ABoVE LVIS 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:

Blair, J. B. and M. Hofton. 2018. *ABoVE LVIS L2 Geolocated Surface Elevation Product, Version 1.* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/IA5WAX7K3YGY. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/ABLVIS2

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

The data in this Level-2 product were collected by the NASA Land, Vegetation, and Ice Sensor (LVIS) as part of the Arctic-Boreal Vulnerability Experiment (ABoVE). ABoVE is a NASA Terrestrial Ecology Program field campaign conducted in Alaska and Western Canada. The ABoVE data are used to study environmental change and its implications for social-ecological systems. The data files of this Level-2 product contain canopy top and ground elevations, as well as relative heights derived from the Level-1B data, the *ABoVE LVIS L1B Geolocated Return Energy Waveforms*. The Level-1B data files contain geolocated laser waveform data for each laser footprint. Other related LVIS data sets include Level-0, Level-1B, and Level-2 products collected as part of the Operation IceBridge campaigns. See Section 4.1 for links to these data sets.

1.1 Format

The data files are in ASCII text format (.TXT). Each data file is paired with an associated XML file (.xml), which contain additional metadata.

1.2 File Naming Convention

The data files are named according to the following conventions and as described in Table 1.

1.2.1 Example File Names

LVIS2_ABoVE2017_0629_R1803_056233.TXT
LVIS2_ABoVE2017_0629_R1803_056233.TXT.xml

1.2.2 File Naming Convention

LVIS2_ABoVEYYYY_MMDD_RYYMM_nnnnnn.NN

Table 1. File Naming Convention

Variable	Description
LVIS2	Short name for LVIS L2 Geolocated Surface Elevation Product
ABoVEYYYY	Campaign identifier. ABoVE = acronym for Arctic-Boreal Vulnerability Experiment; YYYY= four-digit year of campaign
MMDD	Two digit month, two-digit day of campaign
RYYMM	Date (YY year / MM month) of the data release
nnnnnn	Number of seconds since UTC midnight of the day the data collection started
NN	Indicates file type: .TXT (ASCII text file) or .TXT.xml (XML metadata file)

1.3 Spatial Coverage

Spatial coverage for the ABoVE LVIS campaigns includes Alaska and Western Canada, as noted by the coverage below.

Alaska / Canada:
Southernmost Latitude: 48° N
Northernmost Latitude: 72° N
Westernmost Longitude: 158° W
Easternmost Longitude: 104° W

1.3.1 Spatial Resolution

The spatial resolution is on average 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.

1.3.2 Projection and Grid Description

International Terrestrial Reference Frame (ITRF 2008), WGS-84 Ellipsoid.

1.4 Temporal Coverage

29 June 2017 to 17 July 2017

1.4.1 Temporal Resolution

The ABoVE Alaska and Canada campaigns were conducted on 13 days between 29 June and 17 July 2017. Table 2 lists all the flight dates and locations for those days. For more detailed information, visit the NASA ABoVE campaign website.

Table 2. Flight Dates and Locations

Date	Location
29 Jun 2017	Saskatoon to Yellowknife
29 Jun 2017	Slave Lake
30 Jun 2017	Yellowknife to Inuvik
30 Jun 2017	Inuvik to Yellowknife
01 Jul 2017	Daring Lake
02 Jul 2017	W and SW Slave Lake
03 Jul 2017	Yellowknife to Whitehorse

Date	Location
03 Jul 2017	Whitehorse to Fairbanks
06 Jul 2017	Kluane
07 Jul 2017	Healy
09 Jul 2017	Fairbanks to Barrow
14 Jul 2017	Fairbanks to Deadhorse via Toolik Lake
14 Jul 2017	Deadhorse to Fairbanks via Fort Yukon
15 Jul 2017	Fort Yukon
16 Jul 2017	Fairbanks to Ketchikan
16 Jul 2017	Ketchikan to Glasgow
17 Jul 2017	Boreal Ecosystem Research and Monitoring Sites (BERMS) Flight
18 Jul 2017	Glasgow to Toledo

1.5 Parameter or Variable

The data files contain canopy top and ground elevations and relative heights derived from the Level-1B data.

1.5.1 Parameter Description

Parameters contained in the ASCII text files are described in Table 3.

