PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR CHEFORNAK, ALASKA, COLLECTED AUGUST 18, 2022

Keith C. Horen, Jessica E. Christian, Nadine M. Doiron, Autumn C. Poisson, and Zachary J. Siemsen

Raw Data File 2024-26

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., Christian, J.E., Doiron, N.M., Poisson, A.C., and Siemsen, Z.J., 2024, Photogrammetry-derived orthoimagery and elevation data for Chefornak, Alaska, collected August 18, 2022: Alaska Division of Geological & Geophysical Surveys Raw Data File 2024-26, 6 p.
https://doi.org/10.14509/31294

PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR CHEFORNAK, ALASKA, COLLECTED AUGUST 18, 2022

Keith C. Horen[1], Jessica E. Christian[2], Nadine M. Doiron[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 Chefornak, Alaska, on August 18, 2022. 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/10.14509/31294 or elevation.alaska.gov.

LIST OF DELIVERABLES

- Orthoimagery
- Digital Surface Model (DSM)
- Metadata

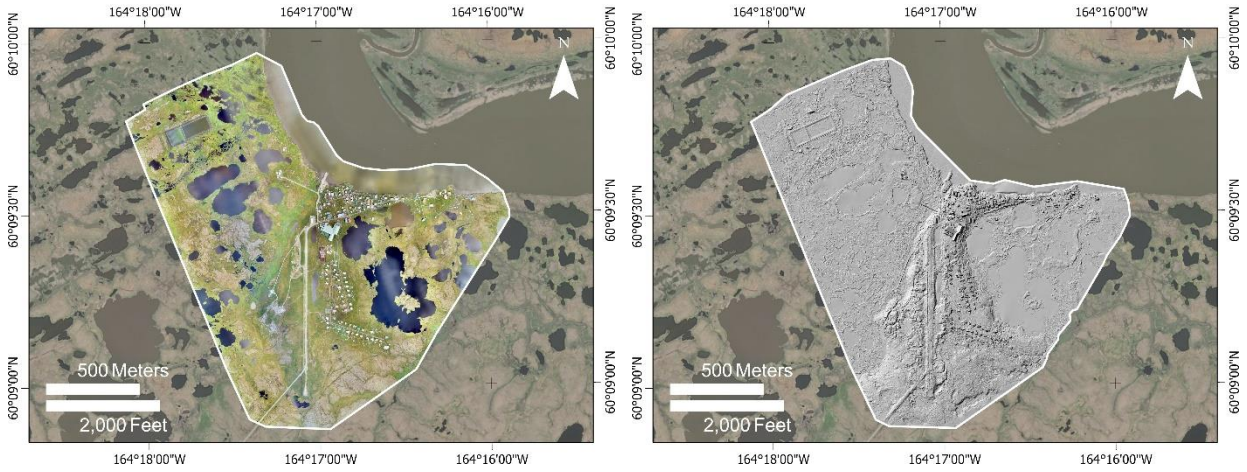

Figure 1. Extent of orthoimage (left) and digital surface model (DSM) (right) for Chefornak, Alaska.

[1] Alaska Division of Geological & Geophysical Surveys, 3354 College Road, Fairbanks, AK 99709

[2] University of Alaska Fairbanks Arctic Coastal Geoscience Lab, P.O. Box 755780, Fairbanks, AK 99775

** 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 August 18, 2022, from approximately 10:15 AM to 1:00 PM AKDT using a DJI Phantom 4 RTK UAV with a FC6310R camera model (8.8 mm lens) to collect 1,306 20-megapixel JPEG photographs (5,472 x 3,648 pixels per image). The operator returned the UAV seven times to change batteries. DGGS flew the aerial survey with 70 percent sidelap and 70 percent frontlap, 110 m above ground-level at 9.5 m/s, with nadir orientation stabilized using a three-axis gimbal. This resulted in images covering 2.383 km^2 with a ground sampling distance (GSD) of 0.022 m. The weather throughout the survey was mostly cloudy with light wind. No abnormalities were observed during the flights.

