‘Towards’

Estimating Tropical Forest Biomass and its Change by Means of Multi-Mission / Multi-Scale Structure Measurements

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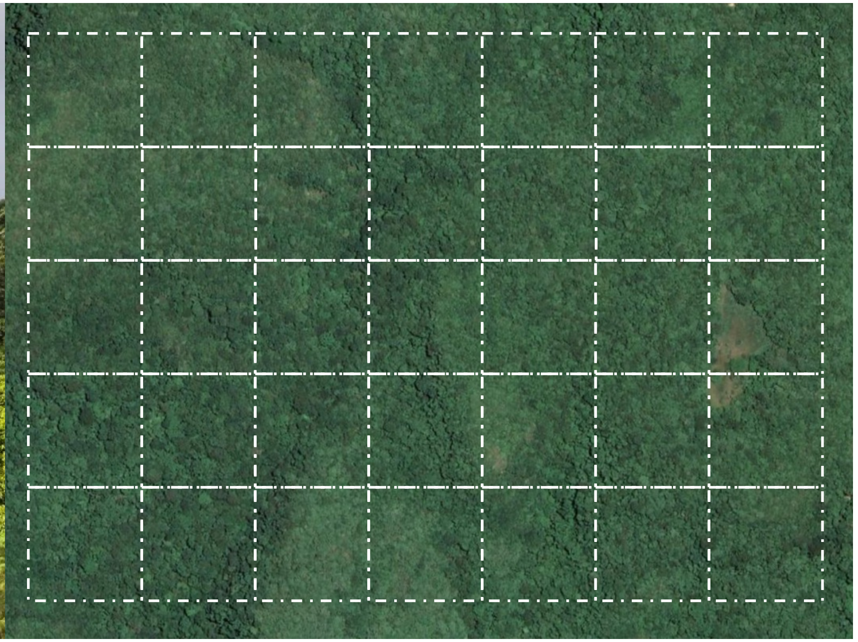
[1] Ludwig-Maximilians-Universität München (LMU)
[2] Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)
[3] Eidgenössische Technische Hochschule Zürich (ETH)
[4] Helmholtz Centre for Environmental Research (UFZ)

The Allometric Function

Single Tree Biomass

$$B_{tree} = V_{trunk} * \rho$$

Forest Stand Biomass



$$B_{stand} = \alpha_0 * CH^{\beta}$$

The Allometric Function

H (Upper) Canopy Height

α Allometric Factor:
- Density variations

β Allometric Exponent
- Species Composition
- Growing Conditions

$$AGB = \alpha_0 * H^{\beta}$$

25 m

GEDI ECOSYSTEM LIDAR

α_0, β

100 - 200 m

biomass

H

The Scale Issue?

200 m

biomass

Constant:

$$AGB = f(\alpha_0, \beta, H)$$

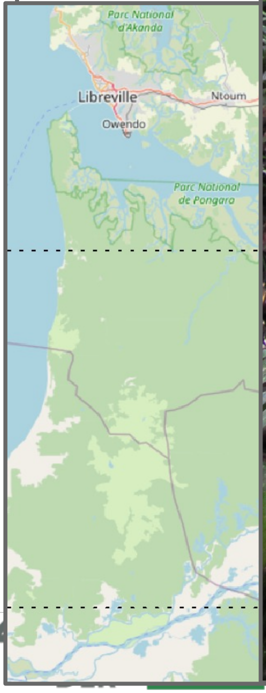
GEDI
ECOSYSTEM LIDAR

25 m

Datasets

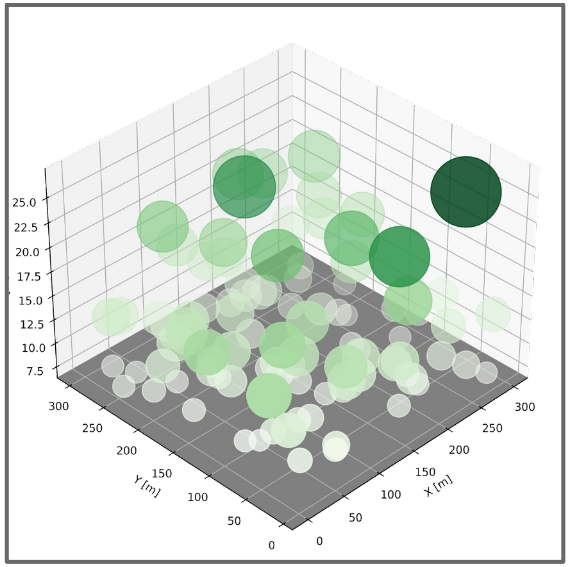
NASA LVI

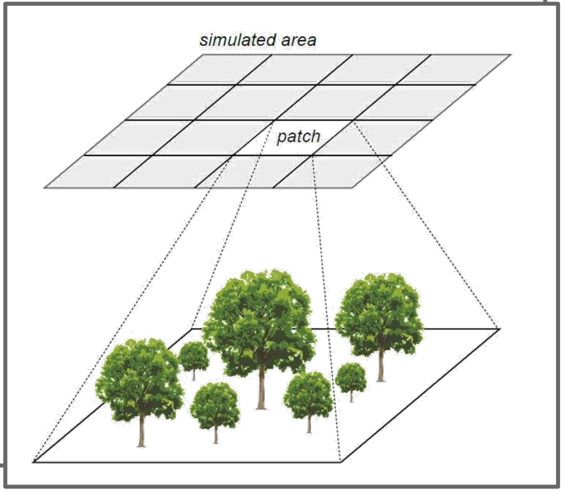
- **Contin**
- **25m m**
- Raw W
- **This D central**
- **Monso**



UFZ FORMIND

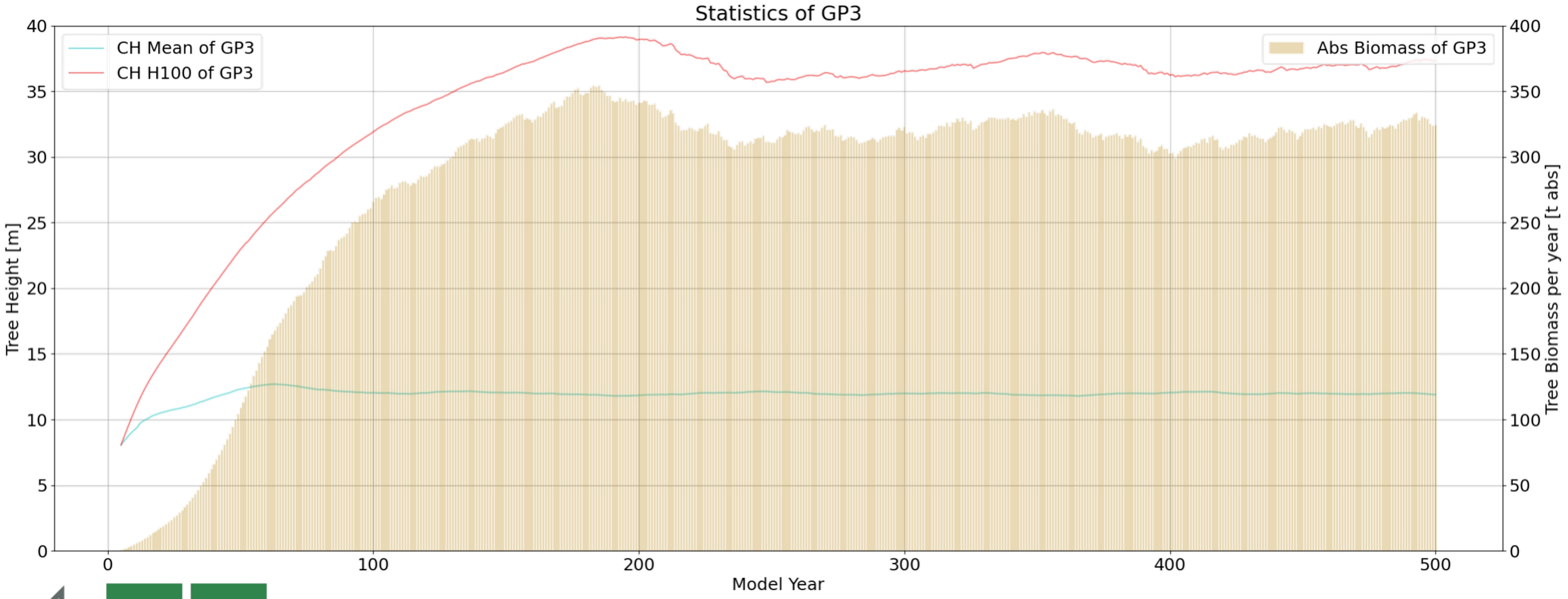
- **Individual tree based forest gap model**
- Each tree is calculated individually, in **high diversity forests, 500 years available**
- **Simulated Disturbances**: fire, landslides, logging or drought





Which Tree Height?

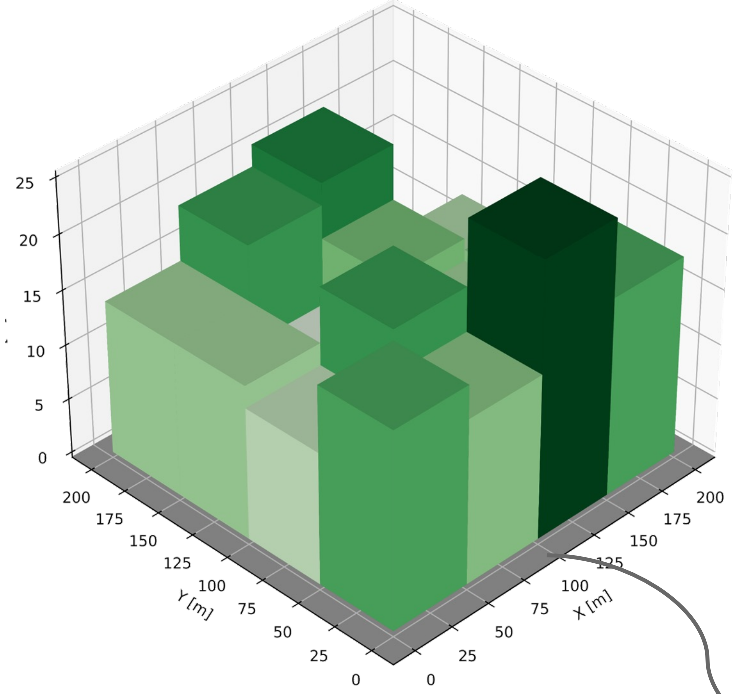
FORMIND Simulation Data for PFT3:



