

**Supporting information: Impact of leaf phenology on estimates of aboveground biomass density in a deciduous broadleaf forest from simulated Global Ecosystem Dynamics Investigation (GEDI) lidar.**

Table S1. Post-hoc Tukey multiple comparison tests for variation in the magnitude of systematic differences in AGBD predictions (from changes in leaf phenology) among candidate GEDI footprint AGBD models for the DBT × Europe prediction stratum. The candidate models are described in Duncanson et al. 2022. Here, the 20 best candidate models under each of 4 feature-set scenarios were compared. Model scenarios were: (1) all RH metrics permitted in candidate models, (2) no RH metrics < RH50 permitted in candidate models, (3) all RH metrics permitted in candidate models and candidate models must contain RH98 as a main effect or interaction, and (4) no RH metrics < RH50 permitted in candidate models and candidate models must contain RH98 as a main effect or interaction.

Scenario comparison	Change in systematic prediction differences (%) [95% CI]	P
(1) – (2)	7.91 [5.82, 9.99]	< 0.001
(1) – (3)	-1.44 [-3.53, 0.64]	0.27
(1) – (4)	8.49 [6.40, 10.57]	< 0.001
(2) – (3)	-9.35 [-11.44, -7.27]	< 0.001
(2) – (4)	0.58 [-1.50, 2.66]	0.88
(3) – (4)	9.93 [7.85, 11.44]	< 0.001

Table S2. Systematic differences in predicted AGBD ( $\text{Mg ha}^{-1}$ ) from changes in leaf phenology for candidate GEDI AGBD models in the DBT  $\times$  Europe prediction stratum. Systematic prediction difference values are from simulated GEDI waveforms in a temperate mountain forest in the southwest Czech Republic. The model being used to predict AGBD in release 1 and release 2 of the GEDI footprint AGBD data product is in bold.

Rank	Model	Systematic prediction difference (%)
Feature set 1: all RH metrics permitted		
1	$\log(\text{AGBD}) = -2.21 \times 10^{01} - 3.22 \times \log(\text{RH10}) + 2.11 \times \log(\text{RH20}) - 2.00 \times \log(\text{RH40} \times \text{RH50}) + 5.34 \times \log(\text{RH60} \times \text{RH98})$	-0.56
2	$\log(\text{AGBD}) = -2.48 \times 10^{01} + 2.86 \times \log(\text{RH40}) + 6.75 \times \log(\text{RH98}) - 1.73 \times \log(\text{RH10} \times \text{RH30})$	-1.39
3	$\log(\text{AGBD}) = -5.57 \times 10^{-02} - 1.89 \times 10^{-02} \times \text{RH10} + 4.71 \times 10^{-02} \times \text{RH98} + 8.62 \times 10^{-05} \times \text{RH60} \times \text{RH70}$	-4.41
