Modeling lidar-derived boreal forest crown cover with SPOT 4 HRVIR data

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Forest crown cover (CC), defined as the proportion of forest floor covered by the vertical projection of the tree crowns, is a commonly used parameter in ecological modeling and it also forms the basis for the international definition of forest. Recent results indicate that airborne scanning lidars can produce accurate estimates for the CC. A simple fraction of lidar pulses that hit the canopy above a specific height limit will produce a level of precision that would otherwise require 30-60 minutes of field work per plot. However, the scan zenith angle must not be too far from vertical, because oblique pulses may overestimate CC as they have larger probability to hit the crowns from the side than the vertical ones.

Airborne lidar data could be too expensive for covering large areas, so in many cases the use of optical satellite images is more efficient. Two-level sampling schemes, where lidar data is combined with field measurements to provide reference data for satellite-based interpretation, are a cost-efficient method for large area inventories. In this study, we calculated the CC for 64 sample plots in Hyytiälä, Finland, directly from the lidar data obtained in July 2007. First echoes closer than 30 m to the plot center were included into the CC calculation. A SPOT 4 HRVIR image with 20 m pixel size was obtained in July 2008. After rectification and atmospheric correction, BRF values were calculated for the plots using average of the nine nearest pixels. Finally, the well known spectral vegetation indices NDVI, SR and RSR were calculated for each plot.

Crown cover was predicted by fitting different single predictor regressions. RSR, which utilizes also the short-wave infrared band in addition to the red and near-infrared bands, provided the smallest absolute standard error: 8.1%. This result was obtained by fitting an exponential curve through the origin using nonlinear regression. The best models obtained with NDVI and SR were clearly worse with standard errors of 13.7% and 15.1%, respectively. The results agree with an earlier study where RSR was found to predict the boreal forest leaf area index with higher precision than the other indices.

In conclusion, the result indicates that boreal forest crown cover can be estimated fairly reliably using a combination of airborne lidar data and medium resolution satellite images. A common situation in CC modeling is that imprecision of the field data weakens the model precision significantly. Our results show that this problem can be largely avoided by using lidar-derived CC instead of quickly made field observations.