IceBridge LVIS L2 Geolocated Surface Elevation Product, Version 2

USER GUIDE

How to Cite These Data

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

Blair, J. B. and M. Hofton. 2019. *IceBridge LVIS L2 Geolocated Surface Elevation Product, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/E9E9QSRNLYTK. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/ILVIS2

National Snow and Ice Data Center

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1 DATA DESCRIPTION

The data in this Level-2 product were collected as part of Operation IceBridge campaigns by the NASA Land, Vegetation, and Ice Sensor (LVIS). The corresponding Level-1B data set, *IceBridge LVIS L1B Geolocated Return Energy Waveforms*, contains the spatially geolocated laser return waveforms. The LVIS Level-2 data products are derived from these waveforms and provide measurements for a variety of scientific applications. See the Related Data Collections section for links to other LVIS data sets.

1.1 Parameters

This data set includes mean elevation and other height measurements. All the parameters contained in the data files are described in Table 1.

Note: The LVIS facility is working toward establishing a standard set of data parameters that are applicable to a range of fields. Thus, not all parameters contained in the Level-2 files are currently relevant to every field of research. Additionally, some parameter names were changed; see the Version History section for more information.

Table 1. ASCII Text File Parameters

Parameter	Description	Units
LFID	LVIS file identification. The format is XXYYYYYZZZ, where XX identifies instrument version, YYYYY is the Modified Julian Date of the flight departure day, and ZZZ represents the file number.	N/A
SHOTNUMBER	LVIS shot number assigned during collection. Together with LFID, it provides a unique identifier to every LVIS laser shot.	N/A
TIME	UTC decimal seconds of the day	Seconds
GLON	Longitude of the lowest detected mode within the waveform	Degrees East
GLAT	Latitude of the lowest detected mode within the waveform	Degrees North
ZG	Mean elevation of the lowest detected mode within the waveform	Meters
HLON	Longitude of the center of the highest detected mode within the waveform	Degrees East
HLAT	Latitude of the center of the highest detected mode within the waveform	Degrees North
ZH	Mean elevation of the highest detected mode within the waveform	Meters

Parameter	Description	Units
TLON	Longitude of the highest detected signal	Degrees East
TLAT	Latitude of the highest detected signal	Degrees North
ZT	Elevation of the highest detected signal	Meters
RH10	Height (relative to ZG) at which 10% of the waveform energy occurs	Meters
RH15	Height (relative to ZG) at which 15% of the waveform energy occurs	Meters
RH20	Height (relative to ZG) at which 20% of the waveform energy occurs	Meters
RH25	Height (relative to ZG) at which 25% of the waveform energy occurs	Meters
RH30	Height (relative to ZG) at which 30% of the waveform energy occurs	Meters
RH35	Height (relative to ZG) at which 35% of the waveform energy occurs	Meters
RH40	Height (relative to ZG) at which 40% of the waveform energy occurs	Meters
RH45	Height (relative to ZG) at which 45% of the waveform energy occurs	Meters
RH50	Height (relative to ZG) at which 50% of the waveform energy occurs	Meters
RH55	Height (relative to ZG) at which 55% of the waveform energy occurs	Meters
RH60	Height (relative to ZG) at which 60% of the waveform energy occurs	Meters
RH65	Height (relative to ZG) at which 65% of the waveform energy occurs	Meters
RH70	Height (relative to ZG) at which 70% of the waveform energy occurs	Meters
RH75	Height (relative to ZG) at which 75% of the waveform energy occurs	Meters
RH80	Height (relative to ZG) at which 80% of the waveform energy occurs	Meters
RH85	Height (relative to ZG) at which 85% of the waveform energy occurs	Meters
RH90	Height (relative to ZG) at which 90% of the waveform energy occurs	Meters

RH95	Height (relative to ZG) at which 95% of the waveform energy occurs	Meters
RH96	Height (relative to ZG) at which 96% of the waveform energy occurs	Meters
RH97	Height (relative to ZG) at which 97% of the waveform energy occurs	Meters
RH98	Height (relative to ZG) at which 98% of the waveform energy occurs	Meters
RH99	Height (relative to ZG) at which 99% of the waveform energy occurs	Meters
RH100	Height (relative to ZG) at which 100% of the waveform energy occurs	Meters
AZIMUTH	Azimuth angle of laser beam	Degrees
INCIDENTANGLE	Off-nadir incident angle of laser beam	Degrees
RANGE	Distance along laser path from the instrument to the ground	Meters
COMPLEXITY	Complexity metric for the return waveform	N/A
CHANNEL_ZT	Flag indicating LVIS channel waveform contained in the matching Level-1B file	N/A
CHANNEL_ZG	Flag indicating LVIS channel used to locate ZG	N/A
CHANNEL_RH	Flag indicating LVIS channel used to calculate RH metrics	N/A

1.2 File Information

1.2.1 Format

The data files are in ASCII text format. Each data file is paired with an associated XML file, which contains additional metadata.

