LVIS Classic L2 Geolocated Surface Elevation and Canopy Height 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. 2020. *LVIS Classic L2 Geolocated Surface Elevation and Canopy Height 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/W569D47GCOUX. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/LVISC2

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DATA DESCRIPTION 2
1.1 Parameters 2
1.2 File Information 2
1.2.1 Format 2
1.2.2 Naming Convention 3
1.3 Spatial Information 3
1.3.1 Coverage 3
1.3.2 Resolution 3
1.3.3 Geolocation 4
1.4 Temporal Information 4
1.4.1 Coverage 4
1.4.2 Resolution 4
2 INSTRUMENTATION 4
3 DATA ACQUISITION AND PROCESSING 5
3.1 Background 5
3.2 Acquisition 6
3.3 Processing Steps 6
3.4 Quality, Errors, and Limitations 6
4 SOFTWARE AND TOOLS 7
5 RELATED DATA SETS 7
6 RELATED WEBSITES 7
7 CONTACTS 7
8 ACKNOWLEDGMENTS 8
9 REFERENCES 8
10 DOCUMENT INFORMATION 8
10.1 Publication Date 8
10.2 Date Last Updated 8
APPENDIX A – DATA FILE PARAMETERS 9

1 DATA DESCRIPTION

This Level-2 data set contains measurements taken by NASA's Land, Vegetation, and Ice Sensor (LVIS) in support of the NASA Arctic-Boreal Vulnerability Experiment (ABoVE) and the NASA Global Ecosystem Dynamics Investigation (GEDI). ABoVE is a NASA Terrestrial Ecology Program conducted in Alaska and Western Canada. The ABoVE data are used to study environmental change and its implications for social-ecological systems. GEDI was launched to the International Space Station (ISS) in December 2018 to measure forest canopy height, structure, and surface elevation to improve characterization of important carbon and water cycle processes, biodiversity, and habitats. These flights provide data for ABoVE science investigations, as well as calibration and validation of GEDI mission in the United States, Canada, and Central America.

Two LVIS instruments were co-mounted and operated during flights, with data products referred to as LVISC (from the LVIS-Classic instrument) and LVISF (from the LVIS-Facility instrument). This data set contains measurements taken by the LVIS-Classic instrument, whereas the corresponding Level-2 LVISF data set, *LVIS Facility L2 Geolocated Surface Elevation and Canopy Height Product*, contains data from the co-mounted LVIS-Facility instrument. These two LVIS instruments differ in the laser footprint size and spacing on the ground. The Level-1B versions of these data sets, *LVIS Classic L1B Geolocated Return Energy Waveforms* and *LVIS Facility L1B Geolocated Return Energy Waveforms*, contain geolocated return energy waveforms used to create the Level-2 data sets.

This data set is also closely related to the *ABoVE LVIS L2 Geolocated Surface Elevation Product* data set, which provides ABoVE data, and the *AfriSAR LVIS L2 Geolocated Surface Elevation Product* data set, which provides GEDI calibration and validation data.

1.1 Parameters

All of the parameters contained in the data files are described in Table A-1 in Appendix A.

1.2 File Information

1.2.1 Format

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

1.2.2 Naming Convention

Example file names:

LVISC2_ABoVE2019_0715_R2002_086485.TXT
LVISC2_ABoVE2019_0715_R2002_086485.TXT.xml

LVISC2_GEDI2019_0521_R2002_073401.TXT
LVISC2_GEDI2019_0521_R2002_073401.TXT.xml

Files are named according to the following convention, which is described in Table 1:

LVISC2_CAMPYYYY_MMDD_RYYMM_nnnnnn.ext

Table 1. File Naming Convention

Variable	Description
`LVISC2`	Data set ID
`CAMPYYYY`	Campaign identifier: ABoVE = Arctic-Boreal Vulnerability Experiment; GEDI = Global Ecosystem Dynamics Investigation; YYYY= four-digit year of campaign
`MMDD`	Two-digit month, two-digit day of start of data collection
`RYYMM`	Date (YY year / MM month) of the data release
`nnnnnn`	Number of seconds since UTC midnight of the day the data collection started
`ext`	Indicates file type: `.TXT` (ASCII text data file) or `.TXT.xml` (XML metadata file)

1.3 Spatial Information

1.3.1 Coverage

Spatial coverage for this data set currently includes parts of Alaska, Western Canada, the continental United States, and central America, as noted by the spatial extents below:

Southernmost latitude: 9° N
Northernmost latitude: 72° N
Westernmost longitude: 168° W
Easternmost longitude: 81° W

1.3.2 Resolution

The nominal spatial resolution of the LVISC data sets is 20 m, but varies slightly with aircraft altitude and speed. Laser spot size is a function of beam divergence and altitude. Nominal spot spacing is a function of scan rate, pulse repetition rate, and airplane ground speed. The instrument

resolution and footprint size are comparable to those in the *AfriSAR LVIS L2 Geolocated Surface Elevation Product* data set, but are lower than in the *ABoVE LVIS L2 Geolocated Surface Elevation Product* and the *LVIS Facility L2 Geolocated Surface Elevation and Canopy Height Product* data sets.