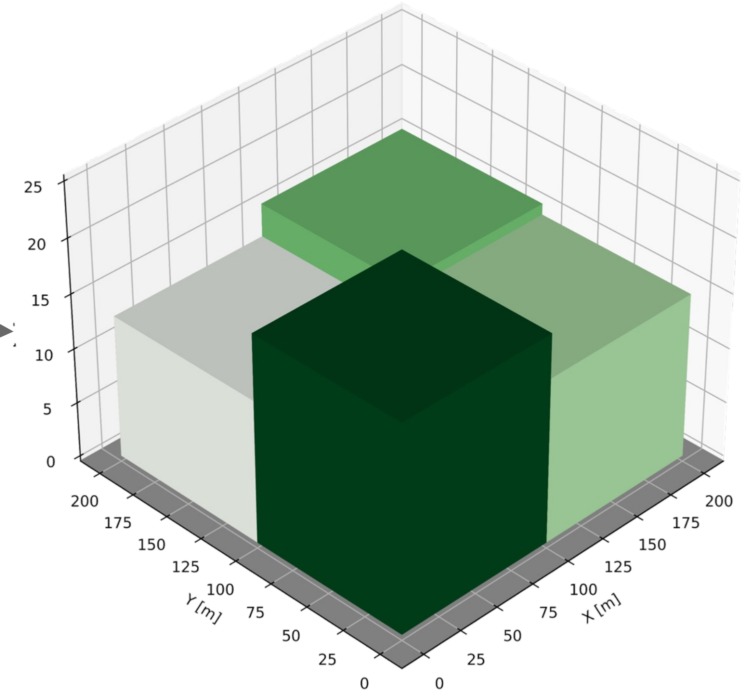
Sampling Process

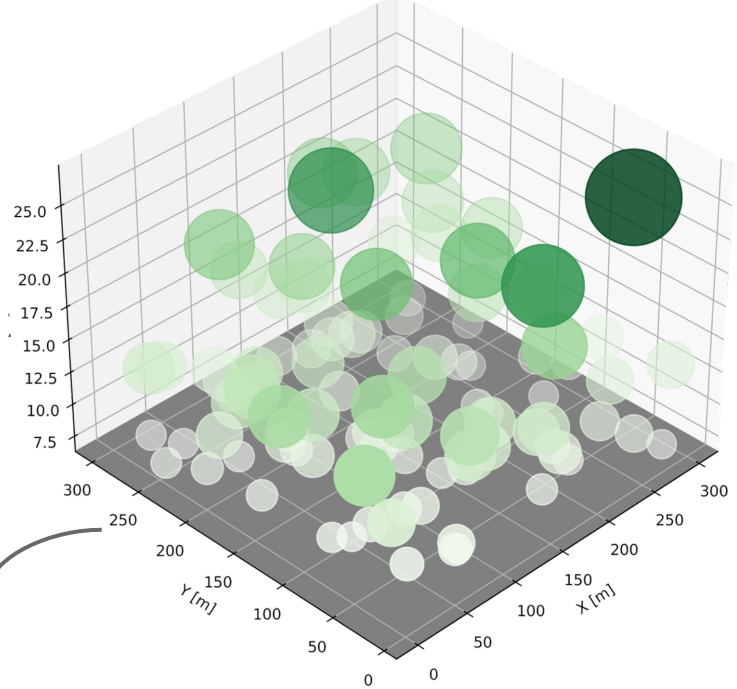
$$CH_{avg} = avg(TH)$$

$$CH_{H100} = avg\left({}^{TH_{100}}/_{ha}\right)$$



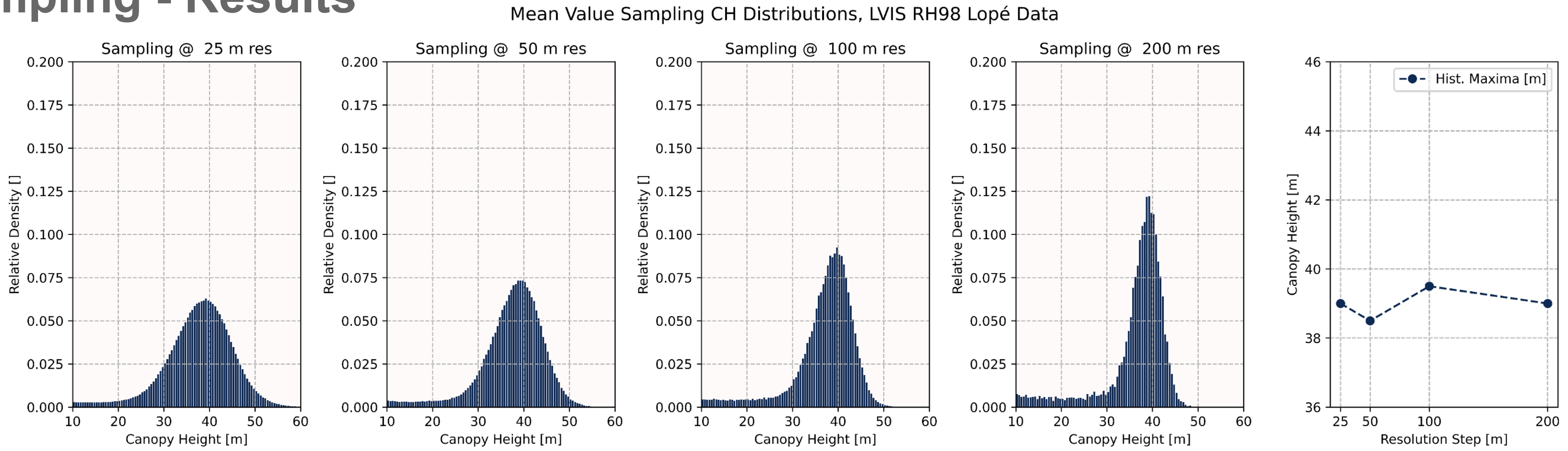
$$CH_{H100\,approx.} = avg(TH_{25\%})$$



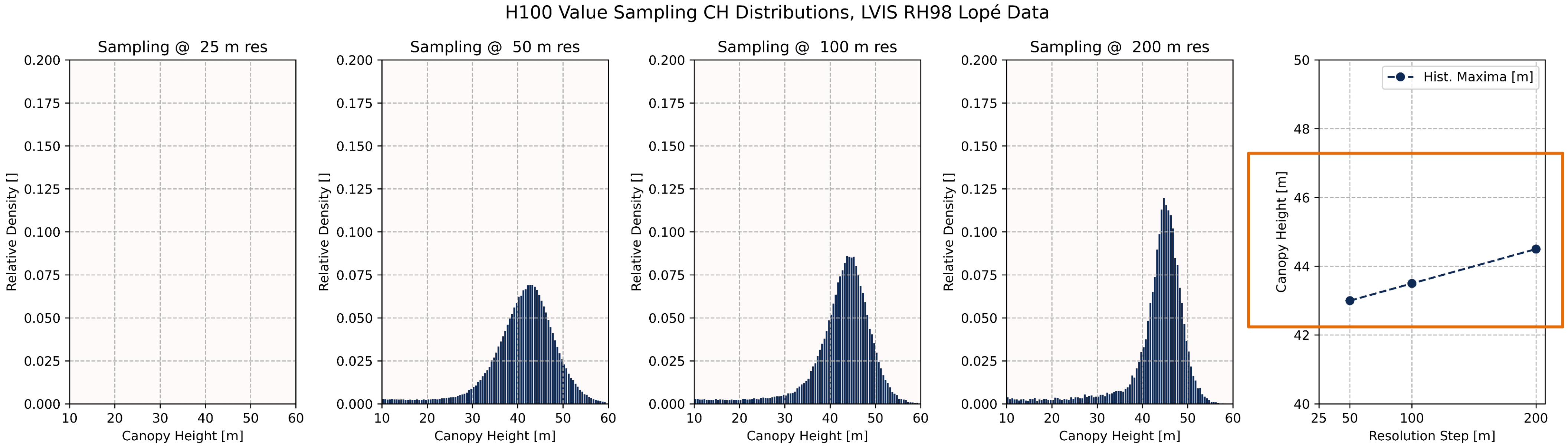


Resampling - Results

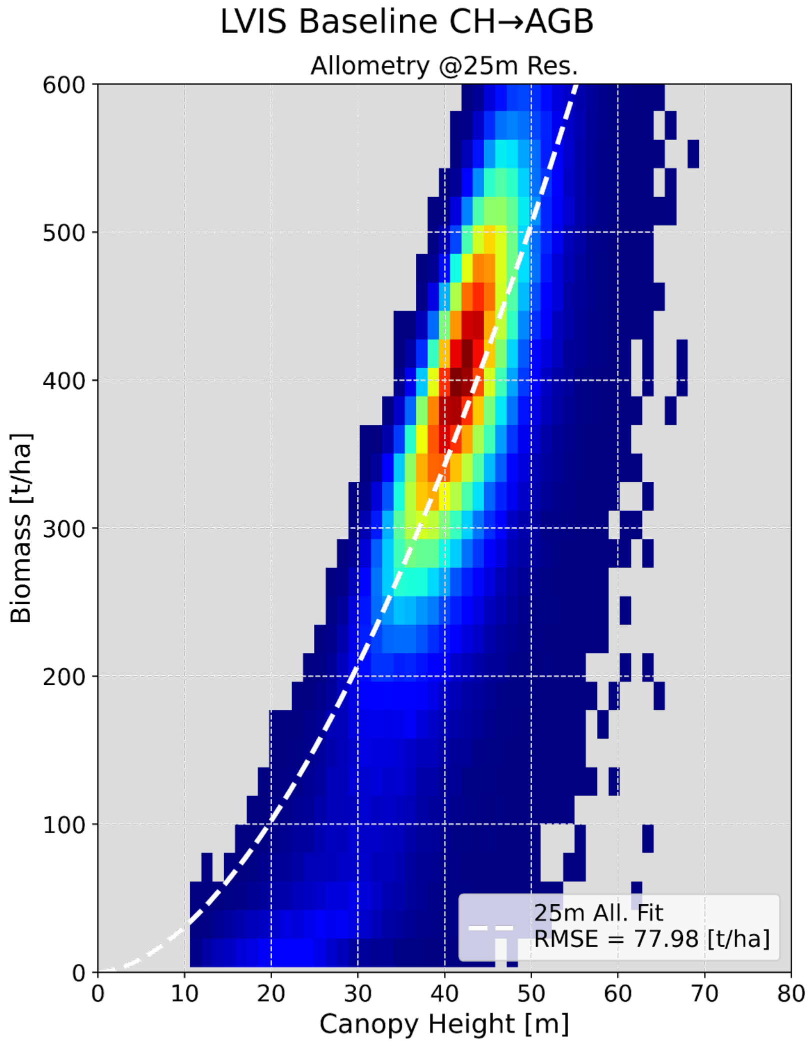
mean()

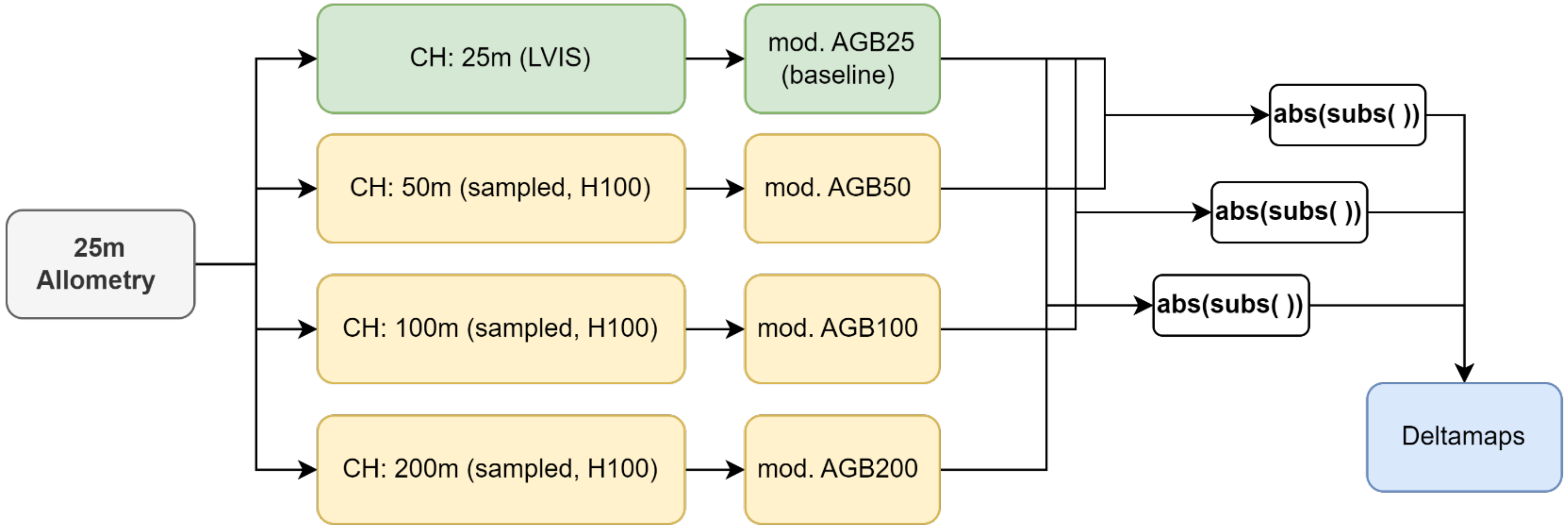


H100()

