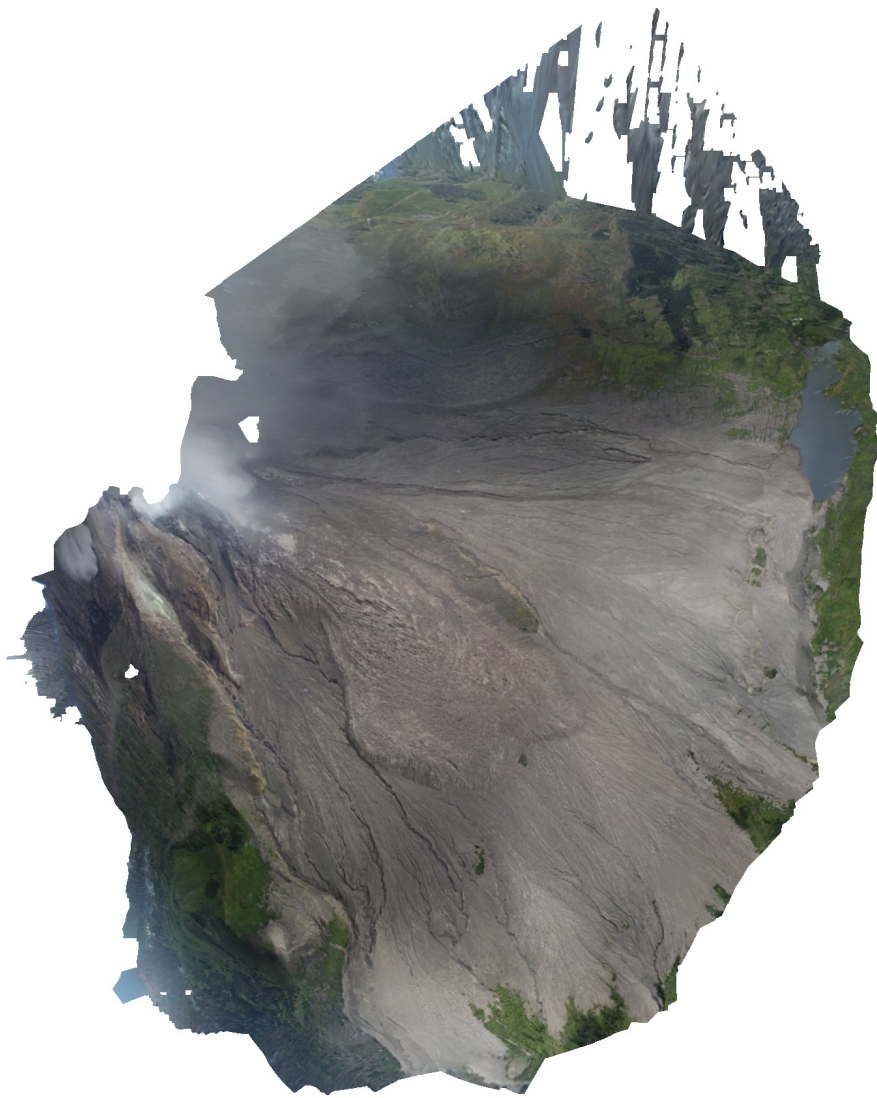


# Sinabung 2018 June 20

Processing Report  
Sinabung18\_2

Sinabung Volcano  
North Sumatra, Indonesia  
June 20, 2018  
sUAS Visual  
Mapping Survey (DJI M210)

