Block MS01 (Mountain South 01)

GRAV-D Airborne Data Release User Manual

Applies to Data Release BETA #1, 11/2018

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Version Notes

11/2018 BETA #1: First release

Introduction to GRAV-D and Data User Manuals

NOAA's National Geodetic Survey (NGS) launched the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) program in 2007. This program is designed to replace the current national vertical datum (NAVD 88) with a datum based upon a gravimetric geoid by 2022. To produce the geoid with 1-2 cm accuracy (where possible), an airborne campaign has been launched to measure the gravity field over all of the US and its holdings.

A more comprehensive description of the GRAV-D project is available in the "GRAV-D General Airborne Gravity Data User Manual." The version of that manual that applies to this release is manual v. 2.X. That manual also describes general details of the nominal airborne field operations, data post-processing software specifics, data naming schemes and distribution, data formats, and how to calculate other commonly-used gravity values from the released data. This manual relates details for this block of data that are in addition to the General User Manual.

GRAV-D uses some specific terminology (e.g. "block" for a geographic area with enough flown data and tie lines to provide error statistics, and "survey" for an occupation by the field team of a particular airport, at a particular time, and with a particular aircraft and instrument suite). For a full list of terminology, refer to the Glossary in the Appendices of the "GRAV-D General Airborne Gravity Data User Manual."

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1. Block Description

GRAV-D Block **MS01** is located in the **M**ountain Time Zone, in the **S**outh half (south of 40° latitude). This was the first (**01**) block of data completed in that region. Block MS01 is 620 km by 330 km, covering parts of New Mexico and Texas (Figure 1). The corner coordinates defining Block MS01 are listed in Table 1.

Figure 1: Google Earth Image of the Location of Block MS01

Table 1: Latitude and Longitude Coordinates of Corner Points Defining Block MS01

Latitude (decimal degrees)	Longitude (decimal degrees)
34.781488780	-108.748231133
31.853873875	-108.553984956
32.153663469	-101.997365340
35.105525838	-101.955964747

2. Survey Design and Execution

Airborne gravity data in Block MS01 were collected during seven surveys: TX13-1 (Texas 2013, first occupation), AZ14-2 (Arizona 2014, second occupation), TX14-2 (Texas 2014, second occupation), AZ16-1 (Arizona 2016, first occupation), AZ16-2 (Arizona 2016, second occupation), TX16-2 (Texas 2016, second occupation), and TX18-1 (Texas 2018, first occupation). Data lines from AZ16-2 were flown at approximately 20,000 ft. Data lines from TX13-1 and TX14-2 were flown at approximately 21,000 ft. Data lines from AZ14-2 and AZ16-1 were flown at approximately 23,000 ft. Data lines and cross lines from TX16-2 and TX18-1 were flown at approximately 24,000 ft. MS01 was surveyed with multiple aircraft and multiple relative gravimeters. Supplementary data from transit (target of opportunity) flights may be made available at a future date. Table 2, Table 3, and Table 4 give a synopsis of survey layout and execution for the data. Figure 2: shows the data coverage, plotted in Google Earth.

In MS01, data lines are East-West and cross lines are North-South. The block consists of 22 data lines and 3 cross line from TX13-1, 6 data lines and 2 cross line from AZ14-2, 14 data lines and 1 cross line from TX14-2, 8 data lines from AZ16-1, 1 cross line from AZ16-2, 4 data lines from TX16-2, and 2 data lines from TX18-1. One data line was reflown: Line MS01113 and MS01213 from TX13-1. The usual line numbering scheme used by GRAV-D (see “General User Manual”) was used for this survey. In the data file, line numbers are preceded by the block name (i.e. MS01101= block MS01’s line 101).

White Sands Missile Range is located in the middle of block MS01, mostly in the southern half. To help with flight planning and coordination with the missile range the lower 21 lines were divided in half. The eastern set of lines are numbered 1 through 21. The western set of lines are numbered 135-155.

Table 2: Survey Overview

Survey	Conducting Organization	Airport Base of Operations	Geographic Location	Survey Dates
TX13-1	NOAA-National Geodetic Survey	Lubbock Preston Smith Internation Airport (LBB) Lubbock, TX FBO: Lubbock Aero	New Mexico and Texas	Feb 1 - Mar 3, 2013
AZ14-2	NOAA-National Geodetic Survey	Tucson International Airport (TUS) Tucson, AZ FBO: Million Aire	New Mexico and Texas	Oct 23 - Nov 24, 2014
TX14-2	NOAA-National Geodetic Survey	Lubbock Preston Smith Internation Airport (LBB) Lubbock, TX FBO: Lubbock Aero	New Mexico and Texas	Sep 22 - Dec 20, 2014

Survey	Conducting Organization	Airport Base of Operations	Geographic Location	Survey Dates
AZ16-1	NOAA-National Geodetic Survey	Tucson International Airport (TUS) Tucson, AZ FBO: Atlantic	New Mexico and Texas	Jan 9 - Mar 4, 2016
AZ16-2	NOAA-National Geodetic Survey	Tucson International Airport (TUS) Tucson, AZ FBO: Million Aire	New Mexico and Texas	Feb 24 - Mar 20, 2016
TX16-2	NOAA-National Geodetic Survey	Rick Husband Amarillo International Airport (AMA) Amarillo, TX FBO: TAC Air	New Mexico and Texas	Oct 11 - Nov 13, 2016
TX18-1	NOAA-National Geodetic Survey	Rick Husband Amarillo International Airport (AMA) Amarillo, TX FBO: TAC Air	New Mexico and Texas	Sep 19 - Oct 1, 2018

