Combining terrestrial and UAV laser scanning for non-destructive biomass prediction at biomass reference sites

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Background

- AGB related satellite missions require cal/val data across hectare scales
  - forest inventories: smaller plots
  - large research plots = rare

- Allometric models based on field inventories with possible bias for large trees (Burt et al., 2020; Burt et al., 2021)


Herold et al. (2019)
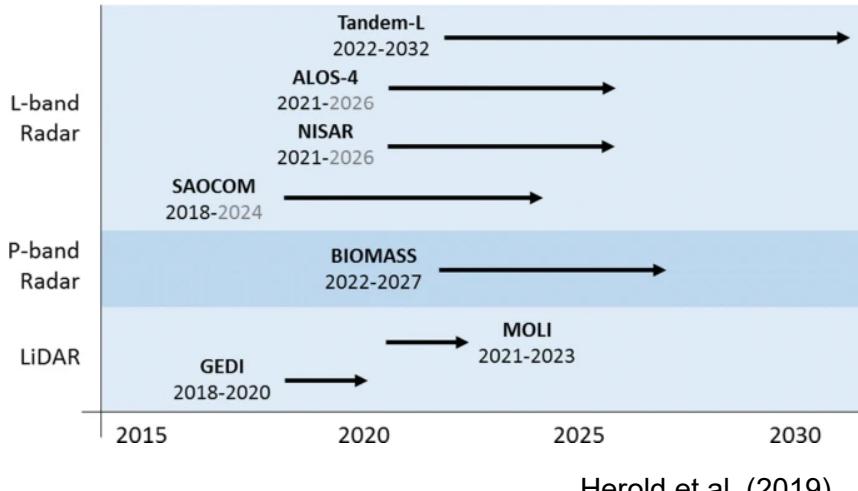
Background

- TLS + QSM as potentially unbiased predictor of wood volume and AGB, also for large trees (Calders et al., 2015; Gonzalez de Tanago et al., 2017)

- TLS across hectares = time-consuming, ca. 3-7 days/ha (Wilkes et al., 2017), although large improvements have been made

Calders et al. (2015)
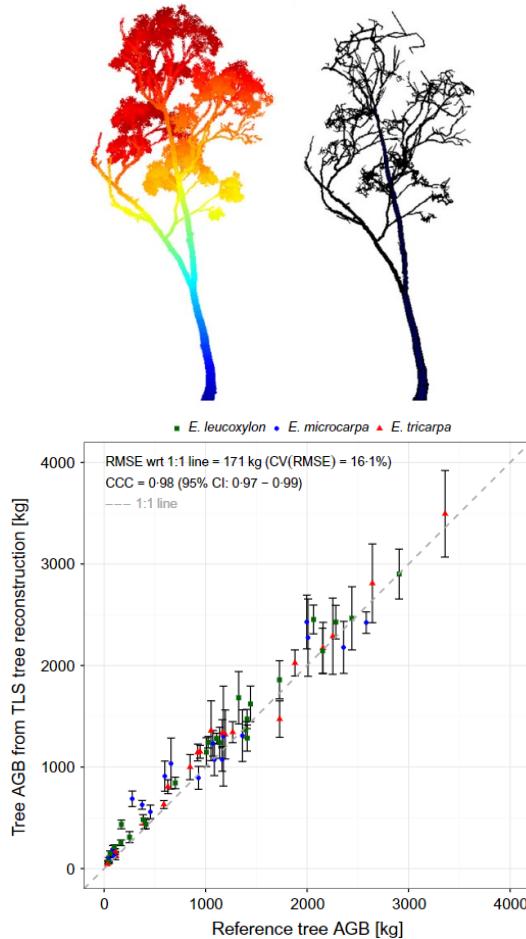
Calders et al. (2015): DOI:10.1111/2041-210X.12301
Gonzalez de Tanago et al. (2017): DOI:10.1111/2041-210X.12904
Wilkes et al. (2017): DOI:10.1016/j.rse.2017.04.030

