

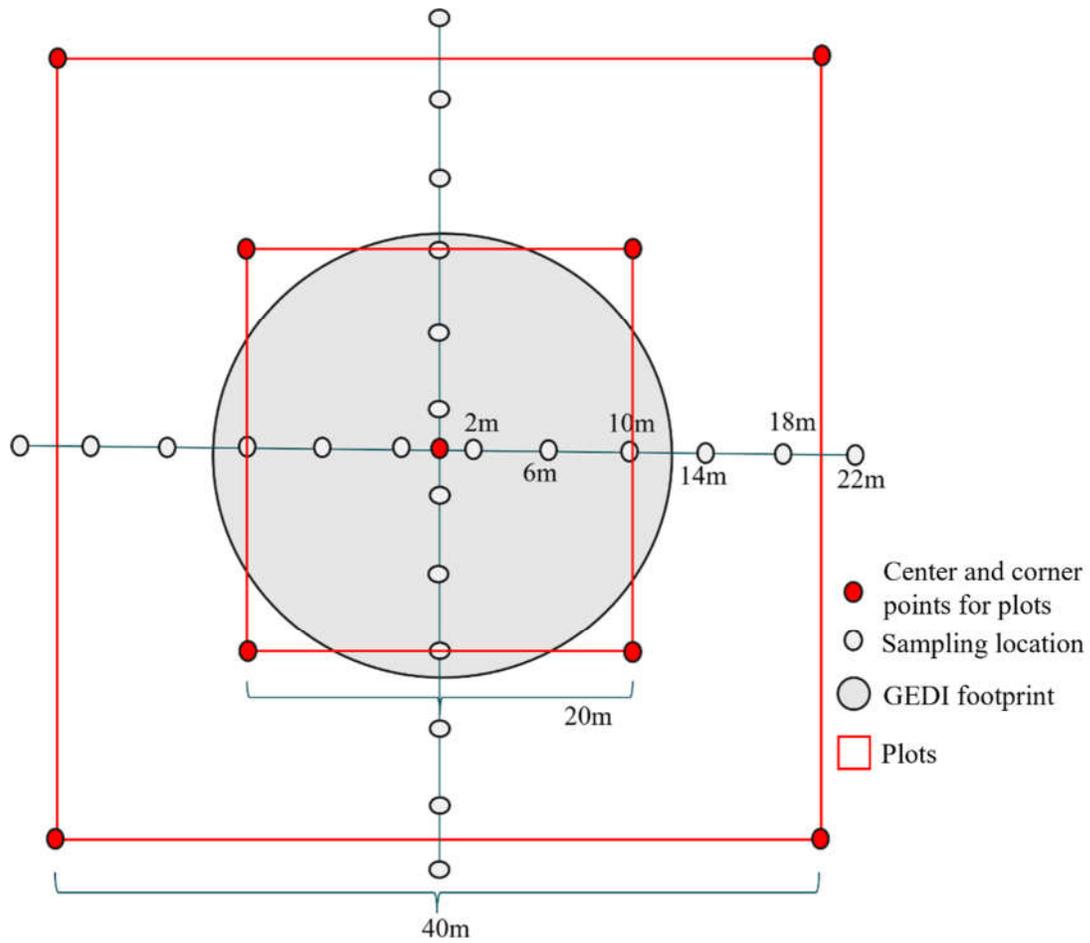
**Table S1.** The NEON AOP discrete LiDAR sites and their features. The ID, Pd, Sangle, Ele, MAP, and MAT represent the climate domain, point density (point/m<sup>2</sup>), scan angle, elevation, mean annual precipitation and mean annual temperature, respectively.

