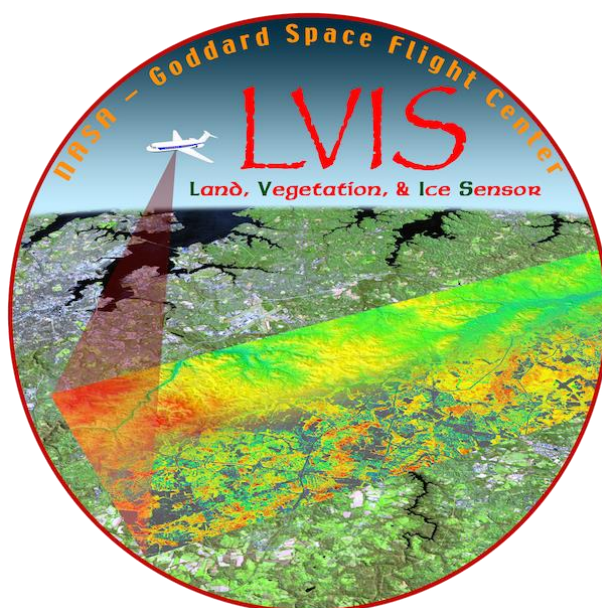


# NASA's Land, Vegetation, and Ice Sensor (LVIS) Facility

## Technical Reference Document



**Version 1.4**

**July 2024**

Helen Cornejo<sup>1</sup>, Michelle Hofton<sup>2</sup>, and J. Bryan Blair<sup>3</sup>

<sup>1</sup>KBR, Inc., Fulton, MD 20759 ([helen.cornejo@nasa.gov](mailto:helen.cornejo@nasa.gov))

<sup>2</sup>Department of Geographical Sciences, University of Maryland, College Park, MD 20742 ([mhofton@umd.edu](mailto:mhofton@umd.edu))

<sup>3</sup>Code 61A, NASA Goddard Space Flight Center, Greenbelt, MD 20771 ([james.b.blair@nasa.gov](mailto:james.b.blair@nasa.gov))

## Document History

Revision	Publication Date	Description
1.0	2023-03-14	Baseline Document
1.1	2023-07-25	Geographical extents corrected
1.2	2023-10-03	Added Gabon 2023 Classic and Camera data
1.3	2024-05-23	Added BioSCape 2023 Corrected release file numbers for ABoVE 2019
1.3.1	2024-07-23	Added file numbers for BioSCape 2023 imagery Corrected release file numbers for GL2022_04
1.4	2024-07-25	Added Lake Ice 2024

## Table of Contents

<b>1. Introduction</b> .....	<b>6</b>
<b>2. Campaigns</b> .....	<b>6</b>
2.1. United States 2018-2019 .....	6
2.2. GEDI 2019 .....	6
2.3. ABoVE 2019 .....	6
2.4. GEDI 2021 .....	7
2.5. Greenland Spring 2022 .....	7
2.6. Greenland 2022 ICESat-2 Cal/Val .....	7
2.7. Gabon 2023 .....	8
2.8. BioSCape 2023 .....	8
2.9. ICESat-2 Lake Ice 2024 .....	9
<b>3. File Naming Convention</b> .....	<b>9</b>
<b>4. United States 2018-2019 (US2018, US2019)</b> .....	<b>10</b>
4.1. Mission Information.....	10
4.2. LVIS Lidar Instruments Flown .....	10
4.3. LVIS Camera Instruments Flown .....	10
4.4. Install-Specific Notes.....	11
4.5. Known Issues.....	11
4.6. Acknowledgments .....	11
<b>5. GEDI 2019 (GEDI2019)</b> .....	<b>11</b>
5.1. Mission Information.....	11
5.2. LVIS Lidar Instruments Flown .....	11
5.3. LVIS Camera Instruments Flown .....	12
5.4. Install-Specific Notes.....	12
5.5. Known Issues.....	12
5.6. Acknowledgments .....	12
<b>6. ABoVE 2019 (ABoVE2019)</b> .....	<b>13</b>
6.1. Mission Information.....	13
6.2. LVIS Lidar Instruments Flown .....	13
6.3. LVIS Camera Instruments Flown .....	13
6.4. Install-Specific Notes.....	13
6.5. Known Issues.....	14
6.6. Acknowledgments .....	14
<b>7. GEDI 2021 (GEDI2021)</b> .....	<b>15</b>

7.1.	Mission Information.....	15
7.2.	LVIS Lidar Instruments Flown .....	15
7.3.	LVIS Camera Instruments Flown .....	15
7.4.	Install-Specific Notes.....	15
7.5.	Known Issues.....	16
7.6.	Acknowledgments .....	16
<b>8.</b>	<b><i>Greenland 2022 Spring (GL2022_04)</i></b> .....	<b>16</b>
8.1.	Mission Information.....	16
8.2.	LVIS Lidar Instruments Flown .....	16
8.3.	LVIS Camera Instruments Flown .....	16
8.4.	Install-Specific Notes.....	17
8.5.	Known Issues.....	17
8.6.	Acknowledgments .....	17
<b>9.</b>	<b><i>Greenland 2022 ICESat-2 Cal/Val (GL2022_07)</i></b> .....	<b>18</b>
9.1.	Mission Information.....	18
9.2.	LVIS Lidar Instruments Flown .....	18
9.3.	LVIS Camera Instruments Flown .....	18
9.4.	Install-Specific Notes.....	19
9.5.	Known Issues.....	19
9.6.	Acknowledgments .....	19
<b>10.</b>	<b><i>Gabon 2023</i></b> .....	<b>19</b>
10.1.	Mission Information.....	20
10.2.	LVIS Lidar Instruments Flown .....	20
10.3.	LVIS Camera Instruments Flown .....	20
10.4.	Install-Specific Notes.....	20
10.5.	Known Issues.....	21
10.6.	Acknowledgments .....	21
<b>11.</b>	<b><i>BioSCape 2023</i></b> .....	<b>21</b>
11.1.	Mission Information.....	21
11.2.	LVIS Lidar Instruments Flown .....	21
11.3.	LVIS Camera Instruments Flown .....	21
11.4.	Install-Specific Notes.....	22
11.5.	Known Issues.....	22
11.6.	Acknowledgments .....	22
<b>12.</b>	<b><i>ICESat-2 Lake Ice 2024</i></b> .....	<b>23</b>