4	$\log(\text{AGBD}) = 6.01 - 8.09 \times 10^{-02} \times \text{RH10} + 4.87 \times 10^{-04} \times \text{RH10} \times \text{RH98} + 8.15 \times 10^{-05} \times \text{RH60} \times \text{RH70}$	-7.09
5	$\log(\text{AGBD}) = -2.61 + 7.26 \times 10^{-02} \times \text{RH98} + 6.82 \times 10^{-05} \times \text{RH10} \times \text{RH50} - 2.65 \times 10^{-04} \times \text{RH10} \times \text{RH98} + 9.03 \times 10^{-05} \times \text{RH20} \times \text{RH98}$	-7.22
6	$\log(\text{AGBD}) = -2.49 + 5.74 \times 10^{-03} \times \text{RH60} + 6.49 \times 10^{-02} \times \text{RH98} - 2.02 \times 10^{-04} \times \text{RH10} \times \text{RH98} + 1.03 \times 10^{-04} \times \text{RH20} \times \text{RH98}$	-7.25
7	$\log(\text{AGBD}) = -2.19 + 6.55 \times 10^{-02} \times \text{RH98} - 2.00 \times 10^{-04} \times \text{RH10} \times \text{RH98} + 9.34 \times 10^{-05} \times \text{RH20} \times \text{RH98} + 2.98 \times 10^{-05} \times \text{RH50} \times \text{RH60}$	-7.50
8	$\log(\text{AGBD}) = -1.91 + 6.06 \times 10^{-02} \times \text{RH98} - 2.02 \times 10^{-04} \times \text{RH10} \times \text{RH98} + 1.06 \times 10^{-04} \times \text{RH20} \times \text{RH98} + 4.06 \times 10^{-05} \times \text{RH60} \times \text{RH98}$	-7.64
9	$\log(\text{AGBD}) = -2.30 + 6.63 \times 10^{-02} \times \text{RH98} - 2.10 \times 10^{-04} \times \text{RH10} \times \text{RH98} + 1.32 \times 10^{-04} \times \text{RH20} \times \text{RH98}$	-7.98
10	$\log(\text{AGBD}) = 2.15 - 1.82 \times 10^{-02} \times \text{RH10} + 7.99 \times 10^{-03} \times \text{RH40} + 2.55 \times 10^{-04} \times \text{RH90} \times \text{RH98}$	-8.14
11	$\log(\text{AGBD}) = 6.16 - 8.34 \times 10^{-02} \times \text{RH10} + 4.93 \times 10^{-04} \times \text{RH10} \times \text{RH98} + 8.40 \times 10^{-05} \times \text{RH50} \times \text{RH70}$	-8.24
12	$\log(\text{AGBD}) = 2.67 - 1.99 \times 10^{-02} \times \text{RH10} + 3.99 \times 10^{-05} \times \text{RH20} \times \text{RH98} + 1.88 \times 10^{-05} \times \text{RH40} \times \text{RH60} + 2.40 \times 10^{-04} \times \text{RH90} \times \text{RH98}$	-8.27
13	$\log(\text{AGBD}) = 2.65 - 2.03 \times 10^{-02} \times \text{RH10} + 6.32 \times 10^{-05} \times \text{RH20} \times \text{RH98} + 2.39 \times 10^{-04} \times \text{RH90} \times \text{RH98}$	-8.28
