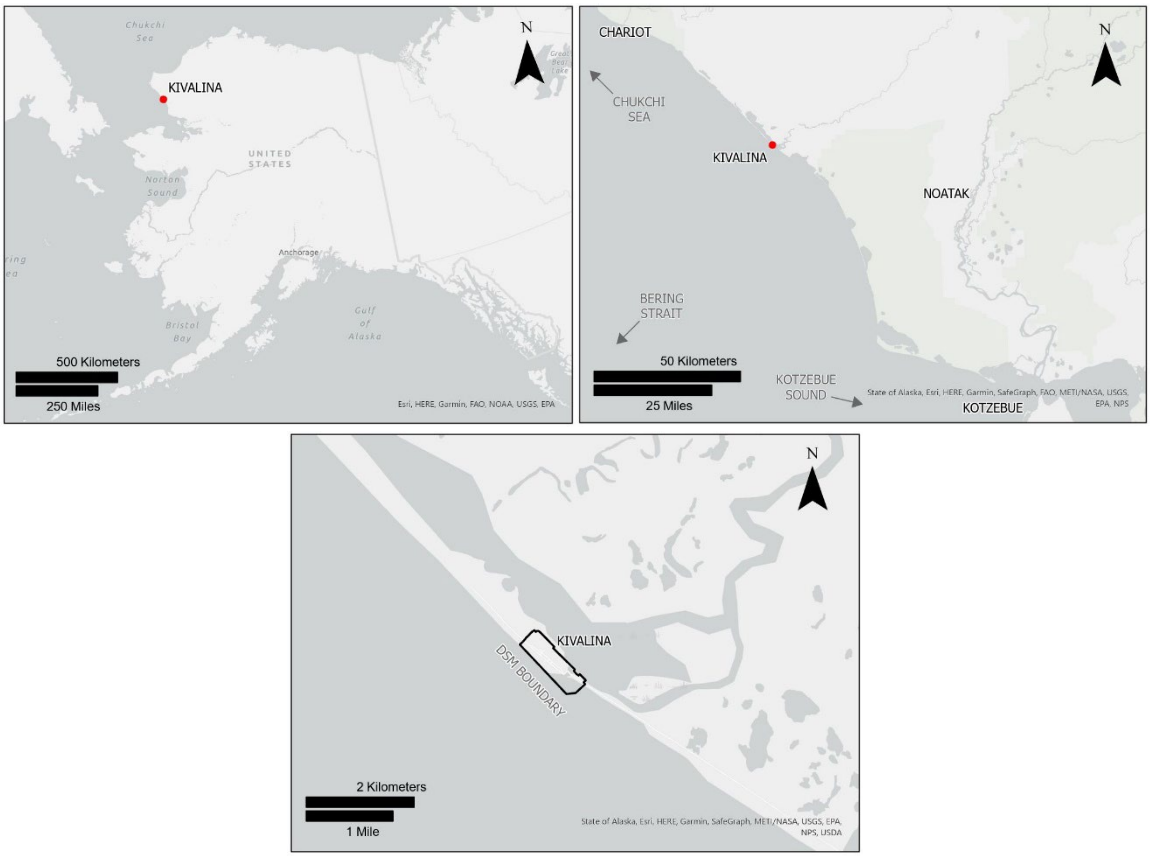
PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR KIVALINA, ALASKA, COLLECTED JUNE 7, 2022

Keith C. Horen, and Zachary J. Siemsen

Raw Data File 2022-12



Location map of survey area

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

2022
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR KIVALINA, ALASKA, COLLECTED JUNE 7, 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) on June 7, 2022 and used Structure-from-Motion (SfM) photogrammetry to produce a digital surface model (DSM) and orthoimagery for the community of Kivalina, Alaska (fig. 1). The orthoimage and elevation data are for assessing coastal hazards and changes. We used Trimble Business Center to process the Global Navigation Satellite System (GNSS) data used for positional control and NOAA VDatum to adjust elevation data. We used Agisoft Metashape to process photogrammetry data. These products are released as a Raw Data File with an open end-user license. All files can be downloaded from https://doi.org/10.14509/30902 or elevation.alaska.gov.

