Block PS01 (Pacific South 01)

GRAV-D Airborne Data Release User Manual

Applies to Data Release BETA #1, 08/2019

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Version Notes

08/2019 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 **PS01** is located in the **P**acific Time Zone, in the **S**outh half (south of 40° latitude). This was the first (**01**) block of data completed in that region. Block PS01 is 440 km by 470 km, covering California and extending into the Pacific Ocean ([Figure 1](#)). The corner coordinates defining Block PS01 are listed in [Table 1](#).

Figure 1: Google Earth Image of the Location of Block PS01

Table 1: Latitude and Longitude Coordinates of Corner Points Defining Block PS01

Latitude (decimal degrees)	Longitude (decimal degrees)
37.766676455	-124.547350037
33.610083627	-121.882312372
34.058542166	-117.181464158
37.920922040	-119.421171039

2. Survey Design and Execution

Airborne gravity data in Block PS01 were collected during 7 surveys: CA11-1 (California 2011, first occupation), CA15-1 (California 2015, first occupation), CA15-2 (California 2015, second occupation), CA16-1 (California 2016, first occupation), CA17-1 (California 2017, first occupation), CA18-1 (California 2018, first occupation), and CA19-1 (California 2019, first occupation). Data lines where flown at at average of about 21,400 ft. PS01 was surveyed with three different aircraft and two 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 a map of the data coverage and data line orientation.

In PS01, data lines are north/south and cross lines are east/west. Block PS01 was originally planned with lines 101-130 in ascending order towards the west. At a later date, lines 131 – 146 were added on the eastern side of the block ascending towards the west. Figure 2 shows how this line numbering scheme is organized. The block consists of 9 data lines from CA11-1, 25 data lines from CA15-1, 9 data lines from CA15-2, 9 data lines and 1 cross line from CA16-1, 2 data lines from CA17-1, 7 data lines and 1 cross line from CA18-1, and 2 data lines and 4 cross lines from CA19-1. Eleven data lines, PS01107, PS01108, PS01109, PS01116, PS01125, PS01126, PS01131, PS01133, PS01134, PS01141, and PS01142 were flown twice with good data collected for the majority of the line each times. 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. PS01101= block PS01’s line 101).

Table 2: Survey Overview

Survey	Conducting Organization	Airport Base of Operations	Geographic Location	Survey Dates
CA11-1	NOAA-National Geodetic Survey	Sacramento McClellan Airport (MCC) Sacramento, CA FBO: McClellan Jet Services	California and coastal Pacific Ocean	January 10 – February 22, 2011
CA15-1	NOAA-National Geodetic Survey	Sacramento McClellan Airport (MCC) Sacramento, CA FBO: McClellan Jet Services	California and coastal Pacific Ocean	January 1 – February 16, 2015
CA15-2	NOAA-National Geodetic Survey	Palm Springs International Airport (PSP) Palm Springs, CA FBO: Signature Flight Support	California and coastal Pacific Ocean	October 18 – December 8, 2015
CA16-1	NOAA-National Geodetic Survey	Palm Springs International Airport (PSP) Palm Springs, CA FBO: Signature Flight Support	California and coastal Pacific Ocean	November 1 – December 15, 2016
CA17-1	NOAA-National Geodetic Survey	Palm Springs International Airport (PSP) Palm Springs, CA FBO: Signature Flight Support	California and coastal Pacific Ocean	January 21 – March 18, 2017

Survey	Conducting Organization	Airport Base of Operations	Geographic Location	Survey Dates
CA18-1	NOAA-National Geodetic Survey	Palm Springs International Airport (PSP) Palm Springs, CA FBO: Signature Flight Support (May 21 – May 31) FBO: Atlantic Aviation (June 1 – June 6)	California and coastal Pacific Ocean	May 21 – June 6, 2018
CA19-1	NOAA-National Geodetic Survey	Ontario International Airport (ONT) Ontario, CA FBO: Guardian Jet Center	California and coastal Pacific Ocean	May 14 – July 2, 2019

