NATIONAL GEODETIC SURVEY | www.ngs.noaa.gov

Block MS05 (Mountain South 05)

GRAV-D Airborne Data Release User Manual

Applies to Data Release BETA #1, 05/2018

Edited by Monica A. Youngman and Jeffery A. Johnson

Version Notes

05/2018 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."

Contents

Figure List

Table List

1. Block Description

GRAV-D Block **MS05** is located in the **M**ountain Time Zone, in the **S**outh half (south of 40° latitude). This was the fifth (**05**) block of data completed in that region. Block MS05 is 610 km by 295 km, covering parts of Colorado, Kansas, New Mexico, Oklahoma, and Texas (Figure 1). The corner coordinates defining Block MS05 are listed in Table 1.

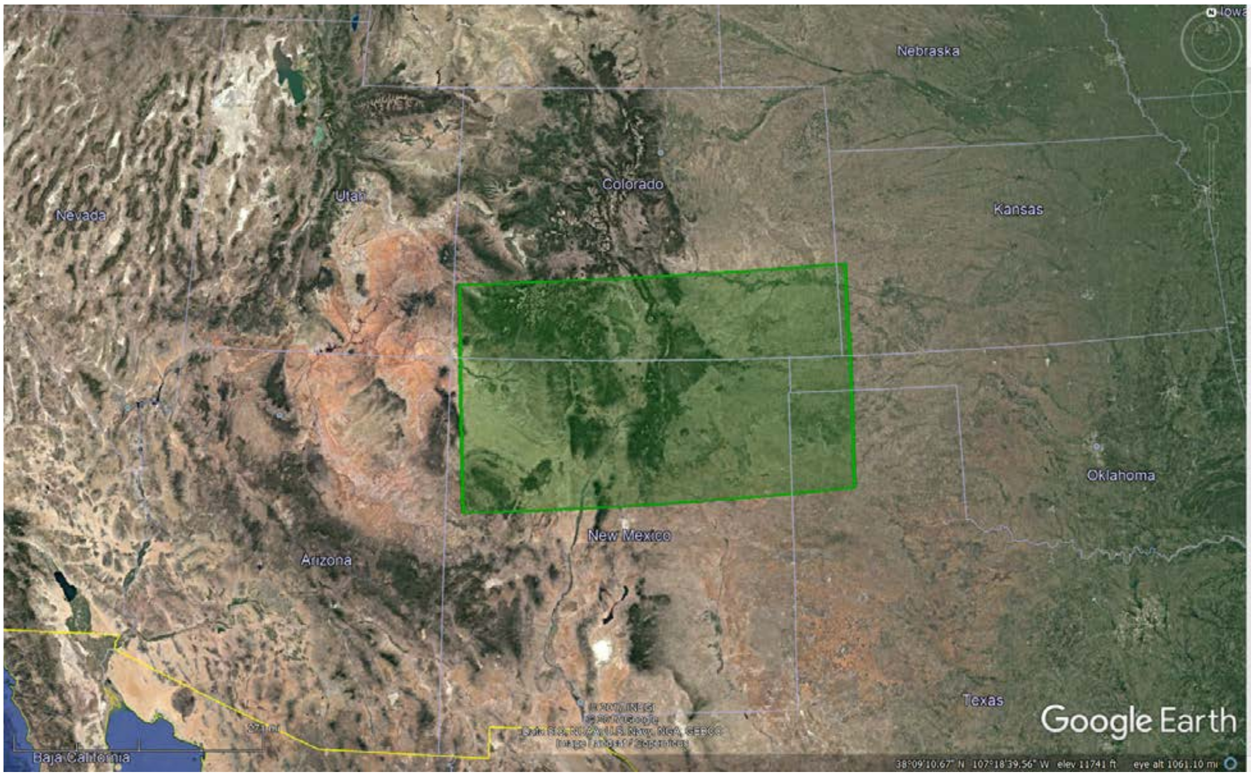


Figure 1: Google Earth Image of the Location of Block MS05

Table 1: Latitude and Longitude Coordinates of Corner Points Defining Block MS05

Latitude (decimal degrees)	Longitude (decimal degrees)
38.335588803	-101.877645199
38.064502422	-108.949715158
34.802660622	-108.738717181
35.116858043	-101.949618428

2. Survey Design and Execution

Airborne gravity data in Block MS05 were collected during four surveys: TX15-1 (Texas 2015, first occupation), TX16-2 (Texas 2016, second occupation), TX17-1 (Texas 2017, first occupation) and CO17-1 (Colorado 2017, first occupation). Data and cross flights for TX15-1, TX16-2, and TX17-1 were done at approximately 20,000 ft with the same aircraft and instrument suite. CO17-1 was flown at approximately 20,000 ft with a different aircraft and instrument suite. Supplementary data from transit (target of opportunity) flights may be made available at a future date. Table 2, Table 3, Table 4, and Table 5 give a synopsis of survey layout and execution for the data. Figure 2: shows the data coverage, plotted in Google Earth.

