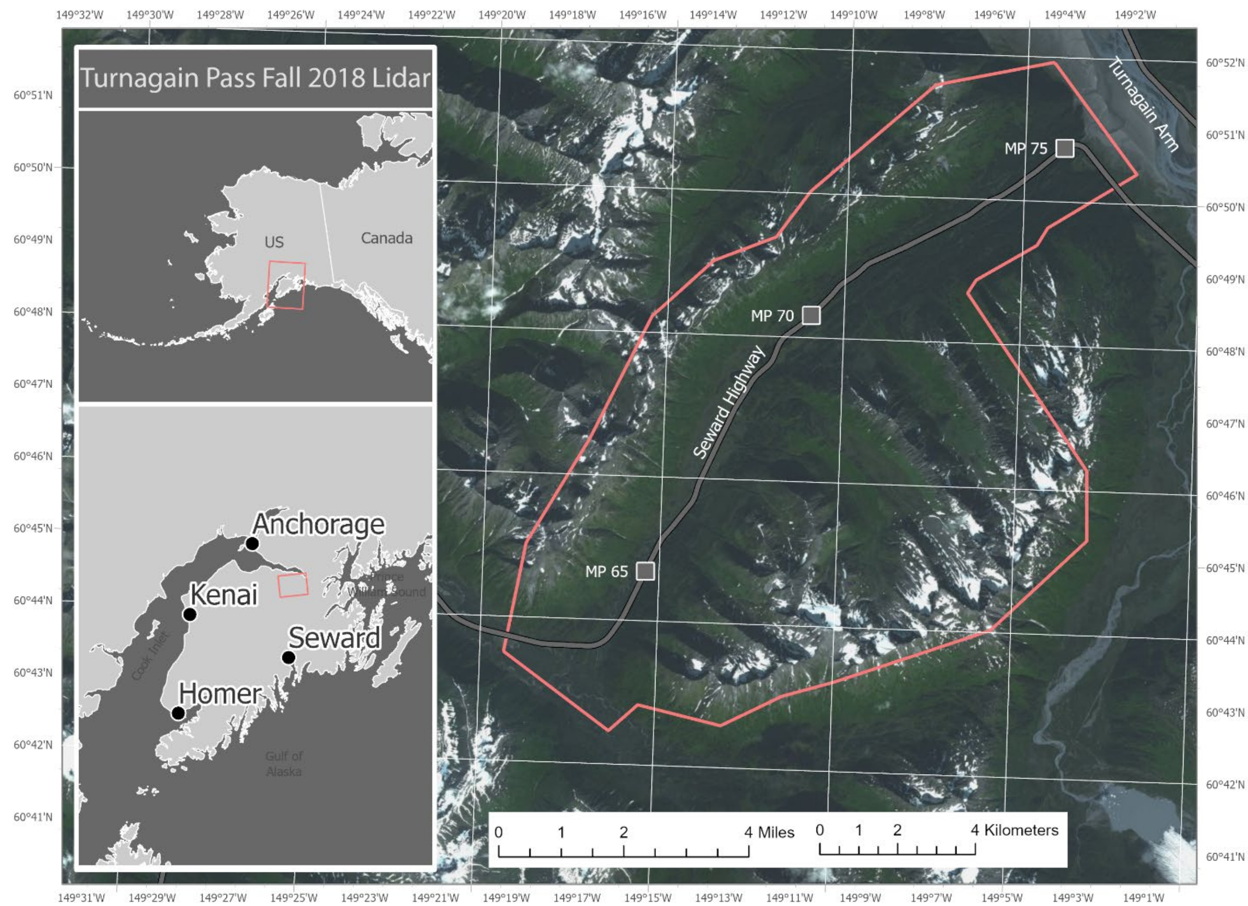
LIDAR-DERIVED ELEVATION DATA FOR TURNAGAIN PASS, SOUTHCENTRAL ALASKA, SEPTEMBER 2, 2018

Katreen Wikstrom Jones, Gabriel J. Wolken, Ronald P. Daanen, and Andrew M. Herbst

Raw Data File 2020-16



Location map of survey area with ortho-image base layer.

