

Evaluating Remote Sensing-Derived Canopy Height Models for Biomass Estimation in Brazil's Atlantic Forest

Authors: Thomas Harris, Manny Flores, Stephen Kinane, Daniel Piotto, Mark Ashton

July 01, 2025

Specific aims

1

Evaluate the accuracy of four canopy height models (10–1000 m resolution) for AGB estimation in the Atlantic Forest.

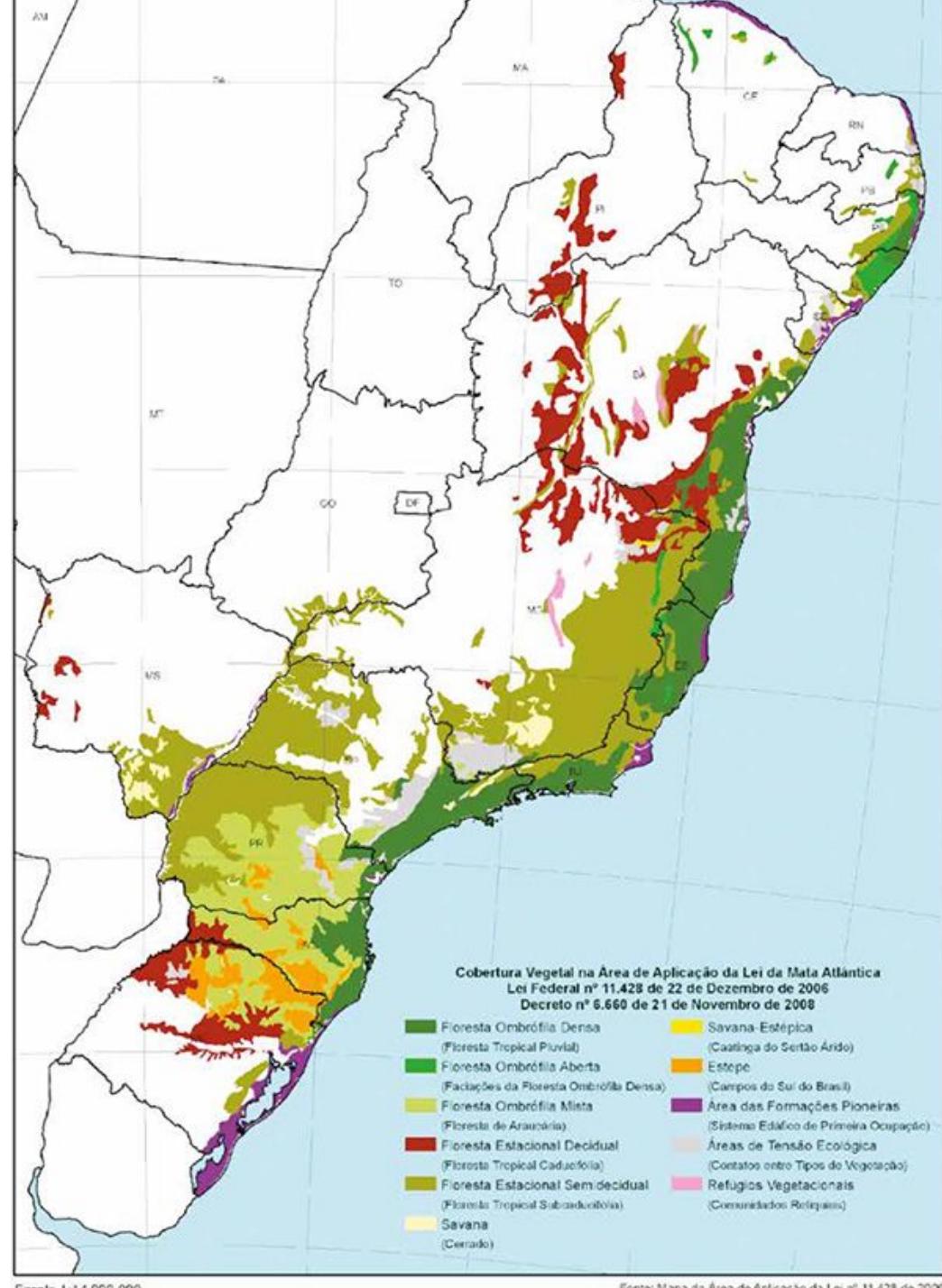
2

Compare 2 input configurations (DBH + height, and canopy height model combinations) to assess their impact on AGB predictions.

Introduction

Mata Atlantica

- Imperiled forest ecosystem in the Atlantic coast of Brazil
- 100,000 km² (7%) remaining
- Forest types:
 - dry forest
 - moist forest
 - mangroves



Global Studies Predicting AGB with Height Alone

scientific **data**

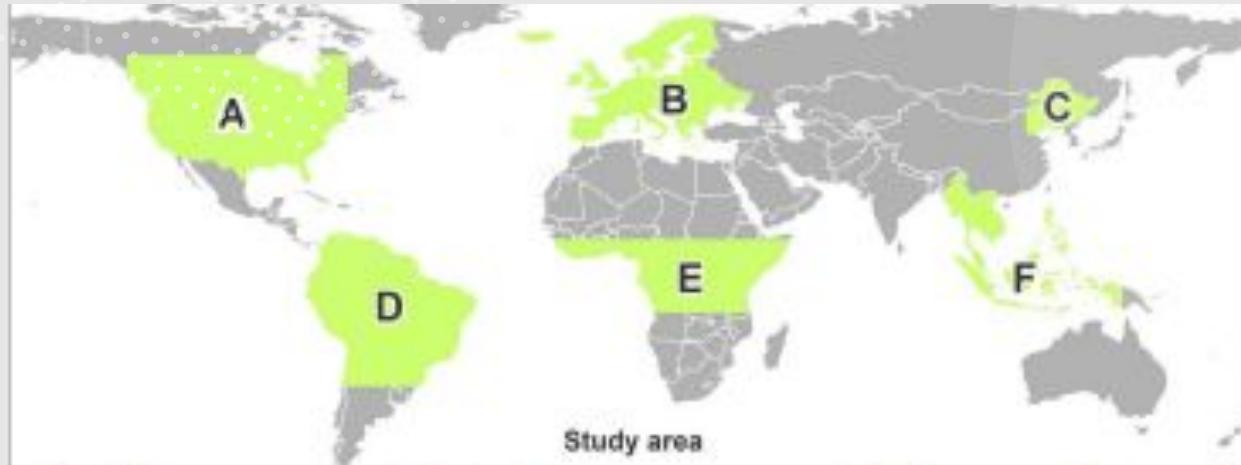
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DATA DESCRIPTOR