In MS05 all data lines are East-West and cross lines North-South. The block consists of 11 data lines and 1 cross line from TX15-1; 14 data lines and 2 cross lines from TX16-2; 2 data lines and 3 cross lines from TX17-1; and 22 data lines and 1 cross line from CO17-1. 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. MS05101= block MS05's line 101).

Flight lines 103-110 and 122 are made up of partial lines collecting in two different flights. See Table 12, Table 13, and Table 14.

Table 2: Survey Overview

Conducting Organization	NOAA- National Geodetic Survey	
Survey Name	TX15-1	TX16-2
Airport Base of Operations	Rick Husband Amarillo International Airport (AMA) Amarillo, TX FBO: TAC Air	Rick Husband Amarillo International Airport (AMA) Amarillo, TX FBO: TAC Air
Geographic Location	Colorado, Kansas, New Mexico, Oklahoma, and Texas	
Dates of Airborne Operations	Nov. 7 – Nov. 21, 2015	Oct. 11 – Nov. 13, 2016
Conducting Organization	NOAA- National Geodetic Survey	
Survey Name	TX17-1	CO17-1
Airport Base of Operations	Rick Husband Amarillo International Airport (AMA) Amarillo, TX FBO: TAC Air	Grand Junction Regional Airport (GJT) Grand Junction, CO FBO: Grand Junction Regional
Geographic Location	Colorado, Kansas, New Mexico, Oklahoma, and Texas	
Dates of Airborne Operations	Jan. 21 – Mar. 2, 2017	Aug. 14 – Sept. 10, 2017

Table 3: Aircraft and Instrumentation (Texas Surveys)

Aircraft	BLM Pilatus PC-12 (N190PE)
Engines, number and type	1, Turboprop
Gravity Instrumentation	Micro-g LaCoste (MGL) TAGS S-137 (relative) MGL A-10 (absolute) LaCoste and Romberg G-157 and G-6 (relative)
GPS Instrumentation	NovAtel DL-4 Plus NovAtel SPAN-SE with Honeywell µIRS (GPS + IMU)

Table 4: Aircraft and Instrumentation (Colorado Survey)

Aircraft	Aurora Flight Science’s Centaur (N49AU)
Engines, number and type	2, Turboprop
Gravity Instrumentation	Micro-g LaCoste (MGL) TAGS S-211(relative) MGL A-10 (absolute) Scintrex CG6 (relative)
GPS Instrumentation	NovAtel DL-4 Plus NovAtel SPAN-SE with Honeywell µIRS (GPS + IMU)

Table 5: 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
Nominal Aircraft Ground Speed	250 knots
Number of Lines Released	Data Lines: 11 (TX15-1), 14 (TX16-2), 2 (TX17-1), 22 (CO17-1) Cross Lines: 1 (TX15-1), 2 (TX16-2), 3 (TX17-1), 1 (CO17-1)
Number of Crossovers	285

