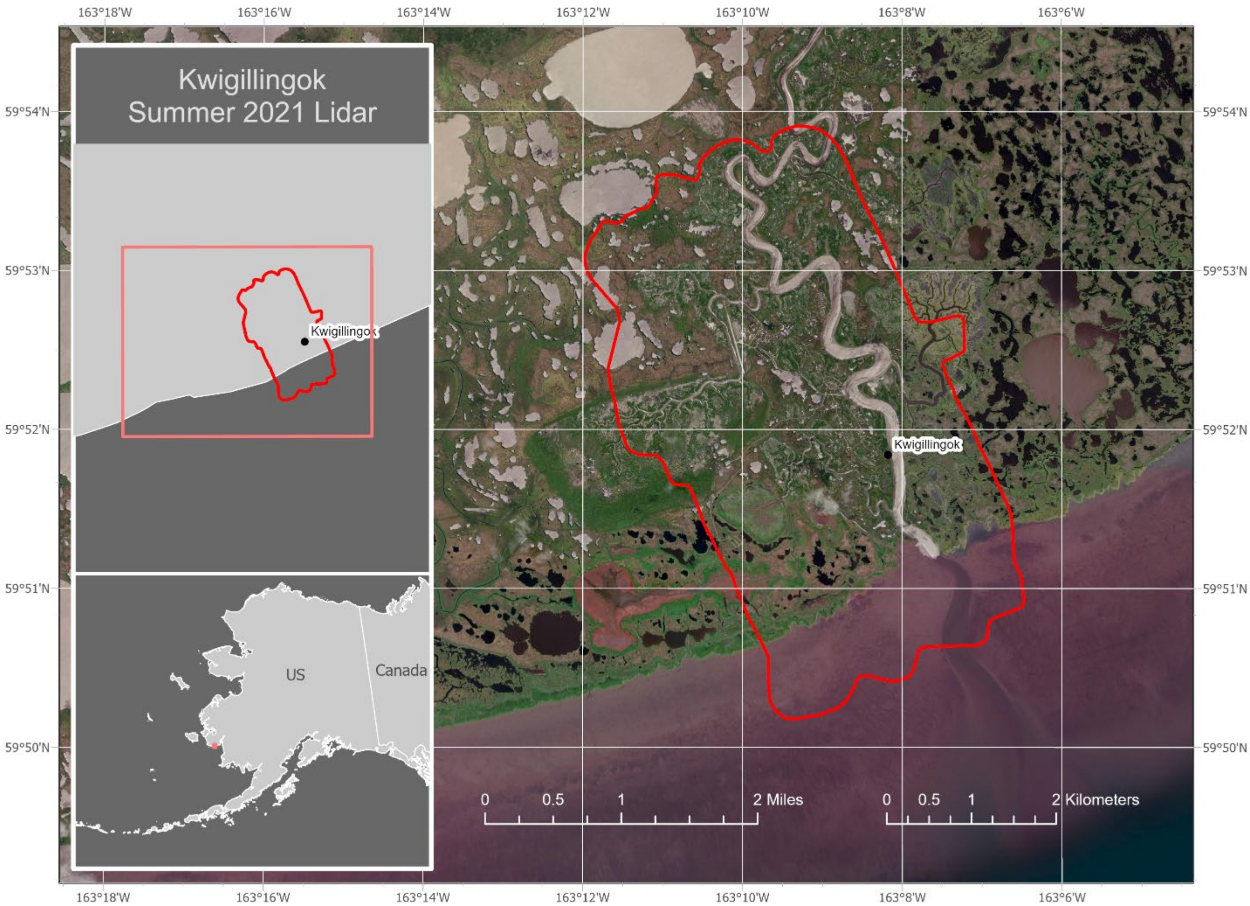
LIDAR-DERIVED ELEVATION DATA FOR KWIGILLINGOK, SOUTHWEST ALASKA, COLLECTED AUGUST 18, 2021

Jenna M. Zechmann, Andrew M. Herbst, and Richard M. Buzard

Raw Data File 2023-19



Location map of survey area with orthometric image.