A dataset of forest regrowth in globally key deforestation regions

Jinlong Zang^{1,2,3,4}, Feng Qiu⁵, Yongguang Zhang^{1,2,3,4}, Rong Shang⁶
& Yunjian Liang⁶

Check for updates



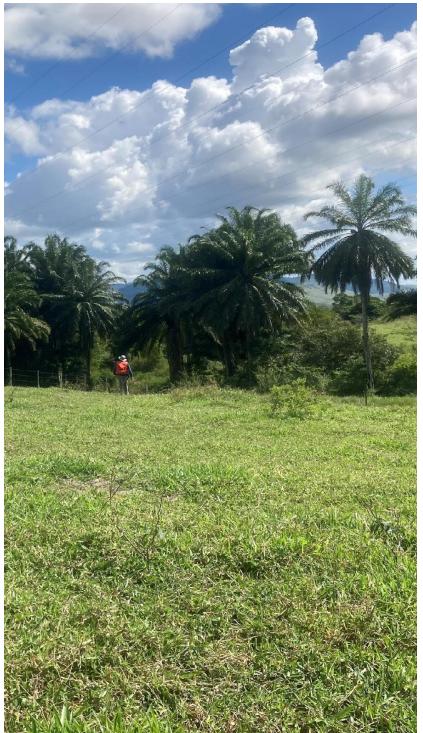
Region	Dominant forest type	Height (H) to AGB (Mg/900m ²) conversion	R ²	RMSE (Mg/ha)
Africa	Broadleaf evergreen	$AGB = 0.0251H^{2.12}$	0.80	—
Europe	Boreal (west)	$AGB = 0.3538H^{1.2103}$	0.84	18.5
North America	Deciduous	$AGB = 0.018H^{2.3}$	0.61	44.6
Northeast China	Boreal (east)	$AGB = 0.018H^{2.2194}$	0.39	19.1
South America	Broadleaf evergreen (Central Amazon)	$AGB = 0.2221H^{1.4706}$	0.74	—
Southeast Asia	Broadleaf evergreen	$AGB = 0.0194H^{2.1604}$	0.58	—

Zang, J., Qiu, F., Zhang, Y. et al. A dataset of forest regrowth in globally key deforestation regions. *Sci Data* **12**, 154 (2025).

Land use decisions



Secondary Forest Stand Dynamics

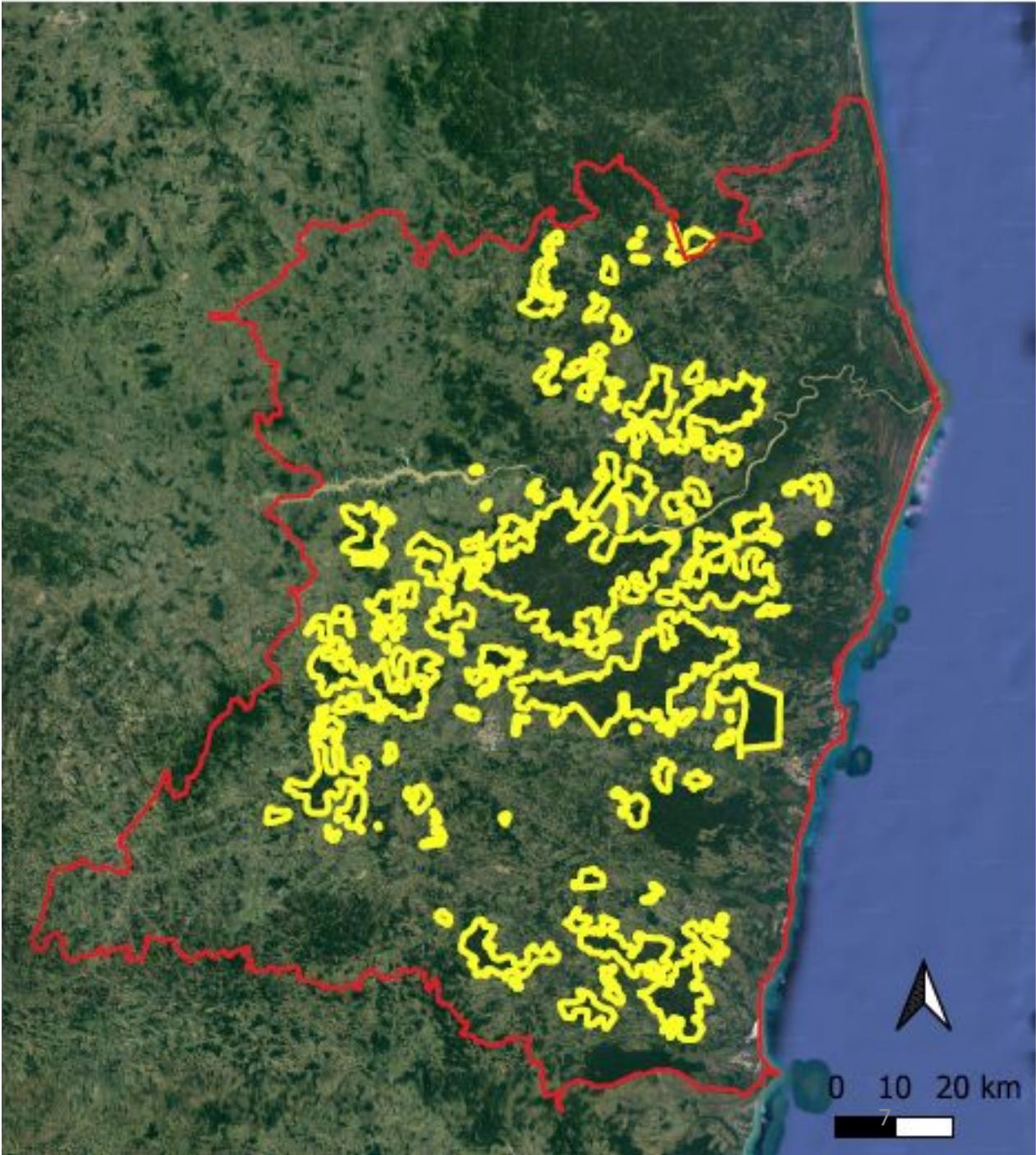


Methods | Study Site

- 11 municipality region in southern Bahia, Brazil
- 1,500,000 ha total area
 - 33% moist rainforest
 - 46% pasture
 - 6% planted forest
 - 15% other
- 207,000 ha managed area (14%)
 - 83,000 ha eucalyptus
 - 93,000 ha second growth forest

