AfriSAR 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:

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/AFLVIS2

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DATA DESCRIPTION

The data in this Level-2 product were collected as part of the AfriSAR mission by the NASA Land, Vegetation, and Ice Sensor (LVIS) in collaboration with the European Space Agency (ESA) and the Gabonese Space Agency. The AfriSAR mission was an airborne campaign that collected radar and field measurements of tropical forests in Gabon, West Africa. The AfriSAR data is a precursor to upcoming spaceborne missions that examine the role of forests in Earth's carbon cycle. The data are also distributed in the Level-1B format, through the *AfriSAR LVIS L1B Geolocated Return Energy Waveforms* data set. 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 for links to these data sets.

1.1 Parameters

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

1.1.1 Parameter Description

Parameters contained in the ASCII text files are described in Table 1.

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

Parameter	Description	Units
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
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

Parameter	Description	Units
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_L1B	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 (.TXT). Each data file is paired with an associated XML file (.xml), which contains additional metadata.

1.2.2 File Contents

Figure 1 shows a sample from the LVIS2_Gabon2016_0220_R1808_038024.TXT data file.

```
# L2 data set collected by NASA's Land, Vegetation and Ice Sensor (LVIS)
# instrument for the 2016 Gabon Deployment as part of the AfriSAR Campaign.
# The L1B data set contains the corresponding spatially geolocated laser
# return waveforms. Please visit lvis.gsfc.nasa.gov for more information.
# These data were collected from ~24,000 ft altitude on the NASA LARC B200
# 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 HLON HLAT ZH 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_L1B CHANNEL_ZG CHANNEL_RH
1657438013    663577   38024.01500    9.791356    0.163344    8.68 -999 -999 -999    9.791355    0.163346
10.92   -1.71   -1.34   -1.11   -0.89   -0.74   -0.59   -0.44   -0.29   -0.14    0.00    0.15    0.23
0.38    0.53    0.75    0.90    1.12    1.49    1.57    1.64    1.79    1.94    2.24  170.88    6.476
5433.23 -999  1  1  1
1657438013    663578   38024.01600    9.791314    0.163292    8.76 -999 -999 -999    9.791313    0.163294
10.99   -1.64   -1.34   -1.12   -0.89   -0.75   -0.60   -0.45   -0.30   -0.15   -0.08    0.07    0.22
0.37    0.52    0.67    0.89    1.12    1.41    1.56    1.64    1.79    1.94    2.23  171.40    6.527
5433.24 -999  1  1  1
1657438013    663596   38024.03400    9.790560    0.162354    8.67 -999 -999 -999    9.790560    0.162357
10.98   -1.71   -1.41   -1.11   -0.96   -0.74   -0.59   -0.44   -0.29   -0.15    0.00    0.15    0.30
0.45    0.60    0.75    0.97    1.19    1.49    1.64    1.71    1.86    2.01    2.31  179.34    7.525
5445.38 -999  1  1  1
1657438013    663597   38024.03500    9.790518    0.162302    8.70 -999 -999 -999    9.790518    0.162304
11.08   -1.71   -1.41   -1.18   -0.96   -0.74   -0.59   -0.44   -0.29   -0.22   -0.07    0.08    0.23
0.38    0.52    0.75    0.90    1.19    1.49    1.56    1.71    1.86    2.01    2.38  179.72    7.584
5446.58 -999  1  1  1
1657438013    663598   38024.03600    9.790476    0.162249    8.65 -999 -999 -999    9.790476    0.162252
11.10   -1.64   -1.34   -1.12   -0.89   -0.74   -0.52   -0.45   -0.30   -0.15   -0.00    0.15    0.30
0.44    0.59    0.74    0.96    1.19    1.56    1.63    1.71    1.86    2.08    2.45  180.09    7.644
5446.59 -999  1  1  1
1657438013    663599   38024.03700    9.790433    0.162197    8.69 -999 -999 -999    9.790433    0.162200
11.21   -1.64   -1.34   -1.12   -0.89   -0.75   -0.60   -0.45   -0.30   -0.15   -0.00    0.15    0.29
0.44    0.59    0.74    0.96    1.19    1.56    1.71    1.78    1.93    2.15    2.52  180.46    7.704
5448.40 -999  1  1  1
1657438013    663600   38024.03800    9.790392    0.162144    8.80 -999 -999 -999    9.790392    0.162147
11.25   -1.63   -1.33   -1.11   -0.89   -0.74   -0.59   -0.44   -0.29   -0.14    0.00    0.08    0.23
```

Figure 1. A sample of records from the LVIS2_Gabon2016_0220_R1808_038024.TXT data file. The column headings and values are wrapped to fit into the figure.

