GEDI L3 Gridded Land Surface Metrics, Version 2

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Documentation Revision Date: 2026-04-22

Dataset Version: 2

Summary

This dataset provides Global Ecosystem Dynamics Investigation (GEDI) Level 3 (L3) gridded mean canopy height, standard deviation of canopy height, mean ground elevation, standard deviation of ground elevation, and counts of laser footprints per 1-km x 1-km grid cells globally within -52 and 52 degrees latitude. These L3 gridded products were derived from Level 2 (L2) geolocated laser footprint return profile metrics from the GEDI instrument onboard the International Space Station (ISS). Canopy height is provided as the mean height (in meters) above the ground of the received waveform signal that was the first reflection off the top of the canopy (RH100). Ground elevation is provided as the mean elevation (in meters) of the center of the lowest waveform mode relative to the WGS84 reference ellipsoid. L3 gridded products can be used to characterize important carbon and water cycling processes, biodiversity, habitat and can also be of immense value for climate modeling, forest management, snow and glacier monitoring, and the generation of digital elevation models. This dataset version uses Version 2 of the input L2 data, which includes improved geolocation of the footprints as well as a modified method to predict an optimum algorithm setting group. The data are provided in cloud optimized GeoTIFF format along with companion files as PNG images and PDF documents.

These L3 data products will be updated as additional observations are captured and calibrations are improved.

There are 30 data files in GeoTIFF (*.tif) format included in this dataset. The data correspond to five variables: gridded canopy height and standard deviation, ground elevation and standard deviation, and laser footprint counts.

The most recent data in this release were computed using footprints from the 19 th through the 343rd mission weeks (2019-04-18 to 2025-07-09). No acquisitions occurred while the GEDI instrument was in storage on the International Space Station (ISS) from March 2023 to April 2024. There are five additional time periods available for each of the variables: 1) the 19th through the 122nd mission weeks (2019-04-18 to 2021-04-14), 2) from the 19 th through the 96th mission weeks (2019-04-18 to 2020-10-13), 3) from the 19 th through the 138th mission weeks (2019-04-18 to 2021-08-04), 4) from the 19th through the 162nd mission weeks (2019-04-19 to 2022-01-19), and 5) from 19 th through 223rd mission weeks (2019-04-19 to 2023-03-22).

There are also 30 files in Portable Network Graphics (*.png) format (one derived from each data file) provided as companion files which must be downloaded separately from the data files, and two additional companion files in Portable Document Format (PDF).