(Fibria Celulose S.A. 2022,
Stora Enso 2024)

VERACEL

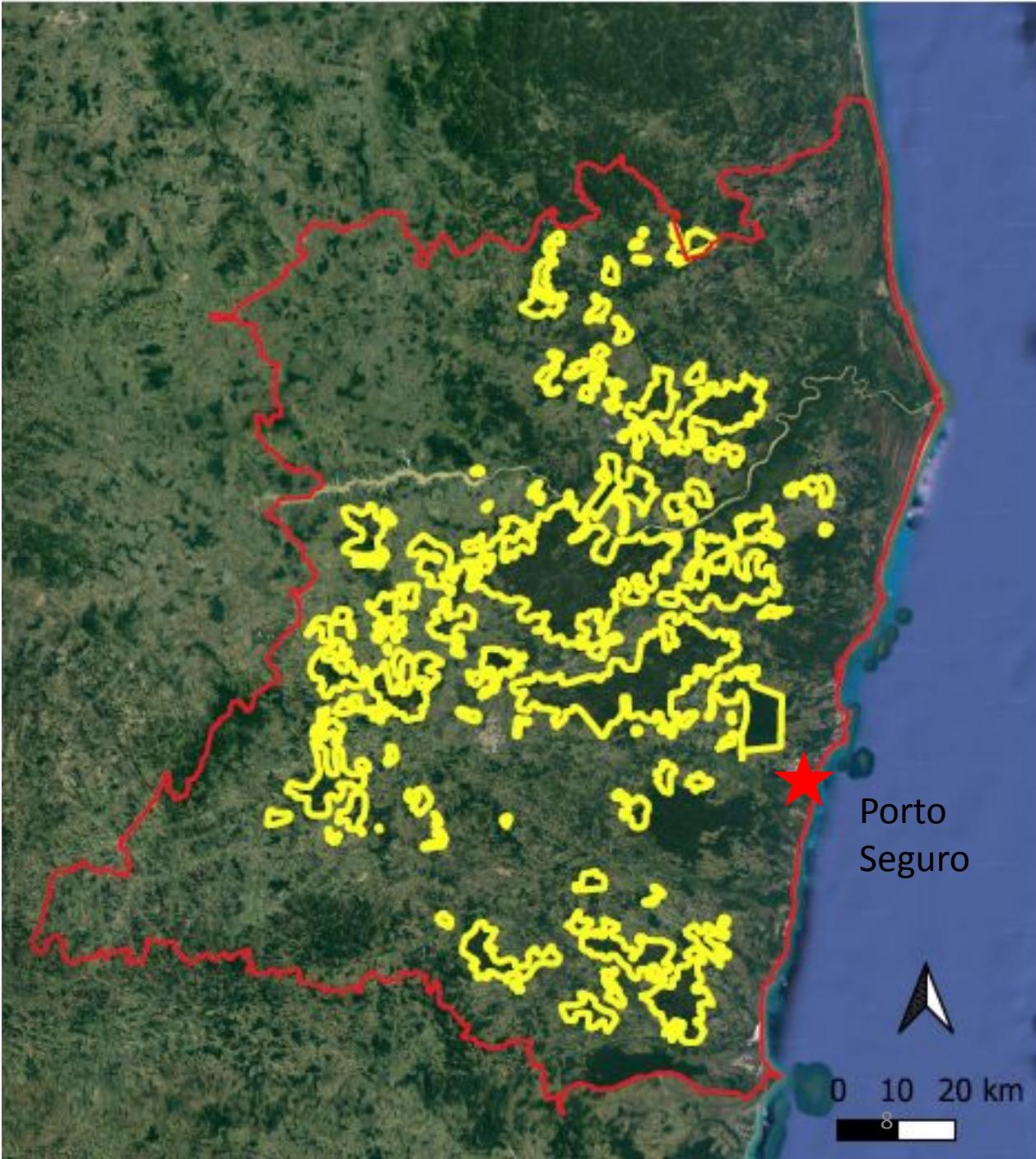


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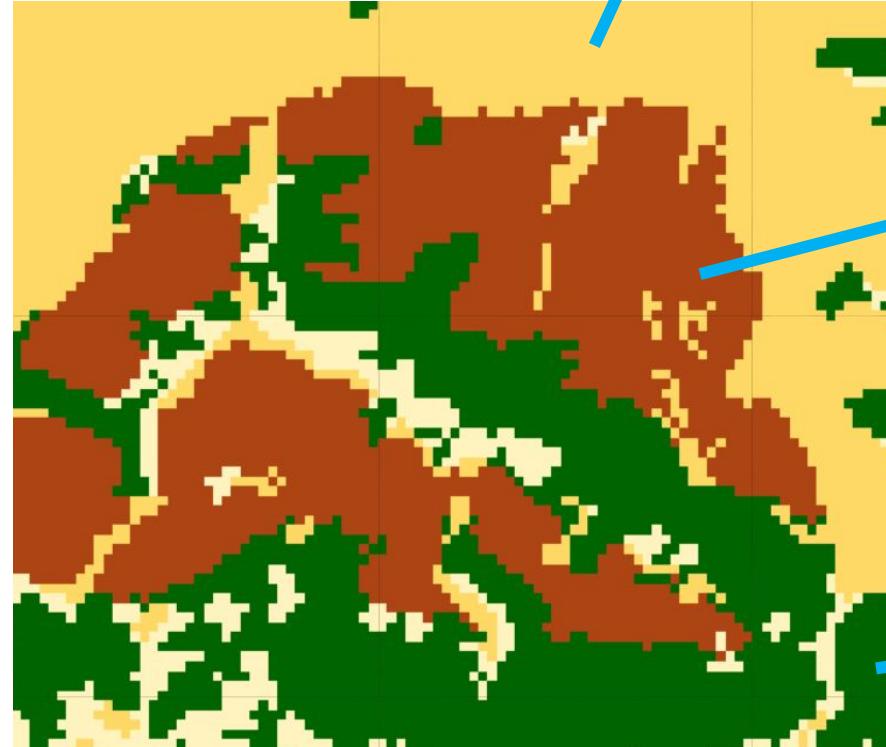
(Fibria Celulose S.A. 2022,
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Methods | Land Cover Data

