PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR STEBBINS, ALASKA, COLLECTED JULY 10, 2022

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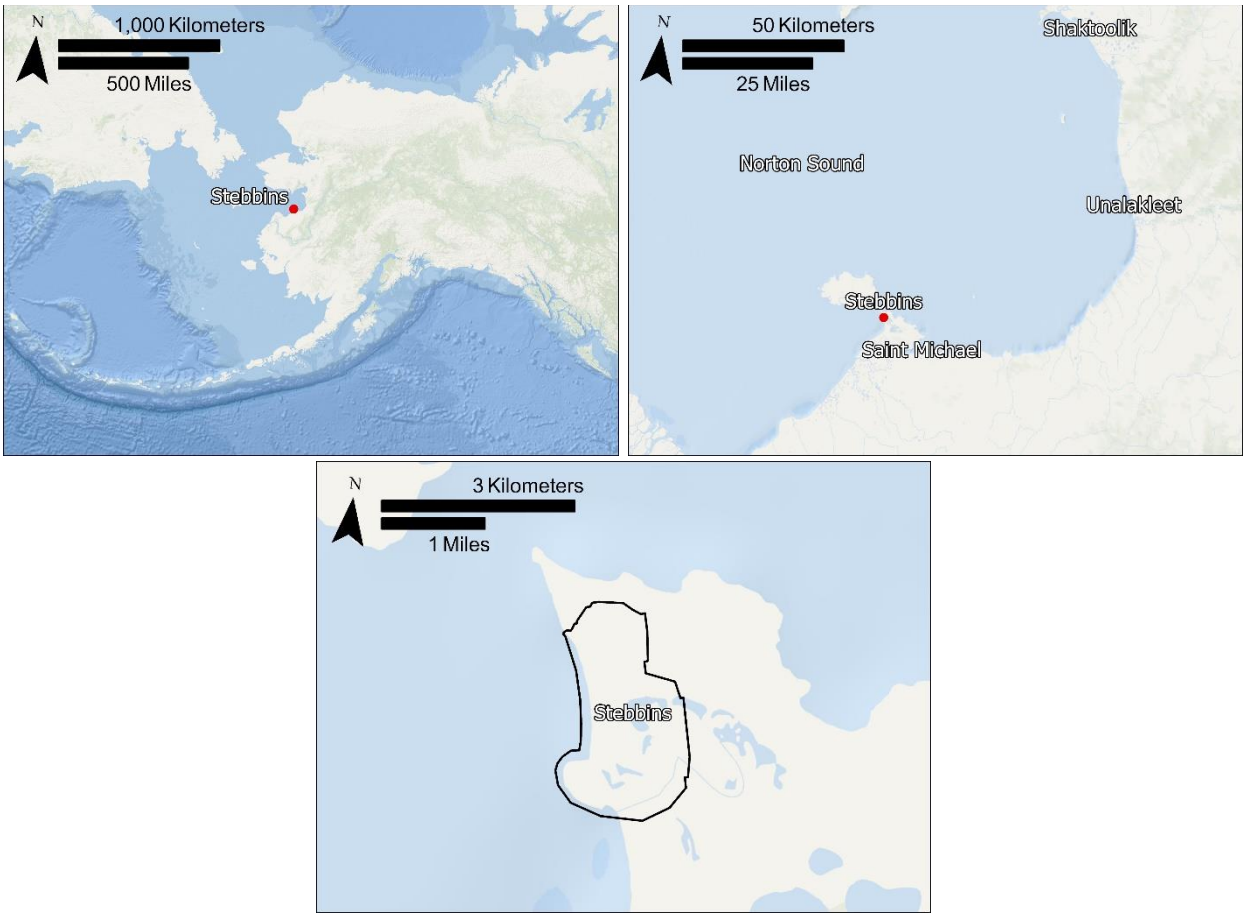
Raw Data File 2024-23



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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DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR STEBBINS, ALASKA, COLLECTED JULY 10, 2022

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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 Stebbins, Alaska, on July 10, 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 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/10.14509/31291 or elevationa.alaska.gov.