Table 3: Aircraft and Instrumentation

Survey	Aircraft	Engines: Number, and Type	Gravity Instrumentation	GPS Instrumentation
CA11-1	DOI Pilatus (N190PE)	1, Turboprop	Micro-g LaCoste (MGL) TAGS S-137	NovAtel DL-V3 or DL-4 Plus NovAtel SPAN-SE with Honeywell µIRS (GPS + IMU)
CA15-1	DOI Pilatus (N190PE)	1, Turboprop	Micro-g LaCoste (MGL) TAGS S-137	NovAtel DL-V3 or DL-4 Plus NovAtel SPAN-SE with Honeywell µIRS (GPS + IMU)
CA15-2	Dynamic Aviation King Air (N43U)	2, Turboprop	Micro-g LaCoste (MGL) TAGS S-161	NovAtel DL-V3 or DL-4 Plus NovAtel SPAN-SE with Honeywell µIRS (GPS + IMU)
CA16-1	Dynamic Aviation King Air (N43U)	2, Turboprop	Micro-g LaCoste (MGL) S-161	NovAtel DL-V3 or DL-4 Plus NovAtel SPAN-SE with Honeywell µIRS (GPS + IMU)
CA17-1	Dynamic Aviation King Air (N43U)	2, Turboprop	Micro-g LaCoste (MGL) S-161	NovAtel DL-V3 or DL-4 Plus NovAtel SPAN-SE with Honeywell µIRS (GPS + IMU)
CA18-1	NOAA Turbo Commander (N45RF)	2, Turboprop	Micro-g LaCoste (MGL) S-161	NovAtel DL-V3 or DL-4 Plus NovAtel SPAN-SE with Honeywell µIRS (GPS + IMU)
CA19-1	NOAA Turbo Commander (N45RF)	2, Turboprop	Micro-g LaCoste (MGL) S-161	NovAtel DL-V3 or DL-4 Plus NovAtel 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 ± 3000 ft.
Nominal Aircraft Ground Speed	250 ± 40 knots
Number of Lines Released	Data Lines: 9 (CA11-1), 25 (CA15-1), 9 (CA15-2), 9 (CA16-1), 2 (CA17-1), 7 (CA18-1), 2 (CA19-1) Cross Lines: 1 (CA16-1), 1 (CA18-1), 4 (CA19-1) Repeat Lines: 11 lines
Number of Crossovers	340

