IceBridge Scintrex CS-3 Cesium Magnetometer L1B Geolocated Magnetic Anomalies, Version 2

USER GUIDE

How to Cite These Data

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

Cochran, J. R., Burton, B., Frearson, N., & Tinto, K. (2014). *IceBridge Scintrex CS-3 Cesium Magnetometer L1B Geolocated Magnetic Anomalies* (IMCS31B, Version 2). [Data set]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/OY7C2Y61YSYW [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/IMCS31B

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Summary

This data set contains magnetic field readings taken over Antarctica using the Scintrex CS-3 Cesium Magnetometer instrument. The data were collected as part of Operation IceBridge funded aircraft survey campaigns.

1.2 File Information

1.2.1 Format

The data are in ASCII CSV file format.

Each CSV file contains data from a single flight. The data have not been broken into flight lines and include the flight target transects at the nominal draped flight altitude of 1,500 feet Above Ground Level (AGL) as well as the transit sections flown at high-altitude, nominally 16,000 ft. Above Sea Level (ASL). The ascent from takeoff to a level flying altitude and final descent from each flight have been removed.

Note: Currently IMCS31B data for 2011 through 2012 are in Geosoft XYZ ASCII format stored separately as IMCS31B Version 1. Beginning with the 2013 Antarctica campaign, all data are provided in CSV format.

1.2.2 File Naming Convention

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

`IMCS31B_Vnn_DDMMYYYY_A.xxx`

Example file names:

`IMCS31B_V02_18112013_A.csv`
`IMCS31B_V02_18112013_A.csv.xml`

Table 1. File Naming Convention

Variable	Description
IMCS31B	Short name for IceBridge Scintrex CS-3 Cesium Magnetometer L1B Geolocated Magnetic Anomalies
Vnn	Data product version number. V02 = Version 2

Variable	Description
DD	Two-digit day
MM	Two-digit month
YYYY	Four-digit year
A	Placeholder for multiple files generated from a single flight.
.xxx	Indicates CSV ASCII text data file (.csv) or XML metadata file (.xml)

1.2.3 File Size

The total data file volume is approximately 1.2 GB.

1.3 Spatial Coverage

The spatial coverage includes Antarctica:

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

1.3.1 Spatial Resolution

Spatial resolution of the data is variable, chiefly from the variable line spacing of flight tracks. At an average flight speed of 240 knots (~120 m/s) the 20 Hz data rate gives a measurement approximately every 6 m along the ground. However, the flight elevation of ~500 m AGL places the plane at least 500 m from the source of the magnetic anomaly, and commonly much greater, as ice thicknesses can be greater than 3000 m. Therefore the along-track spatial resolution of the data is limited primarily by the spreading of the field with distance from source and tends to be ~1000 m.

1.4 Projection and Grid Description

Ellipsoid height WGS-84 (height above GRS 80 ellipsoid).

1.5 Temporal Coverage

18 November 2013 to 25 November 2017

1.5.1 Temporal Resolution

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

1.6 Parameter or Variable

The data files contain data parameters as described in Table 2, plus header information including column headings, flight number, date, and line number.

Table 2. Parameter Description and Units

Column	Description	Units
FLIGHT	Flight number	Number
TIME	UTC time	HH:MM:SS.ss
TIME_SEC	UTC seconds past midnight (continuous)	Seconds
DATE	UTC date	YYYY/MM/DD
LAT	Latitude WGS-84	Decimal degrees
LONG	Longitude WGS-84	Decimal degrees
ELLHT	Ellipsoid height WGS-84; height above Geodetic Reference System 1980 (GRS80) ellipsoid	Meters
TFDSPK	Despiked total magnetic field reading from cesium sensor	nanoTesla (nT)
TFCOMP	Despiked and compensated total magnetic field	nT
DCOR#	Diurnal correction value calculated from # base station(s). The number indicated in the DCOR# column heading, e.g. DCOR2, indicates the number of XXX_30MIN data columns that will appear at the end of the file.	nT
IGRF	International Geomagnetic Reference Field model IGRF2010 value based on flight date	nT
MAGANOM	Magnetic anomaly data (despiked, compensated, diurnally corrected, & IGRF removed)	nT
MAGBW5K	MAGANOM with Butterworth filter (8th degree filter with 5000 m central wavelength cutoff)	nT
MCM_30MIN	MAGANOM with Butterworth filter (8th degree filter with 5000 m central wavelength cutoff)	nT
XXX_30MIN	Magnetic base station data with 30-minute low-pass filter applied. XXX is the code for the base station used. More than one base station may be applied to a single flight.	nT

The coordinates are the location of the center arm of the gravimeter during flight.