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
TLON	Longitude of the highest detected signal	Degrees East
TLAT	Latitude of the highest detected signal	Degrees North

Parameter	Description	Units
TZ	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

Parameter	Description	Units
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 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

1.5.2 Sample Data Record

Figure 1 shows a sample from the LVIS2_ABoVE2017_0629_R1803_056233.TXT data file.

```
# L2 data set collected by NASA's Land, Vegetation and Ice Sensor (LVIS) Facility
# for the 2017 ABoVE Campaign in Canada and Alaska. The corresponding spatially
# geolocated laser return waveforms are contained in the L1B data set. Please visit
# http://lvis.gsfc.nasa.gov/ABoVE2017Map.html for more information.
# These data were collected from ~28,000 ft altitude on a Dynamic Aviation B200T
# airplane. The data have had limited quality assurance checking, although
# obvious lower quality data have been removed, e.g., clouds and cloud-
# obscured returns. We highly recommend that end users contact us about any
# idiosyncrasies or unexpected results.  We also recommend that end users
# review the L1B waveforms for their specific areas of study to verify ground
# return and canopy top identification. We are not able to detect and filter
# all possible anomalies and some rare examples may exist in these data.
# LFID SHOTNUMBER TIME GLON GLAT ZG TLON TLAT ZT RH10 RH15 RH20 RH25 RH30 RH35 RH40 RH45
RH50 RH55 RH60 RH65 RH70 RH75 RH80 RH85 RH90 RH95 RH96 RH97 RH98 RH99 RH100 AZIMUTH
INCIDENTANGLE RANGE COMPLEXITY CHANNEL_ZT CHANNEL_ZG CHANNEL_RH
1957933043   3993109  56233.489  253.219734   52.529359   515.37  253.219735   52.529360
517.28   -0.97   -0.79   -0.64   -0.52   -0.37   -0.30   -0.19   -0.07    0.04    0.11
0.22    0.34    0.45    0.60    0.75    0.93    1.16    1.42    1.50    1.61    1.68    1.80
1.91  209.56    3.647   6906.89 0.017  1  1  1
1957933043   3993110  56233.489  253.219697   52.529379   515.44  253.219697   52.529380
516.82   -0.97   -0.79   -0.64   -0.52   -0.41   -0.34   -0.22   -0.15   -0.07    0.04
0.11    0.19    0.30    0.37    0.49    0.64    0.79    1.01    1.05    1.12    1.20    1.27
1.38  209.99    3.642   6907.34 0.040  1  1  1
1957933043   3993111  56233.489  253.219717   52.529300   515.31  253.219718   52.529301
516.55   -0.82   -0.67   -0.56   -0.45   -0.37   -0.30   -0.19   -0.11   -0.04    0.04
0.11    0.19    0.26    0.37    0.45    0.56    0.71    0.90    0.97    1.01    1.08    1.12
1.23  209.26    3.699   6906.89 0.001  1  1  1
1957933043   3993112  56233.489  253.219679   52.529321   515.28  253.219680   52.529321
516.85   -0.79   -0.64   -0.52   -0.41   -0.34   -0.22   -0.15   -0.07    0.00    0.11
0.19    0.26    0.37    0.49    0.60    0.75    0.97    1.20    1.27    1.31    1.38    1.46
1.57  209.69    3.694   6907.18 0.001  1  1  1
1957933043   3993113  56233.490  253.219641   52.529341   515.19  253.219642   52.529341
516.95   -0.90   -0.71   -0.56   -0.45   -0.37   -0.26   -0.19   -0.07    0.00    0.07
0.19    0.26    0.37    0.49    0.60    0.79    0.97    1.27    1.35    1.42    1.50    1.61
1.76  210.12    3.688   6907.78 0.001  1  1  1
```

Figure 1. Sample records from the LVIS2_ABoVE2017_0629_R1803_056233.TXT data file.

2 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.

3 DATA ACQUISITION AND PROCESSING

As described on the NASA LVIS website, 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 reflection to return yields the range to the target.

Figure 2 shows two example return waveforms. A simple waveform (left) occurs when the surface is relatively smooth within the laser footprint, which generates a laser return waveform that consists of a single mode. The detection threshold is computed relative to the mean noise level and is used to detect the return signals that are geolocated for Level-2 data products. Multilayered surfaces, such as forests, vegetated landcover, ice crevasses, or rocky terrain, produce complex waveforms (right) containing more than one mode. Different modes represent the various surfaces within the footprint, such as the canopy top, the ground, the crevasse bottom, or the top of the broken ice surface, and are distributed according to their relative elevations within the footprint.