**12.1. Mission Information..... 23**  
**12.2. LVIS Camera Instruments Flown ..... 23**  
**12.3. Install-Specific Notes..... 23**  
**12.4. Known Issues ..... 23**  
**12.5. Acknowledgments ..... 23**

## 1. Introduction

NASA's LVIS Facility is an imaging lidar and camera sensor suite for precise and accurate large-area surface mapping and characterization. The Facility uses airborne lidar scanning laser altimeters to collect elevation and 3D surface structure information 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. Two LVIS instruments may be co-mounted on the same platform and operated during flights, with data products referred to as LVISC (from the LVIS-Classic instrument) and LVISF (from the LVIS-Facility instrument).

## 2. Campaigns

### 2.1. United States 2018-2019

Engineering Check Flights were flown in over sites in Maryland, Virginia, and North Carolina on 7 November 2018 and 31 January 2019 out of NASA's Langley Research Center in Hampton, VA.

Sample file names:

- LVISF1B\_US2018\_1107\_R2011\_067463.h5
- LVISF2\_US2019\_0131\_R2011\_067202.TXT
- OLVIS1A\_CAM1\_US2019\_0131\_R2011\_069041.JPG

### 2.2. GEDI 2019

In May-June 2019, the NASA LVIS Facility was deployed to sites in the southeastern United States as well as Central America as part of an airborne campaign to provide calibration and validation of the Global Ecosystem Dynamics Investigation (GEDI) payload on the International Space Station. Flights were based out of Ellington Field in Houston, TX.

Sample file names:

- LVISC1B\_GEDI2019\_0521\_R2002\_075050.h5
- LVISC2\_GEDI2019\_0523\_R2002\_069080.TXT
- LVISF1B\_GEDI2019\_0524\_R2003\_066446.h5
- LVISF2\_GEDI2019\_0529\_R2003\_080145.TXT
- OLVIS1A\_CAM1\_GEDI2019\_0529\_R2005\_080517.JPG
- OLVIS1A\_CAM2\_GEDI2019\_0604\_R2005\_072244.JPG

### 2.3. ABoVE 2019

In July-August 2019, the NASA LVIS Facility was deployed to sites in northern Canada and Alaska as part of NASA's Arctic-Boreal Vulnerability Experiment (ABoVE) 2019 airborne campaign. Flights were based out of multiple airports in Canada and Alaska.

Sample file names:

- LVISC1B\_ABoVE2019\_0713\_R2002\_058325.h5
- LVISC2\_ABoVE2019\_0715\_R2002\_073955.TXT
- LVISF1B\_ABoVE2019\_0718\_R2003\_070393.h5
- LVISF2\_ABoVE2019\_0725\_R2003\_079186.TXT
- OLVIS1A\_CAM1\_ABoVE2019\_0729\_R2005\_062415.JPG
- OLVIS1A\_CAM2\_ABoVE2019\_0801\_R2005\_090836.JPG

## 2.4. GEDI 2021

In July-August 2021, NASA's LVIS Facility flew over the eastern US and French Guiana collecting calibration and validation data for NASA's GEDI. Two LVIS lidars and two camera sensors were operated on the NASA G-V aircraft. Flights were based out of Baltimore, MD and San Juan, PR. Science targets in the US and French Guiana included sections of GEDI reference ground tracks, existing ground-based data collections, and previous LVIS data collection sites.

Sample file names:

- LVISC1B\_GEDI2021\_0720\_R2112\_051758.h5
- LVISC2\_GEDI2021\_0723\_R2112\_049947.TXT
- LVISF1B\_GEDI2021\_0727\_R2203\_065245.h5
- LVISF2\_GEDI2021\_0729\_R2203\_070230.TXT
- OLVIS1A\_CAM1\_GEDI2021\_0731\_R2111\_042191.JPG
- OLVIS1A\_CAM2\_GEDI2021\_0805\_R2111\_067580.JPG

## 2.5. Greenland Spring 2022

In April 2022, NASA's LVIS Facility was used to collect data over sections of the Greenland Ice Sheet and surrounding sea ice, supporting University of Kansas/CRISIS radar flights or future sensor design studies. The LVIS-F lidar sensor was used to collect surface elevation and structure information at low (500 m AGL) or medium (7,000 m) flight altitudes in the NASA P3B, operating with 2 LVIS camera sensors and the KU/CRISIS radar sensor. Because of the different flight altitudes, collection parameters of the LVIS lidar and cameras varied (see mission information tables below for further details).

