



*Supplement of*

## **Multitemporal characterization of a proglacial system: a multidisciplinary approach**

**Elisabetta Corte et al.**

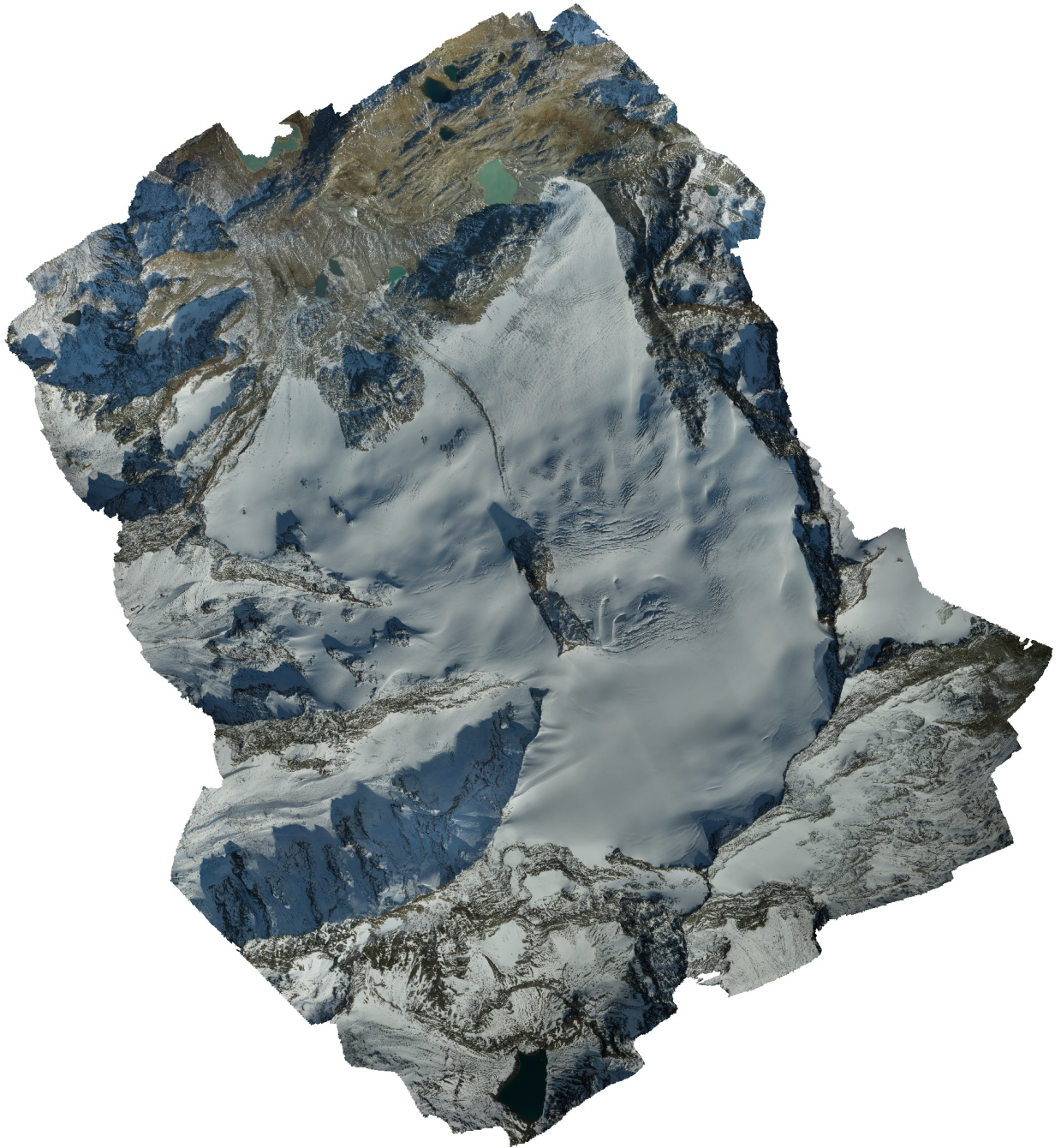
*Correspondence to:* Elisabetta Corte ([elisabetta.corte@polito.it](mailto:elisabetta.corte@polito.it))