LIST OF DELIVERABLES

- Orthoimagery
- Digital Surface Model (DSM)
- Metadata

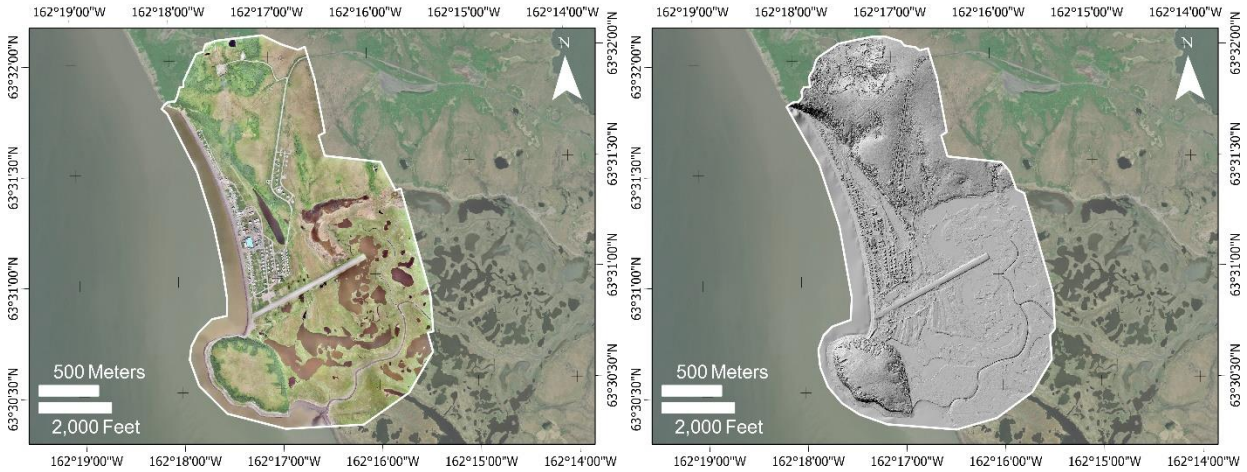

Figure 1. Extent of orthoimage (left) and digital surface model (DSM) (right) for Stebbins, Alaska.

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METHODS

Aerial Photogrammetric Survey Details

DGGS conducted flights on July 10, 2022, from approximately 12:30 PM to 6:00 PM AKDT. DGGS used a DJI Phantom 4 RTK UAV with a FC6310R camera model (8.8 mm lens) to collect 2,598 20-megapixel JPEG photographs (5,472 x 3,648 pixels per image). The operator returned the UAV 11 times to change batteries. DGGS flew the aerial survey with 70 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 4.925 km^2 with a ground sampling distance (GSD) of 0.023 m. The weather throughout the survey was overcast with light wind. No abnormalities were observed during the flights.

Ground Survey Details

On July 10, 2022, DGGS set up a Global Navigation Satellite System (GNSS) base station using a Trimble R10 receiver sampling at 5 Hz 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 31 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 16 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.

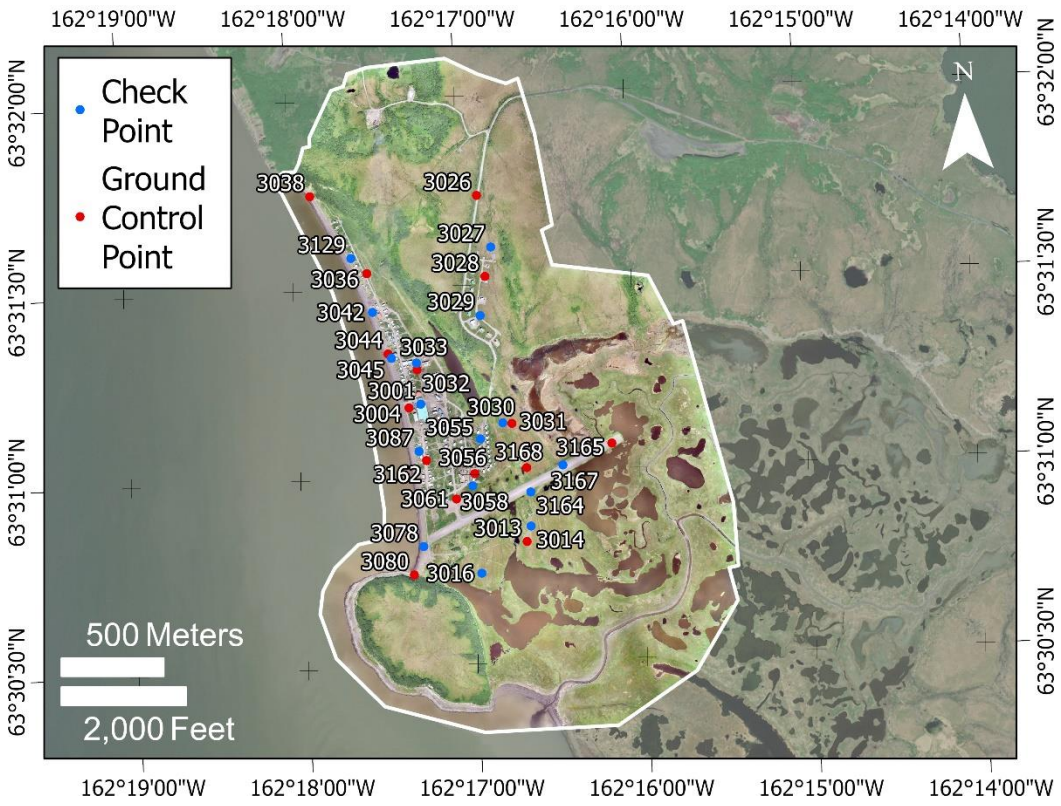

Figure 2. Location of photo-identifiable ground control points (GCP; red) and check points (CHK; blue).