LIST OF DELIVERABLES

- Orthoimagery
- Digital Surface Model (DSM)
- Metadata

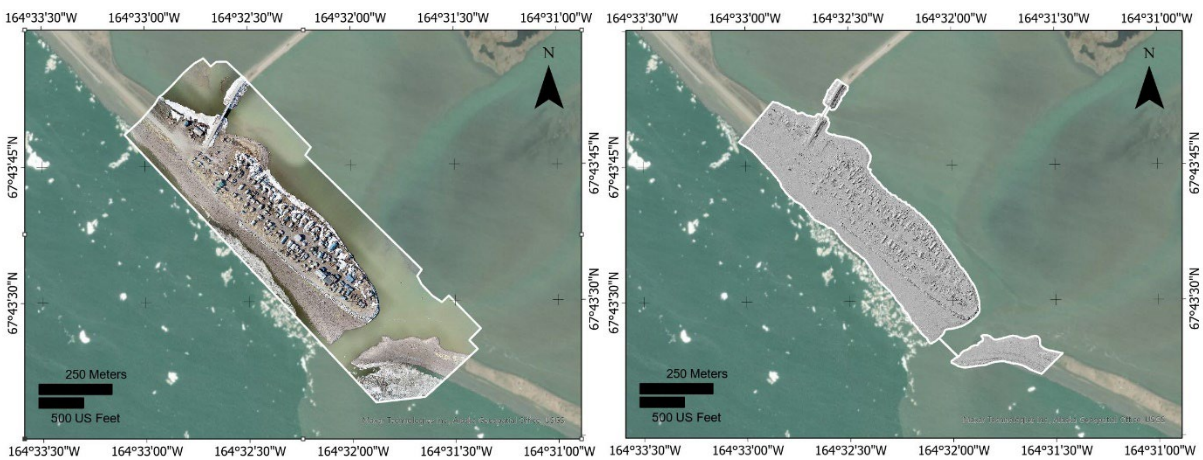

Figure 1. Extent of orthoimage (left) and digital surface model (DSM) (right) for Kivalina.

MISSION PLAN

Aerial Photogrammetric Survey Details

DGGS used a DJI Phantom 4 RTK UAV with a FC6310R camera model (8.8 mm lens) to collect 20-megapixel JPEG photographs (5472 x 3648 pixels per image). We flew the aerial survey with 70 percent sidelap and 80 percent frontlap, 91 m above ground-level at 6.5 m/s, with nadir

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orientation stabilized using a 3-axis gimbal. This resulted in images covering 0.56 km^2 with ground sampling distance (GSD) of 0.016 m.

Weather and Photo Conditions

DGGS conducted flights on June 7, 2022, from approximately 7:45 PM to 8:30 PM AKDT. The operator returned the UAV two times to change batteries. The weather throughout the survey was clear with light wind. No abnormalities were observed during the flights.

SURVEY AND PROCESSING REPORT

Ground Survey Details

DGGS set up a GNSS base station using the Trimble R10 receiver sampling at 5 Hz. The base was installed over known benchmark KVL A with a published solution (found at https://www.ngs.noaa.gov/cgi-bin/ds_mark.prl?PidBox=DN5562). This provided real-time kinematic (RTK) corrections to the Trimble R8s GNSS receiver (ground rover). The corrected base position was derived using the Canadian Spatial Reference System Precision Point Positioning (CSRS-PPP) service (found at https://webapp.csrs-scrs.nrcan-rncan.gc.ca/geod/tools-outils/ppp.php). The R8s' positions were updated using post-processed kinematic (PPK) corrections in Trimble Business Center. DGGS measured 19 photo-identifiable ground control points (GCPs) with the ground rover, 11 of which were utilized for georeferencing during processing (fig. 2). The remaining eight were reserved for quality control checks.