Sample file names:

- LVISF1B\_GL2022\_0419\_R2210\_050694.h5
- LVISF2\_IS\_GL2022\_0425\_R2301\_062358.TXT
- OLVIS1A\_CAM020MP\_GL2022\_0418\_R2210\_039024.JPG
- OLVIS1A\_CAM150MP\_GL2022\_0422\_R2210\_18-14-28.117.JPG

## 2.6. Greenland 2022 ICESat-2 Cal/Val

In July 2022, NASA's LVIS Facility was used to collect data over the Arctic Ocean, including along ICESat-2 Reference Ground Tracks. The LVIS-F lidar sensor was used to collect surface

elevation and structure information from 10,000 m altitude on the NASA G-V airplane, along with data from as low as 500 m AGL. LVIS-F operated for a subset of the low altitude flight lines, where the primary sensor was the Leica Chiroptera-4X System operated by the University of Texas. The LVIS Canon camera (50 MP) was operated at both low and high altitudes. The LVIS Phase One camera (150 MP) was only operated at high altitude. Data on transits to/from data collection sites are also available. Note that the Level 2 data from this mission are distributed in LVIS Data Structure Version (LDS) 2.0.4 (ice surfaces), while the Level 2 data from the transits are distributed in LDS Version 2.0.3 (land surfaces).

Sample file names:

- LVISF1B\_GL2022\_0712\_R2211\_064916.h5
- LVISF2\_GL2022\_0707\_R2212\_045151.TXT (land surface)
- LVISF2\_IS\_GL2022\_0719\_R2212\_061760.TXT (ice surface)
- OLVIS1A\_CAM050MP\_GL2022\_0721\_R2210\_042247.JPG
- OLVIS1A\_CAM150MP\_GL2022\_0726\_R2212\_20-26-14.616.JPG

## 2.7. Gabon 2023

In May 2023, NASA's LVIS Facility was used to collect data over Gabon, Africa and neighboring countries. Two LVIS lidars and one camera were operated on the NASA LaRC Gulfstream-III aircraft. Science targets included sections of GEDI reference ground tracks, areas where complementary ground and airborne-based data collections exist, and LVIS data collection sites flown previously as part of the 2016 AfriSAR campaign. Sections of LVIS data collection areas were also flown by the DLR FSAR sensor during the same time period.

Sample file names:

- LVISC1B\_Gabon2023\_0525\_R2309\_064017.h5
- LVISC2\_Gabon2023\_0525\_R2309\_064017.TXT
- OLVIS1A\_CAM150MP\_Gabon2023\_0529\_R2305\_14-47-50.513.JPG

## 2.8. BioSCape 2023

In October/November 2023, NASA's LVIS Facility flew as a part of the Biodiversity Survey of the Cape (BioSCape) mission, an international collaboration between NASA and several organizations in South Africa to study biodiversity in South Africa's Greater Cape Floristic Region. Sixteen science flights were flown over ground targets identified by the BioSCape project to highlight the region's biodiversity and study the region's ecosystems to help address the information and decision-support needs of stakeholders in the region and internationally.

The primary data collection was from ~7km above ground level on the NASA G-V airplane, however sections of data were collected from lower altitudes. The range parameter can be used to determine flight altitude. The Level 2 data from this mission are distributed in LVIS Data Structure Version (LDS) 2.0.5 which includes two alternate ground elevations options in order to provide flexibility for local site conditions; if selected for use, adjust the values of the RH parameters accordingly. Please consult the User Guide for further information.



Sample file names:

- LVISF2\_BioSCape2023\_1031\_R2404\_036454.TXT
- LVISF1B\_BioSCape2023\_1112\_R2404\_050383.h5

### 2.9. ICESat-2 Lake Ice 2024

On February 26 and March 1, 2024, NASA's LVIS Facility flew over the the Great Lakes collecting calibration and validation data for NASA's Ice, Cloud, and Land Elevation Satellite-2 (ICESat-2). The LVIS Phase One camera (150 MP) was operated on the NASA P-3 aircraft at a nominal altitude of 7,000 m.

Sample file names:

- OLVIS1A\_CAM150MP\_IS2LakeIce2024\_0226\_R2407\_15-12-14.476.JPG

## 3. File Naming Convention

**LVISdataID\_CampaignYYYY\_MMDD\_RYYMM\_nnnnnn.ext**

String	Description
LVISdataID	Dataset ID (see table below)
Campaign	Campaign name (ex: ABoVE, GEDI) or primary location (ex: US, GL)
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 production
nnnnnn	Number of seconds since GPS midnight of the day the data collection started
ext	File extension: .h5 (L1B), .TXT (L2), .JPG or .CR2 (L1A)

Dataset ID:

LVISdataID	Description
LVISF1B	LVIS-Facility Level 1B (geolocated laser return vector)
LVISF2	LVIS-Facility Level 2 (surface elevation, height and other parameters derived from the geolocated laser return vector). Note: LVISF2_IS is part of the LVISF2 dataset, containing data fields relevant to "ice surfaces"
LVISC1B	LVIS-Classic Level 1B (geolocated laser return vector)
LVISC2	LVIS-Classic Level 2 (surface elevation, height and other parameters derived from the geolocated laser return vector)
OLVIS1A_CameraID	LVIS-Camera with camera identifier (geotagged downlooking photos taken during a flight)

Note: The Phase One iXM-RS150F camera system (dataset ID: OLVIS1A\_150MP) is a new addition to the instrument suite for 2022 and has a slightly different naming convention:

**OLVIS1A\_CAM150MP\_CampaignYYYY\_MMDD\_RYYMM\_hh-mm-ss.sss.JPG**

String	Description
OLVIS1A_CAM150MP	Dataset ID
Campaign	Campaign name (ex: ABoVE, GEDI) or primary location (ex: US, GL)
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 production
hh-mm-ss.sss	<b>UTC time</b> of data collection in 2-digit hours, 2-digit minutes, 2-digit seconds, and 3-digit milliseconds

## 4. United States 2018-2019 (US2018, US2019)

### 4.1. Mission Information

Instruments Flown	LVIS-Facility, LVIS-Camera
Flight Platform	NASA LaRC Beechcraft B-200 King Air
Nominal Flight Altitude	8,500 m
Dates	2018-11-07 to 2019-01-31
Campaign File Name	US2018, US2019
Primary Targeted Areas	Southeastern United States
Geographical Extent	281-285 E, 34-39 N
Flight and data locations	<a href="https://lvis.gsfc.nasa.gov/Data/Maps/US2018Map.html">https://lvis.gsfc.nasa.gov/Data/Maps/US2018Map.html</a>

### 4.2. LVIS Lidar Instruments Flown

Instrument	LVIS-Facility	LVIS-Classic
Nominal Footprint Diameter	7 m (0.75 mrad)	not flown
Nominal Swath Width	1.7 km (200 mrad)	not flown
LVISdataID	LVISF1B, LVISF2	not flown
Data Format Version	2.0.3	not flown

### 4.3. LVIS Camera Instruments Flown

Instrument	LVIS-Camera1	LVIS-Camera2
Camera Model	Canon EOS 5DS R	not flown
Lens Model	Carl Zeiss Planar T* 85mm f/1.4 ZE	not flown
Image Resolution	8688 x 5792 pixel (50 MPixel)	not flown
Nominal Resolution	3.6 km x 2.4 km (0.4 m/pixel)	not flown
Nominal Overlap	77%	not flown
LVISdataID	OLVIS1A_CAM1	not flown

#### 4.4. Install-Specific Notes

Number of Science Files per Flight Day:

Date	LVISF1B	LVISF2	LVISC1B	LVISC2	CAM1	CAM2
2018-11-07	30	30	-	-	2367	-
2019-01-31	113	113	-	-	4087	-
Total	143	143	-	-	6454	-

#### 4.5. Known Issues

None

#### 4.6. Acknowledgments

This work was supported through funding from NASA.

## 5. GEDI 2019 (GEDI2019)

### 5.1. Mission Information

Instruments Flown	LVIS-Facility, LVIS-Classic, LVIS-Camera1, LVIS-Camera2
Flight Platform	NASA JSC Gulfstream V
Nominal Flight Altitude	13,000 m
Dates	2019-05-21 to 2019-06-04
Campaign File Name	GEDI2019
Primary Targeted Areas	Southern United States and Costa Rica
Geographical Extent	236-279 E, 9-38 N
Flight and data locations	<a href="https://lvis.gsfc.nasa.gov/Data/Maps/GEDI2019Map.html">https://lvis.gsfc.nasa.gov/Data/Maps/GEDI2019Map.html</a>
Campaign website	<a href="https://gedi.umd.edu/science/calibration-validation/">https://gedi.umd.edu/science/calibration-validation/</a>

### 5.2. LVIS Lidar Instruments Flown

Instrument	LVIS-Facility	LVIS-Classic
Nominal Footprint Diameter	10 m (0.75 mrad)	25 m (2 mrad)
Nominal Swath Width	2.5 km (200 mrad)	2.5 km (200 mrad)
LVISdataID	LVISF1B, LVISF2	LVISC1B, LVISC2
Data Format Version	2.0.3	2.0.3

### 5.3. LVIS Camera Instruments Flown

Instrument	LVIS-Camera 1	LVIS-Camera 2
Camera Model	Canon EOS 5DS R	Canon EOS 5DS R
Lens Model	Carl Zeiss Makro-Planar T* 100mm f/2 ZE	Carl Zeiss Planar T* 85mm f/1.4 ZE
Image Resolution	8688 x 5792 pixel (50 MPixel)	5792 x 8688 pixel (50 MPixel)
Nominal Resolution	4.2km x 2.8km (0.5m/pixel)	3.3km x 4.9km (0.6m/pixel)
Nominal Overlap	67%	80%
LVISdataID	OLVIS1A_CAM1	OLVIS1A_CAM2

### 5.4. Install-Specific Notes

Number of Science Files per Flight Day:

Date	LVISF1B	LVISF2	LVISC1B	LVISC2	CAM1	CAM2
2019-05-21	157	157	36	36	4118	4055
2019-05-23	193	193	41	41	4930	4917
2019-05-24	104	104	24	24	3686	3706
2019-05-29	199	199	42	42	5949	5920
2019-06-04	135	135	30	30	6397	6568
Total	788	788	173	173	25080	25166

### 5.5. Known Issues

For all LVIS-Camera images, the last six numbers in the file name refer to the time at which the picture was taken, indicating the number of seconds past GPS midnight on the day the data collection started. This information can also be found in the Exif data for each file under the “GPS Date/Time” field. Due to a formatting error, a 1-second offset may exist in the image collection time contained in the Exif “GPS Date/Time” field. The affected flights are listed below. For images from these flights, the collection time contained in the file name should be used, or one second should be added to the time contained in the Exif “GPS Date/Time” field

Date	Cameras affected
2019-05-21	Camera 2
2019-05-23	Camera 1
2019-05-24	Camera 1 and Camera 2
2019-05-29	Camera 1 and Camera 2
2019-06-04	None

### 5.6. Acknowledgments

This work was supported through funding from NASA. GEDI flights were supported by the GEDI mission.