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

2023
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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Suggested citation:
Zechmann, J.M., Herbst A.M, and Buzard, R.M., 2023, Lidar-derived elevation data for Kwigillingok, Southwest Alaska, collected August 18, 2021: Alaska Division of Geological & Geophysical Surveys Raw Data File 2023-19. https://doi.org/10.14509/31035

LIDAR-DERIVED ELEVATION DATA FOR KWIGILLINGOK, SOUTHWEST ALASKA, COLLECTED AUGUST 18, 2021

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INTRODUCTION

The Alaska Division of Geological & Geophysical Surveys (DGGS) used aerial lidar to produce a classified point cloud, digital surface model (DSM), digital terrain model (DTM), and intensity model of Kwigillingok, Southwest Alaska (cover figure) during leaf-on ground conditions. The survey provides snow-free surface elevation data for assessing coastal erosion and flooding hazards. Ground control data and aerial lidar data were collected on August 18, 2021, and subsequently processed using a suite of geospatial processing software. This data collection is released as a Raw Data File with an open end-user license. All files are available at https://doi.org/10.14509/31035.

LIST OF DELIVERABLES

Classified Points
DSM and DTM
Intensity Image
Metadata

MISSION PLAN

Aerial Lidar Survey Details

DGGS used a Riegl VUX1-LR laser scanner integrated with a global navigation satellite system (GNSS) and Northrop Grumman LN-200C inertial measurement unit (IMU). The lidar integration system was designed by Phoenix LiDAR Systems. The sensor can collect up to 820,000 points per second at a range of up to 150 m. The scanner operated with a pulse refresh rate of 400,000 pulses per second at a scan rate of 200 lines per second. We used a Cessna 180 fixed-wing platform to survey from an elevation of ~200 m above ground level, at a ground speed of ~40 m/s, and with a scan angle set from 80 to 280 degrees. The total survey area covers ~21 km^2 (cover figure).

Weather Conditions and Flight Times

We flew the aerial survey on August 18, 2021, departing at 5:20 pm from Kwigillingok, Alaska Airport, and landing back at Kwigillingok at 6:10 pm (fig. 1). The weather throughout the survey was clear with no wind.

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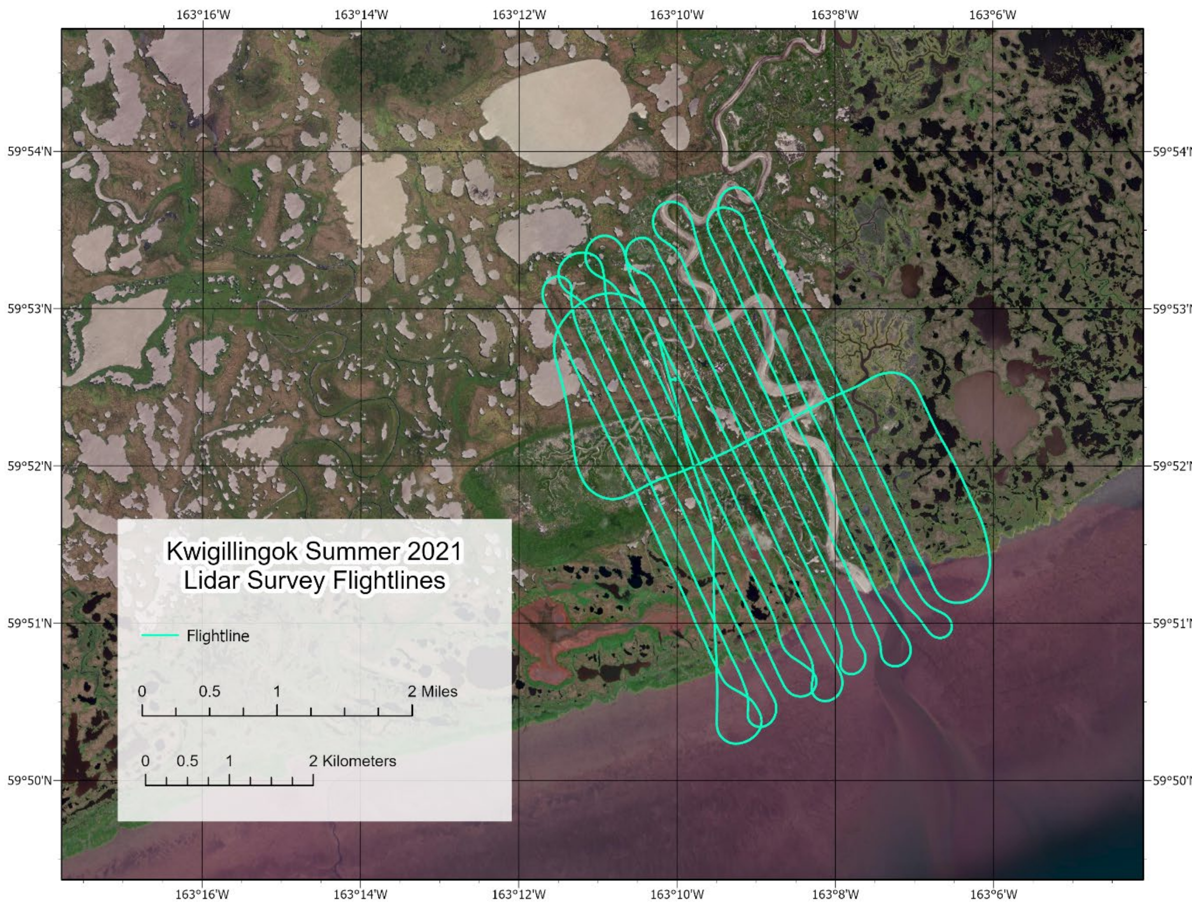

Figure 1. Lidar data collection flightlines.

