IceBridge CMG GT-1A Gravimeter L2 Geolocated Free Air Gravity Disturbances, Version 1

USER GUIDE

How to Cite These Data

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

Blankenship, D. D., Young, D. A., Richter, T. G., & Greenbaum, J. S. (2014). *IceBridge CMG GT-1A Gravimeter L2 Geolocated Free Air Gravity Disturbances* (IGCMG2, Version 1) [Data set]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/3X4CIKKSYQRU [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/IGCMG2

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Summary

This data set contains geolocated free air gravity disturbances derived from measurements taken over Antarctica using the GT-1A gravity meter S-019. The data were collected by scientists working on the Investigating the Cryospheric Evolution of the Central Antarctic Plate (ICECAP) project, which is funded by the National Science Foundation (NSF) and the Natural Environment Research Council (NERC) with additional support from NASA Operation IceBridge.

1.2 Format

Each data file is in space-delimited ASCII text format with an associated XML file. The XML files contain file creation, point latitudes and longitudes, and campaign metadata.

1.3 File Naming Convention

The files are named according to the following convention and as described in Table 1:
IGCMG2_YYYYDOY_PPP_JKB2h_TTTT_grvfld.xxx

Example file names:
IGCMG2_2012339_SCT_JKB2h_Y46b_grvfld.txt
IGCMG2_2012339_SCT_JKB2h_Y46b_grvfld.txt.xml

Table 1. File Naming Convention

Variable	Description
IGCMG2	Short name for IceBridge CMG GT-1A Gravimeter L2 Geolocated Free Air Gravity Disturbances
YYYY	Four-digit year of survey
DOY	Day of year of survey
PPP	Geographic area (Project)
JKB2h	Host platform for timing (System)
TTTT	Transect name within Project
grvfld	Gravity field
.xxx	Indicates .txt or .xml file

1.4 Spatial Coverage

Spatial coverage for this data set is Antarctica, represented by this extent:

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

1.4.1 Spatial Resolution

Small features are progressively suppressed due to low pass filtering to create final output. The filter used has a half amplitude point at 150 second wave period corresponding to about a 6.5 km wide gravity feature.

1.4.2 Projection and Grid Description

WGS-84 ellipsoid; International Terrestrial Reference Frame (ITRF) 2008.

1.5 Temporal Coverage

These data were collected as part of the ICECAP and Operation IceBridge-funded campaigns.

1.5.1 Temporal Resolution

Temporal resolution is seasonal. IceBridge campaigns were conducted on an annual repeating basis. Arctic and Greenland campaigns were typically conducted during March, April, and May; Antarctic campaigns were typically conducted during October and November. Campaigns for this data set typically extend from November to early January.

1.6 Parameter or Variable

1.6.1 Parameter Description

Data parameters are described in Table 2.

Table 2. Free Air Gravity Disturbance Parameter Description

Parameter	Description	Units
YEAR	Year of survey	Year, UTC
DOY	Day Of Year of survey	Day, UTC

SOD	Second of day of survey	Seconds, UTC
LON	Longitude Angle	Degrees WGS-84
LAT	Latitude Angle	Degrees WGS-84
GRV	Free Air Gravity Disturbance	mGal
AC_ELEVATION	Aircraft Elevation	Meters

1.6.2 Sample Data Record

Shown below are the first ten data records from the file `IGCMG2_2012339_SCT_JKB2h_Y46b_grvfld.txt`.

```
# YEAR DOY SOD LON LAT GRV AC_ELEVATION
2012 339 723.0000 115.604552 -66.783575 20.59 826.43
2012 339 723.5000 115.605293 -66.783776 20.37 826.49
2012 339 724.0000 115.606034 -66.783978 20.15 826.56
2012 339 724.5000 115.606774 -66.784179 19.93 826.64
2012 339 725.0000 115.607514 -66.784381 19.71 826.74
2012 339 725.5000 115.608253 -66.784583 19.48 826.83
2012 339 726.0000 115.608992 -66.784785 19.26 826.93
2012 339 726.5000 115.609731 -66.784987 19.03 827.02
2012 339 727.0000 115.610470 -66.785189 18.80 827.10
2012 339 727.5000 115.611208 -66.785392 18.57 827.18
```

