FRM4BIOMASS midterm meeting
WP2 - BIOMASS R package
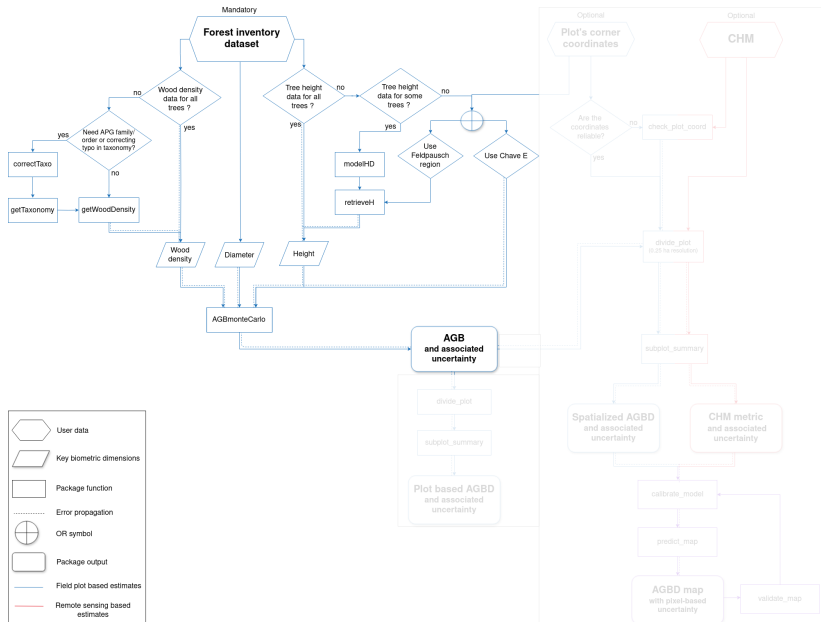
A. Bailly, D. Lamonica, M. Réjou-Méchain