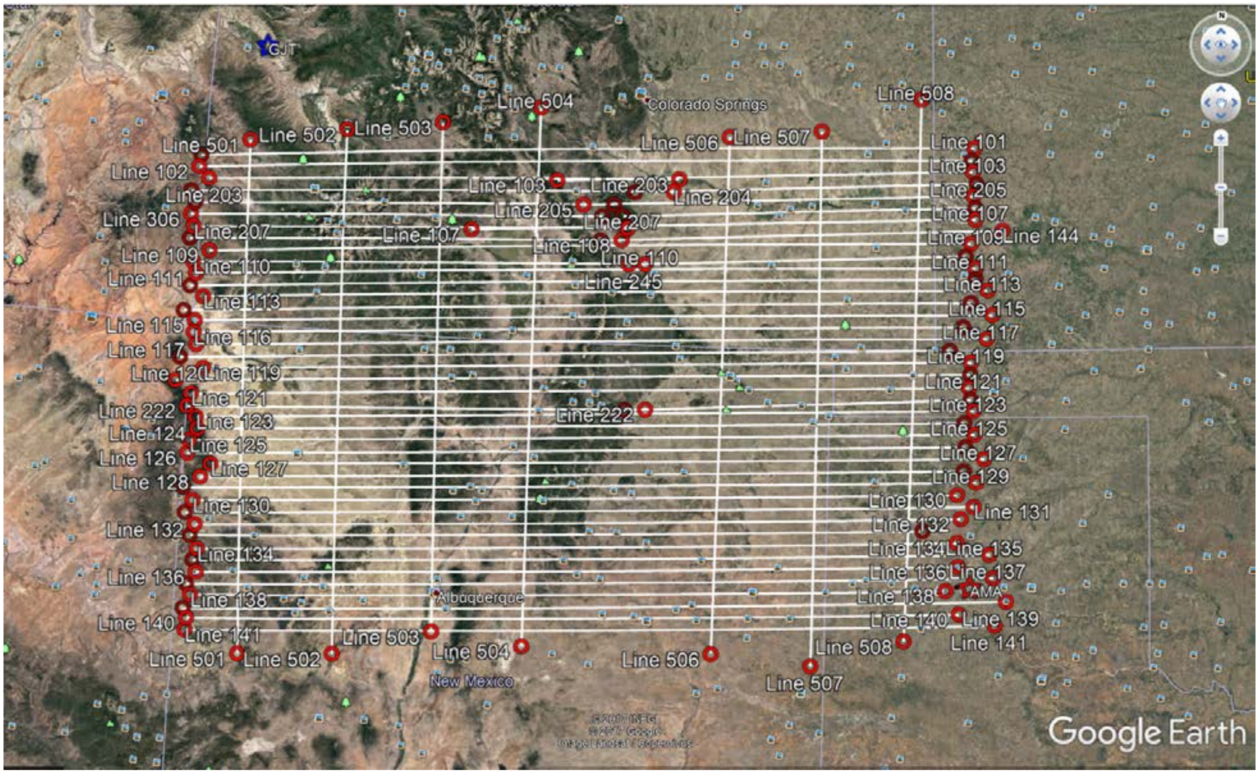


Figure 2: Data Coverage for MS05. Data lines start in the south and range from 101 to 141. TX flights were flown from AMA Rick Husband Amarillo International Airport (Red Star) and CO flights were flown from GJT Grand Junction Regional Airport (Blue Star).

2.1 GPS/IMU Instrumentation

Both the Pilatus PC-12 and the Centaur had one GPS antenna available for scientific measurements. Two geodetic-quality GPS receivers shared the antenna: one NovAtel DL-4 Plus (included as part of the TAGS gravimeter timing unit) and a NovAtel SPAN-SE. The NovAtels' had a data rate of 1 Hz on the Pilatus PC-12 and 20 Hz on the Centaur. The NovAtel SPAN-SE 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 NovAtel PP6 antenna/receivers for TX15-1, TX16-2 and TX17-1, recording at 1 Hz served as GPS base stations throughout the survey. For CO17-1 one DLV3 (20 Hz) and one Trimble R7 (1 Hz) was used. 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 S-137 (Turn-key Airborne Gravimetry System) was mounted in the cargo area of the Pilatus and the TAGS S-211 was mounted into the cargo area of the Aurora Centaur (pilot optional aircraft). The TAGS S-137 records data at 1 Hz and the TAGS S-211 records data at 20 Hz. Each TAGS has a NovAtel timing unit mounted on the gravimeter. The S-137 also records an environmental file at 0.1 Hz, but the S-211 includes environmental information in the same file as the gravity data at 20 Hz. For more information on the instruments, refer to its user manual (Micro-g LaCoste, 2010 and 2015).

The TAGS was mounted to the seat tracks in the center of the fuselage of the aircraft. For TAGS S-137, the IMU was mounted on top of the gravimeter and in the center of the frame. For the TAGS S-211 the IMU was mounted to the right of the gravimeter. Table 6 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 6: Lever Arm Measurements FROM the SPAN TO the Other Instruments

Instrument/Location (Pilatus)	**X (m)**	**Y (m)**	**Z (m)**
Gravimeter	-0.011	0.015	-0.527
Aircraft GPS Antenna	-0.008	0.669	0.615
Instrument/Location (Centaur)	**X (m)**	**Y (m)**	**Z (m)**
Gravimeter	-0.300	-0.100	0.300
Aircraft GPS Antenna	-0.250	-0.070	0.800

3. GPS and Gravity Data Processing

3.1 Whole-Survey Applicable Details

3.1.1 GPS

Table 7: GPS High Rate Data Availability (1 Hz or higher)

