IceBridge LVIS-GH L2 Geolocated Surface Elevation Product, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

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FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/ILVGH2

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

The LVIS-GH Level-2 Geolocated Surface Elevation Product data files are in ASCII text (.TXT) format. Each data file is paired with an associated XML (.xml) file. The XML files contain location, platform, and instrument metadata.

1.2 File Naming Convention

Files are named according to the following convention and as described in Table 1:

File name example:

`ILVGH2_GL2013_1030_R1405_058062.TXT`

`ILVGH2_GL2013_1030_R1405_058062.TXT.xml`

`ILVGH2_LOYYYY_MMDD_RYYMM_TTTTTT.xxx`

Table 1. File Naming Convention

Variable	Description
ILVGH2	Short name for IceBridge LVIS-GH L2 Geolocated Surface Elevation Product
LOYYYY	Campaign identifier. LO = location, where GL = Greenland and AQ = Antarctica. YYYY= four-digit year of campaign
MMDD	Month (MM) and day (DD) of data collection
RYYMM	Release year (YY) and month (MM)
TTTTTT	Number of seconds since UTC midnight of the day the data collection started
.xxx	Indicates file type: ASCII text (.TXT) or XML (.xml)

1.2.1 File Size

Text files range from approximately 10 MB to 89 MB.

XML files range from approximately 10 KB to 57 KB.

1.2.2 Volume

Data volume for the full data set is approximately 33 GB.

1.3 Spatial Coverage

Spatial coverage for the IceBridge LVIS-GH campaigns include the Arctic, Greenland, Antarctica, and surrounding ocean areas. In effect, this represents the coverage noted below.

Arctic / Greenland:
Southernmost Latitude: 60° N
Northernmost Latitude: 90° N
Westernmost Longitude: 180° W
Easternmost Longitude: 180° E

Antarctica:
Southernmost Latitude: 90°S
Northernmost Latitude: 53°S
Westernmost Longitude: 180° W
Easternmost Longitude: 180° E

1.3.1 Spatial Resolution

Spatial resolution is nominally 15 meters, but varies with aircraft altitude. Laser footprint size is a function of beam divergence and altitude. Nominal footprint spacing is a function of scan rate and pulse repetition rate.

1.3.2 Projection and Grid Description

International Terrestrial Reference Frame (ITRF 2000), WGS-84 Ellipsoid.

1.4 Temporal Coverage

These data were collected as part of Operation IceBridge from 26 October 2013 to 14 November 2013.

1.4.1 Temporal Resolution

IceBridge campaigns are conducted on an annual repeating basis. Arctic and Greenland campaigns are conducted during March, April, May, September, October, and November. Antarctic campaigns are conducted during October and November.

1.5 Parameter or Variable

The LVIS-GH Level-2 Geolocated Surface Elevation Products data include elevation measurements of overflown terrain.

1.5.1 Parameter Description

The IceBridge LVIS-GH Level-2 Geolocated Surface Elevation Product in ASCII text format contain fields as described in Table 2.

- Rows with *centroid* refer to the centroid elevation and associated lat/lon position of the corresponding Level-1B waveform.
- Rows with *low* refer to the center of the lowest mode in the waveform (elev/lat/lon), that is the mean elevation of the lowest reflecting surface.
- Rows with *high* refer to the center of the highest mode in the waveform, that is the mean elevation of the highest reflecting surface in the footprint.
- In non-complex terrain (i.e, single mode waveforms are returned, an example being smooth ice), the *high* and *low* products are identical.
- In complex terrain (i.e., multi-mode waveforms are returned), then *high* minus *low* is analogous to the vertical elevation extent in the footprint.