Background

- QSM with UAV-LS difficult
  (Brede et al., 2019)

- Most allometric models use DBH > hard
  to estimate from UAV-LS for dense
  canopies
  (Brede *et al.*, 2017;
  Levick *et al.*, 2021)

- UAV-LS with higher point density than
 ALS:
  more information on tree parameters?
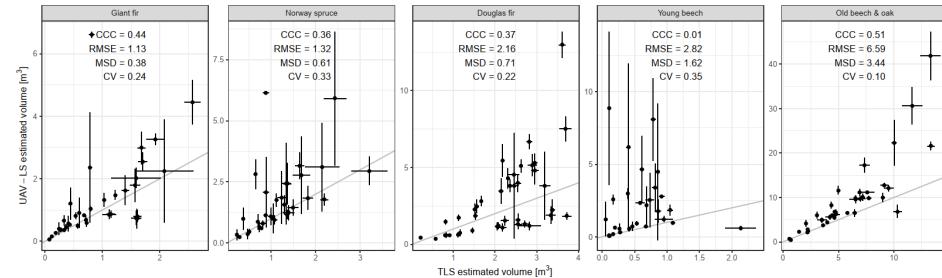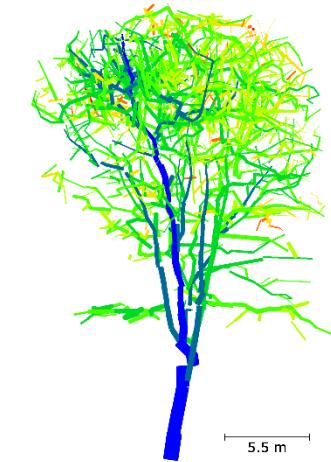
Brede et al. (2019)

Objectives

- Explore modelling strategies based on field inventory, TLS and UAV-LS to predict individual tree AGB

  – Context of local reference site for calibration/validation

Data

Paracou (French Guiana, FG)

Robson Creek (Australia, RC)

Paracou (French Guiana)

Litchfield (LF)

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Speulderbos (NL)

Brede et al. (2022): in review
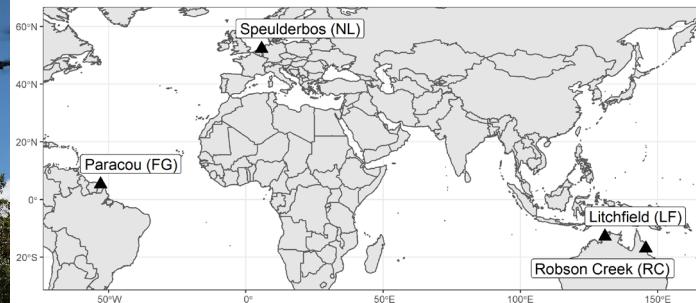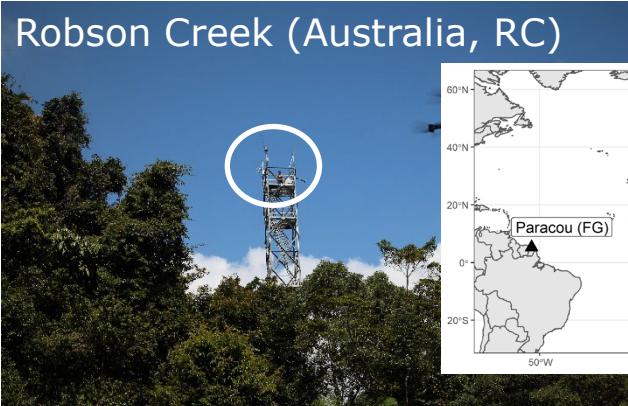
Data: TLS

