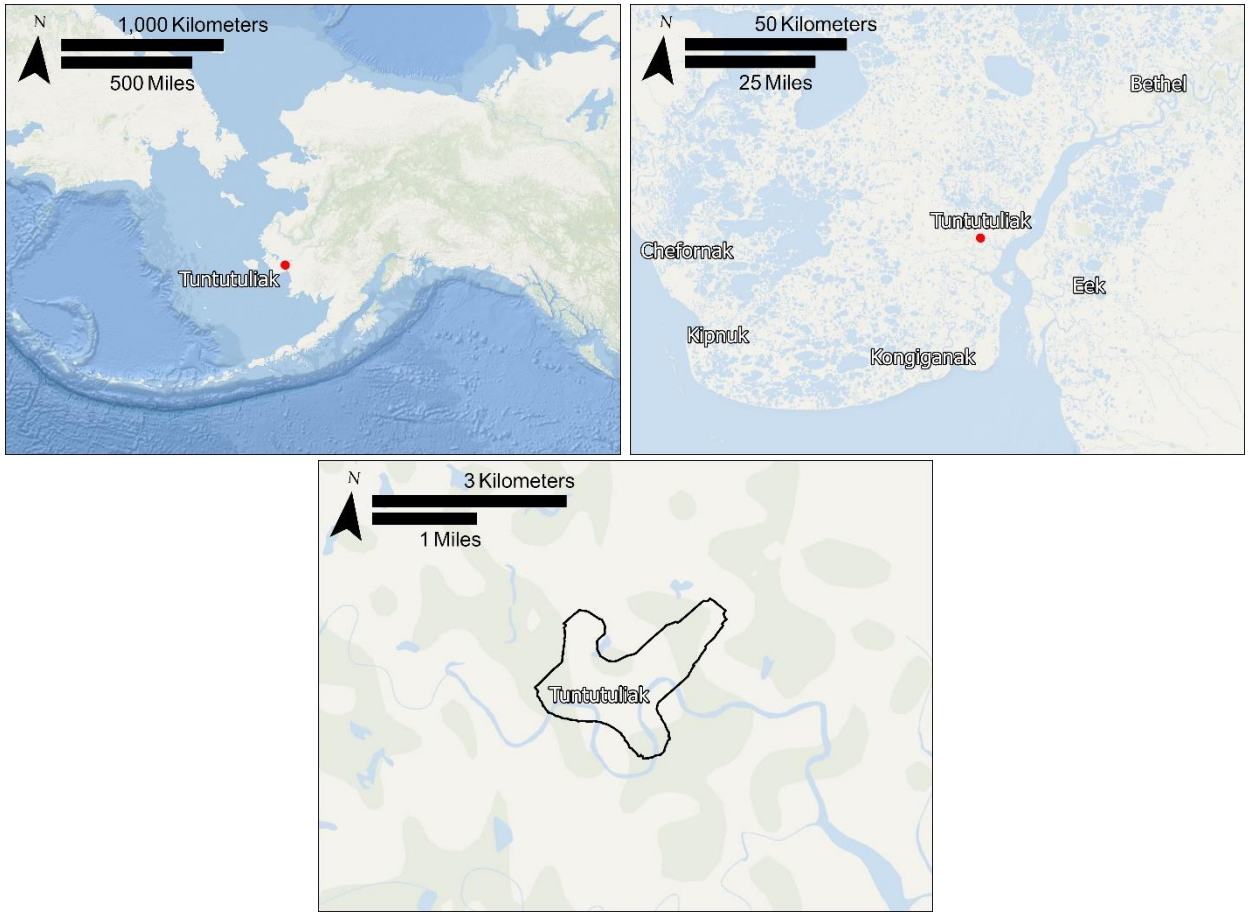
PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR TUNTUTULIAK, ALASKA, COLLECTED JUNE 8, 2023

Keith C. Horen, Nora M. Nieminski, Autumn C. Poisson, and Zachary J. Siemsen

Raw Data File 2024-24



Location maps showing the survey area.