UMR AMAP, IRD

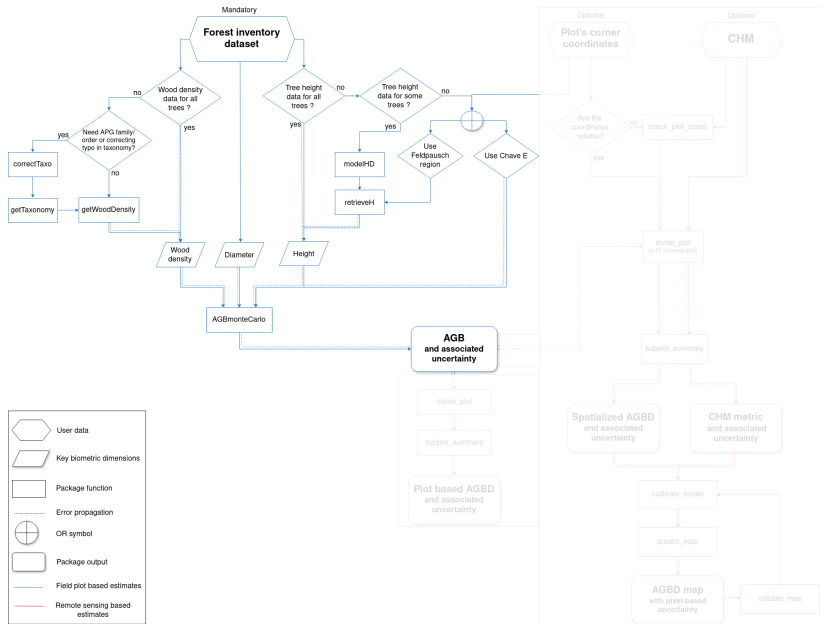2025-06-23

BIOMASS R package pre FRM4BIOMASS
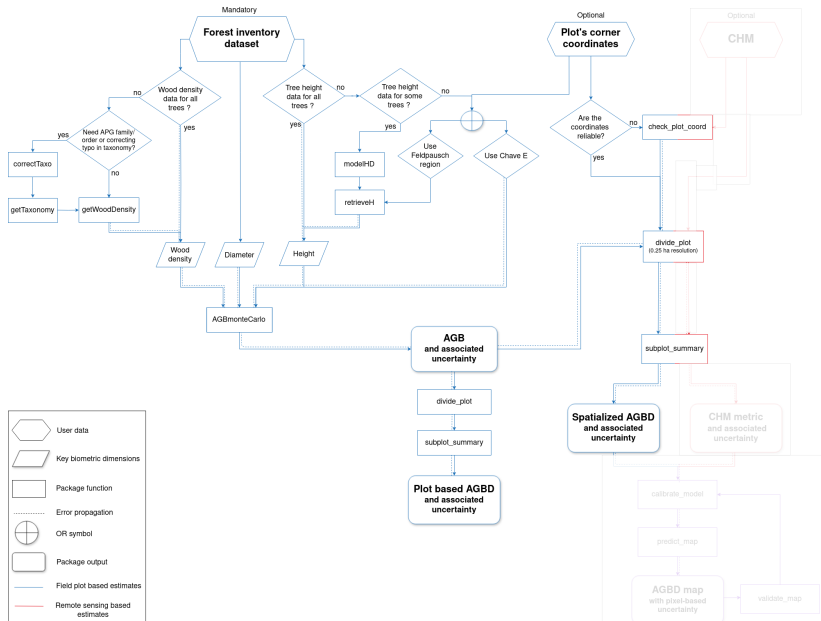
FRM4BIOMASS: what has been done & ongoing work

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

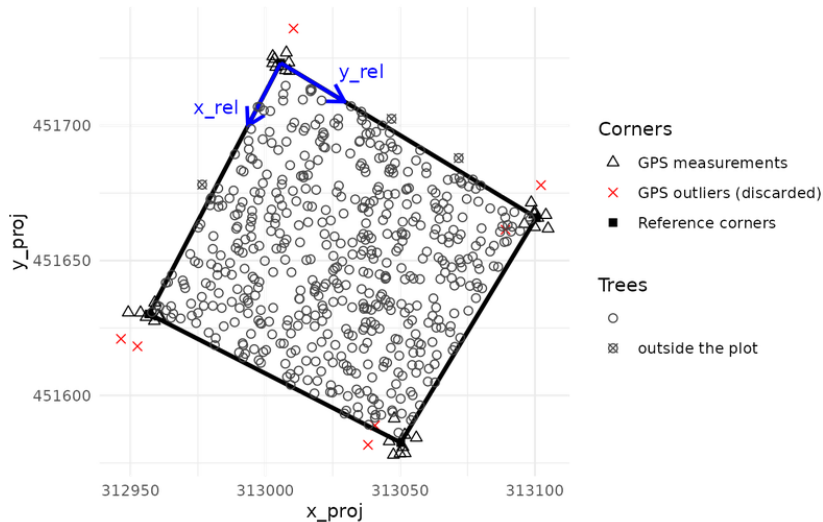## Spatialize trees and forest stand metrics with BIOMASS
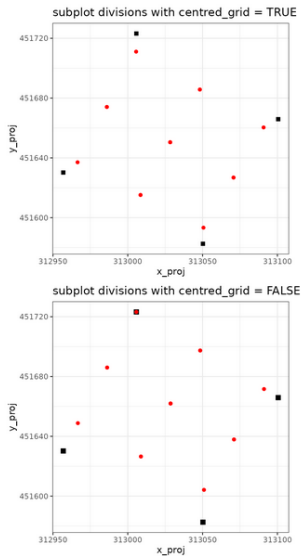
Arthur Bailly

2025-05-22

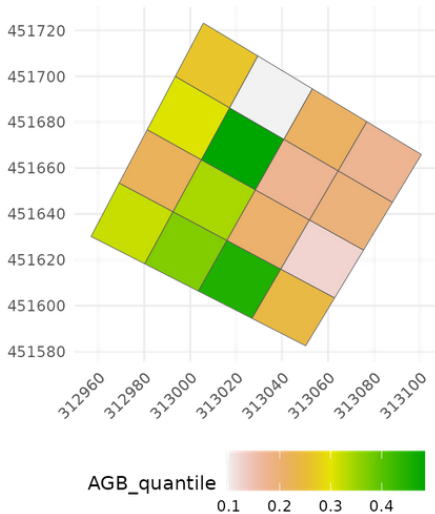Source: vignettes/Vignette_spatialized_trees_and_forest_stand_metrics.Rmd