Table 3: Aircraft and Instrumentation

Aircraft (Surveys)	Dynamic Aviation King Air: N43U (AZ14-2 and AZ16-2)
Engines, number and type	2, Turboprop
Gravity Instrumentation	Micro-g LaCoste (MGL) TAGS S-161 (relative) MGL A-10 (absolute) LaCoste and Romberg D-43 and G-6 (relative)
GPS Instrumentation	NovAtel DL-V3 or DL-4 Plus NovAtel SPAN-SE with Honeywell µIRS (GPS + IMU)
Aircraft (Surveys)	BLM Pilatus PC-12: N190PE (TX13-1, TX14-2, TX16-2, and AZ16-1)
Engines, number and type	1, Turboprop
Gravity Instrumentation	Micro-g LaCoste (MGL) TAGS S-211 (relative) (TX18-1) Micro-g LaCoste (MGL) TAGS S-161 (relative) (TX13-1) Micro-g LaCoste (MGL) TAGS S-137 (relative) (TX14-2, TX16-2, and AZ16-1) MGL A-10 (absolute) LaCoste and Romberg D-43, G-157, and G-6 (relative)
GPS Instrumentation	NovAtel DL-V3 or DL-4 Plus NovAtel SPAN-SE or PP7 with Honeywell µIRS (GPS + IMU)

Table 4: Survey Design and Execution

Line Spacing	Data Lines: 10 km Cross Lines: ~80 km
Type of Layout	Regular data lines & regular cross lines
Nominal Survey Altitude	20,000 ft (AZ16-2), 21,000 ft (TX13-1 and TX14-2), 23,000 ft (AZ14-2 and AZ16-1), 24,000 ft (TX16-2 and TX18-1)
Nominal Aircraft Ground Speed	250 knots
Number of Lines Released	Data Lines: 22 (TX13-1), 6 (AZ14-2), 14 (AZ14-2), 8 (AZ16-1), 4 (TX16-2), 2 (TX18-1) Cross Lines: 3 (TX13-1), 2 (AZ14-2), 1 (TX14-2), 1 (AZ16-2) Repeat Lines: 1 data lines
Number of Crossovers	212

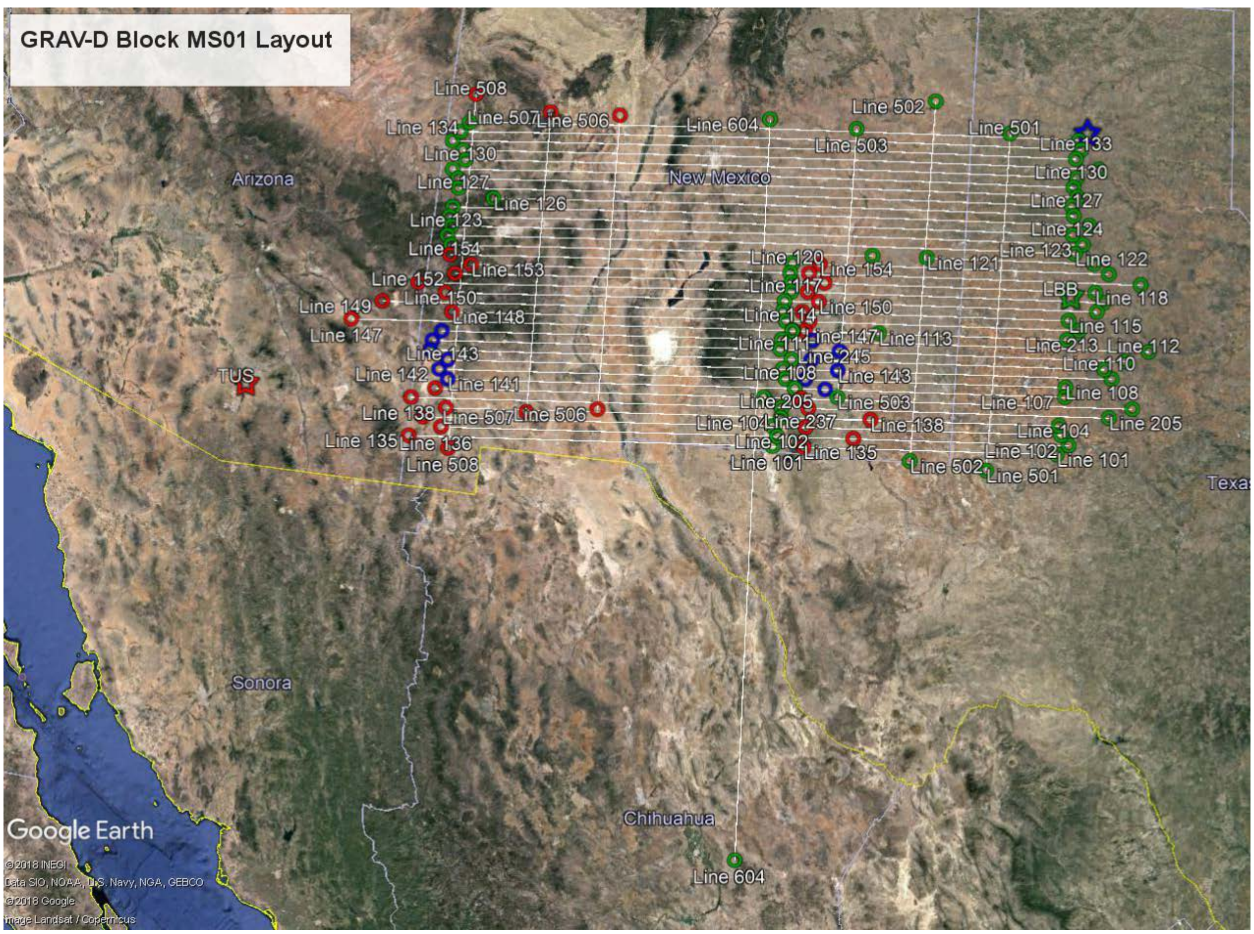

Figure 2: Data Coverage for MS01. Data lines range from 101 to 155. Lines flown from Lubbock Preston Smith International Airport (LBB) and the airport are marked with green. Lines flown from Rick Husband Amarillo International Airport (AMA) and the airport are marked in blue. Lines flown from Tucson International Airport (TUS) and the airport are marked in red.