14	$\log(\text{AGBD}) = 2.67 - 1.98 \times 10^{-02} \times \text{RH10} + 3.52 \times 10^{-05} \times \text{RH20} \times \text{RH98} + 2.05 \times 10^{-05} \times \text{RH40} \times \text{RH50} + 2.42 \times 10^{-04} \times \text{RH90} \times \text{RH98}$	-8.38
15	$\log(\text{AGBD}) = 2.26 - 2.37 \times 10^{-02} \times \text{RH10} + 8.88 \times 10^{-03} \times \text{RH20} + 3.11 \times 10^{-03} \times \text{RH40} + 2.58 \times 10^{-04} \times \text{RH90} \times \text{RH98}$	-9.26
16	$\log(\text{AGBD}) = 1.33 + 6.37 \times 10^{-03} \times \text{RH60} - 3.76 \times 10^{-04} \times \text{RH10} \times \text{RH20} + 1.51 \times 10^{-04} \times \text{RH10} \times \text{RH98} + 3.88 \times 10^{-04} \times \text{RH20} \times \text{RH98}$	-12.36
17	$\log(\text{AGBD}) = 1.69 - 4.17 \times 10^{-04} \times \text{RH10} \times \text{RH20} + 7.61 \times 10^{-05} \times \text{RH10} \times \text{RH60} + 1.19 \times 10^{-04} \times \text{RH10} \times \text{RH98} + 4.13 \times 10^{-04} \times \text{RH20} \times \text{RH98}$	-12.51
18	$\log(\text{AGBD}) = 1.63 - 3.85 \times 10^{-04} \times \text{RH10} \times \text{RH20} + 1.52 \times 10^{-04} \times \text{RH10} \times \text{RH98} + 4.28 \times 10^{-04} \times \text{RH20} \times \text{RH98}$	-13.27
19	$\log(\text{AGBD}) = 1.97 - 3.11 \times 10^{-04} \times \text{RH10} \times \text{RH50} + 1.62 \times 10^{-04} \times \text{RH20} \times \text{RH98} + 3.21 \times 10^{-04} \times \text{RH50} \times \text{RH98}$	-14.18
20	$\log(\text{AGBD}) = 2.00 - 4.36 \times 10^{-04} \times \text{RH10} \times \text{RH20} + 1.06 \times 10^{-04} \times \text{RH10} \times \text{RH50} + 4.95 \times 10^{-04} \times \text{RH20} \times \text{RH98}$	-15.41
Feature set 2: no RH metrics < 50 permitted		
1	$\text{sqrt}(\text{AGBD}) = -4.08 \times 10^{01} + 4.53 \times 10^{-01} \times \text{sqrt}(\text{RH80} \times \text{RH90})$	-13.57
2	$\text{sqrt}(\text{AGBD}) = -9.49 \times 10^{01} - 2.02 \times 10^{-01} \times \text{sqrt}(\text{RH50}) + 1.02 \times 10^{01} \times \text{sqrt}(\text{RH80})$	-15.15
3	$\text{sqrt}(\text{AGBD}) = -3.97 \times 10^{01} - 3.25 \times 10^{-01} \times \text{sqrt}(\text{RH50}) + 4.77 \times 10^{-01} \times \text{sqrt}(\text{RH70} \times \text{RH90})$	-15.50

4	$\text{sqrt}(AGBD) = -9.53 \times 10^{01} + 9.99 \times \text{sqrt}(RH80)$	-15.59
5	$\text{sqrt}(AGBD) = -3.28 \times 10^{01} - 1.47 \times \text{sqrt}(RH50) + 5.25 \times 10^{-01} \times \text{sqrt}(RH70 \times RH80)$	-15.71
