

FRM4BIOMASS midterm meeting

WP2 - BIOMASS R package

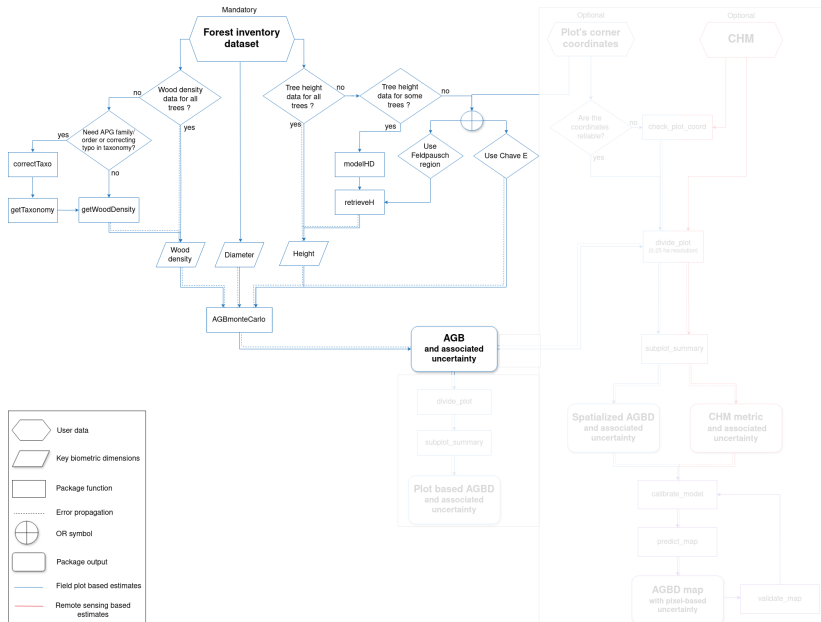
A. Bailly, D. Lamonica, M. Réjou-Méchain

