Forecasting forest health using models to predict tree canopy height

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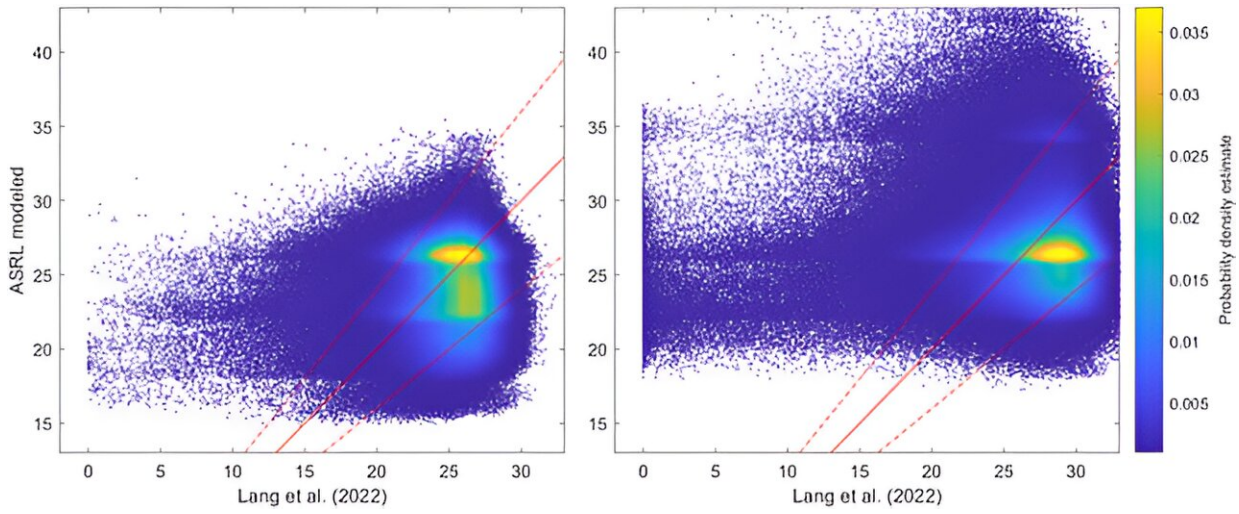

Pixel-by-pixel comparison of ASRL potential tree height and Lang et al. [47] in Ecoregion M212D (left) and the validation region (right). All axes are in meters. Solid lines are the 1:1 line. Dashed lines indicate ±20% deviations. Data point colors indicate estimated kernel density. Credit: *Journal of Remote Sensing* (2023). DOI: 10.34133/remotesensing.0084

Tree height is an important indicator of a forest's maturity and overall health. Forest restoration projects rely on tree height as a predictor and measurement of success, but forecasting a forest's future tree height based on observations alone is almost impossible. Too many factors contribute to the growth and health of trees.

Because so many factors can impact how a tree develops, researchers enhanced a predictive model called the Allometric Scaling and Resource Limitations (ASRL) model and then deployed it using Google Earth Engine, looking at forests in the northeastern United States.

The research is published in the *Journal of Remote Sensing*.

"Potential tree height can reach into the future, seeing a tree's growth over an infinite timeline. Predicting potential tree height is important for future forest development and structure, which is profoundly significant for forest restoration planning and evaluation," said Zhenpeng Zuo, a doctoral student at Boston University in Boston, Massachusetts. "With the advancement in computer simulations of forest processes at various scales, several mechanism-based models for simulating potential height have emerged."

Models that predict potential tree heights factor in known tree growth limitations like the increasing difficulty for trees to lift water (hydraulic constraint), vulnerability to wind damage (mechanical constraint), and ground conditions. This study focuses on the water-balance-based ASRL model. At its most basic, the ASRL model solves for the intersection of three different flow rates, using the tree's potential water demand, water intake, and water dissipation to predict how tall a tree will be.

For this study, researchers tried to improve upon the ASRL model by highlighting forest restoration and deployed it using Google Earth Engine, a geospatial cloud computation platform, to analyze beech-maple-birch forests. This version of the ASRL model not only factored in the flow rates, but also time scale, spatial resolution, and model mechanisms. The model pulled local meteorological datasets for the last ten years (2011 to 2020) to improve predictions and then factored in three allometric measurements: tree height versus stem radius, tree height versus crown height, and tree height versus crown radius.

To show how well the modified ASRL model worked, researchers compared their results with previously reported tree height predictions. There were some cases where the ASRL model overestimated tree height, but researchers attributed most of these over-predictions to very immature forests, which are harder to predict.

Compared with the original version of the ASRL model, the modified version is much more successful at predicting tree height.

"The new version provides more realistic predictions for a particular species group due to improved simulation time scale, more targeted parameterization, and more complete mechanisms, and provides better spatial coverage by using gridded climate reanalysis data. It also does not use the parameter tuning tactics to fit existing tree height observations and therefore retains the prognostic nature of the original model," said Zuo.

In addition to testing the modified ASRL model, researchers reported the results of their findings, which predict that tree height of these beech-maple-birch forests will be negatively impacted by a hotter and less humid climate, which is likely with climate change.

Looking ahead, researchers are hoping to expand the scope of the study area. "We expect to increase the study area from the regional space to the whole contiguous United States, applying the method to more forest types and groups. This work will hopefully result in a data product of species-dependent potential forest heights," said Zuo.

More information: Zhenpeng Zuo et al, Simulating Potential Tree Height for Beech–Maple–Birch Forests in Northeastern United States on Google Earth Engine, *Journal of Remote Sensing* (2023). DOI: 10.34133/remotesensing.0084

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