



# IceBridge CAMBOT L1B Geolocated Images, Version 2

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## USER GUIDE

### How to Cite These Data

As a condition of using these data, you must include a citation:

Studinger, M. and J. Harbeck. 2019. *IceBridge CAMBOT L1B Geolocated Images, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. <https://doi.org/10.5067/B0HL940D452L>. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT [NSIDC@NSIDC.ORG](mailto:NSIDC@NSIDC.ORG)

FOR CURRENT INFORMATION, VISIT <https://nsidc.org/data/IOCAM1B>



National Snow and Ice Data Center

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# 1 DATA DESCRIPTION

## 1.1 Parameters

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This data set contains orthorectified and geolocated images collected over the Arctic and Antarctic by the Continuous Airborne Mapping By Optical Translator (CAMBOT), a part of the Airborne Topographic Mapper (ATM) instrument suite.

## 1.2 File Information

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### 1.2.1 Format

The data files are provided in GeoTIFF (.tif) format. Each image is a three-channel, natural-color RGB image and is stored using lossless Lempel-Ziv-Welch (LZW) compression in TIFF format. The projection data are stored in the GeoTIFF portion of the metadata. The image metadata, including the camera settings, are written to the file using EXIF format standards.

### 1.2.2 File Contents

Figure 1 shows imagery from the file I0CAM1B\_2018\_AN\_NASA\_20181019\_154311.4217.tif.

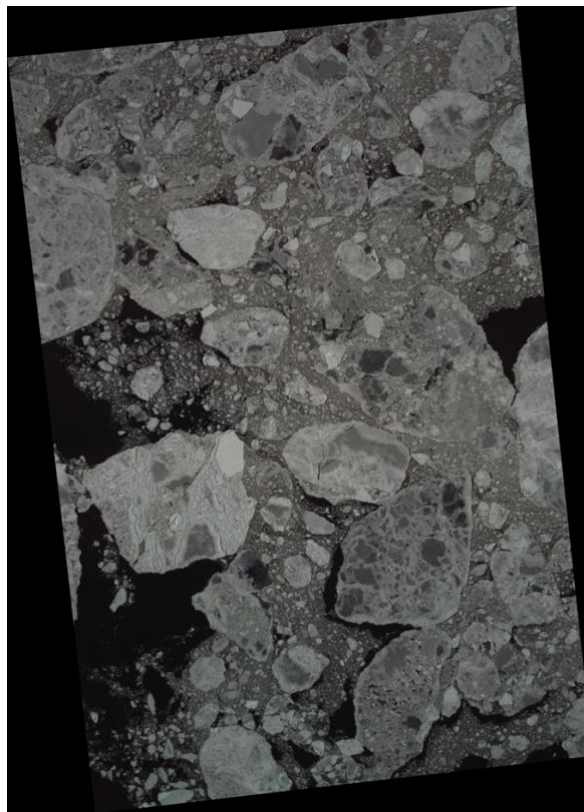


Figure 1. Imagery of Antarctic sea ice from 19 October 2018

### 1.2.3 Naming Convention

Example file name:

IOCAM1B\_2018\_AN\_NASA\_20181019\_154311.4217.tif

The files are named according to the following convention, which is described in more detail in Table 1.

IOCAM1B\_YYYY\_LO\_NASA\_yyyymmdd\_HHMMSS.DDDD.xxx

Table 1. File Naming Convention

Segment of file name	Description
IOCAM1B	Data set ID
YYYY_LO_NASA	NASA campaign identifier: YYYY: 4-digit campaign year LO: location; AN = Antarctica, GR = Greenland/Arctic Example: 2018_AN_NASA
yyyyymmdd	Year, month, and day of image capture
HHMMSS	Hour, minute, and second of image capture in UTC time
DDDD	Fraction of a second of image capture
.ext	File type: .tif: GeoTIFF data file

## 1.3 Spatial Information

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### 1.3.1 Coverage

This data set covers areas within the following geographical boundaries:

Greenland:

Southernmost latitude: 60° N

Northernmost latitude: 90° N

Westernmost longitude: 180° W

Eastermost longitude: 180° E

Antarctica:

Southernmost latitude: 90° S

Northernmost latitude: 53° S

Westernmost longitude: 180° W

Eastermost longitude: 180° E

### 1.3.2 Resolution

The pixel size is dependent on flight altitude and referenced DEM; thus, the spatial resolution typically ranges from 0.06 m to 0.30 m. For a nominal flight altitude of 1,500 ft above ground level, the spatial resolution is 0.087 m.

