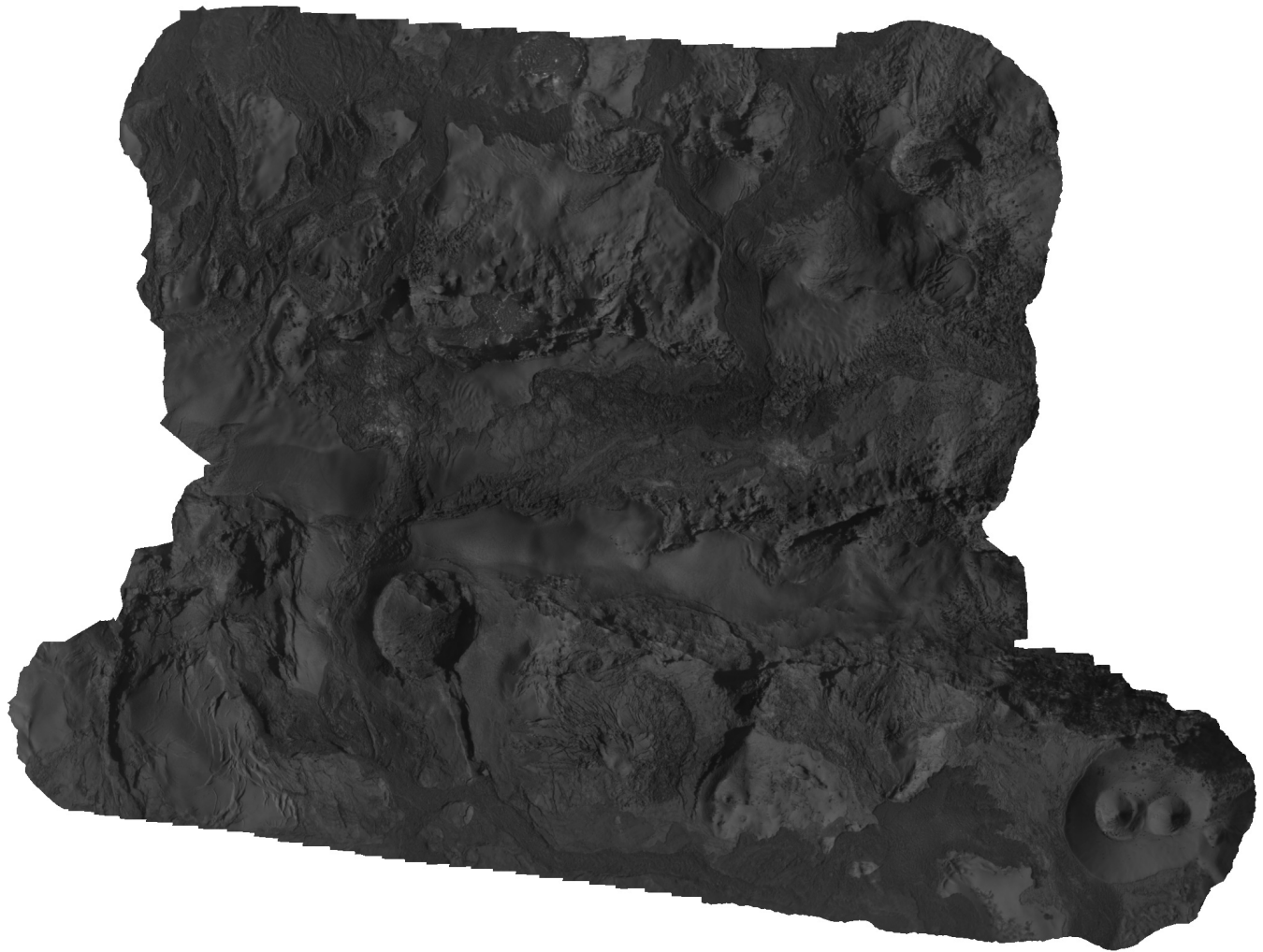


# Galapagos Thermal Inertia Flights

Processing Report  
Flight 2 TIR (scaled)

Sierra Negra Volcano  
Isla Isabela, Galapagos Islands  
October 22, 2018  
DJI M210 UAS  
Zenmuse XT Thermal Camera

