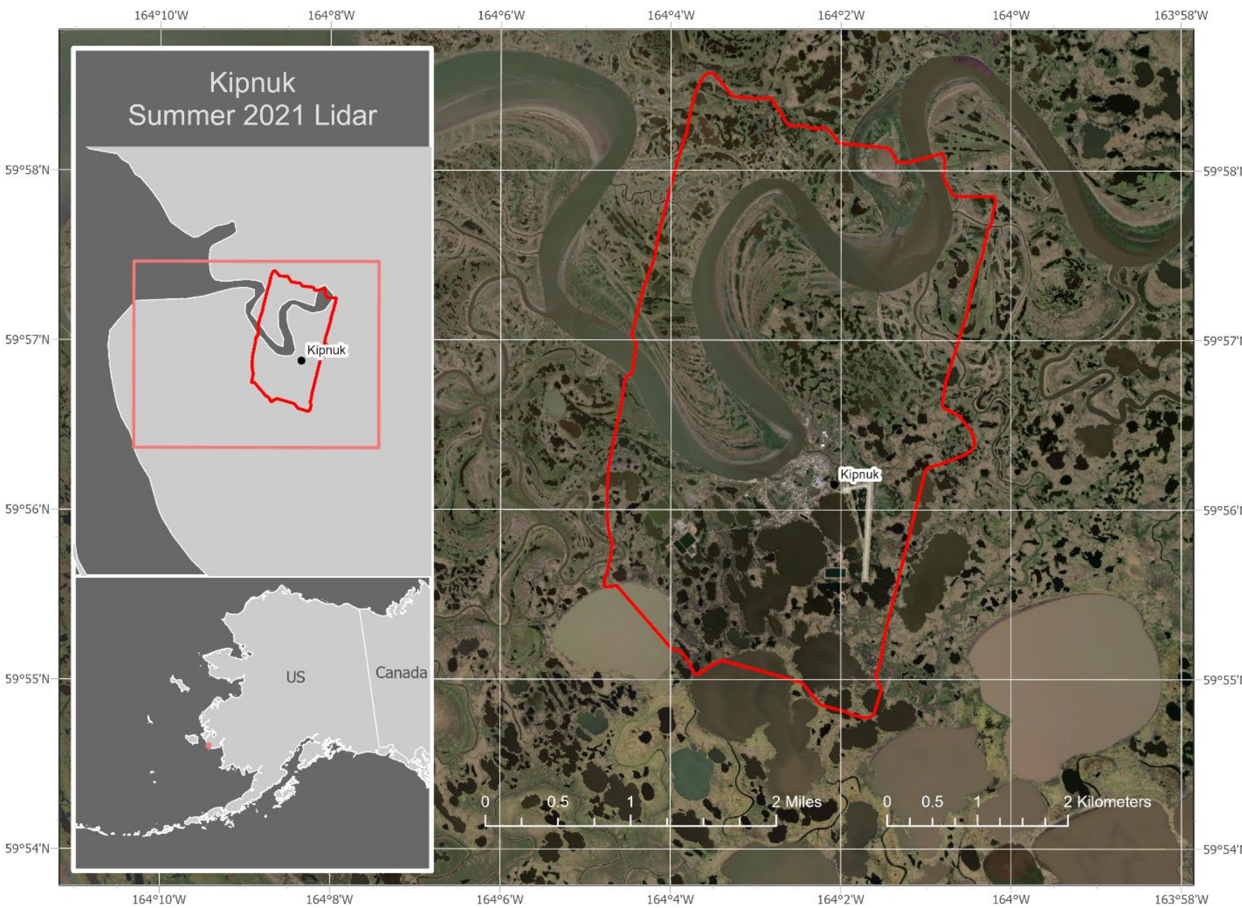
LIDAR-DERIVED ELEVATION DATA FOR KIPNUK, SOUTHWEST ALASKA, COLLECTED AUGUST 18, 2021

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

Raw Data File 2023-20



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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LIDAR-DERIVED ELEVATION DATA FOR KIPNUK, 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 Kipnuk, 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/10.14509/31036.