2.1 GPS/IMU Instrumentation

Each aircraft had one GPS antenna available for scientific measurements. Two geodetic-quality GPS receivers shared the antenna: either a NovAtel DL-V3 or NovAtel DL-4 Plus (included as part of the TAGS gravimeter timing unit) and a NovAtel SPAN-SE or PP7. The NovAtels' had a data rate of 1 Hz. The NovAtel SPAN-SE and PP7 system included a Honeywell Inertial Measurement Unit (IMU) that recorded aircraft orientation information at 200 Hz during the flight, including pitch, roll, yaw, and heading.

On the ground, two Ashtech Z-Extreme antenna/receivers for TX13-1, TX14-2, AZ14-2, and AZ16-2 recording at 1 Hz served as GPS base stations throughout the survey. Two NovAtel PP6 antenna/receivers for TX16-2 and AZ16-1 recording at 1 Hz served as base stations throughout the survey. For TX18-1, one NovAtel DLV operating at 20 Hz served as a base station. See Section 3.2.1 for a table of GPS data available for each flight and processing details.

2.2 Gravity Instrumentation

The Micro-g LaCoste TAGS (Turn-key Airborne Gravimetry System) was mounted in the cargo area of the aircraft. The TAGS records data at 1 Hz and has a NovAtel timing unit mounted on the gravimeter. The gravimeter also records an environmental file at 0.1 Hz. For more information on the instrument, refer to its user manual (Micro-g LaCoste, 2010). The TAGS S-211 records data at 20 Hz and has a NovAtel timing unit mounted on the gravimeter. The gravimeter includes environmental information in the same file as the gravity data at 20 Hz (Micro-g LaCoste, 2015).

The TAGS was mounted to the seat tracks in the center of the fuselage of the aircraft. The IMU was mounted on top of the TAGS and in the center of the frame. Table 5 lists the lever arm measurements between the TAGS and other instruments (distances are measured along the body of the aircraft: X positive toward the right, Y positive toward the nose, and Z positive up.)

Table 5: Lever Arm Measurements FROM the IMU TO the Other Instruments

Instrument/Location	X (m)	Y (m)	Z (m)
TAGS S-211 Gravimeter	-0.001	-0.002	-0.453
TAGS S-161 Gravimeter	-0.016	0.021	-0.503
TAGS S-137 Gravimeter	-0.011	0.036	-0.514
GNSS antenna on Dynamic Aviation King Air (S-161)	-0.133	0.389	0.538
GNSS antenna on BLM Pilatus PC-12 (S-137 and S-161)	-0.008	0.669	0.615
GNSS antenna on BLM Pilatus PC-12 (S-211)	0.01	0.56	0.732

3. GPS and Gravity Data Processing

3.1 Whole-Survey Applicable Details

3.1.1 GPS

Table 6: GPS High Rate Data Availability (1 Hz or higher)

Airport	Type	Receiver	Flight Available	Day of Year Available (UTC)
LBB TX13-1	Kinematic	NovAtel (SPAN)	f06, f07, f10-f17	35, 36, 48, 54, 55, 59-62
	Static	Ashtech 3406	f06, f07, f10-f17	35, 36, 48, 54, 55, 59-62
		Ashtech 2801	f06, f07, f10-f17	35, 36, 48, 54, 55, 59-62
LBB TX14-2	Kinematic	NovAtel (SPAN)	f12, f14-f16, f20, f25, f26, f28	305, 310, 311, 312, 314, 319, 326, 327, 329
	Static	Ashtech North	f12, f14-f16, f20, f25, f26, f28	305, 310, 311, 312, 314, 319, 326, 327, 329
		Ashtech South	f12, f14-f16, f20, f25, f26, f28	305, 310, 311, 312, 314, 319, 326, 327, 329
AMA TX16-2	Kinematic	NovAtel (SPAN)	f19	316
	Static	NovAtel 47	f19	316
		NovAtel 49	f19	316
TUS AZ14-2	Kinematic	NovAtel (SPAN)	f21-f23, f27	331, 332, 342, 354
	Static	Ashtech East	f21-f23, f27	331, 332, 342, 354
		Ashtech West	f21-f23, f27	331, 332, 342, 354
TUS AZ16-1	Kinematic	NovAtel (SPAN)	f01, f02, f04	9-12
	Static	NovAtel 47	f01, f02, f04	9-12
		NovAtel 49	f01, f02, f04	9-12
TUS AZ16-2	Kinematic	NovAtel (SPAN)	f13	78
	Static	Ashtech East	f13	78
		Ashtech West	f13	78
AMA TX18-1	Kinematic	NovAtel (PP7)	f02	272
	Static	DLV	f02	272

Data were processed using GRS80 and ITRF08. The position solution is a tightly coupled kinematic Precise Point Position (PPP) of the GPS and IMU data collected by the rover GNSS receiver. Average position accuracy for the data block is calculated. Position standard deviation is estimated by the GPS processing programs for each flight and those numbers are averaged to provide a survey-wide estimate of GPS position accuracy. For the data lines, the average horizontal position accuracy is ±0.035 m and the average vertical position accuracy is ±0.061 m (95% confidence interval).