- 199, 171, 191, and 310 samples for NL, FG, RC and LF

- NL: deciduous & coniferous species

- Processing: Leaf segmentation & QSM

Speulderbos (NL)
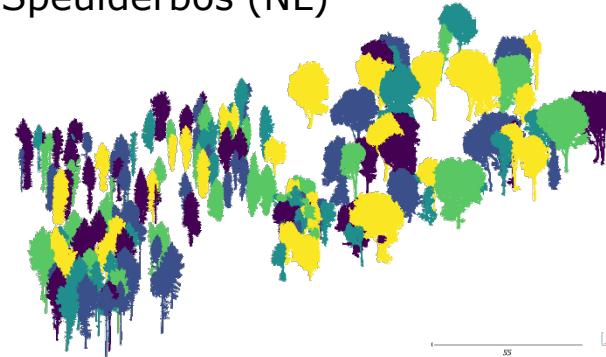
Litchfield (LF)
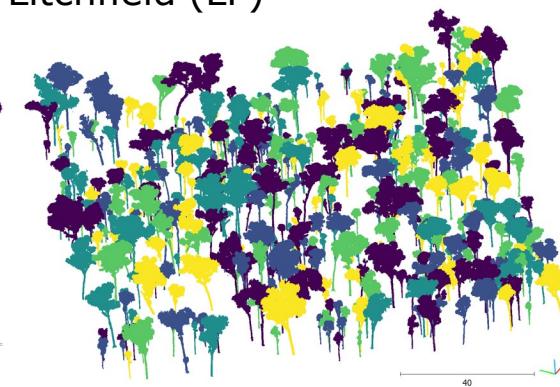
Robson Creek (RC)

Paracou (FG)
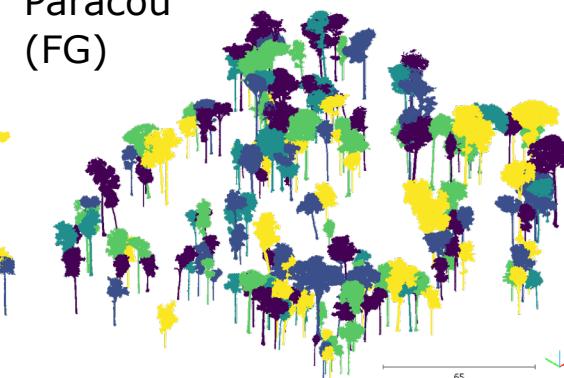
Data: UAV-LS

Litchfield
1 ha @ ø 3744 pts / m²
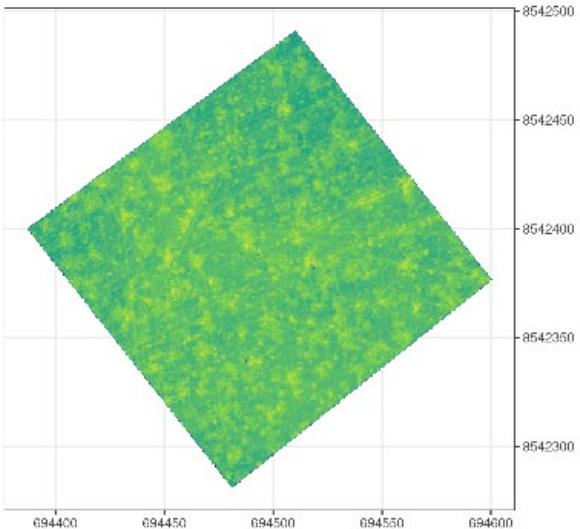
Speulderbos
~2 ha @ ø 3798 pts / m²
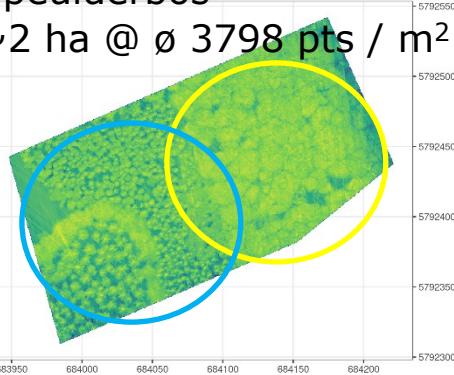
Paracou
4 ha @ ø 10090 pts / m²