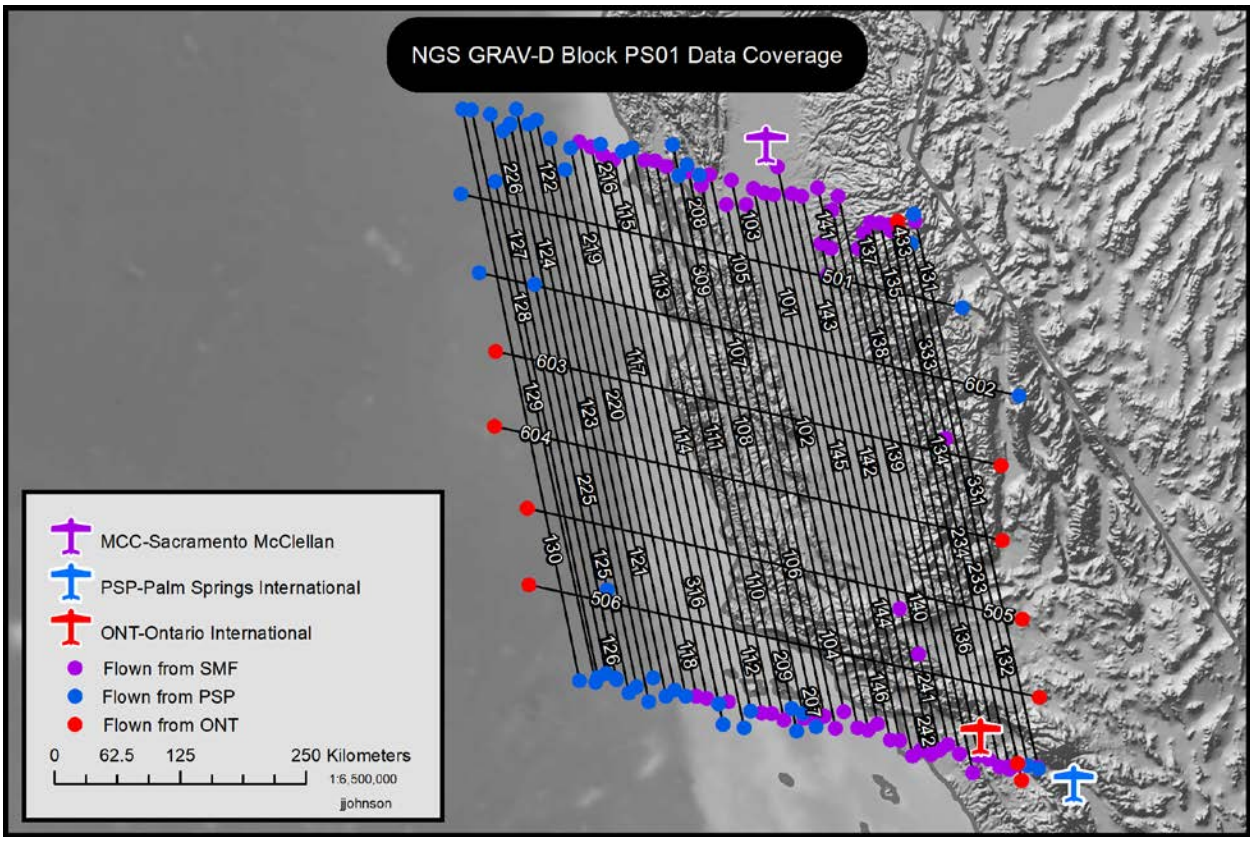

Figure 2: Data Coverage for PS01. Data lines range from 101 to 146 (101-130 on the western side and 131-146 on the eastern side). Sacramento McClellan Airport (MCC) and lines flown from there are marked with purple. Palm Springs International Airport (PSP) and lines flown from there are marked with blue. Ontario International Airport (ONT) and lines flown from there are marked in red.

2.1 GPS/IMU Instrumentation

The 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 (included as part of the Inertial Navigation System). The remote recevers on TAGS S-161 and S-137 surveys had a data rate of 1 Hz, and the remote receivers on TAGS S-211 surveys had a data rate of 20 Hz. The NovAtel SPAN-SE/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, a variety of different GPS receivers operated at either 20 Hz or 1 Hz to act as base stations. See Table 6 and Table 12 for information regarding 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 S-161 and TAGS S-137 record data at 1 Hz and have a Novatel timing unit mounted on the gravimeter. S-161 and S-137 also record a separate environmental file at about 1 Hz (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 IMU 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)
S-161 Gravimeter	-0.016	0.021	-0.503
S-137 Gravimeter	-0.011	0.036	-0.514
GNSS antenna on Dynamic Aviation King Air N43U (S-161)	-0.133	0.389	0.538
GNSS antenna on BLM Pilatus PC-12 (S-137)	0.006	0.674	0.608
GNSS antenna on NOAA Turbo Commander (S-161)	0.092	0.143	0.616

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)
CA11-1 MCC	Kinematic	NovAtel SPAN	f29, f32-f35	44, 51-53
CA11-1 MCC	Static	Ashtech Z-Extreme (EAST)	f29, f32-f35	44, 51-53
CA11-1 MCC	Static	Ashtech Z-Extreme (MIDDLE)	f29, f32-f35	44, 51-53
CA11-1 MCC	Static	Trimble R8 (WEST)	f29, f32-f35	44, 51-53
CA15-1 MCC	Kinematic	NovAtel SPAN	f01, f03-f12, f14	19, 29-34, 42, 44-48
CA15-1 MCC	Static	Ashtech Z-Extreme (EAST)	f01, f03-f12, f14	19, 29-34, 42, 44-48
CA15-1 MCC	Static	Ashtech Z-Extreme (WEST)	f01, f03-f12, f14	19, 29-34, 42, 44-48
CA15-2 PSP	Kinematic	NovAtel PP7	f01-f04, f15	291, 296, 297, 300, 318, 219
CA15-2 PSP	Static	Ashtech Z-Extreme (EAST)	f01-f04, f15	291, 296, 297, 300, 318, 219
CA15-2 PSP	Static	Ashtech Z-Extreme (WEST)	f01-f04, f15	291, 296, 297, 300, 318, 219
CA16-1 PSP	Kinematic	NovAtel	f01-f04	308-310, 314
CA16-1 PSP	Static	NovAtel PP6 (44)	f01-f04	308-310, 314
CA16-1 PSP	Static	Ashtech Z-Extreme (SOUTH)	f01-f04	308-310, 314
CA17-1 PSP	Kinematic	NovAtel SPAN	f10	74
CA17-1 PSP	Static	NovAtel PP6 (44)	f10	74
CA17-1 PSP	Static	Ashtech Z-Extreme (SOUTH)	f10	74
CA18-1 PSP	Kinematic	NovAtel SPAN	f01-f04	149, 152, 154, 155
CA18-1 PSP	Static	NovAtel PP6 (44)	f01-f04	149, 152, 154, 155
CA18-1 PSP	Static	NovAtel PP6 (85)	f01-f04	149, 152, 154, 155
CA19-1 ONT	Kinematic	NovAtel PP7	f02, f03, f08	156, 157, 166

Airport	Type	Receiver	Flight Available	Day of Year Available (UTC)
CA19-1 ONT	Static	Trimble netR9 (1)	f02, f03, f08	156, 157, 166
CA19-1 ONT	Static	Trimble netR9 (2)	f02, f03, f08	156, 157, 166