3.1.2 Ground Gravity Tie

Absolute gravity measurements were performed by NGS with a Micro-g LaCoste A-10 gravimeter in February 2013 (LBB), March 2014 (TUS), and January 2016 (AMA). The A-10 was set up at the exact location of the aircraft. The positions were determed from the GPS collected during the gravity survey while the plane was parked. Table 7 is a summary of the point ID, location and gravity tie from each of the airports.

Table 7: Gravity Ties at the height of the TAGS Gravimeter in the airplane.

Airport	Point ID	Latitude	Longitude	Tie height above mark (cm)	Gravity Tie (mGal)
LBB	KLBB OME	33.64448003°N	-101.8364365°W	163.7	979307.855 ± 0.008
TUS	KTUS TAGS	32.12594468°N	-110.9447505°W	162.5	979210.564 ± 0.008
TUS	KTUS TAGS	32.12594468°N	-110.9447505°W	163.7	979210.561 ± 0.008
AMA	KAMA TAGS	35.21689382°N	-101.7085789°W	163.7	979406.461 ± 0.008

3.1.3 Gravity Filtering

For block MS01, flights were accomplished in seven surveys and were filtered the same way. Newton v1.4 uses a time-domain Gaussian filter that is applied three times to the data during final filtering. The Gaussian filter chosen for this survey has a 6-sigma of 120s, i.e. a 2-sigma of only 40s. Applying the filter three times provides superior noise reduction compared to a single application of the filter. Although the triple application provides better noise reduction, the filter is tailored to best preserve the amplitudes of the long wavelength signal, while allowing some short wavelength noise to remain in the final product. For suggestions on data handling, including on further noise suppression, see Section 4.1 Suggested Data Handling.

3.2 Whole-Block Applicable Details

3.2.1 Gravity Error Analysis

Crossover error analysis was done by identifying the crossing points of the data lines and cross lines and then applying a free-air correction using the confocal method of calculating Normal Gravity to bring all points to the average altitude of the block. There was an unidentified bias in all flight lines, so an additional correction was applied before the crossover analysis to adjust each line's median airborne gravity value to the median gravity value of EGM08 along the line. The bias-corrected difference between the cross line gravity value and data line gravity value is the residual. The square root of the RMS of the residuals yields the total RMS error. For MS01, the result of the crossover analysis is shown in Table 8 and in Figure 3.

Table 8: Gravity Crossover Error Analysis

Nominal Altitude (ft)	Nominal Altitude (m)	Altitude for Analysis (m)	Number of Crossovers	RMS Of Residuals (mGal)	Std. Dev. Of Residuals (mGal)	Mean Crossover Difference (mgal)	RMS Error (mGal)
20,000	6,096	6,679	212	2.71	2.71	-0.26	1.92

One assumption of crossover analysis is that the quality of the cross lines are high and that the crossover difference reflects only the error in the data lines. This is not necessarily the case.

This means that the crossover statistics do not accurately reflect the quality of the data lines, due to the errors in the cross lines. One way to quantify this problem is by reporting the standard deviation and mean of the crossover residuals for each cross line, as in Table 9. The higher the standard deviation of the residuals, the more likely that the cross line was noisy. Also, a non-zero mean could indicate a cross-line bias with respect to the data lines (unlikely here because of the bias correction applied), which would produce false crossover statistics that indicate poor data line quality.