## 6. ABoVE 2019 (ABoVE2019)

### 6.1. Mission Information

Instruments Flown	LVIS-Facility, LVIS-Classic, LVIS-Camera1, LVIS-Camera2
Flight Platform	NASA JSC Gulfstream V
Nominal Flight Altitude	13,000 m
Dates	2019-07-12 to 2019-08-07
Campaign File Name	ABoVE2019
Primary Targeted Areas	Canada and Alaska
Geographical Extent	192-266 E, 28-72 N
Flight and data locations	<a href="https://lvis.gsfc.nasa.gov/Data/Maps/ABoVE2019Map.html">https://lvis.gsfc.nasa.gov/Data/Maps/ABoVE2019Map.html</a>
Campaign website	<a href="https://above.nasa.gov/index.html">https://above.nasa.gov/index.html</a>

### 6.2. LVIS Lidar Instruments Flown

Instrument	LVIS-Facility	LVIS-Classic
Nominal Footprint Diameter	10 m (0.75 mrad)	25 m (2 mrad)
Nominal Swath Width	2.5 km (200 mrad)	2.5 km (200 mrad)
LVISdataID	LVISF1B, LVISF2	LVISC1B, LVISF2
Data Format Version	2.0.3	2.0.3

### 6.3. LVIS Camera Instruments Flown

Instrument	LVIS-Camera 1	LVIS-Camera 2
Camera Model	Canon EOS 5DS R	Canon EOS 5DS R
Lens Model	Carl Zeiss Makro-Planar T* 100mm f/2 ZE	Carl Zeiss Planar T* 85mm f/1.4 ZE
Image Resolution	8688 x 5792 pixel (50 MPixel)	5792 x 8688 pixel (50 MPixel)
Nominal Resolution	4.2km x 2.8km (0.5m/pixel)	3.3km x 4.9km (0.6m/pixel)
Nominal Overlap	67%	80%
LVISdataID	OLVIS1A_CAM1	OLVIS1A_CAM2

### 6.4. Install-Specific Notes

Number of Science Files per Flight Day:

Date	LVISF1B	LVISF2	LVISC1B	LVISC2	CAM1	CAM2
2019-07-12	203	203	45	45	6306	6231
2019-07-13	86	86	18	18	4793	4754
2019-07-15	118	118	27	27	5194	5197
2019-07-16	170	170	37	37	7487	7487
2019-07-18	106	106	22	22	4733	4733
2019-07-22	225	225	49	49	7138	7121
2019-07-23	100	100	22	22	3939	3912

2019-07-25	108	108	25	25	5877	5801
2019-07-27	46	46	12	12	3182	3178
2019-07-28	76	76	18	18	4842	4846
2019-07-29	110	110	25	25	5871	5848
2019-07-31	134	134	30	30	5892	5856
2019-08-01	118	118	27	27	5336	5336
2019-08-07	140	140	32	32	2284	2285
Total	1740	1740	389	380	72874	72585

### 6.5. Known Issues

For all LVIS-Camera images, the last six numbers in the file name refer to the time at which the picture was taken, indicating the number of seconds past GPS midnight on the day the data collection started. This information can also be found in the Exif data for each file under the “GPS Date/Time” field. Due to a formatting error, a 1-second offset may exist in the image collection time contained in the Exif “GPS Date/Time” field. The affected flights are listed below. For images from these flights, the collection time contained in the file name should be used, or one second should be added to the time contained in the Exif “GPS Date/Time” field

Date	Cameras affected
2019-07-12	Camera 1 and Camera 2
2019-07-13	None
2019-07-15	None
2019-07-16	None
2019-07-18	None
2019-07-22	Camera 1 and Camera 2
2019-07-23	Camera 1
2019-07-25	Camera 1 and Camera 2
2019-07-27	Camera 1 and Camera 2
2019-07-28	Camera 1 and Camera 2
2019-07-29	None
2019-07-31	Camera 1 and Camera 2
2019-08-01	None
2019-08-07	None

### 6.6. Acknowledgments

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

## 7. GEDI 2021 (GEDI2021)

### 7.1. Mission Information

Instruments Flown	LVIS-Facility, LVIS-Classic, LVIS-Camera1, LVIS-Camera2
Flight Platform	NASA JSC Gulfstream V
Nominal Flight Altitude	13,000 m (US) and 10,000 m (French Guiana)
Dates	2021-07-16 to 2021-08-06
Campaign File Name	GEDI2021
Primary Targeted Areas	United States and French Guiana
Geographical Extent	262-309 E, 2-45 N
Flight and data locations	<a href="https://lvis.gsfc.nasa.gov/Data/Maps/GEDI2021Map.html">https://lvis.gsfc.nasa.gov/Data/Maps/GEDI2021Map.html</a>
Campaign website	<a href="https://gedi.umd.edu/science/calibration-validation/">https://gedi.umd.edu/science/calibration-validation/</a>

### 7.2. LVIS Lidar Instruments Flown

Instrument	LVIS-Facility	LVIS-Classic
Nominal Footprint Diameter	10 m (US) and 8 m (French Guiana) (0.75 mrad)	25 m (US) and 20 m (French Guiana) (2 mrad)
Nominal Swath Width	2.5 km (US), 2 km (French Guiana) (200 mrad)	2.5 km (US), 2 km (French Guiana) (200 mrad)
LVISdataID	LVISF1B, LVISF2	LVISC1B, LVISC2
Data Format Version	2.0.3	2.0.3