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# Rutor Digisky aerial 2020

Processing Report

07 May 2024



# Survey Data

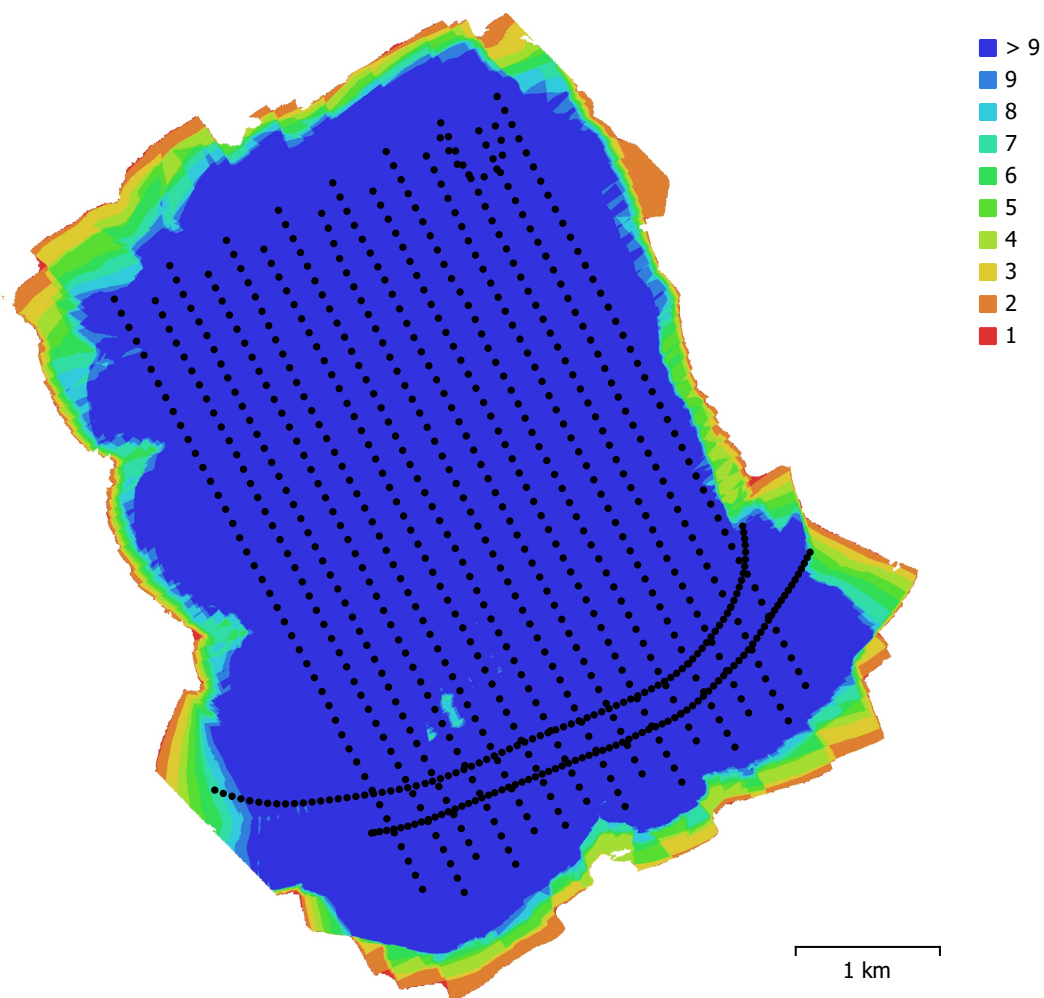


Fig. 1. Camera locations and image overlap.

Number of images:	867	Camera stations:	815
Flying altitude:	818 m	Tie points:	370,551
Ground resolution:	5.96 cm/pix	Projections:	2,553,517
Coverage area:	25.1 km <sup>2</sup>	Reprojection error:	0.395 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
iXM-RS150F, Rodenstoc...	14204 x 10652	50 mm	3.76 x 3.76 $\mu$ m	No

Table 1. Cameras.

# Camera Calibration

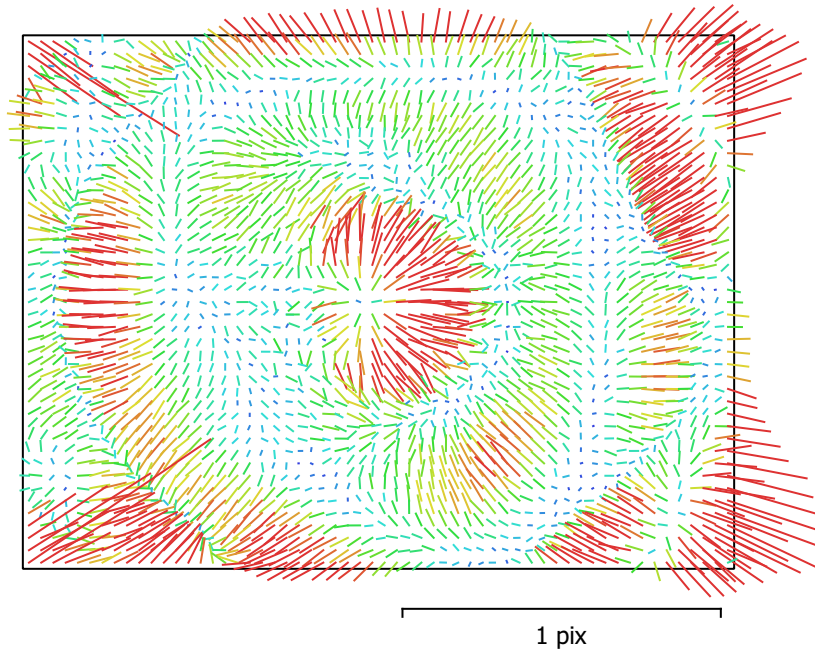


Fig. 2. Image residuals for iXM-RS150F, Rodenstock RS-50mm/Aerial (50mm).

## iXM-RS150F, Rodenstock RS-50mm/Aerial (50mm)

817 images

Type	Resolution	Focal Length	Pixel Size
<b>Frame</b>	<b>14204 x 10652</b>	<b>50 mm</b>	<b>3.76 x 3.76 <math>\mu</math>m</b>

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
<b>F</b>	<b>13743.3</b>	0.038	1.00	-0.08	-0.61	0.18	0.15	-0.10	0.11	-0.09	0.08	-0.01	-0.06
<b>Cx</b>	<b>57.3174</b>	0.0087		1.00	0.04	-0.02	0.03	-0.00	0.01	-0.01	0.01	0.88	-0.01
<b>Cy</b>	<b>-8.78157</b>	0.0093			1.00	-0.13	-0.09	-0.01	0.00	-0.00	0.01	0.00	0.67
<b>B1</b>	<b>0.315167</b>	0.0029				1.00	0.01	0.02	-0.02	0.02	-0.01	0.01	0.01
<b>B2</b>	<b>-0.896992</b>	0.0029					1.00	0.00	0.00	-0.00	0.00	0.01	-0.00
<b>K1</b>	<b>-0.00506231</b>	9.7e-06						1.00	-0.97	0.93	-0.88	-0.01	-0.02
<b>K2</b>	<b>0.0065116</b>	9.1e-05							1.00	-0.99	0.96	0.01	-0.01
<b>K3</b>	<b>0.063094</b>	0.00034								1.00	-0.99	-0.01	0.00
<b>K4</b>	<b>-0.126768</b>	0.00042									1.00	0.01	-0.00
<b>P1</b>	<b>-1.88636e-06</b>	2.3e-07										1.00	0.00
<b>P2</b>	<b>8.44211e-05</b>	2e-07											1.00

Table 2. Calibration coefficients and correlation matrix.