This report has not been reviewed for technical content or for conformity to the editorial standards of DGGS.

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DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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LIDAR-DERIVED ELEVATION DATA FOR TURNAGAIN PASS, SOUTHCENTRAL ALASKA, SEPTEMBER 2, 2018

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ABSTRACT

The State of Alaska Division of Geological & Geophysical Surveys (DGGS) used lidar to produce a digital terrain model (DTM) and digital surface model (DSM) of Turnagain Pass, southcentral Alaska, during snow-free ground conditions. The lidar and Global Navigation Satellite System (GNSS) data were collected on September 2, 2018, and processed using Terrasolid. This data collection is being released as a Raw Data File with an open end-user license. All files can be downloaded from the DGGS website at https://doi.org/10.14509/30567.

INTRODUCTION

The goal of the survey is to provide snow-free surface elevations for deriving snow depth distribution models with repeat surveys during snow-covered surface conditions. This data release is one of a series of DGGS publications to present elevation data.

LIST OF DELIVERABLES

Classified Points

DSM and DTM

Intensity Image

Metadata

MISSION PLAN

Airborne Survey Details

This dataset includes point cloud data, a 32-bit digital terrain model and digital surface model, and an intensity image covering Turnagain Pass located southeast of Anchorage within the Chugach National Forest on the Kenai Peninsula in southcentral Alaska. This lidar survey was flown at an average elevation of 200 m above ground level and a ground speed of approximately 40 meters per second with a fixed-wing Cessna 180. Elevation data were acquired with a Riegl VUX1-LR laser scanner integrated with a GNSS and Northrop Grumman IMU system. The integration was designed by Phoenix LiDAR systems. Lidar data were acquired at a pulse rate ranging from 50,000 pulses per second in the alpine areas to 400,000 pulses per second over forested areas, a scan rate of 200 revolutions per second, and a scan angle range of 80–280 degrees.

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The total area surveyed was approximately 60 mi² (160 km²). This data release is complete and there is no over collect, except for the aircraft turns that were eliminated from the dataset. There are a few areas where data coverage is limited due to laser range exceedance, which is related to the slow response of the fixed wing aircraft to the fast elevation change along the flight path (e.g., in canyons) (fig. 1).

Weather Conditions and Flight Times

The lidar data were collected on September 2, 2018. The sky was clear. No abnormalities were observed during the flights.

Lidar Point Cloud Details

The ground-classified point cloud from which the DTM was derived has an average point spacing of 43 cm (43 cm on the ground in open alpine areas and 32 cm below dense vegetation in the valley) and an average point density of 2.3 points per square meter (fig. 2). The point cloud that was used to generate the DSM (which includes points classified as grounds, and low, medium, and high vegetation), has a point spacing of 20 cm and a point density of 5 points per square meter.

