IceBridge Sander AIRGrav L3 Bathymetry, Version 1

USER GUIDE

How to Cite These Data

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

Tinto, K., R. E. Bell, and J. R. Cochran. 2011. *IceBridge Sander AIRGrav L3 Bathymetry, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/B9DRKO62I5Q9. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/IGBTH3

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

1.1 Format

The data files are ASCII text XYZ grid files.

See the IceBridge Sander AIRGrav L4 Bathymetry (IGBTH4) data set for CSV data files of Arctic fjords and Antarctic ice shelves bathymetry based on measurements from the Sander Geophysics Airborne Inertially Referenced Gravimeter (AIRGrav) system (https://nsidc.org/data/IGBTH4/versions/1).

1.2 File and Directory Structure

Data are available via HTTPS in the following directory:

https://daacdata.apps.nsidc.org/pub/DATASETS/ICEBRIDGE/IGBTH3_AIRGravBathymetry_v01/

1.3 File Naming Convention

The bathymetry data files have the naming convention shown below. File name variables are described in Table 1.

larsen_bathy.xyz
thwaites_bathy.xyz
name_bathy.xyz

Table 1. Gravity Data File Naming Convention

Variable	Description
name	Glacier or ice shelf name, e.g. Larsen, Thwaites
bathy	Indicates bathymetry data
.xyz	Indicates ASCII text x, y, z data file

1.4 File Size

Files range from 290 KB to 673 KB.

1.5 Volume

The entire data set is approximately 1 MB.

1.6 Spatial Coverage

Spatial coverage for this data set includes Antarctic areas.

Southernmost Latitude: 90° S
Northernmost Latitude: 53° S
Westernmost Longitude: 180° W
Easternmost Longitude: 180° E

Note: See the IceBridge Sander AIRGrav L4 Bathymetry (IGBTH4) data set for bathymetry of Arctic ice shelves based on measurements from the Sander Geophysics Airborne Inertially Referenced Gravimeter (AIRGrav) system (https://nsidc.org/data/IGBTH4/versions/1).

1.6.1 Spatial Resolution

The survey over Thwaites Ice Shelf was flown as a series of parallel lines, 10 km apart, approximately perpendicular to the grounding line. Data with high horizontal accelerations due to aircraft maneuvers were excluded from the dataset. Free-air anomalies were filtered with a 70 s full wavelength filter, resulting in approximately 4.9 km half-wavelength resolution for a typical flying speed of 140 m/s (Tinto and Bell, 2011).

For the survey over Larsen Ice Shelf, the spacing of north-south airborne gravity lines is generally about 20 km, while the spacing of east-west lines ranges from 15-50 km. The line spacing and the survey design limit the granularity of the gravity field and impact the spatial resolution of the final bathymetry model (Cochran and Bell, 2012).

1.6.2 Projection and Grid Description

Thwaites Grid: 1 km grid spacing
Larsen Grid: 2 km grid spacing
Projection: Polar Stereographic true at 71 S, 0 up, 180 down, WGS-84 ellipsoid (EPSG 3031)

1.7 Temporal Coverage

01 October 2009 to 30 November 2009

1.7.1 Temporal Resolution

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

1.8 Parameter or Variable

This data set contains location in Polar Stereographic easting and northing, and bathymetry measured positively downwards.

1.8.1 Parameter Description

The bathymetry data files contain fields as described in Table 2

Table 2. Parameter Description and Units

Column	Description	Units
1	Antarctic Polar Stereographic Easting	Meters
2	Antarctic Polar Stereographic Northing	Meters
3	Bathymetry	Meters

1.8.2 Sample Data Record

The figure below shows the first ten records of the larsen_bathy.xyz data file. The fields in each record correspond to the columns described in Table 2 above.

```
-2321006 1207344 400
-2320035 1209208 392
-2319063 1211072 384
-2318089 1212935 376
-2317114 1214798 365
-2316137 1216659 353
-2315158 1218520 337
-2314179 1220380 318
-2313197 1222239 296
-2312214 1224097 270
```

Figure 1. First Ten Records of the larsen_bathy.xyz data file

2 SOFTWARE AND TOOLS

The data files may be opened by any ASCII text reader.

3 DATA ACQUISITION AND PROCESSING

3.1 Theory of Measurements

The gravity signal is extracted from an inertially based system in which a small mass is suspended within a magnetic field. Tiny variations in the acceleration of the gravimeter produce small electrical signals in the sensor as the mass moves within the magnetic field. The processed data from the AIRGrav instrument data consists of two data types: gravity and aircraft attitude.

3.2 Data Acquisition Methods

The gravimeter is located as near the airplane center of mass as possible. Simultaneously acquired gravimeter output GPS data are recorded on hard disks on the plane. Following the flight this data is downloaded onto a PC for processing.