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 ±0.043 m and the average vertical position accuracy is ±0.074 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 on June 2012 (MCC, called KMCC TAGS), February 2015 (PSP, called KPSP1, TAGS), May 2018 (PSP, KPSP2 TAGS and KPSP3 TAGS), and (ONT, called KONT TAGS North). The A-10 was set up at the exact location of the aircraft. The positions were determed from the GPS data 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/ Airplane	Point ID	Latitude	Longitude	Tie height above mark (cm)	Gravity Tie (mGal)
MCC/ BLM Pilatus	KMCC TAGS	38.6596032 °N	121.3932143 °W	163.7	979985.315 ± 0.008
PSP/ Dynamic Aviation King Air (N43U)	KPSP1 TAGS City Hangar	33.8290008 °N	116.5116090 °W	162.5	979506.954 ± 0.008
PSP/ NOAA Turbo Commander	KPSP TAGS2 Signature Flight Support	33.8282444°N	116.5124302°W	80.6	979507.491 ± 0.008
PSP/ NOAA Turbo Commander	KPSP TAGS3 Atlantic Aviation	33.8226269°N	116.4961939°W	80.6	979511.102 ± 0.008
ONT/ NOAA Turbo Commander	KONT TAGS North	34.0522152°N	117.6036854°W	80.6	979529.009 ± 0.008

3.1.3 Gravity Filtering

For block PS01, 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 the confocal ellipsoid normal gravity free-air correction method 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 PS01, 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	6096	6480	340	2.65	2.65	-0.17	1.88

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.