01 September 2020



# Survey Data

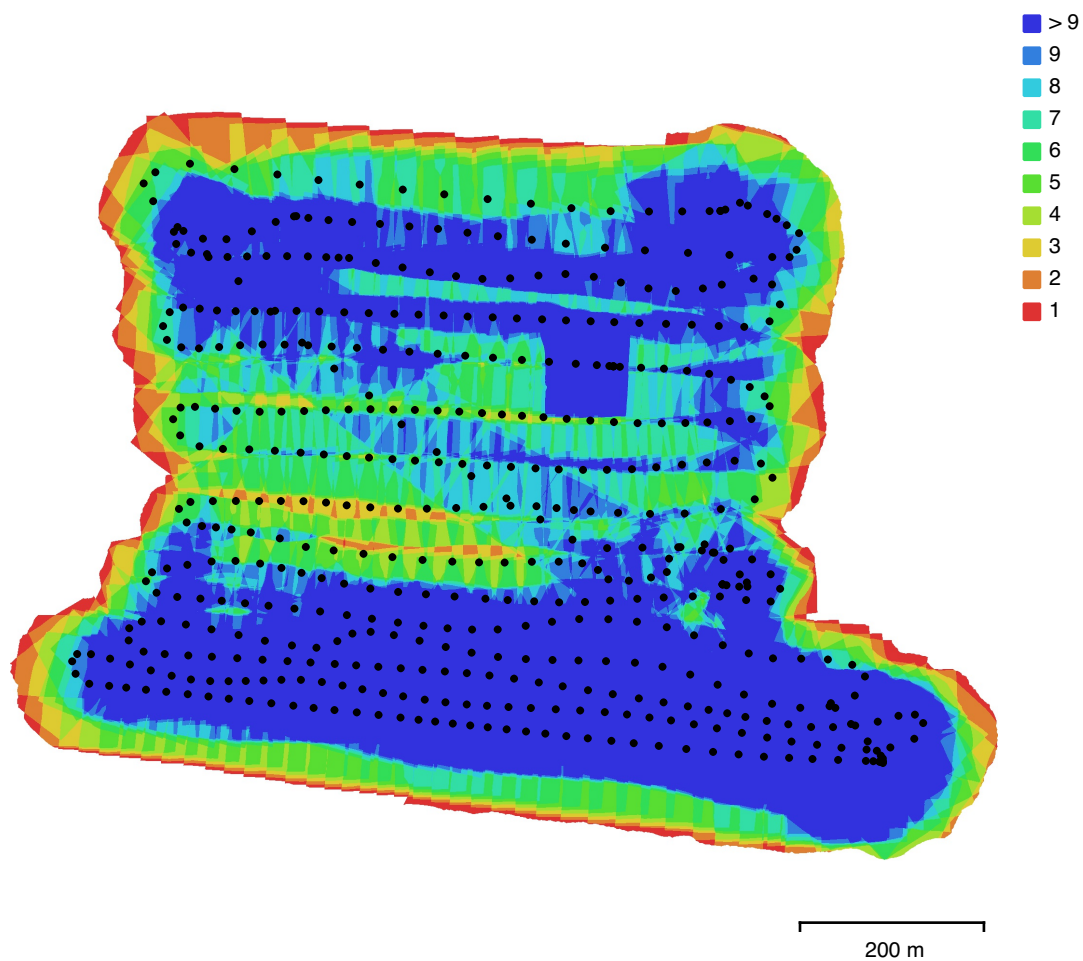


Fig. 1. Camera locations and image overlap.

|                    |                       |                     |           |
|--------------------|-----------------------|---------------------|-----------|
| Number of images:  | 490                   | Camera stations:    | 490       |
| Flying altitude:   | 151 m                 | Tie points:         | 102,705   |
| Ground resolution: | 19 cm/pix             | Projections:        | 454,665   |
| Coverage area:     | 0.613 km <sup>2</sup> | Reprojection error: | 0.378 pix |

| Camera Model | Resolution | Focal Length | Pixel Size | Precalibrated |
|--------------|------------|--------------|------------|---------------|
| unknown      | 640 x 512  | unknown      | unknown    | No            |

Table 1. Cameras.

