Metadata Report

Project Name

Cable Mountain Rockfall, Zion National Park, Washington County, Utah

Summary

In response to a request by Zion National Park to best quantify a rockfall that took place on August 24, 2019, the Utah Geological Survey was invited to document the extent of the event. A team of three geologists with the assistance of the park's physical scientist, performed reconnaissance of the aftermath of the rockfall, which had detached from a cliff face on Cable Mountain, near the popular Weeping Rock trail and Cable Mountain trailhead. With authorization of the National Park Service, a small unmanned aircraft system (sUAS) was used to photograph the area and provide further insight to the event.

Personnel

- PI(s)

Jessica Castleton (jessicacastleton@utah.gov) and Ben Erickson (benerickson@utah.gov)

- Field staff

Jessica Castleton (jessicacastleton@utah.gov), Ben Erickson (benerickson@utah.gov), and Adam Hiscock (adamhiscock@utah.gov)

- Additional team members

Robyn Henderek (robyn_henderek@nps.gov, Zion National Park Physical Scientist)

Site Information

- Site description

Located near Cable Mountain in Zion Canyon.

- Site objective

Fly a high resolution still camera over the rockfall area to create a structure from motion model.

- Site location (GPS cords and/or map)

37.2688903°, -112.9346639°

- Site conditions

Weather conditions were clear, calm, and cool for time of year.

- Date/time spent at each site

October 24-25, 2019

Last Edited: 2/27/19

Survey Results

- **Equipment used**

A DJI Mavic Pro 2 sUAS aircraft with a mounted camera was used for image acquisition. A high precision GPS R8 GNSS receiver using RTK base corrections was used for ground control.

- **GPS solutions**

Seven ground control points were used for model correlation. The ground control points were located with a Trimble R8 GNSS receiver and RTK base.

- **Errors**

The overall ground control total error was 7.25 cm, with X=5.16 cm, Y=4.12 cm, and Z=2.98 cm errors, respectively.

- **Alignments**
- **Collection methods**

608 photos were used in the generation of the structure from motion model. The flying altitude was 138 m above ground surface and a maximum of 500 m.

Products

- **Date of dataset collection**

10/24-25/2019

- **Coordinate system of datasets**

Horizontal: NAD83   (EPSG: 4269)   Vertical: NAVD88 (EPSG: 5703)

- **Spatial resolution**

Ground resolution: 9.24 mm/pix, DEM Resolution: 12.2 cm/pix, Point density: 66.8 points/m²

- **Horizontal Accuracy**

X=5.16 cm, Y=4.12 cm

- **Vertical Accuracy**

Z=2.98 cm

- **Data formats**

Point cloud is packaged in a LAZ format. DEM and orthomosaic are GeoTIFF files.

- **Data processing methods**

Products were produced using Agisoft Metashape Professional.

Misc Notes

For full datasets or original images, please contact Ben Erickson (benerickson@utah.gov). The results of the investigation are available from the Utah Geological Survey in Report of

Investigation 281 (https://ugspub.nr.utah.gov/publications/reports_of_investigations/ri-281.pdf).