### 7.3. LVIS Camera Instruments Flown

Instrument	LVIS-Camera 1	LVIS-Camera 2
Camera Model	Canon EOS 5DS R	Canon EOS 5DS R
Lens Model	Carl Zeiss Makro-Planar T* 100mm f/2 ZE	Carl Zeiss Planar T* 85mm f/1.4 ZE
Image Resolution	8688 x 5792 pixel (50 MPixel)	5792 x 8688 pixel (50 MPixel)
Nominal Resolution	4.2km x 2.8km (0.5m/pixel)	3.3km x 4.9km (0.6m/pixel)
Nominal Overlap	67%	80%
LVISdataID	OLVIS1A_CAM1	OLVIS1A_CAM2

### 7.4. Install-Specific Notes

Some flights included multiple targeted altitudes and footprint size. Flights can be assumed to be at nominal altitude except for sections noted below:

Date	Start time	End time	Altitude	Location
2021-07-29	54150 s	56090 s	7,400 m	French Guiana
2021-07-29	61470 s	63500 s	7,400 m	French Guiana
2021-08-05	59630 s	60810 s	7,400 m	Coweeta (US)

Instrument at 7,400 m	LVIS-Facility	LVIS-Classic
Footprint Diameter	6 m (0.75 mrad)	15 m (2 mrad)
Swath Width	1.5 km (200 mrad)	1.5 km (200 mrad)

### 7.5. Known Issues

None

### 7.6. Acknowledgments

These flights were supported by funding from the GEDI mission.

## 8. Greenland 2022 Spring (GL2022\_04)

### 8.1. Mission Information

Instruments Flown	LVIS-Facility, LVIS-Camera1, LVIS-Camera2
Flight Platform	NASA WFF P-3B Orion
Nominal Flight Altitude	500 m AGL; 7,000 m
Dates	2022-04-12 to 2022-04-27
Campaign File Name	GL2022_04
Primary Targeted Areas	Greenland and Arctic Ocean
Geographical Extent	258-332 E, 37-87 N
Flight and data locations	<a href="https://lvis.gsfc.nasa.gov/Data/Maps/GN202204Map.html">https://lvis.gsfc.nasa.gov/Data/Maps/GN202204Map.html</a>
Campaign website	<a href="https://ae.ku.edu/cresis">https://ae.ku.edu/cresis</a>

### 8.2. LVIS Lidar Instruments Flown

Instrument	LVIS-Facility at 500 m AGL	LVIS-Facility at 7000 m
Nominal Footprint Diameter	1 m (2.136 mrad)	15 m (2.136 mrad)
Nominal Swath Width	80 m (150 mrad)	1.4 km (200 mrad)
LVISdataID	LVISF1B, LVISF2_IS	LVISF1B, LVISF2_IS
Data Format Version	2.0.3 (L1B), 2.0.4 (L2)	2.0.3 (L1B), 2.0.4 (L2)

### 8.3. LVIS Camera Instruments Flown

Instrument	LVIS-Camera 1	LVIS-Camera 2
Camera Model	Phase One iXM-RS150F	Canon EOS 5D Mk II
Lens Model	Rodenstock 180 mm	Carl Zeiss Distagon T* 28mm f/2 ZE
Image Resolution	14,204 x 10,652 pixel (150 MPixel)	5,616 x 3,744 pixel (21 MPixel)
Nominal Resolution	2.1 km x 1.4 km (15 cm/pixel)	600 m x 400 m (10 cm/pixel)
Nominal Overlap	67%	67%
LVISdataID	LVIS_CAM150MP	LVIS_CAM020MP



#### 8.4. Install-Specific Notes

Campaign included install and operation of a newly-acquired Phase One iXM-RS150F camera system. It was primarily operated on high-altitude portions of flights and data from this sensor (dataset ID: OLVIS1A\_CAM150MP) should be considered experimental.

The Canon camera (OLVIS1A\_CAM20MP) was operating on all flights including test flights (2022-04-12) and transits (2022-04-18, 2022-04-27).

Number of Science Files per Flight Day:

Date	LVISF1B	LVISF2_IS	LVISC1B	LVISC2	CAM150MP	CAM020MP
2022-04-12	-	-	-	-	-	4249
2022-04-18	-	-	-	-	-	8183
2022-04-19	178	178	-	-	-	9947
2022-04-21	159	159	-	-	5709	3206
2022-04-22	192	192	-	-	-	16277
2022-04-25	171	171	-	-	8277	3184
2022-04-27	-	-	-	-	-	2835
Total					13986	47934

Operating altitude on science flights:

Date	Details
2022-04-19	Flight was primarily designed for low altitude operations (500 m above the surface) but included initial transit at high altitude. Low altitude operations began approximately around 52300 s.
2022-04-21	High-altitude flight with Phase One camera operating.
2022-04-22	Flight was primarily designed for low altitude operations (500 m above the surface) but included final transit at high altitude. Low altitude operations ended approximately around 62000 s.
2022-04-25	High-altitude flight with Phase One camera operating.

#### 8.5. Known Issues

None

#### 8.6. Acknowledgments

This work was supported through funding from NASA.