Airport	Type	Receiver	Flight Available	Day of Year Available (UTC)
AMA TX15-1	Kinematic	NovAtel (SPAN)	f01, f03-f06	311, 312, 317, 318, 323
		NovAtel PP6 1447	f01, f03-f06	311, 312, 317, 318, 323
		NovAtel PP6 1449	f01, f03-f06	311, 312, 317, 318, 323
AMA TX16-2	Kinematic	NovAtel (SPAN)	f02, f07, f08, f10, f11, f15, f16, f21	287, 295, 296, 301, 302, 313-315, 317, 318
	Static	NovAtel PP6 1447	f02, f07, f08, f10, f11, f15, f16, f21	287, 295, 296, 301, 302, 313-315, 317, 318
		NovAtel PP6 1449	f02, f07, f08, f10, f11, f15, f16, f21	287, 295, 296, 301, 302, 313-315, 317, 318
AMA TX17-1	Kinematic	NovAtel (SPAN)	f04, f10, f11	29, 30, 57, 58, 61
	Static	NovAtel PP6 1447	f04, f10, f11	29, 30, 57, 58, 61
		NovAtel PP6 1449	f04, f10, f11	29, 30, 57, 58, 61
GJT CO17-1	Kinematic	NovAtel (SPAN)	f01, f03-f07, f09-f16	235, 237-241, 243-246, 250-253
	Static	DLV3 GPS 1	f01, f03-f07, f09-f16	235, 237-241, 243-246, 250-253
		Trimble R7 GPS 2	f01, f03-f07, f09-f16	235, 237-241, 243-246, 250-253

Data were processed using GRS80 and ITRF08. After post-processing the GPS-only kinematic data (before processing with coupled IMU), 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 ±0.052 m and the average vertical position accuracy is ±0.087 m (95% confidence interval).

3.1.2 Ground Gravity Tie

Updated absolute gravity measurements were performed by NGS with a Micro-g LaCoste A-10 gravimeter in January of 2016 at Rick Husband Airport, TX and September 2017 at Grand Junction Regional Airport, CO. The A-10 was set up at the exact location of the aircraft: the Pilatus and the Centaur. The positions were determed from the GPS collected during the gravity survey while the plane was parked. In TX the location is designated as KAMA TAGS (35.216893819°N, 101.708578850W) and it has an absolute gravity value of 979406.461± 0.006 mGal at 163.7 cm above the tarmac. In CO the location is designated as KGJT TAGS

(39.118644100°N, 108.525550500°W) and it has an absolute gravity value of 979607.343± 0.008 mGal at 150 cm above the tarmac.

3.1.3 Gravity Filtering

For block MS05, flights were accomplished in four 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