Cable Mountain Rockfall and Hidden Canyon

Zion National Park authorized the flight and creation of this model.
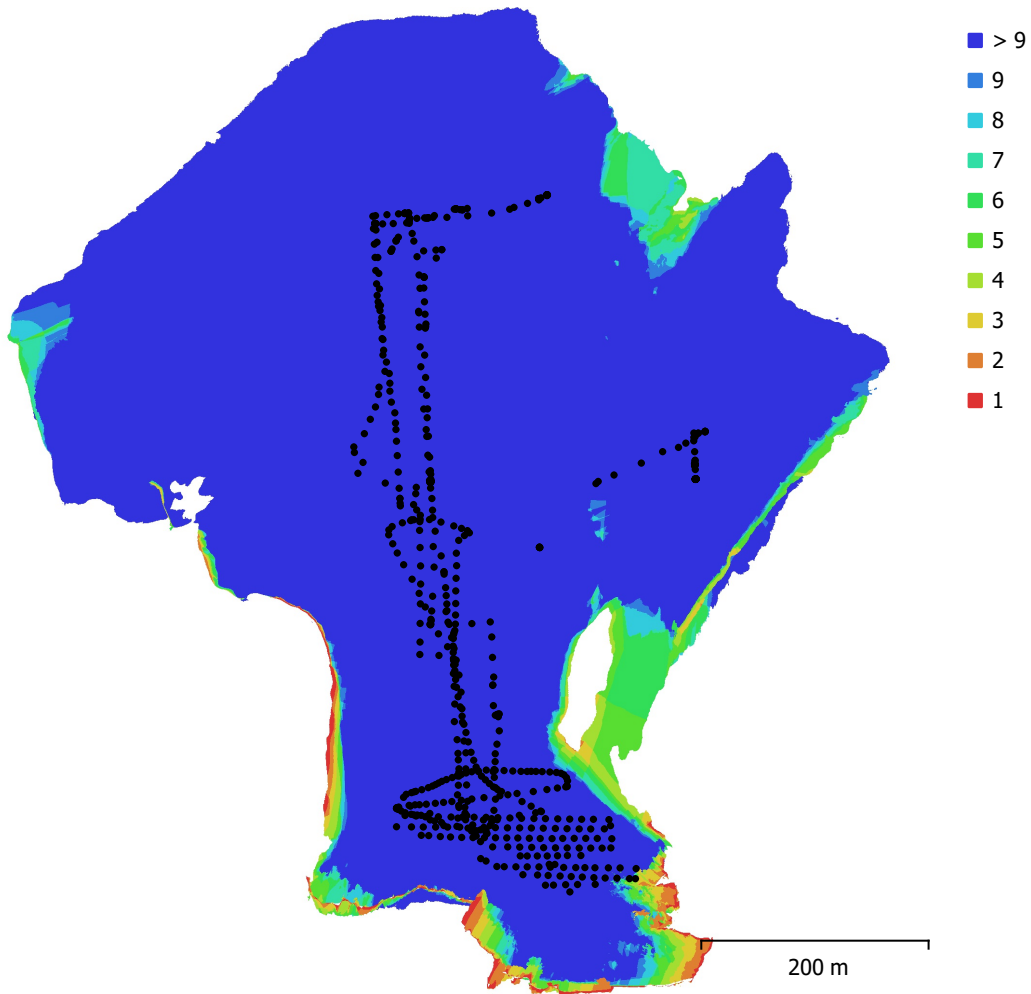**08 October 2019**

Survey Data

Fig. 1. Camera locations and image overlap.

Number of images:	608	Camera stations:	608
Flying altitude:	138 m	Tie points:	450,066
Ground resolution:	3.06 cm/pix	Projections:	2,505,815
Coverage area:	0.366 km²	Reprojection error:	0.702 pix

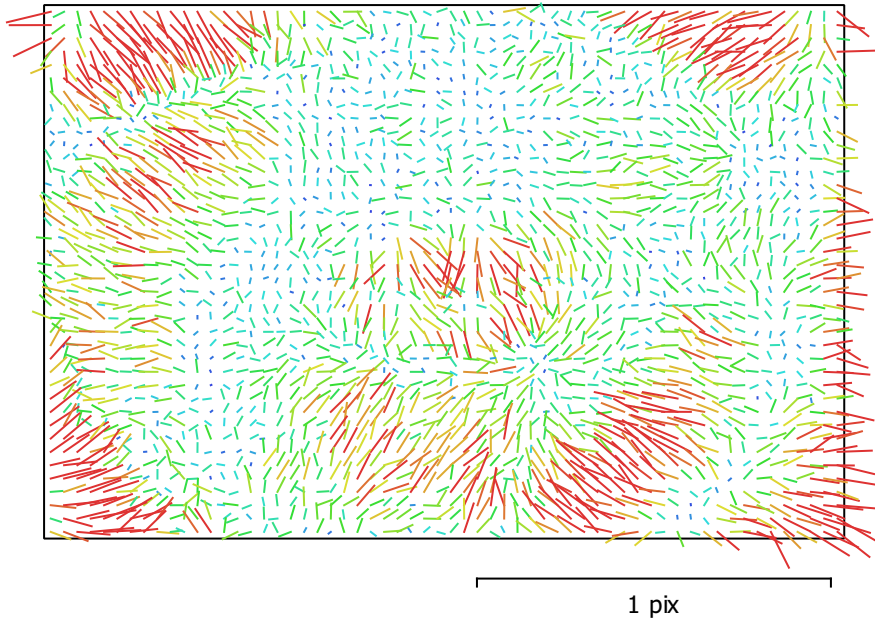| Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
L1D-20c (10.26mm)	5472 x 3648	10.26 mm	2.41 x 2.41 µm	No

Table 1. Cameras.