## 9. Greenland 2022 ICESat-2 Cal/Val (GL2022\_07)

### 9.1. Mission Information

Instruments Flown	LVIS-Facility, LVIS-Camera1 and LVIS-Camera2
Flight Platform	NASA JSC Gulfstream V
Nominal Flight Altitude	10,000 m
Dates	2022-07-01 to 2022-07-27
Campaign File Name	GL2022_07
Primary Targeted Areas	Arctic Ocean
Geographical Extent	-105 to 22 E, 25-88 N
Flight and data locations	<a href="https://lvis.gsfc.nasa.gov/Data/Maps/GN202207Map.html">https://lvis.gsfc.nasa.gov/Data/Maps/GN202207Map.html</a>
Campaign website	<a href="https://icesat-2.gsfc.nasa.gov/pages/lvis-summer-2022-lidar-data">https://icesat-2.gsfc.nasa.gov/pages/lvis-summer-2022-lidar-data</a>

### 9.2. LVIS Lidar Instruments Flown

Instrument	LVIS-Facility at 10,000 m
Nominal Footprint Diameter	12 m (1.27 mrad)
Nominal Swath Width	2 km (200 mrad)
LVISdataID	LVISF1B, LVISF2, LVISF2_IS
Data Format Version	2.0.3 (L1B), 2.0.3 (L2 land surfaces), 2.0.4 (L2 ice surfaces)

Note: Low-altitude operation of the LVISF sensor was not requested by the Science Team, however, the sensor was used to collect data and provided as-is. Nominal parameters for during the low altitude operations were:

Instrument	LVIS-Facility at 500 m AGL
Nominal Footprint Diameter	1 m (1.27 mrad)
Nominal Swath Width	80 m (200 mrad)
LVISdataID	LVISF1B, LVISF2_IS
Data Format Version	2.0.3 (L1B), 2.0.4 (L2 ice surfaces)

### 9.3. LVIS Camera Instruments Flown

Instrument	Camera 1	Camera 2	
Camera Model	Phase One iXM-RS150F	Canon EOS 5DS R	
Lens Model	Rodenstock 180 mm	Carl Zeiss Distagon T* 28mm f/2 ZE	
Image Resolution	14,204 x 10,652 pixel (150 Mpixel)	5,792 x 8,688 pixel (50 MPixel)	
Nominal Resolution	Altitude: 10,000 m	10,000 m	500 m
	3 km x 2 km (20 cm/pixel)	5.6 km x 8.4 km (144 x 64 cm/pixel)	260 m x 390 m (7 x 3 cm/pixel)
Nominal Overlap	67%	67%	
LVISdataID	LVIS_CAM150MP	LVIS_CAM050MP	

#### 9.4. Install-Specific Notes

The Phase One iXM-RS150F camera system (dataset ID: OLVIS1A\_CAM150MP) was not operated during low altitude portions of flights.

Number of Science Files per Flight Day:

Date	LVISF1B	LVISF2	LVISF2_IS	LVISC	CAM150MP	CAM050MP
2022-07-01	-	-	-	-	751	2122
2022-07-06	-	-	-	-	836	311
2022-07-07	116	116	-	-	-	2155
2022-07-11	113	-	113	-	5003	2306
2022-07-12	74	-	74	-	2872	2159
2022-07-19	87	-	87	-	2142	3584
2022-07-21	28	-	28	-	728	5168
2022-07-23	18	-	18	-	718	4975
2022-07-26	88	-	88	-	3137	4343
2022-07-27	96	96	-	-	3139	2397
Total	620	620	-	-	19326	29520

LVISF data was collected at low altitude and provided as-is for the following flights:

Date	Altitude
2022-07-21	Flight was designed for low altitude operations (500 m above the surface) but included transits at higher altitude. LVISF data collected from low altitude is between 49000 and 57000 s.
2022-07-23	Flight was designed for low altitude operations (500 m above the surface) but included transits at higher altitude. LVISF data collected from low altitude starting at 52000 s
2022-07-26	Flight includes low altitude data collection between 59700 and 62100 s before high altitude transit to the US.

#### 9.5. Known Issues

None

#### 9.6. Acknowledgments

This work was supported through funding from NASA.

## 10. Gabon 2023

### 10.1. Mission Information

Instruments Flown	LVIS-Facility, LVIS-Classic, LVIS-Camera1
Flight Platform	NASA LaRC Gulfstream III
Nominal Flight Altitude	8,000 m
Dates	2023-5-15 to 2023-5-31
Campaign File Name	Gabon2023
Primary Targeted Areas	Gabon, Africa
Geographical Extent	-78 to 17 E, -3 to 39 N
Flight and data locations	<a href="https://lvis.gsfc.nasa.gov/Data/Maps/Gabon2023Map.html">https://lvis.gsfc.nasa.gov/Data/Maps/Gabon2023Map.html</a>

### 10.2. LVIS Lidar Instruments Flown

Instrument	LVIS-Facility	LVIS-Classic
Nominal Footprint Diameter	10 m (1.27 mrad)	20 m (2.5 mrad)
Nominal Swath Width	1.5 km (200 mrad)	1.5 km (200 mrad)
LVISdataID	LVISF1B, LVISF2	LVISC1B, LVISC2
Data Format Version	2.0.3	2.0.3

### 10.3. LVIS Camera Instruments Flown

Instrument	LVIS-Camera
Camera Model	Phase One iXM-RS150F
Lens Model	Rodenstock 180 mm
Image Resolution	14,204 x 10,652 pixel (150 Mpixel)
Nominal Resolution	2.4 km x 1.6 km (16 cm/pixel)
Nominal Overlap	70%
LVISdataID	LVIS_CAM150MP

### 10.4. Install-Specific Notes

Number of Science Files per Flight Day:

Date	LVISF1B	LVISF2	LVISC1B	LVISC2	CAM150MP
2023-05-15	-	-	-	-	2942
2023-05-19	tbd	tbd	8	8	1636
2023-05-20	tbd	tbd	17	17	5014
2023-05-22	tbd	tbd	17	17	5535
2023-05-23	tbd	tbd	18	18	4492
2023-05-24	tbd	tbd	27	27	3645
2023-05-25	tbd	tbd	24	24	4089
2023-05-27	tbd	tbd	15	15	3151
2023-05-29	tbd	tbd	8	8	3160

2023-05-30	tbd	tbd	18	18	3881
2023-05-31	tbd	tbd	17	17	4301
Total	tbd	tbd	169	169	41846

10.5. Known Issues

10.6. Acknowledgments

This work was supported by funding from NASA.