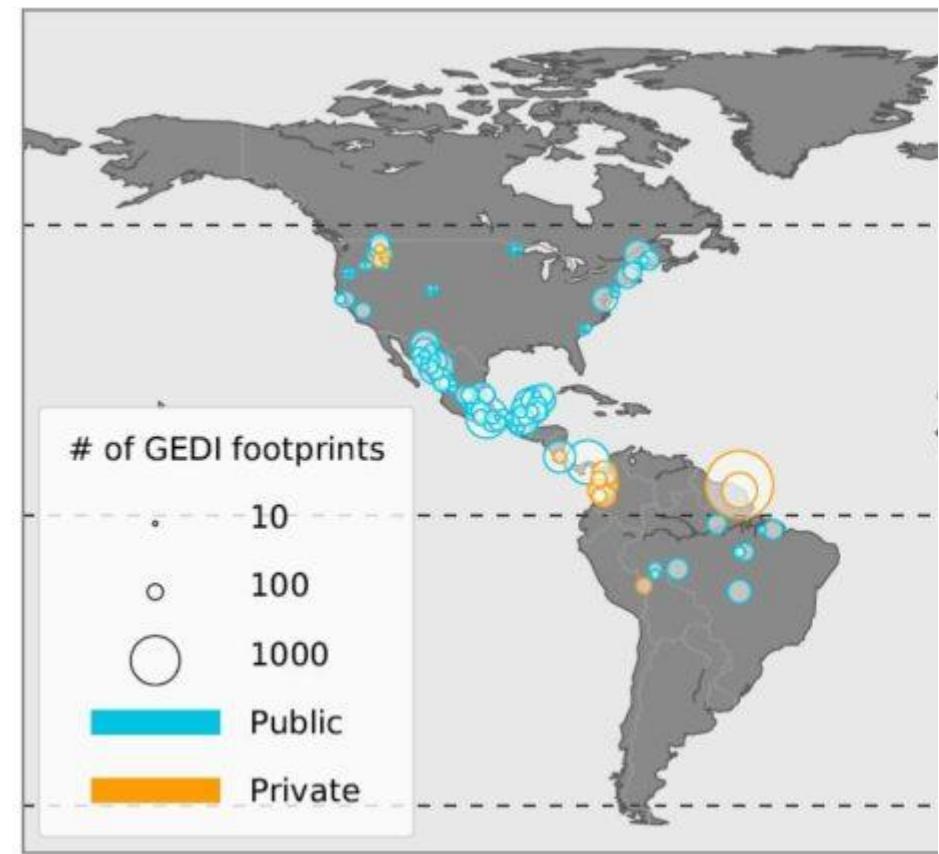
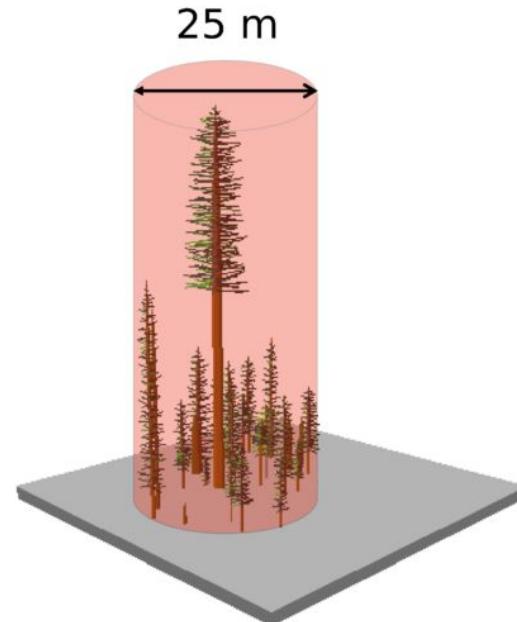
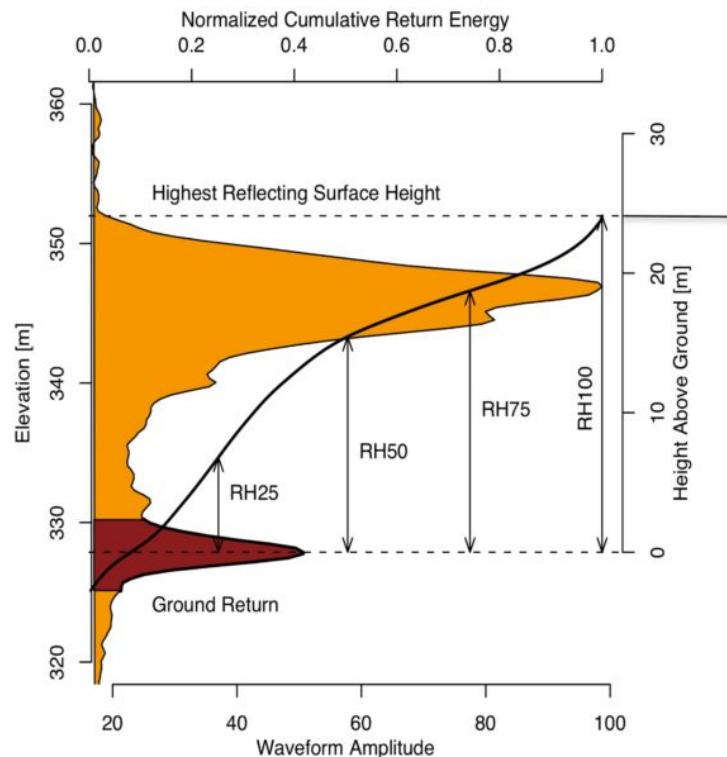
- 1985-2023
- Landsat imagery (30 m x 30m)



Remotely Sensed height Data



Space borne Lidar mounted on the ISS
2018–2026



Estimating dominant height in the plot

Predominant height:

- Average height of the tallest 100 trees/ha

Top height:

- Average height of the 100 trees/ha with the largest DBH

Estimating dominant height in the plot

Predominant height:

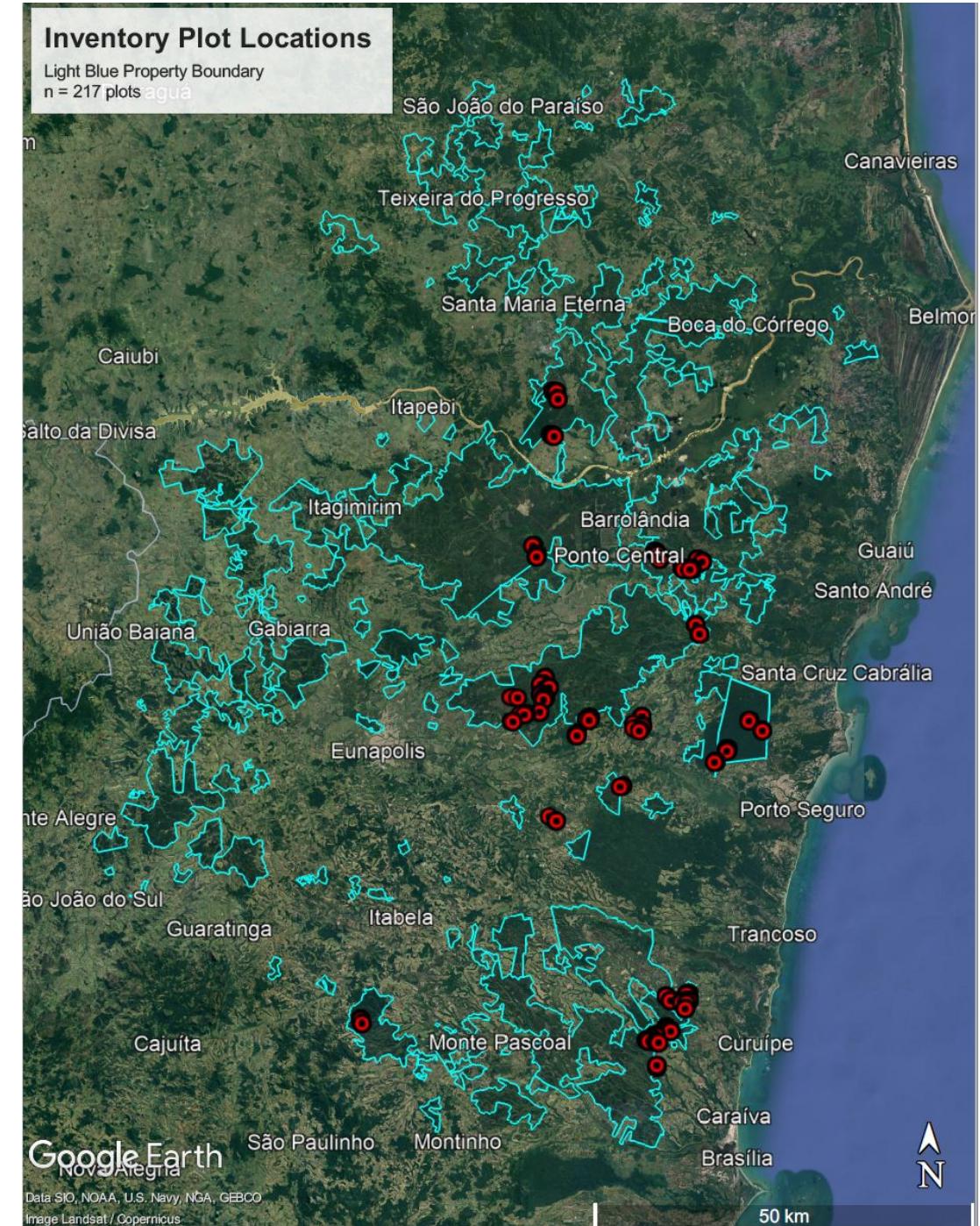
- Average height of the tallest 100 trees/ha

Top height:

- Average height of the 100 trees/ha with the largest DBH

Methods | Forest Inventory Plots

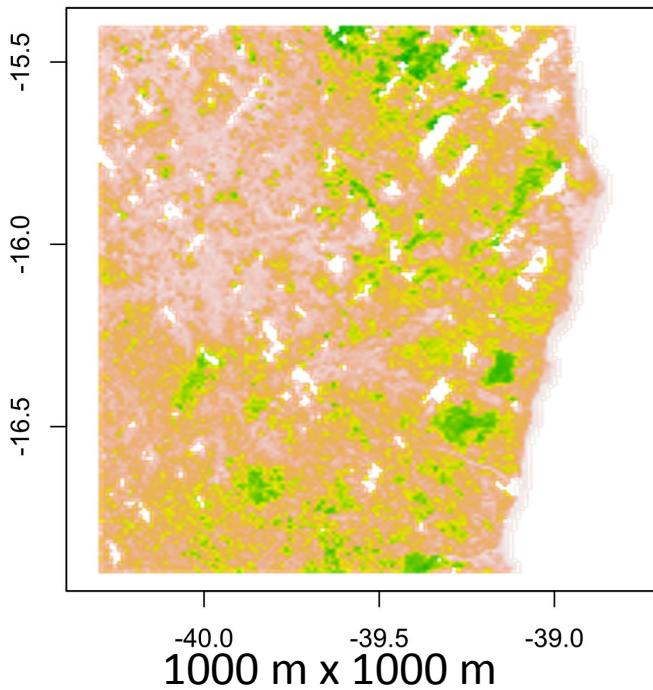
- 217 plots
- Spread across longitudinal gradient
 - 20 – 50 km from the coast
- 7.98 m fixed radius plots (200 m^2)
- All stems $> 10 \text{ cm DBH}$
 - Height and DBH for each stem