Camera Calibration

Fig. 2. Image residuals for L1D-20c (10.26mm).

L1D-20c (10.26mm)

608 images

Type	Resolution	Focal Length	Pixel Size
Frame	**5472 x 3648**	**10.26 mm**	**2.41 x 2.41 μm**

	Value	Error	F	Cx	Cy	K1	K2	K3	P1	P2
F	**4287.52**	0.019	1.00	0.04	-0.36	-0.11	0.20	-0.19	0.03	-0.28
Cx	**2.03162**	0.03		1.00	-0.06	0.00	0.00	-0.00	0.93	-0.03
Cy	**-17.2992**	0.032			1.00	-0.06	0.02	-0.02	-0.03	0.92
K1	**-0.0157966**	1.6e-005				1.00	-0.96	0.90	-0.00	-0.07
K2	**0.0176516**	6.2e-005					1.00	-0.98	0.00	0.02
K3	**-0.023055**	7.4e-005						1.00	-0.00	-0.02
P1	**-0.000109061**	1.8e-006							1.00	-0.01
P2	**-7.51386e-005**	1.8e-006								1.00

Table 2. Calibration coefficients and correlation matrix.
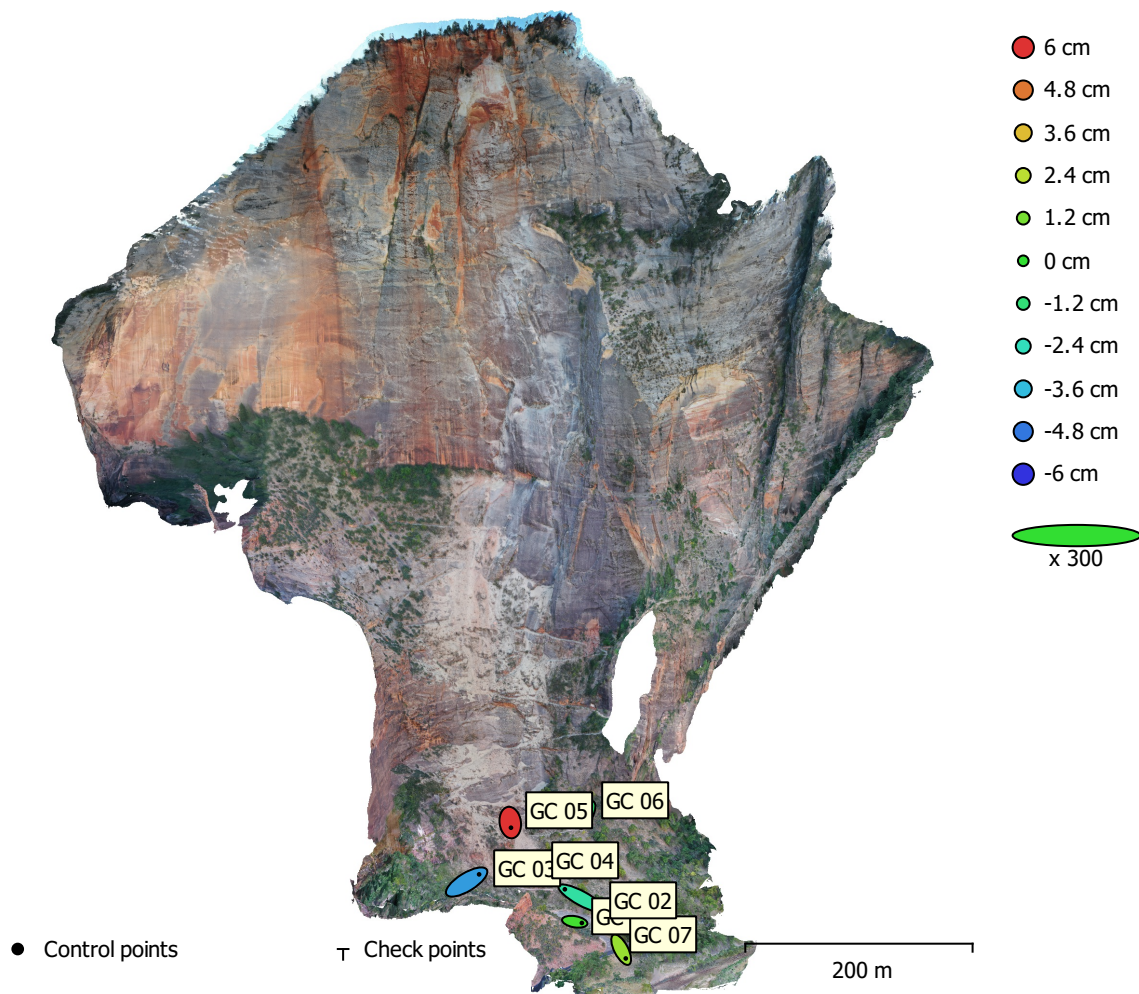
Ground Control Points

