IceBridge LVIS L1B Geolocated Return Energy Waveforms, 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. 2014, updated 2018. *IceBridge LVIS L1B Geolocated Return Energy Waveforms, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/RDT1MZVS0VG9 [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/ILVIS1B

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

This data set contains geolocated return energy waveforms, transmitted waveforms, and ancillary data collected by NASA's Land, Vegetation, and Ice Sensor (LVIS).

1.2 File Information

1.2.1 Format

Data are provided as HDF5 formatted files.

1.2.2 File Contents

Each data file contains the following parameters:

Table 1. File Parameter Description

Parameter	Description	Units
`LFID`	LVIS file identification, including date and time of collection and file number. The third through seventh values in first field represent the Modified Julian Date of data collection.	n/a
`SHOTNUMBER`	Laser shot assigned during collection	n/a
`AZIMUTH`	Azimuth angle of laser beam	degrees
`INCIDENTANGLE`	Off-nadir angle of laser beam	degrees
`RANGE`	Along-laser-beam distance from the instrument to the ground	meters
`TIME`	UTC decimal seconds of the day	seconds
`LON0`	Longitude of the highest sample in the waveform	degrees east
`LAT0`	Latitude of the highest sample in the waveform	degrees north
`Z0`	Elevation of the highest sample in the waveform	meters
`LON527`	Longitude of the lowest sample in the waveform	degrees east
`LAT527`	Latitude of the lowest sample in the waveform	degrees north
`Z527`	Elevation of the lowest sample in the waveform	meters
`SIGMEAN`	Signal mean noise level	counts
`TXWAVE`	Transmitted waveform (120 samples)	counts
`RXWAVE`	Returned waveform (528 samples)	counts

1.2.3 Naming Convention

The data files are named according to the following convention and as described in Table 2.

`ILVIS1B_LOYYYY_MMDD_RYYMM_nnnnnn.h5`

Examples:

```
ILVIS1B_AQ2009_1105_R1408_069261.h5
ILVIS1B_GL2012_0507_R1210_061594.h5
```

Table 2. File Naming Convention

Variable	Description
ILVIS1B	IceBridge LVIS L1B Geolocated Return Energy Waveforms data 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 and MM=month) of the data release
nnnnnn	Number of seconds since UTC midnight of the day the data collection started

1.3 Spatial Coverage

1.3.1 Coverage

Spatial coverage for the IceBridge LVIS campaigns includes the Arctic, Greenland, Antarctica, and surrounding ocean areas, as described by the coordinates below.

Arctic / Greenland:

Southernmost Latitude: 60° N

Northernmost Latitude: 90° N

Westernmost Longitude: 180° W

Easternmost Longitude: 180° E

Antarctic:

Southernmost Latitude: 90° S

Northernmost Latitude: 53° S

Westernmost Longitude: 180° W

Easternmost Longitude: 180° E

1.3.2 Resolution

The spatial resolution is nominally 20 meters 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.

1.3.3 Geolocation

For data up to and including 2015, LVIS used ITRF 2000 / WGS-84. Starting in 2017, LVIS used ITRF 2008 / WGS-84. The following tables provide the geolocation details for this data set.

Table 3. Geolocation Details

Geographic coordinate system	WGS 84
Projected coordinate system	N/A
Longitude of true origin	Prime Meridian, Greenwich
Latitude of true origin	N/A
Scale factor at longitude of true origin	N/A
Datum	WGS 84
Ellipsoid/spheroid	WGS 84
Units	degree
EPSG code	4326
PROJ4 string	+proj=longlat +datum=WGS84 +no_defs +type=crs
Reference	https://epsg.io/4326

Table 4. ITRF Details*

Geographic coordinate system	WGS 84	WGS 84
Prime Meridian	0°	0°
Datum	ITRF 2000	ITRF 2008
Ellipsoid/spheroid	GRS 1980	GRS 1980
Units	meters	meters
False easting	0	0
False northing	0	0
EPSG code	4919	5332
PROJ4 string	+proj=geocent +ellps=GRS80 +units=m +no_defs +type=crs	+proj=geocent +ellps=GRS80 +units=m +no_defs +type=crs
Reference	https://epsg.io/4919	https://epsg.io/5332

*For data up to and including 2015, LVIS used ITRF 2000. Starting in 2017, LVIS used ITRF 2008.

1.4 Temporal Information

1.4.1 Coverage

14 April 2009 to 20 September 2017

1.4.2 Resolution

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

2 DATA ACQUISITION AND PROCESSING

2.1 Background

As described on the NASA LVIS website, 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 from the surface. The precise round-trip time it takes for the reflection to return is defined as the range to the target.

Figure 1 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 (approximately 20 meters in diameter). Mean noise level provides the threshold relative to which the centroid and all modes are later 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. A complex waveform would be more typically returned from multilevel vegetation landcover such as a forest.