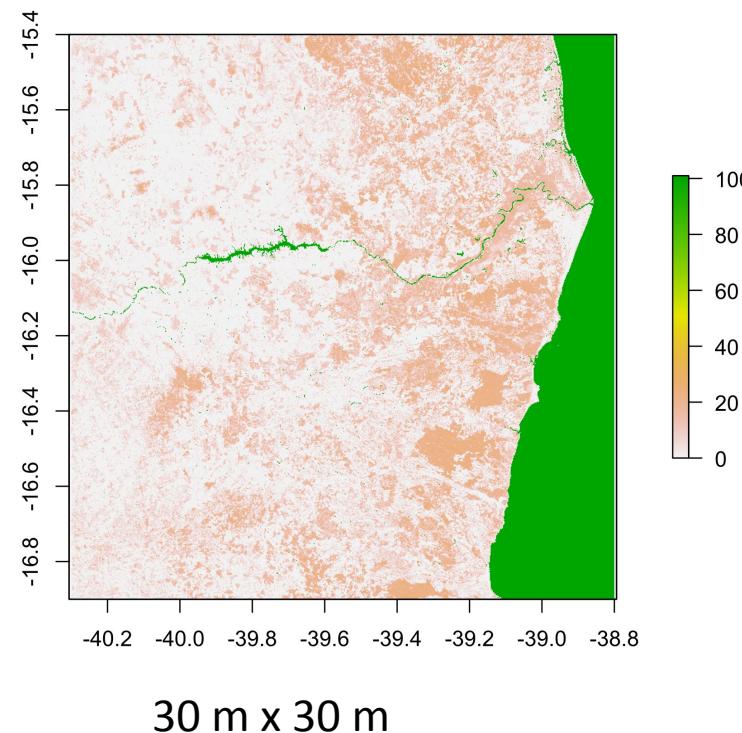
Global canopy height models

- Combine GEDI LIDAR with ALS and other imagery

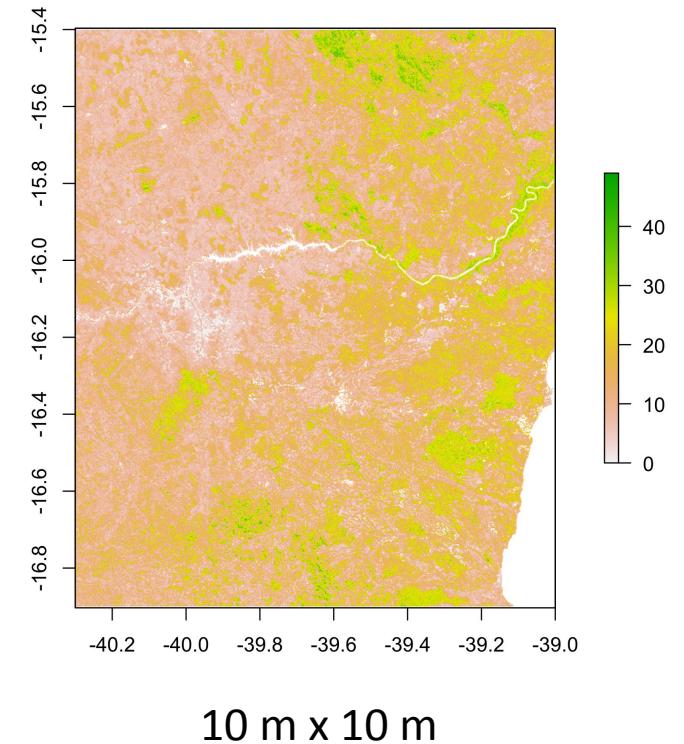
Dubayah *et al.* 2021



Potapov *et al.* 2021

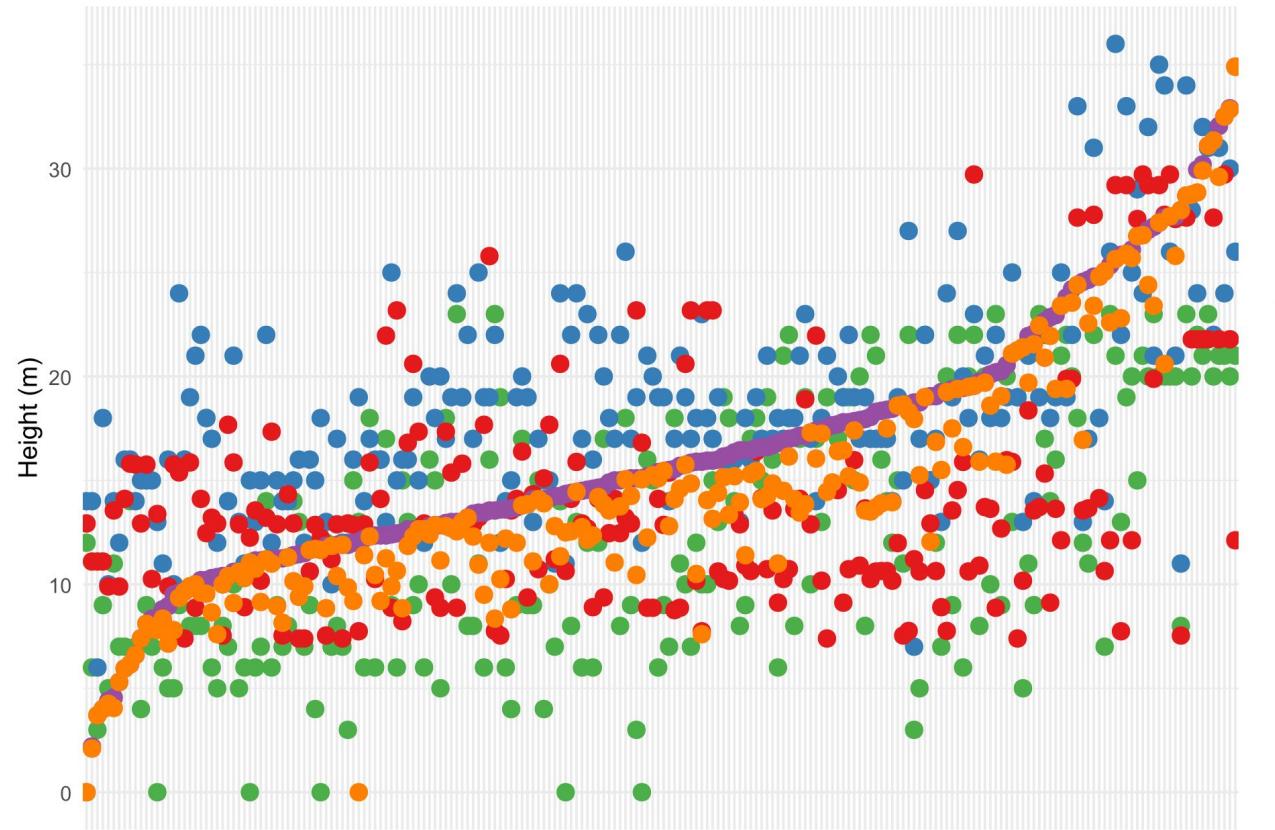


Lang *et al.* 2023

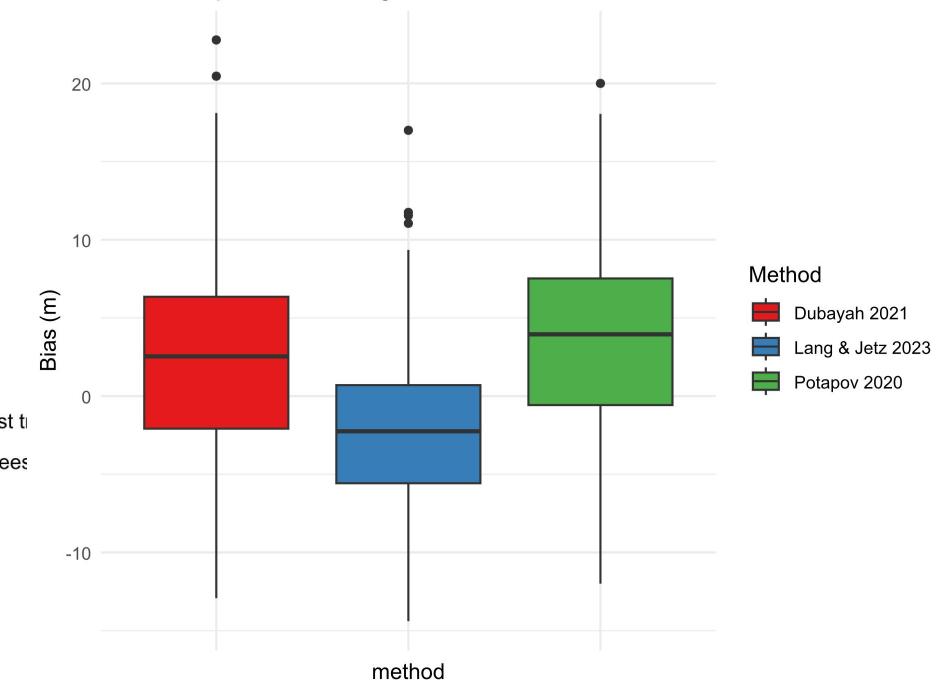