6	$\text{sqrt}(AGBD) = -4.11 \times 10^{01} - 1.77 \times 10^{-03} \times RH50 + 4.61 \times 10^{-01} \times RH80$	-15.93
7	$\text{sqrt}(AGBD) = -5.28 \times 10^{01} + 2.05 \times \text{sqrt}(RH98) + 3.70 \times 10^{-01} \times \text{sqrt}(RH70 \times RH80)$	-15.97
8	$\text{sqrt}(AGBD) = -4.11 \times 10^{01} + 4.60 \times 10^{-01} \times RH80$	-16.01
9	$\text{sqrt}(AGBD) = -4.17 \times 10^{01} + 4.65 \times 10^{-01} \times \text{sqrt}(RH70 \times RH90)$	-16.19
<b>10</b>	<b><math>\text{sqrt}(AGBD) = -9.65 \times 10^{01} + 7.18 \times \text{sqrt}(RH70) + 2.92 \times \text{sqrt}(RH98)</math></b>	<b>-16.29</b>
11	$\text{sqrt}(AGBD) = -2.07 \times 10^{01} + 1.07 \times 10^{-01} \times RH98 + 1.51 \times 10^{-03} \times RH70 \times RH80$	-16.31
12	$\text{sqrt}(AGBD) = -4.18 \times 10^{01} + 3.38 \times 10^{-01} \times RH70 + 1.28 \times 10^{-01} \times RH98$	-16.83
13	$\text{sqrt}(AGBD) = -7.95 \times 10^{01} + 6.98 \times \text{sqrt}(RH70) + 1.43 \times 10^{-01} \times \text{sqrt}(RH90 \times RH98)$	-16.87
14	$\text{sqrt}(AGBD) = -9.86 \times 10^{01} + 5.48 \times \text{sqrt}(RH60) + 4.81 \times \text{sqrt}(RH98)$	-17.15
15	$\text{sqrt}(AGBD) = -9.84 \times 10^{01} + 3.99 \times \text{sqrt}(RH60) + 6.30 \times \text{sqrt}(RH90)$	-17.21
16	$\text{sqrt}(AGBD) = -6.31 \times 10^{01} + 3.85 \times \text{sqrt}(RH60) + 2.92 \times 10^{-01} \times \text{sqrt}(RH80 \times RH98)$	-17.24
17	$\text{sqrt}(AGBD) = -6.42 \times 10^{01} + 3.91 \times \text{sqrt}(RH98) + 2.95 \times 10^{-01} \times \text{sqrt}(RH60 \times RH70)$	-17.34
18	$\text{sqrt}(AGBD) = -7.17 \times 10^{01} + 5.34 \times \text{sqrt}(RH90) + 2.29 \times 10^{-01} \times \text{sqrt}(RH60 \times RH70)$	-17.39
19	$\text{sqrt}(AGBD) = -6.94 \times 10^{01} + 4.95 \times \text{sqrt}(RH60) + 2.44 \times 10^{-01} \times \text{sqrt}(RH90 \times RH98)$	-17.57
20	$\text{sqrt}(AGBD) = -5.84 \times 10^{01} + 2.98 \times \text{sqrt}(RH60) + 3.33 \times 10^{-01} \times \text{sqrt}(RH80 \times RH90)$	-17.64
Feature set 3: forced inclusion of RH98		
1	$\log(AGBD) = -2.48 \times 10^{01} + 2.86 \times \log(RH40) + 6.75 \times \log(RH98) - 1.73 \times \log(RH10 \times RH30)$	-1.39
2	$\log(AGBD) = -5.57 \times 10^{-02} - 1.89 \times 10^{-02} \times RH10 + 4.71 \times 10^{-02} \times RH98 + 8.62 \times 10^{-05} \times RH60 \times RH70$	-4.41