Spatialization (V2.2.4, CRAN release March 2025)
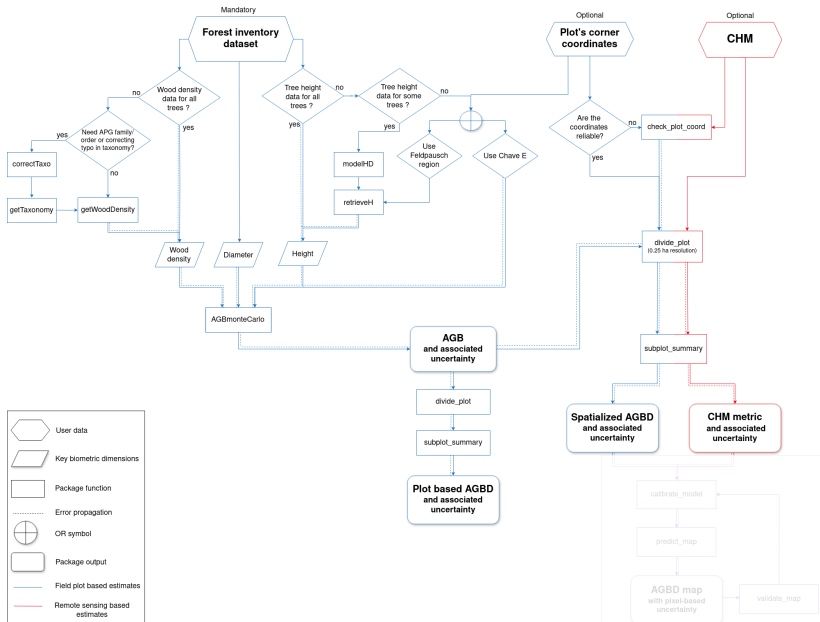
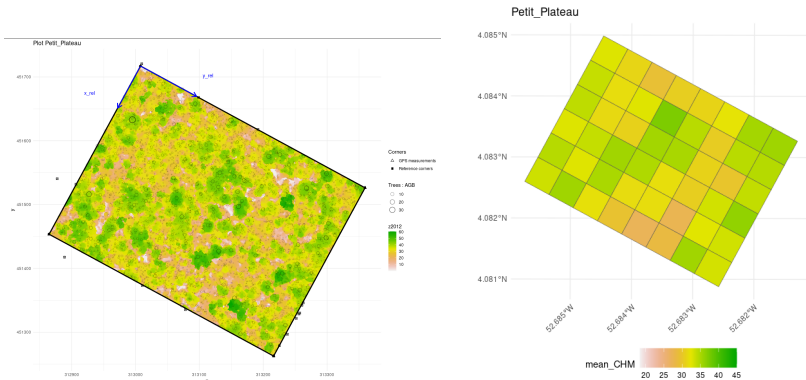# Spatialization (V2.2.4, CRAN release March 2025)
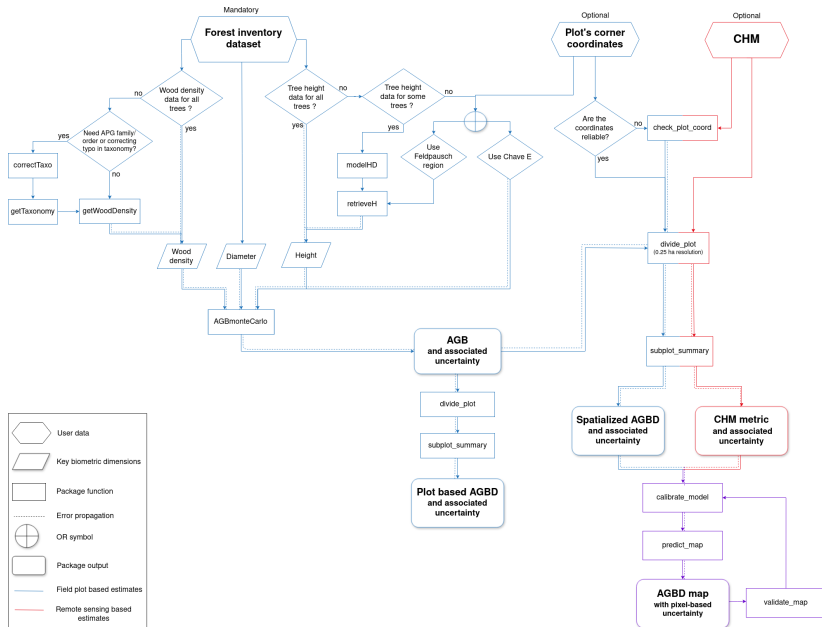
CHM management (V3)

