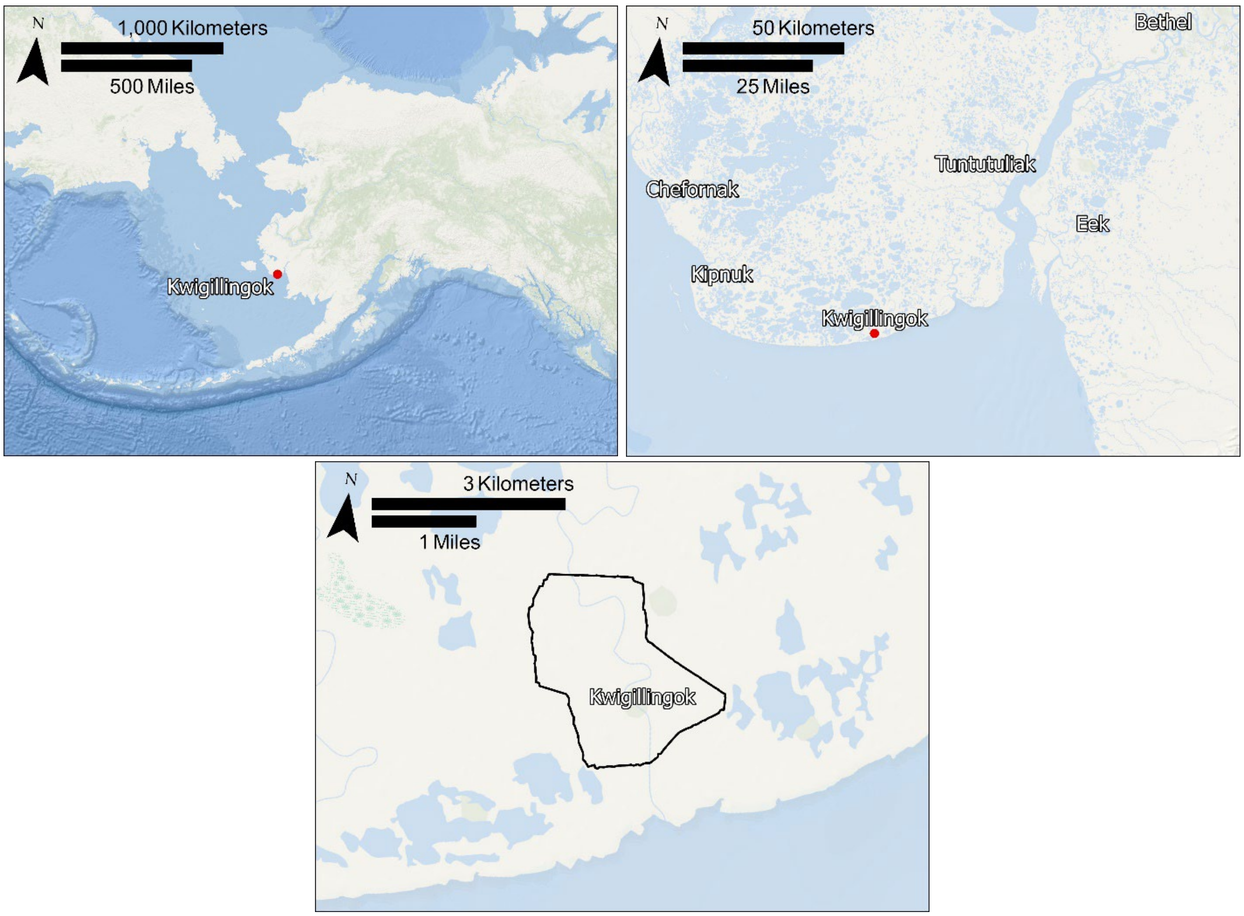
PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR KWIGILLINGOK, ALASKA, COLLECTED JUNE 18-19, 2022

Keith C. Horen, Richard M. Buzard, Jacquelyn R. Overbeck, Autumn C. Poisson, and Zachary J. Siemsen

Raw Data File 2024-21



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
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., Buzard, R.M., Overbeck, J.R., Poisson, A.C., and Siemsen, Z.J., 2024, Photogrammetry-derived orthoimagery and elevation data for Kwigillingok, Alaska, collected June 18-19, 2022: Alaska Division of Geological & Geophysical Surveys Raw Data File 2024-21, 7 p. https://doi.org/10.14509/31289

PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR KWIGILLINGOK, ALASKA, COLLECTED JUNE 18-19, 2022

Keith C. Horen[1], Richard M. Buzard[2*], 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 Kwigillingok, Alaska, on June 18 and 19, 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/10.14509/31289 or elevation.alaska.gov.