Fig. 3. GCP locations and error estimates.
Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.
Estimated GCP locations are marked with a dot or crossing.

Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
7	5.16303	4.12396	2.98284	6.60786	7.24991

Table 3. Control points RMSE.
X - Longitude, Y - Latitude, Z - Altitude.

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GC 01	4.1846	-0.717017	0.298608	4.25607	0.977 (34)
GC 07	2.68436	-5.12966	1.78357	6.05807	2.728 (19)
GC 06	-2.33276	-4.60084	-1.06528	5.26728	3.545 (27)
GC 03	7.30863	4.49875	-4.16717	9.54045	3.022 (54)
GC 04	-2.41948	3.59345	-0.890996	4.42274	1.382 (35)
GC 02	-9.84838	5.36864	-1.95121	11.3851	1.930 (49)
GC 05	0.423134	-3.0133	5.99247	6.72076	1.748 (50)
Total	**5.16303**	**4.12396**	**2.98284**	**7.24991**	**2.292**

Table 4. Control points.

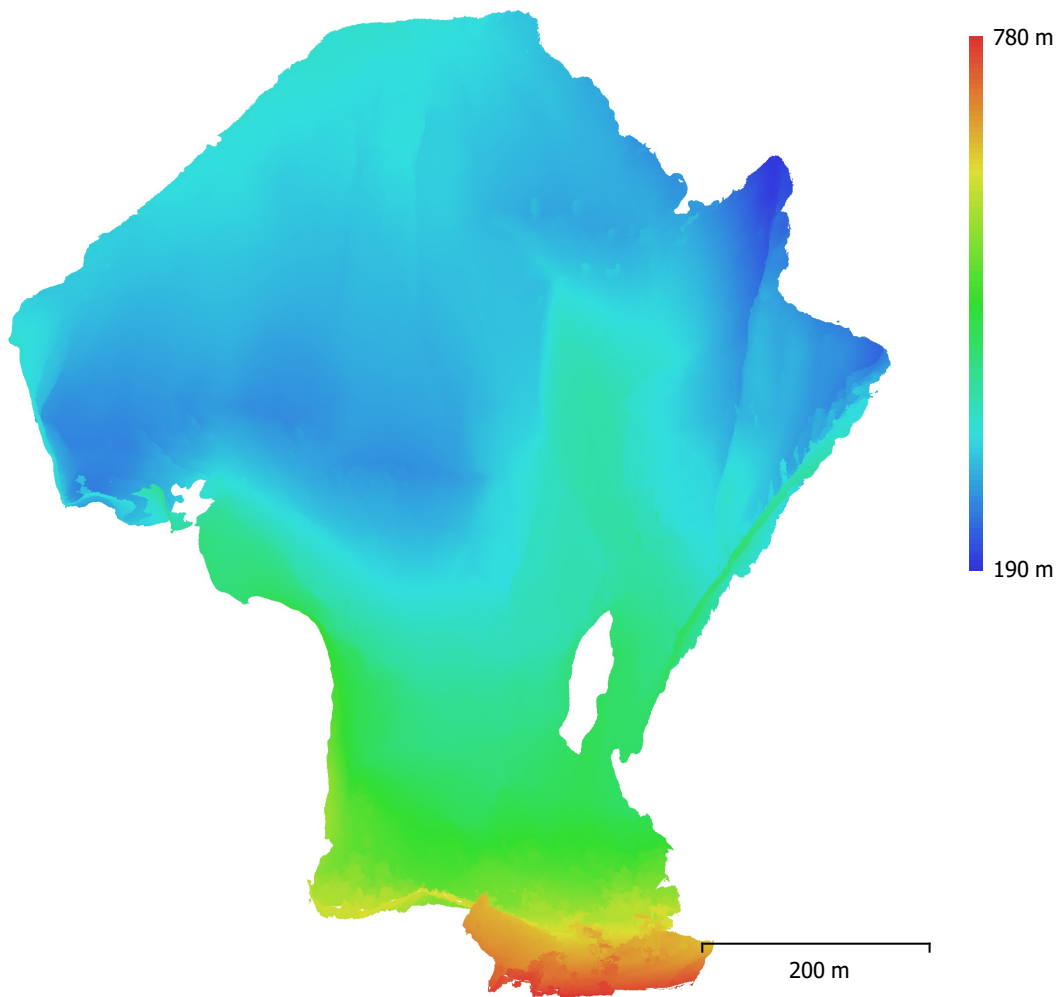X - Longitude, Y - Latitude, Z - Altitude.