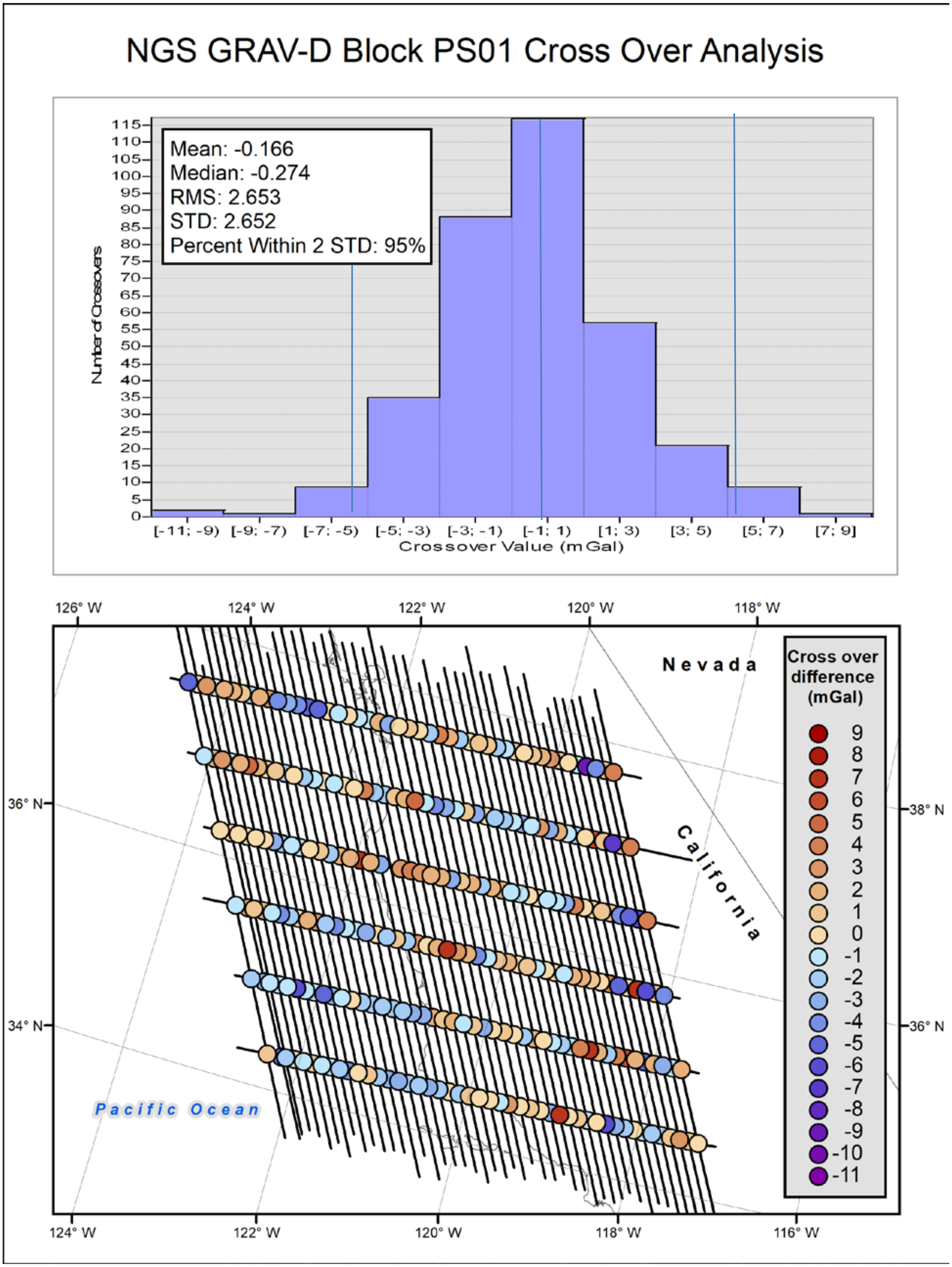

Figure 3: Crossover Residuals, Histogram, and Statistics for Block PS01

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)
PS01501	3.01	-0.60
PS01602	2.46	0.20
PS01603	2.44	0.14
PS01604	3.00	0.19
PS01505	2.70	-0.34
PS01506	2.15	-0.63

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
86	99.61%	0.39%

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 PS01, 11 data lines were re-flown as PS01107/PS01207, PS01108/PS01208, PS01209/PS01309, PS01216/PS01316, PS01125/PS01225, PS01126/PS01226, PS01131/PS01331, PS01333/PS01433, PS01134/PS01234, PS01141/PS01241, and PS01142/PS01242. Table 11 shows the correlation between these two sets of repeat lines.

Table 11: Repeat Line Correlations

Repeat Lines	Correlation
PS01107 PS01207	99.98%
PS01108 PS01208	99.99%
PS01209 PS01309	99.98%
PS01216 PS01316	99.99%
PS01125 PS01225	99.98%
PS01126 PS01226	99.97%
PS01131 PS01331	99.99%
PS01333 PS01433	99.98%
PS01134 PS01234	99.97%
PS01141 PS01241	99.98%
PS01142 PS01242	99.94%

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

Survey	Flight	Rover GPS Unit	Solution Type	Elevation Mask (deg)	Line Num.	NGS Qualtiy Grade
CA11-1	f29	SPAN	GPS + IMU	5	117	100
CA11-1	f29	SPAN	GPS + IMU	5	118	100
CA11-1	f32	SPAN	GPS + IMU	5	115	100
CA11-1	f33	SPAN	GPS + IMU	5	101	100
CA11-1	f33	SPAN	GPS + IMU	5	102	100
CA11-1	f34	SPAN	GPS + IMU	7.5	103	100
CA11-1	f34	SPAN	GPS + IMU	7.5	104	100
CA11-1	f35	SPAN	GPS + IMU	5	105	100
CA11-1	f35	SPAN	GPS + IMU	5	106	100
CA15-1	f01	SPAN	GPS + IMU	5	137	100
CA15-1	f01	SPAN	GPS + IMU	5	138	100
CA15-1	f03	SPAN	GPS + IMU	7.5	139	100
CA15-1	f03	SPAN	GPS + IMU	7.5	140	100
CA15-1	f04	SPAN	GPS + IMU	7.5	141	100
CA15-1	f04	SPAN	GPS + IMU	7.5	142	100
CA15-1	f05	SPAN	GPS + IMU	7.5	143	100
CA15-1	f05	SPAN	GPS + IMU	7.5	144	100
CA15-1	f06	SPAN	GPS + IMU	7.5	135	100
CA15-1	f06	SPAN	GPS + IMU	7.5	136	100
CA15-1	f07	SPAN	GPS + IMU	5	241	100
CA15-1	f07	SPAN	GPS + IMU	5	242	100
CA15-1	f08	SPAN	GPS + IMU	5	145	100
CA15-1	f08	SPAN	GPS + IMU	5	146	100
CA15-1	f09	SPAN	GPS + IMU	7.5	107	100
CA15-1	f09	SPAN	GPS + IMU	7.5	108	100
CA15-1	f10	SPAN	GPS + IMU	7.5	134	100
CA15-1	f11	SPAN	GPS + IMU	7.5	111	100
CA15-1	f11	SPAN	GPS + IMU	7.5	112	100
CA15-1	f12	SPAN	GPS + IMU	7.5	109	100
CA15-1	f12	SPAN	GPS + IMU	7.5	110	100
CA15-1	f12	SPAN	GPS + IMU	7.5	233	100
CA15-1	f12	SPAN	GPS + IMU	7.5	234	100
CA15-1	f14	SPAN	GPS + IMU	7.5	131	100
CA15-1	f14	SPAN	GPS + IMU	7.5	216	100
CA15-2	f01	SPAN	GPS + IMU	7.5	316	100

