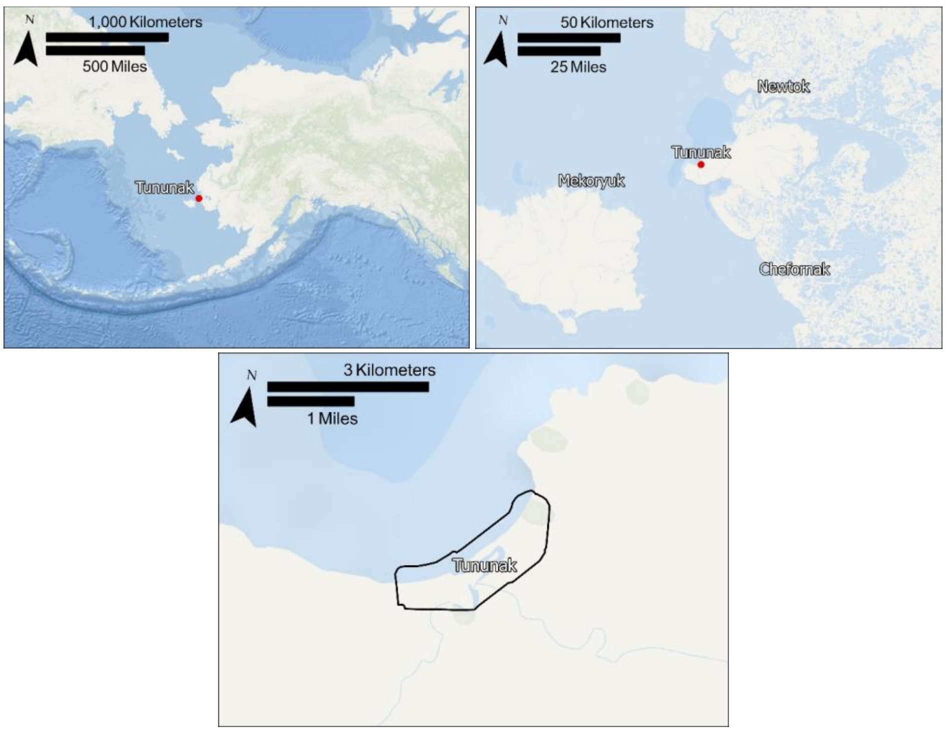
PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR TUNUNAK, ALASKA, COLLECTED SEPTEMBER 13, 2022

Keith C. Horen and Zachary J. Siemsen

Raw Data File 2024-25



Location maps showing the survey area.

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

2024
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DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR TUNUNAK, ALASKA, COLLECTED SEPTEMBER 13, 2022

Keith C. Horen[1] and Zachary J. Siemsen[1*]

INTRODUCTION

The Alaska Division of Geological & Geophysical Surveys (DGGS) collected low-altitude aerial images from an unmanned aerial vehicle (UAV) in the community of Tununak, Alaska, on September 13, 2022. We used Structure-from-Motion (SfM) photogrammetry to produce a digital surface model (DSM) and orthoimagery (fig. 1). The orthoimage and elevation data are useful for assessing coastal and 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/10.14509/31293 or elevation.alaska.gov.

LIST OF DELIVERABLES

- Orthoimagery
- Digital Surface Model (DSM)
- Metadata

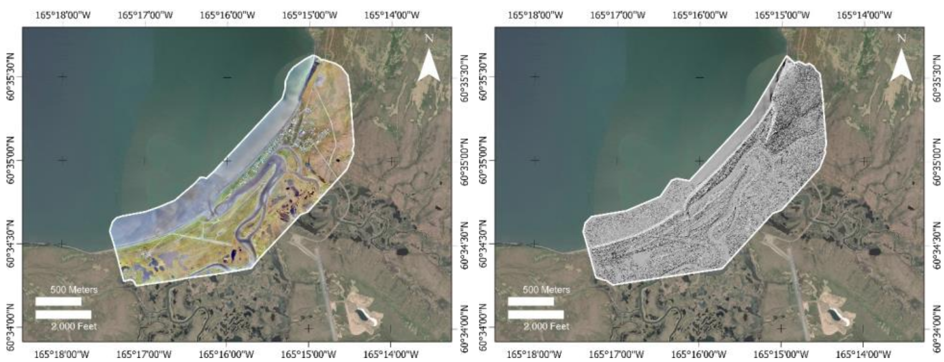

Figure 1. Extent of orthoimage (left) and digital surface model (DSM) (right) for Tununak, Alaska.