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

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PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR TUNTUTULIAK, ALASKA, COLLECTED JUNE 8, 2023

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INTRODUCTION

The Alaska Division of Geological & Geophysical Surveys (DGGS) collected low-altitude aerial images from an unmanned aerial vehicle (UAV) in the community of Tuntutuliak, Alaska, on June 8, 2023. We used Structure-from-Motion (SfM) photogrammetry to produce a digital surface model (DSM) and orthorectified imagery (fig. 1). The orthoimage and elevation data are useful for assessing riverine hazards and changes over time. These products are released as a Raw Data File with an open end-user license. All files can be downloaded from https://doi.org/10.14509/31292 or elevation.alaska.gov.

LIST OF DELIVERABLES

- Orthoimagery
- Digital Surface Model (DSM)
- Metadata

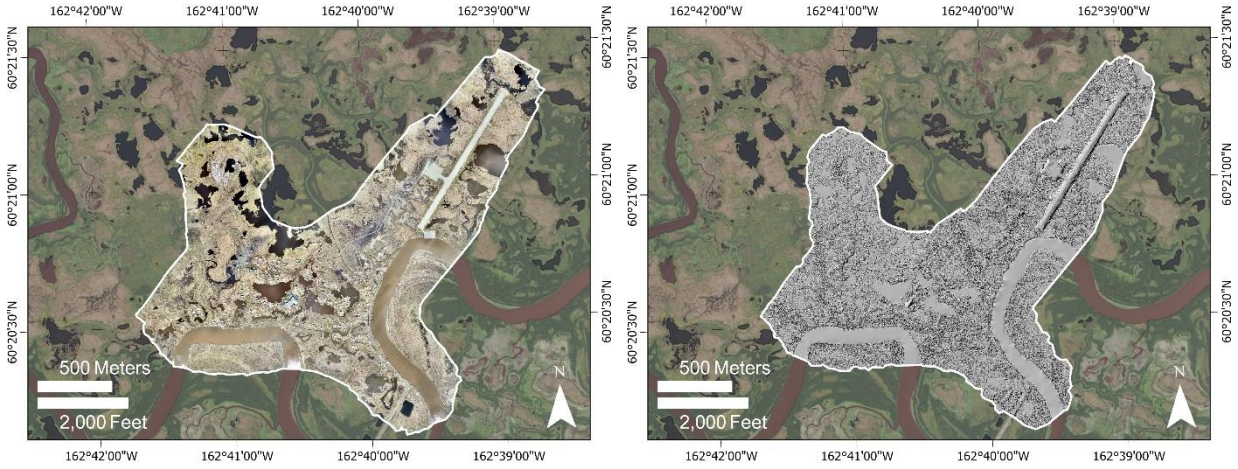

Figure 1. Extent of orthoimage (left) and digital surface model (DSM) (right) for Tuntutuliak, Alaska.

METHODS

Aerial Photogrammetric Survey Details

DGGS conducted flights on June 8, 2023, from approximately 2:00 PM to 4:45 PM AKDT using a DJI Phantom 4 RTK UAV with a FC6310R camera model (8.8 mm lens) to collect 1,993 20-megapixel JPEG photographs (5,472 x 3,648 pixels per image). The operator returned the UAV

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eight times to change batteries. DGGS flew the aerial survey with 75 percent sidelap and 75 percent frontlap, 120 m above ground-level at 9.5 m/s, with nadir orientation stabilized using a three-axis gimbal. This resulted in images covering 3.357 km^2 with a ground sampling distance (GSD) of 0.025 m. The weather throughout the survey was mostly cloudy with light wind. No abnormalities were observed during the flights.

Ground Survey Details

On June 8, 2023, DGGS temporarily installed a Trimble R10 receiver sampling at 5 Hz as a Global Navigation Satellite System (GNSS) base station over a temporary benchmark. This provided real-time kinematic (RTK) corrections to the ground rover, a Trimble R8s GNSS receiver. DGGS measured the location of 38 photo-identifiable ground control points (GCPs) with the ground rover (fig. 2).

Data Processing

Base positions were corrected using Online Positioning User Service (OPUS) solutions (table 1), which were used to update the UAV and ground rover positions with post-processed kinematic (PPK) adjustments.

