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| **Type the title of your abstract:** Afrotropic and neotropic terrestrial laser scanning data reveal that allometric AGB estimates are likely systematically biased downward by 15.3% |
| **Introduction/Aim:**  Accurate assessment of global forest carbon stocks and changes is necessary for understanding the carbon cycle, and for informing appropriate policy and decision making towards forests, as well as channelling finance to their protection and restoration. Recent research has demonstrated that conventional methods that underpin current assessments, namely allometrics, potentially generated biased estimates, particularly in tropical forests, owing to the skewed distributions of their underlying calibration data. New methods using terrestrial laser scanning have the potential to overcome these issues, by collecting detailed 3D measurements describing entire forest scenes. However, obstructing the widespread adoption of these methods is both accurate and timely segmentation of individual tree point clouds. Here, we developed a three steps tree level AGB estimation pipeline: retrained PointNet++ model enabling woody points separation, unsupervised ML instance segmentation tuned for tropical forest, revised QSMs fitting. We applied these methods to data on thousands of trees acquired from 17 x 1 ha plots across Afrotropical and Neotropical forests. We found that these lidar-derived estimates were approximately 15% larger than allometric counterparts, suggesting that the emissions potential of the world’s tropical forests is substantially different than currently thought.  **Methods:**  The study was conducted using high density Terrestrial Laser Scanner scans from the Peru, Gabon and Belize tropical forests: totalling to 17 ha. Firstly, an improved method for leaves removal has been developed by retraining the PointNet++ model described in Krisanski et al. (2021), with a custom tropical forest training dataset. Improved point cloud labelling method allowed better leaves, coarse wood debris and terrain removal, enabling woody points extraction. Resulting point clouds were segmented using an improved TLS2Trees (Wilkes et al., 2023) version: for each tree a path from its trunk to the branches has been found with the new set of connection rules. The algorithm has been tuned for tropical forest, ensuring tight branch connection, lianas avoidance, clear tree separation in dense canopies scenarios. For each individual tree point cloud, quantitative structural models were constructed to enable tree volume estimation, that tree species density, provided AGB estimates. Automatic segmentation results were compared to the traditional allometric equations estimates.  **Results:**  Semantic segmentation showed loss of 0.193 and accuracy (i.e., fraction of correct classifications) of 0.924 and 0.6691 for leaf and wood classification, respectively. Improved semantic segmentation results enabled more accurate woody points separation. Resulting point clouds were used for instance segmentation showing good results in complex forest scenes when each tree was visually inspected. Taking these segmented trees, and comparing their QSM-derived AGB with allometric counterparts, we found these lidar AGB estimates were approximately 15% greater.  **Conclusion:**    The biggest bottleneck for widespread adoption of terrestrial laser scanning data for forest carbon stock estimation is accurate and timely instance segmentation of individual tree-level point clouds. Supervised machine learning methods are enabling this, and providing new insights into the carbon stored in. Applying the methods we are finding that the tropical forest AGB stock likely requires a significant upward revision. |

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