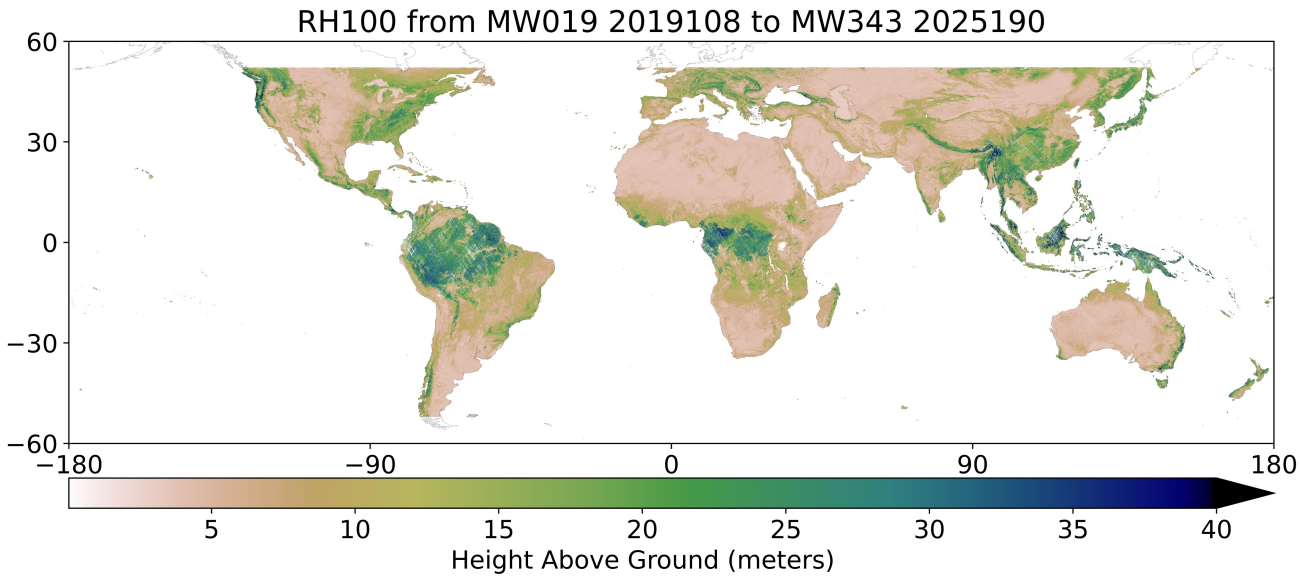

Figure 1. Level 3 estimated canopy height in meters derived from the GEDI Level 2 profile metric RH100 between the 19th and the 343rd mission week. Source: GEDI03_rh100_mean_2019108_2025190_002_05.tif

Citation

Dubayah, R.O., S.B. Luthcke, T.J. Sabaka, J.B. Nicholas, S. Preaux, and M.A. Hofton. 2021. GEDI L3 Gridded Land Surface Metrics, Version 2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1952

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1. Dataset Overview

This dataset provides Global Ecosystem Dynamics Investigation (GEDI) Level 3 (L3) gridded mean canopy height, standard deviation of canopy height, mean ground elevation, standard deviation of ground elevation, and counts of laser footprints per 1-km x 1-km grid cells globally within -52 and 52 degrees latitude. These L3 gridded products were derived from Level 2 (L2) geolocated laser footprint return profile metrics from the GEDI instrument onboard the International Space Station (ISS). Canopy height is provided as the mean height (in meters) above the ground of the received waveform signal that was the first reflection off the top of the canopy (RH100). Ground elevation is provided as the mean elevation (in meters) of the center of the lowest waveform mode relative to the WGS84 reference ellipsoid. L3 gridded products can be used to characterize important carbon and water cycling processes, biodiversity, habitat and can also be of immense value for climate modeling, forest management, snow and glacier monitoring, and the generation of digital elevation models. This dataset version uses Version 2 of the input L2 data, which includes improved geolocation of the footprints as well as a modified method to predict an optimum algorithm setting group.

These L3 data products will be updated as additional observations are captured and calibrations are improved.

Project: Global Ecosystem Dynamics Investigation

The Global Ecosystem Dynamics Investigation (GEDI) produces high resolution laser ranging observations of the 3D structure of the Earth. GEDI's precise measurements of forest canopy height, canopy vertical structure, and surface elevation greatly advance our ability to characterize important carbon and water cycling processes, biodiversity, and habitat. GEDI was funded as a NASA Earth Ventures Instrument (EVI) mission. It was launched to the International Space Station in December 2018 and completed initial orbit checkout in April 2019.

Related Publication

Dubayah, R., J.B. Blair, S. Goetz, L. Fatoyinbo, M. Hansen, S. Healey, M. Hofton, G. Hurtt, J. Kellner, S. Luthcke, J. Armston, H. Tang, L. Duncanson, S. Hancock, P. Jantz, S. Marselis, P.L. Patterson, W. Qi, and C. Silva. 2020. The Global Ecosystem Dynamics Investigation: High-resolution laser ranging of the Earth's forests and topography. Science of Remote Sensing 1:100002. https://doi.org/10.1016/j.srs.2020.100002

Related Datasets

Dubayah, R.O., S.B. Luthcke, T.J. Sabaka, J.B. Nicholas, S. Preaux, and M.A. Hofton. 2021. GEDI L3 Gridded Land Surface Metrics, Version 1. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1865

- The previous release of the GEDI L3 gridded land surface metrics data, covering the period between the 19 th and the 122 nd mission weeks (2019-04-18 to 2020-04-15).