# Ground Control Points

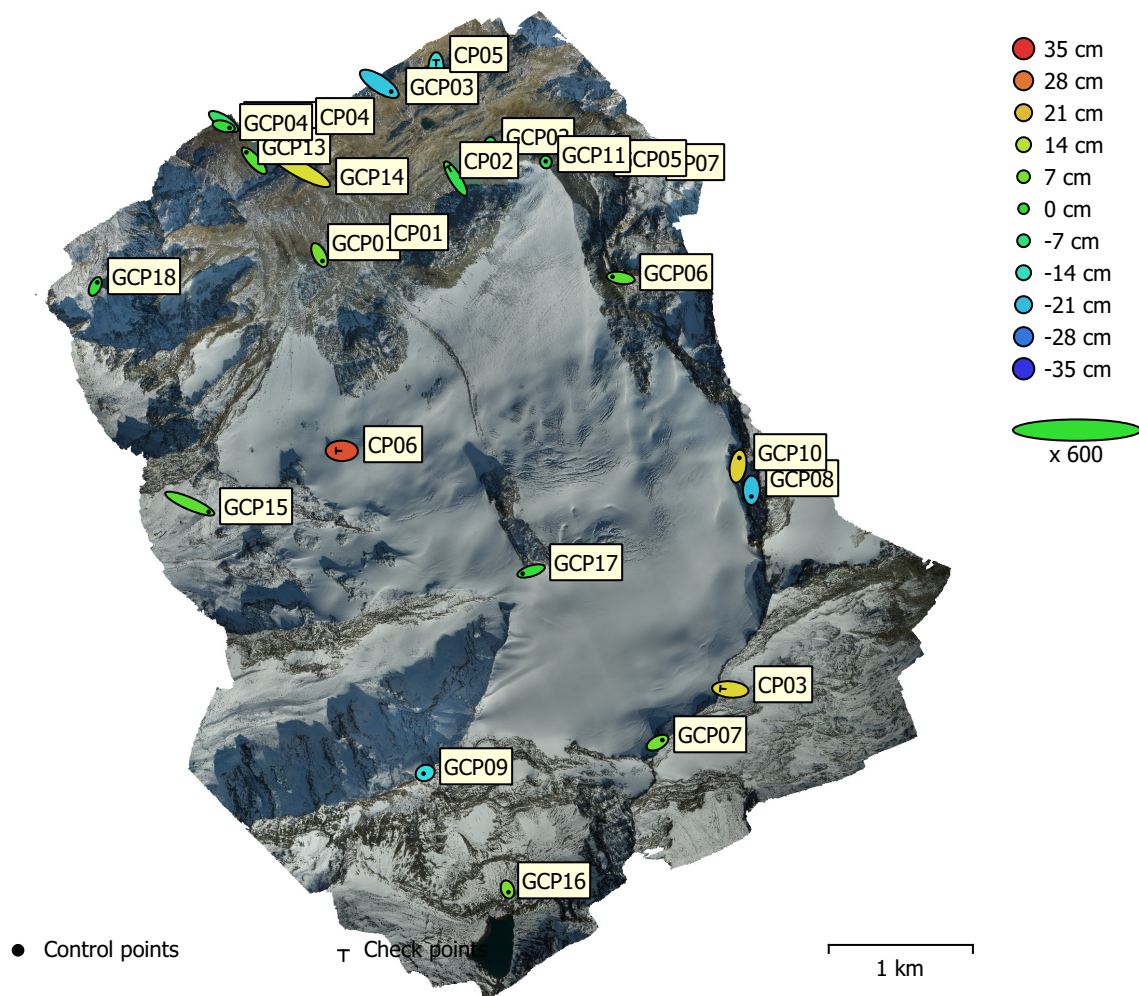


Fig. 3. GCP locations and error estimates.

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)
18	20.4103	13.1059	10.6057	24.2558	26.4731

Table 3. Control points RMSE.

X - Easting, Y - Northing, Z - Altitude.

Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
7	18.9872	14.9458	17.1342	24.1639	29.6222

Table 4. Check points RMSE.

X - Easting, Y - Northing, Z - Altitude.

<b>Label</b>	<b>X error (cm)</b>	<b>Y error (cm)</b>	<b>Z error (cm)</b>	<b>Total (cm)</b>	<b>Image (pix)</b>
GCP03	27.4801	-17.9738	-19.7975	38.3425	4.939 (6)
GCP07	11.1898	6.04222	6.81392	14.4274	7.586 (11)
GCP02	-0.576344	-0.910239	-0.0354436	1.07794	0.880 (4)
GCP12	20.6082	-13.3574	-6.16604	25.3207	9.361 (2)
GCP13	-17.8797	19.4439	3.62027	26.6618	15.538 (6)
GCP14	-53.8209	29.3242	17.1002	63.6318	7.573 (6)
GCP04	13.4534	-3.6229	-0.320234	13.9364	9.602 (2)
GCP01	7.06918	-13.7408	6.86747	16.9099	25.861 (11)
GCP08	-0.18408	-14.3295	-20.7021	25.1783	7.108 (6)
GCP15	43.8527	-19.0332	4.24094	47.9928	1.407 (15)
GCP16	2.13234	-6.34851	7.32216	9.92293	0.441 (38)
GCP17	-19.627	-6.15624	-0.23496	20.5712	2.006 (14)
GCP18	4.50713	9.42268	-0.968811	10.49	1.092 (6)
GCP05	6.10044	-1.36875	2.08238	6.58978	0.626 (12)
GCP06	-18.7612	2.75909	4.20062	19.4227	1.375 (13)
GCP09	-3.7706	-1.32908	-17.4568	17.9088	2.196 (10)
GCP10	2.9897	19.104	18.9162	27.0504	2.015 (8)
GCP11	-0.400681	1.50072	-3.12445	3.48925	0.379 (20)
<b>Total</b>	<b>20.4103</b>	<b>13.1059</b>	<b>10.6057</b>	<b>26.4731</b>	<b>7.542</b>

Table 5. Control points.  
X - Easting, Y - Northing, Z - Altitude.