IMAGERY PRODUCTS

Orthoimagery

The orthoimage is a three-band (red, green, blue), eight-bit unsigned GeoTIFF file derived from a color-adjusted mosaic of 2,593 aerial photographs with a GSD of 0.023 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 0.067 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 16 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, 0.023 m and 0.016 m, respectively. The total horizontal error is the root-sum-square error of X and Y RMS errors, 0.028 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 16 check points used to quantify the horizontal accuracy (fig 2, table 3). The RMS error of Z offsets is 0.048 m. The total RMS error of the DSM (X, Y, and Z) is 0.055 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)
635146.731	7046747.037	16.902	0.007	0.022	0.067

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	634838.578	7046351.980	5.063	-0.003	0.021	-0.035	0.006	0.010
3013	635418.221	7045697.253	4.629	0.010	0.005	-0.070	0.012	0.018
3026	635170.242	7047393.439	36.538	-0.020	-0.001	0.049	0.006	0.008
3028	635210.108	7046996.901	17.323	-0.020	-0.008	-0.018	0.007	0.012
3031	635342.861	7046276.592	3.807	-0.006	0.009	-0.123	0.004	0.006
3032	634877.862	7046539.584	3.261	-0.004	0.012	-0.012	0.006	0.008
3036	634631.474	7047011.228	3.607	-0.035	-0.036	-0.068	0.007	0.008

Point	Easting	Northing	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
3038	634353.282	7047388.241	2.731	0.027	0.043	-0.047	0.007	0.009
3044	634736.220	7046617.128	3.756	-0.032	0.067	0.031	0.007	0.012
3056	635160.395	7046030.200	5.217	0.031	-0.034	0.059	0.011	0.014
3061	635071.975	7045906.652	4.985	0.034	-0.013	0.008	0.008	0.011
3080	634865.050	7045533.221	2.594	0.008	-0.027	0.041	0.008	0.011
3162	634925.515	7046093.650	4.727	0.085	0.016	0.111	0.006	0.007
3165	635832.948	7046180.375	4.473	-0.094	-0.063	0.010	0.006	0.008
3168	635415.466	7046059.172	4.131	0.019	0.009	0.004	0.006	0.008
Mean				0.000	0.000	-0.004	0.007	0.010
Standard Deviation				0.040	0.033	0.059	0.002	0.003
Range				0.179	0.131	0.233	0.008	0.012
Root Mean Square Error				0.039	0.031	0.057	0.002	0.003
Total Error				**0.050**		**0.076**	**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)
3001	634896.136	7046370.078	5.067	0.040	-0.014	-0.001	0.015	0.017
3014	635436.874	7045772.980	4.166	0.024	0.007	-0.133	0.014	0.020
3016	635196.738	7045542.124	4.399	0.010	-0.027	-0.106	0.016	0.021
3027	635238.458	7047141.670	22.599	-0.057	-0.004	0.038	0.006	0.009
3029	635187.706	7046806.207	15.796	0.003	-0.015	0.016	0.007	0.012
3030	635298.293	7046279.455	4.245	0.016	0.017	-0.072	0.009	0.011
3033	634874.822	7046573.003	3.577	0.025	0.008	-0.029	0.006	0.008
3042	634659.920	7046820.648	3.985	0.019	0.006	-0.016	0.007	0.010
3045	634753.126	7046594.807	4.538	0.055	0.006	-0.017	0.007	0.012
3055	635189.049	7046200.926	3.931	0.014	0.001	-0.006	0.009	0.012
3058	635151.519	7045970.911	2.926	0.009	0.029	0.005	0.009	0.011
3078	634912.204	7045672.536	3.481	0.035	-0.018	-0.007	0.007	0.011
3087	634887.740	7046139.387	4.517	0.018	0.017	0.027	0.007	0.010
3129	634554.967	7047084.844	4.739	0.028	-0.020	0.044	0.006	0.011
3164	635436.146	7045940.439	4.302	0.021	-0.023	-0.007	0.006	0.007

Point	Easting	Northing	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
3167	635592.549	7046073.400	5.024	0.003	0.001	-0.044	0.007	0.008
			Mean	0.016	-0.002	-0.019	0.009	0.012
			Standard Deviation	0.024	0.016	0.049	0.003	0.004
			Range	0.112	0.055	0.177	0.010	0.013
			Root Mean Square Error	0.023	0.016	**0.048**	0.003	0.004
			Total Error	**0.028**		**0.055**	**0.005**	
				(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