### 1.3.3 Geolocation

The following table provides details about the coordinate systems used in this data set:

Table 2. Geolocation Details for the Arctic/Greenland and Antarctica Data

	<b>Arctic/Greenland</b>	<b>Antarctica</b>
<b>Geographic coordinate system</b>	WGS 84	WGS 84
<b>Projected coordinate system</b>	WGS 84 / NSIDC Sea Ice Polar Stereographic North	WGS 84 / Antarctic Polar Stereographic
<b>Longitude of true origin</b>	-45° E	0°
<b>Latitude of true origin</b>	70° N	71° S
<b>Scale factor at longitude of true origin</b>	1	1
<b>Datum</b>	WGS 84	WGS 84
<b>Ellipsoid/spheroid</b>	WGS 84	WGS 84
<b>Units</b>	meters	meters
<b>False easting</b>	0	0
<b>False northing</b>	0	0
<b>EPSG code</b>	3413	3031
<b>PROJ4 string</b>	+proj=stere +lat_0=90 +lat_ts=70 +lon_0=-45 +k=1 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs	+proj=stere +lat_0=-90 +lat_ts=-71 +lon_0=0 +k=1 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs
<b>Reference</b>	<a href="#">EPSG: 3413</a>	<a href="#">EPSG: 3031</a>

## 1.4 Temporal Information

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### 1.4.1 Coverage

10 October 2018 to 20 November 2019

## 1.4.2 Resolution

IceBridge campaigns are conducted on an annually repeating basis. Arctic and Greenland campaigns are typically conducted in March, April, and May; Antarctic campaigns are typically conducted in October and November.

# 2 DATA ACQUISITION AND PROCESSING

## 2.1 Instrumentation

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CAMBOT is a digital image acquisition system that supports analysis of laser altimeter data collected by the Airborne Topographic Mapper (ATM). The CAMBOT images provide a qualitative assessment of the surface structure and lower atmosphere conditions sensed by the ATM. CAMBOT is a passive instrument that uses sunlight as the source of illumination. As such, CAMBOT has some limitations, including shadows, daytime-only operation, and reduced data value under high-cloud or low mist conditions. However, the images provide a high-resolution record of ice structures, nunataks, snow, crevasses, sastrugi, leads, and sea ice type.

The CAMBOT raw images are collected by an Allied Vision Prosilica GT4905C camera. The Prosilica GT4905C, a 16 MP machine vision camera designed for extreme environments, operates over ethernet via the GigE command interface. The camera is fitted with a Zeiss Distagon 28 mm f/2 ZF.2 lens to yield an image width below the aircraft that is marginally wider than the ATM wide-scan lidar swath. The camera is rigidly mounted in each science aircraft platform above a down-looking optical window (either glass or acrylic) to provide nadir imagery of the surface below. Finally, the camera is connected to three components: a power supply, an acquisition/control computer, and an intervalometer. The CAMBOT data acquisition and control computer is a SuperLogics Microbox PC that provides an ethernet connection to the camera for transferring data and managing the camera settings. Custom software is used to set up the camera, transfer images, display QA thumbnails, and organize collected images into one-minute duration tar files.

The intervalometer used to trigger the CAMBOT image collection is a Javad Delta/Sigma GPS receiver set to output two pulses per second (PPS). The 2 PPS signal is delivered on every half second, which provides accurate timing of each image acquired.

## 2.2 Input Data

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The ancillary data used to create this data product include an Applanix-smoothed best estimate of trajectory (SBET) and a range-to-surface measurement provided by the ATM lidar. The Applanix SBET is a post-processed PPP solution created from the GPS/IMU data collected by an Applanix

POS AV 610 sensor, which provides the position (latitude, longitude, altitude) and attitude (pitch, roll, yaw) of the camera. The ATM lidar instruments measure the time-of-flight of laser pulses that are transmitted from the instrument to the ground surface below and back. Once calibrated and averaged, an estimated range, corrected for off-nadir pointing angle, is provided for each image. The combination of these two data sets determines the origin, direction, and magnitude of each pixel vector.