Robson Creek
1 ha @ ø 4459 pts / m²

Density 10^1 10^2 10^3 10^4
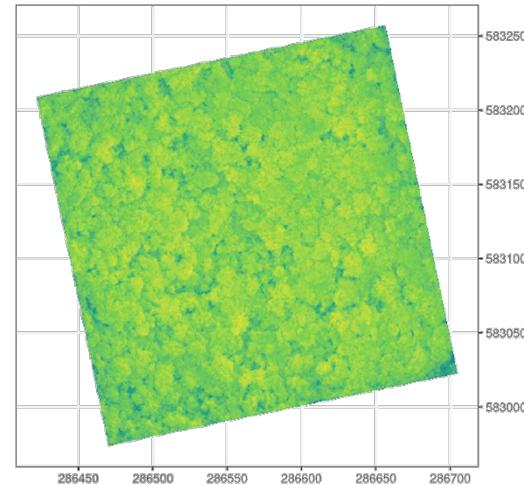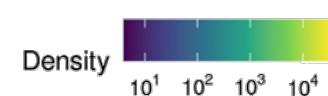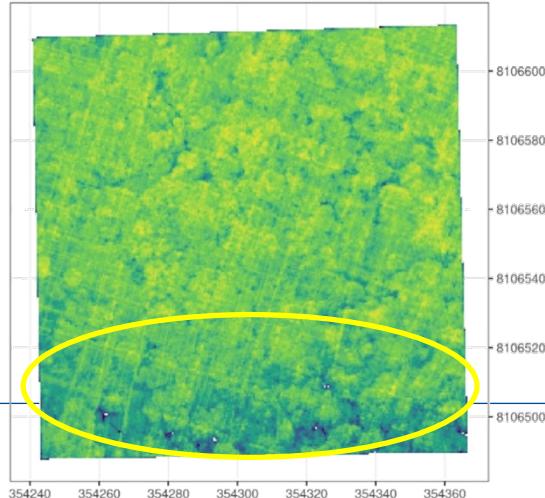
Brede et al. (2022): in review

Data: UAV-LS

J = 0.05

J = 0.29

J = 0.60

Raumonen et al. (2021): DOI:10.1109/IGARSS47720.2021.9554346
Brede et al. (2022): in review
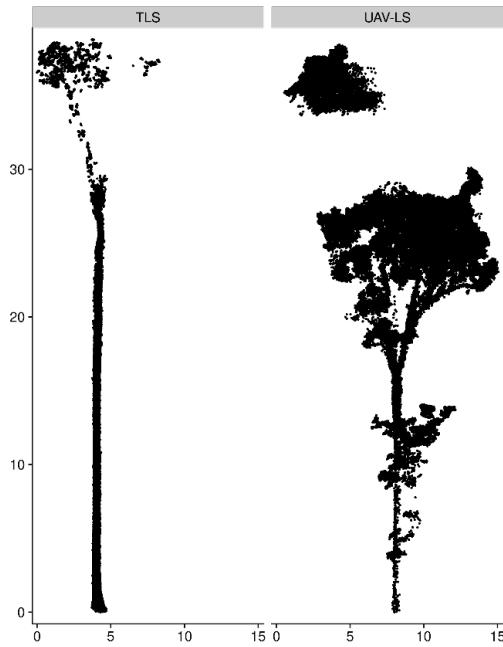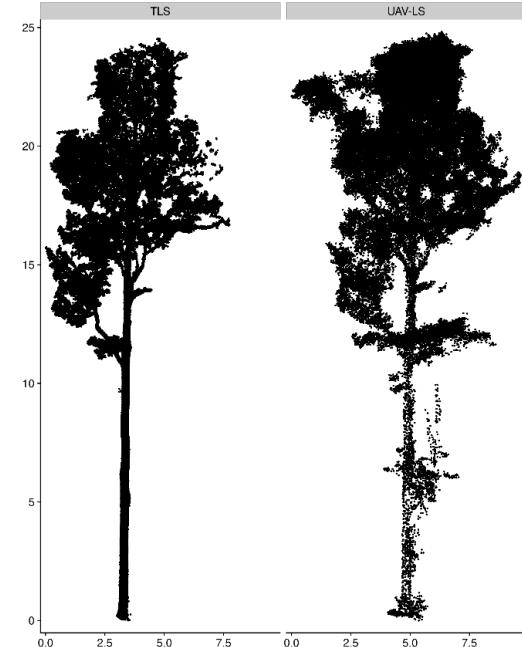
Methods: tree parameters