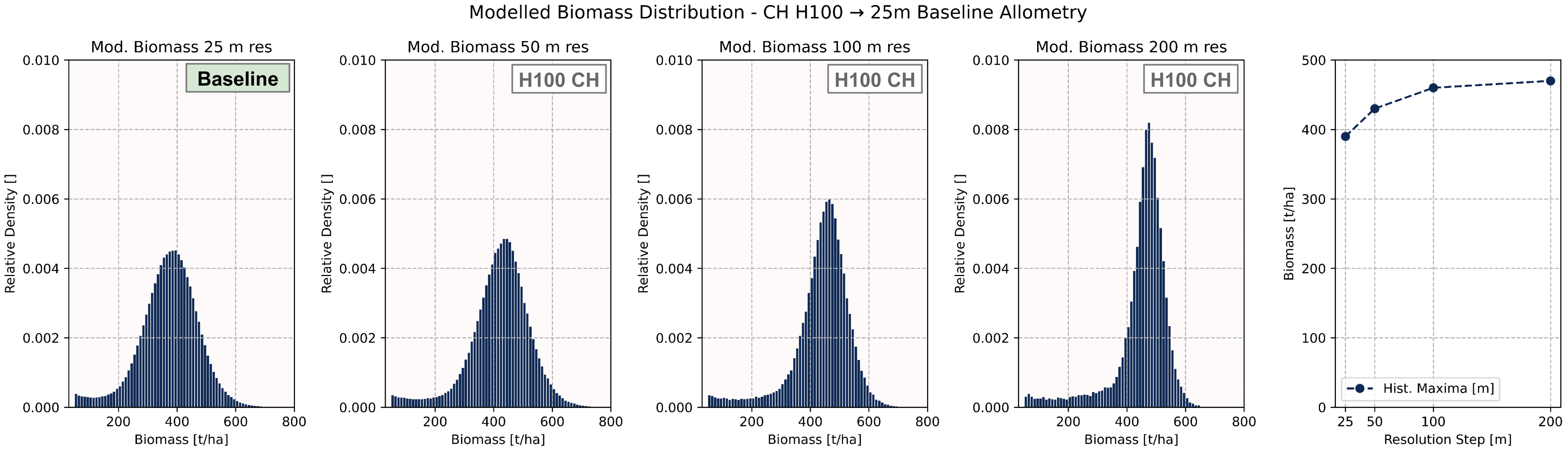


Scale Induced Biomass Change



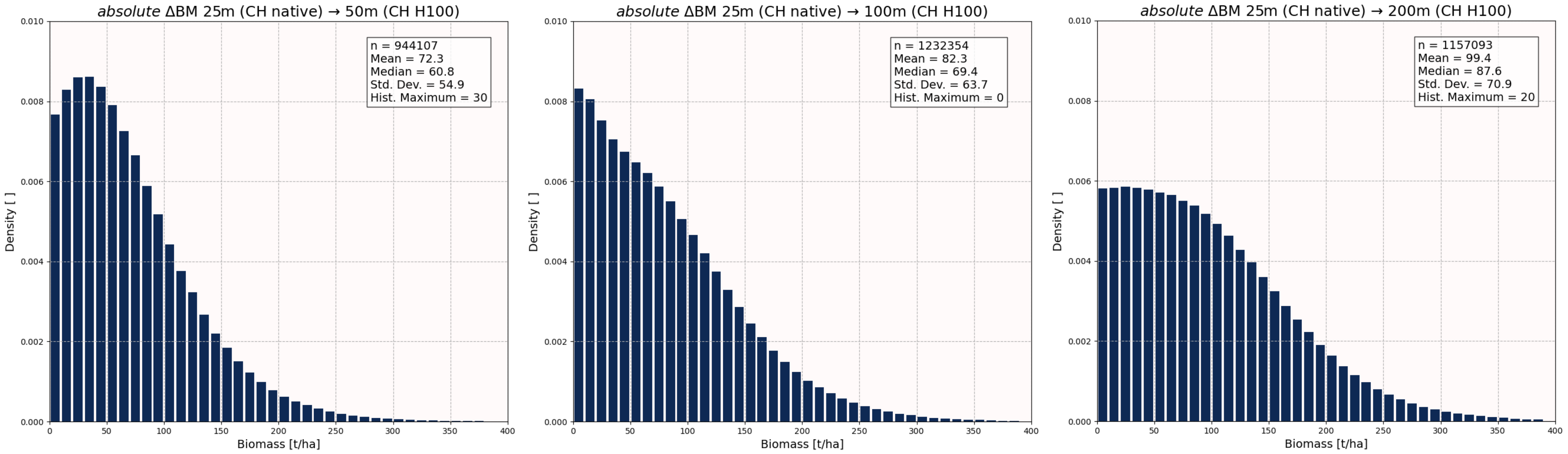


Scale Induced Biomass Change



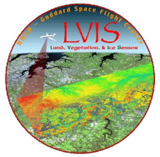
Scale Induced Biomass Change

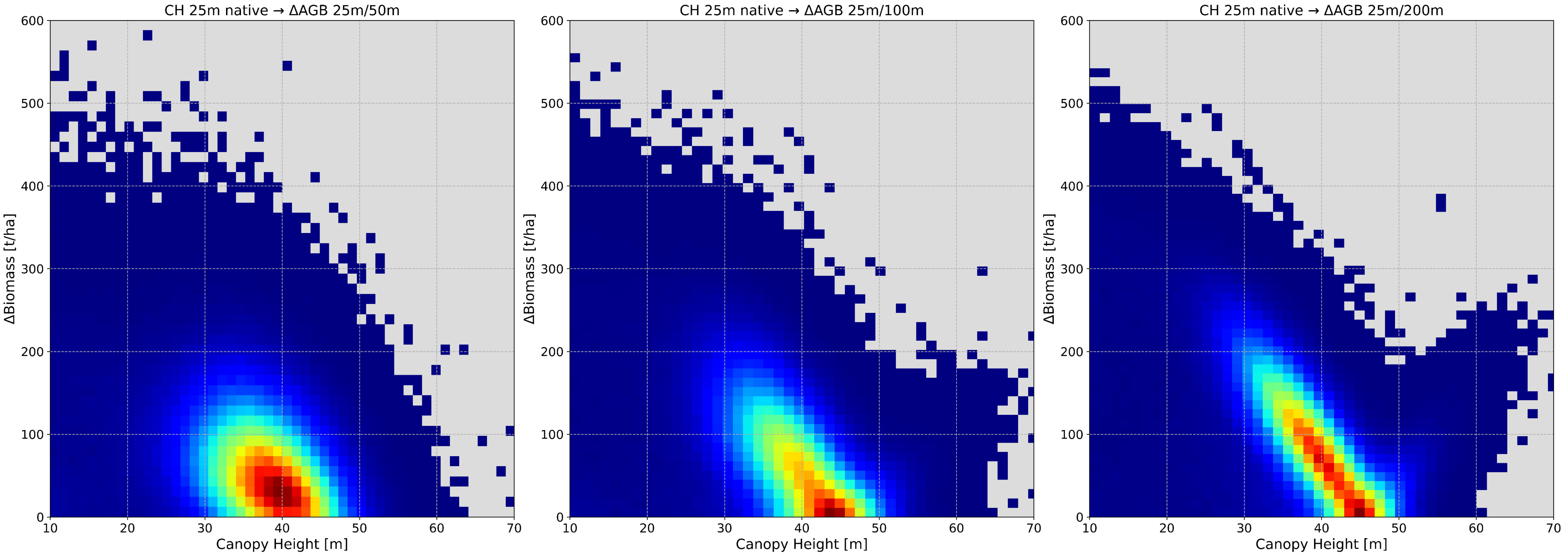
$$abs(\Delta BM \left[{}^{t}/_{ha}\right])$$