Table 2. ASCII Text File Parameter Description

Parameter	**Description**	**Units**
LVIS_LFID	LVIS-GH file identification, including date and time of collection and file number. The third through seventh values in the first field represent the Modified Julian Date of data collection.	n/a
SHOTNUMBER	Laser shot assigned during collection	n/a
TIME	UTC decimal seconds of the day	Seconds
LONGITUDE_CENTROID	Refers to the centroid longitude of the corresponding LVIS-GH Level-1B waveform.	Degrees east
LATITUDE_CENTROID	Refers to the centroid latitude of the corresponding LVIS-GH Level-1B waveform.	Degrees north
ELEVATION_CENTROID	Refers to the centroid elevation of the corresponding LVIS-GH Level-1B waveform.	Meters
LONGITUDE_LOW	Longitude of the lowest detected mode within the waveform	Degrees east
LATITUDE_LOW	Latitude of the lowest detected mode within the waveform	Degrees north
ELEVATION_LOW	Mean elevation of the lowest detected mode within the waveform	Meters
LONGITUDE_HIGH	Longitude of the center of the highest mode in the waveform	Degrees east

Parameter	Description	Units
LATITUDE_HIGH	Latitude of the center of the highest mode in the waveform	Degrees north
ELEVATION_HIGH	Elevation of the center of the highest mode in the waveform	Meters

Figure 1 illustrates the elevation parameters in the Level-2 ASCII text files.

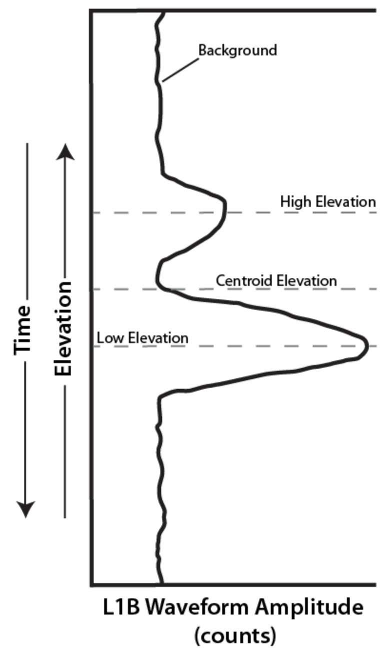

Figure 1. Illustration Describing the Elevation Parameters in the Level-2 ASCII Data Files

1.5.2 Sample Data Records

Below is a sample of records from ASCII data file `ILVGH2_GL2013_1030_R1405_058062.TXT`. The twelve columns in each record correspond to the parameters described in Table 2. The column headings and values are wrapped to fit on this page.

```
# LVIS_LFID SHOTNUMBER TIME LONGITUDE_CENTROID LATITUDE_CENTROID
ELEVATION_CENTROID LONGITUDE_LOW LATITUDE_LOW ELEVATION_LOW LONGITUDE_HIGH
LATITUDE_HIGH ELEVATION_HIGH
1856595404 45582377  58062.10482  294.283245  66.330999    476.681 294.283245  66.330999
476.709 294.283245  66.330999    476.709
1856595404 45582378  58062.10522  294.283323  66.331004    476.828 294.283323  66.331004
476.848 294.283323  66.331004    476.848
1856595404 45582380  58062.10602  294.283479  66.331014    476.934 294.283479  66.331014
476.930 294.283479  66.331014    476.930
1856595404 45582381  58062.10642  294.283556  66.331019    476.906 294.283556  66.331019
476.917 294.283556  66.331019    476.917
1856595404 45582383  58062.10722  294.283707  66.331029    477.009 294.283707  66.331029
477.012 294.283707  66.331029    477.012
1856595404 45582891  58062.31042  294.262008  66.330260    472.220 294.262008  66.330260
472.255 294.262008  66.330260    472.255
```

Figure 2. Sample from ASCII data file `ILVGH2_GL2013_1030_R1405_058062.TXT`.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

As described on the NASA LVIS Web site, a laser altimeter is an instrument that measures range from the instrument to a target object or surface. The device sends a laser beam toward the target, and measures the time it takes for the signal to reflect back from the surface. Knowing the precise round-trip time it takes for the reflection to return yields the range to the target.

Figure 2 shows two examples of return energy waveforms. A simple waveform occurs where the ice surface is relatively smooth within the footprint of the laser pulse. Mean Noise Level provides the threshold relative to which the centroid and all modes are computed. A complex waveform might be returned from a rougher ice surface and could contain more than one mode, originating from different reflecting surfaces within the laser footprint such as crevasse sides and bottom, open water, large snowdrifts, and other steep or multiple slopes.