# Camera Calibration

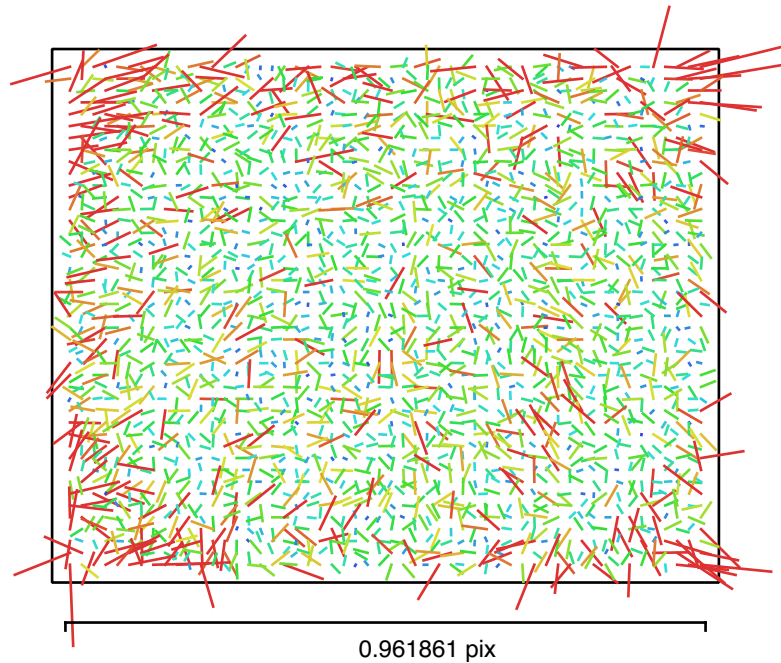


Fig. 2. Image residuals for unknown.

unknown  
490 images

Type  
Frame

Resolution  
640 x 512

Focal Length  
unknown

Pixel Size  
unknown

|    | Value        | Error   | F    | Cx    | Cy    | B1    | B2    | K1    | K2    | K3    | P1    | P2    |
|----|--------------|---------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| F  | 777.542      | 0.25    | 1.00 | -0.14 | -0.93 | 0.54  | -0.11 | -0.19 | 0.11  | 0.02  | 0.04  | 0.25  |
| Cx | -0.242823    | 0.038   |      | 1.00  | 0.13  | -0.07 | 0.11  | 0.01  | -0.01 | -0.01 | 0.81  | -0.01 |
| Cy | -2.37299     | 0.1     |      |       | 1.00  | -0.60 | 0.12  | 0.18  | -0.08 | -0.03 | -0.05 | -0.22 |
| B1 | -1.18872     | 0.025   |      |       |       | 1.00  | -0.14 | -0.33 | 0.04  | 0.02  | 0.12  | 0.71  |
| B2 | 0.193391     | 0.013   |      |       |       |       | 1.00  | 0.07  | -0.02 | 0.00  | -0.02 | -0.14 |
| K1 | -0.0542449   | 0.00057 |      |       |       |       |       | 1.00  | -0.89 | 0.84  | -0.08 | -0.40 |
| K2 | 0.252316     | 0.0049  |      |       |       |       |       |       | 1.00  | -0.98 | 0.01  | 0.03  |
| K3 | 0.550484     | 0.014   |      |       |       |       |       |       |       | 1.00  | -0.01 | -0.01 |
| P1 | 0.000270381  | 1.9e-05 |      |       |       |       |       |       |       |       | 1.00  | 0.17  |
| P2 | -0.000528425 | 5.1e-05 |      |       |       |       |       |       |       |       |       | 1.00  |

Table 2. Calibration coefficients and correlation matrix.