LIST OF DELIVERABLES

- Orthoimagery
- Digital Surface Model (DSM)
- Metadata

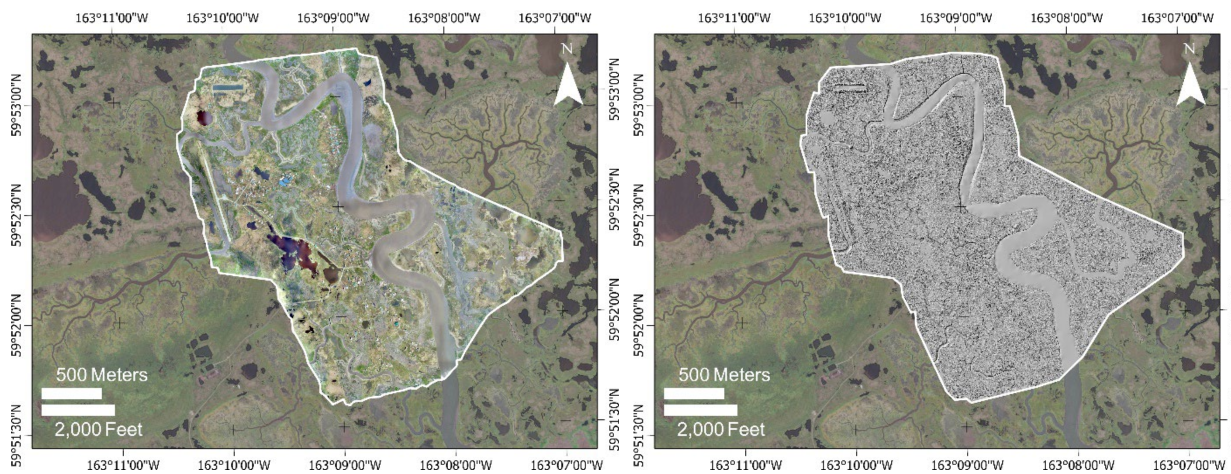


Figure 1. Extent of orthoimage (left) and digital surface model (DSM) (right) for Kwigillingok, Alaska.

[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 U.S. Geological Survey, 2885 Mission St., Santa Cruz, California 95060*
*** 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 June 18 and 19, 2022, from approximately 9:00 AM to 6:00 PM and 11:15 AM to 5:00 PM AKDT, respectively. DGGS used a DJI Phantom 4 RTK UAV with a FC6310R camera model (8.8 mm lens) to collect 3,673 20-megapixel JPEG photographs (5,472 x 3,648 pixels per image). The operator returned the UAV 16 times to change batteries. DGGS flew the aerial survey with 70 percent sidelap and 80 percent frontlap, 122 m above ground-level at 7.9 m/s, with nadir orientation stabilized using a three-axis gimbal. This resulted in images covering 5.567 km^2 with a ground sampling distance (GSD) of 0.024 m. The weather throughout the survey was mostly sunny with light wind. No abnormalities were observed during the flights.

Ground Survey Details

On June 18, 2022, DGGS set up a Global Navigation Satellite System (GNSS) base station using a Trimble R10 receiver sampling at 5 Hz over known tidal benchmark 946 5911 B, a stainless-steel rod in a case with a published solution found at www.ngs.noaa.gov/OPUS/getDatasheet.jsp?PID=BBGM53&ts=19297165248. This provided real-time kinematic (RTK) corrections to the ground rover, a Trimble R8s GNSS receiver. DGGS measured the location of 39 photo-identifiable ground control points (GCP) 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 20 GCPs for photograph alignment and lens distortion parameter optimization (fig. 2, table 2), leaving 19 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.