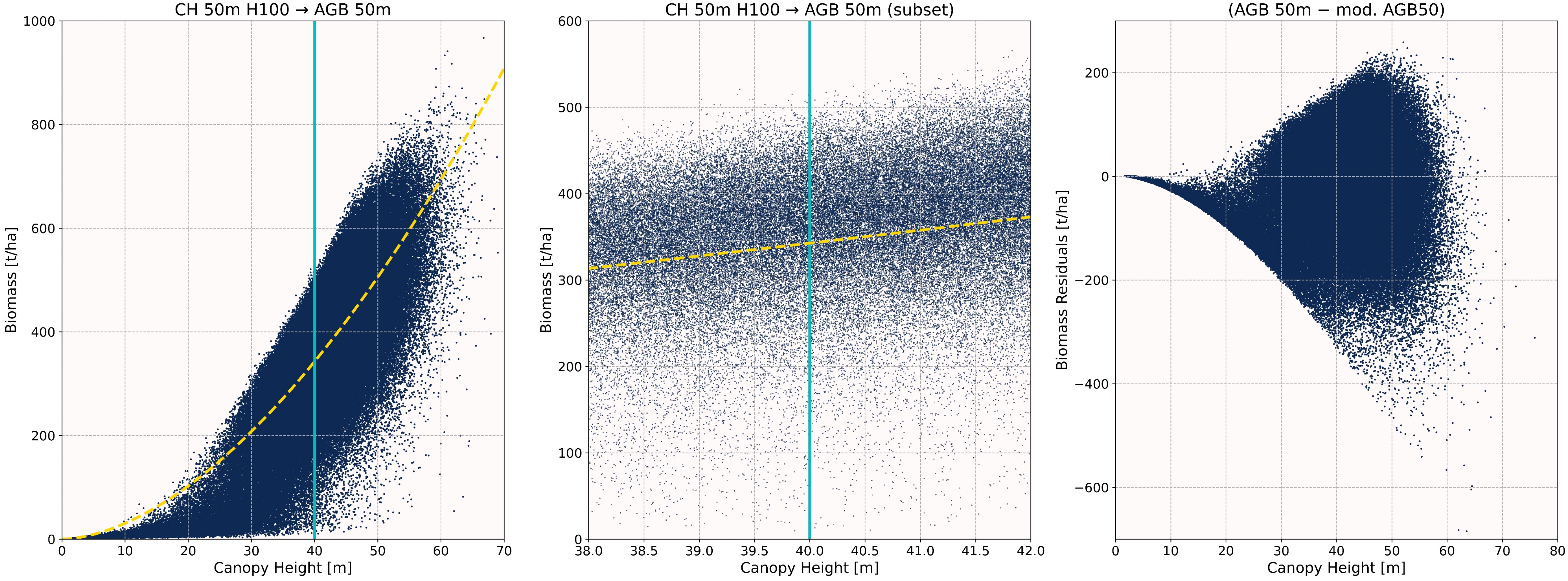
Scale Induced Biomass Change

$$abs(\Delta BM\ [{}^{t}/_{ha}])$$

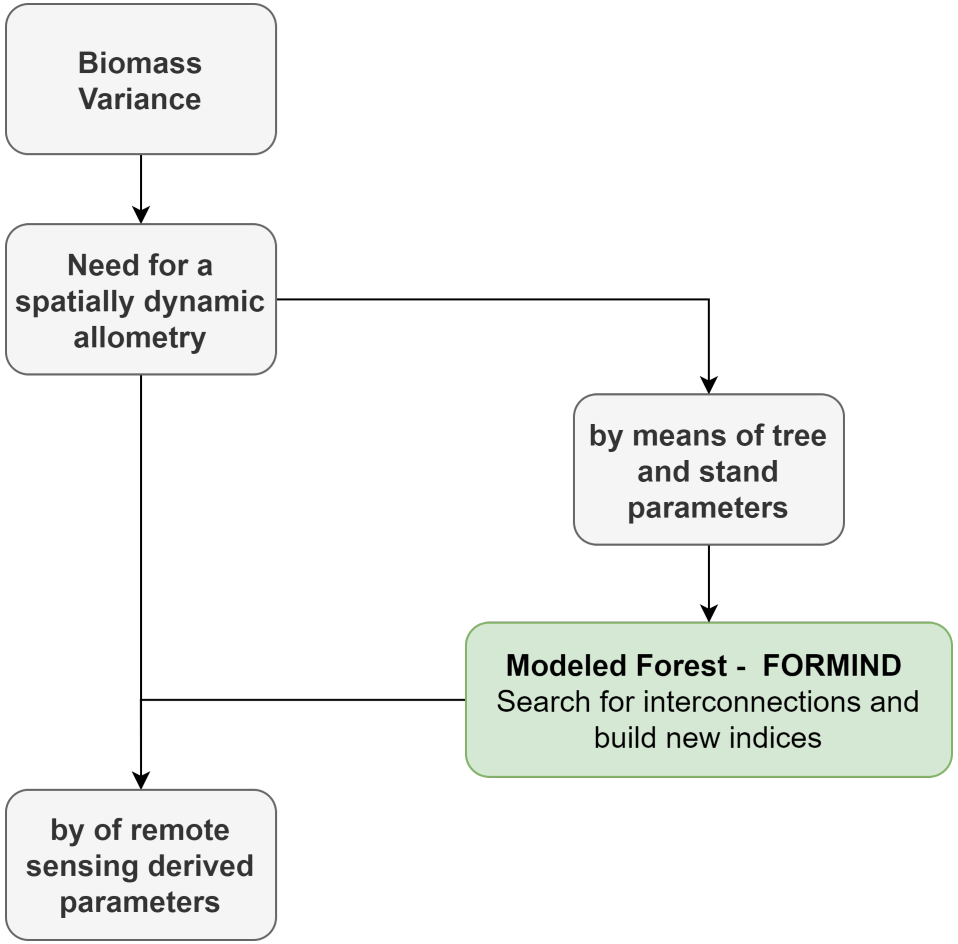


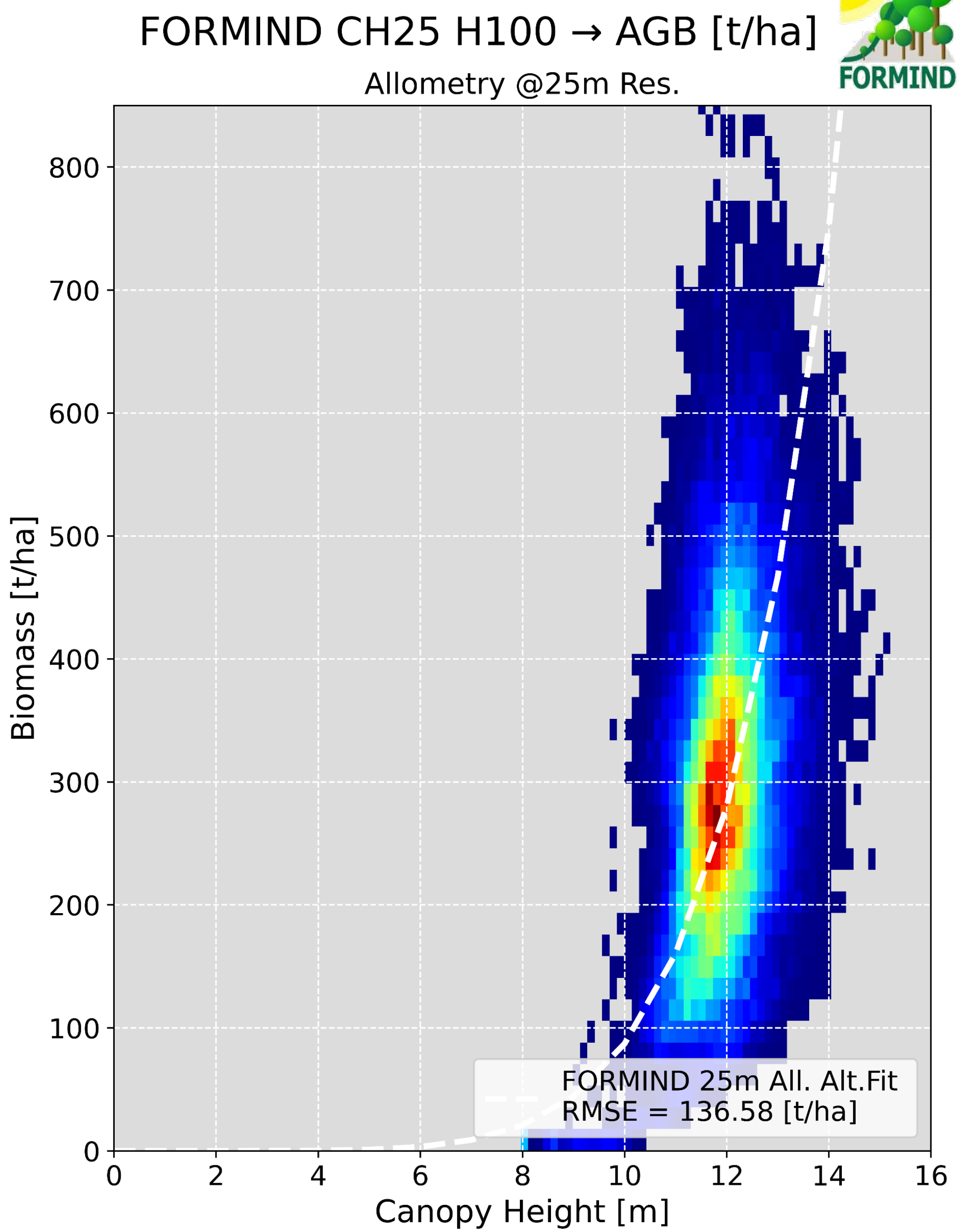


Biomass Variance & Residuals

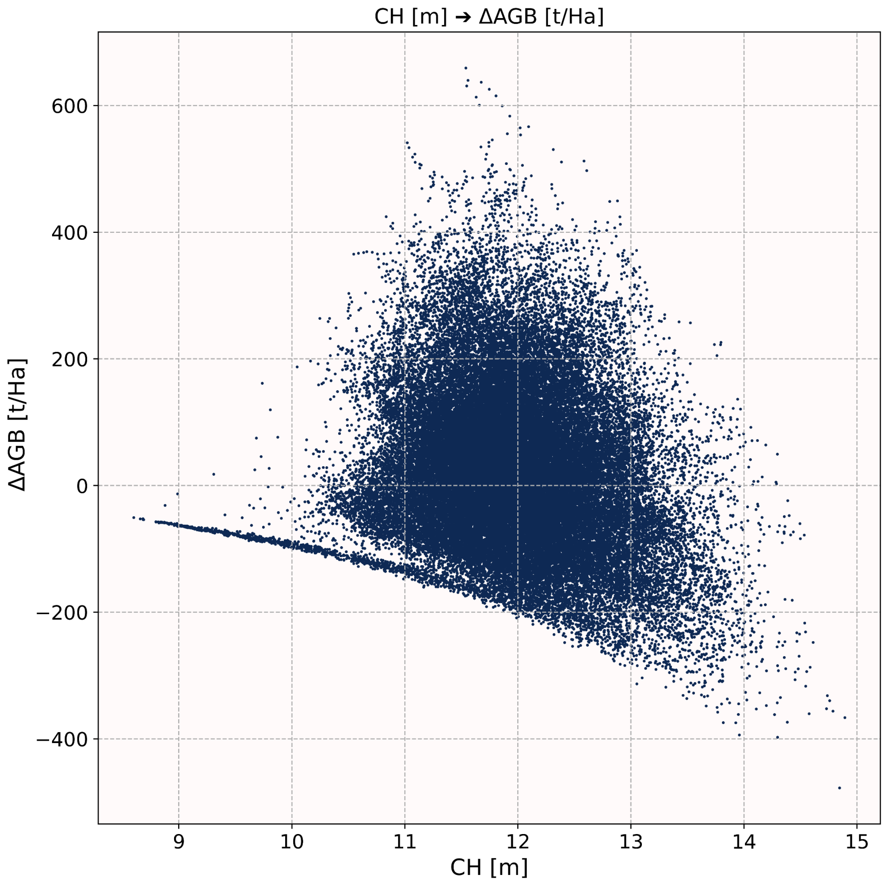


Biomass Variance - How do we proceed?