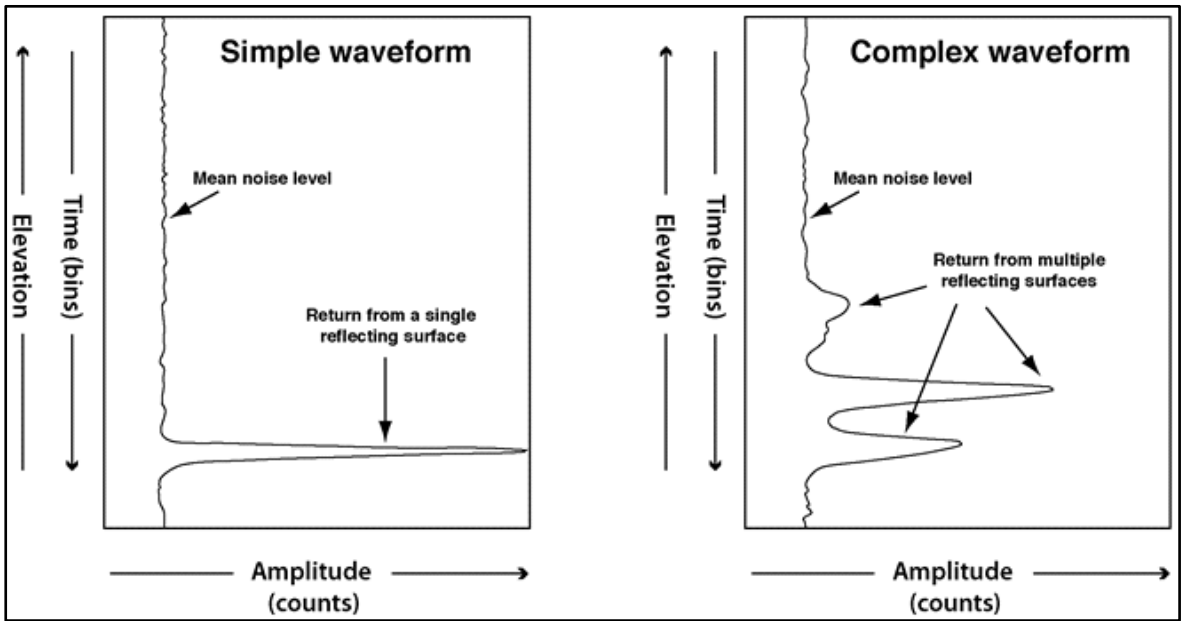

Figure 2. Sample Level-1B product waveforms illustrating some possible distributions of reflected light.

3.1 Data Acquisition Methods

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, 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 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 website for more information.

3.2 Derivation Techniques and Algorithms

This data set is derived from the LVIS Level-1B Geolocated Return Laser Waveform product, as described below.

3.2.1 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. This threshold forms the datum to which the subsequent measurements are referenced.
2. Next 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. 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.

3.3 Sensor or Instrument Description

As described on the NASA LVIS website, 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 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 has a scan angle of approximately 12 degrees and can cover 2 km swaths from an altitude of 10 km. Typical collection size is 10 m to 25 m spots. In addition to waveform data, GPS satellite data is recorded at ground tie locations and on the airborne platform to precisely reference aircraft position. An IMU is attached directly to the LVIS instrument and provides information required for coordinate determination.

4 REFERENCES AND RELATED PUBLICATIONS

Blair, J. B., D. L. Rabine, and M. A. Hofton. 1999. The Laser Vegetation Imaging Sensor: A Medium-Altitude, Digitisation-Only, Airborne Laser Altimeter for Mapping Vegetation and Topography, *ISPRS Journal of Photogrammetry and Remote Sensing*, 54: 115-122.

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.

Hofton, M. A., J. B. Blair, S. B. Luthcke, and D. L. Rabine. 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.

4.1 Related Data Collections

ABoVE LVIS L1B Geolocated Return Energy Waveforms
IceBridge LVIS L0 Raw Ranges
IceBridge LVIS L1B Geolocated Return Energy Waveforms
IceBridge LVIS L2 Geolocated Surface Elevation Product

4.2 Related Websites

LVIS website at NASA Goddard Space Flight Center
ABoVE website at NASA
IceBridge data website at NSIDC

5 CONTACTS AND ACKNOWLEDGMENTS

Bryan Blair
Laser Remote Sensing Laboratory, Code 694
NASA Goddard Space Flight Center
Greenbelt, MD 20771

Michelle Hofton
Department of Geography
2181 LeFrak Hall
University of Maryland
College Park, MD 20742

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6 DOCUMENT INFORMATION

6.1 Publication Date

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6.2 Date Last Updated

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