# Ground Control Points

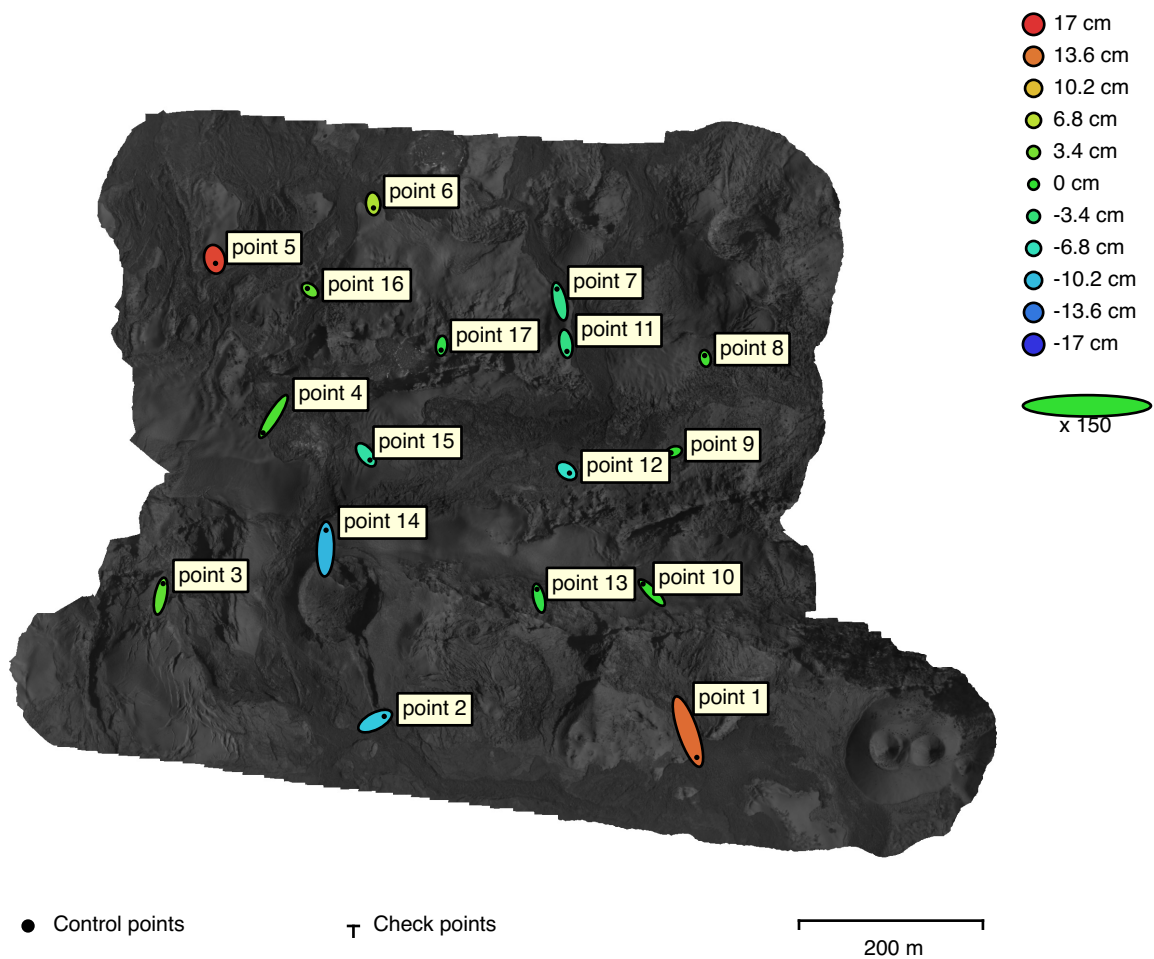


Fig. 3. GCP locations and error estimates.  
 Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.  
 Estimated GCP locations are marked with a dot or crossing.

| Count | X error (cm) | Y error (cm) | Z error (cm) | XY error (cm) | Total (cm) |
|-------|--------------|--------------|--------------|---------------|------------|
| 17    | 7.06819      | 15.4625      | 7.00883      | 17.0014       | 18.3895    |

Table 3. Control points RMSE.  
 X - Easting, Y - Northing, Z - Altitude.

| Label    | X error (cm) | Y error (cm) | Z error (cm) | Total (cm) | Image (pix) |
|----------|--------------|--------------|--------------|------------|-------------|
| point 1  | 12.8905      | -37.455      | 14.1822      | 42.0734    | 2.765 (18)  |
| point 2  | 13.1289      | 6.80957      | -9.57509     | 17.6188    | 1.544 (16)  |
| point 3  | 3.57131      | 18.1522      | 2.22251      | 18.6332    | 2.914 (4)   |
| point 4  | -15.0434     | -23.7822     | 1.29588      | 28.1705    | 2.988 (6)   |
| point 5  | 1.35964      | -5.91024     | 16.0661      | 17.1726    | 2.334 (14)  |
| point 6  | 0.516067     | -6.09848     | 6.05755      | 8.61114    | 1.335 (12)  |
| point 7  | -4.12365     | 17.9679      | -4.30346     | 18.9307    | 1.621 (10)  |
| point 8  | -0.79754     | 4.11357      | 0.798944     | 4.26566    | 0.516 (7)   |
| point 9  | -4.13657     | -1.36645     | 0.0699982    | 4.35698    | 0.526 (6)   |
| point 10 | -12.5759     | 12.6539      | 0.344801     | 17.8436    | 0.985 (11)  |
| point 11 | 1.59652      | -11.084      | -4.01723     | 11.8971    | 1.268 (10)  |
| point 12 | 4.16303      | -3.20254     | -7.34297     | 9.02808    | 1.650 (9)   |
| point 13 | -2.90266     | 12.8631      | -1.01705     | 13.2257    | 2.031 (5)   |
| point 14 | 0.896683     | 27.2626      | -10.5367     | 29.2417    | 3.040 (5)   |
| point 15 | 5.81055      | -7.54134     | -5.60185     | 11.046     | 1.719 (6)   |
| point 16 | -3.6519      | 2.88502      | 2.57023      | 5.31656    | 0.587 (12)  |
| point 17 | -0.701362    | -6.26819     | -1.21362     | 6.423      | 1.152 (6)   |
| Total    | 7.06819      | 15.4625      | 7.00883      | 18.3895    | 1.852       |