Graph edge length (GEL)

Crown diameter (CD)

Height (H100) Jucker *et al.*, 2017

DBH
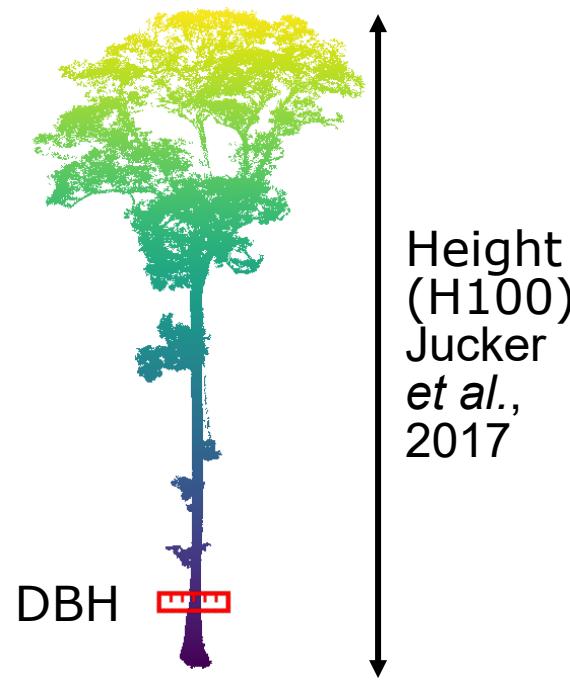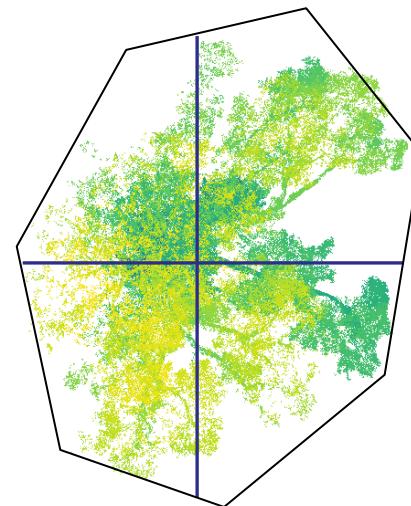
Crown Area (CA) Meyer *et al.*, 2018