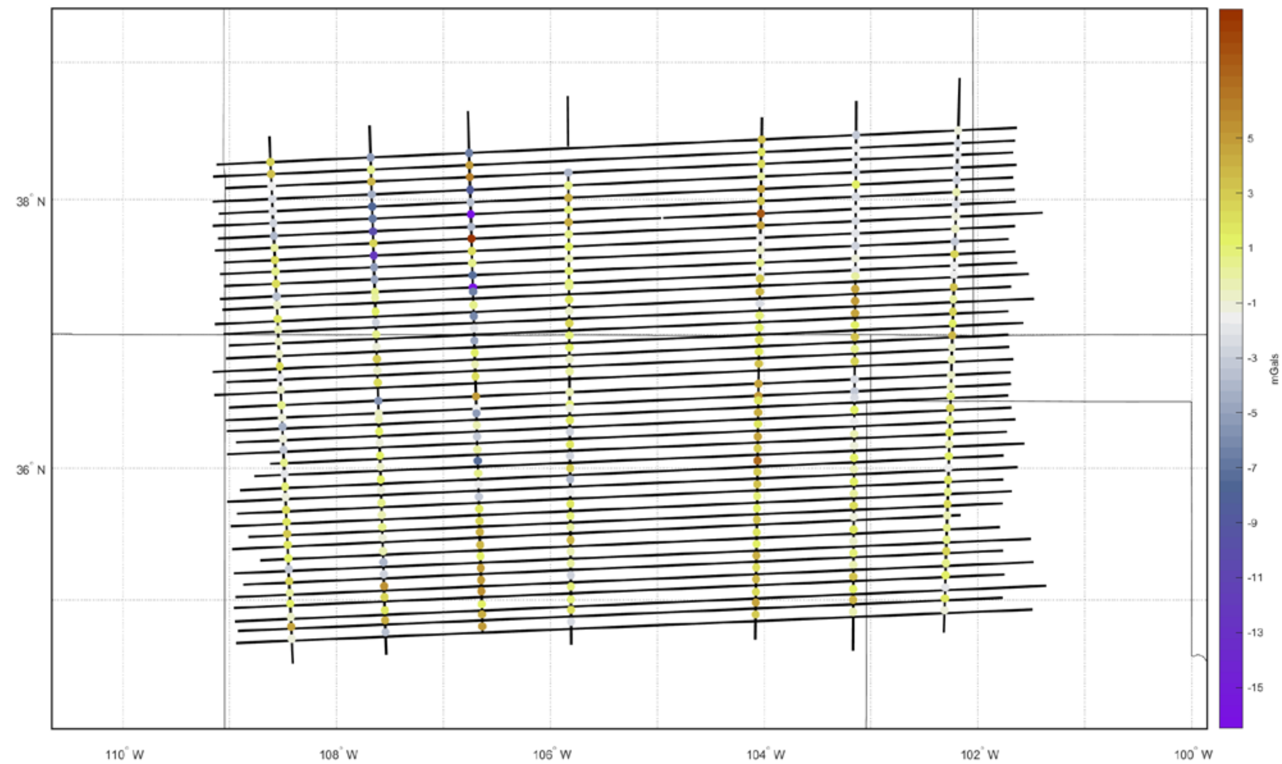
3.2.1 Gravity Error Analysis

Crossover error analysis was done by identifying the crossing points of the data lines and cross lines and then applying the standard free-air correction 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 MS05, 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	6210	285	3.29	3.29	0.48	2.32

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.



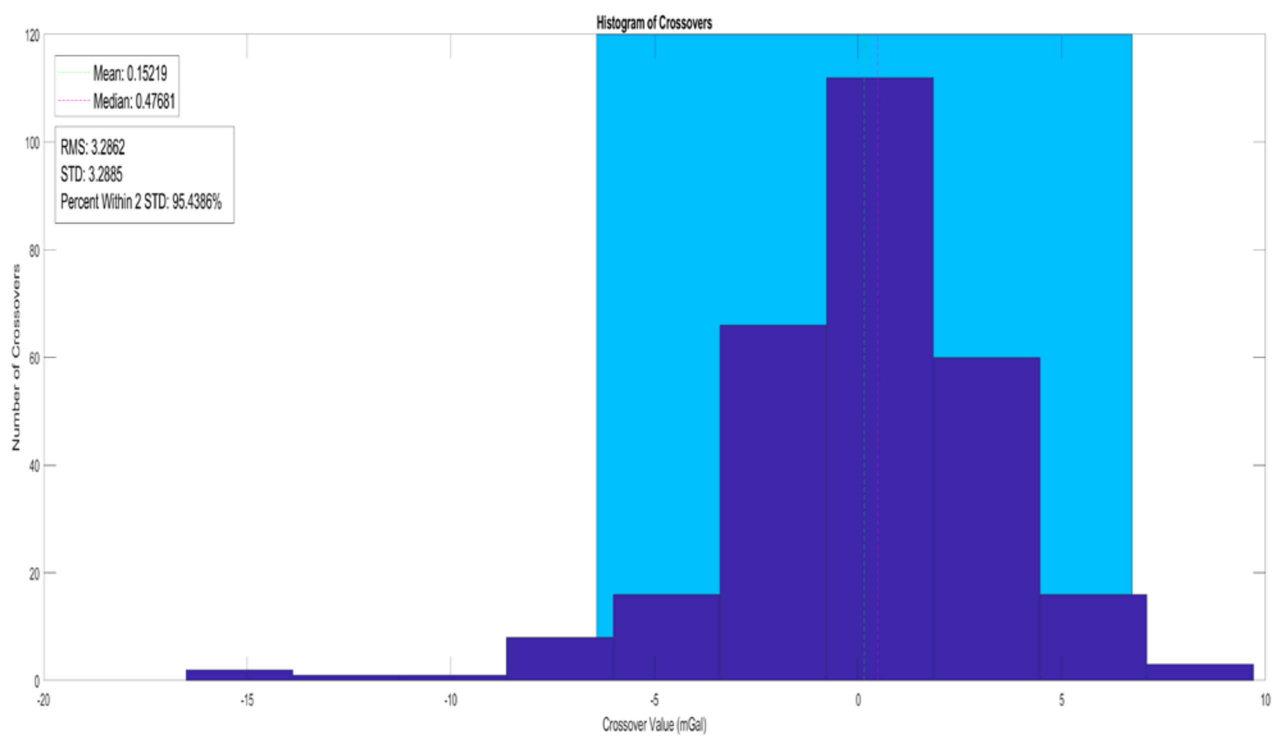


Figure 3: Crossover Residuals, Histogram, and Statistics for Block MS05.

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	2.18	-0.12
502	3.79	-1.18
503	5.67	-0.74
504	2.00	0.37
506	2.13	2.57
507	2.31	0.10
508	1.76	0.09

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
49	92.72%	7.36%

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 MS05 no lines were reflown.