22 October 2019



# Survey Data

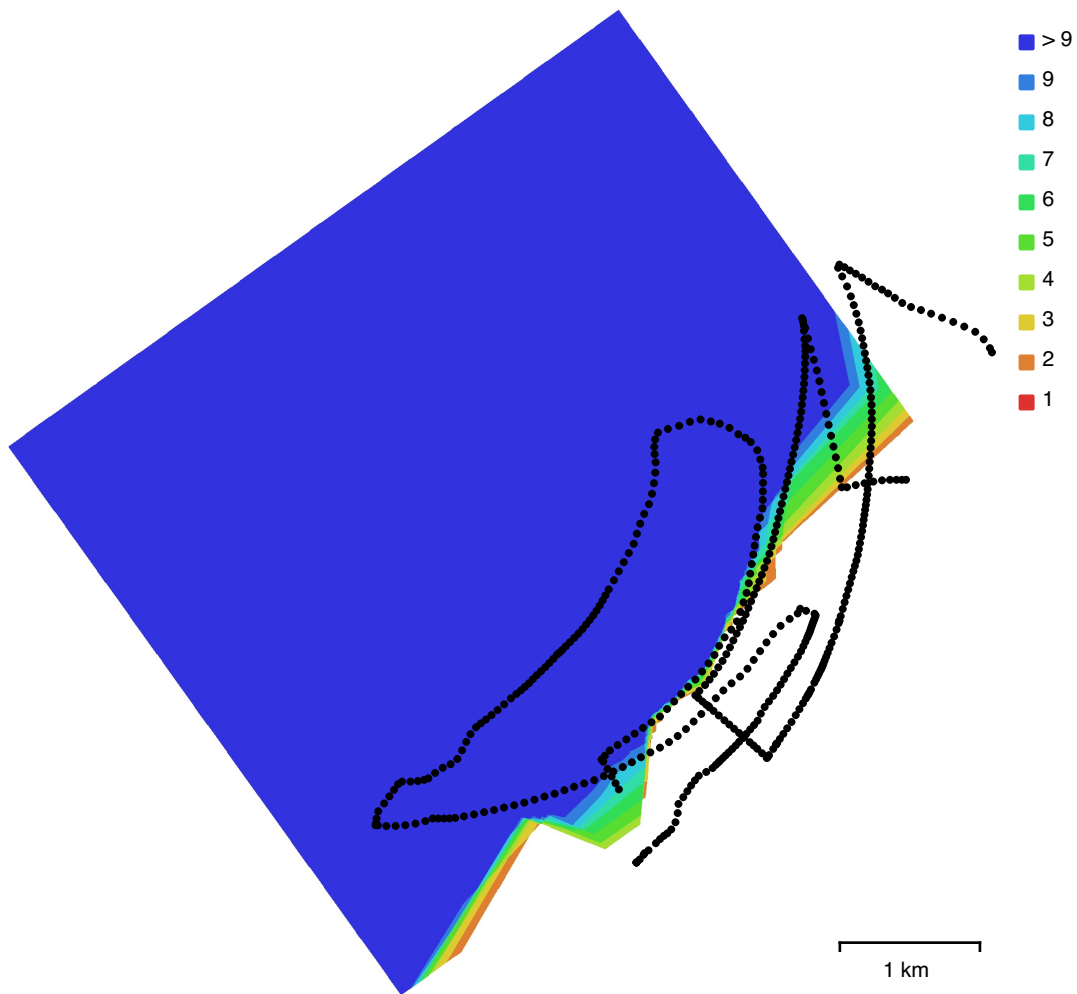


Fig. 1. Camera locations and image overlap.

Number of images:	454	Camera stations:	454
Flying altitude:	1.38 km	Tie points:	1,287,889
Ground resolution:	43.5 cm/pix	Projections:	5,106,247
Coverage area:	22.9 km <sup>2</sup>	Reprojection error:	0.607 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
FC6510 (8.8mm)	5472 x 3078	8.8 mm	2.53 x 2.53 $\mu$ m	No
FC6510 (8.8mm)	5472 x 3078	8.8 mm	2.53 x 2.53 $\mu$ m	No
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FC6510 (8.8mm)	5472 x 3078	8.8 mm	2.53 x 2.53 $\mu$ m	No

Table 1. Cameras.

