PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR SAINT MICHAEL, ALASKA, COLLECTED JULY 8, 2022

Keith C. Horen, Casey E. Brayton, Jessica E. Christian, Jacquelyn R. Overbeck, Autumn C. Poisson, and Zachary J. Siemsen

Raw Data File 2024-22

Location maps showing the survey area.

2024
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

STATE OF ALASKA
Mike Dunleavy, Governor

DEPARTMENT OF NATURAL RESOURCES
John Boyle, Commissioner

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
Melanie Werdon, State Geologist & Director

Publications produced by the Division of Geological & Geophysical Surveys are available to download from the DGGS website (dggs.alaska.gov). Publications on hard-copy or digital media can be examined or purchased in the Fairbanks office:

Alaska Division of Geological & Geophysical Surveys (DGGS)
3354 College Road | Fairbanks, Alaska 99709-3707
Phone: 907.451.5010 | Fax 907.451.5050
dggspubs@alaska.gov | dggs.alaska.gov

DGGS publications are also available at:

Alaska State Library, Historical
Collections & Talking Book Center
395 Whittier Street
Juneau, Alaska 99801

Alaska Resource Library and
Information Services (ARLIS)
3150 C Street, Suite 100
Anchorage, Alaska 99503

Suggested citation:

Horen, K.C., Brayton, B.E., Christian, J.E., Overbeck, J.R., Poisson, A.C., and Siemsen, Z.J., 2024, Photogrammetry-derived orthoimagery and elevation data for Saint Michael, Alaska, collected July 8, 2022: Alaska Division of Geological & Geophysical Surveys Raw Data File 2024-22, 6 p.
https://doi.org/10.14509/31290

PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR SAINT MICHAEL, ALASKA, COLLECTED JULY 8, 2022

Keith C. Horen[1], Casey E. Brayton[2], Jessica E. Christian[3], Jacquelyn R. Overbeck[1*], Autumn C. Poisson[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 Saint Michael, Alaska, on July 8, 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/10.14509/31290 or elevation.alaska.gov.

LIST OF DELIVERABLES

- Orthoimagery
- Digital Surface Model (DSM)
- Metadata

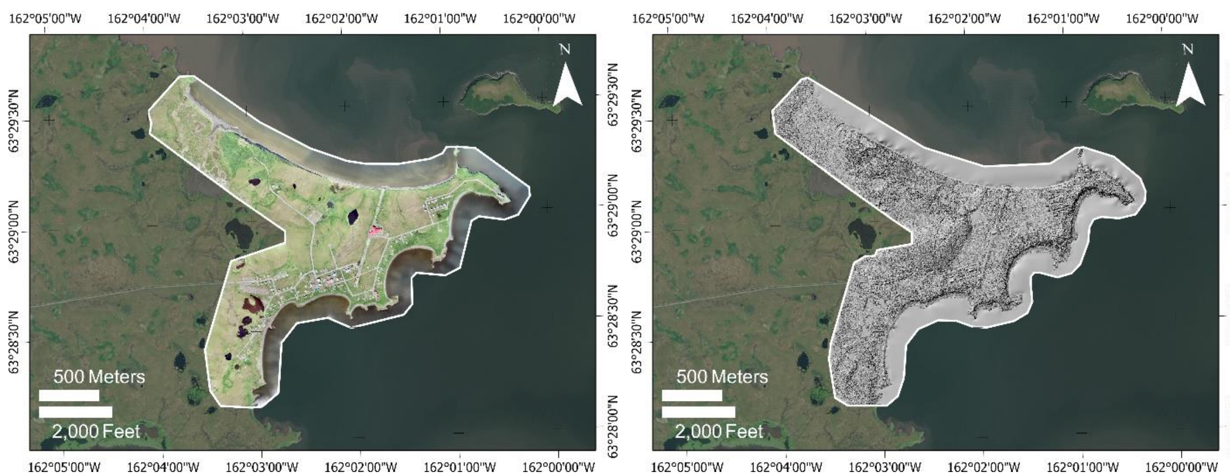

Figure 1. Extent of orthoimage (left) and digital surface model (DSM) (right) for Saint Michael, Alaska.