Acknowledgments

This work was funded by NASA Earth Ventures Instrument (EVI) mission (contract NNL15AA03C) to the University of Maryland for the development and execution of the GEDI mission (Dubayah, Principal Investigator).

2. Data Characteristics

Spatial Coverage: Global within a latitude extent of -52 to +52 degrees

Spatial Resolution: 1 km

Temporal Coverage: 2019-04-18 to 2025-07-09 (will expand with periodic data updates)

Temporal Resolution: One-time estimate

Study Area: Latitude and longitude are given in decimal degrees

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Global	-180	180	52	-52

Data File Information

There are 30 data files in GeoTIFF (*.tif) format included in this dataset. The GeoTIFF files were optimized for use in a cloud environment as described by https://www.cogeo.org. There are also 30 companion files in Portable Network Graphics (*.png) (one derived from each of the 30 data files) and two additional companion files in Portable Document (*.pdf) formats. Companion files must be downloaded separately from the data files.

The files are named *<product>_<variable>_<start_date>_<end_date>_<release>_<version>.<ext>*, where:

- *<product>* is the product shortname "GEDI03", designating GEDI Level 3 data,
- <variable> is one of five measured variables ("counts", "rh100_mean", "rh100_stddev", "elev_lowestmode_mean", or "elev_lowestmode_stddev"),
- <start_date> and <end_date> are the start and end of the time period in *YYYYDDD* format, where *YYYY* is the year and *DDD* is the Julian day (day of year) [e.g., "2019108_2021216" for the 19th and the 138th mission week (2019-04-18 to 2021-08-04)],
- <release> is the release number for the SOC SDS software release,
- <version> is the granule production version, and
- <ext> is the file extension: "tif" (for GeoTIFF) or "png" (for PNG image).

Table 1. File names and descriptions. Each of the five variables has six files corresponding to the mission periods.

File Name	Description
Data Files: 30 GeoTIFF files	
GEDI03_counts_<start_date>_<end_date>_<release>_<version>.tif	Number of valid laser footprints in each grid cell.
GEDI03_elev_lowestmode_mean_<start_date>_<end_date>_<release>_<version>.tif	Ground elevation approximated by the mean elevation of the lowest mode of valid footprints in each grid cell. Derived from the L2A LIDAR metric data product, the elevation of the center of the lowest mode relative to the WGS84 reference ellipsoid.
GEDI03_elev_lowestmode_stddev_<start_date>_<end_date>_<release>_<version>.tif	Standard deviation of the elevation of lowest mode of valid footprints in each grid cell.
GEDI03_rh100_mean_<start_date>_<end_date>_<release>_<version>.tif	Canopy height above ground in each grid cell characterized by the mean RH100 values of valid footprints in each grid cell. RH100 or relative height is the 100^{th} percentile of waveform energy relative to ground elevation. Derived from the L2B LIDAR metric RH100 data product.
GEDI03_rh100_stddev_<start_date>_<end_date>_<release>_<version>.tif	Standard deviation of RH100 for all valid footprints in each grid cell.
Companion Files: 32 total files, including one PNG file for each data file (30) and two additional PDF files	
GEDI03_counts_<start_date>_<end_date>_<release>_<version>.png	Images of the number of valid laser footprints in each grid cell (Fig. 6).
GEDI03_elev_lowestmode_stddev_<start_date>_<end_date>_<release>_<version>.png	Images of the standard deviation of ground elevation.
GEDI03_elev_lowestmode_mean_<start_date>_<end_date>_<release>_<version>.png	Images of the estimated mean ground elevation (Fig. 4).
GEDI03_rh100_mean_<start_date>_<end_date>_<release>_<version>.png	Images of the estimated mean canopy height (Fig. 1).
GEDI03_rh100_stddev_<start_date>_<end_date>_<release>_<version>.png	Images of the standard deviation of canopy height.
GEDI_ATBD_L3R01.pdf	Algorithm Theoretical Basis Document (ATBD) for GEDI L3 Gridded Land Surface Metrics that provides details of L3 algorithms and data products. Also available in Luthcke et al. (2021).
GEDI_L3_Land_Surface_Metrics_V2.pdf	This user guide in PDF format.