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). Phoenix LiDAR Systems designed the lidar integration system. 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 ~20 km^2 (cover figure).

Weather Conditions and Flight Times

We flew the aerial survey on August 18, 2021, departing at 2:30 pm from Kipnuk, Alaska Airport, and landing back at Kipnuk at 3:10 pm (fig. 1). The weather throughout the survey was clear with no wind.

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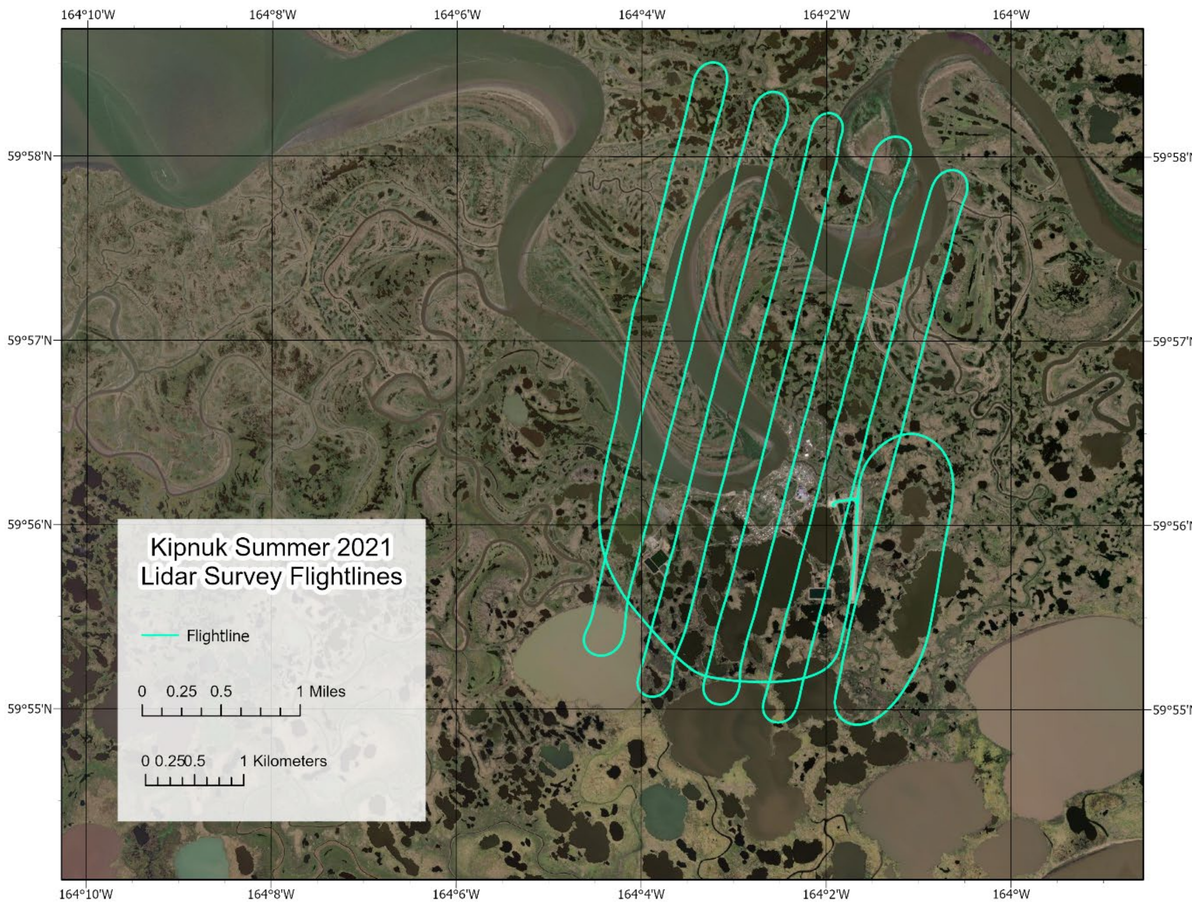

Figure 1. Lidar data collection flight lines.

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 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 the 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 pulse spacing is 42.4 cm, and the average density is 5.56 pts/m^2.