UAV positions were updated in RTKLIB (Version 2.4.3) software with the following settings applied: L1+L2 frequencies forward and backward filtered; a 10-degree elevation mask; receiver dynamics disabled; broadcast ionosphere and Saastamoinen troposphere corrections; a minimum fixed-ambiguity ratio of three; and L1/L2 code/carrier-phase error ratios of 100/100. During post-processing, DGGS applied International GNSS Service (IGS) precise orbits and final clock solutions retrieved from the Crustal Dynamics Data Information System (CDDIS) found at urs.earthdata.nasa.gov. Final corrected data were exported as time-stamped position files in WGS84 horizontal coordinate system with ellipsoidal heights and paired to corresponding photographs using an Aerotas P4RTK PPK Adjustments (Version 1) macro-enabled Microsoft Excel file.

Ground rover positions were updated using PPK corrections in Trimble Business Center (Version 5.51) software using default settings. Final corrected data were exported as comma-delimited text files in WGS84 horizontal coordinate system with ellipsoidal heights.

DGGS used Agisoft Metashape Professional (Version 1.8.3 build 14331) software for photogrammetric processing following the steps and settings outlined in Over and others (2021). During processing, DGGS used 19 GCPs for photograph alignment and lens distortion parameter optimization (fig. 2, table 2), leaving 19 GCPs as horizontal and vertical check points (fig. 2, table 3). A confidence filter was applied to the resulting dense point cloud, eliminating all points derived from fewer than three discrete camera positions. Additional noise was removed from the dense point cloud through visual inspection.

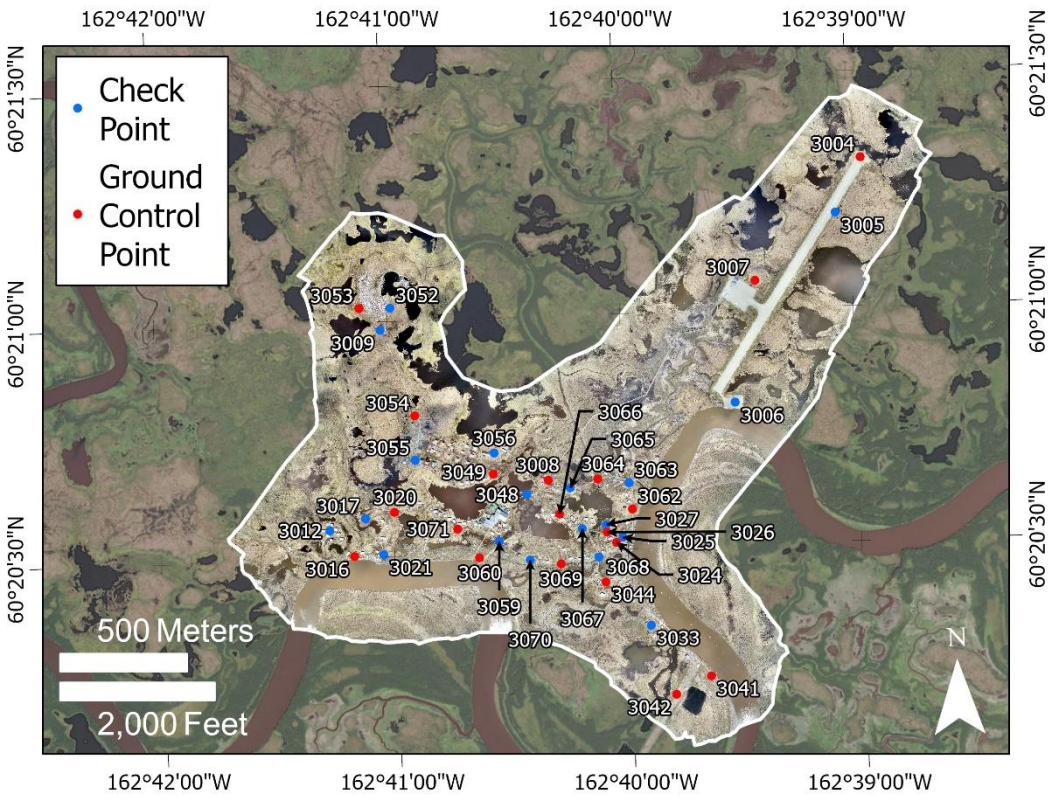

Figure 2. Location of photo-identifiable ground control points (GCP; red) and check points (CHK; blue).