1.2.3 Naming Convention

Example file names:

LVIS2_Gabon2016_0220_R1808_038024.TXT

LVIS2_Gabon2016_0220_R1808_038024.TXT.xml

Files are named according to the following convention, which is described in Table 2:

LVIS2_GabonYYYY_MMDD_RYYMM_nnnnnn.NN

Table 2. File Naming Convention

Variable	Description
`LVIS2`	Short name for LVIS L2 Geolocated Surface Elevation Product
`GabonYYYY`	Campaign identifier. Gabon = location of AfriSAR mission; 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 Information

1.3.1 Coverage

The data set covers rainforests in Gabon, Africa, as noted by the coverage below.

Northernmost Latitude: 1° N
Southernmost Latitude: 2° S
Westernmost Longitude: 8° E
Easternmost Longitude: 12° E

1.3.2 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.

1.3.3 Geolocation

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

1.4 Temporal Information

1.4.1 Coverage

20 February 2016 to 08 March 2016

1.4.2 Resolution

The AfriSAR campaign was conducted on nine days between 20 February and 08 March 2016. Table 3 lists all the flight dates and locations for those days. For more detailed information, visit NASA's AfriSAR ORNL DAAC web page.

Table 3. Flight Dates and Locations

Date	Location
20 Feb 2016	Mabounie site
22 Feb 2016	TanDEM-X and GEDI lines
23 Feb 2016	Biomass transect 1
25 Feb 2016	Mondah site
02 Mar 2016	Lope site
03 Mar 2016	Mondah site -2

Date	Location
04 Mar 2016	Pongara site
07 Mar 2016	RABI site
08 Mar 2016	Fill in: Biomass, Mondah, Pongara sites

2 DATA ACQUISITION AND PROCESSING

2.1 Background

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 or vegetated landcover, produce complex waveforms (right) containing more than one mode. Different modes represent the various surfaces within the footprint, such as the canopy top or the ground, and are distributed according to their relative elevations within the footprint.

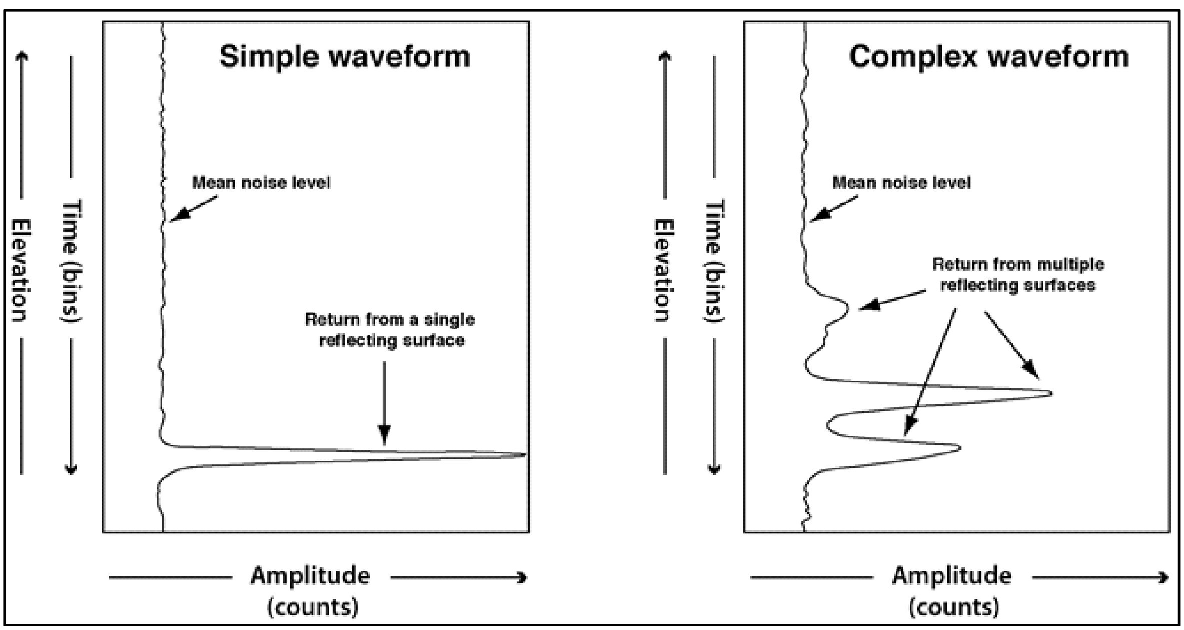

Figure 2. Sample Level-1B product waveforms illustrating some possible distributions of reflected light.

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, 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.

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.

2.3 Processing

This data set is derived from the AfriSAR LVIS L1B Geolocated Return Laser Waveforms product. 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.

2.4 Quality, Errors, and Limitations

Currently, there are no known errors or limitations in this data set.

2.5 Instrumentation

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.

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

4 RELATED DATA SETS

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

5 RELATED WEBSITES

LVIS data website at NSIDC
LVIS website at NASA Goddard Space Flight Center
NASA's AfriSAR ORNL DAAC web page

6 CONTACTS

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8 REFERENCES

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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.

9 DOCUMENT INFORMATION

9.1 Publication Date

15 October 2018

9.2 Date Last Updated

30 September 2020