# Camera Calibration

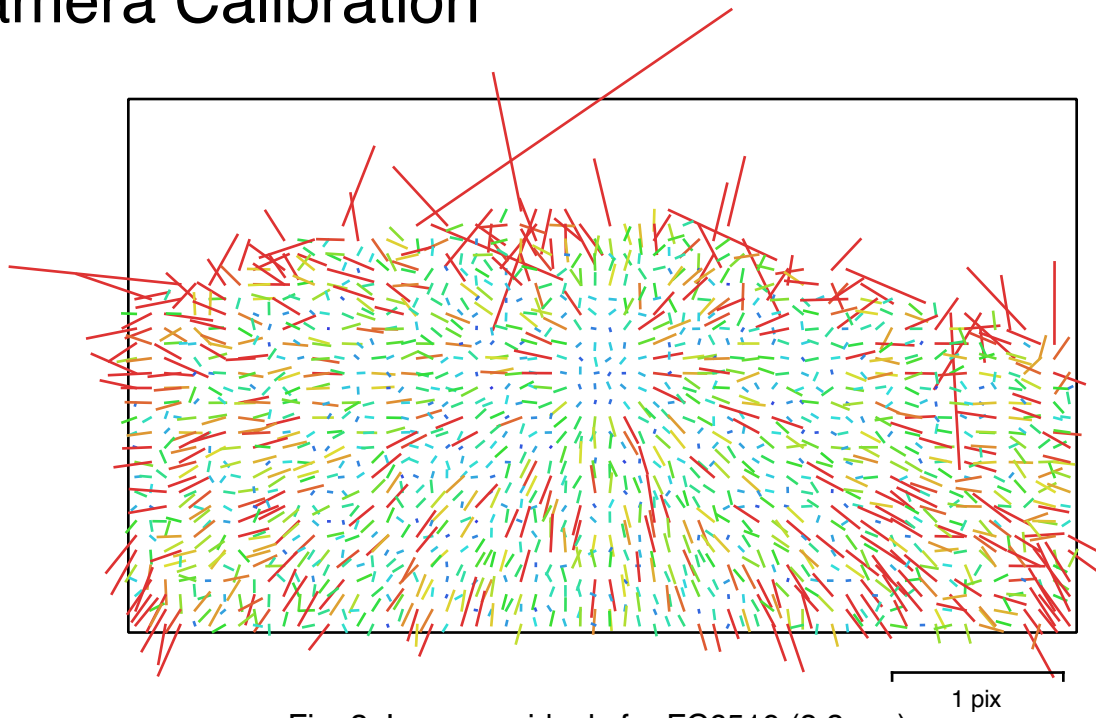


Fig. 2. Image residuals for FC6510 (8.8mm).

FC6510 (8.8mm)  
91 images

Type	Resolution	Focal Length	Pixel Size
Frame	5472 x 3078	8.8 mm	2.53 x 2.53 $\mu\text{m}$

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	3670.7	0.6	1.00	0.01	0.54	-1.00	0.27	-0.02	-0.03	0.05	-0.07	-0.03	0.06
Cx	9.46549	0.095		1.00	0.06	-0.01	0.16	-0.00	0.00	0.00	-0.01	0.96	0.01
Cy	12.0714	0.18			1.00	-0.56	0.27	0.11	-0.12	0.13	-0.14	-0.01	0.15
B1	2.74961	0.62				1.00	-0.26	0.00	0.05	-0.07	0.08	0.03	-0.08
B2	-7.10864	0.14					1.00	0.02	-0.04	0.04	-0.05	0.07	0.07
K1	0.0206647	5.8e-05						1.00	-0.96	0.90	-0.85	0.00	-0.07
K2	-0.0975635	0.00031							1.00	-0.98	0.95	0.00	-0.03
K3	0.183178	0.00067								1.00	-0.99	0.00	0.04
K4	-0.115524	0.0005									1.00	-0.00	-0.04
P1	0.00148518	8.9e-06										1.00	-0.00
P2	-7.62965e-05	3.5e-06											1.00

Table 2. Calibration coefficients and correlation matrix.