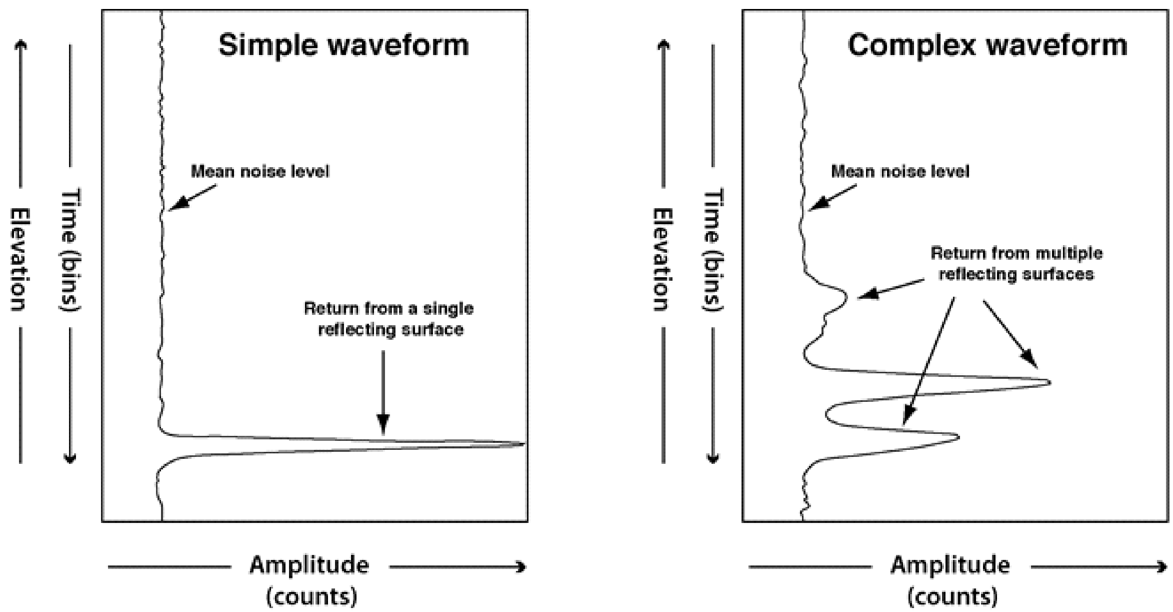

Figure 1. Sample product waveforms illustrating possible distributions of reflected light.

2.2 Instrumentation

LVIS is an airborne lidar scanning laser altimeter used by NASA for collecting surface topography and vegetation coverage data. LVIS uses a signal digitizer with oscillator to measure transmitted and reflected laser pulse energies versus time, thereby capturing 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 12º and can cover 2 km swaths from an altitude of 10 km. Typical collection size is 10 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 inertial measurement unit (IMU) is attached directly to the LVIS instrument and provides information required for determining coordinates.

2.3 Acquisition

The outgoing pulse represents the profile of the individual laser shot, and the return pulse records the interaction of that transmitted pulse with the target surface.

Processing of these waveforms yields many products, but the primary product 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, and sea ice, possibly interspersed with open ocean, exposed rock, and water.

LVIS uses a waveform-based measurement technique to collect data instead of only 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. New techniques can be applied to these data long after collection to extract even more information.

2.4 Processing

The following processing steps are performed by the data provider to produce the binary format Level-1B data.

1. The differential kinematic GPS data are post-processed to generate the airplane trajectory. 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. Laser pulse timing errors, due to the internal system response time and further affected by the amplitude of the return, are determined by calibration experiments. These are performed at the beginning and end of each flight. Each range measurement is corrected accordingly.
4. 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.
5. Several instrument biases are determined next. Timing biases are due to the delay between the actual observation of aircraft attitude and the recording of those data in the computer following the calculations. Laser mounting biases come from slight angular differences between the orientations of the three axes of the INS and those of the airplane. The timing and angle biases are determined after flying the airplane through controlled roll and pitch maneuvers over a known, preferably flat, surface.
6. The offset between the GPS antenna and the laser scan mirror must be known in order to relate the airplane trajectory and the range measurement. The offset vector is found by performing a static GPS survey between several system components inside and outside the grounded airplane.
7. The laser range measurement is transformed from a local reference system within the airplane to a global reference frame and ellipsoid. This creates the geolocated data product.

3 VERSION HISTORY

Table 5. Version History Summary

Version	Release Date	Description of Changes
V1	January 2011	Initial release; binary data
V1.1	November 2012	2011 Antarctica data were replaced due to improvements in the LVIS transmit laser waveform
V2	August 2014	HDF5 format available for data beginning with 2013 Arctic campaign
V2	September 2023	HDF5 format available for all data

4 RELATED DATA SETS

- GLAS/ICESat L1B Global Elevation Data (GLA06)
- IceBridge LVIS L2 Geolocated Surface Elevation Product (ILVIS2)
- IceBridge ATM L1B Elevation and Return Strength (ILATM1B)
- Pre-IceBridge ATM L2 Icessn Elevation, Slope, and Roughness (BLATM2)

5 RELATED WEBSITES

- LVIS webpage at NASA Goddard Space Flight Center
- IceBridge at NSIDC
- IceBridge at NASA
- ICESat/GLAS at NSIDC

6 ACKNOWLEDGMENTS

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7 REFERENCES

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8 DOCUMENT INFORMATION

8.1 Publication Date

August 2014

8.2 Date Last Updated

January 2024