3.3 Derivation Techniques and Algorithms

Inversion of the gravity data for bathymetric relief on the continental shelf underlying the Larsen Ice Shelf was carried out using the Parker-Oldenburg technique (Oldenburg, 1974). The Parker-Oldenburg inversion was employed in the form of a MATrix LABoratory (MATLAB) script that utilizes a grid of gravity anomalies as the input (Gomez-Ortiz and Agarwal, 2005). In order to avoid potential artifacts in less constrained areas, the grid of depths resulting from the inversion was sampled at gravity measurement points and these values were then regridded.

At Thwaites glacier, inversion was performed on 2D profiles using the technique of Talwani (1959) in the GM-SYS gravity and magnetic modeling software.

3.3.1 Processing Steps

The following processing steps are performed by the data provider.

For all bathymetry data sets:

1. The gravimeter data were filtered and decimated to 10 Hz to match the GPS data.
2. GPS-derived accelerations were subtracted from the data.
3. The gravity was corrected for the Eötvös effect.
4. The expected gravity at the measurement latitude was subtracted.
5. The resulting anomalies were decimated to 2 Hz and low-pass filtered to suppress noise.
6. The free-air correction was applied.
7. After evaluating the noise level with different filter lengths, a 70 s filter was used. The filter half-wavelength is approximately 5 km at the average flight speed of 275 knots (142 m/s). Features narrower than the half wavelength can be resolved, but have an attenuated amplitude.
8. Horizontal accelerations associated with turns and other vigorous maneuvers disturb gravity measurements. A routine that examines horizontal accelerations was used to divide each flight into lines that are free of these perturbations.

For the Larsen data (larsen_bathy.xyz) (Cochran and Bell, 2012):

1. The marine free-air gravity data were gridded, upward-continued to the elevation of the Operation IceBridge flights over Larsen C and the upward-continued grid was resampled at the original measurement locations.
2. The combined airborne and upward continued marine data set was gridded on a 2 km grid.
3. The gridded data set was inverted for bathymetry using the Parker-Oldenburg technique.
4. To avoid artifacts, the grid of bathymetry data was sampled at the locations of the gravity data points and then regridded.

For the Thwaites data (thwaites_bathy.xyz) (Tinto and Bell, 2011):

1. A forward model of gravity was generated according to Talwani (1959) with ice density 0.915 g/cc, water density 1.028 g/cc and rock density 2.67 g/cc. Ice surface and base are taken from the NASA Airborne Topographic Mapper (ATM) (Krabill, 2010) and the CReSIS Multichannel Coherent Radar Depth Sounder (MCoRDS) (Allen, 2009).
2. The model was pinned at a point where ice is grounded and nearby gravity variations are due only to variations in topography of the ice/rock interface.
3. A gravity inversion was performed on the water/rock interface under floating ice. This produces a model of the sub-ice shelf bathymetry responsible for the gravity anomaly.
4. 2D inversion results were gridded to produce a bathymetry map.

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3.3.2 Errors and Limitations

Errors are approximated as ±70 m for the Thwaites dataset, incorporating errors in gravity measurement, radar ice thickness, ATM surface elevation, 2D model pinning point and some allowance for geological structures. The model assumes the absence of sea floor sediments. If sea floor sediments are present the true bathymetry will be less deep than the model (Tinto and Bell, 2011).

Errors are estimated to be about ±50 meters for the Larsen survey, based on sensitivity to possible errors in density and the mean depth of the continental shelf. The depths at the bottom of troughs extending across the continental shelf may be overestimated as much as 100 m due to the presence of low density sediments (Cochran and Bell, 2012).

3.4 Sensor or Instrument Description

The gravity instrument is a Sander AIRGrav designed for airborne applications. The AIRGrav system consists of a three-axis gyro-stabilized, Schuler-tuned inertial platform on which three orthogonal accelerometers are mounted. The primary gravity sensor is the vertical accelerometer that is held within 10 arc-seconds (0.0028 degree) of the local vertical by the inertial platform, monitored through the complex interaction of gyroscopes and two horizontal accelerometers (Sander et al., 2004).

An advantage of the AIRGrav system over other airborne gravimeters is that it has been shown to be capable of collecting high-quality data during draped flights (Studinger et al., 2008). The gravimeter records accelerations arising from variations in the Earth's gravity field and accelerations experienced by the airplane. These accelerations are recorded at 128 Hz. Aircraft accelerations are obtained utilizing differential GPS measurements.

4 REFERENCES AND RELATED PUBLICATIONS

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4.1 Related Data Collections

- IceBridge Sander AIRGrav L1B Geolocated Free Air Gravity Anomalies
- IceBridge Sander AIRGrav L4 Bathymetry

4.2 Related Websites

- IceBridge data website at NSIDC (http://nsidc.org/data/icebridge/index.html)
- IceBridge website at NASA (http://www.nasa.gov/mission_pages/icebridge/index.html)
- ICESat/GLAS website at NASA Wallops Flight Facility (http://glas.wff.nasa.gov/)
- ICESat/GLAS website at NSIDC (http://nsidc.org/daac/projects/lidar/glas.html)

5 CONTACTS AND ACKNOWLEDGMENTS

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5.2 Acknowledgments

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6 DOCUMENT INFORMATION

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