[1] Alaska Division of Geological & Geophysical Surveys, 3354 College Road, Fairbanks, AK 99709
[2] Lamont-Doherty Earth Observatory, Columbia University, 61 Rte 9W, Palisades, NY 10964
[3] University of Alaska Fairbanks Arctic Coastal Geoscience Lab, P.O. Box 755780, Fairbanks, AK 99775
*Now at NOAA Office for Coastal Management, 2234 South Hobson Ave., Charleston, South Carolina 29405
** Now at Dewberry, 8401 Arlington Blvd., Fairfax, Virginia 22031
*** Now at PND Engineers, Inc., 1506 W 36th Ave., Anchorage, Alaska 99503

METHODS

Aerial Photogrammetric Survey Details

DGGS conducted flights on July 8, 2022, from approximately 2:30 PM to 7:15 PM AKDT. DGGS used a DJI Phantom 4 RTK UAV with a FC6310R camera model (8.8 mm lens) to collect 1,935 20-megapixel JPEG photographs (5,472 x 3,648 pixels per image). The operator returned the UAV 10 times to change batteries. DGGS flew the aerial survey with 70 percent sidelap and 70 percent frontlap, 112 m above ground-level at 9.0 m/s, with nadir orientation stabilized using a three-axis gimbal. This resulted in images covering 3.675 km^2 with a ground sampling distance (GSD) of 0.024 m. The weather throughout the survey was clear with light wind. No abnormalities were observed during the flights.

Ground Survey Details

On July 8, 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 25 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 13 GCPs for photograph alignment and lens distortion parameter optimization (fig. 2, table 2), leaving 12 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.

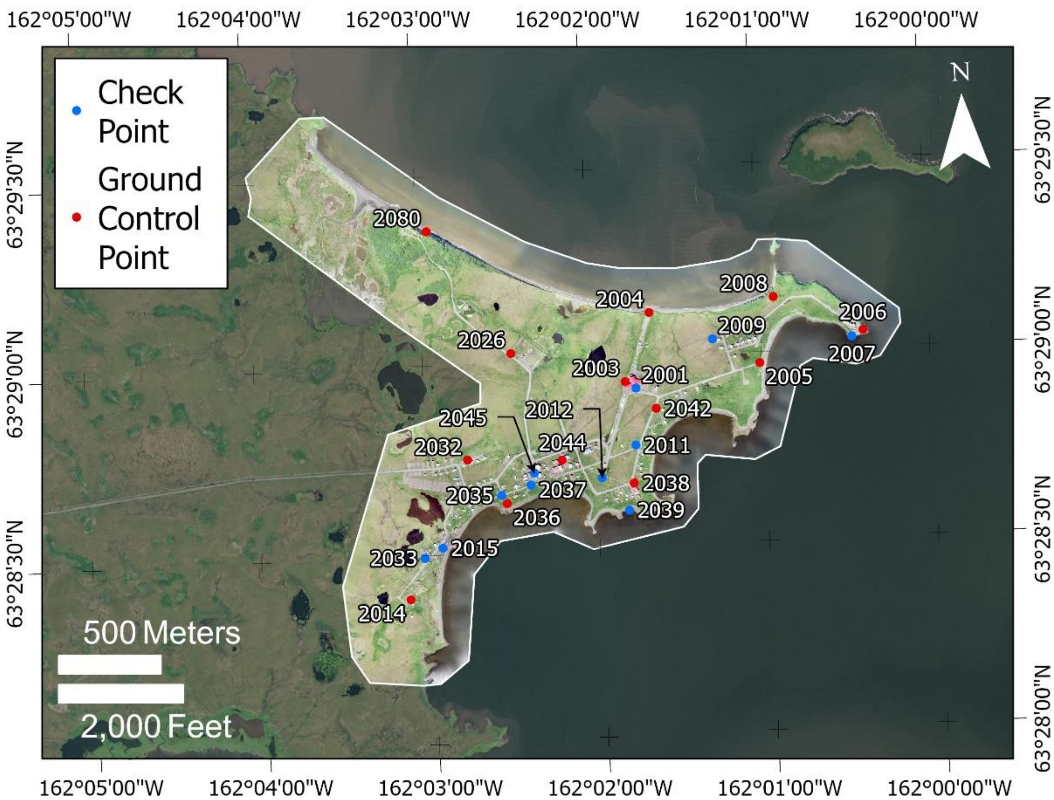

Figure 2. Location of photo-identifiable ground control points (GCP; red) and check points (CHK; blue).

