Efficient derivation of allometric models using laser scanning for improved AGB estimations[1]

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Background and Aim

Above-Ground Biomass (AGB) is a key ecological variable essential for:

- Carbon accounting & climate projections – AGB plays a crucial role in the global carbon cycle.
- Biodiversity & ecosystem monitoring – AGB influences habitat structure and ecosystem dynamics.
- Temperature regulation – Vegetation biomass impacts local and global climate patterns.

Challenges in AGB Estimation

- Dependence on remote sensing data – Satellite-based AGB estimates require calibration and validation with field data.
- Limitations of allometric models as they rely on species- and biome-specific reference data and often do not generalize well.
- Sampling constraints – Destructive sampling for model calibration is time-consuming, costly, and often impractical.

RCT-QSM: A Novel Approach

- Recently developed RayCloudTools[2]-QSM (RCT-QSM) offers a new method for volumetric modeling.
- RCT-QSM
  - Works across different LS platforms (terrestrial & UAV)
  - Allows for a Highly automated workflow
  - Is minimally parametrized

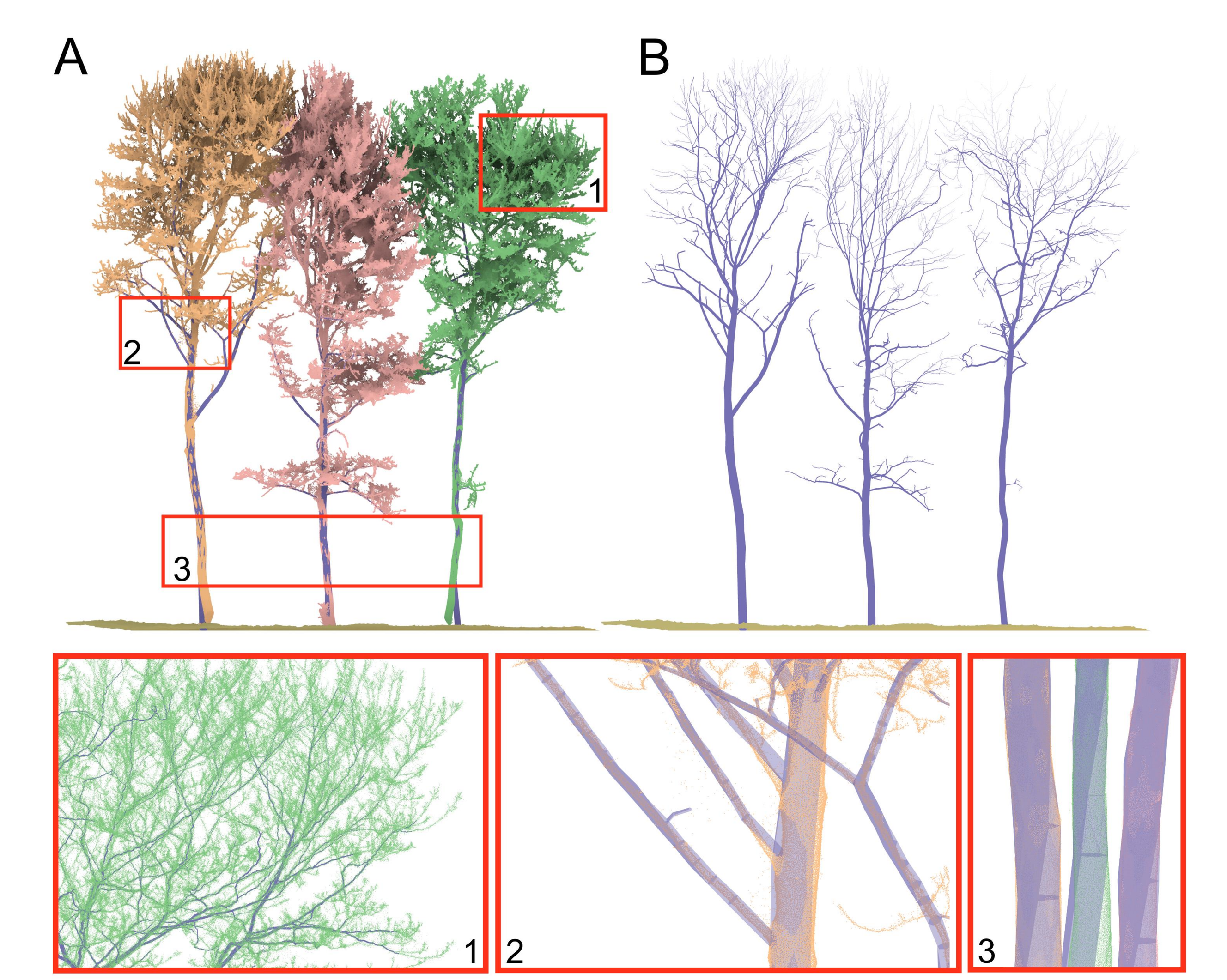


Figure 1: A) Segmented PC and RCT-generated meshes of three trees which are standing next to each other

Aim of this study

Evaluate RCT-QSM performance in terms of accuracy, sensitivity and large-scale applicability to assess its usability for constraining allometric models

RCT-QSM vs. Destructive AGB

Method

Comparing RCT-QSM derived volume with data destructively harvested and scanned trees in different biomes

Location	# trees	Leave/needle conditions	Scanner used	# of scans per tree	Reference
Brasil	4	Leaf-on	RIEGL VZ-400	8	*Burt et al. (2021)*
Germany	12	Leaf-off	Z + F IMAGER 5010	6-8	*Hackenberg et al. (2015)*
China	24	Leaf-on, needle-on	Z + F IMAGER 5010	6-8	*Hackenberg et al. (2015)*
Guyana	10	Leaf-on	RIEGL VZ-400	8-13	*Gonzalez de Tanago et al. (2018)*
Indonesia	10	Leaf-on	RIEGL VZ-400	8-13	*Gonzalez de Tanago et al. (2018)*
Peru	9	Leaf-on	RIEGL VZ-400	8-13	*Gonzalez de Tanago et al. (2018)*
Belgium	65	Leaf-off, needle-on and off	RIEGL VZ-400; VZ-1000	Grid (ca. 20m width)	*Demol et al. (2021)*