Survey	Flight	Rover GPS Unit	Solution Type	Elevation Mask (deg)	Line Num.	NGS Qualtiy Grade
CA15-2	f02	SPAN	GPS + IMU	7.5	127	100
CA15-2	f02	SPAN	GPS + IMU	7.5	129	100
CA15-2	f03	SPAN	GPS + IMU	7.5	128	100
CA15-2	f03	SPAN	GPS + IMU	7.5	130	100
CA15-2	f04	SPAN	GPS + IMU	7.5	125	100
CA15-2	f04	SPAN	GPS + IMU	7.5	126	100
CA15-2	f15	SPAN	GPS + IMU	7.5	123	100
CA15-2	f15	SPAN	GPS + IMU	7.5	124	100
CA16-1	f01	SPAN	GPS + IMU	5	501	100
CA16-1	f02	SPAN	GPS + IMU	5	109	100
CA16-1	f02	SPAN	GPS + IMU	5	209	100
CA16-1	f02	SPAN	GPS + IMU	5	309	100
CA16-1	f03	SPAN	GPS + IMU	5	107	100
CA16-1	f03	SPAN	GPS + IMU	5	108	100
CA16-1	f03	SPAN	GPS + IMU	5	207	100
CA16-1	f03	SPAN	GPS + IMU	5	208	100
CA16-1	f04	SPAN	GPS + IMU	5	121	100
CA16-1	f04	SPAN	GPS + IMU	5	122	100
CA17-1	f10	SPAN	GPS + IMU	5	113	100
CA17-1	f10	SPAN	GPS + IMU	5	114	100
CA18-1	f01	SPAN	GPS + IMU	7.5	132	100
CA18-1	f01	SPAN	GPS + IMU	7.5	231	100
CA18-1	f02	SPAN	GPS + IMU	5	219	100
CA18-1	f02	SPAN	GPS + IMU	5	220	100
CA18-1	f03	SPAN	GPS + IMU	5	225	100
CA18-1	f03	SPAN	GPS + IMU	5	226	100
CA18-1	f04	DLV	GPS Only	5	331	100
CA18-1	f04	DLV	GPS Only	5	602	100
CA19-1	f02	PP7	GPS + IMU	5	333	100
CA19-1	f02	PP7	GPS + IMU	5	433	100
CA19-1	f03	PP7	GPS + IMU	5	505	100
CA19-1	f03	PP7	GPS + IMU	5	506	100
CA19-1	f08	PP7	GPS + IMU	5	603	100
CA19-1	f08	PP7	GPS + IMU	5	604	100

Table 13: Gravity Processing Results

Survey				
CA15-1	f04	142	2015-01-30 23:57:12-2015-01-31 00:01:12	Bump Removed
CA15-1	f10	134	2015-02-14 03:48:40-2015-02-14 03:51:43	Bump Removed
CA15-1	f10	134	2015-02-14 04:29:33-2015-02-14 04:33:50	Bump Removed
CA15-1	f11	112	2015-02-14 23:47:40-2015-02-14 23:51:48	Bump Removed
CA15-1	f12	234	2015-02-15 18:48:50-2015-02-15 18:54:56	Bump Removed
CA19-1	f02	433	2019-06-05 08:58:50-2019-06-05 09:01:05	Bump Removed

Table 14: Bias from EGM08 by Line

Survey	Flight Num.	Line	EGM08 mean
CA11-1	f29	117	-1.29
CA11-1	f29	118	-0.35
CA11-1	f32	115	-1.42
CA11-1	f33	101	-0.04
CA11-1	f33	102	1.77
CA11-1	f34	103	0.42
CA11-1	f34	104	1.95
CA11-1	f35	105	1.22
CA11-1	f35	106	3.06
CA15-1	f01	137	0.17
CA15-1	f01	138	0.89
CA15-1	f03	139	-0.18
CA15-1	f03	140	2.18
CA15-1	f04	141	0.51
CA15-1	f04	142	1.16
CA15-1	f05	143	-1.31
CA15-1	f05	144	0.43
CA15-1	f06	135	-1.13
CA15-1	f06	136	0.99
CA15-1	f07	241	-0.73
CA15-1	f07	242	0.8
CA15-1	f08	145	-0.72
CA15-1	f08	146	0.24