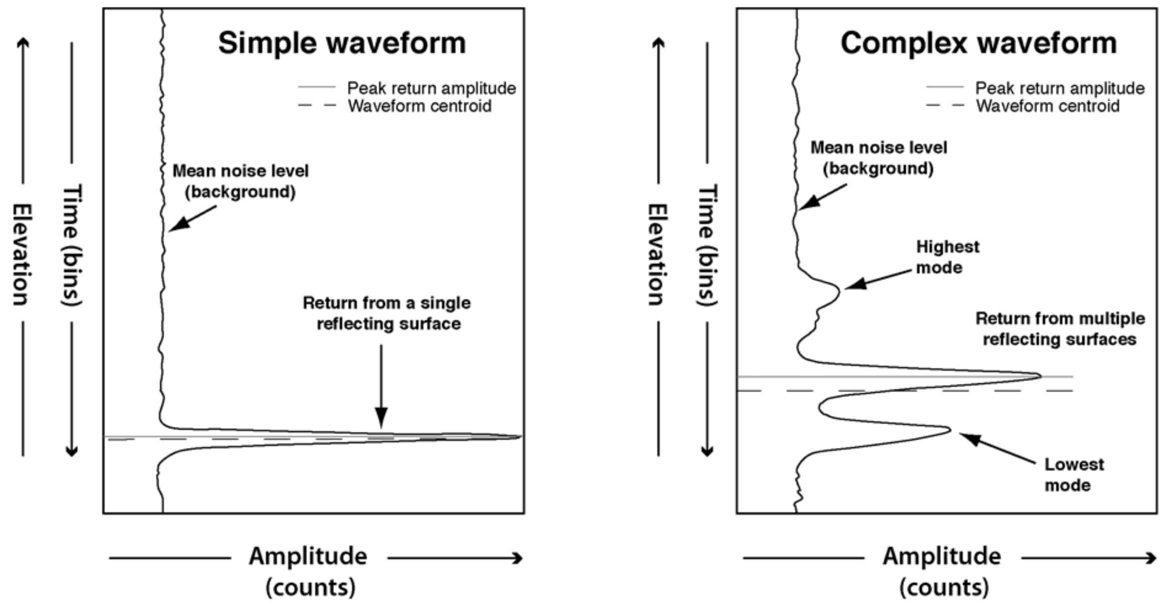

Figure 3. Sample Level-1B Product Waveforms, from which the Level-2 Products are Derived

2.2 Acquisition

LVIS-GH employs three digitizers, disciplined with a single very precise oscillator, to measure both the transmitted and reflected laser pulse energies versus time. These digitized and captured photon histories are known as waveforms. For the outgoing pulse, it represents the profile of the individual laser shot, and for the return pulse it records the interaction of that transmitted pulse with the target surface.

Processing of these waveforms yields many products, but the primary is range from the instrument to the Earth's surface and the distribution of reflecting surfaces within the area of the laser footprint. For vegetated terrain these surfaces are tree canopies, branches, other forms of vegetation, and open ground. For cryospheric data these surfaces are snow, ice, crevasses, snowdrifts, sea ice possibly interspersed with open ocean, exposed rock, and water.

LVIS-GH uses a waveform-based measurement technique to collect data instead of just timing detected returns of the laser pulse. The return signal is sampled rapidly, and stored completely for each laser shot. Retaining all waveform information allows post processing of the data to extract many different products. With the entire vertical extent of surface features recorded, metrics can be extracted about the sampled area. An advantage of saving all of the waveform data is that new techniques can be applied to these data long after collection to extract even more information. See the NASA LVIS Web site.

2.3 Derivation Techniques and Algorithms

The LVIS-GH Level-2 Geolocated Surface Elevation Product is derived from the LVIS-GH Level-1B Geolocated Return Laser Waveform Product, as described in the Processing Steps section.

2.3.1 Processing Steps

The following processing steps are performed by the data provider to produce the ASCII text format Level-2 data.

1. Proceeding from the Level-1B waveform, a background or threshold return energy level is first determined. Waveform records at or above this threshold provide information from which the subsequent measurements are calculated.
2. Next the centroid of the waveform above the threshold is computed. The centroid represents the centroid location and elevation of all reflecting surfaces within the laser footprint.
3. Finally, all modes in the waveform are identified, followed by selection of the highest and lowest modes for output. These correspond to the mean elevation of the highest and lowest reflecting surfaces, respectively, within the laser footprint.