The in-line GPS-magnetic sensor offset is -22.6 m.

Null or unavailable data are denoted by '-999999'.

2 DATA ACQUISITION AND PROCESSING

2.1 Acquisition

2.1.1 2013 Antarctica Data

The total field airborne magnetic data were acquired with a Scintrex CS-3 cesium vapor magnetometer and the fluxgate magnetic data were acquired with a Billingsley TFM100G2 magnetometer. Level 1B processed magnetic data are provided at a 20Hz sample rate.

Table 3. 2013 Base Stations

Location	**Site ID**	**Lat**	**Long**	**Elevation**	**Median Value**	**Sample Rate**	**INTERMAGNET/USGS**
McMurdo station, Antarctica	MCM	77.85° S	166.68° E	91 m	62123 nT	3 sec	USGS
Eyrewell, New Zealand	EYR	43.42° S	172.35° E	120 m	57570 nT	1 min	INTERMAGNET

2.2 Theory of Measurements

The CS3 magnetometer is a passive sensor that records the variation in total field strength of the magnetic field across the survey area during flight. Data are corrected for temporal (diurnal) variation of Earth's field using fixed base stations, either those established specifically for each survey campaign or from the global INTERMAGNET network of permanent magnetic observatories. The magnetic field of the moving airframe is accounted for with a compensation correction that accounts for variation in both heading and aircraft maneuvers.

2.3 Derivation Techniques and Algorithms

Raw data from the magnetometer (from the IceBridge Scintrex CS-3 Cesium Magnetometer L0 Raw Magnetic Field data set) report the total magnetic field recorded by the magnetometer. The processing steps for reducing these data to Level-1B magnetic anomalies are described in the Processing Steps section below. Step TFCOMPF accounts for the variation in the magnetic field caused by the airframe maneuvering through Earth's field. The compensation coefficients used are established from the results of a compensation flight, flown at the start of each campaign. The compensation pattern is a square, flown at high elevation (10,000 ft. AGL) in an area of low magnetic gradient. A series of manoeuvres are flown on each of the four headings of the square.

1. rolls: 10 degrees right bank followed by 10 degrees left bank for 3 oscillations
2. pitches: 5 degrees nose up followed by 5 degrees nose down for 3 oscillations
3. yaws: 5 degrees nose left followed by 5 degrees nose right for 3 oscillations

The period of each complete oscillation (+,-, back to level) is ~5 seconds. The maneuvers are smooth, and the flight altitude is held as constant as possible.

These maneuvers record the variation of the measured field due to the movement of the airframe through Earth's magnetic field. The total magnetic field is measured by the Cesium magnetometer, and the x, y and z components of the field are measured by the Billingsley fluxgate magnetometer. Compensation coefficients are established from the compensation pattern and applied to the total measured field in the raw data using proprietary PicoEnvirotec PEIComp software. Raw data from the compensation flights are available in the IceBridge Scintrex CS-3 Cesium Magnetometer L0 Raw Magnetic Field data set. Compensation values in these data sets are small, and typically less than 10 nT.

2.3.1 Trajectory and Attitude Data

The provided coordinates are the location of the center arm of the gravimeter during flight. The required in-line GPS-magnetic sensor offset is -22.6 meters.

2.3.2 Processing Steps

The magnetic data were processed by the U. S. Geological Survey (USGS), Crustal Geophysics and Geochemistry Science Center, Denver, Colorado.

DCOR#: Multiple base stations were used where applicable and when data were available using the usgs_mbase.gx available in Geosoft Oasis montaj (Phillips, 2007). A median value was calculated for each base station by averaging quiet-time readings, typically around local midnight, for each day data were available throughout the survey.

TFDSPK: The total field and fluxgate data were despiked initially based on selected threshold fourth difference values and then manually despiked further to remove interference from intermittent high-frequency (HF) radio communications during the flights.

