the HRSI-based methods, as well as perspectives for large-scale implementation.