IMAGERY PRODUCTS

Orthoimagery

The orthoimage is a three-band (red, green, blue), eight-bit unsigned GeoTIFF file derived from a color-adjusted mosaic of 1,983 aerial photographs with a GSD of 0.025 m per pixel; the "No Data" value is set to 0.

Digital Surface Model

The DSM represents surface elevations including the height of vegetation, buildings, and other man-made features derived from the dense point cloud. The DSM is a single-band, 32-bit floating point GeoTIFF file with a GSD of 0.049 m; the "No Data" value is set to $-3.4028235 \times 10^{38}$.

ACCURACY REPORT

Coordinate System and Datum

All data were processed in the WGS84 horizontal coordinate system and WGS84 ellipsoid vertical datum. All data were reprojected using Esri ArcGIS Pro (Version 3.0.2) software and are delivered in NAD83 (2011) UTM Zone 3N horizontal coordinate system and NAVD88 (GEOID12B) vertical datum.

Horizontal Accuracy

DGGS quantified the horizontal accuracy of the GNSS position data using the latitudinal and longitudinal peak-to-peak errors provided by OPUS (table 1). Consistent with OPUS shared

solution requirements (NOAA, 2022), DGGS considers high-quality GNSS solutions to have latitudinal and longitudinal errors less than or equal to 0.04 m.

We quantified the horizontal accuracy of the DSM and orthoimage by comparing the known locations of 19 photo-identifiable check points measured with GNSS against their modeled locations in the photogrammetric products (fig. 2, table 3). These are independent checkpoints not used during processing. X and Y errors are calculated as the root-mean-square (RMS) error of offsets, 0.027 m and 0.030 m, respectively. The total horizontal error is the root-sum-square error of X and Y RMS errors, 0.040 m.

Vertical Accuracy

DGGS quantified the vertical accuracy of the GNSS position data using the combined ellipsoidal height peak-to-peak errors provided by OPUS and orthometric height RMS error provided by NOAA's Vertical Datum Transformation software (NOAA, 2016; table 1). Consistent with OPUS shared solution requirements (NOAA, 2022), DGGS considers high-quality GNSS solutions to have vertical errors less than or equal to 0.08 m.

We quantified the vertical accuracy of the DSM using the same 19 check points used to quantify the horizontal accuracy (fig. 2, table 3). The RMS error of Z offsets is 0.031 m (table 3). The total RMS error of the DSM (X, Y, and Z) is 0.050 m.

Table 1. Base station coordinates and GNSS errors.

NAD83 (2011) Easting	NAD83 (2011) Northing	NAVD88 Elevation	GNSS X Error (m)	GNSS Y Error (m)	GNSS Z Error (m)
629173.071	6692778.576	8.341	0.016	0.007	0.063

Table 2. Ground control point coordinates and offsets from orthoimagery and DSM.

Point	Easting	Northing	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
3004	629699.687	6693290.486	5.577	0.045	0.012	-0.031	0.007	0.009
3007	629285.376	6692802.907	6.730	0.011	-0.004	0.018	0.006	0.008
3008	628471.213	6692013.622	4.382	-0.001	-0.001	-0.001	0.007	0.009
3016	627707.144	6691711.568	3.405	0.016	0.029	-0.016	0.007	0.009
3020	627865.295	6691886.142	3.913	0.003	-0.026	-0.006	0.007	0.010
3024	628739.887	6691767.309	3.705	-0.022	0.007	0.046	0.007	0.011
3026	628702.355	6691807.622	3.215	-0.017	0.005	-0.028	0.007	0.010
3041	629113.341	6691241.097	3.620	0.029	0.000	-0.008	0.010	0.010
3042	628976.959	6691167.816	3.627	0.013	-0.009	0.021	0.010	0.010
3044	628698.162	6691612.673	4.030	0.010	0.011	0.067	0.011	0.011
3049	628253.310	6692037.506	3.342	0.022	-0.007	-0.010	0.009	0.012
3053	627723.367	6692690.648	3.056	-0.014	-0.034	0.006	0.011	0.015