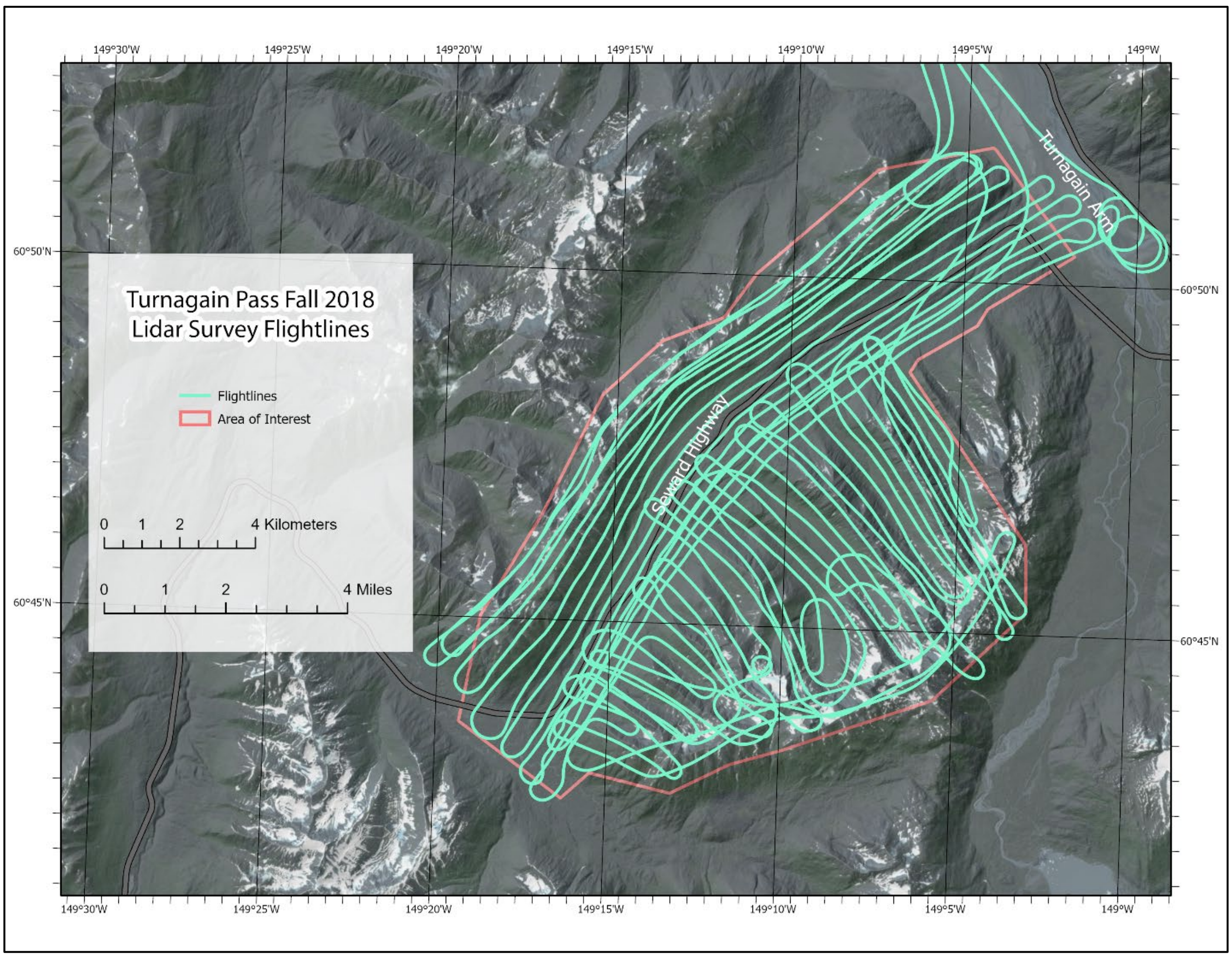

Figure 1. Project flightlines.

PROCESSING REPORT

Lidar Dataset Processing

Raw data were processed using Terrasolid software to produce integrated files for navigation correction and a point cloud for calibration. The navigation was corrected using Inertial Explorer software, where the GNSS and IMU data are integrated to establish correct flight path and orientation of the lidar sensor.

Internal consistency of the dataset was improved by calibrating the point cloud data using global, flight line, and fluctuation (within individual flightlines) tielines in Terrasolid software. The point cloud was classified for ground points as well as low, medium, and high vegetation (0.01–0.5 m, 0.5–3 m, and 3–60 m heights above the ground, respectively, in accordance with ASPRS lidar classification codes). Some manual processing was required to eliminate erratically placed points and misclassified ground points. All low points and air points were eliminated from the dataset.

A LAS dataset was created in ArcMAP, from which a 50 cm DTM, DSM, and intensity image were produced. The DTM was derived from elevation values of ground-classified points only, and built using the binning technique of minimum elevation and linear void fill. The DSM was derived from elevation values from first returns from all point classes, and built using the binning technique of average elevation values and linear void fill. The intensity image was derived from intensity values of first return points.