Site	ID	Date	Pd	Sangle (°)	Areas (km <sup>2</sup> )	Ele(m)	MAP (mm)	MAT (°C)	Dominant land cover types
Abby Road (ABBY)	D16	2019-7	16	±18	74	363	2530	8.00	Broadleaf forest
Bartlett Experimental Forest (BART)	D01	2019-8	4	±36	118	232	1056	8.00	Forest
Blandy Experimental Farm NEON (BLAN)	D02	2019-6	4	±18	210	183	983	12.1	Fragmented secondary forests and successional shrubs
Lyndon B. Johnson National Grassland (CLBJ)	D11	2019-5	11	±32	158	272	926	17.50	Forest and grassland
Dead Lake (DELA)	D08	2019-5	4	±42	122	25	1372	17.60	Forest and agriculture
Great Smoky Mountains National Park, Twin Creeks (GRSM)	D07	2019-5	6	±36	166	579	1396	13.00	Deciduous old-growth forest
Harvard Forest & Quabbin Watershed NEON (HARV)	D01	2019-7	6	±18	391	348	1199	7.4	Deciduous forest
Jones Ecological Research Center (JERC)	D03	2019-9	11	±18	193	44	1307	19.50	Forest, grassland, and wetland
Lenoir Landing (LENO)	D08	2019-5	4	±33	115	20	1429	18.00	Mixed forest, grassland, and wetlands
Mountain Lake Biological Station (MLBS)	D07	2018-5	15	±18	166	1126	1030	13.00	Deciduous forest
Niwot Ridge Mountain Research Station (NIWO)	D13	2019-8	14	±18	152	3513	758	0.00	Mixed forest
Ordway-Swisher Biological Station (OSBS)	D03	2019-4	4	±36	239	46	1302	20.90	Coniferous forest
Rocky Mountain National Park, CASTNET(RMNP)	D10	2018-9	17	±18	190	2743	520	4.00	Mixed pine forest
Smithsonian Environmental	D02	2019-5	8	±34	245	15	1107	14.00	Mixed forest

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Research Center (SERC)										
Soaproot Saddle (SOAP)	D1 7	2019-6	4	±36	172	121 0	900	13.40	Evergreen Forest, Shrub/Scrub Deciduous Forest, Mixed Forest, Woody Wetlands Deciduous Forest, Evergreen Forest, Mixed Forest	
Steigerwaldt- Chequamegon (STEI/ CHEQ)	D0 5	2019-6	16	±18	297	481	782	5.00	Evergreen Forest, Shrub/Scrub Deciduous Forest, Mixed Forest, Woody Wetlands Deciduous Forest, Evergreen Forest, Mixed Forest	
Talladega National Forest (TALL)	D0 8	2019-5	5	±30	136	166	1383	17.20	Evergreen Forest, Shrub/Scrub Deciduous Forest, Mixed Forest	
Lower Teakettle (TEAK)	D1 7	2019-6	5	±30	188	214 7	941	7.00	Evergreen Forest, Shrub/Scrub Deciduous Forest, Mixed Forest	
University of Kansas Field Station NEON (UKFS)	D0 6	2019-7	10	±18	204	322	990	12.7	Evergreen coniferous forest Deciduous forest and mixed forest	
University of Notre Dame (UNDE)	D0 5	2019-7	6	±18	208	521	802	4.3	Evergreen coniferous forest Evergreen Forest, Mixed Forest	
Wind River Experimental Forest NEON (WREF)	D1 6	2019-8	25	±18	330	351	2225	9.2	Evergreen coniferous forest Evergreen Forest, Mixed Forest	
Yellowstone Northern Range (Frog Rock) (YELL)	D1 2	2019-7	4	±28	245	211 6	509	0.00	Evergreen Forest, Grassland/Herb aceous, Shrub/Scrub	

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**Figure S1.** Locations for taking DHP imageries within a plot. The locations were marked with a white ellipse. The black circle represented the GEDI footprint, while the red rectangle represented the NEON Lidar plot.

**Table S2.** Field-measured LAIe and LAIt corresponding to the 22 footprints of GEDI in the Fenghuang Mountains. GEDI shot\_number is the identification of the GEDI footprint. DBH is the diameter of breast height. The units of tree height, DBH, Tree density, LAIe, and LAIt are m, cm, tress/hm<sup>2</sup>, m<sup>2</sup>/m<sup>2</sup>, and m<sup>2</sup>/m<sup>2</sup>, respectively.