The following processing steps are performed by the data provider to produce the LVIS-GH binary format Level-1B data, from which the Level-2 data are derived.

1. The GPS data are post-processed to generate the airplane trajectory. Precise Point Positioning (PPP) techniques are used. The trajectory is merged with the laser data to produce the latitude, longitude, and altitude of the airplane for each laser shot.
2. An atmospheric correction is applied to each laser measurement. This adjustment is necessary due to effects of temperature and pressure on the speed of light through the atmosphere. It is computed using a model, and data extrapolated from the nearest meteorological station.
3. The attitude (roll, pitch, and yaw) of the airplane is recorded by the Inertial Navigation System (INS), and is interpolated for the time of each laser shot to know the precise pointing.
4. Measurement model parameters are determined from airplane maneuvers performed during pre- and post-mission calibration flights and during science flights. Parameters include timing, rotational and translational offsets, for example, angular differences between the Inertial Measurement Unit (IMU) and laser pointing reference frames. The measurement model parameters are determined after flying the airplane through controlled maneuvers over a known, preferably flat, surface.
5. The laser range measurement, laser pointing, and laser positioning information are combined using the measurement model parameters to calculate the location of two reference points in each laser return waveform (referred to as bin 0 and bin 528) relative to a global reference frame. This creates the geolocated Level-1B data product. Further details can be found in Hofton et al. 2000.

2.4 Instrumentation

2.4.1 Description

The Land, Vegetation, and Ice Sensor-Global Hawk (LVIS-GH) is an airborne LIDAR scanning laser altimeter developed by NASA for use in the Global Hawk Unmanned Aerial Vehicle (UAV) and available for install in other aircraft. This instrument is used primarily for collecting surface topography and 3D structure information. LVIS-GH uses a three digitizer system with a single oscillator to measure transmitted and reflected laser pulse energies versus time capturing photon histories as waveforms. The laser beam and telescope field of view scan a raster pattern along the surface perpendicular to aircraft heading as the aircraft travels over a target area. LVIS-GH has scan angles of approximately 12 degrees, and can cover a 4 km swath from an altitude of 20 km. The nominal footprint size is 15 meters in diameter from an altitude of 20 km. In addition to waveform data, GPS satellite data is recorded at fixed ground locations and on the airborne platform to precisely reference aircraft position. An IMU is attached directly to the LVIS-GH instrument and provides information required for coordinate determination.

3 SOFTWARE AND TOOLS

The data files can be opened by any software that reads ASCII text files.

Also available: an IDL program that reads the LVIS-GH Level-2 data into an IDL structure: read_ilvis2.pro.

4 RELATED DATA SETS

- Antarctic 5-km Digital Elevation Model from ERS-1 Altimetry
- GLAS/ICESat 500 m Laser Altimetry Digital Elevation Model of Antarctica
- GLAS/ICESat L1B Global Elevation Data
- IceBridge ATM L1B Qfit Elevation and Return Strength
- IceBridge ATM L2 Icessn Elevation, Slope, and Roughness
- IceBridge LVIS L1B Geolocated Return Energy Waveforms
- Pre-IceBridge ATM L2 Icessn Elevation, Slope, and Roughness

5 RELATED WEBSITES

- LVIS Web site at NASA Goddard Space Flight Center
- IceBridge Data Web site at NSIDC
- IceBridge Web site at NASA
- ICESat/GLAS Web site at NASA Wallops Flight Facility
- ICESat/GLAS Web site at NSIDC

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7 REFERENCES

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Hofton, M. A., Blair, J. B., Luthcke, S. B., and Rabine, D. L. 2008. Assessing the performance of 20-25 m footprint waveform lidar data collected in ICESat data corridors in Greenland, Geophysical Research Letters, 35: L24501, doi:10.1029/2008GL035774.

Hofton, M. A., J. B. Blair, J. B. Minster., J. R. Ridgway, N. P. Williams, J. L Bufton, and D. L. Rabine. 2000. An Airborne Scanning Laser Altimetry Survey of Long Valley, California, International Journal of Remote Sensing, 21(12): 2413-2437.

8 DOCUMENT INFORMATION

8.1 Publication Date

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8.2 Document Update Date

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