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 the Newton gravity code 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 11: GPS+IMU and GPS-only Kinematic Processing Results

Survey	Flight	Rover GPS Unit	Solution Type	Elevation Mask (deg)	Line Num.	NGS Qualtiy Grade
TX15-1 AMA	1	SPAN	GPS + IMU	7.5	119	100
					120	100
	3	SPAN	GPS + IMU	5	141	100
					501	100
	4	DL-4 Plus	GPS + IMU	7.5	113	100
					114	100
	5	SPAN	GPS + IMU	5	117	100
					118	100
	6	SPAN	GPS + IMU	5	137	100
					138	100
					139	100
					140	100
TX16-2 AMA	2	SPAN	GPS + IMU	5	135	100
					136	100
	7	SPAN	GPS + IMU	7.5	133	100
					134	100
	8	SPAN	GPS + IMU	7.5	131	100
					132	100
	10	SPAN	GPS + IMU	5	129	100
					130	100
	11	SPAN	GPS + IMU	7.5	127	100
					128	100
	15	SPAN	GPS + IMU	5	125	100
					126	100
	16	SPAN	GPS + IMU	5	507	100
					508	100
	21	SPAN	GPS + IMU	5	123	100
					124	100
TX17-1 AMA	4	SPAN	GPS + IMU	5	115	100
					116	100
	10	SPAN	GPS + IMU	5	503	100
					504	100
	11	SPAN	GPS + IMU	5	502	100
CO17-1 GJT	1	SPAN	GPS + IMU	5	*103	100
					*142 (104)	100

	3	SPAN	GPS + IMU	5	*107	100
					*144 (108)	100
	4	SPAN	GPS + IMU	5	109	100
					*245 (110)	100
	5	SPAN	GPS + IMU	5	111	100
	6	SPAN	GPS + IMU	5	121	100
					*122	100
	7	SPAN	GPS + IMU	5	**110	100
					**108	100
	9	DL-4 Plus	GPS Only	5	**222	100
	10	SPAN	GPS + IMU	5	**203	100
					**204	100
	11	SPAN	GPS + IMU	5	101	100
					102	100
	12	SPAN	GPS + IMU	5	506	100
	13	SPAN	GPS + IMU	7.5	*205	100
					*243 (106)	100
	14	SPAN	GPS + IMU	5	**305	100
					**306	100
	15	SPAN	GPS + IMU	5	**207	100
	16	SPAN	GPS + IMU	7.5	312	100

* Eastern partial half of a line. The standard name of the line from the original flight plan is inside the parenthesis unless it is obvious.

** Western partial half of line. The standard name of the from the original flight plan is inside the parenthesis.

Table 12: Gravity Processing Results

Survey	Flight Num.	Line Num.	Time of Deleted Data	Comments
TX15-1 AMA	1	119		
		120		
	3	141		
		501		
	4	113		
		114		
	5	117		
		118		
	6	137		
		138		
		139		
		140		
TX16-2 AMA	2	135		
		136	2016-10-13 14:16:51 - 2016-10-13 14:19:43	bump removed
	7	133		
		134		
	8	131		
		132		
	10	129		
		130		
	11	127		
		128		
	15	125		
		126		
	16	507		
		508		
	21	123		
		124		
TX17-1 AMA	4	115		
		116		
	10	503		
		504	2017-02-27 00:10:29 - 2017-02-27 00:12:40	bump removed
	11	502		
CO17-1 GJT	1	*103		
		*142 (104)		
	3	*107		
		*144 (108)		

	4	109	2017-08-26 13:20:16 - 2017-08-26 13:22:52 2017-08-26 13:25:47 - 2017-08-26 13:28:58	bumps removed
		*245 (110)		
	5	111	2017-08-27 12:52:50 - 2017-08-27 12:56:27	bump removed
	6	121		
		*122		
	7	**108		
		**110	2017-08-29 14:03:17 - 2017-08-29 14:06:04	bump removed
	9	**222		
	10	**203		
		**204		
	11	101	2017-09-02 13:19:39 - 2017-09-02 13:23:34	bump removed
		102		
	12	506		
	13	*205		
		*243 (106)		
	14	**305	2017-09-08 13:13:09 - 2017-09-08 13:15:58 2017-09-08 13:20:38 - 2017-09-08 13:23:40	bumps removed
		**306	2017-09-08 14:48:26 - 2017-09-08 14:52:59 2017-09-08 15:03:56 - 2017-09-08 15:09:10	bumps removed
	15	**207		
	16	312		

* Eastern partial half of a line. The standard name of the line from the original flight plan is inside the parenthesis unless it is obvious.