Data File Details

Table 2. Variable names and descriptions in the data files.

Variable Name	Description	Native Data Type	No Data Value
counts	Count of valid laser footprints	INT32	0
elev_lowestmode_mean	Ground elevation in meters	FLOAT32	-9999
elev_lowestmode_stddev	Ground elevation-standard deviation in meters	FLOAT32	-9999
rh100_mean	Canopy height in meters	FLOAT32	-9999
rh100_stddev	Canopy height-standard deviation in meters	FLOAT32	-9999

Properties of the GeoTIFF Files

- Bands: 1
- Scale factor: 1
- 34,704 columns x 14,616 rows
- Tile size (or Block size): 256 by 256
- Map Projection: Equal-Area Scalable Earth (EASE)-Grid 2.0 Global (https://nsidc.org/data/ease), WGS 84 datum, EPSG: 6933
- X-axis map coordinate of the outer edge of the upper-left pixel: -17367530.45
- Y-axis map coordinate of the outer edge of the upper-left pixel: 7314540.83

User Notes

GEDI measurements are made over the Earth's surface nominally between 51.6° and -51.6° latitude. Because the instrument can be rotated on its ISS mount up to 6°, the lasers can be pointed up to 40 km on either side of the ISS ground track. Thus, the exact spatial coverage of L2 products will vary slightly by orbit. In addition, L3 gridded coverage might differ slightly from L2 data owing to footprint quality checks and grid cell filtering. L3 grid cells failing quality checks and those outside the measurement extent are assigned the no data value. Currently, the data files have a range of 85° to -85° latitude that corresponds to the full extent of the EASE-Grid 2.0. All data collected beyond 51.6° to -51.6° latitude have values set to -9999, except for the variable *count* where they are set to 0.

Filtering granules and shots adversely affected by geolocation uncertainty and/or low cloud may result in the omission of woody vegetation patches in otherwise open landscapes (e.g., riparian zones), see Figure 2 for examples. A revised filtering approach is currently being evaluated for common application to Level 3 and 4 gridded products and will be made available in Release 3.

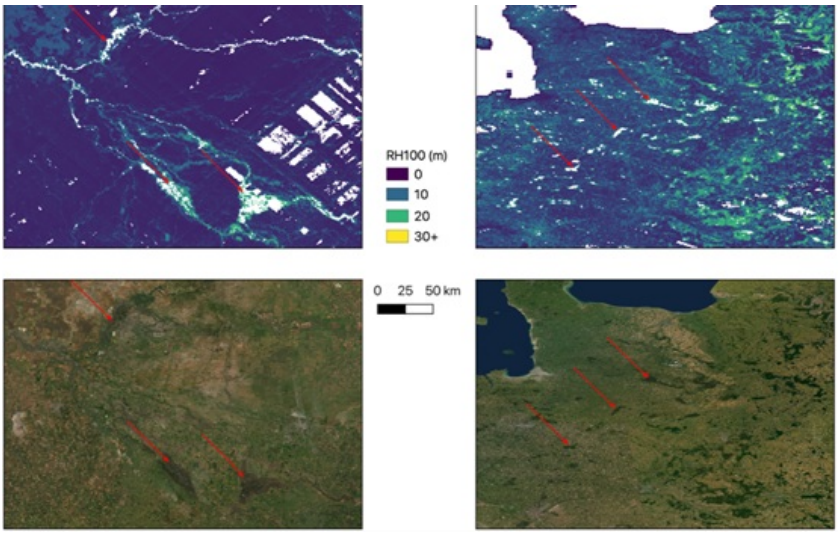

Figure 2. Examples of woody vegetation removed by the current filtering. The red arrows point to forest patches removed by the filtering algorithm and absent from the GEDI RH100 maps shown in the top row of images.

3. Application and Derivation

The GEDI Level 3 (L3) dataset provides information on forest canopy height and surface elevation, which are used to characterize important carbon and water cycling processes, biodiversity, and habitat. The products can also be of immense value for weather forecasting, forest management, snow and glacier monitoring, and the generation of digital elevation models.