Point	Easting	Northing	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
3054	627944.231	6692266.437	5.717	-0.002	-0.009	-0.019	0.011	0.014
3060	628200.417	6691706.624	3.689	-0.018	0.005	-0.015	0.010	0.014
3062	628803.239	6691899.867	3.401	-0.007	0.007	0.010	0.008	0.011
3064	628664.617	6692017.445	2.968	-0.019	0.016	0.049	0.008	0.011
3066	628514.938	6691879.624	4.097	-0.002	0.013	-0.004	0.012	0.016
3069	628521.075	6691683.499	2.915	-0.026	0.043	0.016	0.013	0.017
3071	628113.538	6691820.661	3.979	0.020	0.020	0.012	0.015	0.018
Mean				0.002	0.004	0.006	0.009	0.012
Standard Deviation				0.019	0.018	0.026	0.002	0.003
Range				0.071	0.077	0.098	0.008	0.010
Root Mean Square Error				0.019	0.017	**0.026**	0.002	0.003
Total Error				**0.026**		**0.036**	**0.004**	
				(XY)		**(XYZ)**	**(XYZ)**	

Table 3. Check point coordinates and offsets from orthoimagery and DSM.

Point	Easting	Northing	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
3005	629601.830	6693070.809	6.767	0.025	0.009	0.002	0.007	0.008
3006	629207.319	6692320.531	4.368	-0.002	0.023	-0.020	0.007	0.009
3009	627806.115	6692603.616	4.260	-0.003	-0.009	0.021	0.008	0.010
3012	627608.957	6691813.104	4.080	0.016	-0.044	0.030	0.008	0.009
3017	627749.178	6691860.363	3.649	0.007	-0.006	-0.032	0.007	0.009
3021	627822.671	6691718.650	4.908	0.010	-0.015	-0.009	0.007	0.010
3025	628764.568	6691787.478	3.666	-0.055	-0.079	0.000	0.007	0.011
3027	628699.796	6691837.883	3.181	-0.033	0.053	-0.016	0.007	0.010
3033	628876.540	6691441.023	3.683	-0.026	0.006	-0.033	0.010	0.013
3048	628385.153	6691956.701	4.289	0.000	-0.007	-0.003	0.006	0.008
3052	627846.479	6692692.425	3.973	0.035	-0.020	0.021	0.011	0.015
3055	627945.970	6692090.510	3.196	-0.027	0.003	-0.006	0.011	0.014
3056	628256.635	6692119.412	4.149	0.045	0.003	-0.008	0.010	0.013
3059	628277.465	6691771.188	3.728	-0.004	0.000	0.009	0.011	0.014
3063	628788.762	6692003.220	3.212	0.024	-0.001	0.059	0.008	0.011
3065	628557.711	6691982.897	4.644	0.004	0.029	-0.006	0.008	0.012
3067	628605.038	6691821.756	4.371	-0.049	0.022	-0.077	0.012	0.017

Point	Easting	Northing	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
3068	628670.538	6691710.823	3.829	-0.021	-0.042	0.000	0.012	0.017
3070	628399.069	6691697.426	3.844	0.014	-0.004	-0.041	0.014	0.017
			Mean	-0.002	-0.004	-0.006	0.009	0.012
			Standard Deviation	0.023	0.027	0.029	0.002	0.003
			Range	0.100	0.132	0.136	0.008	0.009
			Root Mean Square Error	0.027	0.030	**0.031**	0.002	0.003
			Total Error	**0.040**		**0.050**	**0.004**	
				(XY)		**(XYZ)**	**(XYZ)**	

Data Consistency and Completeness

DGGS visually inspected the orthoimage for data errors such as shifts, seamline mismatches, and water noise overlapping land. Visual errors common to these SfM photogrammetry products include discontinuous powerlines and distortion near high-angle features like buildings, as well as water boundaries. Highly reflective objects such as water bodies, metal roofs, and white paint may cause overexposure, leading to spurious elevation points. There were no significantly erroneous areas that required repair.

ACKNOWLEDGMENTS

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