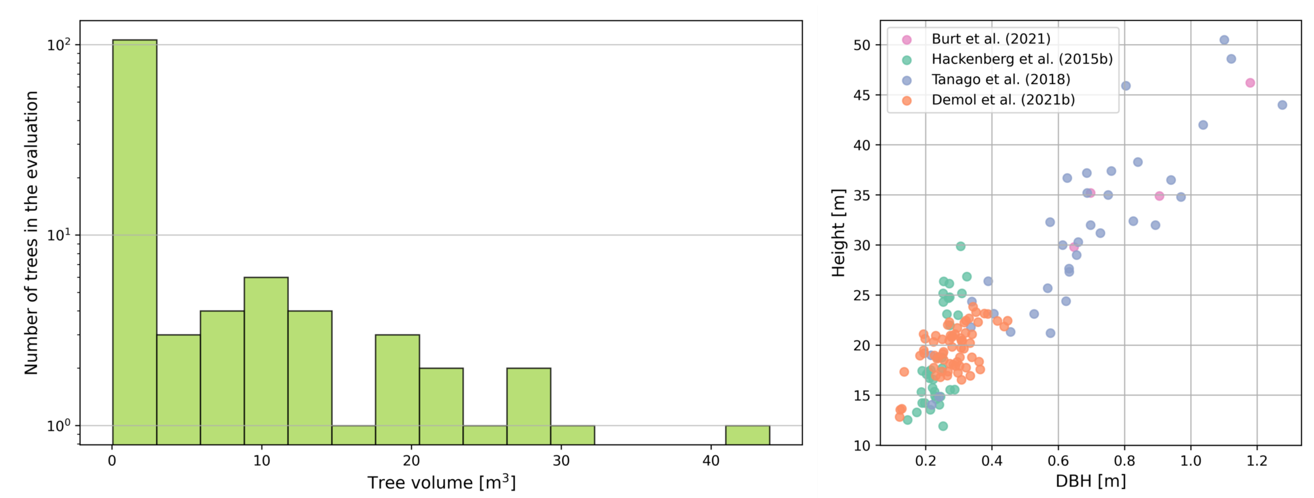


Figure 2: Characteristics of used destructive datasets

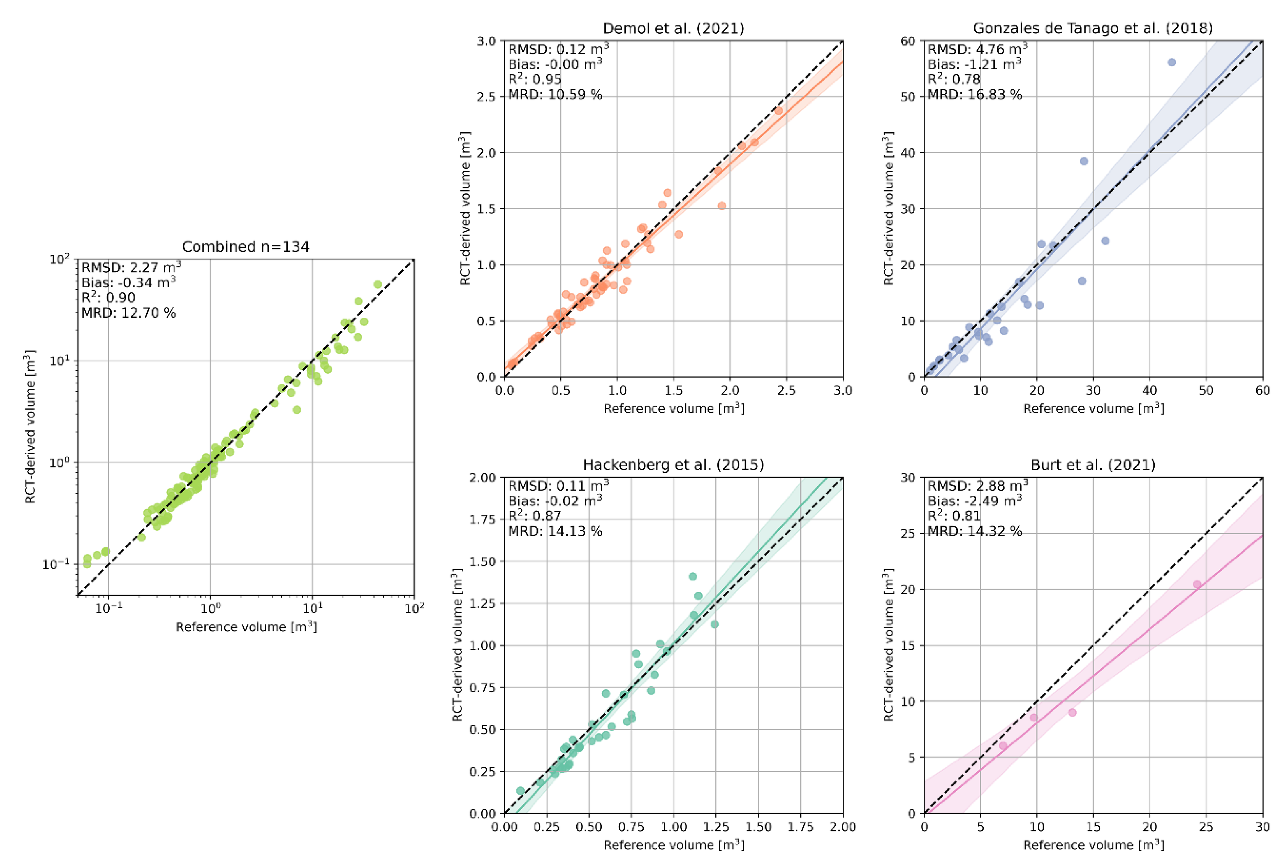


Figure 3: Comparison of destructively measured volumes with RCT-QSM-derived volumes across all datasets (top row) and for individual datasets (subsequent rows).

Take-Away 1

Comparison with AGB of 134 destructively sampled trees shows good correspondence of RCT-QSM.