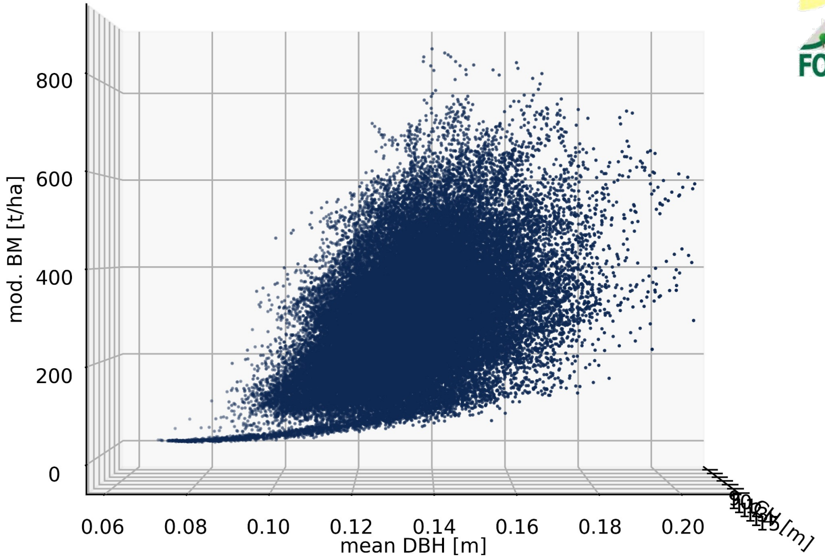


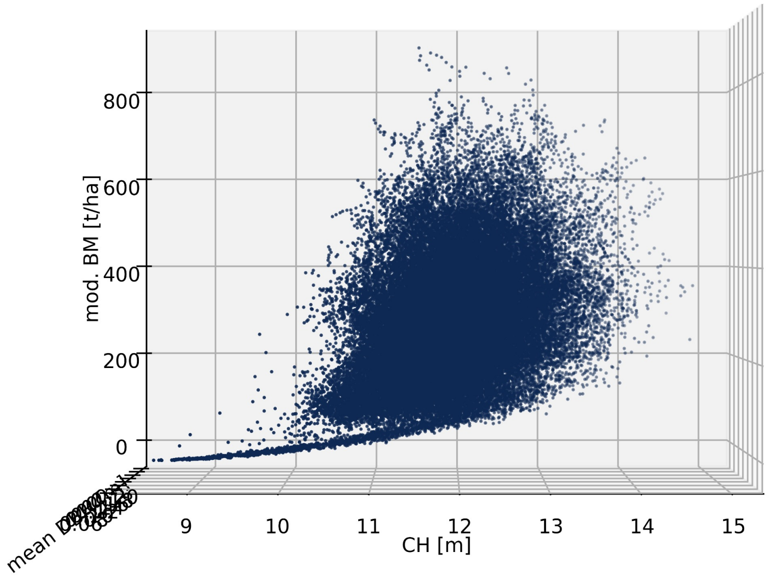
Multivariate Statistics

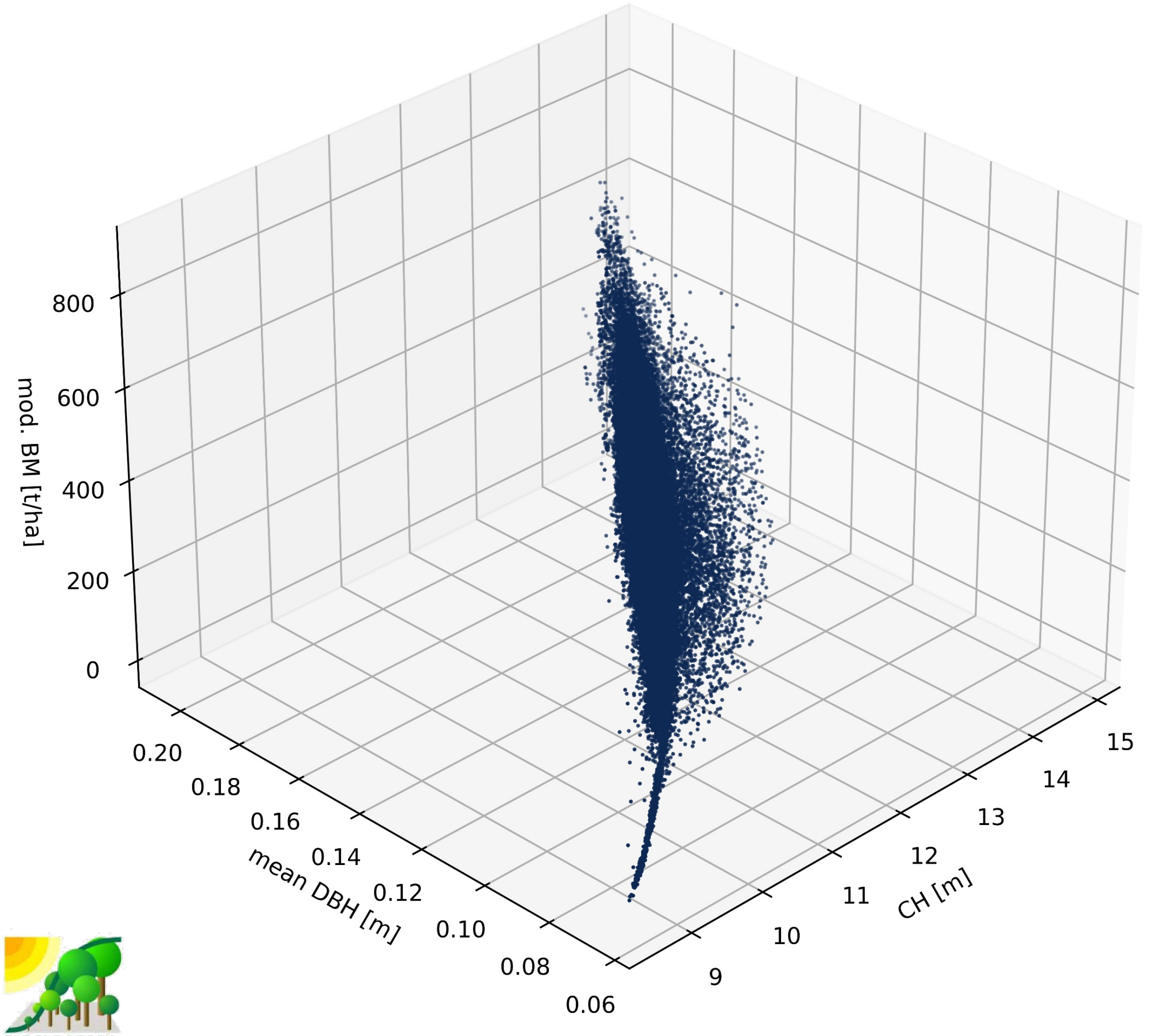


Additional Parameters

- **DBH**
- **Crown Radius**







Mod1

$$AGB = \alpha * CH^{\beta}$$

$$\log AGB = \log \alpha + \beta * \log CH$$

➢ $R^2 = 0.22$

Mod2

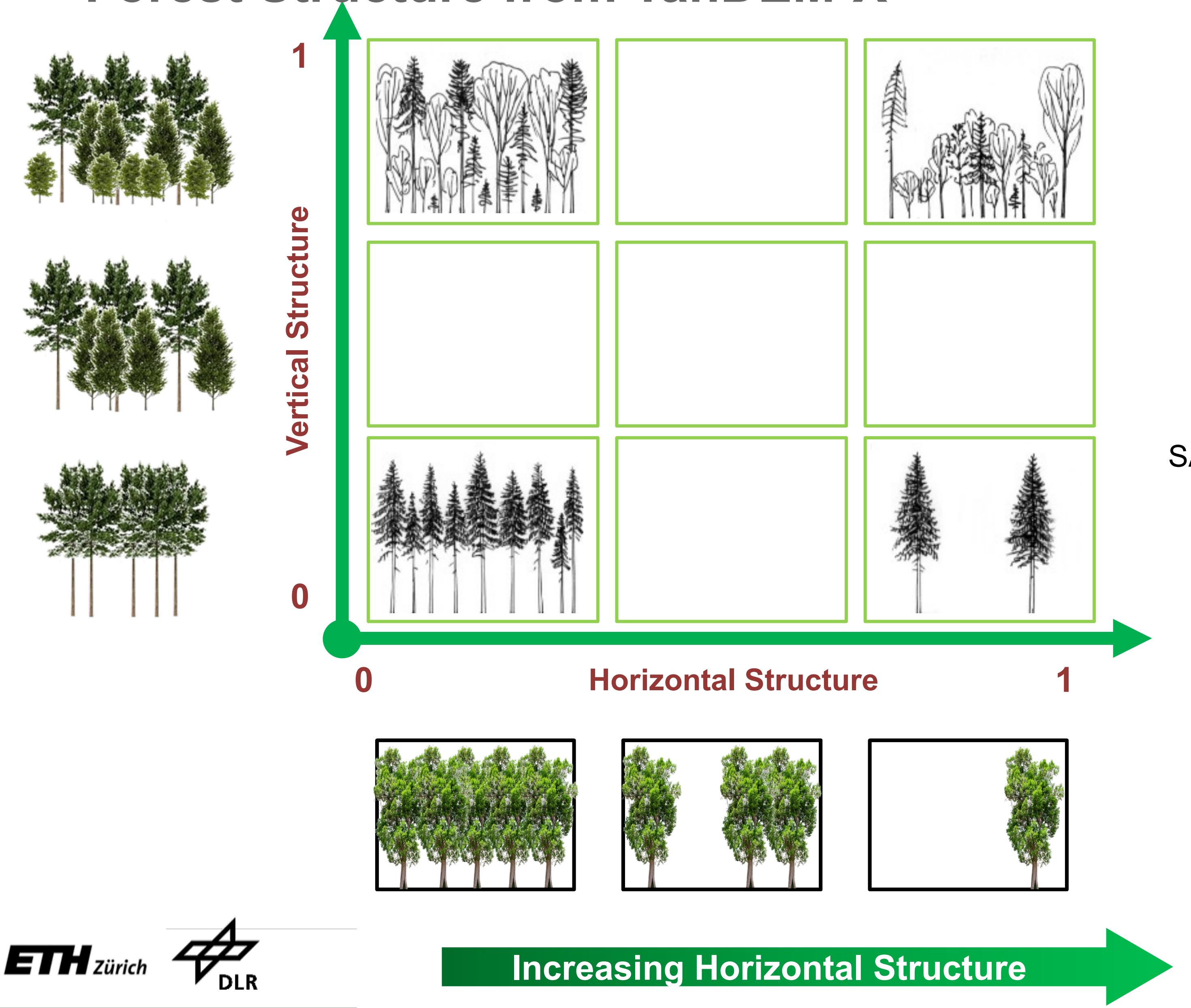
$$AGB_{new} = \alpha * DBH^{\gamma} * CH^{\beta}$$

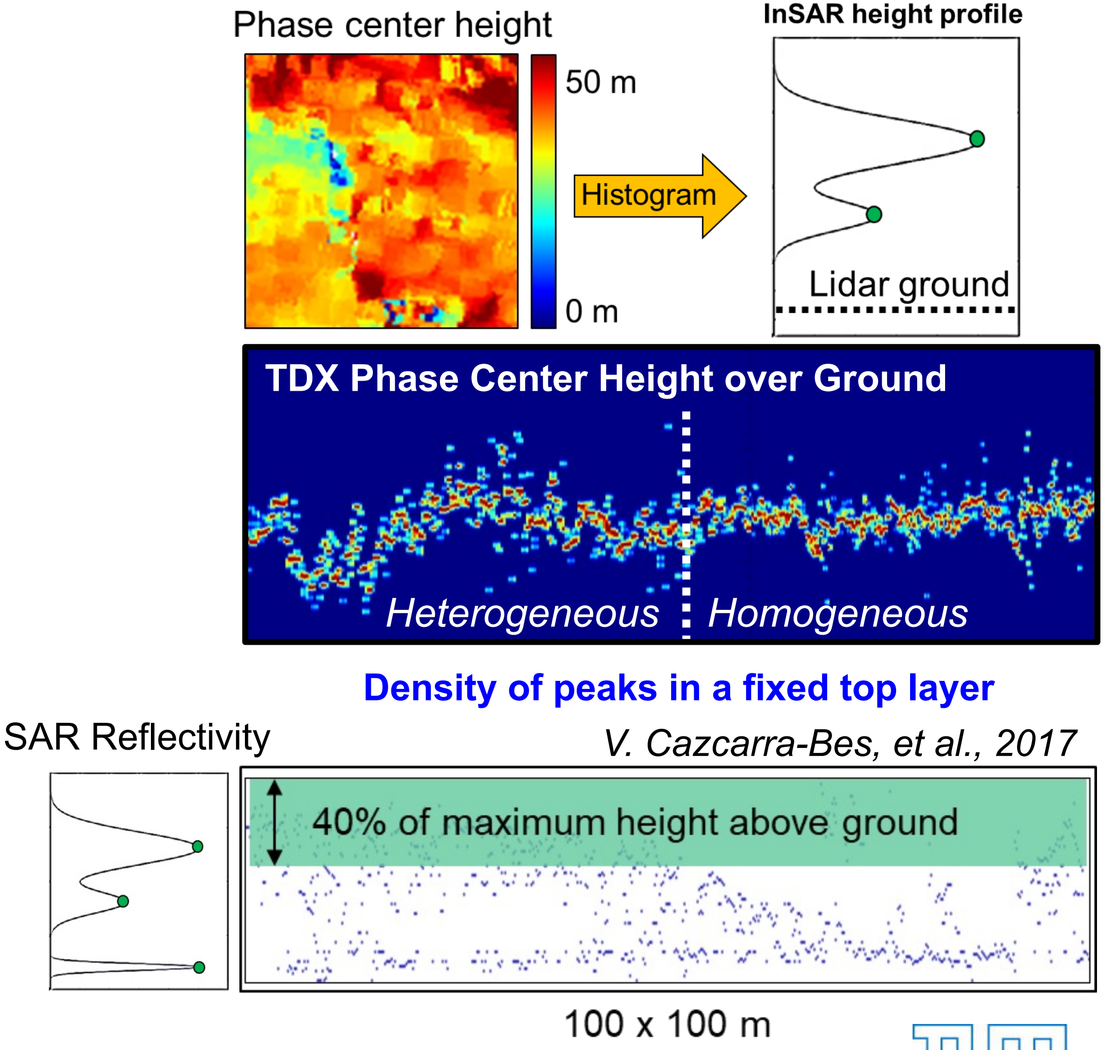
$$\log AGB = \log \alpha + \gamma * \log DBH + \beta * \log CH$$