UMR AMAP, IRD

2025-06-23

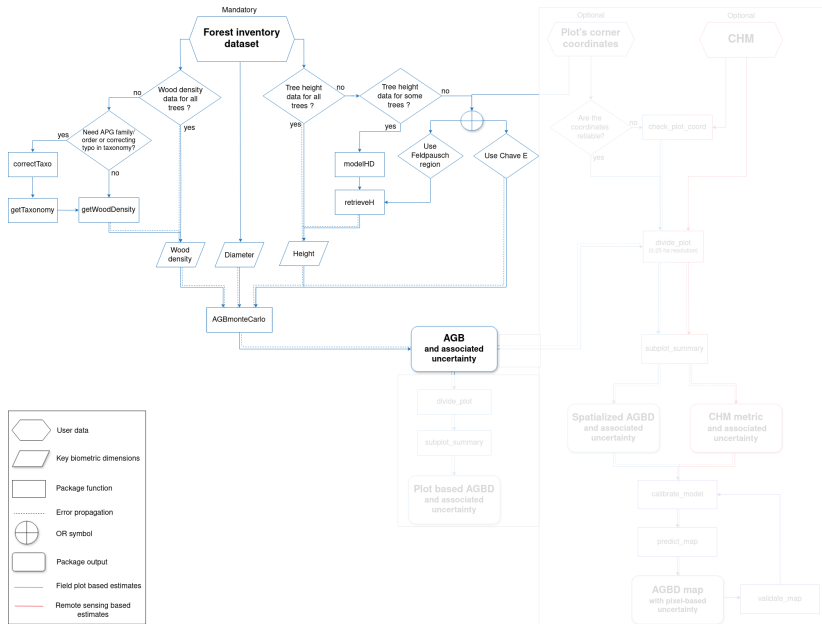


BIOMASS R package pre FRM4BIOMASS

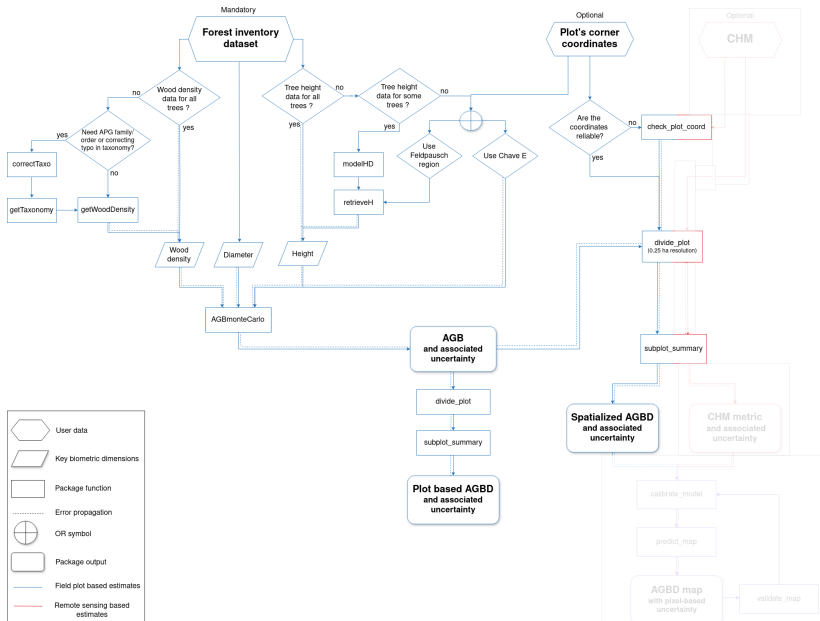


FRM4BIOMASS: what has been done & ongoing work

Shiny app for BIOMASS



Spatialization (V2.2)



Spatialization (V2.2.4, CRAN release March 2025)

- ▶ check plot coordinates
- ▶ divide plot into subplots
- ▶ spatialized AGB (*ie* AGBD) products at subplot level

BIOMASS 2.2.4 Articles ▾ Reference

Spatialize trees and forest stand metrics with BIOMASS

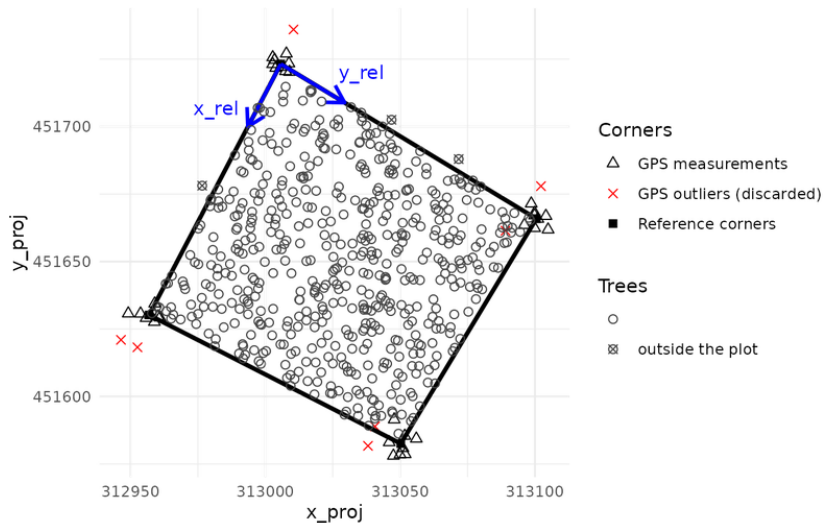
Arthur Bailly

2025-05-22

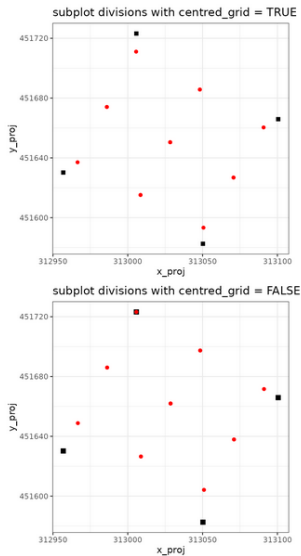
Source: [vignettes/Vignette_spatialized_trees_and_forest_stand_metrics.Rmd](#)



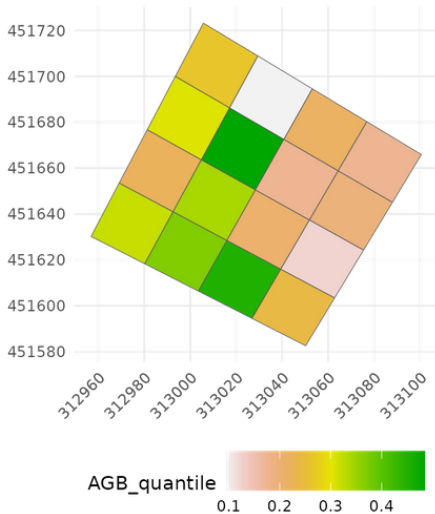
Spatialization (V2.2.4, CRAN release March 2025)