TFCOMP: Two magnetic compensation flights were flown in 2011; one from Kangerlussuaq (flight 115) and one from Thule (flight 131). A single magnetic compensation flight was flown in 2012 from Kangerlussuaq (flight 232). Due to time constraints, a second compensation flight from Thule was not flown in 2012, so the compensation coefficients from the 2011 Thule compensation flight were used. In 2013, a compensation flight was flown during the check flight, prior to the first survey flight (flight 901 on UTC date Nov. 17). A single set of compensation coefficients was applied to each flight based on the flight's path and its proximity to the compensation boxes. Because the flight data have not been separated into flight lines, artifacts from the compensation coefficient corrections are present in the turns where heading variations are greatest.

TFPROC = TFCOMP - DCOR# - IGRF

MAGANOM = TFCOMP - DCOR# - IGRF

TFBW5K: An eighth-order, low-pass Butterworth filter with a 5000 m central wavelength cutoff was applied to the TFPROC channel to remove high-frequency signal and to minimize the compensation artifacts. This channel is only in the 2011 Level-1B data set (see the IceBridge Scintrex CS-3 Cesium Magnetometer L1B Geolocated Magnetic Anomalies, Version 1, data set).

MAGBW5K: An eighth-order, low-pass Butterworth filter with a 5000 m central wavelength cutoff was applied to the MAGANOM channel to remove high-frequency signal and to minimize the compensation artifacts. The MAGBW5K channel is the same as the TFBW5K channel in the 2011 Level-1B data set.

Tables 4, 5, and 6 summarize 2011, 2012, and 2013 flight processing and base stations.

Table 4. 2011 Flight Processing Summary

Flight Number	Flight Name	Date	Compensation	Base Station(s)
101	Sea Ice Connor Corridor	16 March	Thule	BRW,RES,THL
102	Sea Ice CryoSat-2 Underflight	17 March	Thule	BRW,HRN,RES,THL
103	Sea Ice ZigZag West	18 March	Thule	HRN,RES,THL
104	North Basin Transect/Thule-Fairbanks	22 March	Thule	BRW,CMO,RES,THL

Flight Number	Flight Name	Date	Compensation	Base Station(s)
105	Sea Ice - ICEX Camp Survey/Fairbanks	23 March	Thule	BRW,CMO
106	South Basin Transect/Fairbanks-Thule	25 March	Thule	BRW,CMO,RES,THL
107	Sea Ice ZigZag East	26 March	Thule	HRN,THL
108	Sea Ice Fram Gateway	28 Marcy	Thule	HRN,THL
109	CryoSat Land ice	29 Marcy	Thule	GDH,THL
110	Jakobshavn 02/Thule-Kangerlussuaq	31 March	Thule	GDH,THL
111	No flight data, flight was aborted before takeoff	5 April		
112	Jakobshavn 01	6 April	Kangerlussuaq	GDH,KNG
113	Umanaq 01	7 April	Kangerlussuaq	GDH,KNG
114	SW Mopup 01	8 April	Kangerlussuaq	KNG
115	Magnetic compensation and radar calibration	9 April	Kangerlussuaq	KNG
116	SE Glaciers Mopup 01	9 April	Kangerlussuaq	KNG,NAQ
117	SE Coastal 02	12 April	Kangerlussuaq	KNG,NAQ
118	Russell 02 Mopup	13 April	Kangerlussuaq	KNG
119	SE Flank 01	14 April	Kangerlussuaq	KNG,NAQ
120	Sea Ice CryoVEx	15 April	Kangerlussuaq	THL
121	SW Mopup 02	16 April	Kangerlussuaq	KNG
122	SE Fjords 01	18 April	Kangerlussuaq	KNG,NAQ
123	Helheim-Kangerdlugssuaq	19 April	Kangerlussuaq	KNG
124	Jakobshavn/Lakes	22 April	Kangerlussuaq	GDH,KNG

Flight Number	Flight Name	Date	Compensation	Base Station(s)
125	Umanaq 02	23 April	Kangerlussuaq	GDH,KNG
126	Duck-Clusters	25 April	Kangerlussuaq	KNG
127	Geikie 01	26 April	Kangerlussuaq	GDH,KNG
128	Baffin Bay Sea Ice	28 April	Thule	GDH,THL
129	Petermann 03	29 April	Thule	TGS
130	NEIS 04	2 May	Thule	HRN,THL
131	Magnetic compensation	4 May	Thule	THL
132	Devon Ice Cap - CryoVEx	5 May	Thule	RES,THL
133	Layers NEEM-NGRIP	6 May	Thule	THL
134	Petermann 02	7 May	Thule	THL
135	North Glaciers	9 May	Thule	HRN,THL
136	Ellesmere Island 01	10 May	Thule	RES,TGS
137	NW Coastal 04	11 May	Thule	GDH,THL
138	Barnes Ice Cap/Bylot Island	12 May	Thule	THL
139	NW Glaciers	13 May	Thule	GDH,THL
140	NW Coastal 05	16 May	Thule	GDH,THL