➢ $R^2 = 0.39$

FORMIND

Forest Structure from TanDEM-X





$$HS_0 = \frac{\text{count}\{\text{peaks top layer}\}}{\text{Area}}$$

$$HS = 1 - HS_0/\max(HS_0)$$

$HS = 0$ (Homogeneous. or dense)

$HS = 1$ (Heterogeneous or sparse)

Forest Structure from TanDEM-X

Increas

Wednesday

09:20 - 09:40 Estimating Forest Structure Change by Means of Wavelet Statistics · *(ID: 151)*

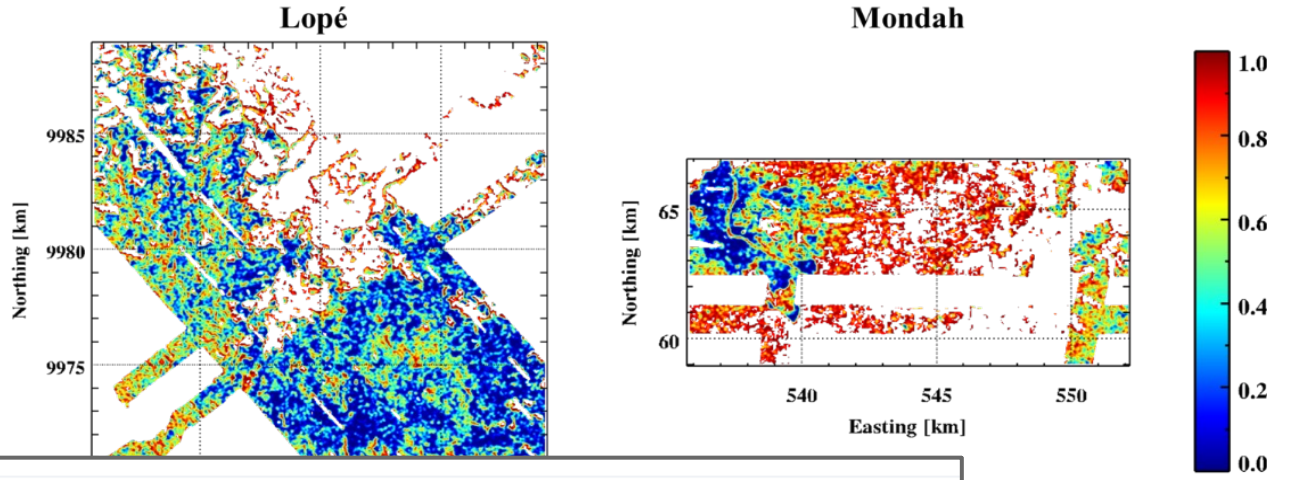
Presenting: Albrecht, Lea

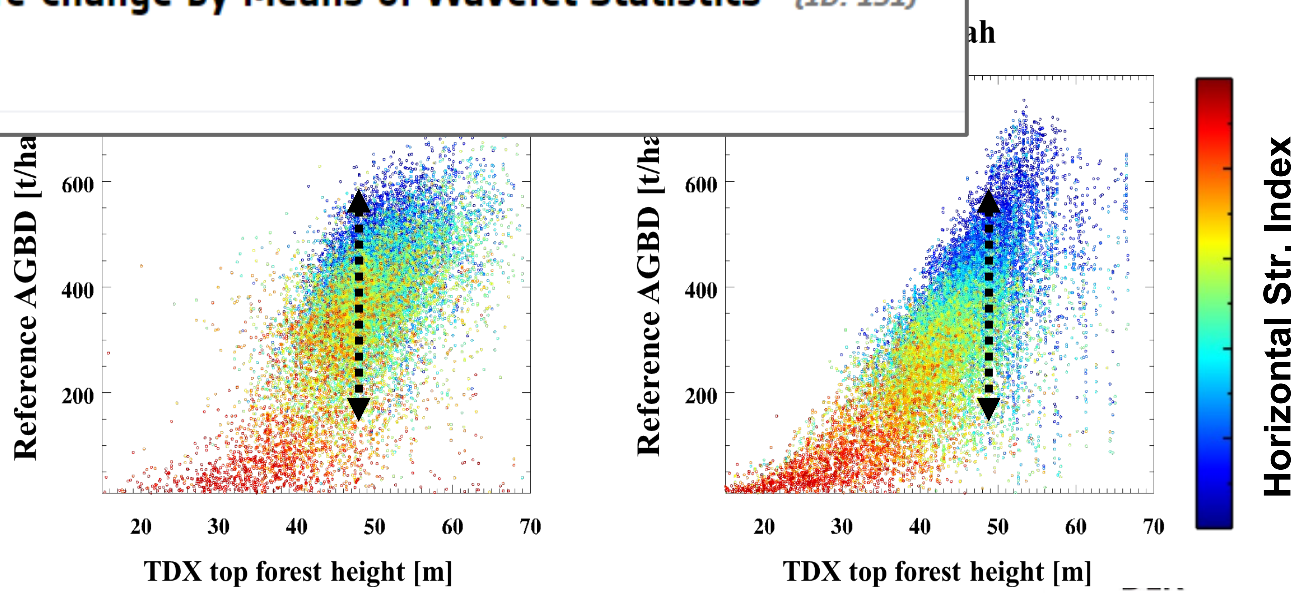
$\mathrm{HS}_0 =$ count

$\mathrm{HS} = 1 - \mathrm{HS}_0/\max(\mathrm{HS}_0)$

$\mathrm{HS} = 0$ (Homogeneous. or dense)

$\mathrm{HS} = 1$ (Heterogeneous or sparse)





Conclusion

Resampling / Rasterization Process:

- Top canopy height measurements is what Pol-InSAR height inversion allows;
- One possible way to express top canopy height is the H100 concept (based individual tree measures);
- Implementation / Approximation of H100 from raster data can be in different ways;
- H100 more sensitive to biomass than other height metrics yet proving more challenging when resampling.

Scale Induced Biomass Change:

- Scale dependency of the biomass when modeled with H100 data is weak but clearly visible
- Albeit the relatively small error (up to 80 t/ha), the scale induced change must be taken into consideration

Biomass Variance:

- Both LVIS and FORMIND datasets show very high biomass variances for the different canopy height classes;
- FORMIND proves as excellent tool to understand interconnections and possibly implement further multi-sensor remote sensing data to improve the allometric formula;
- A multivariate approach to improve the fit of the allometries proves to be a promising, albeit challenging pathway.

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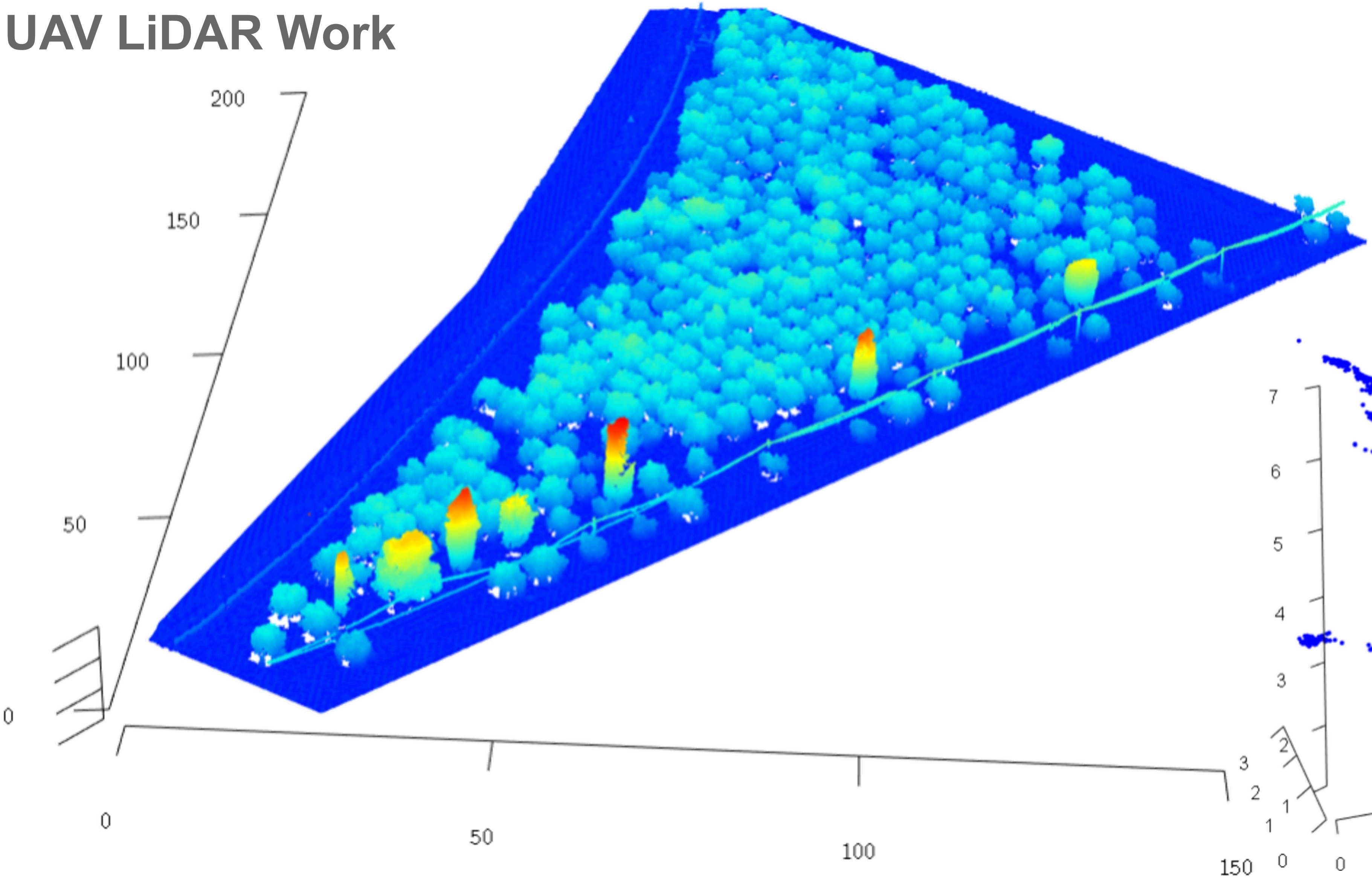
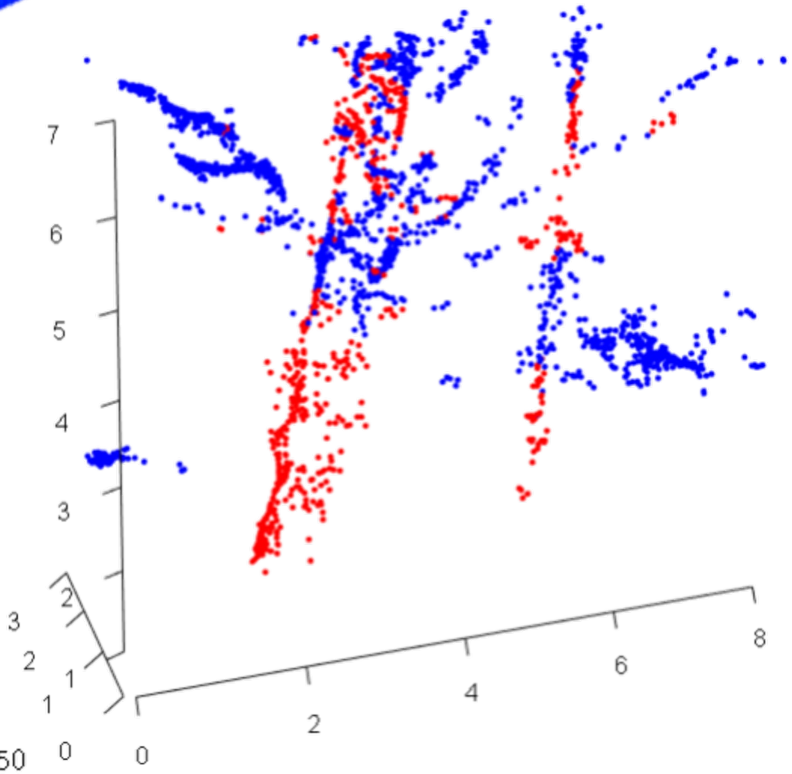
DLR