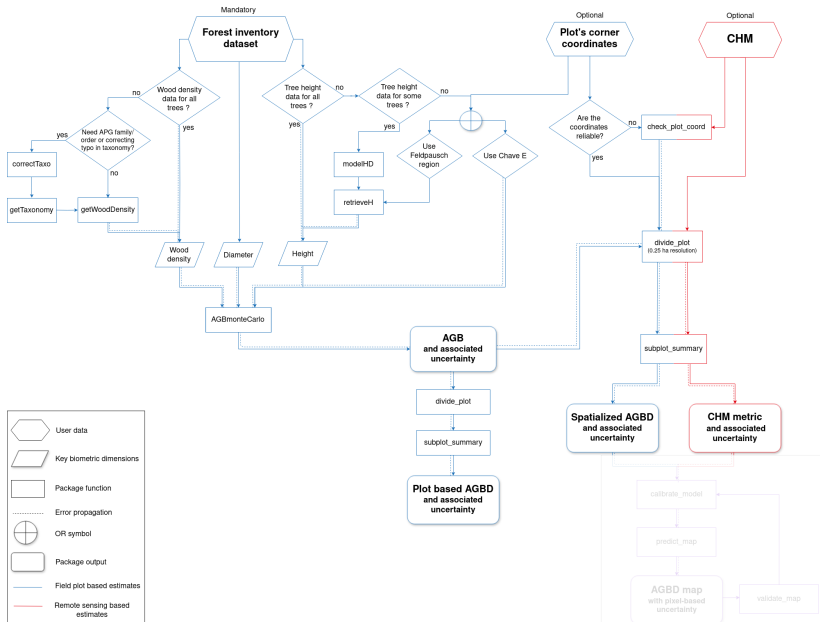
Spatialization (V2.2.4, CRAN release March 2025)



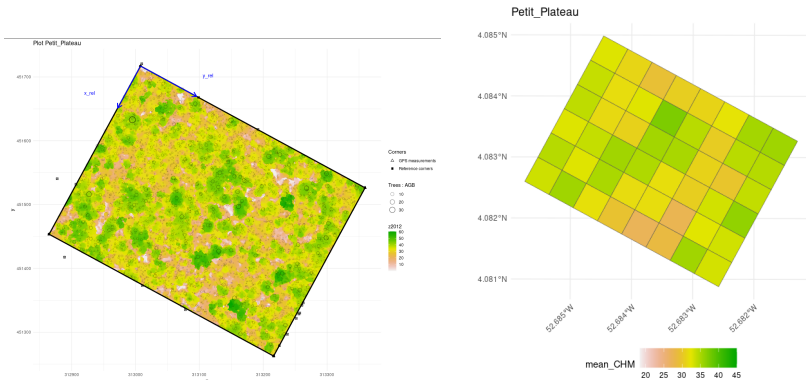
AGB quantile



CHM management (V3)

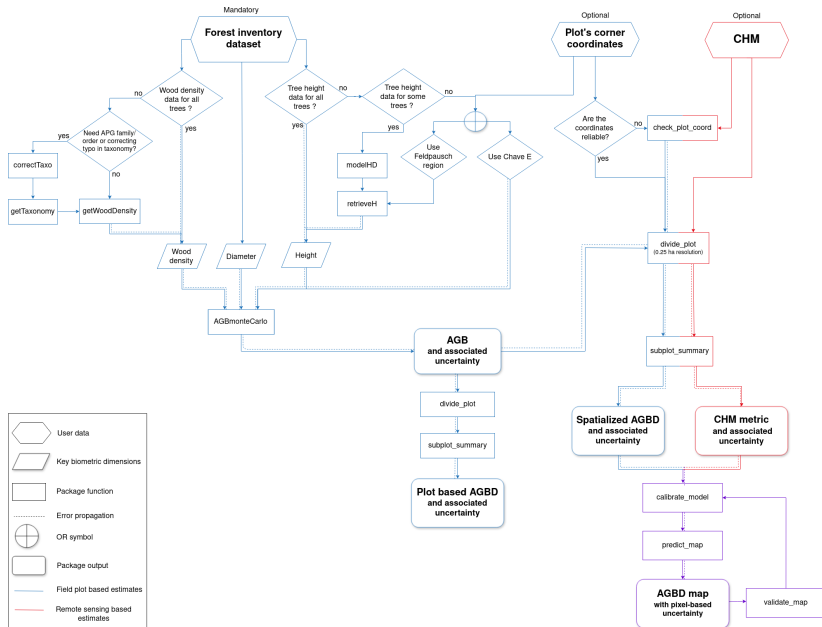


CHM management (V3, implemented but not released yet)