Methods

- DBH as strong & reliable predictor

- Effect of segmentation on parameter accuracy

Brede et al. (2022): in review
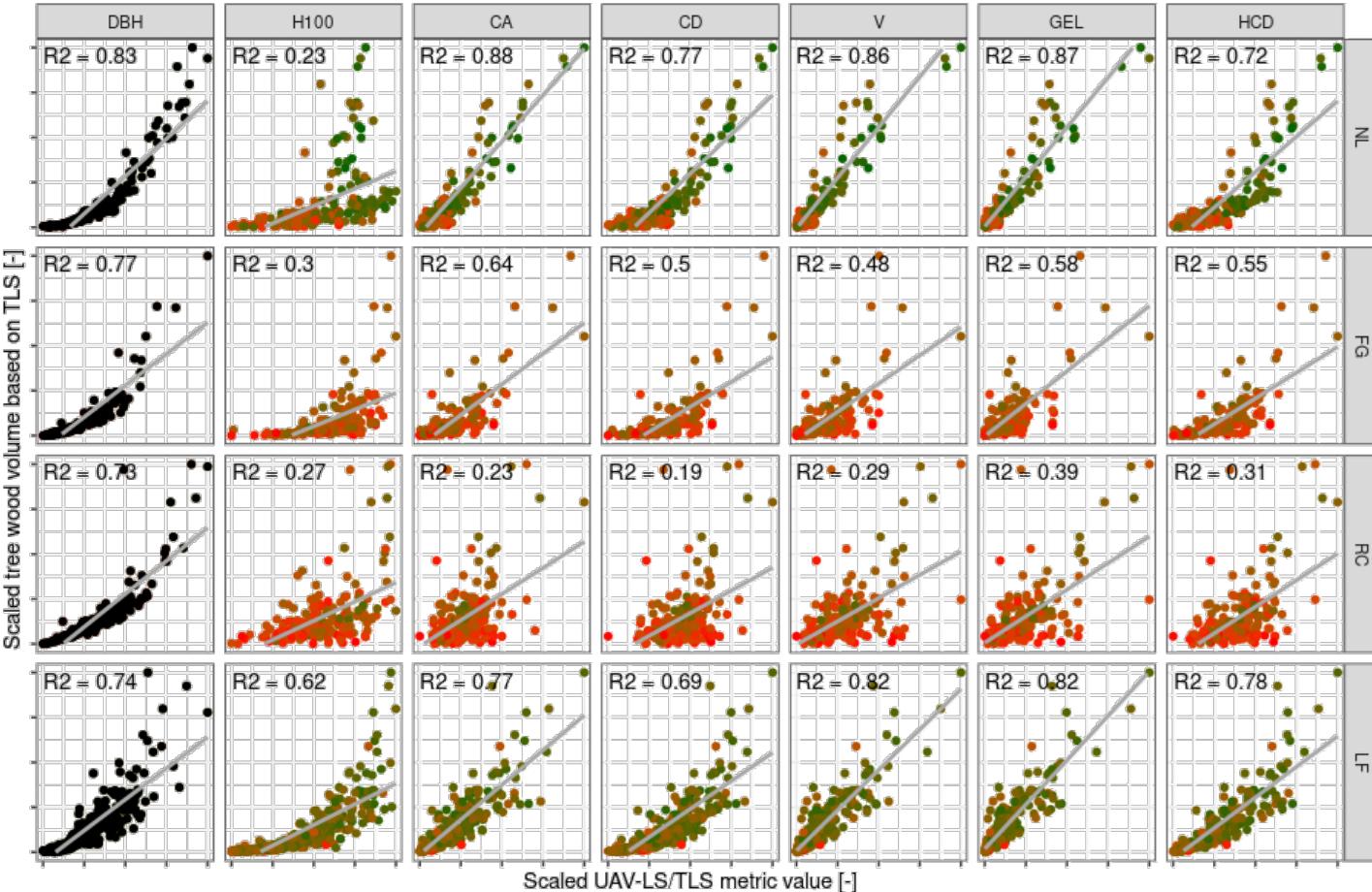
Methods: modeling approaches

- A: field inventory

$$ln(AGB) = \alpha + \beta ln(\rho D^2 H) + \epsilon$$

- B: parametric for UAV-LS (Jucker et al., 2017)

$$ln(AGB) = \alpha \times \beta ln(H \times CD)$$

- C: non-parametric for UAV-LS

  AGB ~ all parameters with Random Forest

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Methods: validation

- Leave-one-out-Validation

- Simulate errors when only n samples are available for model calibration

Jucker et al. (2017). DOI:10.1111/gcb.13388
Brede et al. (2022): in review
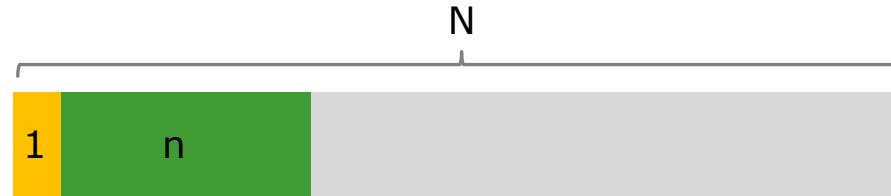
Results