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

▶ 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], María de los Ángeles 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

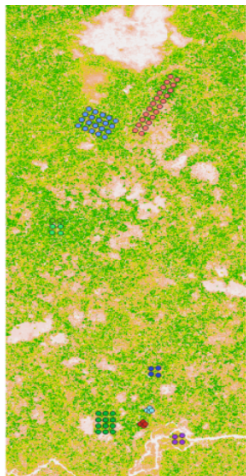$$y(s) = (\alpha + \tilde{\alpha}(s)) + (\beta + \tilde{\beta}(s)) \times x(s) + \epsilon(s)$$
with $\tilde{\alpha}(s_1), ..., \tilde{\alpha}(s_n) \sim MVN(0, C_\alpha(s_i, s_j))$
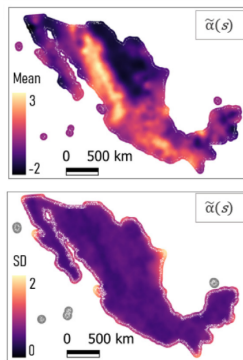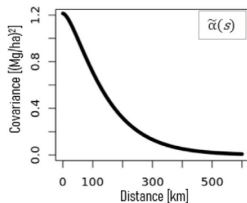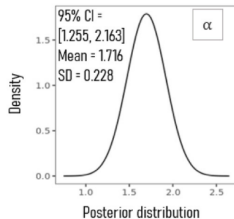
CHM-AGBD model calibration: example with Nouragues data

▶ SPV-I model
$$log(AGBD(s)) =$$
$$(\alpha + \tilde{\alpha}(s)) + \beta \times log(CHM(s)) + \epsilon(s)$$
with
$$\tilde{\alpha}(s_1), ..., \tilde{\alpha}(s_n) \sim MVN(0, C_\alpha(s_i, s_j))$$

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

Parameter posterior distributions
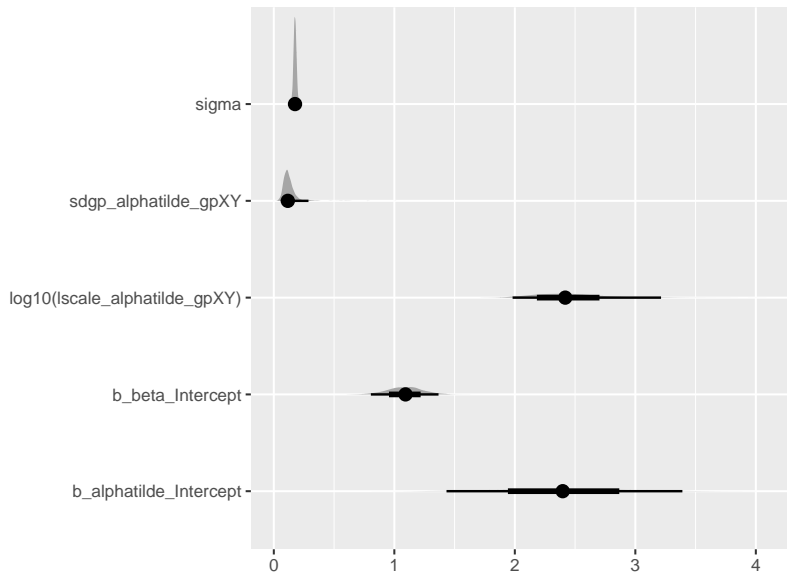
CHM-AGBD model estimates and plot prediction (2/2)
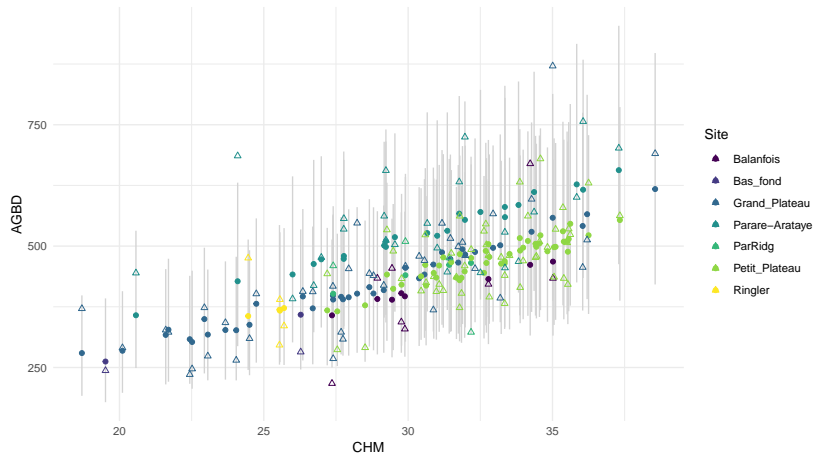
CHM-AGBD model errors: plots

