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PHOTOGRAMMETRY-DERIVED DIGITAL SURFACE MODEL AND ORTHOIMAGERY OF LAND AREAS NEAR RESURRECTION BAY, ALASKA

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ABSTRACT

The State of Alaska Division of Geological & Geophysical Surveys (DGGS) produced a digital surface model (DSM) and an orthorectified aerial optical image mosaic (orthoimagery) of the Resurrection Bay watershed, surrounding the city of Seward in south-central Alaska (fig. 1). Aerial photographs and Global Navigation Satellite System (GNSS) data were collected on August 13, 2015, and were processed using Structure-from-Motion (SfM) photogrammetric techniques to create the DSM and orthoimagery. The project was part of an ongoing investigation of the impact of flooding, slope instability, and cryosphere hazards on infrastructure and public safety. For the purpose of enabling open access to geospatial datasets in Alaska, this collection is being released as a Raw Data File with an open end-user license. All files can be downloaded free of charge from the DGGS website (http://doi.org/10.14509/29824).

DATA ACQUISITION

The State of Alaska Division of Geological & Geophysical Surveys contracted the collection of digital aerial photographic data on August 13, 2015. The aerial photography survey used a fixed-wing airborne platform and was planned so flight lines and photograph frequency provided 60 percent side lap and 80 percent end lap coverage, with an average above-sea-level flying height of 1260 m. The aerial photography survey covered 383 km^2, resulting in 4021 photos with 0.2 m ground sample distance (GSD).

A Nikon D800 camera with AF-Nikkor 28mm f/2.8D lens was used to collect 36.2-megapixel JPEG photographs (7360 x 4912 pixels per image) which were compressed for optimal quality. During the aerial survey, the photograph coordinates were determined using an OxTS GPS-IMU system and a Cirrus Digital Systems intervalometer that linked the camera shutter release to the GPS-IMU. The camera was mounted inside the aircraft with the GPS antenna positioned over the camera. The GPS antenna offset (X=0.3, Y=0.0, Z=0.94) was corrected during GPS post-processing to solve for the camera coordinates. A Trimble 5700 GPS receiver with a Trimble Zephyr 4-point feed antenna was deployed approximately 160 meters north of the northeast corner of the Seward Airport and was used as the GPS base station for horizontal and vertical control during the aerial survey.

Nineteen photo-identifiable checkpoints were collected by University of Alaska Fairbanks, Geophysical Institute personnel in September 2015 using two Trimble R8s GPS receivers (fig. 2). The base station was located on National Geodetic Survey benchmark X-74 (PID: TT0396), located west of the Seward Airport.

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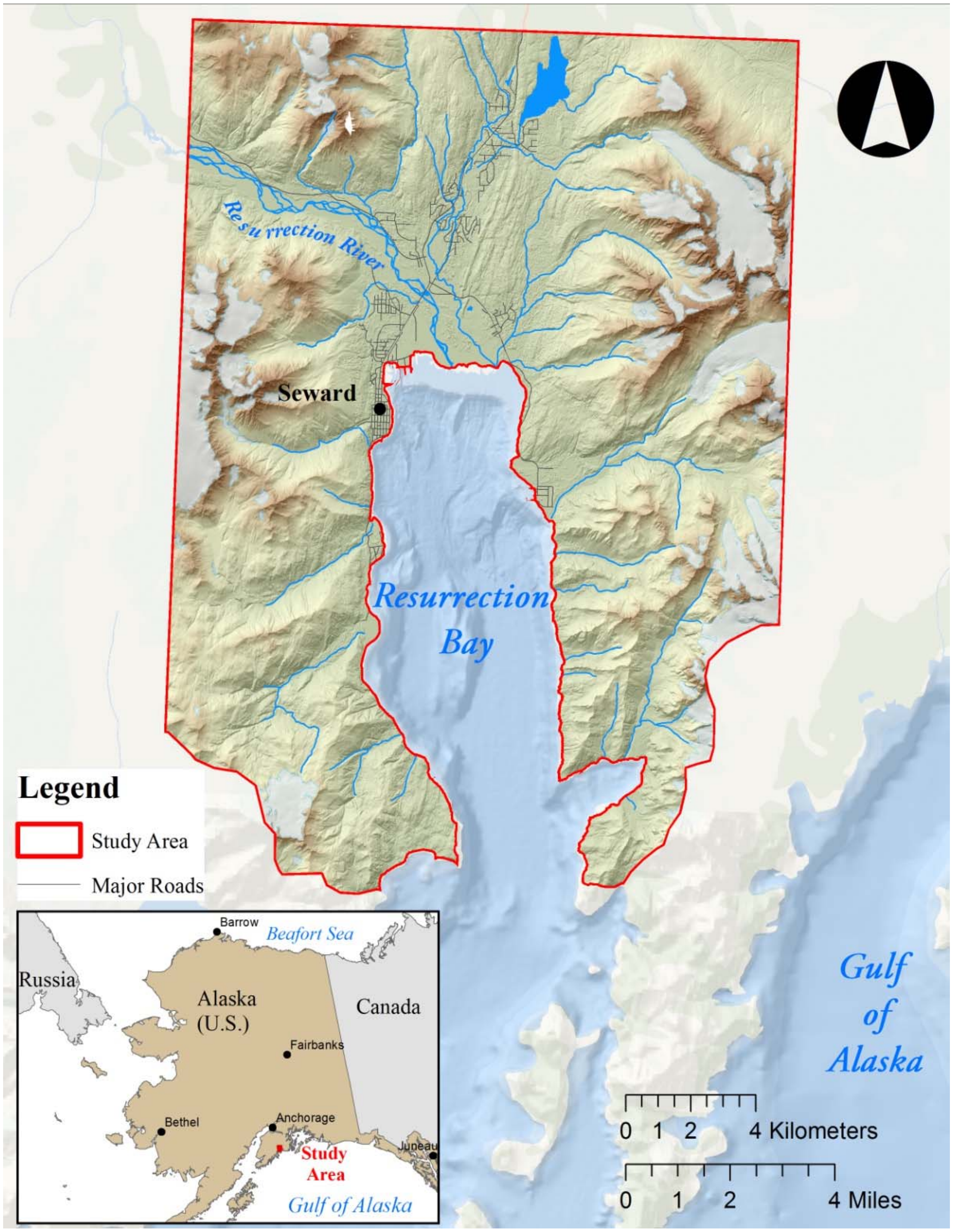