** Western partial half of line. The standard name of the from the original flight plan is inside the parenthesis.

Table 13: Bias from EGM08 by Line

Survey	Flight Num.	Line	EGM08 mean
TX15-1 AMA	1	119	0.73
		120	-1.06
	3	141	0.81
		501	0.61
	4	113	1.06
		114	-1.62
	5	117	0.01
		118	-2.06
	6	137	0.49
		138	-1.87
		139	0.06
		140	-2.30
TX16-2 AMA	2	135	1.76
		136	-0.69
	7	133	0.63
		134	-0.91
	8	131	0.37
		132	-1.11
	10	129	0.41
		130	-1.59
	11	127	0.13
		128	-1.99
	15	125	0.74
		126	-1.25
	16	507	0.53
		508	0.30
	21	123	1.41
		124	-0.85
TX17-1 AMA	4	115	1.19
		116	-1.18
	10	503	-1.12
		504	-0.98
	11	502	-0.35
CO17-1 GJT	1	*103	3.04
		*142 (104)	2.84
	3	*107	2.24
		*144 (108)	1.58

	4	109	0.53
		*245 (110)	3.01
	5	111	1.60
	6	121	1.22
		*122	2.00
	7	**108	0.87
		**110	0.24
	9	**222	1.14
	10	**203	1.52
		**204	2.21
	11	101	1.48
		102	2.14
	12	506	2.39
	13	*205	1.70
		*243 (106)	2.46
	14	**305	1.94
		**306	4.01
	15	**207	1.72
	16	312	2.56

* Eastern partial half of a line. The standard name of the line from the original flight plan is inside the parenthesis unless it is obvious.

** Western partial half of line. The standard name of the from the original flight plan is inside the parenthesis.

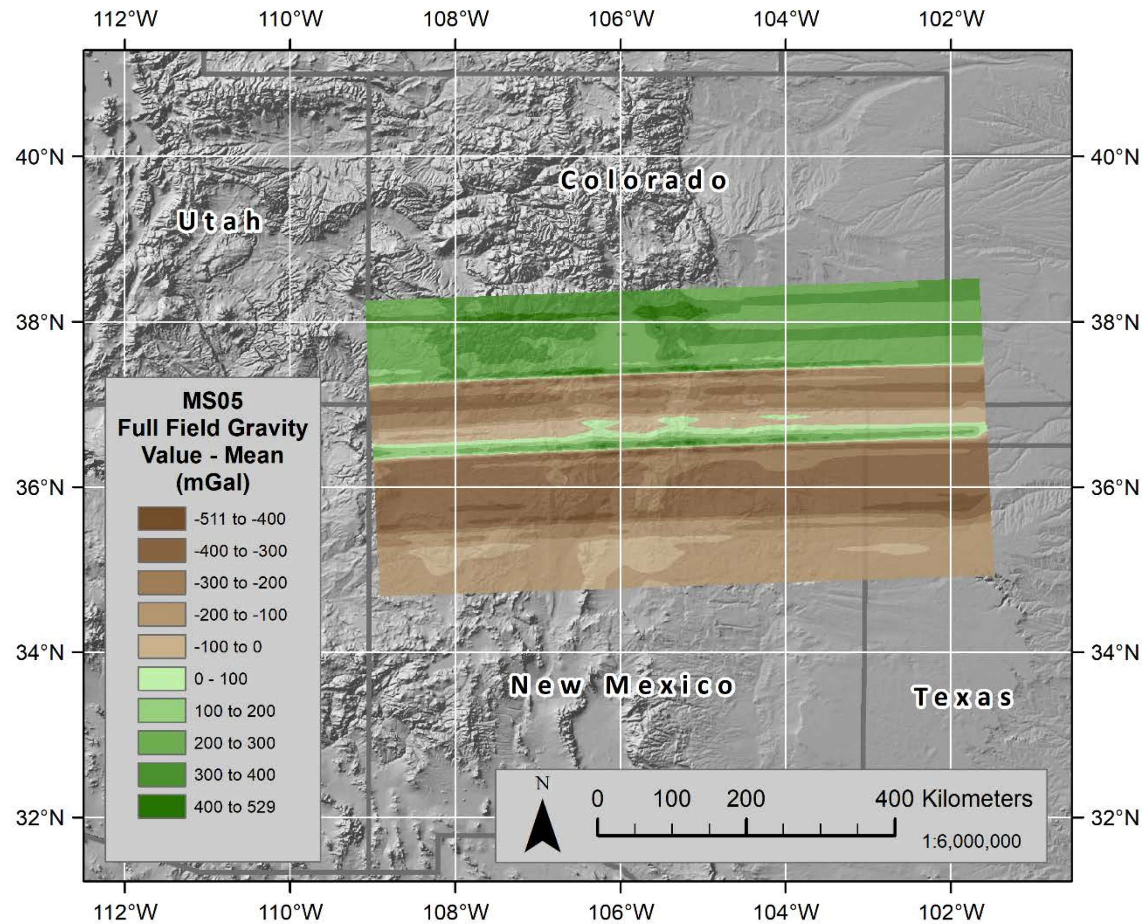


Figure 4: Full-field gravity at altitude (mean removed) for Block MS05. This is the data in the gravity release ".txt" file and includes the effects of differing altitudes along flight lines.