<b>Label</b>	<b>X error (cm)</b>	<b>Y error (cm)</b>	<b>Z error (cm)</b>	<b>Total (cm)</b>	<b>Image (pix)</b>
CP01	-5.1403	9.42173	-10.3172	14.8875	0.692 (17)
CP02	-17.3952	28.0749	-2.35034	33.1107	0.622 (12)
CP06	-13.6064	0.165417	31.9515	34.7284	2.317 (9)
CP07	38.0926	-0.224173	14.8818	40.897	2.382 (5)
CP05	0.221481	22.0909	-16.7647	27.7329	0.281 (7)
CP04	-4.0905	13.9503	-8.84522	17.0171	0.972 (6)
CP03	-23.2729	1.99389	18.4778	29.7831	0.820 (23)
<b>Total</b>	<b>18.9872</b>	<b>14.9458</b>	<b>17.1342</b>	<b>29.6222</b>	<b>1.186</b>

Table 6. Check points.  
X - Easting, Y - Northing, Z - Altitude.

# Digital Elevation Model

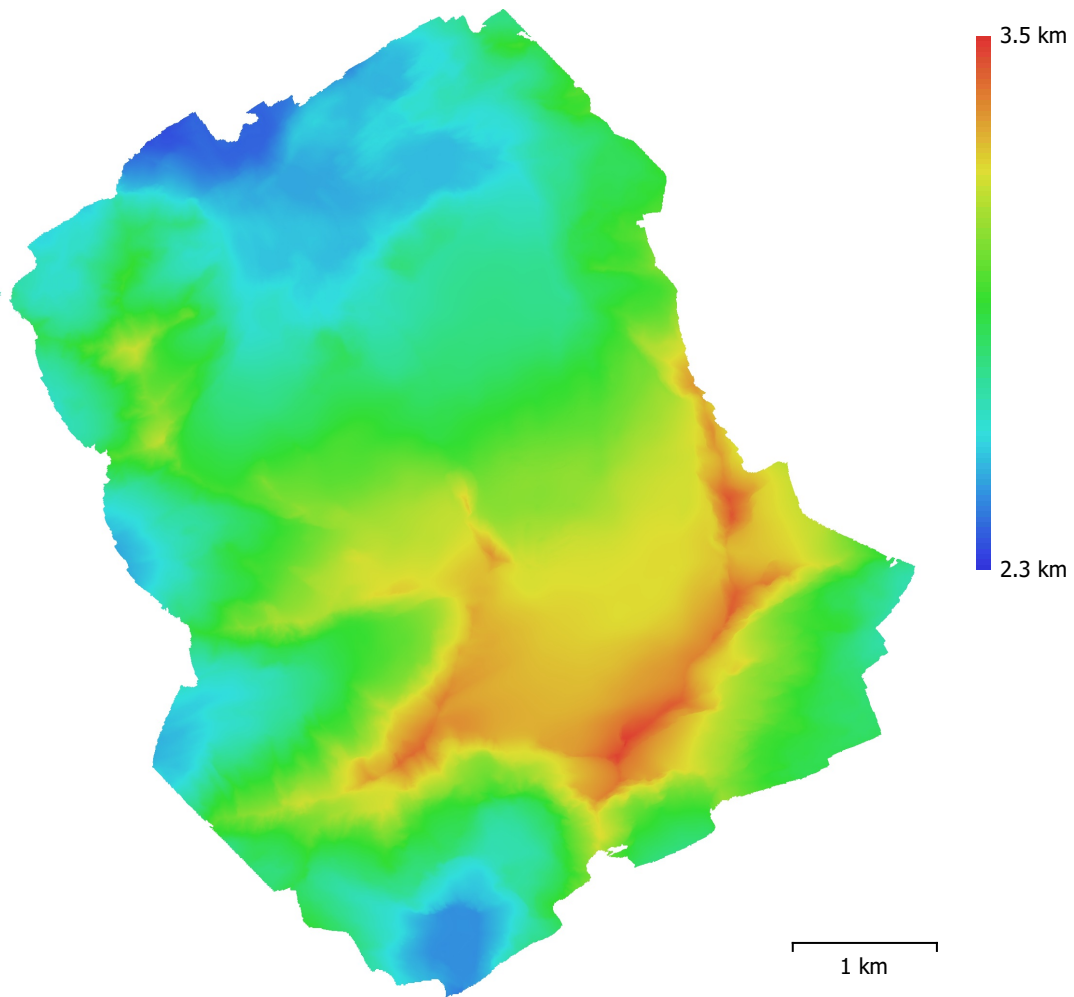


Fig. 4. Reconstructed digital elevation model.

Resolution: 9.14 m/pix  
Point density: 0.012 points/m<sup>2</sup>



# Processing Parameters

## General

Cameras	817
Aligned cameras	815
Markers	25
Coordinate system	RDN2008 / UTM zone 32N (N-E) (EPSG::6707)
Rotation angles	Yaw, Pitch, Roll

## Tie Points

Points	370,551 of 457,787
RMS reprojection error	0.164229 (0.395351 pix)
Max reprojection error	1.50459 (26.8786 pix)
Mean key point size	1.9327 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	7.48877

## Alignment parameters

Accuracy	Highest
Generic preselection	Yes
Reference preselection	No
Key point limit	40,000
Key point limit per Mpx	1,000
Tie point limit	4,000
Exclude stationary tie points	No
Guided image matching	No
Adaptive camera model fitting	No
Matching time	1 hours 6 minutes
Matching memory usage	749.31 MB
Alignment time	4 minutes 29 seconds
Alignment memory usage	705.62 MB

## Optimization parameters

Parameters	f, b1, b2, cx, cy, k1-k4, p1, p2
Adaptive camera model fitting	No
Optimization time	9 seconds
Date created	2021:11:15 15:02:18
Software version	1.7.4.13028
File size	62.21 MB

## Model

Faces	893,126
Vertices	448,567
Vertex colors	3 bands, uint8
Texture	8,192 x 8,192, 4 bands, uint8