Table 4. Control points.  
X - Easting, Y - Northing, Z - Altitude.

# Digital Elevation Model

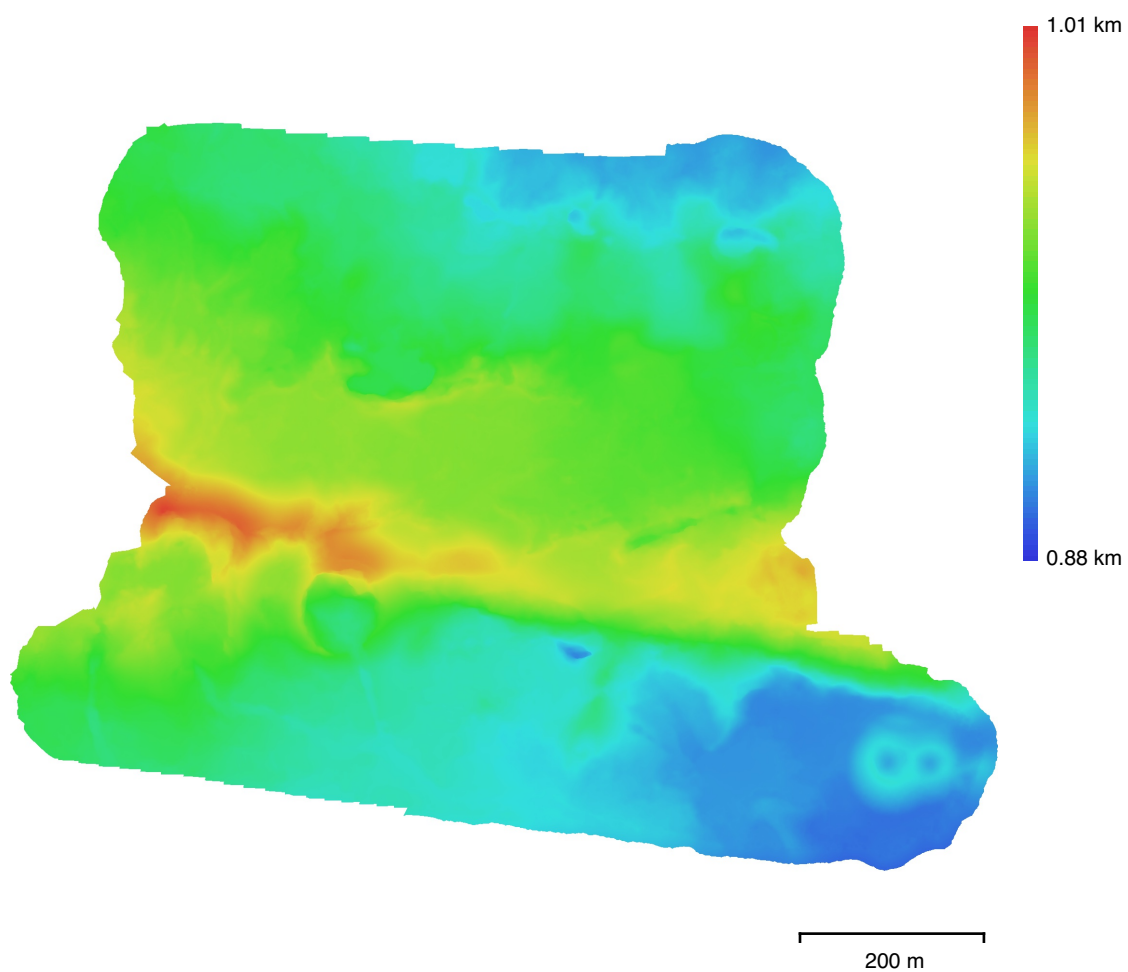


Fig. 4. Reconstructed digital elevation model.