1.3.3 Geolocation

International Terrestrial Reference Frame 2008 (ITRF08), WGS-84 ellipsoid

1.4 Temporal Information

1.4.1 Coverage

21 May 2019 to 06 August 2021

1.4.2 Resolution

Varies

2 INSTRUMENTATION

NASA's LVIS is an imaging lidar sensor suite for precise and accurate large-area surface mapping and characterization. LVIS uses airborne lidar scanning laser altimeters to collect topography and vegetation coverage data over land, ocean, and ice surfaces, along with downward-looking, high-resolution camera imagery. The LVIS instruments differ in laser footprint size and spacing on the ground but generate near-identical data products.

Laser altimeters send a laser beam toward a target object and measure the time it takes for the signal to reflect back from the surface. Knowing the precise round-trip time for the reflection to return allows the distance, or range, to the target to be calculated. Range is combined with the pointing and positioning of the laser at the time of each laser shot to determine the location of each laser footprint on the ground relative to a reference ellipsoid (e.g.: Hofton et al., 2000). LVIS employs a signal digitizer with a very precise oscillator to measure both the transmitted and reflected laser pulse energies versus time. These digitized and captured histories are known as waveforms (i.e., the transmitted and return waveforms). The outgoing signal represents the profile of the individual laser pulse versus time; the return pulse comprises the interaction of that transmitted pulse with the target surface versus time.

As the aircraft travels over a target area, the laser beam and the telescope field-of-view scan a pattern along the surface perpendicular to the aircraft heading. LVIS instruments have a scan angle

of approximately 12° (+-6° around nadir), allowing them to cover 2 km swaths from an altitude of 10 km. The typical diameter of the laser footprint on the ground is 10 m to 25 m, depending on the aircraft altitude, as well as laser repetition rate and divergence. Laser positioning at the time of each laser shot is provided by GPS satellite data. Laser pointing information is provided by an Inertial Measurement Unit (IMU) attached directly to the LVIS instrument.

3 DATA ACQUISITION AND PROCESSING

3.1 Background

Figure 1 shows two examples of return waveforms: a simple waveform (left) and a complex waveform (right). The simple waveform occurs when the surface is relatively smooth within the laser footprint, thus generating 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. Complex waveforms containing more than one mode are produced when the laser beam hits multilayered surfaces, such as forests, vegetated land cover, ice crevasses, or rocky terrain. Different modes represent the various surfaces within the footprint, such as the canopy top, the ground, the crevasse bottom, or the top of broken ice surface, and are distributed according to their relative elevations within the footprint.