PROCESSING REPORT

Lidar Dataset Processing

We processed point data in SDCimport software for initial filtering and multiple-time-around (MTA) disambiguation. MTA errors, corrected in this process, result from ambiguous interpretations of received pulse time intervals and occur more frequently with higher pulse refresh rates. We processed IMU and GNSS data in Inertial Explorer, and we used Spatial Explorer software to integrate flightline information with the point cloud. We calibrated the point data at an incrementally precise scale of sensor movement and behavior, incorporating sensor velocity, roll, pitch, and yaw fluctuations throughout the survey.

We created macros in Terrasolid software and classified points following American Society for Photogrammetry and Remote Sensing (ASPRS) 2019 guidelines. Once classified, we applied a geometric transformation and converted the points from ellipsoidal heights to GEOID12B (Alaska) orthometric heights.

We used ArcGIS Pro to derive raster products from the point cloud. The DSM was interpolated from maximum return values from the ground, vegetation, bridge deck, and building classes using a binning method. The DTM was interpolated from all ground class returns also using a binning method and minimum values. In ArcGIS Pro, we produced an intensity image by binning and averaging ground, vegetation, building, and bridge deck classes.

Classified Point Cloud

Classified point cloud data are provided in compressed LAZ format. Data are classified following ASPRS 2019 guidelines (table 1) and contain return and intensity information. The average ground point spacing is 37.6 cm, and the average density is 7.09 pts/m^2.

Table 1. Point cloud class code definitions.

Class Code	Description
1	Unclassified
2	Ground
3	Low Vegetation (>0.05, ≤0.2 meters above the ground)
4	Medium Vegetation (>0.2, ≤3 meters above the ground)
5	High Vegetation (>3, ≤40 meters above the ground)
6	Building
7	Low Noise
17	Bridge Deck
18	High Noise

Digital Surface Model

The DSM represents surface elevations, including heights of vegetation, buildings, powerlines, etc. The DSM is a single-band, 32-bit GeoTIFF file of 50-centimeter resolution. No Data value is set to -3.40282306074e+38 (32-bit, floating-point minimum).

Digital Terrain Model

The DTM represents bare earth elevations, excluding vegetation, bridges, buildings, etc. The DTM is a single-band, 32-bit float GeoTIFF file of 50-centimeter resolution. No Data value is set to -3.40282306074e+38.

Lidar Intensity Image

The lidar intensity image depicts the relative amplitude of reflected signals contributing to the point cloud. Lidar intensity is primarily a function of scanned object reflectance in relation to the signal frequency, is dependent on ambient conditions, and is not necessarily consistent between separate scans. The intensity image is a single-band, 32-bit float GeoTIFF file of 1-meter resolution. No Data value is set to -3.40282306074e+38.