ID	GEDI shot_number	Longitude	Latitude	Tree height	DBH	Tree density	LAIe	LAIt
1	132530600300518483	117°7'11"	34°12'50"	4.70×4.34	5.5×5.5	5000	1.34	2.88
2	132530600300518482	117°7'09"	34°12'51"	4.50×3.95	6.2×5.5	5178	1.67	3.14
3	132530600300518481	117°7'07"	34°12'53"	4.2×5.68	6.2×7.7	2500	1.47	3.59
4	132530600300518478	117°7'03"	34°12'56"	5.72	6	4444	1.5	2.52
5	132530600300518477	117°7'01"	34°12'58"	7.76	7.4	3056	1.25	2.59
6	132530600300518492	117°7'25"	34°12'38"	5.32	7.2	2678	1.49	2.97
7	132530600300518491	117°7'24"	34°12'40"	5	7.9	1389	0.57	1.45
8	132531100300317716	117°8'59"	34°10'18"	8.14	7	1667	1.41	2.12
9	132531100300317715	117°8'57"	34°10'20"	7.66	7.3	1389	1.43	2.67
10	132531100300317712	117°8'52"	34°10'23"	5.14×6.80	7.8×6.2	1111	0.8	1.48
11	132531100300317711	117°8'50"	34°10'25"	5.32	5.6	2222	1.17	2.24
12	132531100300317709	117°8'47"	34°10'27"	4.6	6	1333	0.47	1.01
13	132531100300317707	117°8'44"	34°10'30"	7.85	7.3	1556	0.97	1.83
14	132531100300317706	117°8'42"	34°10'31"	7.00	8.3	1222	1.65	2.71
15	132530800300323005	117°9'21"	34°10'28"	7.50×9.80	7.1×7.3	2356	1.25	2.18
16	132530800300322996	117°9'06"	34°10'39"	7.20×4.97	6.8×6.1	2089	1.19	2.38
17	132530800300322995	117°9'05"	34°10'40"	6.42×8.60	7.0×3	2222	1.75	3.34
18	132530800300322993	117°9'01"	34°10'43"	7.12×4.05	5.5×7.8	5556	1.88	4.12
19	27580300300316300	117°5'25"	34°10'45"	5.8	8.6	1389	0.75	1.27
20	27580300300316299	117°5'24"	34°10'46"	5.93	7.3	2222	0.97	2.48
21	27580300300316298	117°5'22"	34°10'48"	5.6	7.9	2222	0.93	2.01
22	27580300300316297	117°5'21"	34°10'49"	5.9	7.65	1389	1.2	3.17

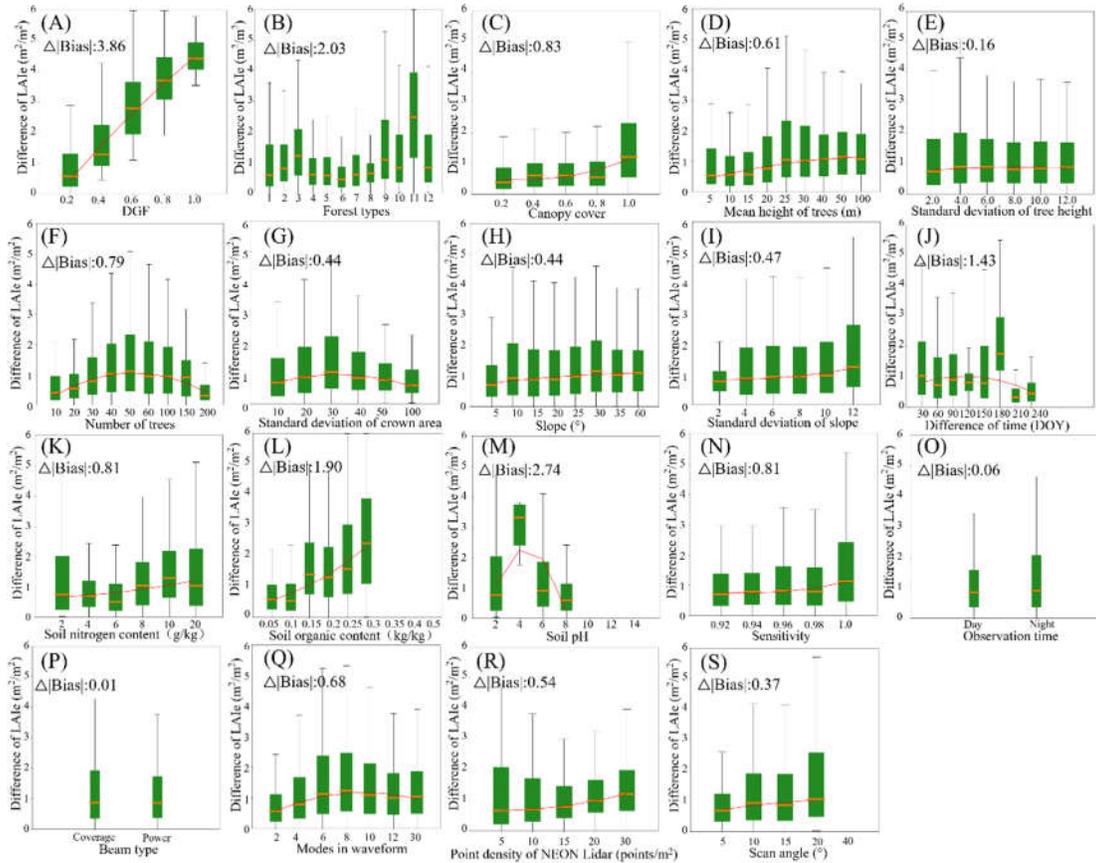
**Table S3.** The relative importance of each factor for the absolute deviation of GEDI LAIe (referred to as LAIe deviation) and the difference between gap fraction derived from GEDI and NEON Lidar (referred to as DGF).