Ground Survey Details

On August 18, 2022, DGGS staff set up a Global Navigation Satellite System (GNSS) base station using a Trimble R10 receiver sampling at 5 Hz over known tidal benchmark 946 6084 D, a stainless-steel rod in a lidded case, with a published solution found at https://www.ngs.noaa.gov/OPUS/getDatasheet.jsp?PID=BBHK19&ts=21202103238. This provided real-time kinematic (RTK) corrections to the ground rover, a Trimble R8s GNSS receiver. DGGS measured the location of 33 photo-identifiable ground control points (GCPs) with the ground rover.

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 17 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.

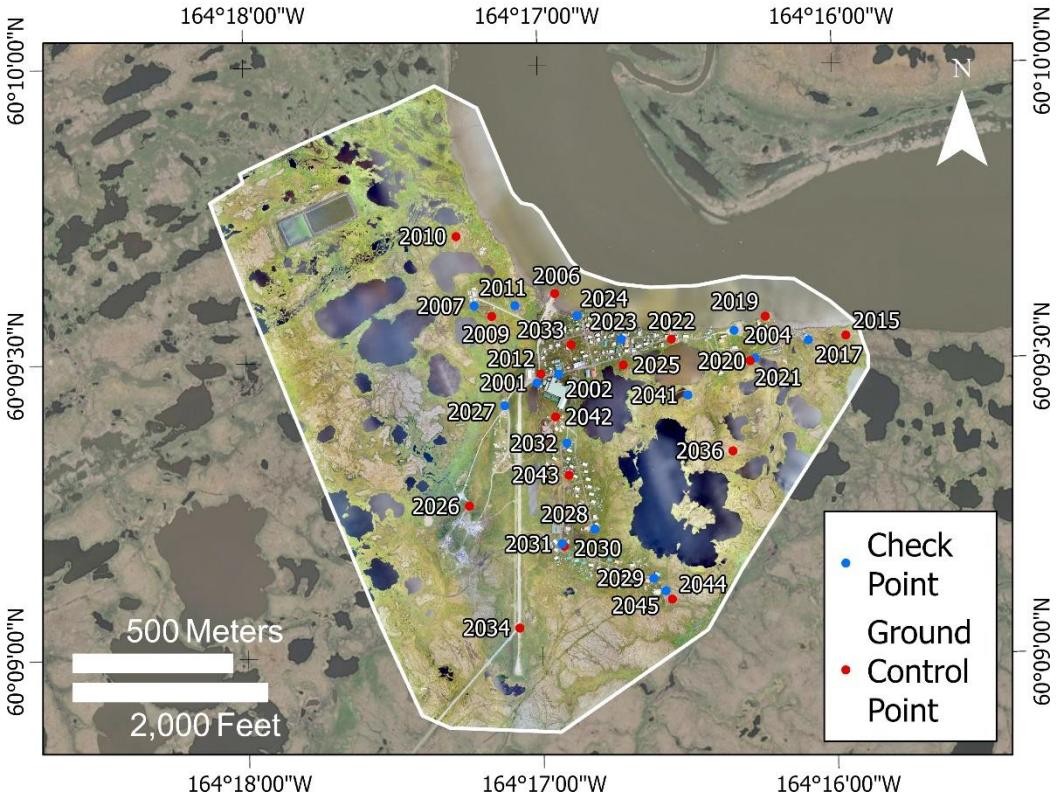

Figure 2. Location of photo-identifiable ground control points (GCP; red) and check points (CHK; blue).