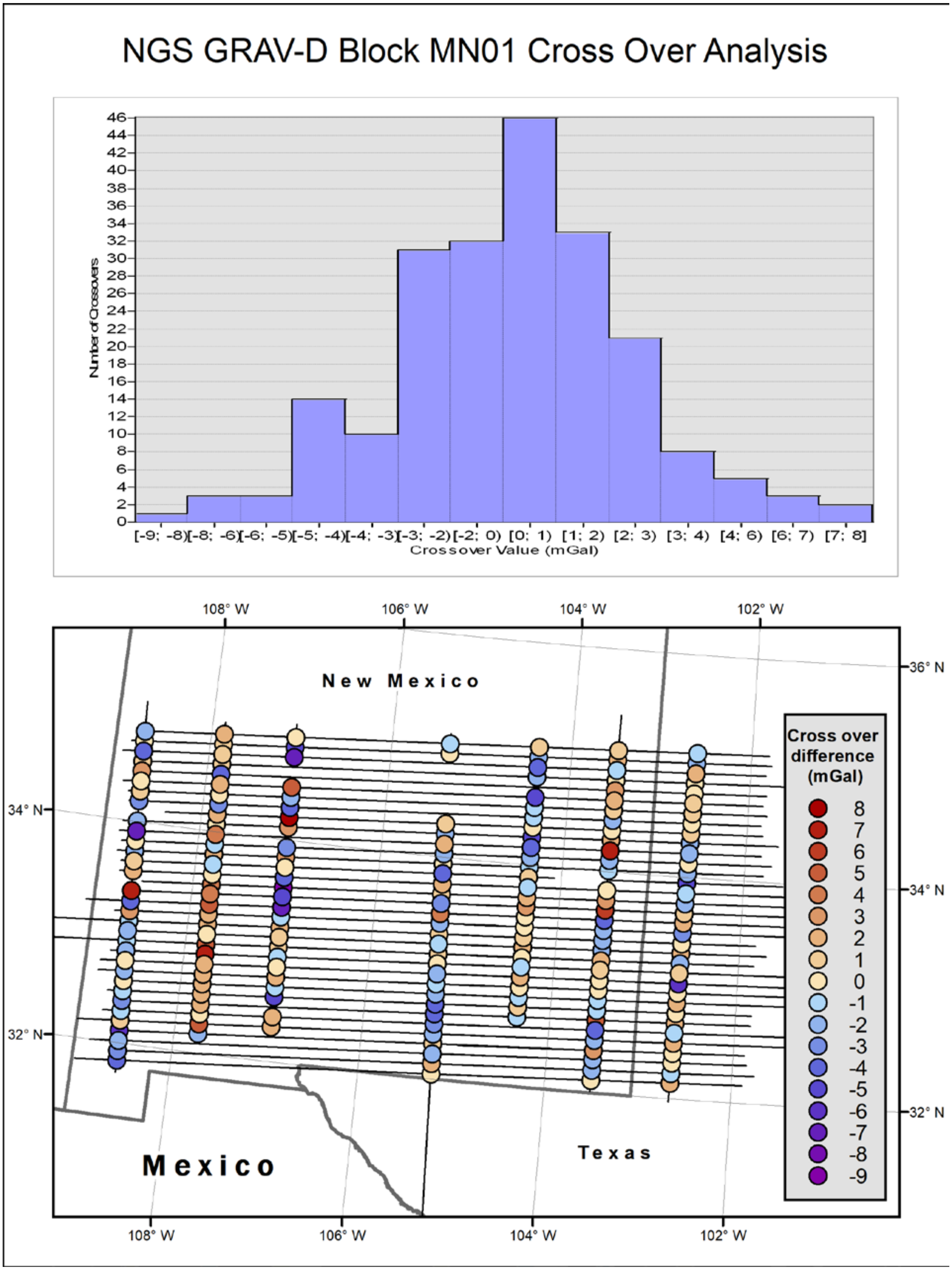

Figure 3: Crossover Residuals, Histogram, and Statistics for Block MS01

Table 9: Quality of Cross Lines Used in Crossover Analysis

Cross Line Number	Standard Deviation of Residuals Along Line (mGal)	Mean of Residuals Along Line (mGal)
501	1.95	-0.32
502	2.65	0.36
503	2.05	-0.79
604	2.09	-0.80
506	3.94	-0.99
507	2.37	1.50
508	2.85	-1.00

Another way to evaluate the quality of gravity data is to calculate the correlation of the gravity values along two adjacent data lines. Average correlation and statistics on the spread of correlations can yield information about the quality of the data lines (Table 10) This technique works well as a measure of data quality in areas with little lateral variability in the gravity field (such as the Gulf of Mexico). But the technique doesn't work well when the correlations are not expected to be high, such as in areas with large changes in topography and/or density from data line to data line. Line correlations were calculated for adjacent lines and then averaged to give an overall quality measurement. Correlations > 80% mean the lines are very highly correlated, 70% - 80% mean the lines are highly correlated, 50% - 70% mean the lines are more correlated than not, and <50% are more uncorrelated than correlated.

Table 10: Average Data Line Correlation

Number of Correlations	Average Data Line Correlation	Standard Deviation of Correlations
56	96.38%	2.23%

A fourth way of gauging data quality is by calculating the repeatability of the gravity signal along reflown lines of good quality. Reflight analysis can also help to pinpoint the lightest filtering that produces highly-correlated results. In MS01 one data line was reflown, MS01113. The correlations between these reflown lines are found in (Table 11).

Table 11: Correlations between Reflown Lines

Survey	Line Track Number	Correlation
TX13-1	MS01113	97.70
TX13-1	MS01213	

3.3 Flight- and Line-Specific Details

3.3.1 GPS processing- by flight

GPS data were processed in Inertial Explorer (IE) v. 8.7. A lever arm correction (to move the position solution from that of the GPS antenna to that of the center of the gravimeter) was applied within the IE software and included in the GPS+IMU solution. In the case of the GPS-only solution, no IMU data were available and a translation-only, vertical lever arm correction was instead applied by Inertial Explorer to translate the GPS-only positions to the center of the gravimeter.

NGS has developed an independent method of measuring the quality of GPS position solutions based on information available from both Inertial Explorer. For the GPS-only part of the position solution, the quality analysis takes into account the following: whether a fixed or float solution was achieved, the magnitude of the combined separation between forward and reverse solutions (a measure of precision), and the estimated position accuracy. For details on the calculation, please refer to the “GRAV-D General Airborne Gravity Data User Manual.”

3.3.2 Gravity processing- by line

All gravity processing was done with NGS’ Newton v1.4 software. For a description of the package, refer to the “GRAV-D General Airborne Gravity Data User Manual.” The final gravity data file contains full-field gravity at altitude (Figure 4), although other gravity products such as free-air anomalies or free-air disturbances (Figure 5) can be easily calculated by following directions in Section 4 of the “GRAV-D General Airborne Gravity Data User Manual”.