3	$\log(AGBD) = -3.74 + 1.15 \times 10^{-02} \times RH20 + 5.57 \times 10^{-03} \times RH50 + 7.55 \times 10^{-02} \times RH98 - 1.94 \times 10^{-04} \times RH10 \times RH98$	-6.35
4	$\log(AGBD) = -3.07 + 1.10 \times 10^{-02} \times RH20 + 7.00 \times 10^{-02} \times RH98 - 1.92 \times 10^{-04} \times RH10 \times RH98 + 4.79 \times 10^{-05} \times RH50 \times RH98$	-6.77
5	$\log(AGBD) = -2.55 + 7.17 \times 10^{-02} \times RH98 + 7.58 \times 10^{-05} \times RH10 \times RH60 - 2.72 \times 10^{-04} \times RH10 \times RH98 + 9.36 \times 10^{-05} \times RH20 \times RH98$	-6.79
6	$\log(AGBD) = 2.77 \times 10^{-01} - 2.18 \times 10^{-02} \times RH10 + 4.46 \times 10^{-02} \times RH98 + 3.67 \times 10^{-05} \times RH30 \times RH98 + 7.03 \times 10^{-05} \times RH60 \times RH70$	-6.81
7	$\log(AGBD) = -2.61 + 7.26 \times 10^{-02} \times RH98 + 6.82 \times 10^{-05} \times RH10 \times RH50 - 2.65 \times 10^{-04} \times RH10 \times RH98 + 9.03 \times 10^{-05} \times RH20 \times RH98$	-7.22
8	$\log(AGBD) = -2.49 + 5.74 \times 10^{-03} \times RH60 + 6.49 \times 10^{-02} \times RH98 - 2.02 \times 10^{-04} \times RH10 \times RH98 + 1.03 \times 10^{-04} \times RH20 \times RH98$	-7.25
9	$\log(AGBD) = 2.58 \times 10^{-01} - 2.63 \times 10^{-02} \times RH10 + 4.94 \times 10^{-02} \times RH98 + 5.22 \times 10^{-05} \times RH20 \times RH40 + 5.13 \times 10^{-05} \times RH60 \times RH70$	-7.39
10	$\log(AGBD) = -2.41 - 8.67 \times 10^{-03} \times RH60 + 7.74 \times 10^{-02} \times RH98 - 2.18 \times 10^{-04} \times RH10 \times RH98 + 1.30 \times 10^{-04} \times RH20 \times RH60$	-7.48
11	$\log(AGBD) = 7.58 \times 10^{-02} - 3.91 \times 10^{-02} \times RH10 + 1.03 \times 10^{-02} \times RH20 + 5.42 \times 10^{-02} \times RH98 + 9.70 \times 10^{-05} \times RH10 \times RH50$	-7.49
12	$\log(AGBD) = -2.19 + 6.55 \times 10^{-02} \times RH98 - 2.00 \times 10^{-04} \times RH10 \times RH98 + 9.34 \times 10^{-05} \times RH20 \times RH98 + 2.98 \times 10^{-05} \times RH50 \times RH60$	-7.50
13	$\log(AGBD) = 8.54 \times 10^{-01} - 2.36 \times 10^{-02} \times RH10 + 3.68 \times 10^{-02} \times RH98 + 2.24 \times 10^{-05} \times RH20 \times RH30 + 1.26 \times 10^{-04} \times RH60 \times RH90$	-7.54
14	$\log(AGBD) = 2.14 \times 10^{-01} - 2.58 \times 10^{-02} \times RH10 + 4.97 \times 10^{-02} \times RH98 + 4.19 \times 10^{-05} \times RH20 \times RH40 + 5.81 \times 10^{-05} \times RH50 \times RH70$	-7.54
