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.

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

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DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
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PHOTOGRAMMETRY-DERIVED ORTHOIMAGERY AND ELEVATION DATA FOR SAINT MICHAEL, ALASKA, COLLECTED JULY 8, 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 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](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.

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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 1,935,250-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 sidelay 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 km² 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 5.5.1) 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.

<table>
<thead>
<tr>
<th>NAD83 (2011) Easting</th>
<th>NAD83 (2011) Northing</th>
<th>NAVD88 Elevation</th>
<th>GNSS X Error (m)</th>
<th>GNSS Y Error (m)</th>
<th>GNSS Z Error (m)</th>
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<td>0.006</td>
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**Table 2.** Ground control point coordinates and offsets from orthoimagery and DSM.

<table>
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<tr>
<th>Point</th>
<th>Easting</th>
<th>Northing</th>
<th>Elevation</th>
<th>X Offset (m)</th>
<th>Y Offset (m)</th>
<th>Z Offset (m)</th>
<th>GNSS X/Y Error (m)</th>
<th>GNSS Z Error (m)</th>
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<td>0.027</td>
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<tr>
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<td>Northing</td>
<td>Elevation</td>
<td>X Offset (m)</td>
<td>Y Offset (m)</td>
<td>Z Offset (m)</td>
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<td>0.003</td>
</tr>
</tbody>
</table>

Table 3. Check point coordinates and offsets from orthoimagery and DSM.
**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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