Figure 1. Sample Data Record

2 DATA ACQUISITION AND PROCESSING

2.1 Theory of Measurements

This data set was created using the current standard techniques of use for stabilized platform airborne scalar gravimeters. The gravimeter consists of a high sensitivity accelerometer which is kept vertical via a gimbaled platform. Carrier phase GPS is recorded and post processed to determine the accelerations on the gravimeter which are due to aircraft motions. The vertical accelerations due to aircraft motions are subtracted from the vertical accelerations observed by the gravimeter to create a residual signal which consists of the measured acceleration due to gravity contaminated with noise and deterministic non-gravitational accelerations. This residual is corrected for known meter characteristics and other non-gravitational deterministic effects (Eotvos, etc.) then low pass filtered to produce the best estimate of the actual gravitational acceleration values.

2.2 Data Acquisition Methods

The GT-1A gravimeter instrument was operated according to Canadian Microgravity published procedures. More information can be found in the GT-1A and GT-2A Airborne Gravimeters Specification Document.

2.3 Derivation Techniques and Algorithms

The data reduction algorithms are embedded within the vendor's reduction software. A Kalman filter in the software is used to estimate the gravity result from recorded meter data including vertical and horizontal accelerations.

Gravity values recorded by the meter were referenced using a Lacoste and Romberg portable gravity meter (G-399) to conduct regular gravity ties between the aircraft parking site and a gravity measurement point on the north side of the Casey Station Science Building, where a value of 982379.929 mGal had been previously recorded by Geoscience Australia.

Table 3. Gravity Tie Measurements during 2011 at Casey Station (scale factor of 10.04547 for first 2 digits and 1.04543 for next 2 digits for G-399)

Date	Location	Reading (counts)	Reading (mGals)	Science avg (mGal)	Science - Aircraft (mGal)
Nov. 20, 2013	Science	5770.5	6,022.163	6022.455535	98.8389026
	Aircraft	5676.24	5,923.617		
	Science	5771.06	6,022.748		
Nov. 22, 2013	Science	5771.03	6,022.717	6022.899843	99.10548045
	Aircraft	5676.41	5,923.794		
	Science	5771.38	6,023.083		
Nov. 28, 2013	Science	5771	6,022.686	6022.94166	99.45048395
	Aircraft	5676.12	5,923.491		
	Science	5771.49	6,023.198		
Nov. 30, 2013	Science	5771.51	6,023.219	6023.276198	99.37728825
	Aircraft	5676.51	5,923.899		
	Science	5771.62	6,023.334		
Dec. 1, 2013	Science	5771.51	6,023.219	6023.286652	99.30410495
	Aircraft	5676.59	5,923.983		
	Science	5771.64	6,023.355		
Dec. 1, 2013	Science	5771.61	6,023.323	6023.422558	99.36682795
	Aircraft	5676.66	5,924.056		

Date	Location	Reading (counts)	Reading (mGals)	Science avg (mGal)	Science - Aircraft (mGal)
	Science	5771.8	6,023.522		
Dec. 2, 2013	Science	5771.65	6,023.365	6023.427785	99.3197816
	Aircraft	5676.71	5,924.108		
	Science	5771.77	6,023.491		

2.3.1 Trajectory and Attitude Data

The aircraft trajectory data is available in the position and height data included in the data records. Attitude data is available in the input data files listed in the Processing Steps section.

2.3.2 Processing Steps

Input data: IceBridge CMG 1A Dynamic Gravity Meter Time-Tagged L1B Vertical Accelerations (IGCMG1B) and IceBridge GPS/IMU L1B Primary Position and Attitude Solution (IPUTG1B).

