AfriSAR LVIS L1B Geolocated Return Energy Waveforms, 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. *AfriSAR LVIS L1B Geolocated Return Energy Waveforms, Version 1.* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/ED5IYGVTB50Z. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/AFLVIS1B

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DATA DESCRIPTION

The data in this Level-1B 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-2 format, through the *AfriSAR LVIS L2 Geolocated Surface Elevation Product* data set. The Level-2 data files contain canopy top and ground elevations, as well as relative heights derived from the Level-1B data. 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 include geolocated return energy waveforms (RXWAVE), transmitted waveforms (TXWAVE), and ancillary data.

1.1.1 Parameter Description

Parameters contained in the HDF5 files are described in Table 1.

Table 1. HDF5 File Parameters

Group	Parameter	Description	Units
`/(root)`	`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
	`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
	`TIME`	UTC decimal seconds of the day	Seconds

	LON0	Longitude of the highest sample of the return waveform	Degrees East
	LAT0	Latitude of the highest sample of the return waveform	Degrees North
	Z0	Elevation of the highest sample of the waveform with respect to the reference ellipsoid	Meters
	LON1023	Longitude of the lowest sample of the return waveform	Degrees East
	LAT1023	Latitude of the lowest sample of the return waveform	Degrees North
	Z1023	Elevation of the lowest sample of the waveform with respect to the reference ellipsoid	Meters
	SIGMEAN	Signal mean noise level, calculated in-flight	Counts
	TXWAVE	Transmitted waveform, 128 bins long, 16 bits at 1GHz	Counts
	RXWAVE	Return waveform, 1024 bins long, 16 bits at 1GHz	Counts
/ancillary_data/	HDF5Version	HDF5 version number based on IDL version	Number
	Maximum Latitude	Maximum value of latitude to be found in this file	Degrees North
	Maximum Longitude	Maximum value of longitude to be found in this file	Degrees East
	Minimum Latitude	Minimum value of latitude to be found in this file	Degrees North
	Minimum Longitude	Minimum value of longitude to be found in this file	Degrees East
	ancillary_text	Ancillary information relevant to data collection and processing	N/A
	reference_frame	Reference frame for LVIS data products, derived from reference frame for global navigation satellite system (GNSS) orbits. Using International Terrestrial Reference Frame (ITRF 2005).	N/A

1.2 File Information

1.2.1 Format

The data files are in HDF5 format (.h5). Each data file is paired with an associated XML file (.xml), which contains additional metadata.

1.2.2 File Contents

Figure 1 shows an illustration of LAT1023 and RANGE values from a sample of the LVIS1B_Gabon2016_0220_R1808_038024.h5 data file as displayed in the HDFView tool.

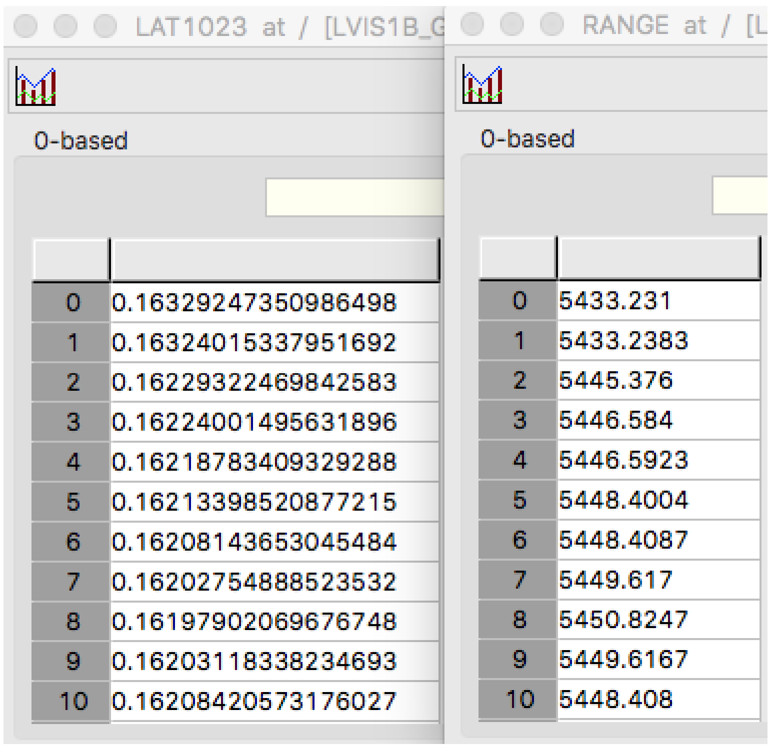

Figure 1. A sample of values for the parameters LAT1023 (left) and RANGE (right), visualized using the HDFView software.