Results | Canopy height Field vs. CHM

Height Estimates by Plot

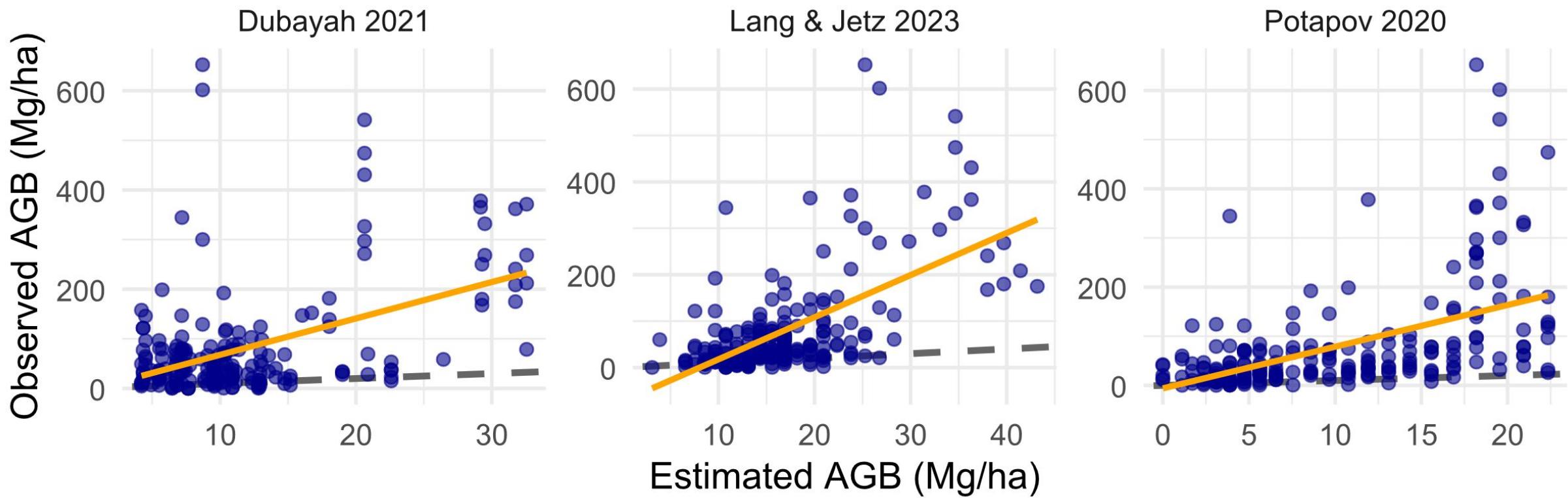


Bias Comparison of Height Estimates



Results | CHM in combination with Zang *et al* 2025 AGB function

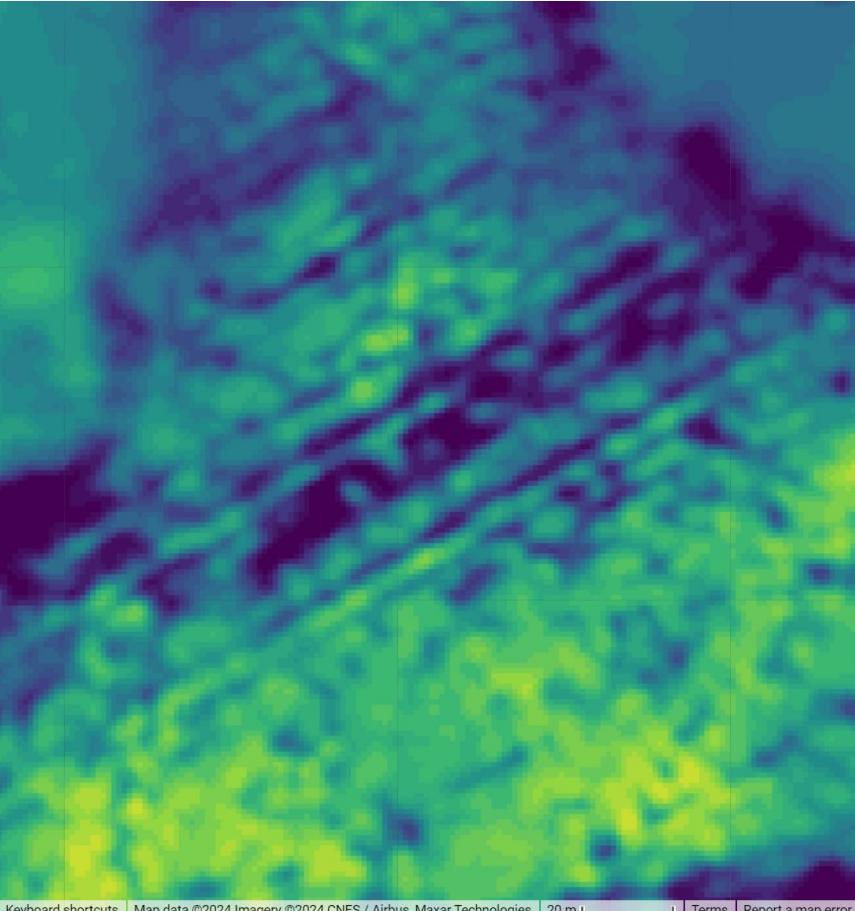
Comparison of Observed vs Estimated Aboveground Biomass