## Texturing parameters

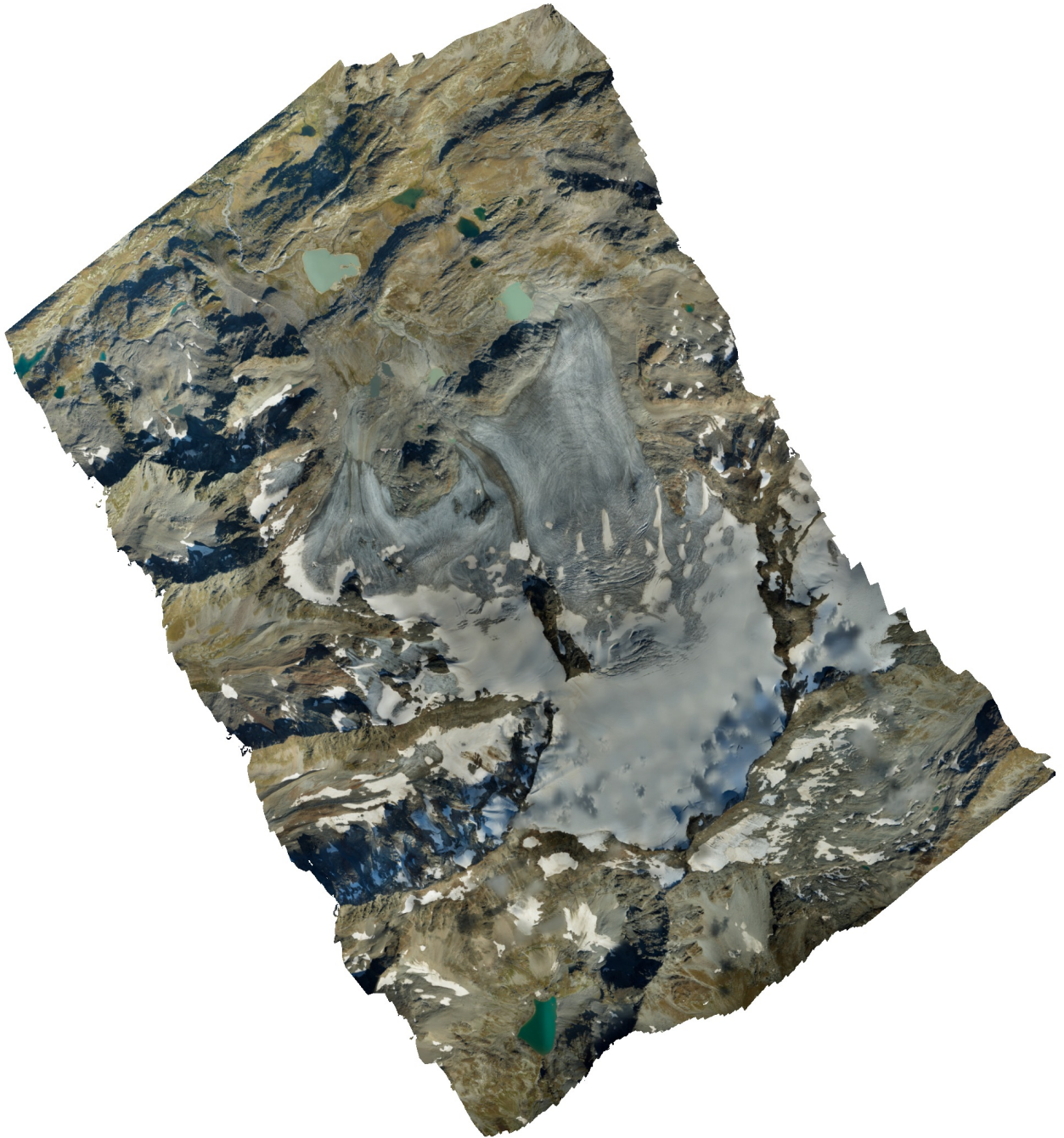
Mapping mode	Generic
Blending mode	Mosaic
Texture size	8,192
Enable hole filling	Yes
Enable ghosting filter	Yes
UV mapping time	1 minutes 25 seconds
UV mapping memory usage	875.45 MB
Blending time	7 hours 31 minutes
Blending memory usage	21.83 GB

File size	261.90 MB
<b>System</b>	
Software name	Agisoft Metashape Professional
Software version	2.0.3 build 16960
OS	Windows 64 bit
RAM	63.69 GB
CPU	Intel(R) Core(TM) i9-9900X CPU @ 3.50GHz
GPU(s)	NVIDIA GeForce RTX 2060