Digital Terrain Model

The DTM represents elevations of ground surfaces, excluding vegetation, bridges, buildings, etc. The DTM is a single-band, 32-bit float GeoTIFF file, with a ground sample distance of 50 cm. No Data value is set to -3.40282306074e+038.

Digital Surface Model

The DSM represents surface elevations, for example heights of vegetation, buildings, bridges, etc. The DSM is a single band, 32-bit GeoTIFF file, with a ground sample distance of 50 cm. No Data value is set to -3.40282306074e+038.

Intensity Image

The intensity image represents the return strengths of the first return laser pulses. The intensity image is a single band, 32-bit GeoTIFF file, with a ground sample distance of 50 centimeter and normalized to the 0-255 range. No Data value is set to -3.40282306074e+038.

SURVEY REPORT

Ground Survey Details

Ground control and check points were collected on September 2, 2018. A Trimble R7 GNSS receiver with Zephyr-2 antenna was deployed near the center of the study area and provided a base station occupation and real-time kinematic (RTK) corrections to points surveyed with a rover Trimble R8-4 GNSS receiver (internal antenna). 78 total ground control points and check points were collected to be used for calibration and assessment of the vertical accuracy of the point cloud. All points were collected on a paved road surface.

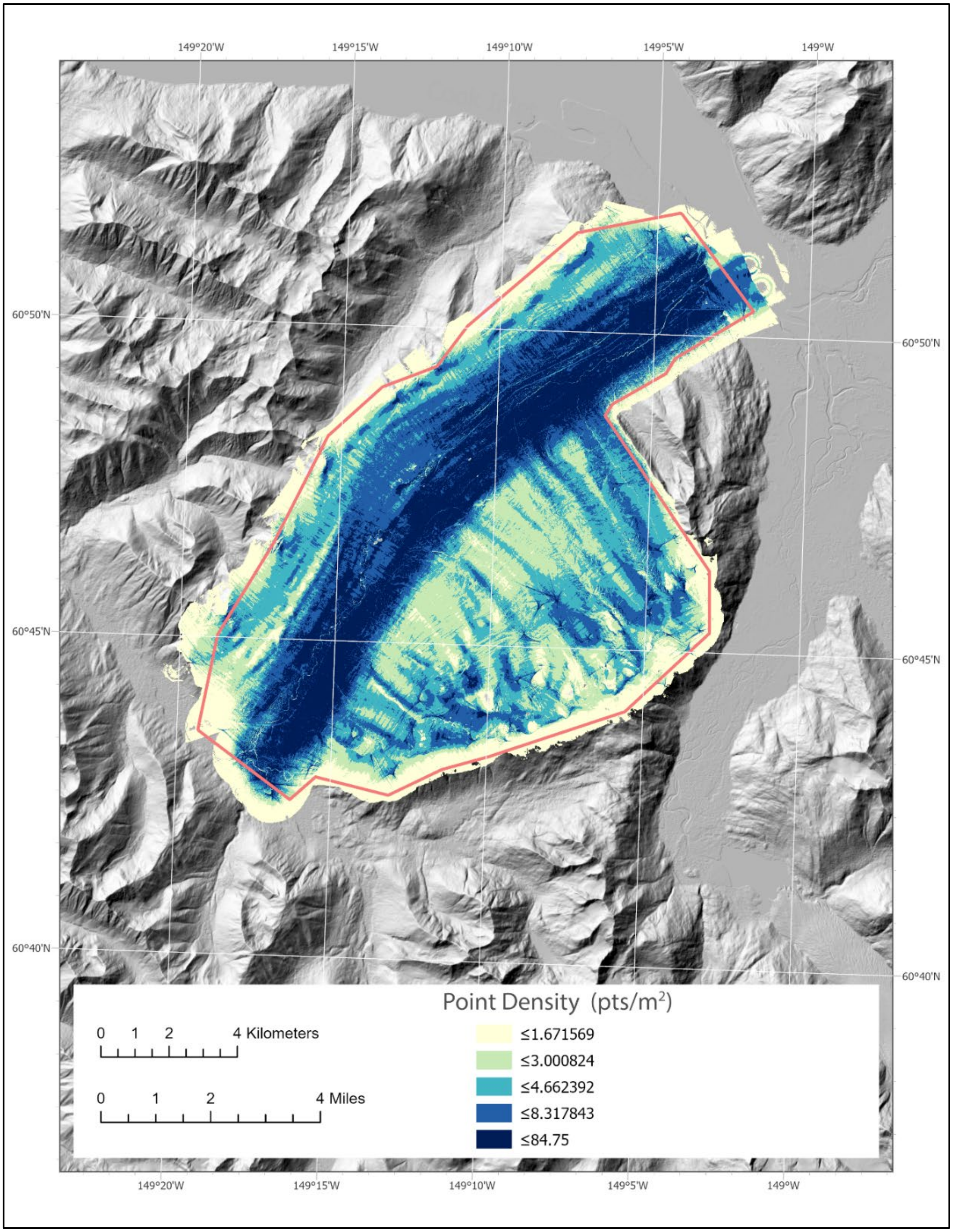

Figure 2. Ground point density displayed as 1-meter raster for the survey.

Coordinate system and Datum

All data were processed and delivered in NAD83 (2011) UTM6N and vertical datum NAVD88 with a geoid correction following the latest GEOID12B for Alaska.

Vertical Accuracy

The elevation values of 62 ground control points were compared with the elevation values of the lidar points classified as ground points. The average vertical offset was corrected with a z-transformation. 15 check points were used to determine the final accuracy of the z-transformed lidar point cloud. The lidar point cloud had a vertical offset of +2.2 cm (root mean squared error [RMSE] 3.6 cm) compared to ground control, therefore a vertical transformation of -2.2 cm was applied to the lidar point cloud (appendix 1). The final accuracy assessment showed a mean vertical offset of -0.3 cm and RMSE of 3.3 cm (appendix 2). Relative accuracy for this dataset was evaluated as the interswath overlap consistency and was measured at 1.2 cm RMSE.