Table 12: GPS+IMU and GPS-only Kinematic Processing Results

Survey	Flight	Rover GPS Unit	Solution Type	Elevation Mask (deg)	Line Num.	NGS Qualtiy Grade
AZ14-2	f21	SPAN	GPS+IMU	7.5	135	100
AZ14-2	f21	SPAN	GPS+IMU	7.5	136	100
AZ14-2	f22	SPAN	GPS+IMU	7.5	138	100
AZ14-2	f22	SPAN	GPS+IMU	7.5	237	100
AZ14-2	f23	SPAN	GPS+IMU	7.5	507	100
AZ14-2	f23	SPAN	GPS+IMU	7.5	508	100
AZ14-2	f27	SPAN	GPS+IMU	7.5	139	100
AZ14-2	f27	SPAN	GPS+IMU	7.5	140	100
AZ16-1	f01	DLV	GPS+IMU	5	153	100
AZ16-1	f01	SPAN	GPS+IMU	5	154	100
AZ16-1	f02	SPAN	GPS+IMU	5	149	100
AZ16-1	f02	SPAN	GPS+IMU	5	150	100
AZ16-1	f02	SPAN	GPS+IMU	5	151	100
AZ16-1	f02	SPAN	GPS+IMU	5	152	100
AZ16-1	f04	SPAN	GPS+IMU	5	147	100
AZ16-1	f04	SPAN	GPS+IMU	5	148	100
AZ16-2	f13	SPAN	GPS+IMU	5	506	100
TX13-1	f06	SPAN	GPS+IMU	5	133	100
TX13-1	f06	SPAN	GPS+IMU	5	134	100
TX13-1	f07	SPAN	GPS+IMU	7.5	131	100
TX13-1	f07	SPAN	GPS+IMU	7.5	132	100
TX13-1	f10	SPAN	GPS+IMU	7.5	503	100
TX13-1	f11	SPAN	GPS+IMU	5	125	100
TX13-1	f11	SPAN	GPS+IMU	5	126	100
TX13-1	f12	SPAN	GPS+IMU	7.5	501	100
TX13-1	f12	SPAN	GPS+IMU	7.5	502	100
TX13-1	f13	SPAN	GPS+IMU	7.5	113	100
TX13-1	f13	SPAN	GPS+IMU	7.5	114	100
TX13-1	f13	SPAN	GPS+IMU	7.5	115	100
TX13-1	f13	SPAN	GPS+IMU	7.5	116	100
TX13-1	f13	SPAN	GPS+IMU	7.5	213	100
TX13-1	f14	SPAN	GPS+IMU	5	121	100
TX13-1	f14	SPAN	GPS+IMU	5	122	100
TX13-1	f14	SPAN	GPS+IMU	5	155	100
TX13-1	f15	SPAN	GPS+IMU	7.5	101	100
TX13-1	f15	SPAN	GPS+IMU	7.5	102	100
TX13-1	f15	SPAN	GPS+IMU	7.5	103	100

Survey	Flight	Rover GPS Unit	Solution Type	Elevation Mask (deg)	Line Num.	NGS Qualtiy Grade
TX13-1	f15	SPAN	GPS+IMU	7.5	104	100
TX13-1	f16	SPAN	GPS+IMU	5	123	100
TX13-1	f16	SPAN	GPS+IMU	5	124	100
TX13-1	f17	SPAN	GPS+IMU	5	107	100
TX13-1	f17	SPAN	GPS+IMU	5	108	100
TX14-2	f12	SPAN	GPS+IMU	5	604	100
TX14-2	f14	SPAN	GPS+IMU	7.5	127	100
TX14-2	f14	SPAN	GPS+IMU	7.5	130	100
TX14-2	f15	SPAN	GPS+IMU	7.5	128	100
TX14-2	f15	SPAN	GPS+IMU	7.5	129	100
TX14-2	f16	SPAN	GPS+IMU	5	205	100
TX14-2	f16	SPAN	GPS+IMU	5	206	100
TX14-2	f20	SPAN	GPS+IMU	5	109	100
TX14-2	f20	SPAN	GPS+IMU	5	110	100
TX14-2	f25	SPAN	GPS+IMU	5	111	100
TX14-2	f25	SPAN	GPS+IMU	5	112	100
TX14-2	f26	SPAN	GPS+IMU	7.5	117	100
TX14-2	f26	SPAN	GPS+IMU	7.5	118	100
TX14-2	f28	SPAN	GPS+IMU	5	119	100
TX14-2	f28	SPAN	GPS+IMU	5	120	100
TX16-2	f19	SPAN	GPS+IMU	5	141	100
TX16-2	f19	SPAN	GPS+IMU	5	142	100
TX16-2	f19	SPAN	GPS+IMU	5	143	100
TX16-2	f19	SPAN	GPS+IMU	5	144	100
TX18-1	f02	PP7	GPS+IMU	5	246	100
TX18-1	f02	PP7	GPS+IMU	5	245	100

Table 13: Gravity Processing Results

Survey	Flight Num.	Line Num.	Time of Deleted Data	Comments
AZ16-2	f13	506	2016-03-18 05:57:26- 2016-03-18 05:59:00	Bump Removed
AZ16-2	f13	506	2016-03-18 06:22:00- 2016-03-18 06:24:10	Bump Removed
AZ16-2	f13	506	2016-03-18 06:31:01- 2016-03-18 06:33:01	Bump Removed
TX14-2	f12	604	2014-11-01 18:35:38- 2014-11-01 18:42:24	Bump Removed
TX14-2	f14	130	2014-11-06 15:00:23- 2014-11-06 15:11:23	Bump Removed

Table 14: Bias from EGM08 by Line

Survey	Flight Num.	Line	EGM08 mean
AZ14-2	f21	135	0.68
AZ14-2	f21	136	1.6
AZ14-2	f22	138	1.86
AZ14-2	f22	237	0.26
AZ14-2	f23	507	0.53
AZ14-2	f23	508	0.45
AZ14-2	f27	139	-0.63
AZ14-2	f27	140	0.05
AZ16-1	f01	153	-1.86
AZ16-1	f01	154	0.39
AZ16-1	f02	149	-0.55
AZ16-1	f02	150	2.28
AZ16-1	f02	151	-0.7
AZ16-1	f02	152	1.56
AZ16-1	f04	147	1.12
AZ16-1	f04	148	4.12
AZ16-2	f13	506	-0.15
TX13-1	f06	133	0.92
TX13-1	f06	134	-1.88
TX13-1	f07	131	2.31
TX13-1	f07	132	0.6
TX13-1	f10	503	0.99
TX13-1	f11	125	1.82
TX13-1	f11	126	-1.31
TX13-1	f12	501	1.72
TX13-1	f12	502	4.06
TX13-1	f13	113	-0.68
TX13-1	f13	114	0.86
TX13-1	f13	115	0.38
TX13-1	f13	116	1.58
TX13-1	f13	213	1.1
TX13-1	f14	121	2.62
TX13-1	f14	122	-1
TX13-1	f14	155	1.49
TX13-1	f15	101	-2.15
TX13-1	f15	102	-0.5
TX13-1	f15	103	-0.79
TX13-1	f15	104	0.67
TX13-1	f16	123	1.35
TX13-1	f16	124	-0.88
TX13-1	f17	107	-1.35
TX13-1	f17	108	0.72
TX14-2	f12	604	1.12
TX14-2	f14	127	1.54