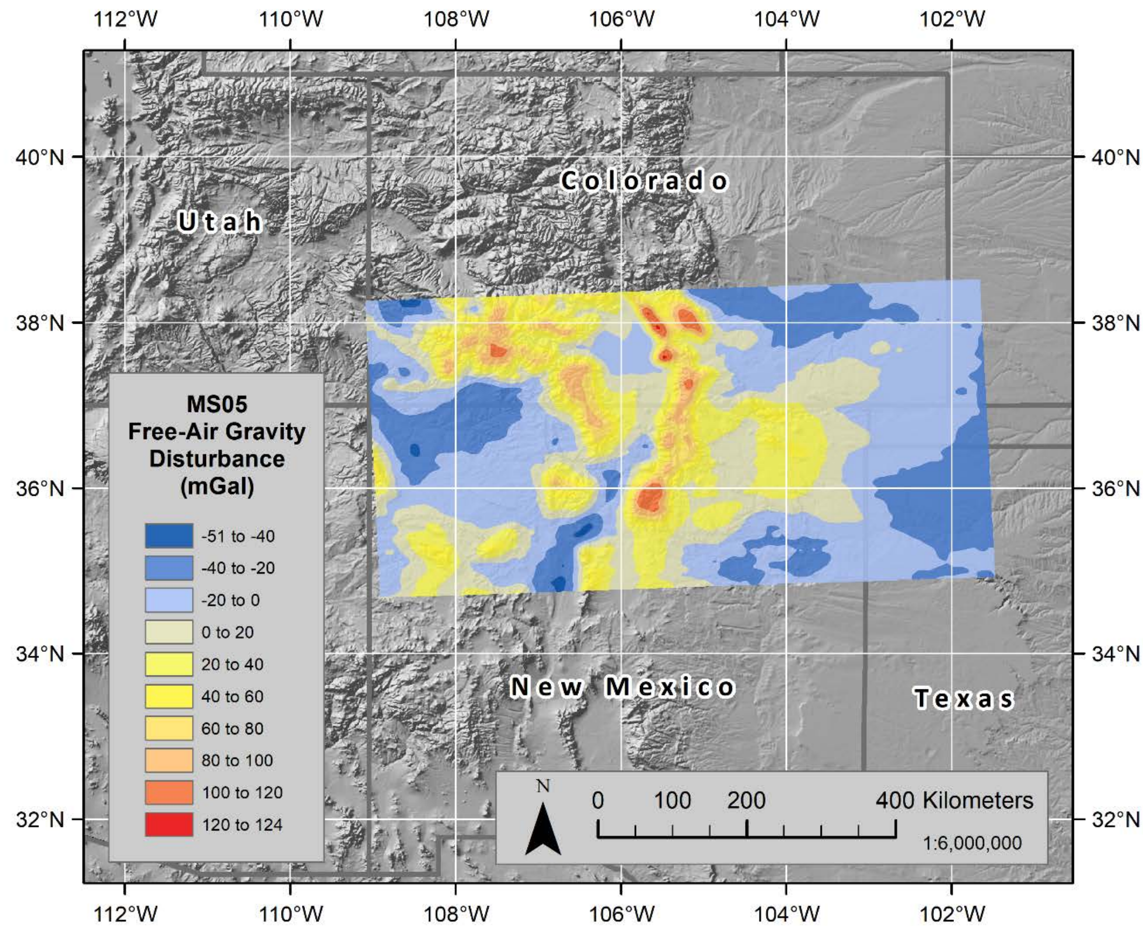


Figure 5: Free-air gravity disturbance for Block MS05 with respect to the GRS80 ellipsoid.

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 Science Team, in alphabetical order, are: Vicki A. Childers, Theresa M. Damiani, Jeff Kanney, Jeffery A. Johnson, Derek van Westrum, and Monica A. Youngman.

To reference the MS05 data file, reference the webpage:
GRAV-D Science Team (2017). "Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project, Airborne Gravity Data; Block MS05". Available *DATE*. Online at: http://www.ngs.noaa.gov/GRAV-D/data_PS02.shtml

To reference the block and survey details, reference the block user manual:
GRAV-D Science Team (2017). "Block MS05 (Mountain South 05); 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_MS05.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 Turnkey Airborne Gravity System 6 User Manual."