15	$\log(AGBD) = -2.52 + 4.76 \times 10^{-03} \times RH50 + 6.62 \times 10^{-02} \times RH98 - 2.03 \times 10^{-04} \times RH10 \times RH98 + 1.03 \times 10^{-04} \times RH20 \times RH98$	-7.63
16	$\log(AGBD) = -1.91 + 6.06 \times 10^{-02} \times RH98 - 2.02 \times 10^{-04} \times RH10 \times RH98 + 1.06 \times 10^{-04} \times RH20 \times RH98 + 4.06 \times 10^{-05} \times RH60 \times RH98$	-7.64
17	$\log(AGBD) = -2.32 + 6.77 \times 10^{-02} \times RH98 - 1.94 \times 10^{-04} \times RH10 \times RH98 + 6.33 \times 10^{-05} \times RH20 \times RH98 + 4.42 \times 10^{-05} \times RH40 \times RH50$	-7.81
18	$\log(AGBD) = -2.30 + 6.63 \times 10^{-02} \times RH98 - 2.10 \times 10^{-04} \times RH10 \times RH98 + 1.32 \times 10^{-04} \times RH20 \times RH98$	-7.98

19	$\log(AGBD) = 1.25 - 2.52 \times 10^{-02} \times RH10 + 3.18 \times 10^{-02} \times RH98 + 4.89 \times 10^{-05} \times RH20 \times RH98 + 1.26 \times 10^{-04} \times RH60 \times RH90$	-7.99
20	$\log(AGBD) = -6.12 \times 10^{-02} - 2.41 \times 10^{-02} \times RH10 - 5.62 \times 10^{-03} \times RH60 + 5.68 \times 10^{-02} \times RH98 + 9.18 \times 10^{-05} \times RH30 \times RH50$	-9.41
Feature set 4: no RH metrics < 50 permitted and forced inclusion of RH98		
1	$\text{sqrt}(AGBD) = -3.70 \times 10^{01} + 4.09 \times 10^{-01} \times RH98$	-5.99
2	$\text{sqrt}(AGBD) = -5.28 \times 10^{01} + 2.05 \times \text{sqrt}(RH98) + 3.70 \times 10^{-01} \times \text{sqrt}(RH70 \times RH80)$	-15.97
<b>3</b>	<b><math>\text{sqrt}(AGBD) = -9.65 \times 10^{01} + 7.18 \times \text{sqrt}(RH70) + 2.92 \times \text{sqrt}(RH98)</math></b>	<b>-16.29</b>
4	$\text{sqrt}(AGBD) = -2.07 \times 10^{01} + 1.07 \times 10^{-01} \times RH98 + 1.51 \times 10^{-03} \times RH70 \times RH80$	-16.31
5	$\text{sqrt}(AGBD) = -4.18 \times 10^{01} + 3.38 \times 10^{-01} \times RH70 + 1.28 \times 10^{-01} \times RH98$	-16.83
6	$\text{sqrt}(AGBD) = -9.86 \times 10^{01} + 5.48 \times \text{sqrt}(RH60) + 4.81 \times \text{sqrt}(RH98)$	-17.15
7	$\text{sqrt}(AGBD) = -5.93 \times 10^{01} + 3.03 \times \text{sqrt}(RH98) + 3.35 \times 10^{-01} \times \text{sqrt}(RH60 \times RH80)$	-17.27
8	$\text{sqrt}(AGBD) = -6.42 \times 10^{01} + 3.91 \times \text{sqrt}(RH98) + 2.95 \times 10^{-01} \times \text{sqrt}(RH60 \times RH70)$	-17.34
9	$\text{sqrt}(AGBD) = -5.25 \times 10^{01} + 1.77 \times \text{sqrt}(RH98) + 3.94 \times 10^{-01} \times \text{sqrt}(RH60 \times RH90)$	-17.34