CHM-AGBD model landscape predictions (1/2)

Covariance of the spatially−varying random effect
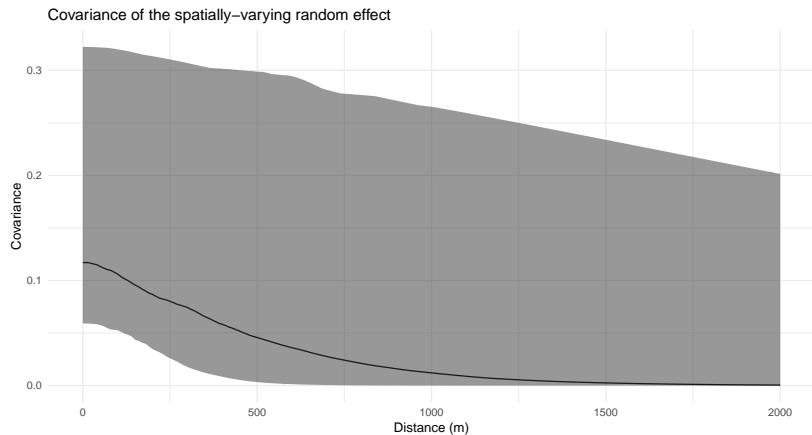
CHM-AGBD model landscape predictions (2/2)

(predicted map)

CHM-AGBD model calibration: implementation possibilities & difficulties
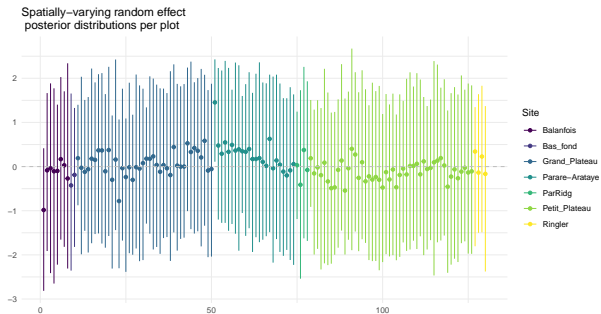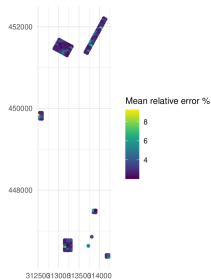
▶ brms package, STAN, geostat module in JAGS

▶ 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.
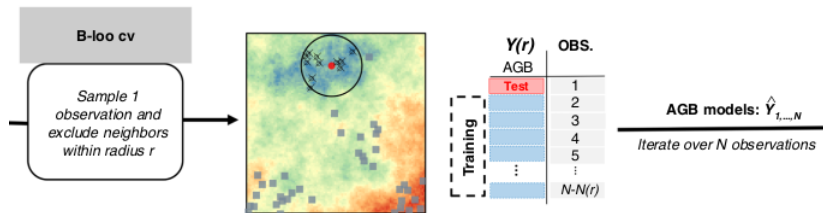
- ▶ but computationally super intensive, so external validation (using independent dataset or splitting dataset) to be considered

- ▶ 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) $\rightarrow$ Bayesian inference & propagation (eg, using brms package)

▶ waiting for wood density database update

▶ update taxonomy correction, currently we do not deal with synonymy $\rightarrow$ 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