The raw GEDI waveform is captured after a near-infrared pulse of laser energy is fired towards the surface where it is reflected by leaves, branches, and the below canopy bare Earth surface within an approximately 25-m diameter footprint (Fig. 3). The returned waveform is processed to find ground topography, canopy height, and various relative height (RH) metrics. From these metrics, a variety of other products may be derived, including plant density profile, canopy cover, and aboveground biomass.

The current version of L3 products is grid cell mean and standard deviation, supplying the number of shots within a grid cell within each data range to enable the computation of the standard error of the mean and other weighting, smoothing, and filtering by the user.

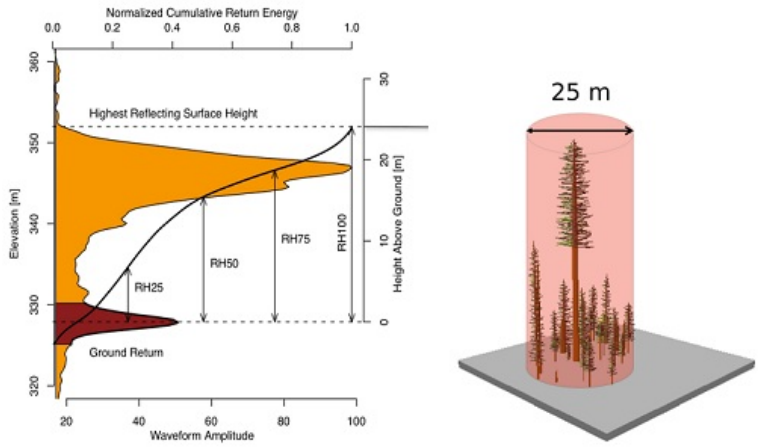

Figure 3. Sample of the GEDI lidar waveform (left). The light brown area under the curve represents return energy from the canopy, while the dark brown area signifies the return from the underlying topography. The black line is the cumulative return energy, starting from the bottom of the ground return (normalized to 0) to the top of the canopy (normalized to 1). RH metrics give the height at which a certain quantile returned energy is reached relative to the ground (i.e., the center of the ground return). The diagram on the right shows the distribution of trees that produced the waveform. Source: Dubayah et al. (2020).

4. Quality Assessment

The quality of global surface elevation grids was assessed by comparing with re-gridded TanDEM-X (TDX) and Shuttle Radar Topography Mission (SRTM) data. However, SRTM banding and swath errors and minimal TDX penetration were observed in heavily vegetated areas. These characteristics of TDX and SRTM limit the regions where they provide high fidelity comparisons with GEDI products. In future versions, data from additional instruments and projects such as 3DEP and LVIS will be used for calibration and validation of the L3 products in specific regions. The 3DEP project aims to collect airborne lidar over the whole continental US by 2023 resulting in a 1-m^2 resolution grid of surface topography. More information on the 3DEP project (https://www.usgs.gov/core-science-systems/ngp/3dep). The LVIS data provide near-continuous mapping with ~20-m footprints, and therefore, provide an excellent dataset for GEDI assessment. The footprint data produced by LVIS is nearly identical to that produced by GEDI. More information on LVIS can be found at https://lvis.gsfc.nasa.gov/Home/index.html. The companion file GEDI_ATBD_L3R01.pdf (Luthcke et al., 2021) provides details on quality assessment.

5. Data Acquisition, Materials, and Methods

The quality of global surface elevation grids was assessed by comparing with re-gridded TanDEM-X (TDX) and Shuttle Radar Topography Mission (SRTM) data. However, SRTM banding and swath errors and minimal TDX penetration were observed in heavily vegetated areas. These characteristics

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Data Acquisition, Materials, and Methods

The GEDI Level 3 (L3) global gridded products include canopy height (Fig.1) and standard deviation, ground elevation (Fig. 4) and standard deviation, and counts of valid laser footprints per grid cell (Fig. 6) derived from GEDI L2 data.