- Inventory-based (A) with lowest RMSE

- Parametric (B) and non-parametric (C) modelling with UAV-LS with similar RMSE

- Effect of segmentation
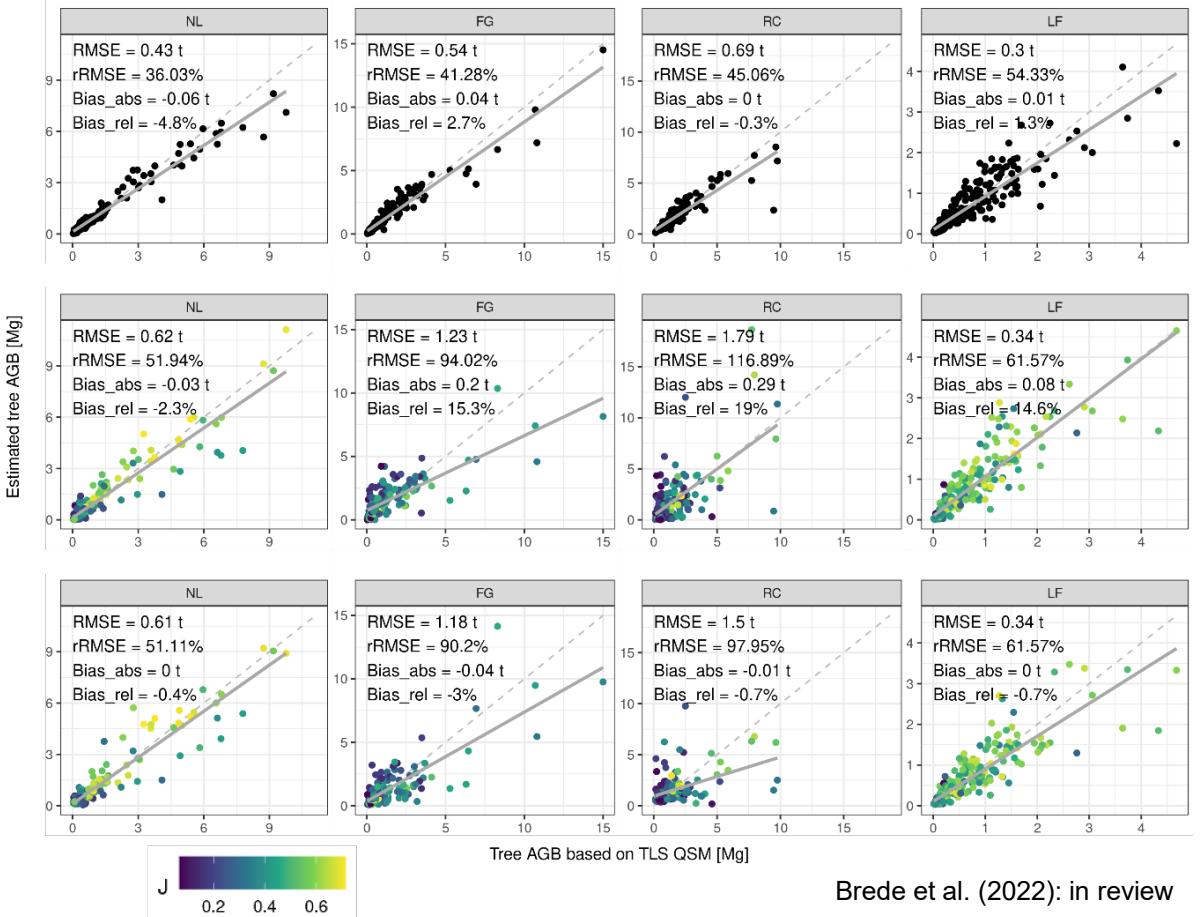
Brede et al. (2022): in review