ACKNOWLEDGMENTS

These data products were funded by U.S. Geological Surveys and Alaska Department of Natural Resources, Division of Geological & Geophysical Surveys. We thank Clearwater Air for their aviation expertise and contribution to these data products.

APPENDIX 1: GROUND CONTROL POINTS

Number	Easting (m)	Northing (m)	Known Z (m)	Laser Z (m)	Dz (m)
1	379278.224	6740620.077	291.995	292.03	0.04
2	379250.008	6740563.274	290.647	290.66	0.01
3	379220.714	6740502.224	289.221	289.24	0.02
4	379160.19	6740384.617	286.252	286.28	0.03
5	379102.752	6740265	284.396	284.41	0.01
6	379046.551	6740155.735	283.986	284.01	0.02
7	379006.714	6740073.262	284.295	284.30	0.01
8	378915.716	6739889.098	285.193	285.23	0.04
9	378914.119	6739904.678	285.109	285.14	0.03
10	378951.303	6739985.044	284.75	284.74	-0.01
11	378983.971	6740055.846	284.427	284.43	0.00
12	379062.544	6740225.849	284.048	284.04	-0.01
13	379076.448	6740256.109	284.244	284.22	-0.02
14	379106.389	6740319.061	284.927	284.90	-0.03
15	379131.278	6740371.021	285.795	285.81	0.02
16	379185.769	6740484.51	288.549	288.58	0.03
17	379212.339	6740539.647	290.257	290.25	-0.01
18	379244.158	6740605.541	292.234	292.22	-0.01
19	379271.682	6740658.826	293.598	293.61	0.01
20	379306.985	6740721.494	295.273	295.27	0.00
21	379328.52	6740756.893	296.172	296.19	0.02
22	379349.382	6740790.711	296.884	296.92	0.04
23	379377.048	6740835.399	297.82	297.85	0.03
24	379434.273	6740927.745	300.321	300.37	0.05
25	379454.098	6740959.727	301.106	301.12	0.01
26	379465.702	6740954.012	301.273	301.30	0.03
27	379459.433	6740930.024	300.626	300.65	0.02
28	379423.929	6740872.874	299.1	299.13	0.03
29	379399.918	6740834.243	298.069	298.09	0.02
30	379385.756	6740811.446	297.377	297.41	0.03
31	379347.656	6740750.2	295.666	295.69	0.02
32	379301.411	6740669.963	293.433	293.41	-0.02
33	377190.656	6736921.804	243.428	243.44	0.01
34	377188.078	6736904.201	243.179	243.24	0.06
35	377179.891	6736859.998	242.387	242.40	0.01
36	377154.62	6736808.988	241.308	241.36	0.05
37	377134.148	6736766.343	240.402	240.45	0.05
38	377113.185	6736722.282	239.426	239.48	0.05
39	377102.06	6736698.809	238.945	239.01	0.07
40	377070.54	6736660.05	238.014	238.06	0.05