# Camera Calibration

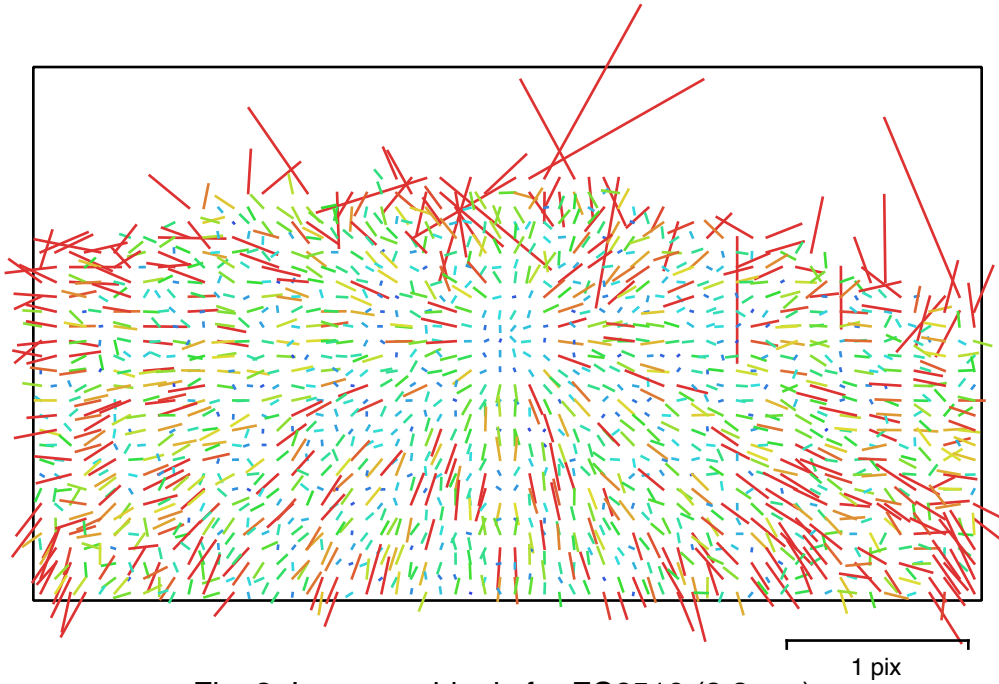


Fig. 3. Image residuals for FC6510 (8.8mm).

FC6510 (8.8mm)  
307 images

Type	Resolution	Focal Length	Pixel Size
Frame	5472 x 3078	8.8 mm	2.53 x 2.53 $\mu\text{m}$

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	3670.6	0.6	1.00	0.01	0.56	-1.00	0.26	-0.01	-0.05	0.09	-0.12	-0.03	0.06
Cx	9.49471	0.091		1.00	0.06	-0.00	0.16	0.00	-0.00	0.01	-0.01	0.96	-0.00
Cy	12.4383	0.17			1.00	-0.58	0.29	0.12	-0.14	0.17	-0.18	-0.01	0.16
B1	2.81696	0.62				1.00	-0.26	0.00	0.07	-0.10	0.13	0.03	-0.08
B2	-7.07642	0.14					1.00	0.03	-0.05	0.07	-0.07	0.07	0.07
K1	0.0207429	4.3e-05						1.00	-0.96	0.90	-0.84	0.01	-0.07
K2	-0.0984975	0.00022							1.00	-0.98	0.95	-0.00	-0.05
K3	0.185777	0.00046								1.00	-0.99	0.00	0.06
K4	-0.117739	0.00033									1.00	-0.00	-0.06
P1	0.00148591	8.5e-06										1.00	-0.01
P2	-7.543e-05	3.4e-06											1.00

Table 3. Calibration coefficients and correlation matrix.