► allows to propagate plot and pixel position errors

CHM-AGBD model calibration (V3)



CHM-AGBD model calibration: proposed statistical framework

- ▶ geostatistical model with SPV-I/C (SPatially Varying Intercept/Coefficients) to integrate spatial correlation:
- ▶ $y(s) = (\alpha + \tilde{\alpha}(s)) + (\beta + \tilde{\beta}(s)) \times x(s) + \epsilon(s)$
with $\tilde{\alpha}(s_1), \dots, \tilde{\alpha}(s_n) \sim MVN(0, C_{\alpha}(s_i, s_j))$
- ▶ references



LiDAR based prediction of forest biomass using hierarchical models with spatially varying coefficients

Chad Babcock ^a, Andrew O. Finley ^{b,*}, John B. Bradford ^c, Randall Kolka ^d, Richard Birdsey ^e, Michael G. Ryan ^f



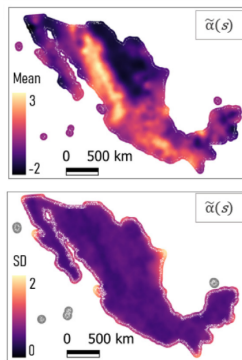
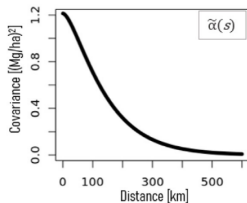
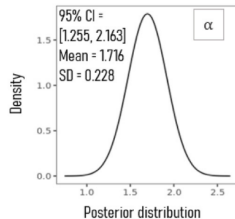
A geostatistical approach to enhancing national forest biomass assessments with Earth Observation to aid climate policy needs

Neha Hunka ^{a,*}, Paul May ^b, Chad Babcock ^c, José Armando Alanís de la Rosa ^d, Maria de los Angeles Soriano-Luna ^d, Rafael Mayorga Saucedo ^d, John Armston ^a, Maurizio Santoro ^e, Daniela Requena Suarez ^f, Martin Herold ^f, Natalia Málaga ^f, Sean P. Healey ^g, Robert E. Kennedy ^h, Andrew T. Hudak ⁱ, Laura Duncanson ^a

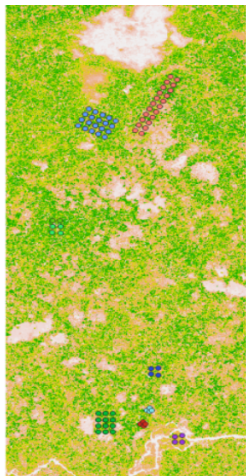
CHM-AGBD model calibration: proposed statistical framework

$$y(s) = (\alpha + \tilde{\alpha}(s)) + (\beta + \tilde{\beta}(s)) \times x(s) + \epsilon(s)$$

with $\tilde{\alpha}(s_1), \dots, \tilde{\alpha}(s_n) \sim MVN(0, C_{\alpha}(s_i, s_j))$



