Estimating above-ground biomass of tropical rainforest of different degradation levels in Northern Borneo using airborne LiDAR

Abstract

Deforestation and degradation of forests have severely depleted carbon storage in tropical countries, whose forests have the most carbon-rich ecosystems in the world. Estimating above-ground biomass (AGB) with high accuracy is critical to quantifying carbon stocks in the tropics. We propose a model to estimate AGB in the tropical montane forests of northern Borneo with different disturbance histories using airborne LiDAR data. The level of forest degradation was determined from species composition and field-observed AGB. Of 50 sample plots established in forests with various levels of degradation, we categorized 20 as highly degraded (AGB: 52.18-229.11Mg/ha), 16 as moderately degraded (AGB: 136.00-382.59Mg/ha), and 14 as old-growth forest (AGB: 280.31-622.79Mg/ha). Height metrics and laser penetration rate (LP) at specific heights from the ground were derived from vertical point profiles of LiDAR data. After testing the performance of single variables, we used stepwise multiple regressions to select variables to include in the model for AGB estimation. The best model with a single variable used the mean height from the laser returns (R2=0.78, RMSE=65.54Mg/ha). All LP variables were sensitive to AGB (R2>0.60). The final model from stepwise analysis included the mean height of the canopy height model and LP at 7m height (adjusted R2=0.81, RMSE=61.26Mg/ha). The results confirm the suitability of LP variables for estimating AGB. We suggest that airborne LiDAR data can capture AGB variability at fine spatial scales, which correspond to deforestation and forest degradation caused by human activities and natural disturbances.