Results

- Continuous low RMSE for field-inventory: power of DBH as predictor for AGB

- Possible bias with parametric modelling

- Non-parametric modelling can achieve bias <5% with N>50
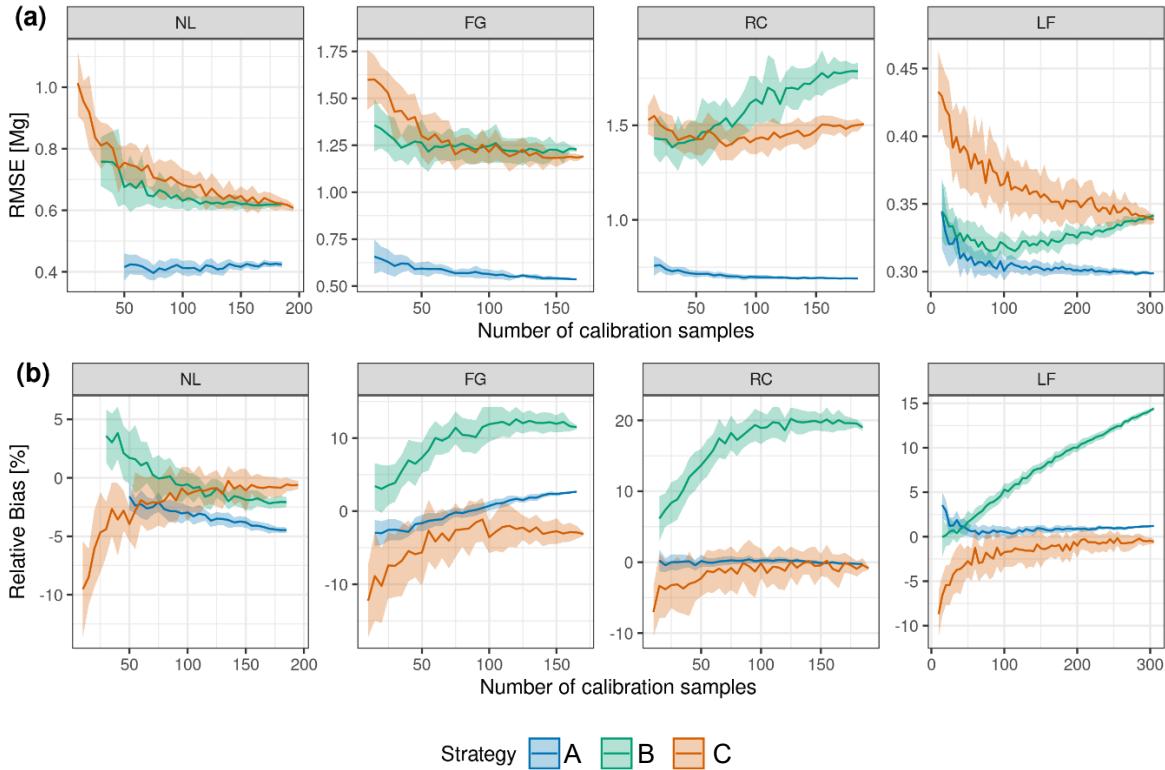
Brede et al. (2022): in review

Discussion

- Reproduceable workflow when new algorithms become available (e.g., segmentation, QSM)

- Species information needed for wood density estimation

- Need for investigation:
  omission / commission errors for automatic segmentation > relevant for plot scale AGB

Thank you for your attention!

Acknowledgements

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