Figure 1. Location and extent of photogrammetry-derived products resulting from the aerial survey conducted on August 13, 2015.

Figure 2. Location of checkpoints used to assess data quality September 2015.

DATA PROCESSING

GNSS

Aerial survey GPS data were processed using GrafNav GNSS Post-Processing Software, Version 8.40.5121 using post-processing kinematic (PPK) methods. The Trimble Zephyr base station position was corrected using the National Geodetic Survey OPUS with the IGS08 (EPOCH:2015.6162) solution. Both aerial and base GPS data were collected and processed in WGS84 (G1674) using the WGS84 ellipsoid. Standard deviations for the GPS event marker horizontal and vertical positions were less than 0.06 m.

After post-processing, GPS event marker coordinates needed to be converted to the datum most frequently used by DGGS stakeholders. We used the National Oceanic and Atmospheric Administration's VDatum tool to transform the GPS event marker coordinates to the North American Datum 1983 (NAD83; 2011) European Petroleum Survey Group Well Known Identification Number (EPSG) 6337 and the North American Vertical Datum of 1988 (NAVD88; Geoid12A; EPOCH 2010.00). The coordinates are projected in UTM Zone 6 North and are in meters.

GPS event marker coordinates were manually correlated to image filenames to create a camera exterior orientation file for import into the SfM software, Agisoft Photoscan Professional. The exterior orientation file provides the X, Y, Z positions and Yaw, pitch, and roll for each photograph taken during the survey.

Photogrammetry

Aerial stereo-photographs were imported into the commercially available Agisoft Photoscan Professional software (Version 1.2.3 build 2331). Photos were processed in Photoscan on a Windows PC to align aerial photos, edit the sparse point cloud, optimize the bundle block adjustment, construct the dense point cloud and triangulated irregular network geometry, and export the natural color (RGB) orthoimagery GeoTIFF.

DATA PRODUCTS

The data files available for download are tiled DSM and RGB orthoimage GeoTIFFs. All data are projected in UTM Zone 6 North (meters) using the NAD83 (2011; EPSG 26906) horizontal datum and NAVD88 (Geoid12A; EPOCH 2010.00) vertical datum.

Orthoimagery

The orthoimage is a three-band, 8-bit unsigned GeoTIFF file using LZW compression. The orthoimage has a GSD of 0.2 m per pixel, and the No Data value is set to 0. Variable lighting in the orthoimages may result from variable sky conditions during the time of data acquisition.

Digital surface model (DSM)

DSMs represent surface elevations of all surfaces, including vegetation, vegetation-free land, bridges, buildings, etc. The DSM is a single-band, 32-bit float GeoTIFF files using Lempel-Ziv-Welch (LZW) compression, with a ground sample distance (GSD) of 0.41 m. The No Data value is set to -32767.