METHODS

Aerial Photogrammetric Survey Details

DGGS conducted flights on September 13, 2022, from approximately 11:15 AM to 2:00 PM AKDT. DGGS used a DJI Phantom 4 RTK UAV with a FC6310R camera model (8.8 mm lens) to collect 1,679 20-megapixel JPEG photographs (5,472 x 3,648 pixels per image). The operator returned the UAV eight times to change batteries. DGGS flew the aerial survey with 70

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percent sidelap and 70 percent frontlap, 110 m above ground-level at 9.0 m/s, with nadir orientation stabilized using a three-axis gimbal. This resulted in images covering 3.190 km^2 with a ground sampling distance (GSD) of 0.025 m. The weather throughout the survey was mostly overcast with light wind. No abnormalities were observed during the flights.

Ground Survey Details

On September 13, 2022, DGGS set up a Global Navigation Satellite System (GNSS) base station using a Trimble R10 receiver sampling at 5 Hz over a found Bureau of Land Management brass cap monument. This provided real-time kinematic (RTK) corrections to the ground rover, a Trimble R8s GNSS receiver. DGGS measured the location of 29 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° 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 15 GCPs for photograph alignment and lens distortion parameter optimization (fig. 2, table 2), leaving 14 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.

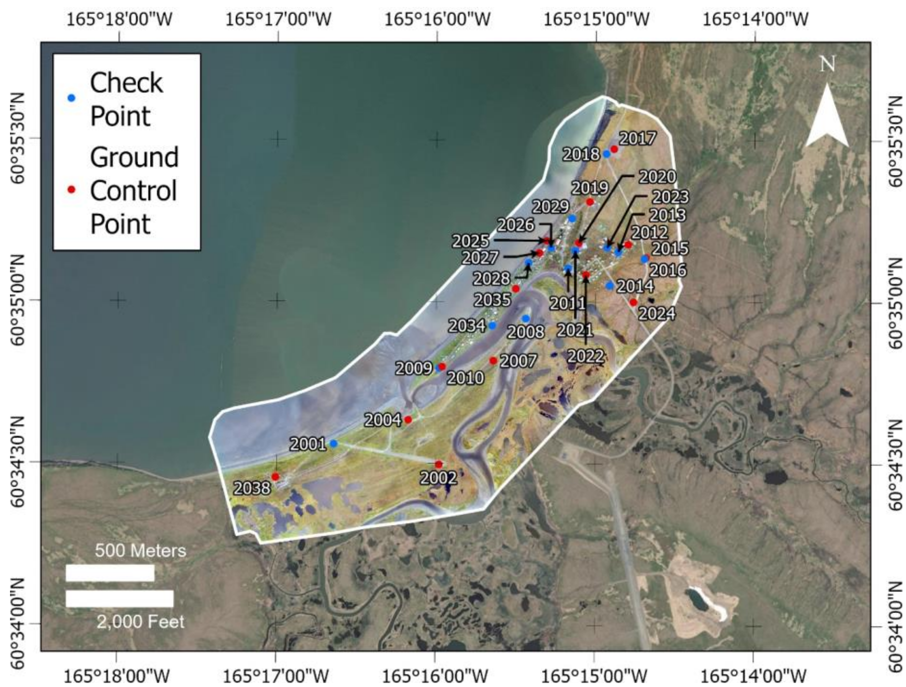

Figure 2. Location of photo-identifiable ground control points (GCP; red) and check points (CHK; blue).

IMAGERY PRODUCTS

Orthoimagery

The orthoimage is a three-band (red, green, blue), eight-bit unsigned GeoTIFF file derived from a color-adjusted mosaic of 1,668 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 0.070 m; the "No Data" value is set to -3.4028235 x 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.