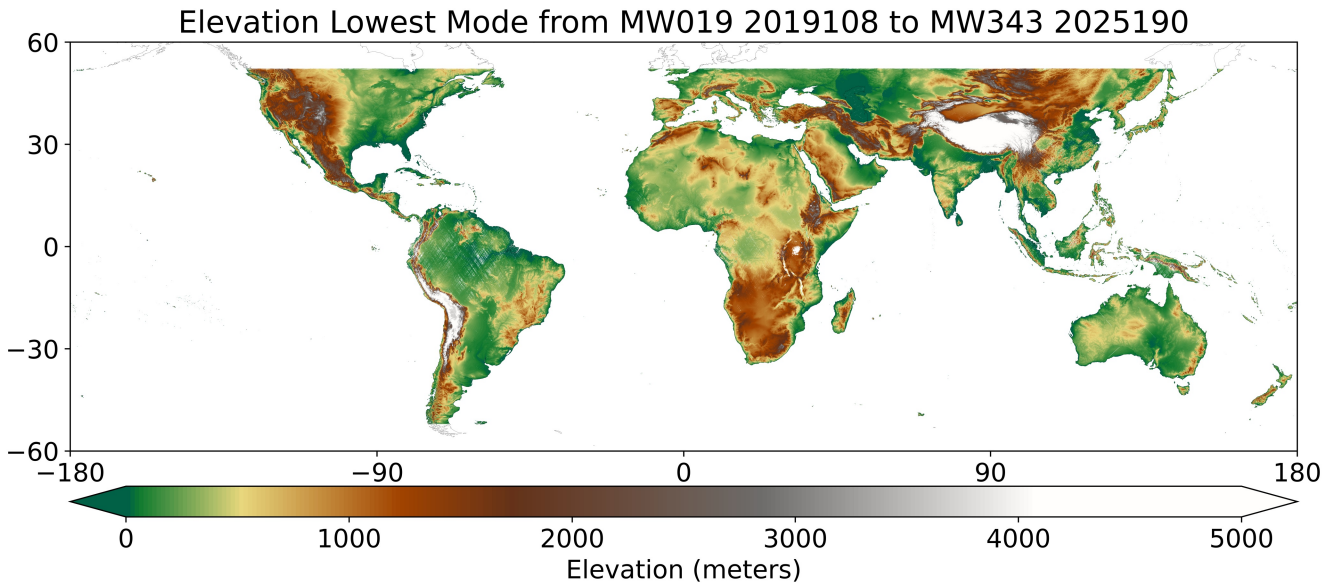

Figure 4. Estimated mean elevation of lowest mode. Image derived from the dataset file GEDI03_elev_lowestmode_mean_2019108_2025190_002_05.tif.

The GEDI instrument, launched on December 5, 2018, produces high-resolution laser ranging observations of the three-dimensional structure of the Earth, collecting data globally between 51.6ºN and 51.6°S latitudes at the highest resolution and densest sampling of any lidar instrument in orbit to date. The instrument consists of three lasers producing a total of eight beam ground transects, which consist of ~30 m footprint samples spaced approximately every 60 m along-track. The beam transects are spaced approximately 600 m apart on the Earth's surface in the cross-track direction, for an across-track width of ~4.2 km (Fig. 5).