CHM-AGBD model calibration: example with Nouragues data

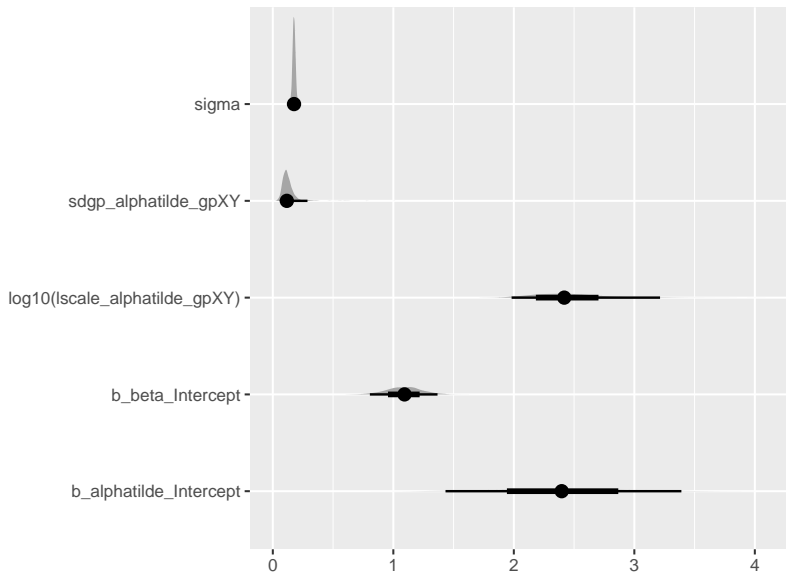


► SPV-I model

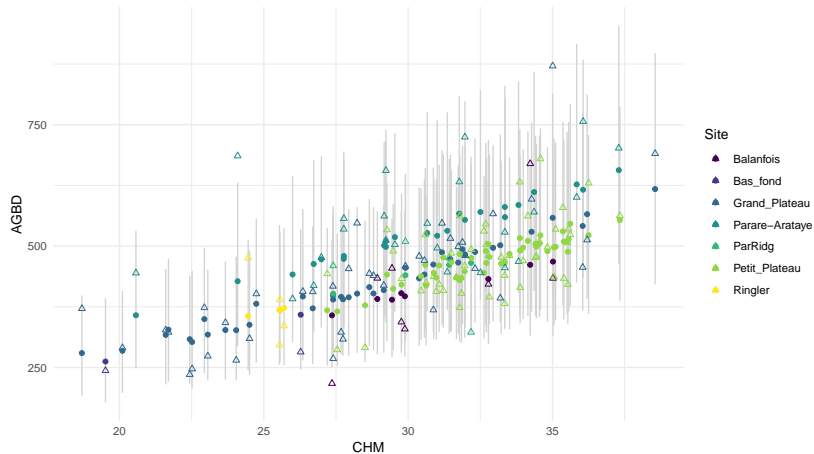
$$\begin{aligned} \log(AGBD(s)) = & \\ & (\alpha + \tilde{\alpha}(s)) + \beta \times \log(CHM(s)) + \epsilon(s) \\ \text{with} & \\ & \tilde{\alpha}(s_1), \dots, \tilde{\alpha}(s_n) \sim MVN(0, C_{\alpha}(s_i, s_j)) \end{aligned}$$

CHM-AGBD model estimates and plot prediction (1/2)

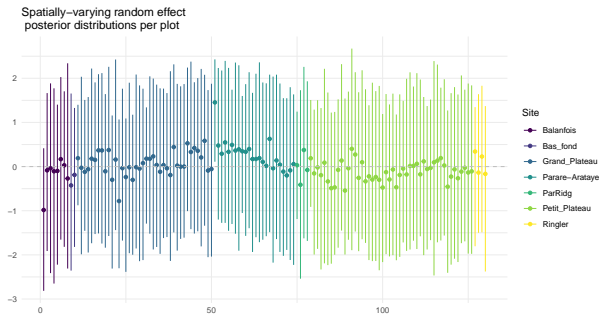
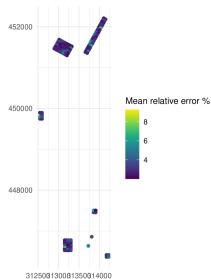
Parameter posterior distributions



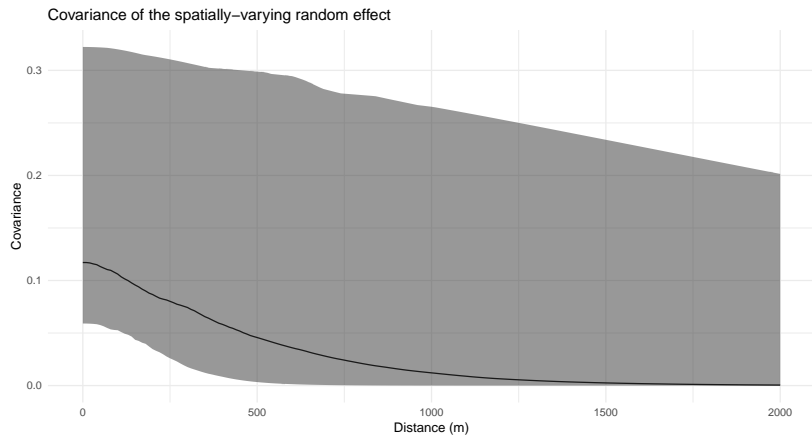
CHM-AGBD model estimates and plot prediction (2/2)