Number	Easting (m)	Northing (m)	Known Z (m)	Laser Z (m)	Dz (m)
41	377096.884	6736709.022	239.075	239.15	0.08
42	377120.642	6736756.862	240.115	240.15	0.04
43	377143.424	6736802.815	241.097	241.13	0.03
44	377180.458	6736877.464	242.688	242.72	0.03
45	380326.304	6742081.355	318.691	318.60	-0.09
46	380337.023	6742110.258	318.668	318.62	-0.05
47	380354.521	6742155.551	318.397	318.45	0.05
48	380382.777	6742228.147	317.628	317.68	0.05
49	380445.075	6742368.69	314.73	314.76	0.03
50	380462.321	6742397.666	313.76	313.77	0.01
51	380531.5	6742490.28	309.915	309.96	0.05
52	380559.075	6742519.781	308.551	308.57	0.02
53	380633.272	6742570.691	306.165	306.22	0.06
54	380667.649	6742595.905	305.55	305.56	0.01
55	380688.072	6742610.637	305.288	305.31	0.02
56	380726.808	6742638.603	304.959	304.97	0.01
57	380747.201	6742653.328	304.769	304.79	0.02
58	380766.291	6742667.105	304.655	304.67	0.02
59	380785.993	6742681.365	304.501	304.50	0.00
60	380647.935	6742581.681	305.887	305.93	0.04
61	380591.485	6742535.625	307.334	307.36	0.03
62	380464.996	6742381.077	313.848	313.93	0.08
Average dz (m)	0.022				
Minimum dz (m)	-0.091				
Maximum dz (m)	0.082				
Average magnitude (m)	0.030				
Root mean square error (m)	0.036				
Standard deviation (m)	0.029				

APPENDIX 2: CHECK POINTS

Number	Easting (m)	Northing (m)	Known Z (m)	Laser Z (m)	Dz (m)
1	379202.3	6740465	288.254	288.26	0.006
2	378952.6	6739963	284.814	284.79	-0.024
3	379016	6740125	284.119	284.11	-0.009
4	379159.6	6740430	287.129	287.12	-0.009
5	379294.1	6740699	294.683	294.65	-0.033
6	379406.9	6740884	299.153	299.15	-0.003
7	379447.5	6740911	300.158	300.17	0.012
8	379316.6	6740698	294.267	294.18	-0.087
9	377165.8	6736832	241.765	241.81	0.045
10	377082.4	6736657	238.052	238.08	0.028
11	377163.8	6736844	241.938	241.97	0.032
12	380374.7	6742207	317.888	317.93	0.042
13	380542.5	6742503	309.316	309.3	-0.016
14	380707	6742624	305.163	305.17	0.007
15	380805.9	6742696	304.421	304.39	-0.031
Average dz (m)	-0.003				
Minimum dz (m)	-0.087				
Maximum dz (m)	0.045				
Average magnitude (m)	0.026				
Root mean square error (m)	0.033				
Standard deviation (m)	0.034				