Digital Elevation Model

Fig. 4. Reconstructed digital elevation model.

Resolution: 12.2 cm/pix
Point density: 66.8 points/m²

Processing Parameters

General
  Cameras   608

General		
Cameras	608	
Aligned cameras	608	
Markers	7	
Shapes		
Polygons	1	
Coordinate system	NAD83 (EPSG::4269)	
Coordinate system	WGS 84 (EPSG::4326)	
Rotation angles	Yaw, Pitch, Roll	
Point Cloud		
Points	450,066 of 577,182	
RMS reprojection error	0.153769 (0.702395 pix)	
Max reprojection error	0.463912 (43.5476 pix)	
Mean key point size	4.0622 pix	
Point colors	3 bands, uint8	
Key points	No	
Average tie point multiplicity	7.12891	
Alignment parameters		
Accuracy	High	
Generic preselection	Yes	
Reference preselection	Yes	
Key point limit	40,000	
Tie point limit	6,000	
Adaptive camera model fitting	No	
Matching time	8 minutes 18 seconds	
Alignment time	13 minutes 41 seconds	
Software version	1.5.5.9097	
Dense Point Cloud		
Points	51,794,403	
Point colors	3 bands, uint8	
Depth maps generation parameters		
Quality	Medium	
Filtering mode	Moderate	
Processing time	1 hours 47 minutes	
Dense cloud generation parameters		
Processing time	1 hours 32 minutes	
Software version	1.5.5.9097	
Model		
Faces	10,028,952	
Vertices	5,026,915	
Vertex colors	3 bands, uint8	
Texture	4,096 x 4,096, 4 bands, uint8	
Depth maps generation parameters		
Quality	Medium	
Filtering mode	Moderate	
Processing time	1 hours 47 minutes	
Reconstruction parameters		
Surface type	Arbitrary	
Source data	Dense cloud	
Interpolation	Enabled	

General
    Strict volumetric masks   No
    Processing time   46 minutes 6 seconds
  Texturing parameters
    Mapping mode   Adaptive orthophoto
    Blending mode   Mosaic
    Texture size   4,096
    Enable hole filling   Yes
    Enable ghosting filter   No
    UV mapping time   1 minutes 20 seconds
    Blending time   14 minutes 41 seconds
  Software version   1.5.5.9097

Tiled Model
  Texture   3 bands, uint8
  Depth maps generation parameters
    Quality   Medium
    Filtering mode   Moderate
    Processing time   1 hours 47 minutes
  Reconstruction parameters
    Source data   Dense cloud
    Tile size   256
    Face count   High
    Enable ghosting filter   Yes
    Processing time   7 hours 1 minutes
  Software version   1.5.5.9097

DEM
  Size   11,379 x 10,947
  Coordinate system   WGS 84 (EPSG::4326)
  Reconstruction parameters
    Source data   Dense cloud
    Interpolation   Enabled
    Processing time   1 minutes 1 seconds
  Software version   1.5.5.9097

Orthomosaic
  Size   32,206 x 29,430
  Coordinate system   WGS 84 (EPSG::4326)
  Colors   3 bands, uint8
  Reconstruction parameters
    Blending mode   Mosaic
    Surface   DEM
    Enable hole filling   Yes
    Processing time   24 minutes 34 seconds
  Software version   1.5.5.9097

Software
  Version   1.5.5 build 9097
  Platform   Windows 64