# Rutor Digisky aerial 2021

Processing Report

07 May 2024



# Survey Data

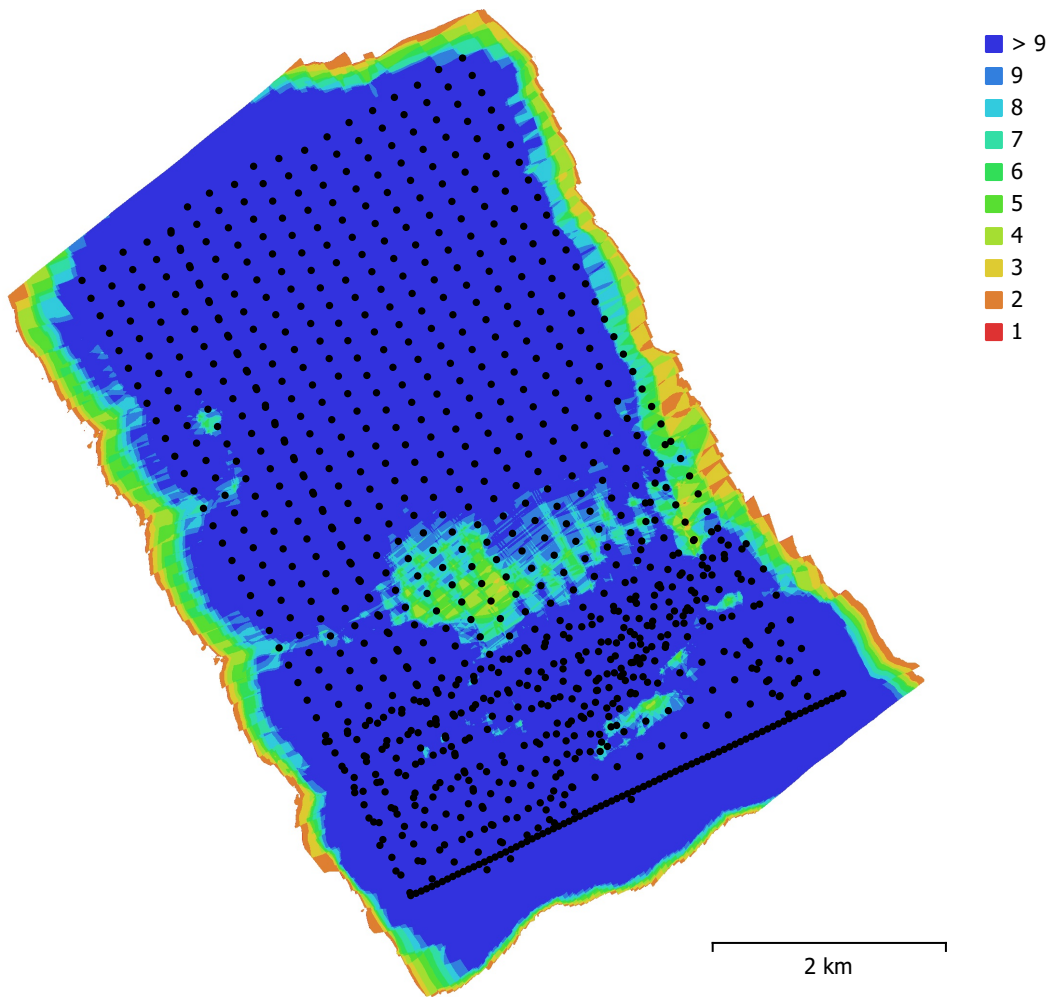


Fig. 1. Camera locations and image overlap.

Number of images:	1,030	Camera stations:	997
Flying altitude:	804 m	Tie points:	505,977
Ground resolution:	6.27 cm/pix	Projections:	3,425,721
Coverage area:	34.8 km <sup>2</sup>	Reprojection error:	0.586 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
iXM-RS150F, Rodenstoc...	14204 x 10652	50 mm	3.76 x 3.76 μm	No

Table 1. Cameras.

# Camera Calibration

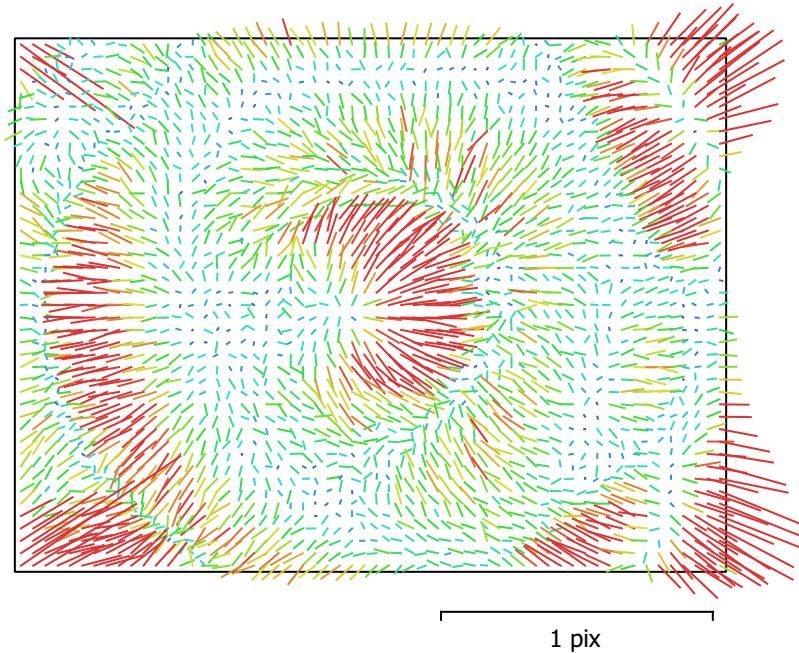


Fig. 2. Image residuals for iXM-RS150F, Rodenstock RS-50mm/Aerial (50mm).

## iXM-RS150F, Rodenstock RS-50mm/Aerial (50mm)

1014 images

Type	Resolution	Focal Length	Pixel Size
<b>Frame</b>	<b>14204 x 10652</b>	<b>50 mm</b>	<b>3.76 x 3.76 <math>\mu</math>m</b>

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
<b>F</b>	<b>13740.6</b>	0.1	1.00	-0.31	-0.67	0.05	-0.06	-0.06	0.06	-0.05	0.04	-0.01	-0.01
<b>Cx</b>	<b>58.0346</b>	0.013		1.00	0.20	-0.05	0.08	-0.00	0.00	-0.00	0.01	0.76	-0.01
<b>Cy</b>	<b>-7.72876</b>	0.014			1.00	-0.08	0.02	0.00	-0.01	0.00	0.00	0.00	0.57
<b>B1</b>	<b>0.217977</b>	0.0036				1.00	-0.00	0.02	-0.02	0.02	-0.02	0.01	0.01
<b>B2</b>	<b>-0.90192</b>	0.0036					1.00	0.00	-0.00	0.00	0.00	0.00	0.02
<b>K1</b>	<b>-0.00483364</b>	1.4e-05						1.00	-0.98	0.93	-0.89	-0.01	-0.00
<b>K2</b>	<b>0.0106506</b>	0.00013							1.00	-0.99	0.96	0.01	-0.01
<b>K3</b>	<b>0.0479761</b>	0.00047								1.00	-0.99	-0.01	0.01
<b>K4</b>	<b>-0.111596</b>	0.00058									1.00	0.01	-0.00
<b>P1</b>	<b>1.54472e-05</b>	2.9e-07										1.00	-0.00
<b>P2</b>	<b>9.69403e-05</b>	2.6e-07											1.00

Table 2. Calibration coefficients and correlation matrix.