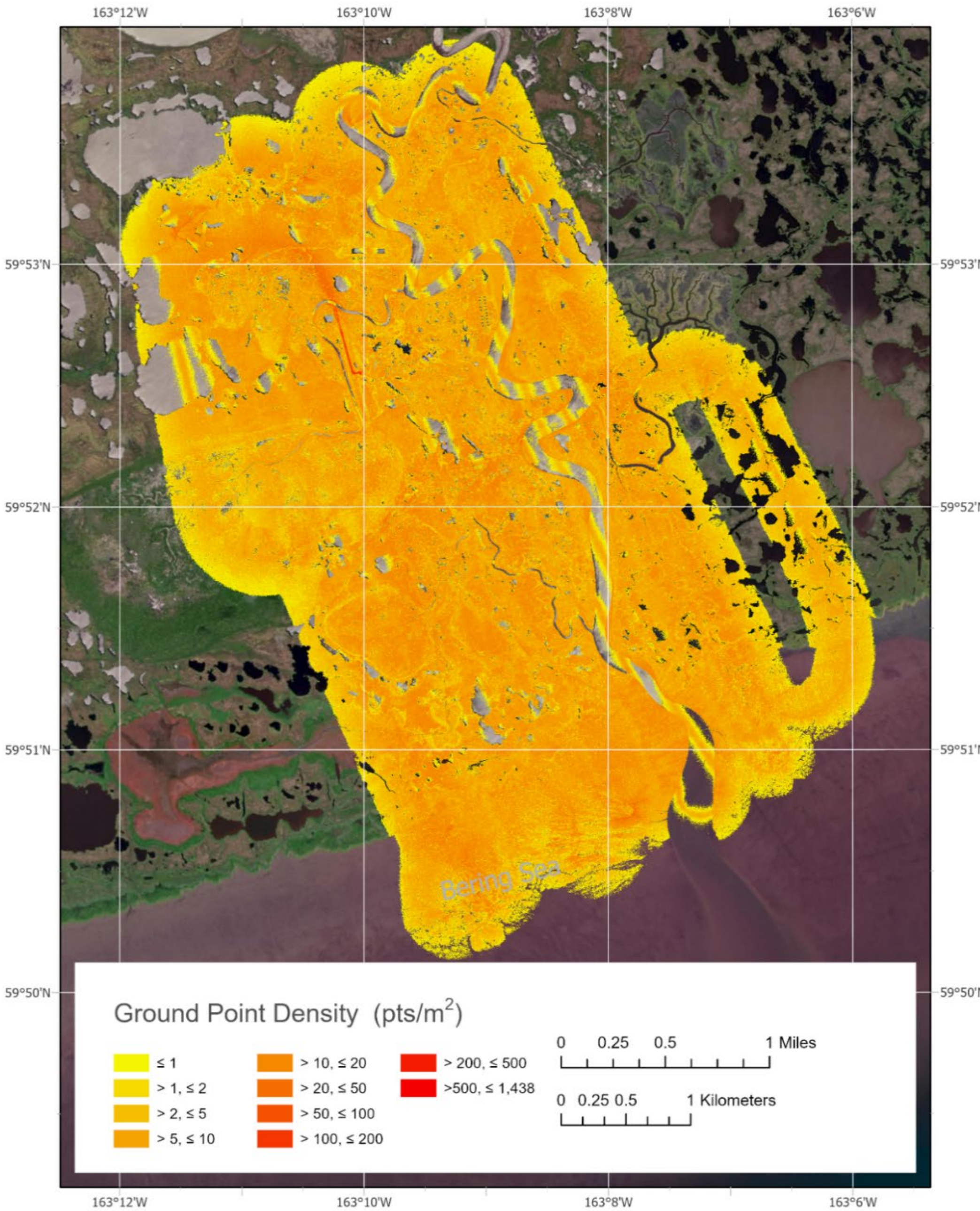

Figure 2. Ground point density for the survey displayed as a 1-meter raster.

SURVEY REPORT

Ground Survey Details

We collected ground control and checkpoints on August 18, 2021. We deployed a Trimble R10 GNSS receiver with Zephyr-2 antenna at a benchmark near the Kwigillingok Airport. It provided a base station occupation and real-time kinematic (RTK) corrections to points we surveyed with a rover Trimble R8 GNSS receiver (internal antenna). We collected 58 ground control and checkpoints to use for calibration and to assess the vertical accuracy of the point cloud. All points were collected on bare earth surfaces.

Coordinate System and Datum

We processed and delivered all data in NAD83 (2011) UTM3N and vertical datum NAVD88 GEOID12B.

Horizontal Accuracy

We did not measure horizontal accuracy for this collection.

Vertical Accuracy

We measured a mean offset of -22.3 cm between 58 control points and the point cloud (app. 1). We reduced this offset to -5.5 cm by performing a vertical transformation of the lidar point data. We used six checkpoints to determine the non-vegetated vertical accuracy (NVA) of the point cloud ground class using a Triangulated Irregular Network (TIN) approach. We calculated the project NVA to have a root mean square error (RMSE) of 7.2 cm (app. 2). We evaluated the relative accuracy for this dataset as the interswath overlap consistency and measured it at 6.1 cm RMSE.

Data Consistency and Completeness

This is a full-release dataset. There was no over-collect except for aircraft turns that were eliminated from the dataset. The data quality is consistent throughout the survey.