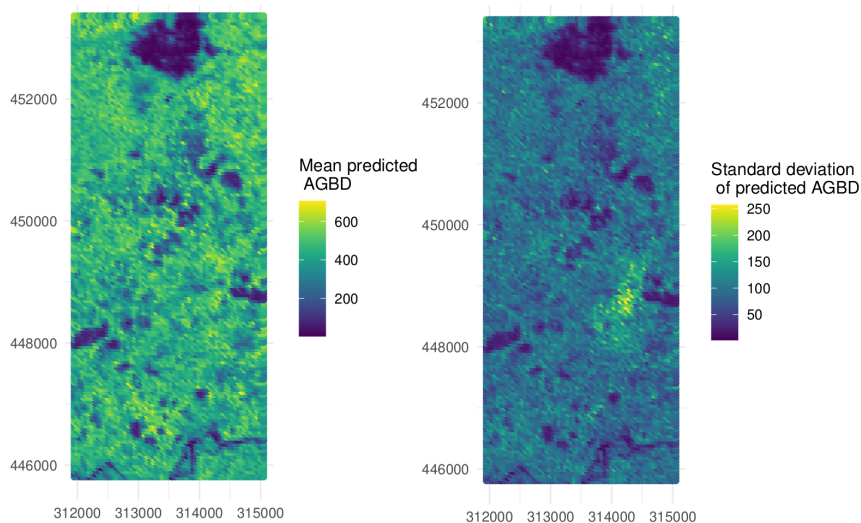
CHM-AGBD model errors: plots



CHM-AGBD model landscape predictions (1/2)



CHM-AGBD model landscape predictions (2/2)

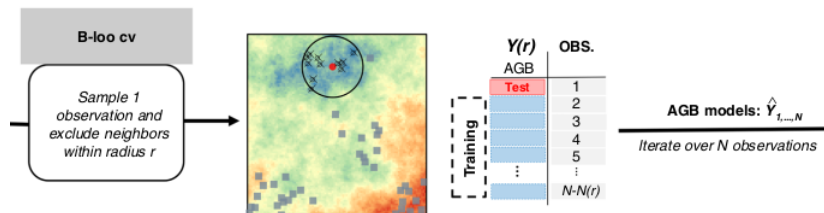


CHM-AGBD model calibration: implementation possibilities & difficulties

- ▶ brms package, STAN, geostat module in JAGS
- ▶ how to propagate AGBD estimates uncertainties, computation wise (eg Monte Carlo procedure, or directly into the model ?)
- ▶ pixel error propagation: Monte Carlo procedure
- ▶ future statistical development to use all the CHM spatial structure: better use of available information for a more robust & precise full spatial AGBD prediction (for a next major version)

CHM-AGBD model validation

- initially, proposed framework: spatial Leave-One-Out, Ploton et al. 2020 Nature Com.



- but computationally super intensive, so external validation (using independent dataset or splitting dataset) to be considered
- needs further discussion!

Final product: uncertainty sources & how to deal with them

$$U_{ref} = U_{Inst} + U_{Model} + U_{Location} + U_{Area} + U_{Representativeness}$$

- ▶ wood density, height, diameter U_{Inst}
- ▶ plot based AGB prediction: allometric relationship with Monte Carlo procedure U_{Model}
- ▶ plot based AGBD-CHM calibration: spatial structure with SPVI/C (Bayesian framework) U_{Model}
- ▶ full spatial AGBD prediction: plot based AGBD uncertainties with Monte Carlo procedure ? U_{Model}
- ▶ plot based AGB density & CHM computation: pixel error with Monte Carlo procedure $U_{Location}$ & U_{Area}

Perspectives

Short term perspectives - with Arthur

- ▶ new allometric relationship to predict AGB
- ▶ companion paper for V3 BIOMASS R package
- ▶ currently under estimation of uncertainties in HD model (only residual error, no parameter uncertainties propagation) → Bayesian inference & propagation (eg, using brms package)
- ▶ waiting for wood density database update
- ▶ update taxonomy correction, currently we do not deal with synonymy → waiting for Renato's package to be on CRAN
- ▶ error detection: outliers (diameter, height, wood density)

Long term perspectives - with ?

Temporal BIOMASS

- ▶ propagating joint errors on differentes dates, for plots and LiDAR
- ▶ technically challenging: package implementation and structure to integrate temporal dynamics
- ▶ approaches for allometric relationships and differences in AGBD, CHM ?

Thank you for your attention