11. BioSCape 2023

11.1. Mission Information

Instruments Flown	LVIS-Facility, LVIS-Camera1 and LVIS-Camera2
Flight Platform	NASA JSC Gulfstream V
Nominal Flight Altitude	7,000 m; 5,000 m
Dates	2023-10-20 to 2023-11-15
Campaign File Name	BioSCape2023
Primary Targeted Areas	South Africa
Geographical Extent	17 to 27 E, 35 to 31 S
Flight and data locations	<a href="https://lvis.gsfc.nasa.gov/Data/Maps/SouthAfrica2023Map.html">https://lvis.gsfc.nasa.gov/Data/Maps/SouthAfrica2023Map.html</a>
Campaign website	<a href="https://www.bioscape.io/">https://www.bioscape.io/</a>

11.2. LVIS Lidar Instruments Flown

Instrument	LVIS-Facility at 7,000 m	LVIS-Facility at 5,000 m
Nominal Footprint Diameter	8 m (1.16 mrad)	6 m
Nominal Swath Width	1.1 km (164 mrad)	0.9 km (180 mrad)
LVISdataID	LVISF1B, LVISF2	LVISF1B, LVISF2
Data Format Version	2.0.3 (L1B), 2.0.5 (L2)	2.0.3 (L1B), 2.0.5 (L2)

11.3. LVIS Camera Instruments Flown

Instrument	LVIS-Camera1	LVIS-Camera2
Camera Model	Phase One iXM-RS150F	Canon EOS 5DS R
Lens Model	Rodenstock 180 mm	Carl Zeiss Distagon T* 28mm f/2 ZE

Image Resolution	14,204 x 10,652 pixel (150 MPixel)	5,792 x 8,688 pixel (50 MPixel)
Nominal Resolution	2.1 km x 1.4 km (15 cm/pixel)	1.6 km x 1.1 km (30 cm/pixel)
Nominal Overlap	67%	67%
LVISdataID	LVIS_CAM150MP	LVIS_CAM050MP

#### 11.4. Install-Specific Notes

Number of Science Files per Flight Day:

Date	LVISF1B	LVISF2	LVISC1B	LVISC2	CAM150MP	CAM050MP
2023-10-20	78	78	-	-	5292	4343
2023-10-22	183	183	-	-	10080	8059
2023-10-25	164	164	-	-	10031	8247
2023-10-26	144	144	-	-	10135	8147
2023-10-28	91	91	-	-	6752	5442
2023-10-29	107	107	-	-	7926	6428
2023-10-30	161	161	-	-	10894	8923
2023-10-31	100	100	-	-	6443	5466
2023-11-01	88	88	-	-	5280	4756
2023-11-05	190	190	-	-	9940	9046
2023-11-08	179	179	-	-	8888	7977
2023-11-09	193	193	-	-	9117	8684
2023-11-10	211	211	-	-	9512	9597
2023-11-12	158	158	-	-	7765	7123
2023-11-13	152	152	-	-	6269	-
2023-11-15	129	129	-	-	6893	6355
Total	2328	2328	-	-	131286	108593

#### 11.5. Known Issues

#### 11.6. Acknowledgments

## 12. ICESat-2 Lake Ice 2024

### 12.1. Mission Information

Instruments Flown	LVIS-Camera1
Flight Platform	NASA WFF P-3B Orion
Nominal Flight Altitude	7,000 m
Dates	February 26 and March 1, 2024
Campaign File Name	IS2LakeIce2024
Primary Targeted Areas	Great Lakes
Geographical Extent	276 to 285 E, 37 to 47 N
Flight and data locations	<a href="https://lvis.gsfc.nasa.gov/Data/Maps/USLakeIce2024Map.html">https://lvis.gsfc.nasa.gov/Data/Maps/USLakeIce2024Map.html</a>

### 12.2. LVIS Camera Instruments Flown

Instrument	LVIS-Camera 1
Camera Model	Phase One iXM-RS150F
Lens Model	Rodenstock 180 mm
Image Resolution	14,204 x 10,652 pixel (150 MPixel)
Nominal Resolution	2.1 km x 1.4 km (15 cm/pixel)
Nominal Overlap	67%
LVISdataID	LVIS_CAM150MP

### 12.3. Install-Specific Notes

Number of Science Files per Flight Day:

Date	CAM150MP
2024-02-26	7700
2024-03-01	6667
Total	14367

### 12.4. Known Issues

Leaking jet fuel over the LVIS view port during the flight on February 26 caused varying levels of surface obscuration throughout the flight. Camera imagery from this flight may show partial obscuration of the surface as a result. The leak was fixed prior to the flight on March 1.

### 12.5. Acknowledgments

This work was supported through funding from NASA.