Processing: GTGRAV v45 proprietary Gravimetric Technologies code.

Data were processed using differential dual carrier phase GPS solutions to estimate aircraft vertical and horizontal accelerations.

An (effectively) 150 second filter was used to smooth the resulting data.

Data were automatically edited based on horizontal and vertical acceleration thresholds.

The final result is the disturbance from the GRS-80 conventional series formula for the global gravity field corrected with the 1967 international free air correction formula:

$$\text{GRS80 conventional normal gravity} = 9.780327*(1 + 0.00530 \sin^2(\text{LAT}) - 0.0000058 \sin^2(2*\text{LAT})) \text{ m/s2}$$

$$\text{Free Air Correction} = (0.308768 - 0.000440*\sin^2(\text{LAT}) - 0.000000144*\text{AC\_ELEVATION})*\text{AC\_ELEVATION}$$

No continuation or leveling has been applied to the data.

Missing values have been replaced by `nan`.

2.3.3 Error Sources

Environmental conditions: the precise accelerations and attitudes recorded by the gravimeter are subject to degradation by aircraft maneuvering, turbulence and shocks; and to a lesser extent by

smooth changes in altitude and turns. The best results are from smooth, straight, level flight as can be determined by examination of the GPS trajectory data and instrument records of accelerometer saturation events. The resolution of gravity data is fundamentally limited by the distance from the source of the gravity anomaly; in the case of this survey that was determined by the thickness of the ice, the depth of the sea water, and the height of the aircraft (typically 200 to 800 meters).

Positioning limitations: The GPS data were processed using a base at Casey Station as the reference for differential GPS processing. Observations at long distances from this base are expected to be degraded somewhat. In particular, the November 22 and 23, 2012 flights between Davis and Casey Station were flown at more than 1000 km from the GPS base.

Hardware issues: The GT-1A instrument was running new development software for polar operations that may have introduced errors. Power was lost to the instrument due to blizzards at Casey Skiway prior to the November 22, 2012 and November 26 2012 flight, the instrument was still warming up during these flights.

2.3.4 Quality Assessment

This data set has not been analyzed sufficiently to assign quantitative accuracy values. A related set obtained on the same field season in West Antarctica exhibited noise with a RMS amplitude of 2.2 to 2.4 milligal (via analysis of crossovers, and without leveling). The East Antarctic data set was gathered under more varied conditions. Smooth flights with few altitude changes will have comparable or better accuracy.

2.4 Sensor or Instrument Description

Gravity was measured using GT-1A gravity meter S-019 leased from CMG Operations of Perth, Australia. The GT-1A system is a three-axis stabilized gravimeter, with a ±500 Gal dynamic range primary vertical accelerometer. Accelerations are sampled on board at 300 Hz. These are averaged over 16 sample intervals, for an effective sample rate of 18.75 Hz. The system has demonstrated accuracy on the order of 0.5 mGal in airborne surveys with spatial resolutions of a few km.

3 REFERENCES

V. N.Berzhitzky, Y. V. Bolotin, A. A. Golovan, V. N. Ilyin, N. A. Parusnikov, Y. L. Smoller, and S. S. Yurist. 2002. *GT-1A Inertial Gravimeter System Results of Flight Tests*, Moscow. Describes the GT-1A gravimeter and its early tests.

3.1 Related Data Collections

IceBridge BGM-3 Gravimeter L0 Raw Accelerations
IceBridge BGM-3 Gravimeter L1B Time-Tagged Accelerations
IceBridge BGM-3 Gravimeter L2 Geolocated Free Air Anomalies
IceBridge CMG 1A Dynamic Gravity Meter Time-Tagged L1B Vertical Accelerations
IceBridge GPS/IMU L1B Primary Position and Attitude Solution

4 ACKNOWLEDGEMENTS

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5 DOCUMENT INFORMATION

5.1 Publication Date

June 2014

5.2 Date Last Updated

March 2025