Survey	Flight Num.	Line	EGM08 mean
TX14-2	f14	130	-0.13
TX14-2	f15	128	0.88
TX14-2	f15	129	-1.08
TX14-2	f16	205	3.04
TX14-2	f16	206	-0.69
TX14-2	f20	109	2.98
TX14-2	f20	110	0.38
TX14-2	f25	111	3.2
TX14-2	f25	112	0.07
TX14-2	f26	117	2.29
TX14-2	f26	118	0.05
TX14-2	f28	119	-1.32
TX14-2	f28	120	-3.83
TX16-2	f19	141	1.15
TX16-2	f19	142	-1.49
TX16-2	f19	143	1.85
TX16-2	f19	144	-1.84
TX18-1	f02	246	0.56
TX18-1	f02	245	1.41

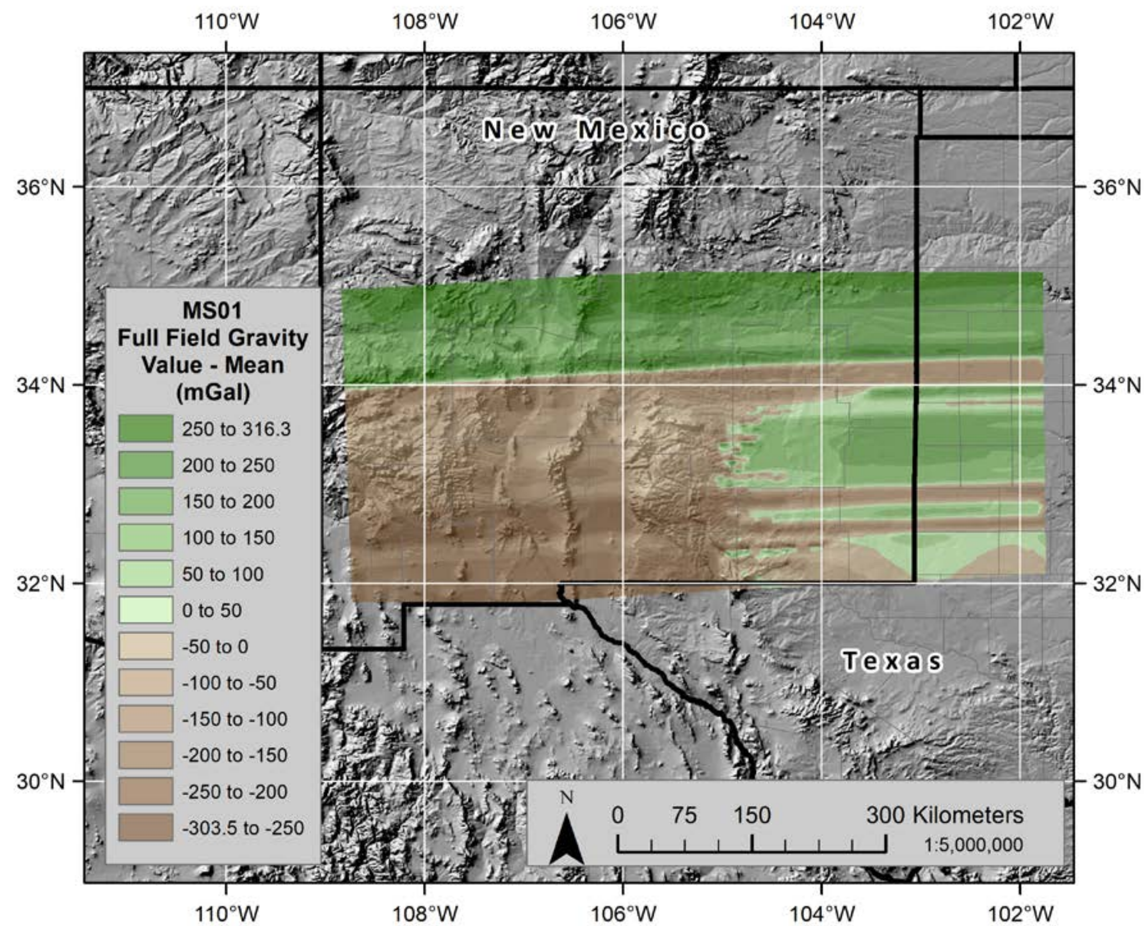

Figure 4: Full-field gravity at altitude (mean removed) for Block MS01. This is the data in the gravity release ".txt" file and includes the effects of differing altitudes along flight lines.

