|  |
| --- |
| **Estimation of tree cover extent using ICESat-2 spaceborne lidar data** |
| **Introduction/Aim:**    The boreal forest biome is experiencing a northward shift and structural changes due to climate change. Spaceborne lidar systems are suitable for estimating these changes in the biome as they have global coverage and high temporal resolution, while simultaneously providing information on the vertical structure of the canopy. In this research, our objective was to estimate the boreal tree cover extent using ICESat-2 spaceborne lidar data. The Food and Agriculture Organization of the United Nations (FAO) defines forest, among other criteria, based on the area’s land use class. Since land use is not determinable solely via remote sensing, tree cover extent is estimated instead of forest area. An area with tree cover is defined in this study as an area having canopy cover of at least 10% and dominant height of at least 5 meters.  **Methods:**  The study was conducted in two study areas in Finland: Pello and Valtimo. The main tree species were Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*) and birches (*Betula spp.*). This study utilized field plots with canopy cover and dominant height measurements, wall-to-wall airborne laser scanning (ALS) data, and ICESat-2 data (ATL03 and ATL08 products). The field plots and ALS data were used to build models for predicting canopy cover and dominant height on the ICESat-2 locations. These attributes were then used with ICESat-2 derived height metrics to train tree cover classifiers for ICESat-2 data.  The tree cover was predicted with two methods: logistic regression and prediction-based classification. In logistic regression, the area was classified as having tree cover if the class probability was 50% or over. In prediction-based classification, the canopy cover and dominant height were predicted first. If the predicted canopy cover was over 10% and the predicted dominant height was over 5 m, the area was classified as having tree cover. The constructed models were cross-validated by applying models constructed in Pello in Valtimo and vice versa.  **Results:**  This study yielded promising results with tree cover prediction accuracies varying between 89.8–95.6% (validation 88.1–95.8%) with logistic regression and between 89.5–95.4% (validation 89.6–95.4%) with prediction-based classification. The F1-scores of logistic regression and prediction-based classification were between 0.93–0.97 (validation 0.92–0.98) and 0.93–0.97 (validation 0.93–0.97), respectively. The canopy cover models had relative root mean square error (rRMSE) values ranging between 29.5–60.1%, and the dominant height models had rRMSE values between 19.1–41.0%. The performance of the models was highly dependent on the quality of the ICESat-2 data. The accuracy was consistently lower in Pello compared to Valtimo, where the ICESat-2 data was of better quality with less noise. In future research, improved noise filtering methods should be applied to decrease the effect of background noise. |