# Camera Calibration

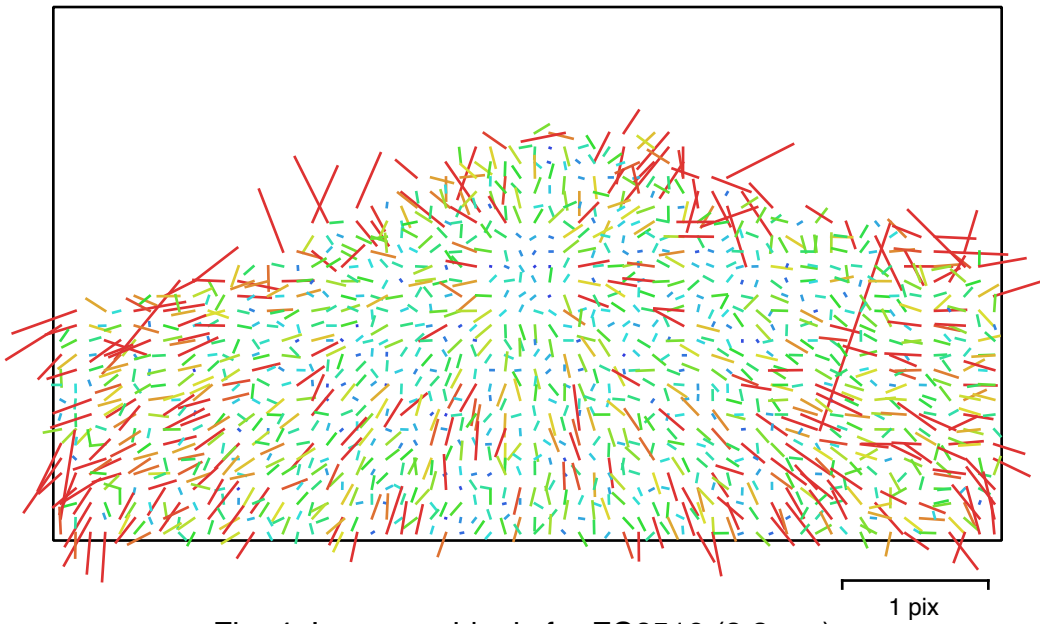


Fig. 4. Image residuals for FC6510 (8.8mm).

FC6510 (8.8mm)  
13 images

Type	Resolution	Focal Length	Pixel Size
Frame	5472 x 3078	8.8 mm	2.53 x 2.53 $\mu\text{m}$

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	3670.69	0.61	1.00	0.01	0.30	-1.00	0.24	-0.05	0.03	-0.01	0.01	-0.02	0.03
Cx	9.46246	0.13		1.00	0.09	-0.01	0.21	0.01	-0.01	0.01	-0.01	0.96	-0.02
Cy	11.9683	0.27			1.00	-0.36	0.22	0.27	-0.24	0.22	-0.21	-0.01	0.06
B1	2.71199	0.62				1.00	-0.24	-0.01	0.03	-0.03	0.04	0.02	-0.03
B2	-7.04767	0.16					1.00	0.01	-0.01	0.02	-0.02	0.09	0.04
K1	0.0206618	0.00014						1.00	-0.97	0.92	-0.86	-0.01	-0.11
K2	-0.0976011	0.00076							1.00	-0.99	0.96	0.01	0.03
K3	0.184062	0.0017								1.00	-0.99	-0.01	-0.01
K4	-0.11688	0.0013									1.00	0.01	-0.01
P1	0.00147892	1.2e-05										1.00	-0.02
P2	-8.55664e-05	4.6e-06											1.00

Table 4. Calibration coefficients and correlation matrix.