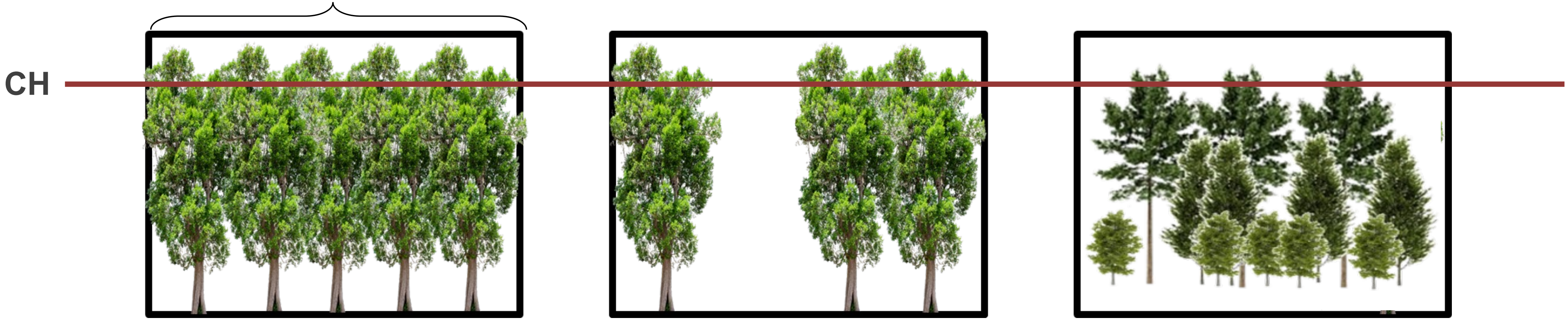
LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