Table 5. 2012 Flight Processing Summary

Flight Number	Flight Name	Date	Compensation	Base Station(s)
201	Sea Ice - North Basin Transect	2012/03/14	Thule	THL,CMO
202	Sea Ice - Beaufort-Chukchi Zigzag	2012/03/15	Thule	CMO
203	Sea Ice - Beaufort-Chukchi Diamond	2012/03/16	Thule	BRW,CMO
204	Sea Ice - Alaskan Coastal Zigzag A	2012/03/17	Thule	CMO
205	Sea Ice - South Basin Transect	2012/03/19	Thule	TGS,CMO
206	Sea Ice - North Pole Transect	2012/03/21	Thule	TGS
207[1]	Sea Ice - Connor Corridor	2012/03/22	Thule	TGS,RES
208a,b[2]	Sea Ice - Canada Basin	2012/03/23	Thule	THL,RES

209	Sea Ice - Wingham Box	2012/03/26	Thule	TGS,RES
210	Sea Ice - Zigzag East	2012/03/27	Thule	TGS
211	Sea Ice - Cryosat	2012/03/28	Thule	THL
212	Sea Ice - Zigzag West Cryovex	2012/03/29	Thule	TGS
213	CryoSat Land	2012/03/30	Thule	TGS,GDH
214	Sea Ice - Fram Gateway	2012/04/02	Thule	TGS,HRN
215[3]	Gap-Summit	2012/04/04	Thule	THL,GDH
216	Sea Ice - MABEL Underflight	2012/04/10	Kangerlussuaq	KNG,HRN
217	East Glaciers 01	2012/04/11	Kangerlussuaq	KNG
218	Geikie 02	2012/04/12	Kangerlussuaq	KNG
219	East Central Grid 01	2012/04/13	Kangerlussuaq	KNG
220	Helheim Kangerdlugssuaq Gap 01	2012/04/14	Kangerlussuaq	KNG
221	Geikie 03	2012/04/16	Kangerlussuaq	KNG
222	No flight data; flight aborted shortly after takeoff	2012/04/17		
223	Helheim Kangerd	2012/04/17	Kangerlussuaq	KNG
224	Southeast Mopup 01	2012/04/18	Kangerlussuaq	KNG
225	East Central Grid 03	2012/04/19	Kangerlussuaq	KNG,HRN
226	Southwest Coastal 01	2012/04/20	Kangerlussuaq	KNG,NAQ
227	Disko Bay 01	2012/04/21	Kangerlussuaq	KNG,GDH
228	Helheim Kangerdlugssuaq Gap 02	2012/04/23	Kangerlussuaq	KNG
229	Southwest Glaciers 01	2012/04/25	Kangerlussuaq	KNG,NAQ
230	Southeast Glaciers 01	2012/04/28	Kangerlussuaq	KNG,NAQ
231	Jakobshavn Basin 01	2012/04/29	Kangerlussuaq	KNG,GDH
232	Umanaq-Sarqardliupsermia (mag comp)	2012/04/30	Kangerlussuaq	GDH
233	Jakobshavn 02	2012/05/02	Kangerlussuaq	GDH,THL
234	North Glaciers 02	2012/05/03	Thule	TGS,HRN
235	Devon 01	2012/05/04	Thule	TGS,RES
236	Northeast Grid 02	2012/05/07	Thule	HRN
237	Northeast Grid 03	2012/05/08	Thule	HRN
238	Northwest Fjords 01	2012/05/09	Thule	TGS,GDH
239	Cape Alexander 01	2012/05/10	Thule	THL,TGS
240	Humboldt 01	2012/05/11	Thule	THL
241	NEIS ICESat	2012/05/14	Thule	TGS,HRN
242	Northwest Glaciers	2012/05/15	Thule	THL,GDH
243	North Flux 01	2012/05/16	Thule	TGS