# Camera Calibration

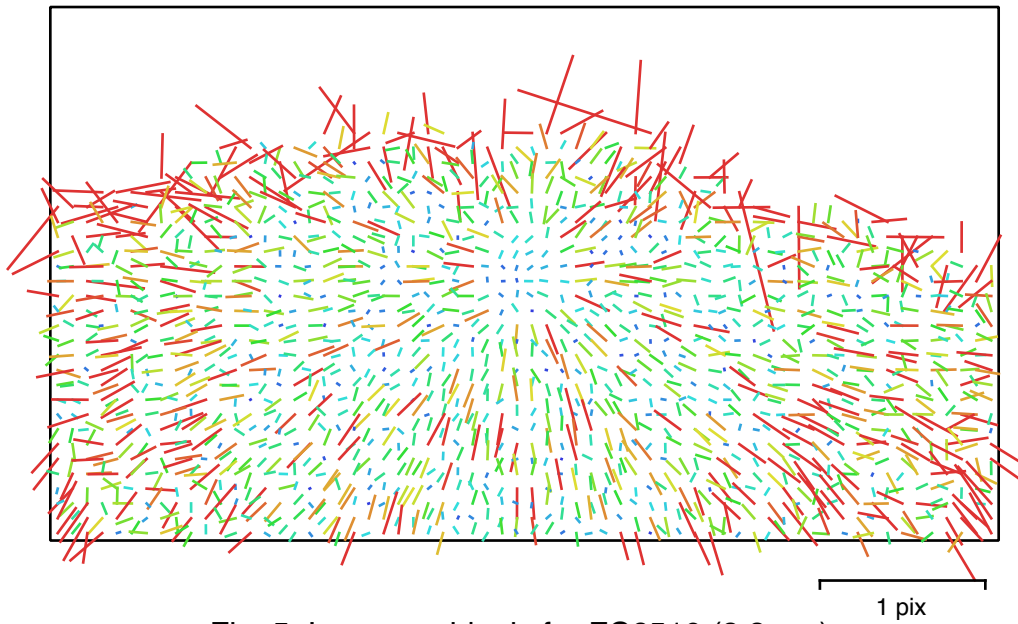


Fig. 5. Image residuals for FC6510 (8.8mm).

FC6510 (8.8mm)  
43 images

Type	Resolution	Focal Length	Pixel Size
Frame	5472 x 3078	8.8 mm	2.53 x 2.53 $\mu\text{m}$

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	3670.69	0.6	1.00	0.00	0.52	-1.00	0.26	-0.02	-0.01	0.03	-0.04	-0.03	0.05
Cx	9.62882	0.1		1.00	0.05	-0.00	0.17	-0.00	-0.00	0.00	-0.00	0.96	0.03
Cy	12.2237	0.18			1.00	-0.54	0.25	0.11	-0.12	0.12	-0.12	-0.00	0.14
B1	2.78526	0.62				1.00	-0.26	-0.00	0.04	-0.05	0.06	0.03	-0.07
B2	-7.01679	0.14					1.00	0.01	-0.03	0.03	-0.03	0.07	0.07
K1	0.0204317	7.5e-05						1.00	-0.96	0.91	-0.85	0.00	-0.08
K2	-0.0961586	0.00041							1.00	-0.98	0.95	-0.00	-0.01
K3	0.179474	0.00089								1.00	-0.99	0.00	0.02
K4	-0.112225	0.00066									1.00	-0.00	-0.03
P1	0.00149772	9.3e-06										1.00	0.02
P2	-7.46462e-05	3.7e-06											1.00

Table 5. Calibration coefficients and correlation matrix.