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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 14 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, 0.032 m and 0.033 m, respectively. The total horizontal error is the root-sum-square error of X and Y RMS errors, 0.046 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 14 check points used to quantify the horizontal accuracy (fig. 2, table 3). The RMS error of Z offsets is 0.032 m. The total RMS error of the DSM (X, Y, and Z) is 0.056 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)
486177.416	6716751.170	12.263	0.003	0.008	0.074

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)
2002	485402.090	6715474.083	4.016	-0.010	0.066	0.002	0.007	0.010
2004	485227.829	6715731.176	5.439	-0.061	-0.047	0.015	0.007	0.010
2007	485715.970	6716069.536	3.974	-0.004	-0.024	0.021	0.006	0.008
2010	485422.463	6716035.443	6.278	-0.057	-0.080	0.020	0.010	0.010
2012	486490.380	6716735.242	11.769	0.020	0.027	0.022	0.006	0.007
2015	486591.607	6716659.037	13.044	0.001	0.022	0.057	0.007	0.008
2017	486411.491	6717283.122	42.393	0.035	-0.001	0.048	0.007	0.009
2019	486271.014	6716978.746	27.678	-0.020	0.023	0.017	0.007	0.009
2020	486206.910	6716744.466	14.913	0.004	-0.019	0.013	0.008	0.014

Commented [MW4]: Easting and Northings columns or headers appear to be switched. Northings are the 7-digit ones.

Point	Easting	Northing	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
2022	486247.207	6716560.360	5.586	0.022	0.109	-0.049	0.008	0.013
2024	486521.513	6716404.842	8.252	-0.028	0.007	-0.047	0.006	0.009
2025	486022.738	6716757.287	5.901	-0.032	-0.030	0.019	0.006	0.008
2027	485980.987	6716688.339	5.644	-0.029	-0.018	0.031	0.005	0.008
2035	485845.476	6716483.417	5.345	-0.044	-0.024	0.022	0.008	0.011
2038	484465.068	6715403.412	4.792	-0.010	0.049	0.043	0.010	0.016
			Mean	-0.014	0.004	0.016	0.007	0.010
			Standard Deviation	0.028	0.048	0.029	0.001	0.002
			Range	0.096	0.189	0.106	0.005	0.009
			Root Mean Square Error	0.027	0.046	0.028	0.001	0.002
			Total Error	**0.053**		**0.061**	**0.003**	
				(XY)		**(XYZ)**	**(XYZ)**	

Commented [MW4]: Easting and Northings columns or headers appear to be switched. Northings are the 7-digit ones.

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)
2001	484799.923	6715593.251	5.077	0.072	0.010	-0.011	0.006	0.009
2008	485903.013	6716310.890	3.593	0.048	-0.023	-0.011	0.005	0.008
2009	485405.992	6716027.887	4.420	-0.038	-0.051	-0.016	0.006	0.008
2011	486146.242	6716598.072	7.799	0.067	0.015	0.033	0.006	0.007
2013	486433.985	6716692.446	10.105	0.001	0.007	0.019	0.006	0.007
2014	486385.460	6716498.511	7.487	-0.014	0.048	0.003	0.006	0.007
2016	486591.607	6716659.037	13.044	-0.007	0.042	0.057	0.007	0.008
2018	486366.442	6717255.220	39.662	0.015	-0.055	0.054	0.007	0.009
2021	486186.958	6716700.619	13.940	0.015	-0.017	0.029	0.011	0.014
2023	486369.824	6716716.679	10.114	-0.017	0.007	-0.001	0.006	0.010
2026	486047.740	6716718.263	4.773	-0.007	-0.065	-0.074	0.005	0.008
2028	485918.761	6716630.241	5.550	0.047	0.016	0.018	0.005	0.008
2029	486169.259	6716883.924	5.153	0.023	0.006	0.002	0.005	0.008
2034	485710.103	6716271.751	4.418	0.011	0.000	0.004	0.008	0.011
			Mean	0.015	-0.004	0.008	0.006	0.009
			Standard Deviation	0.033	0.034	0.033	0.001	0.002
			Range	0.111	0.113	0.131	0.006	0.007
			Root Mean Square Error	0.032	0.033	**0.032**	0.001	0.002
			Total Error	**0.046**		**0.056**	**0.002**	
				(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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REFERENCES

National Oceanic and Atmospheric Administration (NOAA), 2016, Estimation of vertical uncertainties in VDatum. https://vdatum.noaa.gov/docs/est_uncertainties.html

———2022, About OPUS: National Geodetic Survey webpage, retrieved from https://geodesy.noaa.gov/OPUS/about.jsp

Over, J.R., Ritchie, A.C., Kranenburg, C.J., Brown, J.A., Buscombe, D., Noble, T., Sherwood, C.R., Warrick, J.A., and Wernette, P.A., 2021, Processing coastal imagery with Agisoft Metashape Professional Edition, version 1.6—Structure from motion workflow documentation: U.S. Geological Survey Open-File Report 2021-1039, 46 p. https://doi.org/10.3133/ofr20211039