DATA QUALITY

Horizontal accuracies of the orthoimagery and DSM were assessed using 19 photo-identifiable checkpoints along the road systems in and near Seward, Alaska. Lower horizontal accuracy is possible in areas of extreme terrain, dense vegetation, and heavy shadow. The X-coordinates have a root-mean-square error (RMSE) of 0.32m and a mean absolute error (MAE) of 0.28 m. The Y Coordinates have an RMSE of 0.47 m and a MAE of 0.42 m. The horizontal linear RMSE in the radial direction ($RMSE_r$) is 0.57 m.

Check Point	Easting (X)	Northing (Y)	Elevation (m)	Horizontal offset X (m)	Horizontal offset Y (m)	Vertical offset Z (m)
GCP 00	364990.189026	6668706.403270	12.08	-0.48	0.37	-0.06
GCP 01	364990.2042	6668706.363	12.06	N/A	N/A	-0.04
GCP 02	364044.063791	6669225.506310	47.89	-0.20	0.35	0.15
GCP 04b	359417.514721	6673903.826340	67.89	-0.34	0.61	0.75
GCP 05	364798.154784	6671096.922540	20.87	-0.30	0.52	-0.15
GCP 06b	368360.057464	6676052.310180	67.79	-0.08	0.32	0.07
GCP 08	368559.680233	6664762.714420	38.01	-0.38	0.73	0.06
GCP 09	368824.310825	6665860.809820	60.86	-0.04	0.10	0.50
GCP 10	368832.126827	6665866.313190	61.74	-0.09	0.23	0.43
GCP 11	368371.586338	6667355.498050	6.08	-0.48	0.49	-0.08
GCP 12	365066.135759	6667375.300940	7.31	-0.24	0.85	-0.07
GCP 13	364500.346763	6666392.240130	4.75	-0.14	0.46	0.13
GCP 14	363473.6677	6665404.855	68.83	N/A	N/A	0.38
GCP 15	363620.723744	6665488.895810	60.57	-0.17	0.21	0.69
GCP 16	364146.575202	6665143.182910	11.26	-0.22	0.28	-0.21
GCP 17	363935.320662	6662118.063280	12.40	-0.30	0.21	0.02
GCP 18	364056.686632	6661541.327030	21.78	-0.66	0.43	-0.16
GCP 19	364193.739304	6661294.687430	3.99	-0.41	0.20	0.23
GCP 20	364044.143028	6662918.463820	5.98	-0.47	0.77	-0.15
GCP 21	364484.205699	6665155.154920	6.08	-0.17	0.39	-0.04
GCP 23	368918.366054	6663692.554110	5.92	-0.17	0.50	0.75
GCP x74	365230.0257	6668862.468	9.95	N/A	N/A	0.27
			Mean	-0.29	0.42	0.12
			Std. Dev.	0.17	0.21	0.31
			Range	0.62	0.75	0.96
			MAE	0.28	0.42	0.28
			RMSE	0.32	0.47	0.38
			$RMSE_r$	0.57		

Total Check Points = 22					
DSM cell size = 0.41 m Ortho cell size = .20 m			Difference: SfM - Survey		

Table 1. Accuracy assessment of orthoimage (horizontal) DSM (vertical). All data are projected in UTM Zone 6 North (meters) using the NAD83 (2011; EPSG 26906) horizontal datum and NAVD88 (Geoid12A; EPOCH 2010.00) vertical datum.

Vertical accuracy of the DSM was assessed by comparing the elevation values of 22 checkpoints (described above; fig 2) to the elevation values at the same location in the DSM. The mean vertical offset is 0.12 m, with a RMSE of 0.38 m and a MAE of 0.28 m. An additional evaluation of the vertical accuracy of the DSM was performed by comparing randomly sampled elevation values of points (n = 2876) on the road network from a LiDAR-derived digital elevation model (2009) to the elevation values at the same location in the DSM. The mean vertical offset is 0.24 m, with a RMSE of 0.42 m and a MAE of 0.28 m.

The DSM and orthoimagery have been visually inspected for data errors such as pits, border artifacts, and shifting. Pits and peaks are present over water bodies such as lakes. The end-user should be aware that DSM data were not hydro-flattened. Some small areas along the boundary and northern region of the survey area have NO DATA values, which is due to insufficient overlap (gaps) in the aerial photographic survey in areas of extreme topographic relief. The end user is advised that such areas may have a less accurate geographic position than reported for the rest of the scene.

ACKNOWLEDGMENTS

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