# Camera Locations

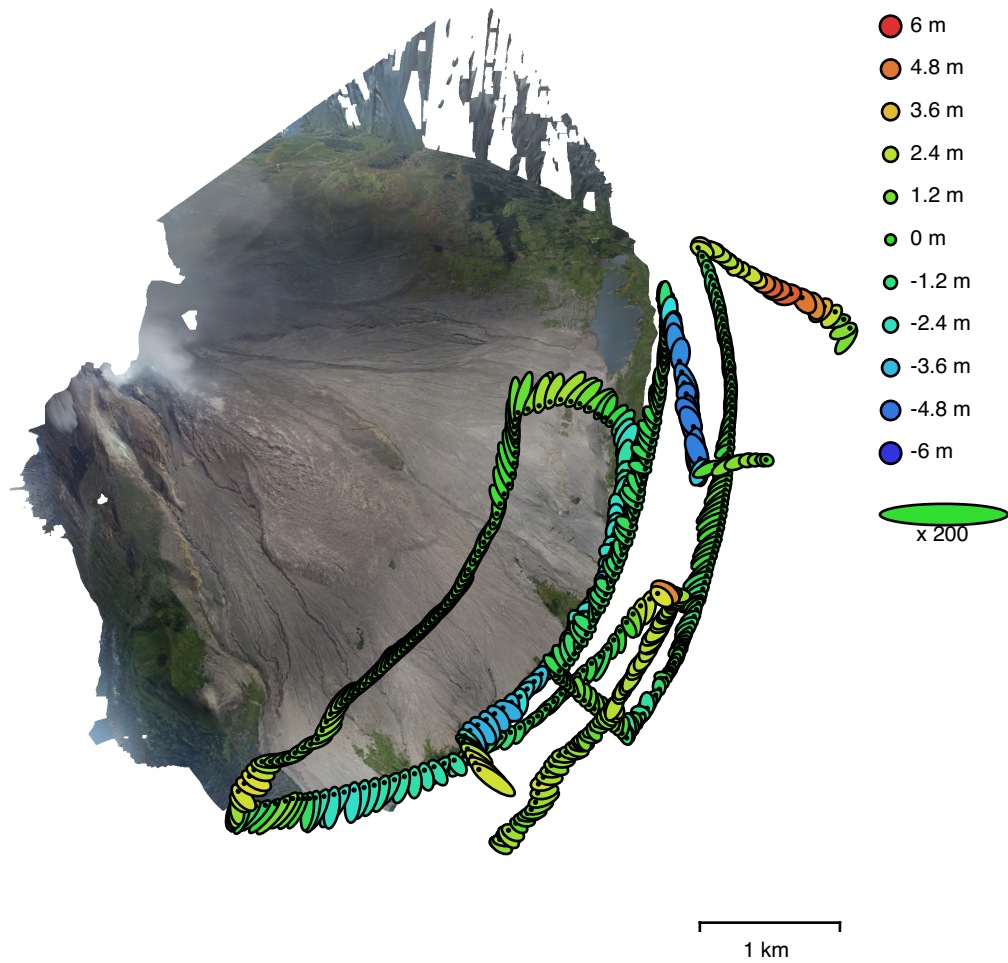


Fig. 6. Camera locations and error estimates.  
 Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.  
 Estimated camera locations are marked with a black dot.

X error (m)	Y error (m)	Z error (m)	XY error (m)	Total error (m)
0.363065	0.520205	1.79232	0.634373	1.90128

Table 6. Average camera location error.  
 X - Easting, Y - Northing, Z - Altitude.