# Ground Control Points

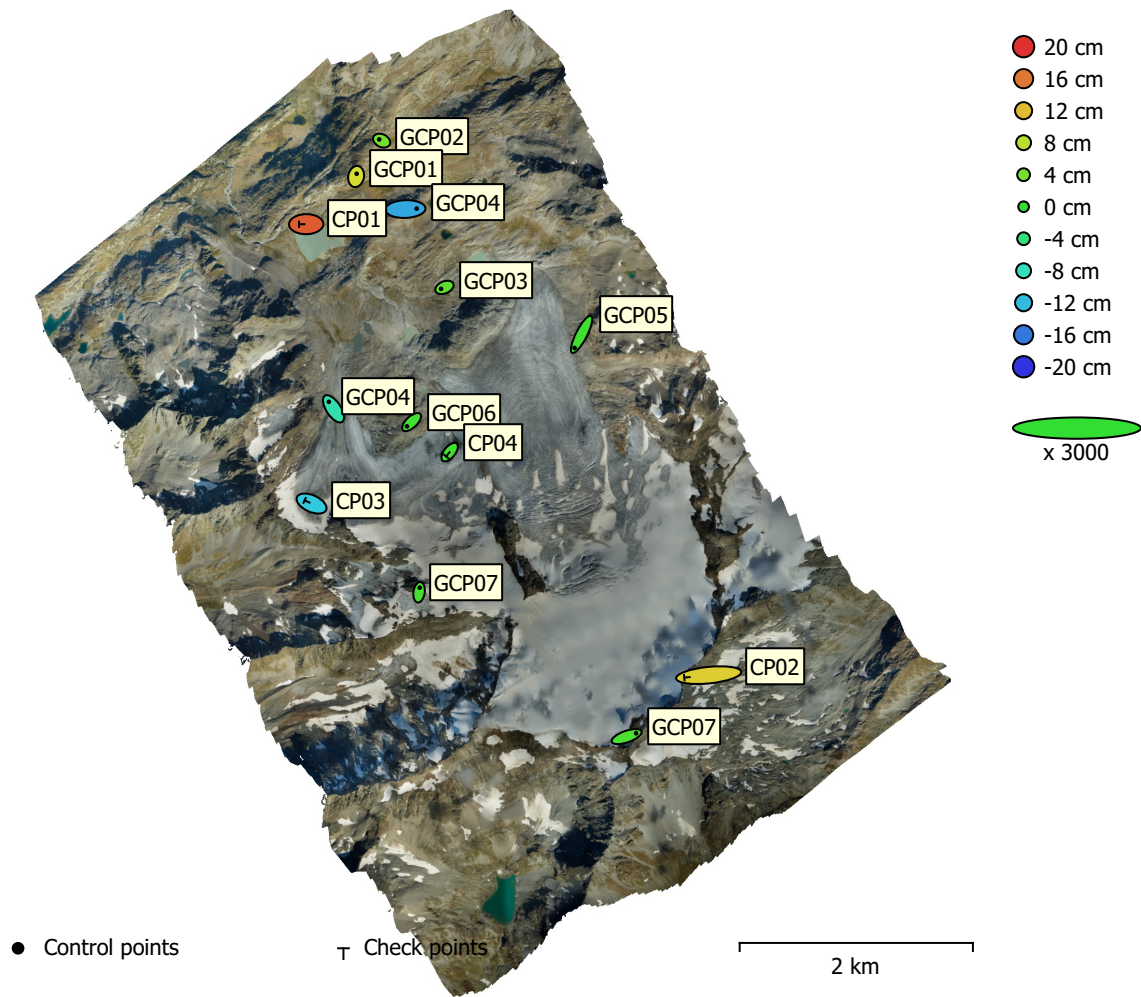


Fig. 3. GCP locations and error estimates.

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)
9	3.44737	3.2796	6.15283	4.75816	7.77801

Table 3. Control points RMSE.

X - Easting, Y - Northing, Z - Altitude.

Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
4	7.59541	1.6699	11.7984	7.77681	14.1309

Table 4. Check points RMSE.

X - Easting, Y - Northing, Z - Altitude.



<b>Label</b>	<b>X error (cm)</b>	<b>Y error (cm)</b>	<b>Z error (cm)</b>	<b>Total (cm)</b>	<b>Image (pix)</b>
GCP07	0.376596	2.63743	1.19937	2.92171	0.336 (11)
GCP04	-2.66182	4.03174	-7.0668	8.56037	0.309 (32)
GCP02	-1.3843	0.683368	3.88985	4.185	0.348 (21)
GCP07	5.41751	1.89144	1.57074	5.9493	1.067 (8)
GCP03	-1.94006	-0.826232	2.51957	3.28554	0.316 (20)
GCP01	0.32524	1.57072	9.46181	9.59681	0.331 (29)
GCP06	-2.62369	-2.45089	0.962234	3.71706	0.231 (17)
GCP05	-3.98059	-7.76768	0.672345	8.75409	0.280 (16)
GCP04	6.47053	0.2299	-13.2094	14.7108	2.227 (10)
<b>Total</b>	<b>3.44737</b>	<b>3.2796</b>	<b>6.15283</b>	<b>7.77801</b>	<b>0.667</b>

Table 5. Control points.  
X - Easting, Y - Northing, Z - Altitude.

<b>Label</b>	<b>X error (cm)</b>	<b>Y error (cm)</b>	<b>Z error (cm)</b>	<b>Total (cm)</b>	<b>Image (pix)</b>
CP03	-3.9849	1.78171	-11.2822	12.0972	0.248 (21)
CP04	-2.00467	-2.45014	0.929865	3.29948	0.430 (6)
CP01	-4.0963	-0.0558166	17.5501	18.0219	0.311 (5)
CP02	-13.9314	-1.40479	10.9844	17.7964	0.322 (8)
<b>Total</b>	<b>7.59541</b>	<b>1.6699</b>	<b>11.7984</b>	<b>14.1309</b>	<b>0.305</b>

Table 6. Check points.  
X - Easting, Y - Northing, Z - Altitude.