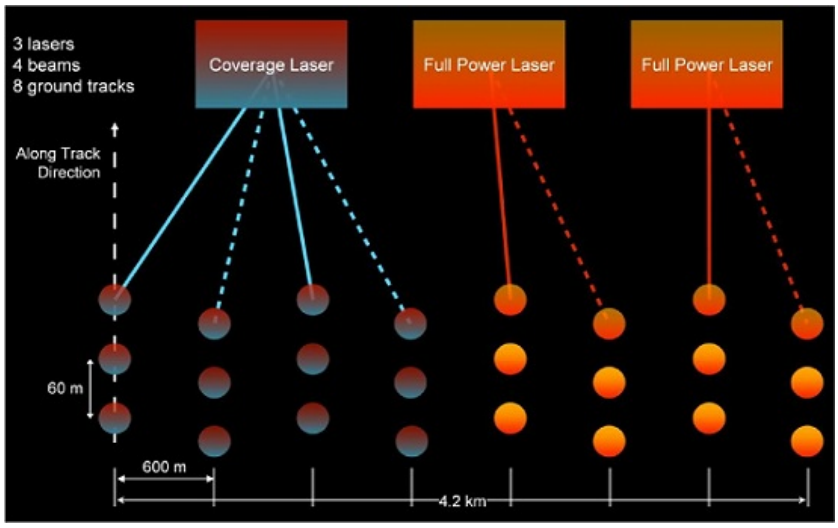

Figure 5. GEDI Beam Ground-track Configuration. Source: Luthcke et al. (2021).

EASE Grid

The 1-km^2 resolution global EASE-Grid 2.0 is used for GEDI L3 products. This grid features equal-area cells and compatibility with many existing biosphere datasets. More information on the grid can be found in Brodzic et al. (2012) and online from the National Snow and Ice Data Center at https://nsidc.org/data/user-resources/help-center/guide-ease-grids.

Footprint Processing

GEDI L3 products are grids produced from the Level 2 (L2) geolocated footprint data. L2 footprint positions in latitude and longitude are converted to x- and y-coordinates in the EASE grid 2.0. The L2 footprints are then assigned to 1-km^2 grid cells based on the projected ground position at the footprint center (Fig. 6).

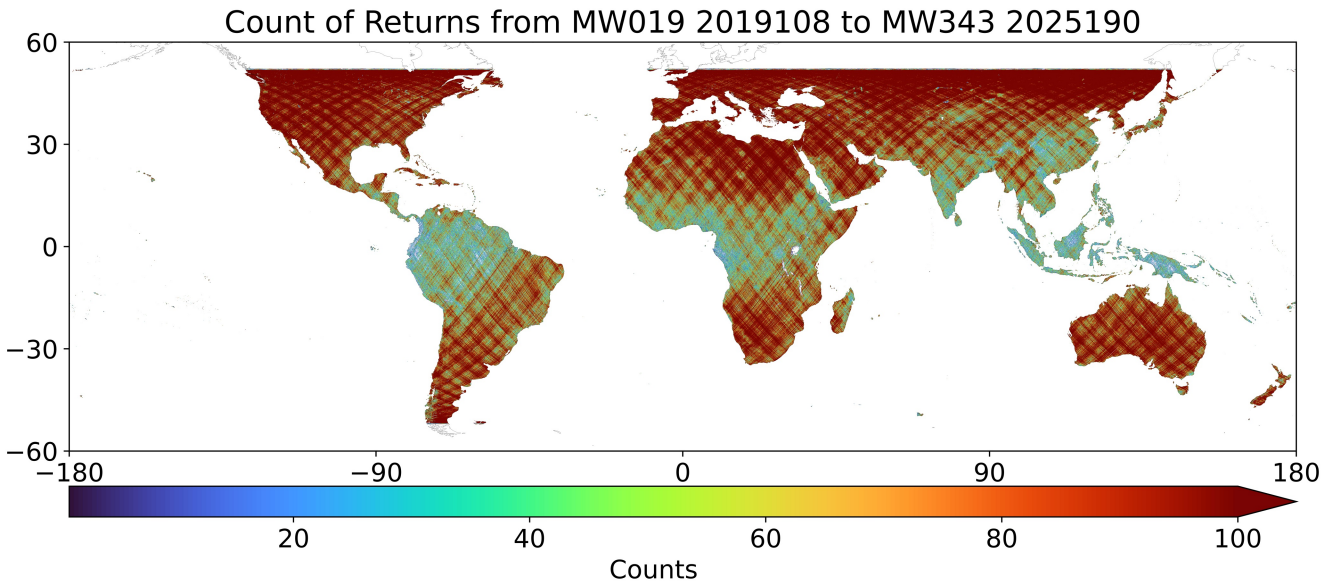

Figure 6. Count of valid laser footprints per grid cell. Image derived from dataset file GEDI03_counts_2019108_2025190_002_05.tif.