IMAGERY PRODUCTS

Orthoimagery

The orthoimage is a three-band (red, green, blue), eight-bit unsigned GeoTIFF file derived from a color-adjusted mosaic of 1,276 aerial photographs with a GSD of 0.022 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 0.062 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 check points not used during processing. X and Y errors are calculated as the root-mean-square (RMS) error of offsets, 0.022 m and 0.038 m, respectively. The total horizontal error is the root-sum-square error of X and Y RMS errors, 0.044 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 0.025 m. 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)
539646.500	6668795.998	12.031	0.015	0.027	0.073

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

Point	Northing	Easting	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
2006	539828.385	6669473.270	5.577	-0.012	0.016	0.022	0.008	0.012
2009	539630.685	6669400.639	6.730	0.004	-0.009	-0.035	0.008	0.013
2010	539518.426	6669652.115	4.382	-0.025	-0.007	-0.017	0.009	0.015
2012	539785.528	6669220.127	3.405	0.001	-0.007	0.011	0.009	0.012
2015	540743.701	6669342.252	3.913	0.032	0.011	0.000	0.009	0.011
2019	540490.691	6669401.713	3.705	-0.036	0.005	-0.047	0.009	0.012
2021	540443.633	6669261.885	3.215	-0.002	0.008	0.026	0.008	0.011
2022	540195.740	6669329.917	3.620	0.009	-0.046	-0.001	0.008	0.011
2025	540043.849	6669248.581	3.627	0.031	0.003	0.007	0.007	0.010

Point	Northing	Easting	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
2026	539560.196	6668804.623	4.030	0.071	-0.074	-0.016	0.007	0.009
2030	539858.939	6668678.901	3.342	-0.001	0.016	0.003	0.007	0.010
2033	539880.780	6669311.704	3.056	0.000	0.004	0.019	0.008	0.009
2034	539719.248	6668422.264	5.717	0.066	-0.011	-0.020	0.007	0.009
2036	540389.310	6668979.033	3.689	0.021	0.034	0.012	0.007	0.010
2042	539831.207	6669085.789	3.401	-0.029	-0.028	0.024	0.008	0.009
2043	539873.473	6668902.497	2.968	-0.008	-0.006	0.018	0.008	0.009
2044	540198.775	6668512.992	4.097	-0.048	-0.010	-0.004	0.009	0.011
			Mean	0.004	-0.006	0.000	0.008	0.011
			Standard Deviation	0.032	0.025	0.021	0.001	0.002
			Range	0.119	0.107	0.073	0.003	0.006
			Root Mean Square Error	0.031	0.024	0.021	0.001	0.002
			Total Error	**0.040**		**0.045**	**0.002**	
				(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	539773.304	6669192.767	7.450	0.038	0.079	0.042	0.006	0.008
2002	539841.232	6669218.727	9.310	-0.025	0.049	0.036	0.007	0.008
2004	540393.029	6669357.311	2.820	0.001	-0.043	0.001	0.007	0.010
2007	539575.316	6669433.915	3.050	0.036	-0.030	-0.025	0.008	0.012
2011	539703.535	6669435.136	2.589	0.006	0.018	0.009	0.009	0.012
2017	540626.303	6669327.789	3.364	-0.005	0.023	-0.013	0.010	0.012
2020	540457.950	6669270.316	3.530	-0.013	-0.012	-0.070	0.007	0.009
2023	540037.571	6669328.742	7.263	-0.021	0.006	-0.008	0.008	0.011
2024	539898.834	6669403.617	3.189	0.018	0.088	-0.006	0.007	0.010
2027	539671.641	6669120.062	5.615	-0.008	0.010	0.005	0.007	0.010
2028	539955.006	6668732.962	9.037	-0.018	0.007	0.000	0.007	0.009
2029	540140.377	6668578.220	7.725	-0.031	-0.012	0.011	0.007	0.010
2031	539851.692	6668686.000	11.283	-0.014	0.001	0.004	0.007	0.010
2032	539867.789	6669002.531	8.488	0.022	-0.013	0.017	0.008	0.011
2041	540247.935	6669154.346	4.264	-0.024	-0.038	0.025	0.008	0.010
2045	540178.367	6668539.294	7.346	-0.037	-0.035	-0.005	0.009	0.012
			Mean	-0.005	0.006	0.001	0.008	0.010
			Standard Deviation	0.023	0.039	0.026	0.001	0.001

Point	Easting	Northing	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
			Range	0.075	0.131	0.112	0.004	0.004
			Root Mean Square Error	0.022	0.038	**0.025**	0.001	0.001
			Total Error	**0.044**		**0.050**	**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 Chefornak 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