# Digital Elevation Model

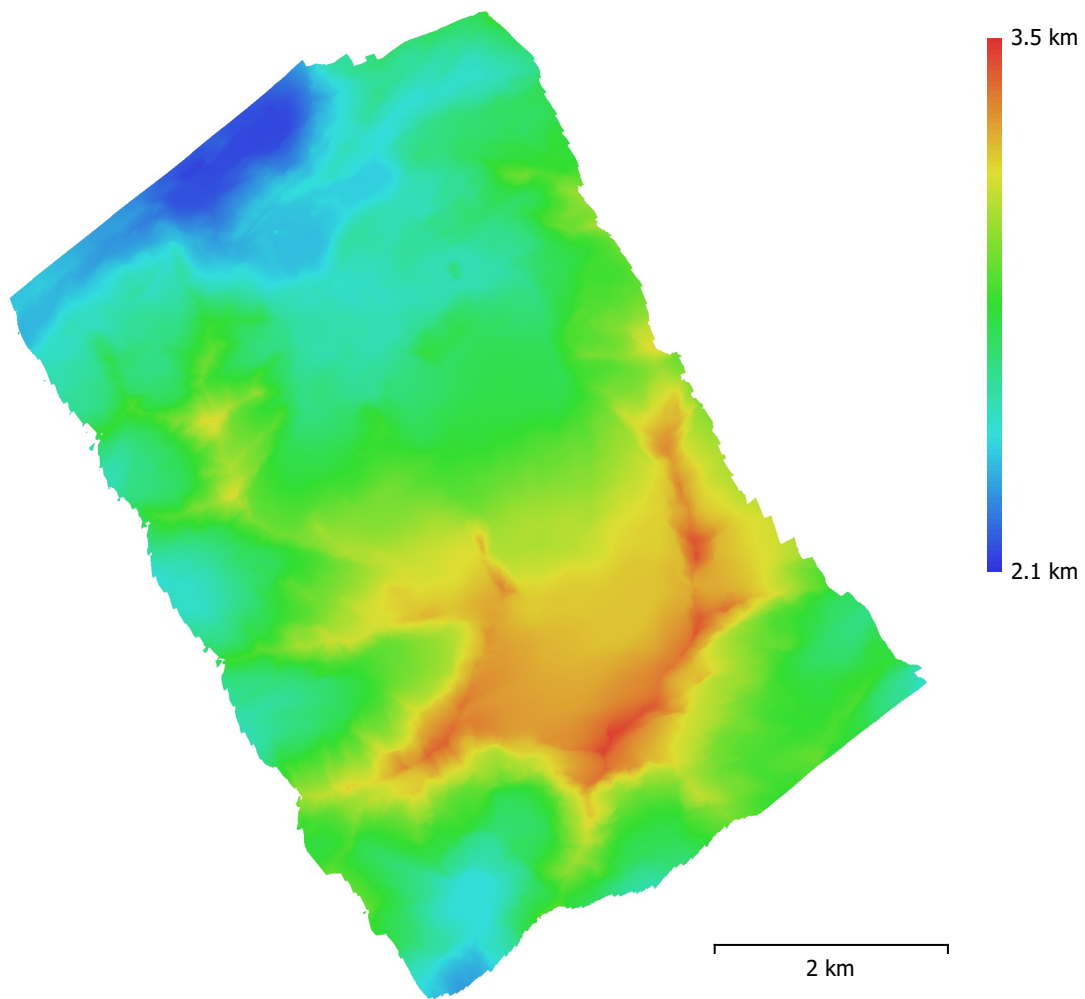


Fig. 4. Reconstructed digital elevation model.

Resolution: 12.5 cm/pix  
Point density: 63.6 points/m<sup>2</sup>

# Processing Parameters

## General

Cameras	1014
Aligned cameras	997
Markers	13
Coordinate system	RDN2008 / UTM zone 32N (N-E) (EPSG::6707)
Rotation angles	Yaw, Pitch, Roll

## Tie Points

Points	505,977 of 587,355
RMS reprojection error	0.105898 (0.586334 pix)
Max reprojection error	0.509266 (43.2814 pix)
Mean key point size	4.98914 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	7.45368

## Alignment parameters

Accuracy	Medium
Generic preselection	Yes
Reference preselection	No
Key point limit	40,000
Key point limit per Mpx	1,000
Tie point limit	4,000
Exclude stationary tie points	No
Guided image matching	No
Adaptive camera model fitting	No
Matching time	1 hours 11 minutes
Matching memory usage	1.08 GB
Alignment time	4 minutes 30 seconds
Alignment memory usage	439.61 MB

## Optimization parameters

Parameters	f, b1, b2, cx, cy, k1-k4, p1, p2
Adaptive camera model fitting	No
Optimization time	9 seconds
Date created	2021:10:30 10:20:40
Software version	1.7.4.13028
File size	80.19 MB

## Depth Maps

Count	1033
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## Depth maps generation parameters

Quality	High
Filtering mode	Mild
Max neighbors	40
Processing time	14 hours 37 minutes
Memory usage	56.47 GB
Date created	2021:11:20 08:08:36
Software version	1.7.4.13028
File size	44.83 GB

## Point Cloud

Points	3,342,984,543
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## Point attributes

Color	3 bands, uint8
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Normal	
Confidence	1 - 80
<b>Point classes</b>	
Created (never classified)	3,342,984,543
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Max neighbors	40
Processing time	14 hours 37 minutes
Memory usage	56.47 GB
<b>Point cloud generation parameters</b>	
Processing time	1 days 2 hours
Memory usage	54.45 GB
Date created	2023:06:20 15:39:22
Software version	1.8.3.14331
File size	46.60 GB
<b>DEM</b>	
Size	76,675 x 78,207
Coordinate system	RDN2008 / UTM zone 32N (N-E) (EPSG::6707)
<b>Reconstruction parameters</b>	
Source data	Point cloud
Interpolation	Enabled
Processing time	48 minutes 30 seconds
Memory usage	380.62 MB
Date created	2023:06:21 08:11:46
Software version	1.8.3.14331
File size	7.69 GB
<b>Orthomosaic</b>	
Size	125,215 x 135,015
Coordinate system	RDN2008 / UTM zone 32N (N-E) (EPSG::6707)
Colors	3 bands, uint8
<b>Reconstruction parameters</b>	
Blending mode	Mosaic
Surface	DEM
Enable hole filling	Yes
Enable ghosting filter	No
Processing time	10 hours 39 minutes
Memory usage	5.97 GB
Date created	2023:06:21 17:55:54
Software version	1.8.3.14331
File size	193.27 GB
<b>System</b>	
Software name	Agisoft Metashape Professional
Software version	2.0.3 build 16960
OS	Windows 64 bit
RAM	63.68 GB
CPU	Intel(R) Core(TM) i9-9900X CPU @ 3.50GHz
GPU(s)	Quadro RTX 4000