IMAGERY PRODUCTS

Orthoimagery

The orthoimage is a three-band (red, green, blue), eight-bit unsigned GeoTIFF file derived from a color-adjusted mosaic of 1,864 aerial photographs with a GSD of 0.024 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 0.071 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.

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 12 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 12 check points used to quantify the horizontal accuracy (fig. 2, table 3). The RMS error of Z offsets is 0.025 m. The total RMS error of the DSM (X, Y, and Z) is 0.053 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)
647364.062	7042625.528	25.616	0.005	0.006	0.068

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)
2003	647905.222	7042756.234	10.034	-0.015	-0.007	-0.018	0.007	0.011
2004	648021.427	7043094.381	8.839	-0.013	-0.001	0.027	0.008	0.011
2005	648566.085	7042848.388	8.201	0.016	-0.031	-0.001	0.008	0.012
2006	649070.882	7043012.325	11.249	0.014	0.003	-0.010	0.010	0.014
2008	648630.327	7043172.779	19.425	0.014	-0.022	0.005	0.011	0.015
2014	646855.417	7041685.415	6.334	0.003	0.011	0.059	0.009	0.014
2026	647343.361	7042894.496	7.560	-0.052	-0.027	0.011	0.007	0.011
2032	647131.552	7042369.881	9.220	0.013	0.029	0.007	0.009	0.012

Point	Easting	Northing	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
2036	647327.885	7042156.734	7.123	0.001	0.015	-0.003	0.011	0.014
2038	647949.980	7042258.164	11.415	0.066	0.019	-0.013	0.011	0.016
2042	648056.865	7042623.869	11.472	-0.039	0.028	0.010	0.010	0.013
2044	647596.589	7042369.997	9.534	0.002	-0.013	0.007	0.009	0.019
2080	646929.287	7043491.054	2.592	-0.011	-0.004	0.065	0.008	0.014
Mean				0.000	0.000	0.011	0.009	0.013
Standard Deviation				0.029	0.020	0.025	0.001	0.002
Range				0.118	0.060	0.082	0.004	0.008
Root Mean Square Error				0.028	0.019	0.024	0.001	0.002
Total Error				**0.034**		**0.042**	**0.003**	
				(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)
2001	647957.383	7042723.290	11.451	-0.052	0.038	0.011	0.012	0.012
2002	647890.947	7042639.800	11.422	-0.022	-0.003	-0.001	0.007	0.010
2007	649016.844	7042981.488	3.597	-0.038	0.051	-0.002	0.011	0.016
2009	648331.934	7042965.230	7.993	0.023	-0.056	0.061	0.010	0.014
2011	647956.860	7042444.872	9.662	-0.025	0.013	-0.017	0.009	0.013
2012	647793.436	7042283.362	11.359	0.031	0.044	-0.014	0.008	0.010
2015	647011.955	7041938.779	3.167	0.068	0.047	0.003	0.007	0.011
2033	646925.581	7041889.279	4.296	0.002	0.032	0.026	0.009	0.011
2035	647298.445	7042197.233	8.493	0.005	0.080	-0.001	0.011	0.014
2037	647442.284	7042249.012	9.027	0.010	0.048	-0.008	0.011	0.015
2039	647925.066	7042125.683	1.442	-0.023	0.044	-0.051	0.011	0.015
2045	647459.957	7042306.729	10.164	0.023	0.042	0.007	0.010	0.015
Mean				0.000	0.032	0.001	0.010	0.013
Standard Deviation				0.034	0.034	0.026	0.002	0.002
Range				0.120	0.136	0.111	0.005	0.005
Root Mean Square Error				0.032	0.033	**0.025**	0.002	0.002
Total Error				**0.046**		**0.053**	**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

We thank the Native Village and City of Saint Michael for supporting the creation of these data products, made possible with National Fish and Wildlife Foundation's National Coastal Resilience Funding through our partners at the Alaska Native Tribal Health Consortium. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the Alaska Division of Geological & Geophysical Surveys, the U.S. Government, or the National Fish and Wildlife Foundation and its funding sources. Mention of trade names or commercial products does not constitute their endorsement by the Alaska Division of Geological & Geophysical Surveys, the U.S. Government, or the National Fish and Wildlife Foundation and its funding sources.

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