Survey	Flight Num.	Line	EGM08 mean
CA15-1	f09	107	1.31
CA15-1	f09	108	1.88
CA15-1	f10	134	0.6
CA15-1	f11	111	-0.62
CA15-1	f11	112	-0.23
CA15-1	f12	109	-0.4
CA15-1	f12	110	0.89
CA15-1	f12	233	-1.79
CA15-1	f12	234	0.26
CA15-1	f14	131	-0.24
CA15-1	f14	216	-2.17
CA15-2	f01	316	1.13
CA15-2	f02	127	1.82
CA15-2	f02	129	1.64
CA15-2	f03	128	-0.38
CA15-2	f03	130	1.17
CA15-2	f04	125	-0.06
CA15-2	f04	126	-2.56
CA15-2	f15	123	1.02
CA15-2	f15	124	0.24
CA16-1	f01	501	2.33
CA16-1	f02	109	2.96
CA16-1	f02	209	3.45
CA16-1	f02	309	3.45
CA16-1	f03	107	1.5
CA16-1	f03	108	0.13
CA16-1	f03	207	1.5
CA16-1	f03	208	0.13
CA16-1	f04	121	1.53
CA16-1	f04	122	1.15
CA17-1	f10	113	-0.14
CA17-1	f10	114	0.82
CA18-1	f01	132	1.58
CA18-1	f01	231	1.91
CA18-1	f02	219	0.7
CA18-1	f02	220	0.23
CA18-1	f03	225	2.74
CA18-1	f03	226	0.54
CA18-1	f04	331	1.19

Survey	Flight Num.	Line	EGM08 mean
CA18-1	f04	602	0.79
CA19-1	f02	333	4.2
CA19-1	f02	433	4.49
CA19-1	f03	505	1.5
CA19-1	f03	506	0.09
CA19-1	f08	603	3.96
CA19-1	f08	604	2.39

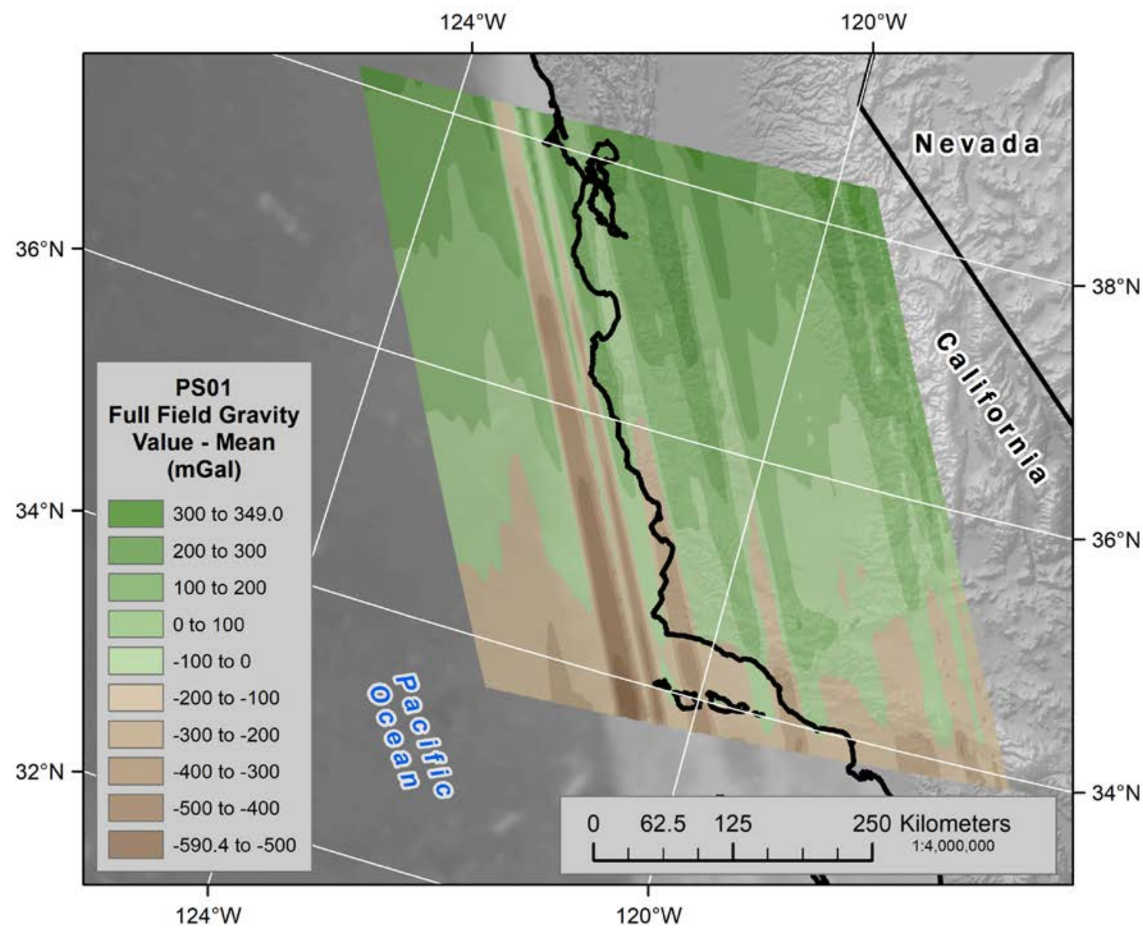

Figure 4: Full-field gravity at altitude (mean removed) for Block PS01. This is the data in the gravity release ".txt" file and includes the effects of differing altitudes along flight lines.