Resolution: 37.9 cm/pix  
Point density: 6.96 points/m<sup>2</sup>

# Processing Parameters

## General

|                   |                                     |
|-------------------|-------------------------------------|
| Cameras           | 490                                 |
| Aligned cameras   | 490                                 |
| Markers           | 17                                  |
| Coordinate system | WGS 84 / UTM zone 15S (EPSG::32715) |
| Rotation angles   | Yaw, Pitch, Roll                    |

## Point Cloud

|                                |                        |
|--------------------------------|------------------------|
| Points                         | 102,705 of 142,894     |
| RMS reprojection error         | 0.12272 (0.378193 pix) |
| Max reprojection error         | 0.435487 (5.05816 pix) |
| Mean key point size            | 2.9582 pix             |
| Point colors                   | 1 bands, uint16        |
| Key points                     | No                     |
| Average tie point multiplicity | 5.0796                 |

## Alignment parameters

|                               |                       |
|-------------------------------|-----------------------|
| Accuracy                      | High                  |
| Generic preselection          | No                    |
| Key point limit               | 0                     |
| Tie point limit               | 0                     |
| Adaptive camera model fitting | Yes                   |
| Matching time                 | 51 minutes 57 seconds |
| Alignment time                | 4 minutes 59 seconds  |

## Optimization parameters

|                               |                                  |
|-------------------------------|----------------------------------|
| Parameters                    | f, b1, b2, cx, cy, k1-k3, p1, p2 |
| Adaptive camera model fitting | No                               |
| Optimization time             | 4 seconds                        |

## Dense Point Cloud

|                                   |                      |
|-----------------------------------|----------------------|
| Points                            | 5,153,991            |
| Point colors                      | 1 bands, uint16      |
| Depth maps generation parameters  |                      |
| Quality                           | High                 |
| Filtering mode                    | Aggressive           |
| Processing time                   | 20 minutes 1 seconds |
| Dense cloud generation parameters |                      |
| Processing time                   | 23 seconds           |

## Model

|                                  |                                |
|----------------------------------|--------------------------------|
| Faces                            | 1,030,797                      |
| Vertices                         | 516,672                        |
| Vertex colors                    | 1 bands, uint16                |
| Texture                          | 8,192 x 8,192, 2 bands, uint16 |
| Depth maps generation parameters |                                |
| Quality                          | High                           |
| Filtering mode                   | Aggressive                     |
| Reconstruction parameters        |                                |
| Surface type                     | Arbitrary                      |
| Source data                      | Dense cloud                    |
| Interpolation                    | Enabled                        |
| Processing time                  | 4 minutes 54 seconds           |
| Texturing parameters             |                                |
| Mapping mode                     | Orthophoto                     |
| Blending mode                    | Mosaic                         |

## General

|                        |            |
|------------------------|------------|
| Texture size           | 8,192      |
| Enable hole filling    | Yes        |
| Enable ghosting filter | No         |
| UV mapping time        | 5 seconds  |
| Blending time          | 38 seconds |

## Orthomosaic

|                           |                                     |
|---------------------------|-------------------------------------|
| Size                      | 5,663 x 4,328                       |
| Coordinate system         | WGS 84 / UTM zone 15S (EPSG::32715) |
| Colors                    | 1 bands, uint16                     |
| Reconstruction parameters |                                     |
| Blending mode             | Mosaic                              |
| Surface                   | Mesh                                |
| Enable hole filling       | Yes                                 |
| Processing time           | 46 seconds                          |
| Software version          | 1.6.1.10009                         |

## System

|                  |                                           |
|------------------|-------------------------------------------|
| Software name    | Agisoft Metashape Professional            |
| Software version | 1.6.1 build 10009                         |
| OS               | Mac OS 64 bit                             |
| RAM              | 16.00 GB                                  |
| CPU              | Intel(R) Core(TM) i7-4870HQ CPU @ 2.50GHz |
| GPU(s)           | None                                      |