Factors	Relative importance for absolute deviation of LAIe	Relative importance for DGF	Factors	Relative importance for absolute deviation of LAIe	Relative importance for DGF
DGF	49.82		Slope (°)	0.43	1.62
Forest types	0.00	0.17	Standard deviation of slope	0.39	1.55
Canopy cover	21.41	48.11	Sensitivity (0.9-1.0)	1.12	1.28
Mean height of trees (m)	0.00	11.47	Observation time (day and night)	3.08	0.14
Standard deviation of tree height	1.76	15.00	Beam type (power beam and coverage beam)	0.08	0.32
Number of trees	0.03	0.10	Modes in waveform (1-20)	2.10	1.68
Standard deviation of crown area	0.00	7.85	Point density of NEON Lidar (point/m <sup>2</sup> )	1.90	2.50
Soil nitrogen content(g/kg)	0.00	5.09	Scan angle (°)	0.36	0.55
Soil organic content (kg/kg)	15.10	2.19	Difference of time between GEDI and NEON Lidar (Day of year)	1.35	0.22
Soil pH	1.07	0.14			

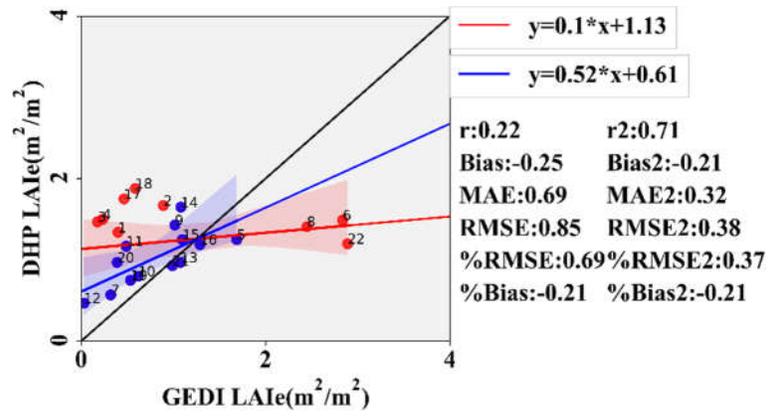
**Table S4.** Path parameters in a structural equation model for GEDI LAIe deviation analysis. The estimate is the regression coefficient, Standarded estimate is the standardized estimate, S.E. is the approximate standard error, C.R. is the critical ratio, which is the ratio of the Standarded estimate to S.E., \*\*\* indicates that the independent variable has a significant effect on the dependent variable ( $p < 0.05$ ).

	Estimate	Standarded estimate	S.E.	C.R.	<i>p</i>
Gap difference → LAIe difference	0.34	0.35	0.07	5.18	** *
Canopy crown area → gap difference	-0.20	-0.21	0.08	-2.62	** *
Soil SOC → gap difference	-0.18	-0.17	0.08	-2.30	** *
Soil SOC → LAIe difference	0.32	0.33	0.07	4.33	** *
Canopy crown area → LAIe difference	0.33	0.35	0.07	4.50	** *
Standard deviation of tree height → gap difference	0.48	0.46	0.07	6.37	** *
Standard deviation of tree height → LAIe difference	-0.24	-0.25	0.07	-3.41	** *