# Digital Elevation Model

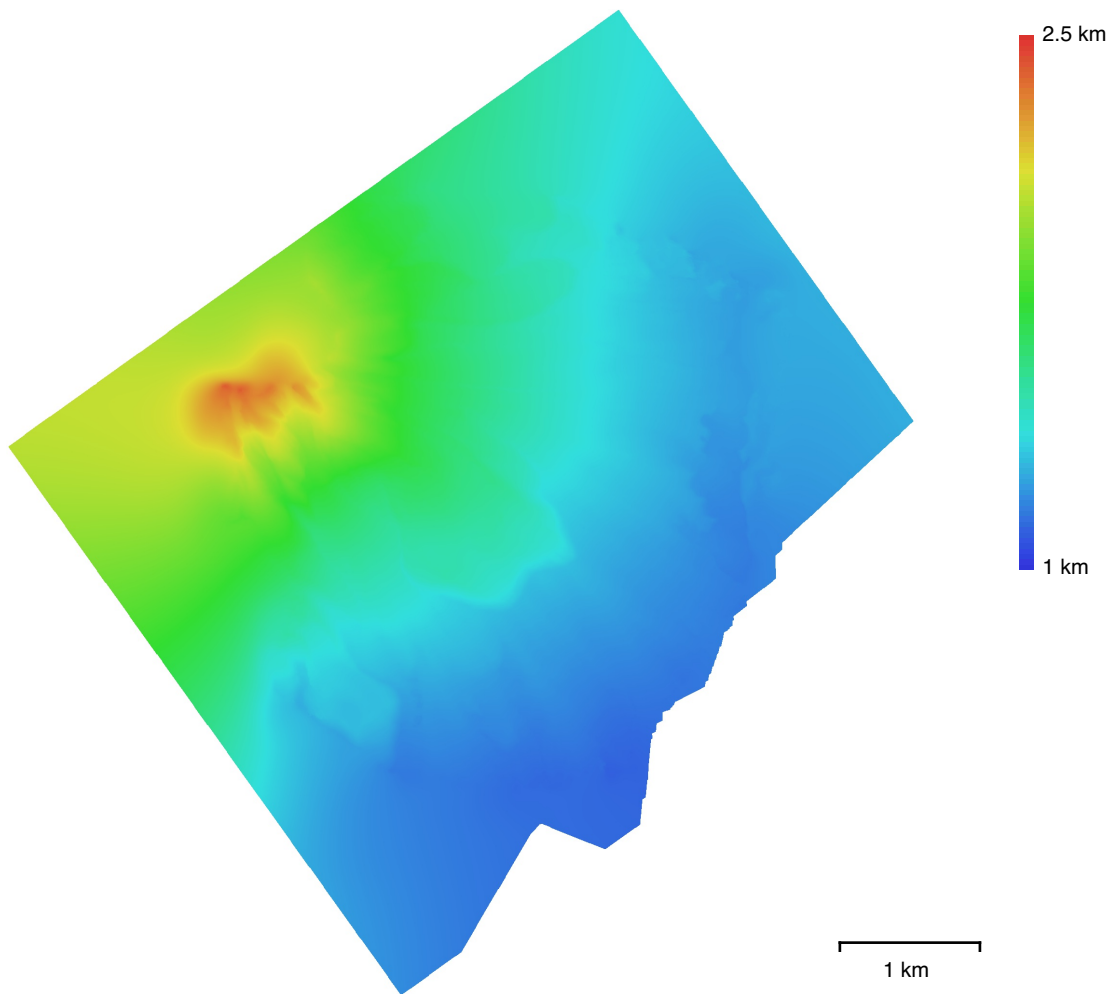


Fig. 7. Reconstructed digital elevation model.

Resolution: 86.9 cm/pix  
Point density: 1.32 points/m<sup>2</sup>

# Processing Parameters

## General

Cameras	454
Aligned cameras	454
Coordinate system	WGS 84 / UTM zone 47N (EPSG::32647)
Rotation angles	Yaw, Pitch, Roll

## Point Cloud

Points	1,287,889 of 1,680,091
RMS reprojection error	0.159237 (0.607327 pix)
Max reprojection error	0.495091 (16.0609 pix)
Mean key point size	3.45004 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	5.16437

## Alignment parameters

Accuracy	High
Generic preselection	No
Reference preselection	Yes
Key point limit	0
Tie point limit	0
Filter points by mask	Yes
Adaptive camera model fitting	Yes
Matching time	26 minutes 12 seconds
Alignment time	27 minutes 30 seconds

## Optimization parameters

Parameters	f, b1, b2, cx, cy, k1-k4, p1, p2
Adaptive camera model fitting	No
Optimization time	1 minutes 10 seconds

## Dense Point Cloud

Points	23,386,513
Point colors	3 bands, uint8
Reconstruction parameters	
Quality	High
Depth filtering	Aggressive
Depth maps generation time	22 hours 29 minutes
Dense cloud generation time	1 days 19 hours

## Model

Faces	4,677,301
Vertices	2,341,509
Vertex colors	3 bands, uint8
Texture	8,192 x 8,192, 4 bands, uint8
Reconstruction parameters	
Surface type	Arbitrary
Source data	Dense
Interpolation	Enabled
Quality	High
Depth filtering	Aggressive
Face count	4,677,302
Processing time	22 minutes 35 seconds

## Texturing parameters

Mapping mode	Orthophoto
Blending mode	Mosaic

## General

Texture size	8,192 x 8,192
Enable hole filling	Yes
Enable ghosting filter	No
UV mapping time	16 seconds
Blending time	37 minutes 44 seconds

## DEM

Size	8,247 x 8,104
Coordinate system	WGS 84 (EPSG::4326)
Reconstruction parameters	
Source data	Dense cloud
Interpolation	Enabled
Processing time	35 seconds

## Orthomosaic

Size	14,875 x 16,207
Coordinate system	WGS 84 (EPSG::4326)
Colors	3 bands, uint8
Reconstruction parameters	
Blending mode	Mosaic
Surface	DEM
Enable hole filling	Yes
Processing time	1 hours 25 minutes

## Software

Version	1.5.1 build 7618
Platform	Mac OS 64