Sensitivity analysis of RCT-QSM

Method

Systematic resampling of input PC (0.1 - 50cm) to assess the sensitivity of RCT-QSM to point cloud densities and

Figure 4: Two examples from the sensitivity analysis. First row: point clouds; second row: RCT-QSMs

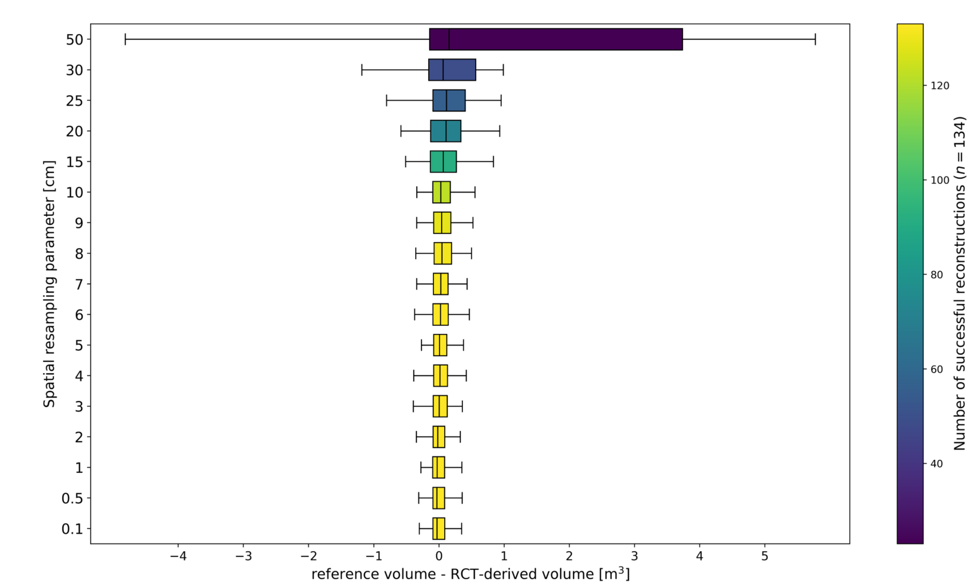


Figure 5 Boxplot-diagram showing the residual volumes for the trees from the destructive datasets for different resolutions

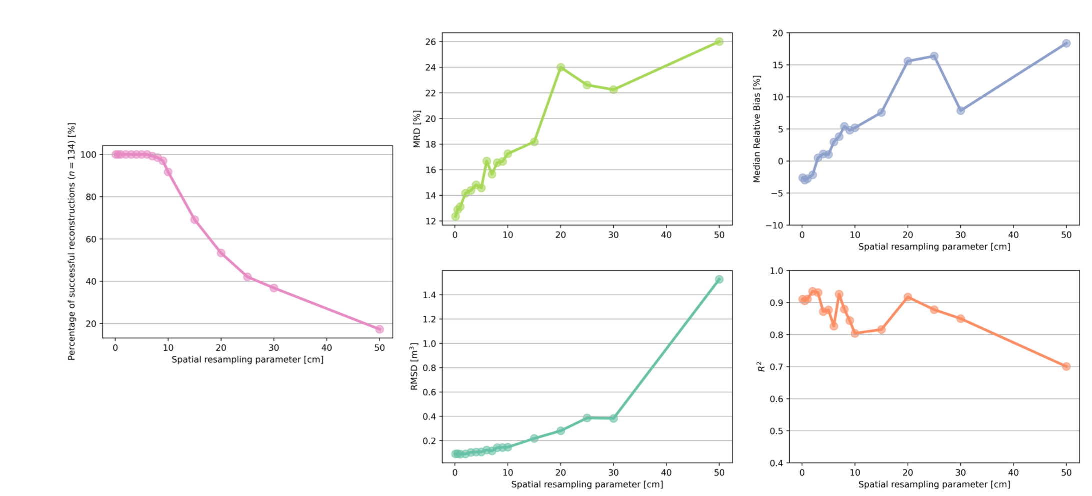


Figure 6: Median performance metrics for the various tested resampling parameters