Conclusions

- Canopy height models (CHMs) derived from remote sensing show systematic bias, especially in mature, high-biomass forests.
 - Aboveground biomass (AGB) is consistently **underestimated** when using CHMs alone due to saturation of height values, which fails to capture the upper tail of forest structure.
- ✓ Specific Aim 1: Revealed strong divergence in AGB estimates by canopy height source, with underprediction most severe in tall, dense forests.
- ✓ Specific Aim 2: Models using DBH + height significantly outperformed those using remotely sensed canopy height alone.
- Remote sensing is a valuable tool, but field data remain essential for local calibration and forest management.

Emerging canopy height data products



Submeter Canopy Heights

Tolan et al. 2024

Collaboration between Meta and
World Resource Institute (WRI)

Self-Supervised Learning
(SSL)

pixel 0.5 m x 0.5 m

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- Yale Center for Natural Carbon Capture

Landowners + Access

- Veracel

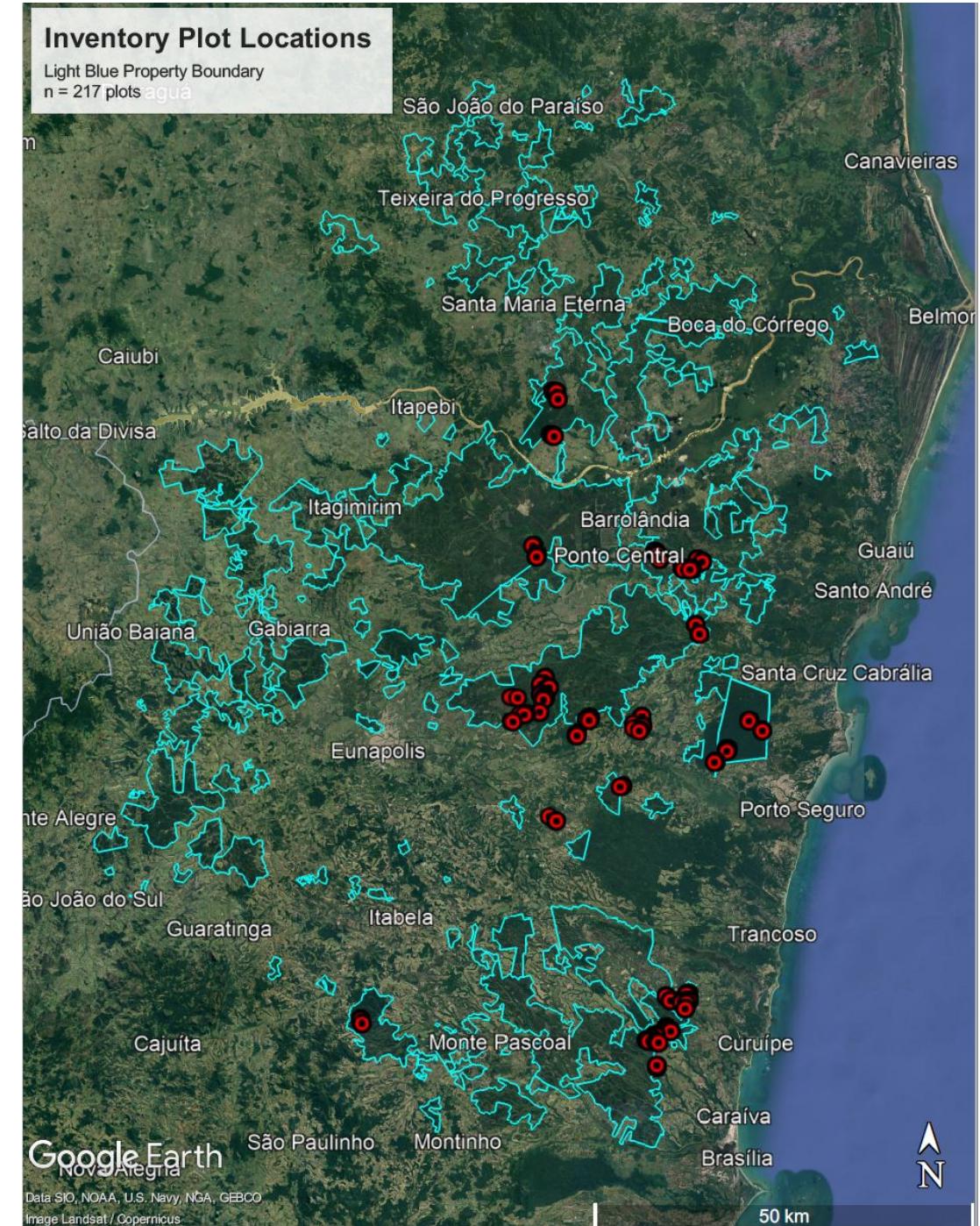
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- Odatha Kotagama (YSE – Yale)
- Manoela Lima (UESB)
- Angie Sanchez (Yale College)

Field Assistants and Veracel RPPN Staff



Methods | Forest Inventory Plots

- 200 plots
- Age: 5-39 years
- TPH: 200 – 1,950
- BA: 0.4 – 34 m²/ha
- AGB: 0.5 – 189.2 Mg/ha



Pantropical Biomass Equations (with and without height)

Chave et al. 2014; 58 sites, 4004 trees; DBH 5-212 cm

Improved allometric models to estimate the aboveground biomass of tropical trees

J Chave, M Réjou-Méchain, A Búrquez, E Chidumayo, MS Colgan, WBC Delitti, A Duque...

Global change biology, 2014 • Wiley Online Library

Abstract

Terrestrial carbon stock mapping is important for the successful implementation of climate change mitigation policies. Its accuracy depends on the availability of reliable allometric models to infer oven-dry aboveground biomass of trees from census data. The degree of uncertainty associated with previously published pantropical aboveground biomass allometries is large. We analyzed a global database of directly harvested trees at 58 sites, spanning a wide range of climatic conditions and vegetation types (4004 trees ≥ 5 cm

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