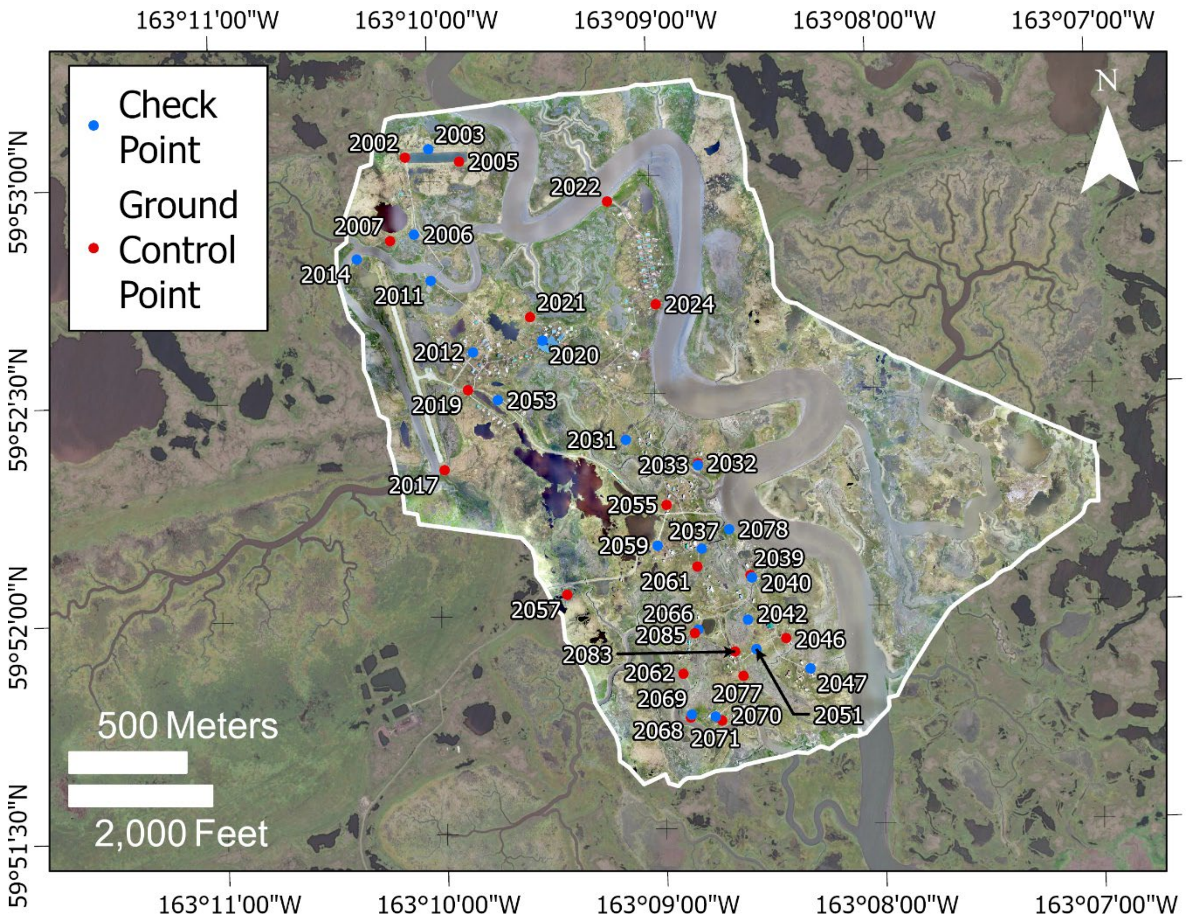


Figure 2. Location of photo-identifiable ground control points (GCP; red) and check points (CHK; blue).

IMAGERY PRODUCTS

Orthoimagery

The orthoimage is a three-band (red, green, blue), eight-bit unsigned GeoTIFF file derived from a color-adjusted mosaic of 3,663 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 0.067 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 19 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 0.017 m, respectively. The total horizontal error is the root-sum-square error of X and Y RMS errors, 0.036 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 19 check points used to quantify the horizontal accuracy (fig. 2, table 3). The RMS error of Z offsets is 0.035 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)
602670.520	6639531.038	4.111	0.005	0.014	0.071
604236.993	6637715.523	3.669	0.005	0.014	0.063