Table 1. Pointcloud 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
10	Hard Surface (≥0.5, ≤4 meters above the ground)
17	Bridge Deck
18	High Noise

Digital Surface Model

The DSM represents surface elevations, including heights of vegetation, buildings, boardwalks, 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.

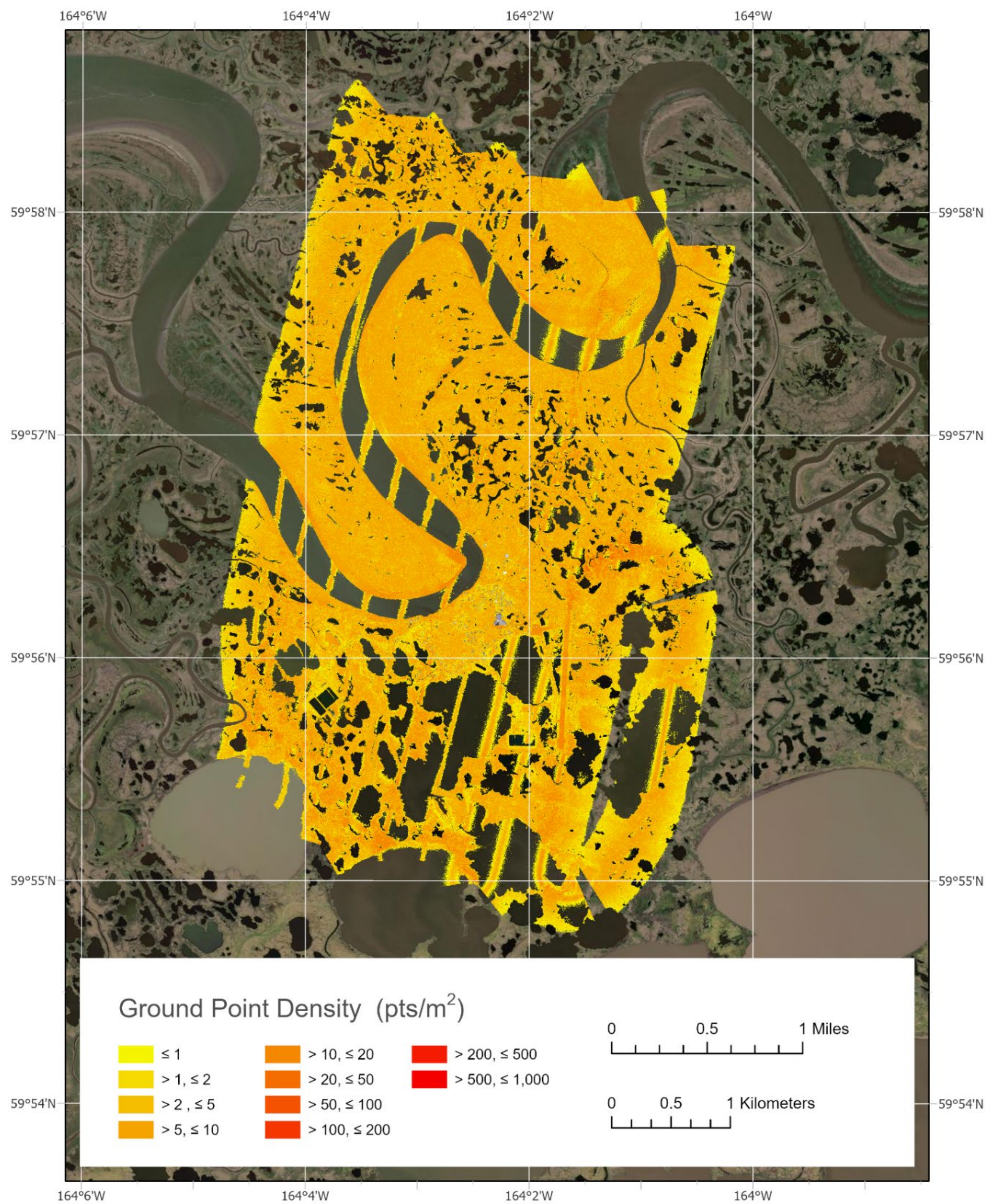

Figure 2. Ground point density for the survey displayed as a 1-meter raster.