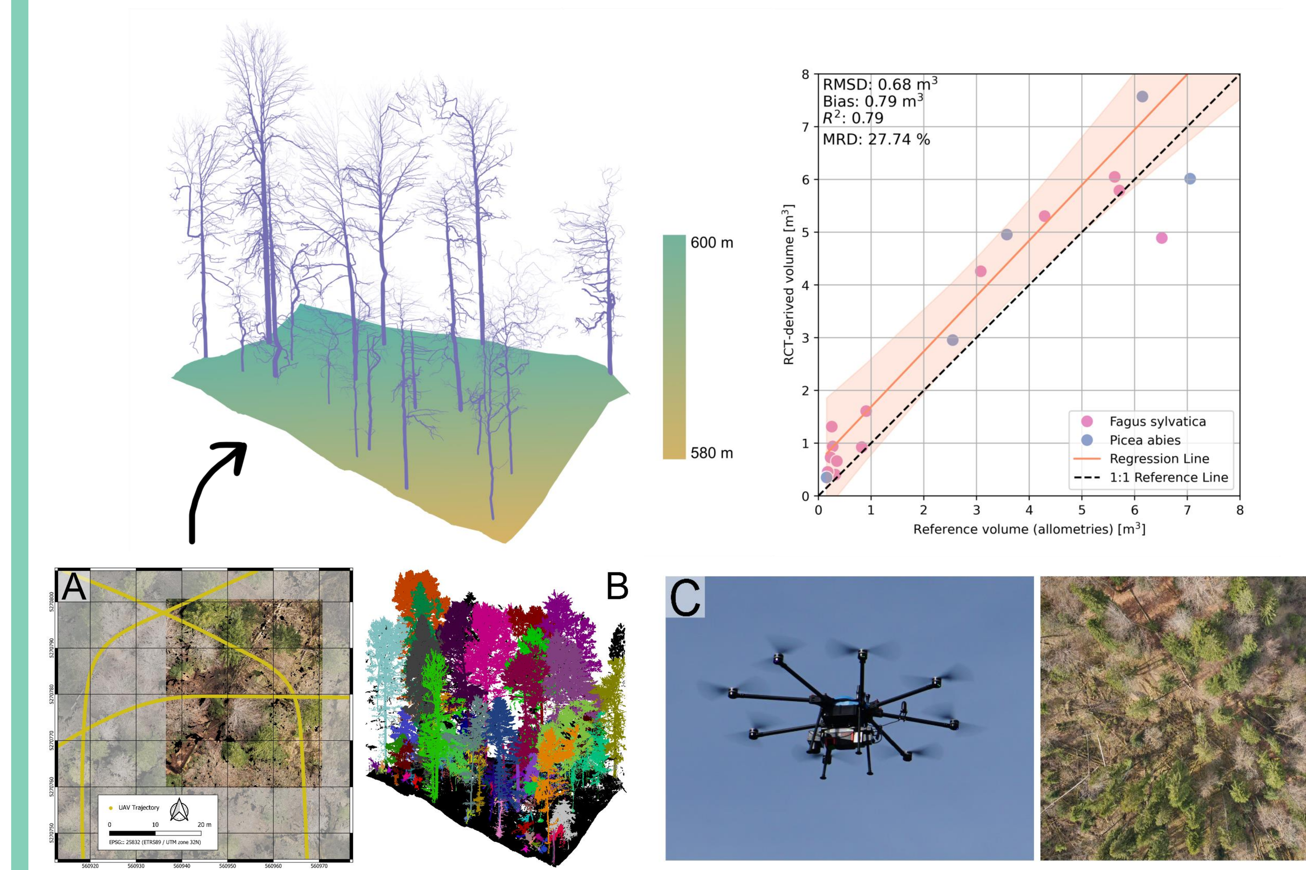
Take-Away 2

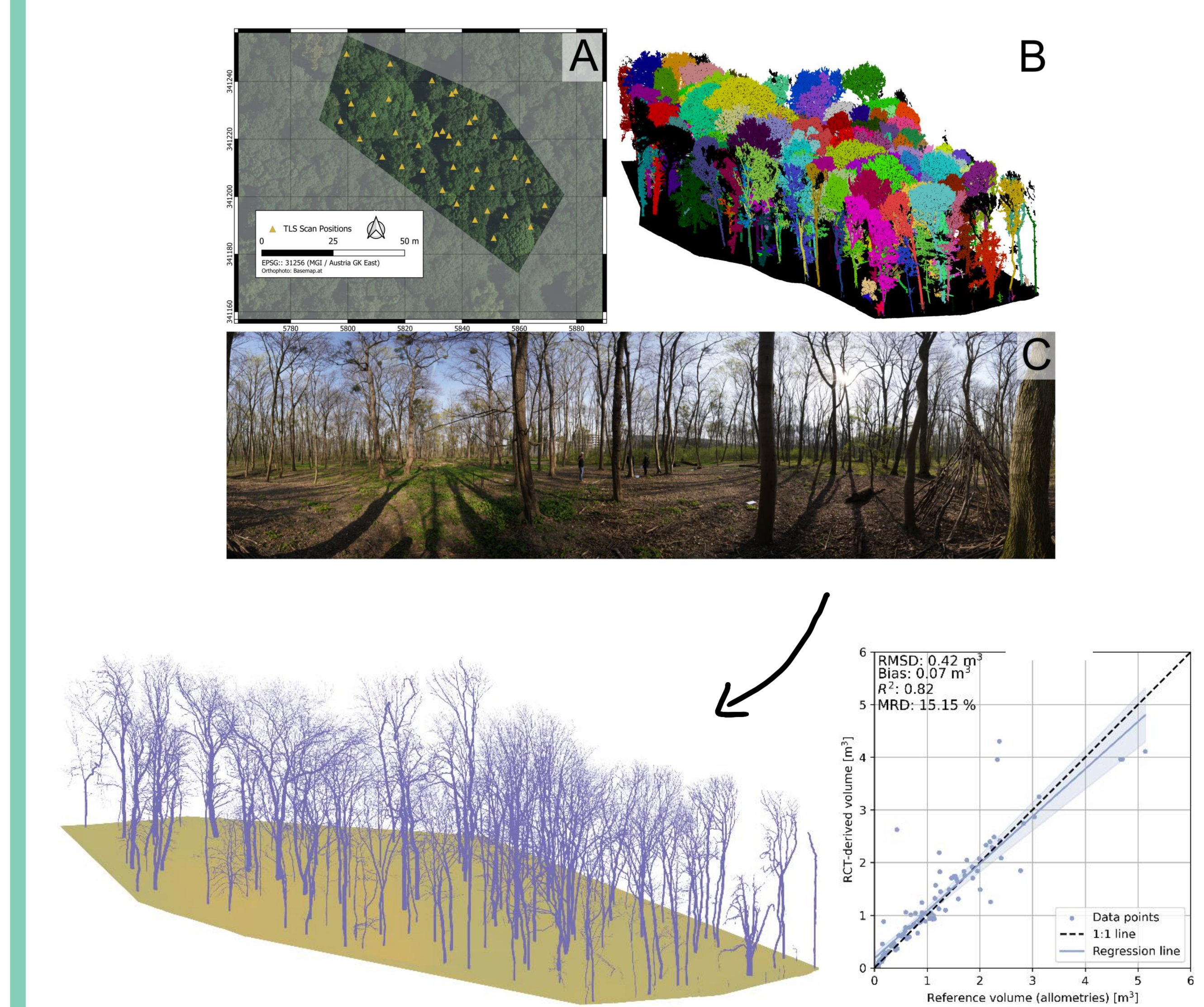
RCT-QSM remains robust and accurate down to 1 point per 10 cm³. Reconstruction success rates decline sharply below this threshold.

Large-Scale Applicability

Method

Terrestrial and UAV-based Laser Scans as input for RCT-QSM to compare against results from species specific allometries for two experimental plots in Austria





Take-Away 3

Comparison with AGB of 134 destructively sampled trees shows good correspondence of RCT-QSM and unseen large-scale applicability

This work is part of the project "Citizens for Copernicus (C4C): Combing Copernicus and Crowdsource Data for Forest Resources Monitoring" funded by the Austrian Research Promotion Agency (FFG) under the ASAP 2022 call, Application ID: https://projekte.ffg.at/projekt/4712922.

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