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Utility of hyperspectral remote sensing data in estimating biomass and structure variables in boreal forest of Finland

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Three-quarters of Finland's land surface area (22.8 million hectares) is filled with forests. The role of remote sensing in large area inventories is crucial. The forests of Finland serve as an important resource for the nation's nature conservation as well as for the forestry industry. Furthermore, forests are significant carbon sinks and play a great role in climate change mitigation. Research on vegetation parameter retrieval is of special relevance in order to extend our knowledge about the vegetation dynamics and terrestrial carbon stocks at regional and global scales.

In future in addition to multispectral satellites, hyperspectral satellite missions will start to provide remote sensing data to support the needs of forestry and other natural resource management practices. We investigated the influence of spectral and spatial resolution of remote sensing data on retrieval of biomass and other forest properties. The study contributed to better information productivity on forest variables in boreal forest ecosystem.

We used the remote sensing data by Sentinel-2 (10 bands, resolution 10 m) and hyperspectral AISA imager (128 bands, 400–1000 nm, resolution 0.7 m). As reference data, we used new forest resource dataset provided by the Finnish Forest Centre and additional independent in situ measurements. We applied kernel-based regression methods to relate the forest variables of interest with the remotely sensed data. Based on recent studies, we selected Gaussian process regression (GPR) and support vector regression (SVR), which have proven to work well with hyperspectral and multispectral remote sensing data. Regression estimations were performed for stem biomass, basal area, mean height, leaf area index (LAI) and main tree species. The estimation accuracies were examined with absolute and relative root-mean-square errors.

Successful forest variable estimations showed that kernel-based regression algorithms are suitable tools for quantification of forest structure and assessment of its change. The estimation accuracies between the two algorithms were similar. However, the faster SVR algorithm was found to be more practical, especially considering large scale mapping and future near real-time applications. Based on the study results, the additional value of hyperspectral remote sensing data in forest variable estimation in Finnish boreal forest is mainly related to variables with species-specific information, such as main tree species and LAI. The more interesting variables for forestry industry, such as basal area or stem biomass, can also be estimated accurately with more traditional multispectral remote sensing data.