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Height integration into pantropical tree biomass estimates

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Accurate estimates of above ground dry mass in tropical trees (B) are essential to quantify carbon stocks, determine geographic patterns in B distribution, and compensate for above ground carbon storage and avoided deforestation. Key determinants of individual tree biomass are, in descending order of importance, stem diameter (D), wood density and height (H). Height for a given diameter of tree can vary substantially across regions and zones of transition (ZOTs) where forest and savanna overlap. Even so, pantropical B estimates commonly lack H integration to parameterise estimates to local forest allometric characteristics. Using newly published H:D models from our tree architecture database (Feldpausch et al. Biogeosciences Discussions, 7, 7727-7793, 2010), we provide a pantropical evaluation of the effects of inclusion of H effects on B estimates by geographic region (Plot, Region, Continent and Pantropical) and environment (precipitation and dry season length). Our objective was to determine where and in what manner inclusion of H modifies B estimates. We hypothesised that inclusion of H in B estimates significantly alters estimates relative to estimating B from D and wood density alone, potentially scaling down B estimates in dry, transitional forest ZOTs where trees are generally shorter for a given D. In this study we 1) determined the efficacy of including H in B estimates by comparison with destructive B estimates; 2) examined the percent and absolute deviation caused by the lack of modelled H in estimating B, and where B estimates are most sensitive to inclusion of H (e.g. dry forest ZOTs); 3) quantified regional estimated B stocks based on inclusion of H in B calculations. Height holds an integral role in improving B estimates, its inclusion reducing mean plot-level estimation error from 17% to 1% across all trees, with the improvement reducing plot-level error from 23% to 3% for the largest trees of > 40 cm diameter. Error in estimates varied substantially by region. For example, plot-level B for trees was overestimated by 14% for trees in the Brazilian Shield and 33% for trees in central Africa and only underestimated by 4% for trees in West Africa and 7% in SE Asia, when ignoring height. Inclusion of our region-specific height model on average provided the best estimates of true B. We recomputed plot-level wet to dry ZOT pantropical above ground tree B based on the most recent census of permanent plot data from the RAINFOR, TROBIT, and AfriTRON networks and evaluated regional deviations in B estimates based on H integration. Based on our findings, we recommend that region-specific height models are used to estimate tree height to reduce uncertainty in tropical B estimates. Biomass estimates from some areas that exclude height in B estimates will misrepresent carbon stocks, emissions from deforestation and potential ecosystem services through carbon gain.