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

Photogrammetric Dataset Processing

During the survey, the UAV maintained RTK connection. Within the UAV GNSS receiver settings, the lever arm correction is automatically applied and camera GNSS coordinates are written to the image metadata in WGS84 ellipsoid. Yaw, pitch, and roll information are not written to the image metadata. During processing we update UAV positions using an X, Y, and Z shift from the initial to corrected base position.

DGGS processed using Agisoft Metashape Professional software (Version 1.6.3 build 10732). We masked image corners where shadows and image warping were disruptive. Processing steps included aligning images, identifying GCPs, manually cleaning sparse point cloud, optimizing the bundle block adjustment (refining camera position and lens distortion parameters), constructing the dense point cloud, building the DSM, and creating the orthomosaic image. During processing, we used 11 GCPs to create the model, leaving eight GCPs as horizontal and vertical check points.

Orthoimagery

The orthoimage is a three-band (red, green, blue), 8-bit unsigned GeoTIFF file with a GSD of 0.016 m per pixel; the "No Data" value is set to 256.

Digital Surface Model

The DSM represents surface elevations such as the height of vegetation and buildings. We filtered the dense cloud to remove low confidence points with less than three contributing image renderings containing distance information. Since water bodies can introduce noise, we manually delineated the beach boundaries to restrict the DSM to land only. Boundaries were identified using both visual selection from collected aerial images and point confidence. The DSM is a single-band, 32-bit floating point GeoTIFF file with a GSD of 0.031 m; the "No Data" value is set to $-3.4028231 \times 10^{38}$.

ACCURACY REPORT

Coordinate System and Datum

All data were processed and delivered in NAD83 (2011) UTM Zone 3N and vertical datum NAVD88 (GEOID12B).

Horizontal Accuracy

We quantify the horizontal accuracy of the DSM and orthoimage by comparing the known locations of eight photo-identifiable check points measured with GNSS against their modeled locations in the photogrammetric products (fig. 2). These are independent checkpoints not used in processing. X and Y errors are calculated as the root-mean-square (RMS) error of offsets. The total horizontal error is the root-sum-square error of X and Y RMS errors, 0.042 m (table 1).

Vertical Accuracy

We assess the vertical accuracy of the DSM using the same check points. The RMS error of Z offsets is 0.066 m (table 1). The total error of the DSM (X, Y, and Z) is 0.078 m.

Data Consistency and Completeness

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

Table 1. Check point coordinates and offsets from orthoimagery and DSM.

Check Point	Easting	Northing	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
2027	519623.769	7512554.409	2.936	-0.026	-0.025	0.058	0.007	0.012
2029	519486.498	7512416.285	3.529	-0.049	-0.002	-0.111	0.006	0.011
2042	519454.544	7512585.157	4.108	-0.033	-0.015	-0.023	0.006	0.010
2044	519411.094	7512703.023	3.544	-0.009	0.010	0.044	0.006	0.010
2046	519318.877	7512580.320	3.564	-0.013	0.026	0.010	0.006	0.010
2056	519299.436	7512731.805	4.606	-0.041	0.039	-0.006	0.007	0.010
2058	519291.887	7512893.915	7.540	-0.076	0.031	-0.121	0.009	0.014
2062	519113.576	7512835.942	4.848	0.040	0.061	0.053	0.007	0.013
Mean				-0.026	0.016	-0.012	0.007	0.011
Standard Deviation				0.034	0.029	0.070	0.001	0.001
Range				0.116	0.085	0.179	0.003	0.004
Root Mean Square Error				0.032	0.027	0.066	0.001	0.001
Total Error				**0.042**		**0.078**	**0.001**	
				(XY)		**(XYZ)**	**(XYZ)**	

ACKNOWLEDGMENTS

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