1.2.2 Naming Convention

Example file names:

`ILVIS2_GL2013_1114_R1406_043900.TXT`

`ILVIS2_GL2013_1114_R1406_043900.TXT.xml`

The data files are named according to the following convention and as described in Table 1:

`ILVIS2_LOYYYY_MMDD_RYYMM_nnnnnn.xxx`

Table 2. File Naming Convention

Variable	Description
ILVIS2	Short name for IceBridge LVIS L2 Geolocated Surface Elevation Product
LOYYYY	Campaign identifier. LO = location, where GL = Greenland and AQ = Antarctica(*). YYYY= four-digit year of campaign
MMDD	Two-digit month, two-digit day of campaign
RYYMM	Date (YY year / MM month) of data release
nnnnnn	Number of seconds since UTC midnight of the day on which the data collection started
.xxx	Indicates file type: ASCII data file (.TXT) XML metadata file (.TXT.xml)

(*)**NOTE:** The 2014 ARISE Alaska campaign file names contain the same campaign identifier as the Greenland file names (GL).

1.3 File Size

The total data file volume is approximately 241 GB.

1.4 Spatial Information

1.4.1 Coverage

Spatial coverage for this data set includes areas of the Arctic and Greenland, as noted below:

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

1.4.2 Spatial Resolution

Spatial resolution is nominally 20 m, but varies with aircraft altitude. Laser spot size is a function of beam divergence and altitude. Nominal spot spacing is a function of scan rate and pulse repetition rate.

1.4.3 Geolocation

The following table provides the geolocation details for this data set.

Table 3. Geolocation Details

Geographic coordinate system	WGS 84
Projected coordinate system	WGS 84 / NSIDC Sea Ice Polar Stereographic North
Longitude of true origin	-45° E
Latitude of true origin	70° N
Scale factor at longitude of true origin	1
Datum	WGS 84
Ellipsoid/spheroid	WGS 84
Units	meters
False easting	0
False northing	0
EPSG code	3413
PROJ4 string	+proj=stere +lat_0=90 +lat_ts=70 +lon_0=-45 +k=1 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs
Reference	https://epsg.io/3413

1.5 Temporal Coverage

25 August 2017 to 20 September 2017

1.5.1 Temporal Resolution

IceBridge campaigns are conducted on an annually repeating basis. Arctic, Greenland, and Alaska campaigns are typically conducted in March, April, and May; Antarctic campaigns are typically conducted in October and November.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

A laser altimeter is an instrument that measures the 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 for the signal 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. The mean noise level provides the threshold relative to which all signal processing is referenced. 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. A complex waveform is also typically returned from multilevel vegetation land cover such as a forest.

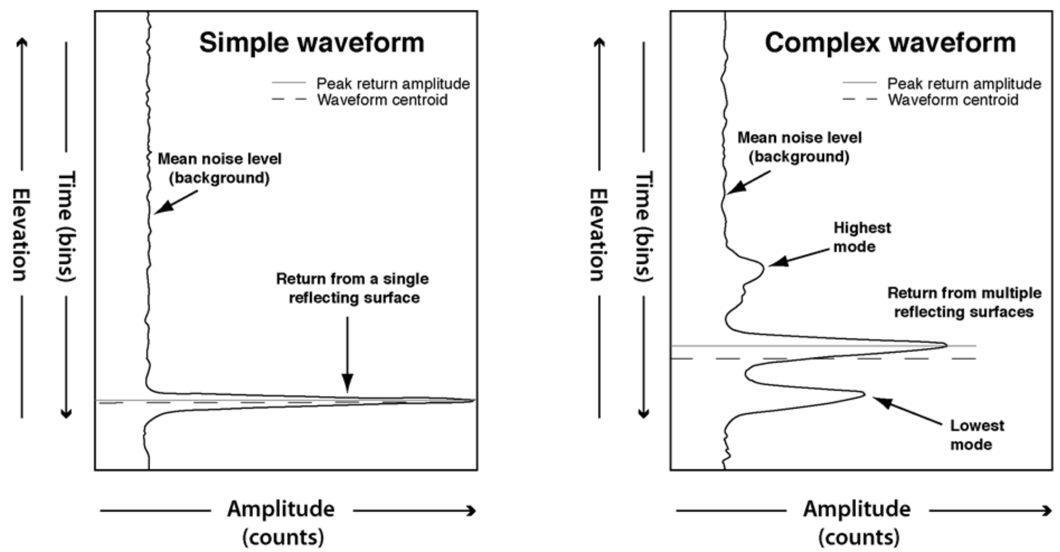

Figure 1 . Sample Level-1B product waveforms, from which the Level-2 products are derived.