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	602505.901	6639941.995	6.721	0.008	0.051	0.060	0.007	0.008
2005	602735.973	6639925.089	5.136	-0.024	-0.045	0.053	0.007	0.008
2007	602442.661	6639587.028	3.570	0.069	-0.036	-0.071	0.007	0.008
2017	602675.321	6638610.782	3.415	0.008	-0.058	-0.016	0.009	0.012
2019	602774.709	6638950.948	4.077	-0.005	-0.058	0.034	0.010	0.012
2021	603039.088	6639262.023	3.688	0.015	-0.021	0.043	0.011	0.014
2022	603365.780	6639755.021	3.377	0.016	-0.031	-0.003	0.009	0.013
2024	603573.843	6639318.021	3.953	-0.028	-0.035	0.020	0.007	0.010
2032	603753.472	6638639.947	3.680	-0.003	-0.031	0.019	0.007	0.009
2039	603979.208	6638164.049	3.580	0.021	-0.032	0.011	0.007	0.010
2046	604129.983	6637894.218	3.607	0.055	-0.049	0.033	0.007	0.011
2055	603619.605	6638462.758	3.629	0.025	-0.042	0.017	0.007	0.009
2057	603197.671	6638078.735	3.522	0.057	0.056	0.035	0.007	0.009
2061	603751.348	6638200.054	3.478	0.068	-0.040	-0.014	0.008	0.010
2062	603692.641	6637743.378	3.182	0.026	-0.001	-0.012	0.009	0.014
2068	603725.027	6637555.770	3.518	0.004	-0.061	-0.018	0.007	0.010
2070	603858.684	6637542.992	3.435	-0.002	-0.023	-0.044	0.007	0.009
2077	603949.171	6637734.861	3.848	0.017	-0.046	-0.050	0.006	0.008
2083	603913.755	6637836.946	3.468	-0.014	-0.060	-0.081	0.016	0.023
2085	603741.094	6637916.754	3.324	-0.015	-0.054	-0.059	0.019	0.027
Mean				0.015	-0.031	-0.002	0.009	0.012
Standard Deviation				0.029	0.032	0.042	0.003	0.005
Range				0.097	0.117	0.142	0.013	0.020
Root Mean Square Error				0.028	0.032	0.041	0.003	0.005
Total Error				**0.042**		**0.059**	**0.006**	
				(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)
2003	602604.675	6639977.292	5.503	0.055	0.001	0.036	0.007	0.008
2006	602543.554	6639614.520	4.004	-0.009	-0.034	0.056	0.007	0.008
2011	602614.467	6639417.325	3.392	0.037	-0.051	0.047	0.007	0.009
2012	602794.955	6639112.891	4.442	0.007	-0.036	0.052	0.008	0.009
2014	602300.685	6639507.145	3.563	-0.037	-0.066	0.050	0.008	0.010

Point	Easting	Northing	Elevation	X Offset (m)	Y Offset (m)	Z Offset (m)	GNSS X/Y Error (m)	GNSS Z Error (m)
2020	603092.091	6639163.744	4.590	-0.041	-0.051	0.043	0.012	0.015
2031	603447.866	6638739.925	4.287	0.002	-0.040	0.053	0.007	0.009
2033	603753.640	6638632.170	3.536	-0.042	-0.050	0.021	0.007	0.009
2037	603771.924	6638276.292	3.493	0.014	-0.025	-0.002	0.007	0.010
2040	603985.122	6638152.117	3.494	0.016	-0.049	0.022	0.007	0.010
2042	603968.458	6637972.330	3.241	-0.007	-0.054	-0.018	0.007	0.011
2047	604235.367	6637766.191	3.440	0.000	-0.020	0.004	0.008	0.012
2051	604003.604	6637848.689	3.735	0.032	-0.062	-0.002	0.007	0.009
2053	602901.194	6638907.822	3.933	0.014	-0.041	0.039	0.005	0.006
2059	603583.286	6638289.508	4.021	0.063	-0.016	0.063	0.007	0.009
2066	603755.726	6637931.278	3.445	0.050	-0.029	-0.019	0.009	0.014
2069	603729.165	6637568.616	3.394	0.007	-0.046	-0.047	0.007	0.009
2071	603830.143	6637561.103	3.418	0.041	-0.057	-0.049	0.007	0.009
2078	603887.512	6638358.176	3.428	-0.035	-0.029	-0.026	0.007	0.009
			Mean	0.009	-0.040	0.017	0.007	0.010
			Standard Deviation	0.033	0.017	0.036	0.001	0.002
			Range	0.105	0.067	0.112	0.007	0.009
			Root Mean Square Error	0.032	0.017	0.035	0.001	0.002
			Total Error	**0.036**		**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 of Kwigillingok 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