Terrestrial LiDAR and 3D Reconstruction Models for Large Individual Tree Biomass Estimation in Tropics

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Abstract:

Tropical forest biomass is an important component on estimation of carbon emission in REDD+ context. Nevertheless, calibration and validation of such estimates require accurate an effective methods for in-situ estimation of aboveground biomass – AGB. Current methods to estimate AGB are indirect methods based on allometric relationships from tree parameter. This type of estimation has been reported as major source of uncertainty, especially on tropical trees. Airborne and space-borne sensors have been used for regional-scale estimations. Nevertheless, resolution and accuracy are insufficient to derive detailed AGB estimates and these method have limitations due to closed canopies and high-biomass density, mainly because AGB is a 3D measurement, while most remote sensing datasets are 2D structured.
Terrestrial LiDAR (Light Detection and Ranging) has demonstrated to be more accurate to infer forest AGB in a non-destructive and more direct approach. This method has been applied and validated in an open Eucalyptus in Australia. Nevertheless, application on tropical forest trees still has its challenges, mostly due to occlusion, tree structural complexity and large scale application. We propose a method to estimate AGB from individual tropical trees by estimating tree volume from terrestrial LiDAR point clouds.
Nine plots of 30 x 40 m were scanned with a Riegl VZ-400 terrestrial laser scanner – TLS following a spatial grid covering three study sites (Peru, Indonesia and Guyana). We identified the largest tree per plot, extracted its point cloud and calculated tree wood volume by modelling 3D tree architecture using quantitative structure models (TLS.QSM method). To validate our method, we harvested the scanned trees, took detailed measurements of stems and all branches up to 10cm and reconstructed tree volume as well. Then, tree wood volume was converted to AGB using species-specific wood density values. To compare TLS estimates with present methods, we estimated AGB using the most recent pantropical allometric models.
Results showed that AGB estimates from TLS-QSM method perform better than allometric equations. The RMSE for the proposed method was 2.72 Mg compared to 3.51 Mg from the closest allometric equation. Coefficient of variation of RMSE was also lower 17.22 %, compared to 22.19 % from the closest allometric equation. Bias of our method was the lowest, with 0.86 Mg, compared to the closest value, -1.66 Mg. We conclude that our proposed method is able to estimate AGB of large individual trees in tropical forest more accurately than pantropical allometric models and offers an approach for validation and selection of existing and more accurate allometric equations.