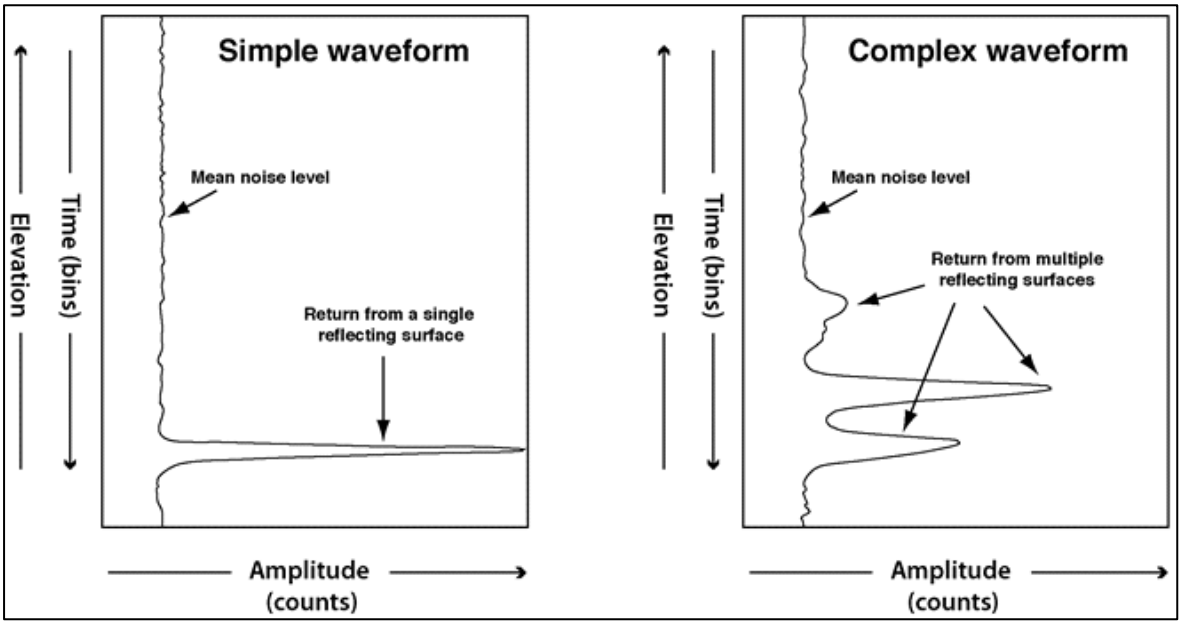

Figure 1. Sample Level-1B product waveforms illustrating possible distributions of reflected light.

3.2 Acquisition

The primary Level-1B data product is the geolocated laser return waveforms, representing the vertical distribution of reflecting surfaces within the area of the laser footprint over the sampled terrain. For vegetated terrain these surfaces include tree canopies, branches, other forms of vegetation, and open ground. For cryospheric areas these surfaces comprise 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 many different products to be extracted during data post-processing, such as the data presented in the Level-2 data 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 additional information. See the LVIS website at NASA Goddard Space Flight Center for more information.

3.3 Processing Steps

This data set is derived from the Level-1B data set, *LVIS Classic L1B Geolocated Return Energy Waveforms*. The following processing steps are performed by the data provider to produce the Level-2 data:

1. A background, or threshold, return energy level is determined from the Level-1B waveform data. 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 elevation of all reflecting surfaces within the laser footprint.
3. All modes in the waveform are identified, followed by a selection of the highest and lowest modes for output. These modes correspond to the mean elevation of the highest and lowest reflecting surfaces, respectively, within the laser footprint.

For more details see Hofton et al. (2000).

3.4 Quality, Errors, and Limitations

Obvious lower quality data, such as data collected in areas with clouds and cloud-obscured returns, were removed; however, spurious returns may still be present. Data collected in aircraft turns have been removed from this data set. It is recommended that users review the waveforms

for their specific areas of study to verify ground return and canopy top identification. It is possible that some anomalies are still present in the data.

4 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 supported by the LVIS team that reads the LVIS Level-2 data into an IDL structure.

5 RELATED DATA SETS

LVIS Classic L1B Geolocated Return Energy Waveforms
LVIS Facility L1B Geolocated Return Energy Waveforms
LVIS Facility L2 Geolocated Surface Elevation and Canopy Height Product
ABoVE LVIS L1B Geolocated Return Energy Waveforms
ABoVE LVIS L2 Geolocated Surface Elevation Product
AfriSAR LVIS L1B Geolocated Return Energy Waveforms
AfriSAR LVIS L2 Geolocated Surface Elevation Product

6 RELATED WEBSITES

LVIS website at NSIDC
LVIS website at NASA Goddard Space Flight Center
ABoVE website at NASA
GEDI website

7 CONTACTS

Bryan Blair
Laser Remote Sensing Laboratory, Code 61A
NASA Goddard Space Flight Center
Greenbelt, MD 20771

Michelle Hofton
Department of Geographical Sciences
University of Maryland
College Park, MD 20742

8 ACKNOWLEDGMENTS

This work was supported through funding from NASA. GEDI flights were supported by the GEDI mission. ABoVE flights were supported by Hank Margolis (NASA - SMD - ESD Terrestrial Ecology).

9 REFERENCES

Hofton, M. A., Blair, J. B., Minster, J.-B., Ridgway, J. R., Williams, N. P., Bufton, J. L., & Rabine, D. L. (2000). An airborne scanning laser altimetry survey of Long Valley, California. International Journal of Remote Sensing, 21(12), 2413–2437. https://doi.org/10.1080/01431160050030547

10 DOCUMENT INFORMATION

10.1 Publication Date

09 March 2020

10.2 Date Last Updated

06 February 2022

APPENDIX A – DATA FILE PARAMETERS

Table A-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
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

Parameter	Description	Units
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
SENSITIVITY(*)	Sensitivity metric for the return waveform	N/A

Parameter	Description	Units
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

Note:

(*) This parameter was newly added. The rest of the parameters are the same as in the *AfriSAR LVIS L2 Geolocated Surface Elevation Product* data set.