The relationship between the absolute deviation of GEDI LAIe and factors was analyzed (Figure C1). Results showed that the absolute Bias of GEDI LAIe increased with the increase of DGF, canopy cover, mean height of trees, topographic slope, Standard deviation of the slope, nitrogen content, organic matter content, sensitivity, point density, and scan angle. While, the absolute deviation of GEDI LAIe increased first and then decreased with the increase of the number of trees, Standard deviation of crown area, Difference of DOY between GEDI and NEON Lidar, pH, and Modes in the waveform. For those discontinuous factors, the absolute deviation of GEDI LAIe in broadleaf forests is higher than in coniferous and mixed forests. For GEDI LAIe estimation, the GEDI power beam was slightly better than the coverage beam, while the night observation was not prior to the day estimation. Even though having a relationship between the absolute deviation of GEDI LAIe and factors from characteristics of slope and sensor system parameters, the influence of these factors is ignored due to the low variation of the absolute deviation of GEDI LAIe ( $\Delta |Bias|$  less than  $0.85 \text{ m}^2/\text{m}^2$ ).

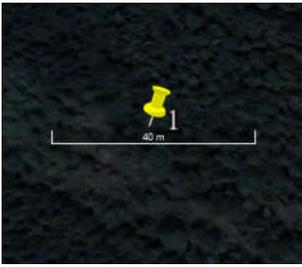
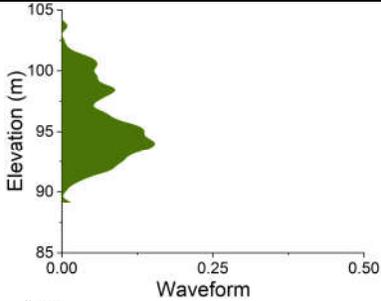
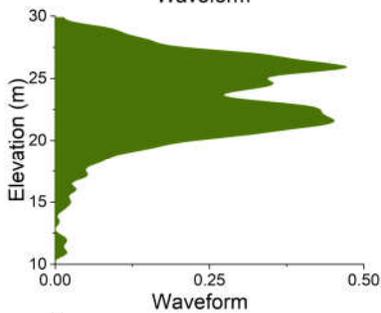
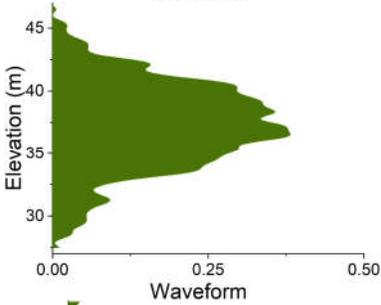


**Figure S2.** The relationship between the absolute deviation of GEDI LAle ( $|Bias|$ ) and factors. The  $\Delta|Bias|$  was the variation of the  $|Bias|$  along with the change of a factor which represented the influence degree of the factor on the  $|Bias|$ . The red line showed the fitting linear of median  $|Bias|$  and factors. The orange line was the value of the median for each bar. The (A–S) represent difference of gap fraction and NEON Lidar, forest types, canopy cover, mean height of trees, standard deviation of tree height, number of trees, standard deviation of crown area, topographic slope, standard deviation of slope, difference of time between GEDI and NEON Lidar (Day of year), soil nitrogen content (g/kg), soil organic content (kg/kg), soil pH, sensitivity, observation time, beam type, modes in waveform, point density of NEON Lidar, and Scan angle.



**Figure S3.** Accuracy comparison of GEDI LAIe between before and after filtering outliers when compared to field-measured LAIe based on Digital Hemispherical Photography imagery. The point number is identification of field survey plot. The n is number of samples. The r and r<sup>2</sup>, Bias and Bias<sub>2</sub>, MAE and MAE<sub>2</sub>, RMSE and RMSE<sub>2</sub>, %RMSE and %RMSE<sub>2</sub>, %Bias and %Bias<sub>2</sub> are accuracy metrics for before and after filtering outliers, respectively.

**Table S5.** Examples of forest landscape for GEDI footprint to conduct field survey and the corresponding GEDI waveform. The yellow pin represents the GEDI footprint center, the scale displays a range of 40 m with center of GEDI footprint, the number shows the point ID, and the images were collected from Google earth engine collected in 04/2019 and 09/2020.

Plot ID	04/2019	09/2020	Waveform
1			
6			
8			
18			