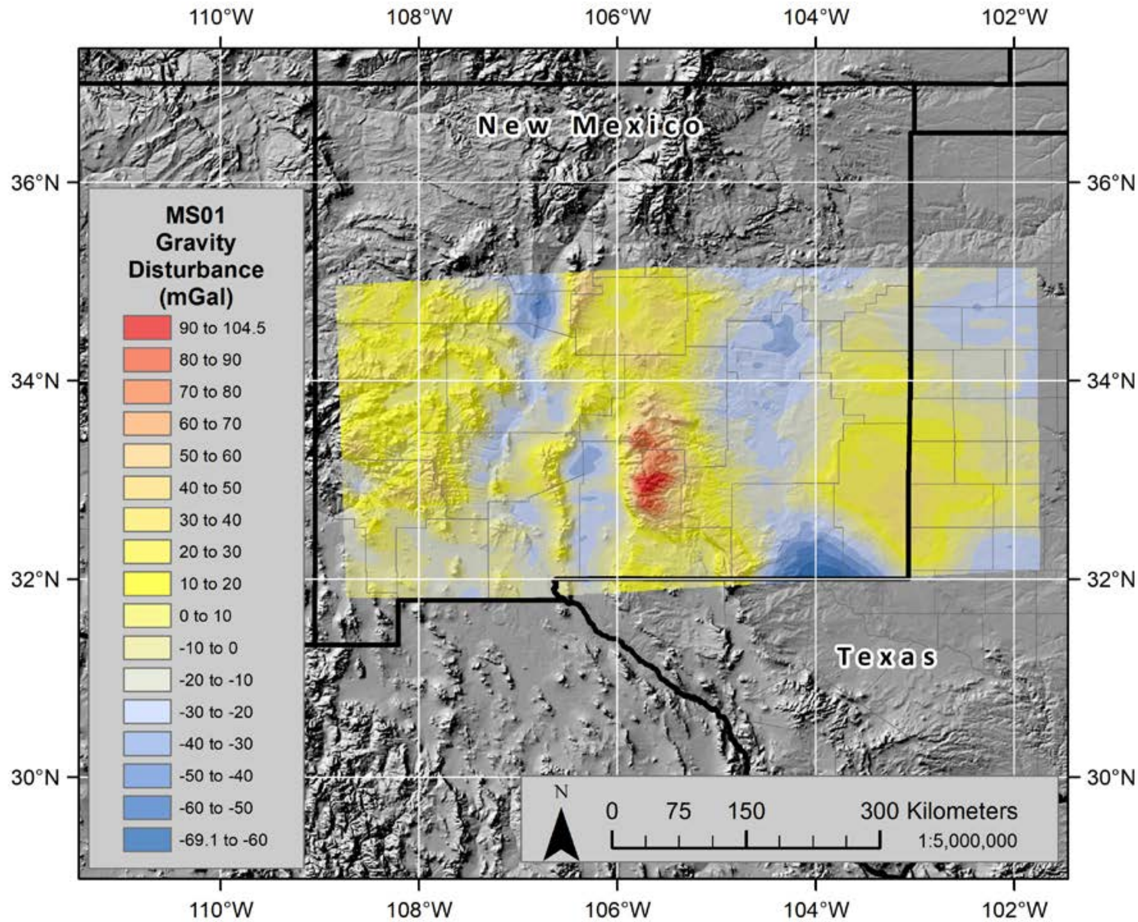

Figure 5 Free-air gravity disturbance for Block MS01 with respect to the GRS80 ellipsoid

4. Data Usage Guidelines

4.1 Suggested Data Handling

This data product was purposefully filtered to preserve the amplitude of the long-wavelength gravity signal. As a trade-off, the filter allows some short wavelength noise to remain in the product. Prior to use for geophysical purposes, the data should be run through a frequency-domain low-pass filter to remove that excess short wavelength noise. For geodetic purposes, higher frequencies can be damped during inclusion into a spherical harmonic model. In any case where downward continuation will be done with this data, the high frequency noise should first be filtered out, damped, or otherwise dealt with so that the downward continuation does not amplify the noise.

4.2 Documentation

The survey block User Manual, the general GRAV-D User Manual, and metadata for the block should all be downloaded with the data and kept in the same directory. The contents of the manuals are critical to understanding the quality of the data and using the data properly.

4.3 How to Cite These Data

The following citations should be used in all presentations or publications that reference the GRAV-D work. Please replace the *DATE* tag in the following references with the date you downloaded the data or reports from the NGS website.

The GRAV-D Team, in alphabetical order, are: Vicki A. Childers, Justin Dahlberg, Theresa M. Damiani, Jeff Kanney, Jeffery A. Johnson, Chris Villarreal, Derek van Westrum, and Monica A. Youngman.

To reference the MS01 data file, reference the webpage:
GRAV-D Science Team (2018). “Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project, Airborne Gravity Data; Block MS01”. Available *DATE*. Online at: http://www.ngs.noaa.gov/GRAV-D/data_MS01.shtml

To reference the block and survey details, reference the block user manual:
GRAV-D Science Team (2018). “Block MS01 (Mountain South 01); GRAV-D Airborne Gravity Data User Manual.” Monica A. Youngman and Jeffery A. Johnson, ed. Version BETA. Available *DATE*. Online at: http://www.ngs.noaa.gov/GRAV-D/data_MS01.shtml

To reference the general GRAV-D project operations, reference the General User Manual:
GRAV-D Science Team (2017). “GRAV-D General Airborne Gravity Data User Manual.” Theresa Damiani, Monica Youngman, and Jeffery Johnson, ed. Version 2.1. Available *DATE*. Online at: http://www.ngs.noaa.gov/GRAV-D/data_products.shtml

5. References

Micro-g LaCoste, 2010. “TAGS Turnkey Airborne Gravity System AIR III Hardware & Operations Manual.”

Micro-g LaCoste, 2015. “TAGS-6 Turnkey Airborne Gravity System 6 AIR User’s Manual.”