UAV LiDAR Work

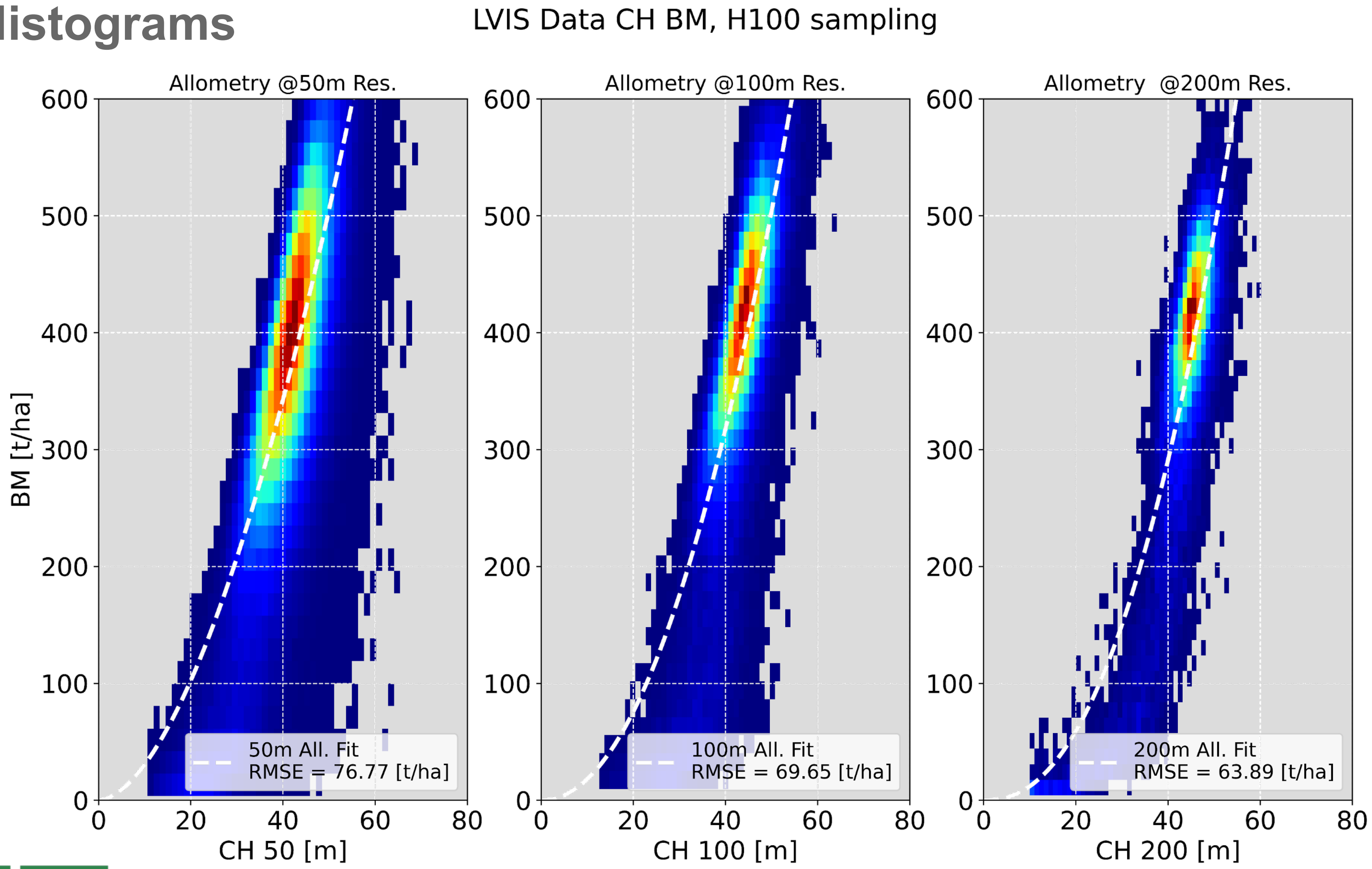




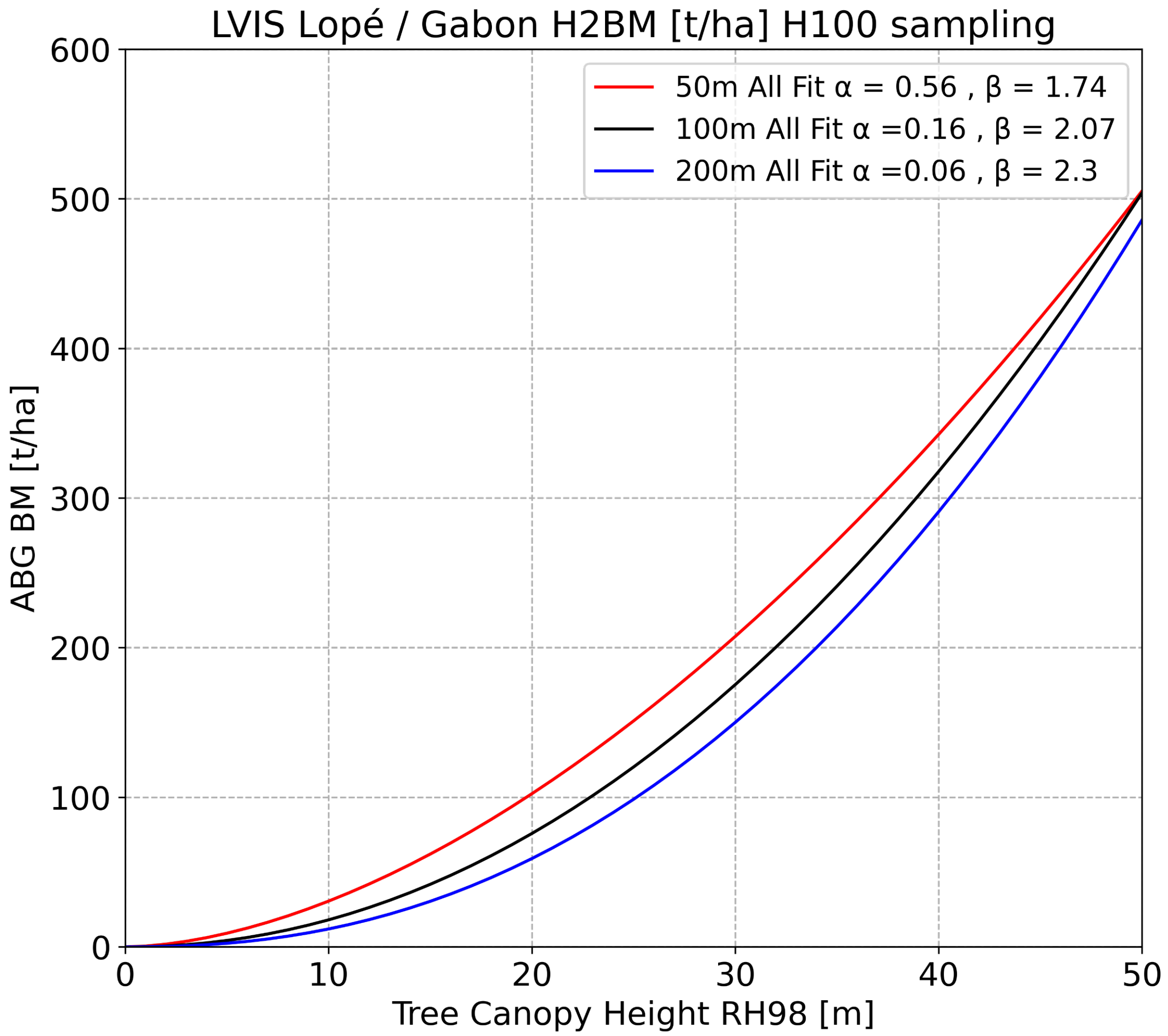
Stand Density

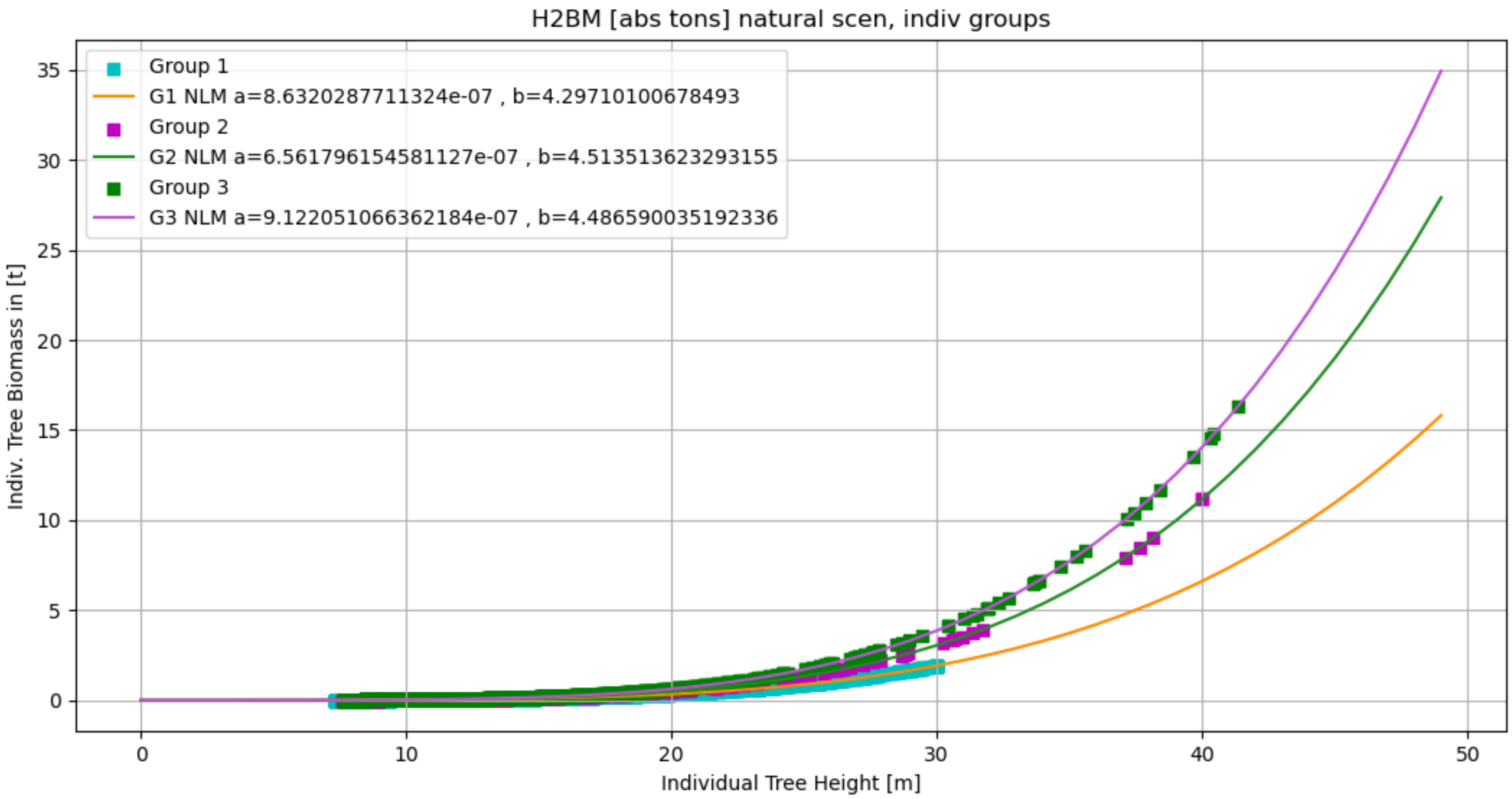


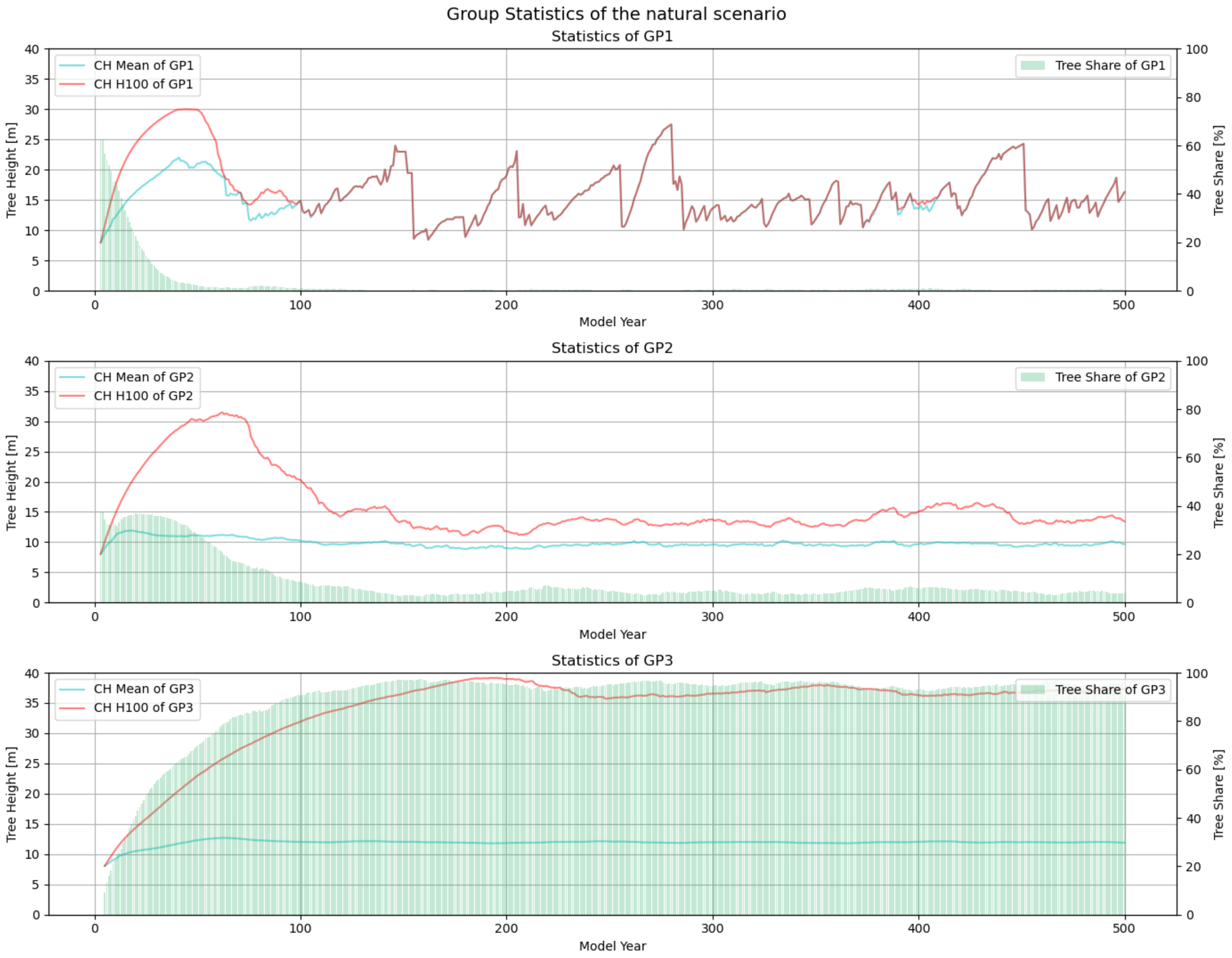
H2BM Histograms



H2BM Fitted Allometries



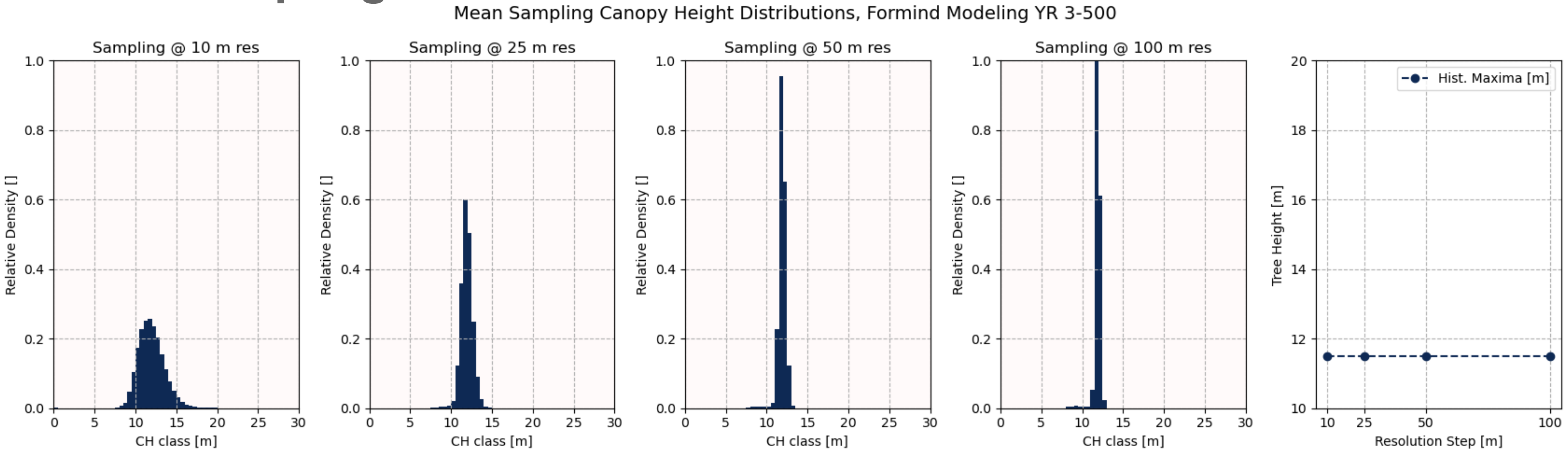

H2BM [abs tons] natural scen, indiv groups
Group 1
G1 NLM a=8.6320287711324e-07 , b=4.29710100678493
Group 2
G2 NLM a=6.561796154581127e-07 , b=4.513513623293155
Group 3
G3 NLM a=9.122051066362184e-07 , b=4.486590035192336
Indiv. Tree Biomass in [t]
Individual Tree Height [m]
0
5
10
15
20
25
30
35
0
10
20
30
40
50


Group Statistics of the natural scenario
Statistics of GP1
CH Mean of GP1
CH H100 of GP1
Tree Share of GP1
Tree Height [m]
Tree Share [%]
Model Year
Statistics of GP2
CH Mean of GP2
CH H100 of GP2
Tree Share of GP2
Tree Height [m]
Tree Share [%]
Model Year
Statistics of GP3
CH Mean of GP3
CH H100 of GP3
Tree Share of GP3
Tree Height [m]
Tree Share [%]
Model Year

Group Statistics of the fire scenario

FORMIND Resampling

mean()



H100()