10	$\text{sqrt}(AGBD) = -9.83 \times 10^{01} + 3.91 \times \text{sqrt}(RH50) + 6.33 \times \text{sqrt}(RH98)$	-17.37
11	$\text{sqrt}(AGBD) = -4.30 \times 10^{01} + 2.62 \times 10^{-01} \times RH60 + 2.13 \times 10^{-01} \times RH98$	-17.80
12	$\text{sqrt}(AGBD) = -2.06 \times 10^{01} + 9.32 \times 10^{-02} \times RH98 + 1.62 \times 10^{-03} \times RH60 \times RH90$	-17.82
13	$\text{sqrt}(AGBD) = -2.35 \times 10^{01} + 1.43 \times 10^{-01} \times RH98 + 1.41 \times 10^{-03} \times RH60 \times RH80$	-17.85
14	$\text{sqrt}(AGBD) = -7.40 \times 10^{01} + 5.61 \times \text{sqrt}(RH98) + 2.21 \times 10^{-01} \times \text{sqrt}(RH50 \times RH60)$	-17.91
15	$\text{sqrt}(AGBD) = -4.28 \times 10^{01} + 1.88 \times 10^{-01} \times RH50 + 2.84 \times 10^{-01} \times RH98$	-17.96
16	$\text{sqrt}(AGBD) = -2.57 \times 10^{01} + 1.78 \times 10^{-01} \times RH98 + 1.27 \times 10^{-03} \times RH60 \times RH70$	-18.02
17	$\text{sqrt}(AGBD) = -6.26 \times 10^{01} + 3.58 \times \text{sqrt}(RH98) + 3.12 \times 10^{-01} \times \text{sqrt}(RH50 \times RH90)$	-18.11
18	$\text{sqrt}(AGBD) = -6.95 \times 10^{01} + 4.82 \times \text{sqrt}(RH98) + 2.57 \times 10^{-01} \times \text{sqrt}(RH50 \times RH70)$	-18.36
19	$\text{sqrt}(AGBD) = -6.61 \times 10^{01} + 4.21 \times \text{sqrt}(RH98) + 2.84 \times 10^{-01} \times \text{sqrt}(RH50 \times RH80)$	-18.37
20	$\text{sqrt}(AGBD) = -2.84 \times 10^{01} + 2.19 \times 10^{-01} \times RH98 + 1.11 \times 10^{-03} \times RH50 \times RH70$	-19.01

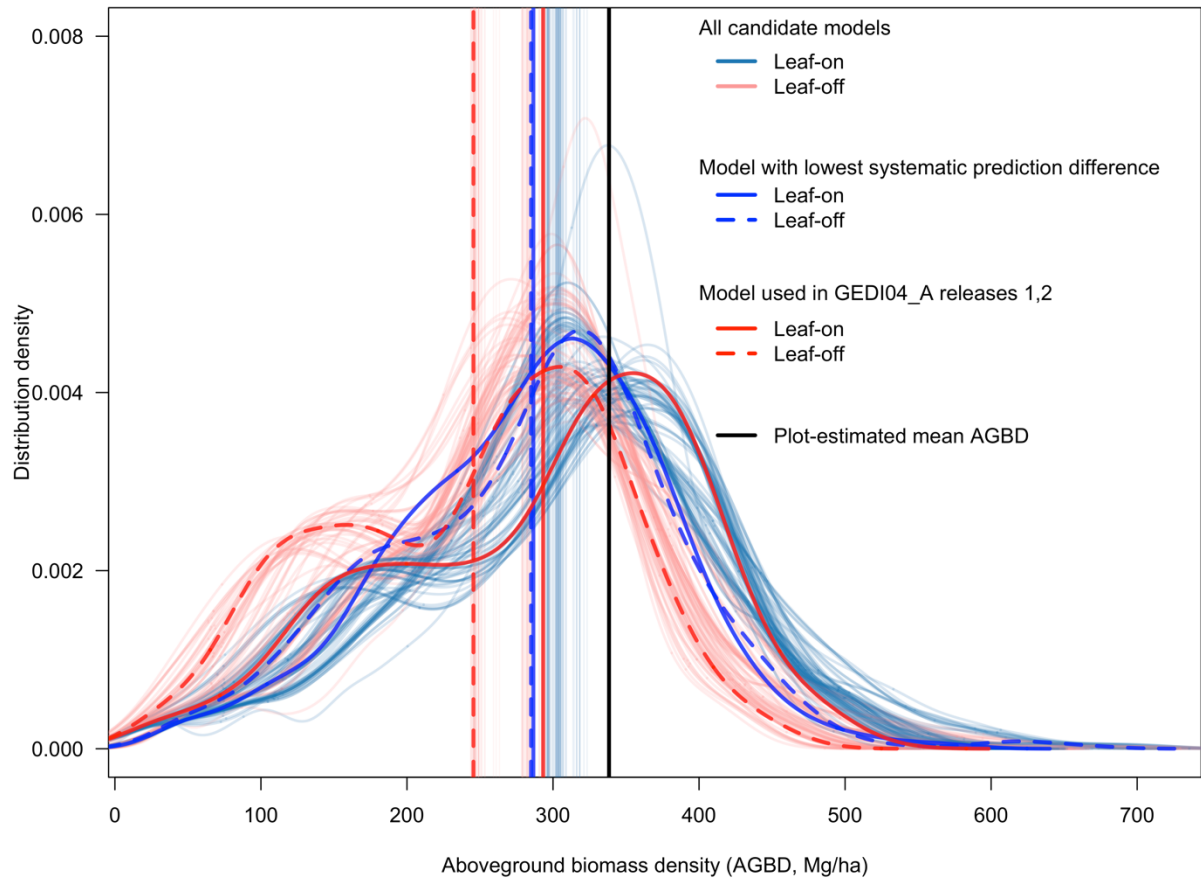


Figure S1. Density distribution of footprint-level predicted AGBD values for 570 simulated GEDI waveforms collected during leaf-on and leaf-off leaf phenology conditions, 51 days apart, in a temperate mountain forest in the southwest Czech Republic. Distributions are shown for all 80 candidate models considered in this paper (Table S2); the model with the lowest systematic prediction difference between leaf-on and leaf-off predictions is highlighted in dark blue and the model used in releases 1 and 2 of the GEDI04\_A data product is highlighted in red. Vertical lines denote the mean AGBD for each model, and the mean AGBD estimated from plot data (black). Density values represent the relative frequency of predicted AGBD values among waveforms in the field plot.