244	Ellesmere 01	2012/05/17	Thule	TGS,RES

Table 6. 2013 Flight Processing Summary

Flight Number	Flight Name	Date	Compensation	Base Station(s)
401	Land Ice - TAM West	2013/11/18 - 2013/11/19	MCM	401
402	Land Ice - Victoria 01	2013/11/19 - 2013/11/20	MCM	402
403	Sea Ice - Ross Sea Fluxgate	2013/11/20 - 2013/11/21	MCM	403
404	Land Ice - Siple Coast 03	2013/11/25 - 2013/11/26	MCM	404
405	Land Ice - Dome C – Vostok	2013/11/26 - 2013/11/27	MCM	402
406	Sea Ice - CryoSat /Christchurch Transit	2013/11/27 - 2013/11/28	MCM, EYR	406

[1] The cesium sensor and pre-amplifier assembly were replaced between flights 207 and 208 to troubleshoot the data spikes in the total field data. It was later determined to be caused by the lack of a low-pass hardware filter being applied to the incoming data on the first logger (100 Hz sample rate).

[2] Flight 208 data were acquired with two different data loggers: 208a and 208b were acquired at original sample rates of 100 Hz and 160 Hz, respectively.

[3] Engine #3 was shut down at approximately 15:23:00 UTC time due to a malfunction, at which time the remainder of the planned survey was aborted and headed directly to Kangerlussuaq with only three operational engines. This engine was replaced between flights 215 and 216.

[4] Data from DMC and VOS INTERMAGNET observatories were not available for this flight.

2.4 Quality, Errors, and Limitations

2.4.1 Quality Assessment

Data quality was assessed during the 2011 Operation IceBridge campaign by comparing the magnetic anomaly calculated from measurements made during six repeats of a survey line between Thule and Camp Century. Individual profiles were differenced from the mean of all six repeats and the standard deviation of the differences was 7 nT.

2.4.2 Errors

Major sources of error in magnetic surveys are unaccounted for temporal variations in the magnetic field during surveys, including geomagnetic storms. No magnetic storms were identified during these survey periods. The processing steps applied here correct for smooth diurnal variation of Earth's field, as recorded at fixed base stations. Survey data are despiked to remove high-frequency magnetic field variations, including those associated with aircraft communications.

2.5 Instrumentation

2.5.1 Description

The Magnetics system includes a total field cesium sensor, a pre-amplifier, a three-axis fluxgate and a data acquisition system. The sensor is mounted at the end of a non-magnetic boom attached to the tail of the P-3B Orion aircraft. As the aircraft flies, the sensor measures the total incident magnetic field. The size of the signal is proportional to the magnitude of the field through which the sensor is flown and the rate at which the field is cut. Therefore, to extract the signal of the magnetic anomalies that the aircraft is flying over it is necessary to account for accelerations in the airframe, which are derived from the fluxgate data, the Earth's background field as defined by the IGRF, and the diurnal signal recorded on a fixed base station. The non-magnetic region of the tail-boom continues for approximately 20 ft rearwards of the tail of the aircraft. The sensor is connected to the pre-amp, located about 10 ft away inside the boom. The pre-amp regulates power to the sensor and sends a signal proportional to the magnetic flux passing by the sensor back to the data acquisition system. The data acquisition system is located in the Gravity rack inside the aircraft cabin where the data are time stamped and stored in the data acquisition system. The fluxgate is located inside the tail-boom away from both the sensor and the pre-amp.

3 VERSION HISTORY

IMCS31B Version 1: Currently the IceBridge Scintrex CS-3 Cesium Magnetometer L1B Geolocated Magnetic Anomalies data for 2011 through 2012 are in Geosoft XYZ ASCII format stored separately as Version 1. In the near future, data from all campaigns prior to Fall 2013 will be replaced with CSV data and added to Version 2. For details on the Version 1 data, see the .

IMCS31B Version 2: Beginning with the 2013 Antarctica campaign, all data are provided in CSV format.

4 RELATED DATA SETS

IceBridge Scintrex CS-3 Cesium Magnetometer L0 Raw Magnetic Field

5 ACKNOWLEDGMENTS

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6 REFERENCES

Phillips, J.D. 2007. Geosoft eXecutables (GX's) Developed by the U.S. Geological Survey, Version 2.0, with Notes on GX Development from Fortran code. U.S. Geological Survey Open-File Report 2007-1355. http://pubs.usgs.gov/of/2007/1355/

7 DOCUMENT INFORMATION

7.1 Publication Date

August 2014

7.2 Date Last Updated

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