1.2.3 Naming Convention

Example file names:

LVIS1B_Gabon2016_0220_R1808_038024.h5
LVIS1B_Gabon2016_0220_R1808_038024.h5.xml

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

LVIS1B_GabonYYYY_MMDD_RYYMM_nnnnnn.NN

Table 2. File Naming Convention

Variable	Description
`LVIS1B`	Short name for LVIS L1B Geolocated Return Energy Waveforms
`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: `.h5` (HDF5 file) or `.h5.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
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.

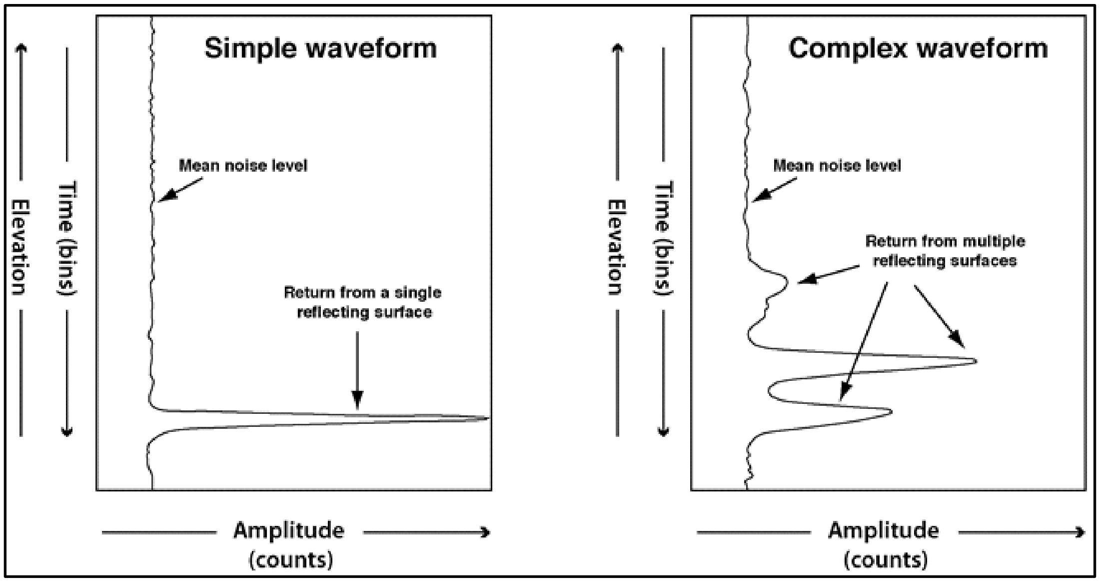

Figure 2. Sample Level-1B product waveforms illustrating some possible distributions of reflected light.

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 generated from the raw instrument data as described under Section 2.3.1. More details can be found in Hofton et al. (2000).

2.3.1 Processing Steps

The following processing steps are performed by the data provider to produce the 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 because temperature and pressure affect 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.

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 following external links provide access to software for reading and viewing HDF5 data files. Please be sure to review instructions on installing and running the programs.

- HDFView: Visual tool for browsing and editing HDF4 and HDF5 files.
- Panoply netCDF, HDF and GRIB Data Viewer: Cross-platform application. Plots geo-gridded arrays from netCDF, HDF and GRIB datasets.
- For additional tools, see the HDF-EOS Tools and Information Center.
- Also available: read_ilvis1b.pro, an IDL program supported by the LVIS team that reads the LVIS Level-1B data into an IDL structure.

4 RELATED DATA SETS

AfriSAR LVIS L2 Geolocated Surface Elevation Product
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