2.2 Acquisition

LVIS employs a signal digitizer, disciplined with a 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; however, the primary products are the elevations of the Earth's surface and the distribution of reflecting surfaces within the laser footprint area. For vegetated terrain, these surfaces include tree canopies, branches, other forms of vegetation, and open ground. For cryospheric data, these surfaces are snow, ice, crevasses, snowdrifts, and sea ice, possibly interspersed with open ocean, exposed rock, and water.

LVIS 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. For more information, see the NASA LVIS website.

2.3 Processing

LVIS employs a signal digitizer, disciplined with a 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; however, the primary products are the range from the instrument to the Earth's surface and the distribution of reflecting surfaces within the laser footprint area. For vegetated terrain, these surfaces include tree canopies, branches, other forms of vegetation, and open ground. For cryospheric data, these surfaces are snow, ice, crevasses, snowdrifts, and sea ice, possibly interspersed with open ocean, exposed rock, and water.

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2.4 Quality, Errors, and Limitations

The data have received limited quality assurance checking. Obvious low-quality data were removed, such as clouds and cloud-obscured returns. Currently, there are no known errors or limitations in this data set.

2.5 Derivation Techniques and Algorithms

2.5.1 Processing Steps

This data set is derived from the LVIS Level-1B Geolocated Return Laser Waveform product. The following processing steps are performed by the data provider to produce the Level-2 data in ASCII text format.

1. Proceeding from the Level-1B waveform, a background or threshold return energy level is first determined. This threshold forms the datum to which the subsequent measurements are referenced.

2. The centroid of the waveform above the threshold is computed. The centroid represents the mean location and mean elevation of all reflecting surfaces within the laser footprint.

3. 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.

2.6 Instrumentation

2.6.1 Description

LVIS is an airborne lidar scanning laser altimeter used by NASA to collect surface topography and vegetation coverage data. LVIS uses a signal digitizer with oscillator to measure transmitted and reflected laser pulse energies versus time and capture photon histories as waveforms. The laser beam and telescope field of view scan a raster pattern along the surface perpendicular to the aircraft heading as the aircraft travels over a target area. LVIS has a scan angle of approximately 12°, and can cover 2 km swaths from an altitude of 10 km. A typical collection size is 10 m to 25 m spots. In addition to waveform data, GPS satellite data are recorded at ground tie locations and on the airborne platform to precisely reference the aircraft position. An IMU is attached directly to the LVIS 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: read_ilvis2.pro, an IDL program that reads the LVIS Level-2 data into an IDL structure.

4 VERSION HISTORY

The data for 2009 through 2015 are stored in Version 1 of this data set.

Version 2 of this data set contains more parameters than Version 1. In addition, some parameters were renamed or removed. Essentially, Version 2 comprises the following changes:

- LVIS_LFID is now called LFID.
- LONGITUDE_LOW, LATITUDE_LOW, and ELEVATION_LOW were renamed to GLON, GLAT, and ZG.
- LONGITUDE_HIGH, LATITUDE_HIGH, and ELEVATION_HIGH were renamed to HLON, HLAT, and ZH.
- LONGITUDE_CENTROID, LATITUDE_CENTROID, and ELEVATION_CENTROID were removed.
- TLON, TLAT, and ZT were added.
- RH10 through RH100 were added.
- AZIMUTH, INCIDENTANGLE, RANGE, and COMPLEXITY were added.
- CHANNEL_ZT, CHANNEL_ZG, and CHANNEL_RH were added.

5 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

6 RELATED WEBSITES

- LVIS website at NASA Goddard Space Flight Center
- IceBridge data website at NSIDC
- IceBridge website at NASA
- ICESat/GLAS website at NASA Wallops Flight Facility
- ICESat/GLAS website at NSIDC

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8 REFERENCES

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9 DOCUMENT INFORMATION

9.1 Publication Date

7 March 2019

9.2 Date Last Updated

28 August 2019