## 2.3 Geolocation Procedure

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Since the sensor is mounted on an aircraft which is constantly in motion, a series of coordinate transformations are applied to convert position and attitude as measured by the GPS and INS systems to obtain the geolocation for each recorded image pixel. In this procedure, the camera orientation is here assumed that if the airplane is traveling due north the image (0, 0) pixel is assumed to be in the upper left (northwest) corner of the image.

## 2.4 Lens distortion

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To account for lens distortion effects prior to flight operation, a checkerboard calibration target was imaged with both the primary and backup CAMBOT cameras in a laboratory to determine the lens radial and tangential distortion coefficients. The sizes of the checkerboard squares were measured with a scale and the calibration target was imaged at different orientations. The images were analyzed using the Caltech Calibration Toolbox software package to determine the lens distortion coefficients (Bouget, 2016). An inverse model was then applied to convert between the actual image pixel position  $(x_i, y_i)$  and the effective pixel position  $(x_{ip}, y_{ip})$  after lens distortion.

## 2.5 Geolocation procedure for the camera sensor

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- For each image, differential GPS and aircraft attitude measurements are synced with the camera time stamp.
- To determine the position of the camera sensor from this information, the spatial distance between the CAMBOT camera and GPS antenna,  $r_{ant}$ , is measured prior to each Operation IceBridge campaign using a North, East, Down (NED) coordinate system.
- Coordinate transformations are then applied to correct for the camera offset from the GPS antenna location and determine the camera sensor location.

## 2.6 Geolocation procedure for image pixels

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- To determine the geolocation of each camera pixel, the vector between an image pixel and the surface is calculated using a simple projection camera model. This approach is similar

to the methodology described in Barber et al. (2006) but with modifications to account for the measurement system used on the IceBridge aircraft.

- Two transformation matrices accounting for aircraft motion and mounting biases are constructed using homogeneous coordinates.
- To account for mounting biases of the camera, another transformation matrix is calculated in an equivalent manner but using u, v, and w, which correspond to the bias in the camera pitch, roll, and heading, respectively. The procedure for determining the mounting biases is described in the Quality, Errors, and Limitations section.

**NOTE:** For more detailed information on the geolocation procedures for the camera sensor and the image pixels, including mathematical equations, see the [Geolocation of CAMBOT Imagery from Operation IceBridge Surveys](#) document.

## 2.7 Quality, Errors, and Limitations

Mounting biases for airborne data are determined by using surveyed targets on or near airport ramps, which are used by the IceBridge ATM laser altimeter system for calibration. The image pixels of the survey targets were identified in a series of images and the mounting biases were found by an iterative method, adjusting the camera pitch, roll, heading, and timing biases to minimize the error in the distance between the known and calculated locations.

## 3 SOFTWARE AND TOOLS

Software that recognizes the GeoTIFF file format is recommended for these images, such as the GIS software QGIS or ArcGIS. See also the [libGeoTIFF](#) and [GDAL](#) websites for more information.

## 4 VERSION HISTORY

Table 3 provides a version history for this data set.

Table 3. Version History

Version Number	Time Frame	Description
1	31 March 2009 to 26 April 2013	The data files were provided as non-geolocated JPG images.
2	19 October 2018 to present	The raw, Level-0 JPG images were orthorectified and geolocated to create the GeoTIFF files in this data set.



2.1	19 October 2018 to present	A georeferencing issue was discovered in three sea ice flights from the 2018 Antarctic campaign and six from the 2019 Arctic spring campaign. Subsequent algorithm improvements, both in georeferencing and generation of input ATM data, were made after the delivery of these flights. These improvements significantly increased the reliability of the final product and these initial nine sea ice flights were reprocessed in an effort to standardize the output quality of the IOCAM1B product.
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## 5 RELATED DATA SETS

[IceBridge ATM L1B Qfit Elevation and Return Strength](#)

[IceBridge DMS L0 Raw Imagery](#)

[IceBridge DMS L1B Geolocated and Orthorectified Images](#)

## 6 RELATED WEBSITES

[Operation IceBridge web page at NSIDC](#)

[Operation IceBridge web page at NASA](#)

[Caltech Camera Calibration Toolbox for Matlab \(Bouget, 2016\) here](#)

## 7 CONTACTS AND ACKNOWLEDGMENTS

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## 8 REFERENCES

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## 9 DOCUMENT INFORMATION

### 9.1 Publication Date

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20 November 2019

### 9.2 Date Last Updated

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