ACKNOWLEDGMENTS

This survey area is on the traditional homelands of the Yup'ik people. These data products were funded by the National Coastal Resilience Fund and collected and processed by DGGS. We thank Clearwater Air for their aviation expertise and contribution to these data products. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

REFERENCES

The American Society for Photogrammetry & Remote Sensing, 2019, LAS Specification 1.4 - R15. https://www.asprs.org/wp-content/uploads/2019/07/LAS_1_4_r15.pdf

APPENDIX 1: GROUND CONTROL POINTS

GCP	Easting (m)	Northing (m)	Control point Z (m)	Pointcloud Z (m)	Dz (m)
1	602836.8	6638888	3.688	3.830	0.142
2	602920.1	6638825	3.771	3.910	0.139
3	603586.4	6638317	4.119	4.280	0.161
4	603636.1	6638247	3.980	4.150	0.170
5	603694.5	6638261	3.727	3.920	0.193
6	603756.0	6638273	3.706	3.940	0.234
7	603785.4	6638139	3.382	3.620	0.238
8	603822.2	6638054	3.914	4.140	0.226
9	603835.6	6637991	3.450	3.680	0.230
10	603916.6	6637825	3.506	3.740	0.234
11	603940.0	6637651	3.404	3.620	0.216
12	603983.8	6637830	3.670	3.920	0.250
13	604054.3	6637882	4.042	4.300	0.258
14	604130.7	6637805	3.511	3.800	0.289
15	604089.8	6637904	3.653	3.940	0.287
16	604046.4	6638033	4.132	4.410	0.278
17	603993.3	6638141	3.645	3.910	0.265
18	603887.5	6638276	4.167	4.450	0.283
19	603727.0	6638360	3.797	4.030	0.233
20	603671.5	6638490	3.713	3.950	0.237
21	603610.9	6638560	3.663	3.930	0.267
22	603543.2	6638708	3.560	3.800	0.240
23	603341.2	6639013	3.642	3.850	0.208
24	603438.8	6639116	3.758	4.030	0.272
25	603487.8	6639235	3.639	3.890	0.251
26	603482.6	6639336	3.593	3.860	0.267
27	603555.0	6639382	4.748	5.030	0.282
28	603545.3	6639447	4.729	5.000	0.271
29	603278.1	6639075	3.511	3.710	0.199
30	603209.2	6639104	4.283	4.480	0.197
31	603132.0	6639101	4.251	4.450	0.199
32	603042.5	6639132	4.070	4.250	0.180
33	602992.5	6639109	4.182	4.360	0.178
34	602835.3	6639046	4.229	4.360	0.131
35	602857.0	6639176	4.172	4.300	0.128
36	602637.3	6639001	4.180	4.310	0.130
37	602770.6	6638952	3.898	4.040	0.142
38	603027.7	6638769	3.817	3.980	0.163

GCP	Easting (m)	Northing (m)	Control point Z (m)	Pointcloud Z (m)	Dz (m)
39	603146.1	6638686	3.986	4.120	0.134
40	603275.2	6638665	4.018	4.160	0.142
41	603474.5	6638515	3.616	3.840	0.224
42	603560.8	6638436	3.378	3.580	0.202
43	603606.3	6638380	3.635	3.810	0.175
44	603689.4	6638431	3.835	4.050	0.215
45	603421.7	6638899	3.626	3.880	0.254
46	602776.9	6639077	4.669	4.770	0.101
47	602955.6	6638814	3.470	3.620	0.150
48	603614.1	6638287	3.653	3.860	0.207
49	603751.3	6638222	3.435	3.680	0.245
50	603934.7	6637731	4.255	4.490	0.235
51	603776.9	6638292	3.564	3.850	0.286
52	603437.3	6639155	3.627	3.900	0.273
53	602908.6	6639075	3.953	4.080	0.127
54	603072.7	6638717	3.305	3.560	0.255
55	603370.1	6638606	3.304	3.770	0.466
56	603861.6	6637903	3.126	3.400	0.274
57	604076.0	6637977	3.775	4.100	0.325
58	603913.5	6638266	3.274	3.670	0.396
Average dz (m)	0.223				
Minimum dz (m)	0.101				
Maximum dz (m)	0.466				
Average magnitude error (m)	0.223				
Root mean square error (m)	0.233				
Standard deviation	0.067				

APPENDIX 2: CHECK POINTS

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Dz (m)
1	603027.7	6638769	3.817	3.740	-0.077
2	603606.3	6638380	3.635	3.590	-0.045
3	603614.1	6638287	3.653	3.640	-0.013
4	602908.6	6639075	3.953	3.860	-0.093
5	603934.7	6637731	4.255	4.270	0.015
6	602776.9	6639077	4.669	4.550	-0.119
Average dz (m)	-0.055				
Minimum dz (m)	-0.119				
Maximum dz (m)	0.015				
Average magnitude error (m)	0.060				
Root mean square error (m)	0.072				
Standard deviation (m)	0.051				