The Good, The Bad, and The UAV: Identification and Quantification of Digital Elevation Models Variances Created by Uncrewed Aerial Vehicle photogrammetry J.A. Nolan[1], C. Kennedy-Mazanec[2], A.H. Graettinger[3], [1] University of Missouri-Kansas City, Earth and Environmental Sciences, 5100 Rockhill Rd, Kansas City, MO 64110, janww8@umkc.edu, cmmiller@mail.umkc.edu, [2] University of Missouri-Kansas City, Earth and Environmental Sciences, 5100 Rockhill Rd, Kansas City, MO 64110, [3] University of Missouri-Kansas City, Earth and Environmental Sciences, 5100 Rockhill Rd, Kansas City, MO 64110, graettingera@umkc.edu.

Introduction: Uncrewed Aerial Vehicle (UAV) photogrammetry has rapidly increased in popularity for analog data collection due to increased UAV availability and lower cost, especially when compared to LiDAR alternatives. Digital Elevation Models (DEM) produced through UAV photography and LiDAR have inaccuracies related to the collection and processing techniques. Identification and quantification of these inaccuracies, both small and large, is important for learning the best applications and limitations of the technique. Areas of inaccuracies include misshapen objects, smoothing/rounding of terrain, differences in min/max elevations, and min/max locations. Properly constraining sources of inaccuracies is a necessary step to making UAV photogrammetry a powerful tool in terrestrial analog morphometry.

Method. UAV photography was collected in July 2019 of Diamond Craters, OR (DCOR) [1] volcanic landforms for inclusion into the Small-volume Monogenetic Igneous Landforms and Edifices Statistics (SMILES) [2] developed for analogs to Martian volcanic landform candidates. Target landforms aerial photography contained 3-5 ground control points (GCP), collected with 1-8 flights at 50 or 70 m above take-off point. Comparisons between DEM produced by UAV photography were made to LiDAR [3] collected October 2014 through May 2015 by Oregon LiDAR Consortium for analysis of morphometric variance. The LiDAR was smoothed to remove vegetation.

UAV photogrammetry and DEMs were processed using Agisoft Metashape. Measured variances in the UAV/LiDAR DEMs include changes in location and elevation of the minimum and maximum elevation of the landform, difference in relative relief (max-min elevation), asymmetry angle between the two surface planes, contour, and profile line agreement.

To identify loss or distortion from original shape resulting from UAV collection and processing, scenes of various polyhedra were staged. Polyhedra include cubes, spheres, cones, and pyramids. Polyhedra albedo, color, proximal polyhedra distance and size were varied in staged scenes to constrain sources of loss/distortion. Polyhedra aerial photography collected at 10-50 m above take-off point and DEMs processed using Agisoft Metashape.

Landform Data Analysis. Target landforms major axis [4] range from 16.5 – 1095.9 m with relief ranging in elevation from 4.03 – 84.59 m. Location offsets of maximum and minimum elevation range from <1 – 280 m, with elevation differences ranging from <5 cm – 1.89 m, with no discernable correlation in the azimuth of the offset. Landforms included spatter vents, maars, collapse pits, and lava flows.

Polyhedra Data Analysis. Polyhedra sizes ranged from 0.0017 – 1.25 m^3. Polyhedra experienced merging into proximal polyhedra, distortion, flattening, or large gaps of missing data. The degree of merging and distortions are correlated with altitude of imagery, albedo, insolation saturation, and angle of camera during collection. Understanding these distortions is important as DEMs produced by photogrammetric techniques ramps up on other planetary bodies.

Proximal polyhedra merged into single indiscernible objects with as little as 12 cm separation starting at 10 m flight height. Changes in albedo across polyhedra faces caused distortion from original shape, i.e., cubes become pyramids, pyramids become bullets, spheres became pyramids.

Resultant contour and profile line mostly agree between both collection methods. LiDAR provided a smoothed curve on pointed or high angle features. UAV datasets captured and retained many smaller, possibly important, features such as vegetation and boulders, and had more accurate min/max locations when compared with field observations. DEMs created through UAV provide more accurate reconstructions of cliff faces and overhangs than LiDAR. Densely vegetated regions provide a challenge to UAV techniques due to lack of penetration to surface. UAV photogrammetry offers a low-cost accurate alternative to LiDAR techniques.

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