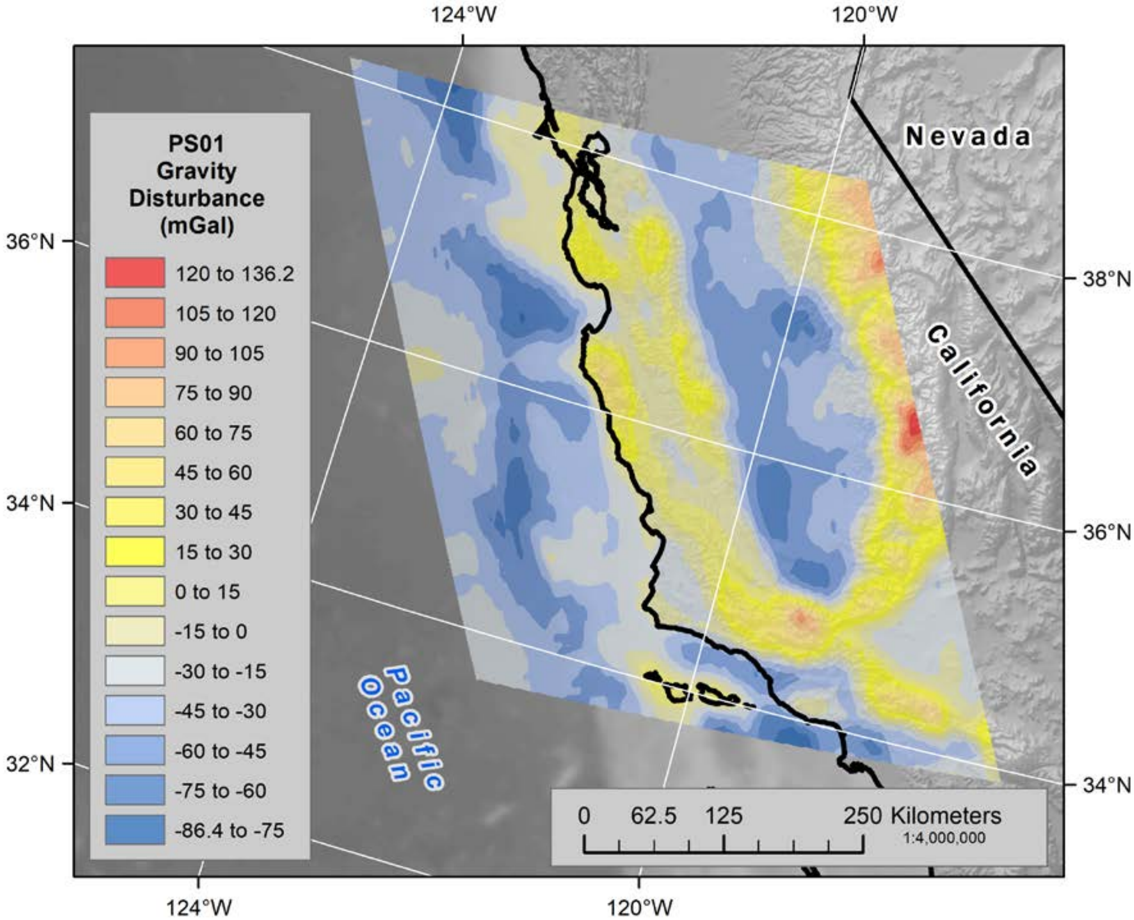

Figure 5: Gravity disturbance for Block PS01 with respect to the GRS80 ellipsoid. Calculated with the confocal ellipsoid method of calculating normal gravity.

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 Damiani, Jeff Kanney, Jeffery Johnson, Chris Villarreal, Derek van Westrum, and Monica Youngman.

To reference the PS01 data file, reference the webpage:
GRAV-D Science Team (2019). “Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project, Airborne Gravity Data; Block PS01”. Available *DATE*. Online at: http://www.ngs.noaa.gov/GRAV-D/data_PS01.shtml

To reference the block and survey details, reference the block user manual:
GRAV-D Science Team (2019). “Block PS01 (Pacific South 01); GRAV-D Airborne Gravity Data User Manual.” Jeffery A. Johnson, ed. Version BETA. Available *DATE*. Online at: http://www.ngs.noaa.gov/GRAV-D/data_PS01.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.”