Area-based vs tree-centric approaches to mapping forest carbon in Southeast Asian forests from airborne laser scanning data

ABSTRACT

Tropical forests are a key component of the global carbon cycle and mapping their carbon density is essential for understanding human influences on climate and for ecosystem-service-based payments for forest protection. Discrete-return airborne laser scanning (ALS) is increasingly recognised as a high-quality technology for mapping tropical forest carbon, because it generates 3D point clouds of forest structure from which aboveground carbon density (ACD) can be estimated. Area-based models are state of the art when it comes to estimating ACD from ALS data, but discard tree-level information contained within the ALS point cloud. This paper compares area-based and tree-centric models for estimating ACD in lowland old-growth forests in Sabah, Malaysia. These forests are challenging to map because of their immense height. We compare the performance of (a) an area-based model developed by Asner and Mascaro (2014), and used primarily in the neotropics hitherto, with (b) a tree centric approach that uses a new algorithm (itcSegment) to locate trees within the ALS canopy height model, measures their heights and crown widths, and calculates biomass from these dimensions. We find that Asner and Mascaro's model needed regional calibration, reflecting the distinctive structure of Southeast Asian forests. We also discover that forest basal area is closely related to canopy gap fraction measured by ALS, and use this finding to refine Asner and Mascaro's model. Finally, we show that our tree-centric approach is less accurate at estimating ACD than the best-performing area-based model (RMSE 18% vs 13%). Tree-centric modelling is appealing because it is based on summing the biomass of individual trees, but until algorithms can detect understory trees reliably and estimate biomass from crown dimensions precisely, areas-based modelling will remain the method of choice.