SURVEY REPORT

Ground Survey Details

We collected ground control and checkpoints on August 18, 2021. We deployed a Trimble R10 GNSS receiver at benchmark IIK-A near the Kipnuk Airport (figure 1). 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 45 ground control and checkpoints 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 55.1 cm between 33 control points and the point cloud (app. 1). We reduced this offset to 2.5 cm by performing a rubbersheet vertical transformation of the lidar point data. We used 12 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 5.8 cm (app. 2). We evaluated the relative accuracy for this dataset as the interswath overlap consistency and measured it at 5.7 cm RMSE.

Data Consistency and Completeness

This publication 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. They 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)	Checkpoint Z (m)	Pointcloud Z (m)	Dz (m)
1	553835.1	6644940	2.780	3.400	0.620
2	553821.0	6645053	2.949	3.570	0.621
3	553960.1	6645421	3.177	3.770	0.593
4	553948.1	6645283	2.871	3.460	0.589
5	553652.5	6644937	3.221	3.750	0.529
6	553444.2	6644715	2.967	3.540	0.573
7	553396.7	6644652	3.038	3.570	0.532
8	553148.7	6644176	3.114	3.670	0.556
9	553770.0	6644809	3.423	4.000	0.577
10	554078.8	6644575	4.791	5.310	0.519
11	553919.8	6644630	3.030	3.550	0.520
12	553952.7	6644764	2.743	3.250	0.507
13	553889.1	6644921	2.668	3.240	0.572
14	553650.2	6645177	2.921	3.450	0.529
15	553611.9	6645316	3.370	3.820	0.450
16	553611.3	6644878	3.196	3.670	0.474
17	553204.0	6644629	3.327	3.900	0.573
18	553116.3	6644667	2.978	3.580	0.602
19	553285.3	6644402	3.184	3.690	0.506
20	553342.3	6644335	3.055	3.580	0.525
21	553404.3	6644349	3.091	3.600	0.509
22	553509.0	6644456	3.171	3.680	0.509
23	553568.5	6644626	3.107	3.580	0.473
24	553625.1	6644613	2.927	3.410	0.483
25	553711.2	6644694	2.890	3.440	0.550
26	553803.1	6644981	2.704	3.320	0.616
27	553278.4	6644657	2.904	3.440	0.536
28	553152.2	6644517	3.271	3.860	0.589
29	553295.6	6644300	3.197	3.710	0.513
30	553713.6	6645090	2.921	3.590	0.669
31	553474.6	6644818	2.693	3.430	0.737
32	553519.5	6644494	3.472	3.920	0.448
33	553533.2	6644612	2.900	3.500	0.600
Average dz (m)	0.551				
Minimum dz (m)	0.448				
Maximum dz (m)	0.737				
Average magnitude error (m)	0.551				
Root mean square error (m)	0.555				
Standard deviation	0.062				

APPENDIX 2: CHECK POINTS

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Dz (m)
1	553957.4	6644605	3.364	3.400	0.036
2	553945.5	6645216	2.838	2.870	0.032
3	553743.7	6644922	3.663	3.630	-0.033
4	553159.2	6644595	3.166	3.190	0.024
5	553551.9	6644522	3.725	3.680	-0.045
6	553869.7	6644615	3.287	3.360	0.073
7	553828.4	6645439	2.712	2.730	0.018
8	553180.8	6644713	3.243	3.220	-0.023
9	553462.4	6644408	2.955	2.960	0.005
10	553729.9	6644774	3.016	3.000	-0.016
11	553876.9	6645146	2.833	2.980	0.147
12	553694.1	6644673	2.891	2.970	0.079
Average dz (m)	0.025				
Minimum dz (m)	-0.045				
Maximum dz (m)	0.147				
Average magnitude error (m)	0.044				
Root mean square error (m)	0.058				
Standard deviation (m)	0.055				