Profile Metrics Processing

L2 Footprint Selection

For each product type, the L2 footprint data for each 1-km^2 block is identified and filtered according to defined quality criteria. Returns that failed L2A quality checks and were determined to be ocean or failed elevation standard comparisons were excluded. Footprints from previously identified poor-performing orbits were also excluded. Individual footprints are then filtered based on the additional elevation comparisons. Finally, 1-km^2 cells were compared to surrounding cells and excluded if either the mean ground elevation or the mean top of canopy height is greater than 3 times the standard deviation of the means from cells in a 125-km box centered on the cell. Refer to the companion file GEDI_ATBD_L3R01.pdf (Luthcke et al., 2021) for details.

L3 Products

GEDI L3 data are gridded products with a cell size of 1 km x 1 km produced from the selected L2 geolocated footprint data. The current release of L3 products uses simple averages and standard deviations of the valid footprints within each 1-km2 cell. This release uses the Version 2 of the input L2 data, which includes improved geolocation of the footprints as well as a modified method to predict an optimum algorithm setting group.

Future releases will use advanced gridding algorithms that can more accurately represent the topography and canopy structure within the grid (Luthcke et al., 2021).

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

GEDI L3 Gridded Land Surface Metrics, Version 2

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

Brodzik, M.J., B. Billingsley, T. Haran, B. Raup, and M.H. Savoie. 2012. EASE-Grid 2.0: Incremental but significant improvements for Earth-gridded data sets. ISPRS International Journal of Geo-Information 1:32–45. https://doi.org/10.3390/ijgi1010032

Dubayah, R., J.B. Blair, S. Goetz, L. Fatoyinbo, M. Hansen, S. Healey, M. Hofton, G. Hurtt, J. Kellner, S. Luthcke, J. Armston, H. Tang, L. Duncanson, S. Hancock, P. Jantz, S. Marselis, P.L. Patterson, W. Qi, and C. Silva. 2020. The Global Ecosystem Dynamics Investigation: High-resolution laser ranging of the Earth's forests and topography. Science of Remote Sensing 1:100002. https://doi.org/10.1016/j.srs.2020.100002

Luthcke, S.B., T.J. Sabaka, J. Nicholas, S. Preaux, and M. Hofton. 2021. Algorithm Theoretical Basis Document (ATBD) for GEDI L3 Gridded Land Surface Metrics. https://gedi.umd.edu/data/documents (Also provided as companion file *GEDI_ATBD_L3R01.pdf*)

8. Dataset Revisions

Version	Release Date	Revision Notes
2.0	2026-04-22	This release adds new files for the 19th to 343rd mission weeks (2019-04-18 to 2025-07-09). No acquisitions occurred while the GEDI instrument was in storage on the International Space Station (ISS) from March 2023 to April 2024.
2.0	2023-08-23	This update adds new files for the 19th to 223rd mission weeks (2019-04-18 to 2023-03-22).
2.0	2022-06-20	This update adds new files for the 19th to 162nd mission weeks (2019-04-18 to 2022-01-19).

2.0	2022-01-31	This update adds new files for 19th to 138th mission weeks (2019-04-18 to 2021-08-04). Filtering of granules and shots adversely affected by geolocation uncertainty and/or low cloud may result in the omission of woody vegetation patches in otherwise open landscapes (e.g., riparian zones).
2.0	2021-11-23	This release was constructed using Version 2 of Level 2 data, including improved geolocation of the footprints and a modified method to predict an optimum algorithm setting group. Each of the five variables was produced using GEDI observations collected during two different date ranges that include periods between the 19th and the 96th mission weeks (2019-04-18 to 2020-10-13) and between the 19th and the 122nd mission weeks (2019-04-18 to 2021-04-14).
1.0	2021-03-15	Initial release of data with GEDI observations captured during the period 2019-04-18 (19th mission week) to 2020-04-15 (70th mission week). Superseded by Version 2 and available only upon request.