

Appendix

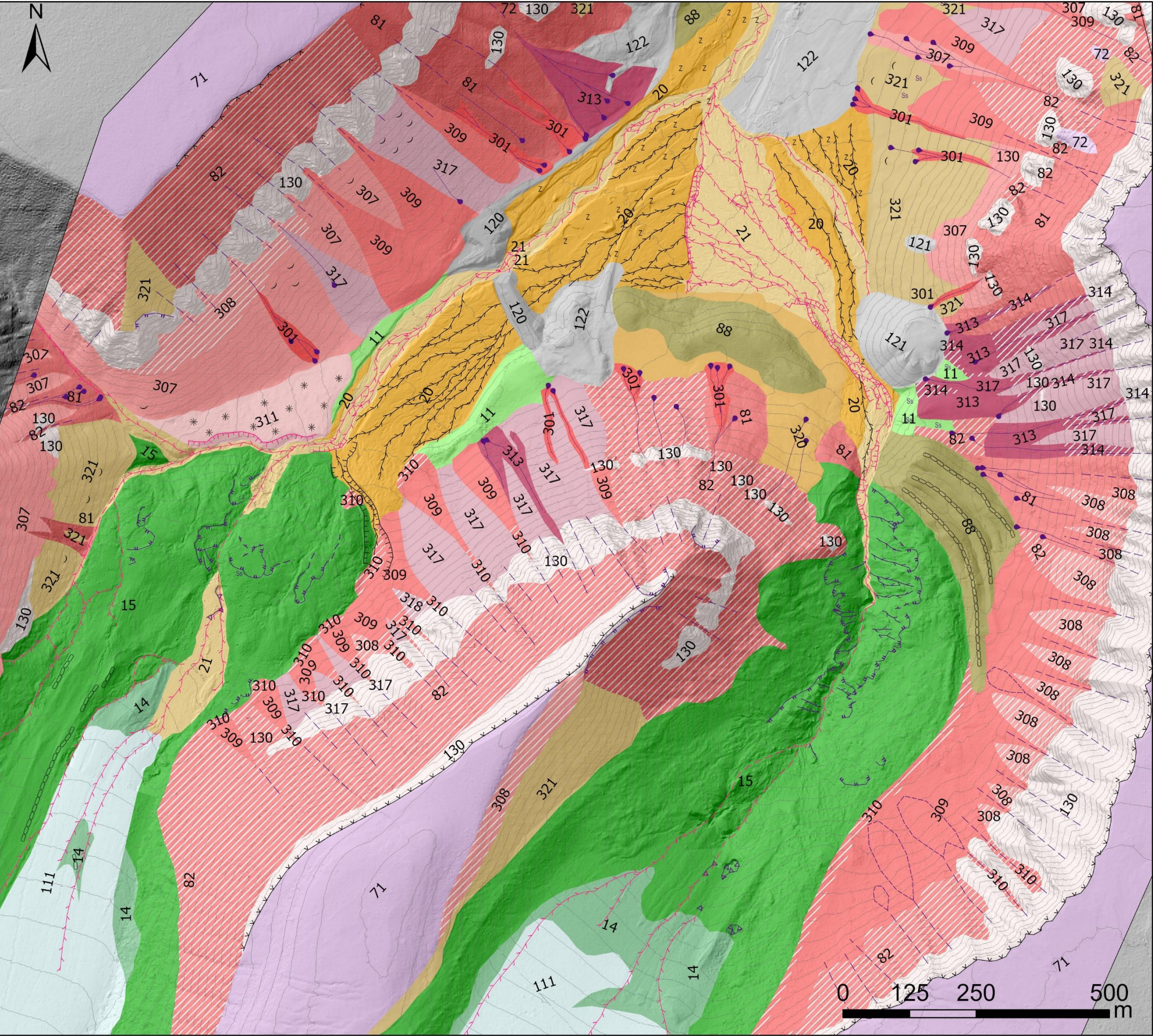
A Quaternary map of Upper Longyeardalen with geomorphological elements (A3 Format)

B Drone modelling in Longyeardalen 2021: Processing reports from Agisoft metashape Pro including orthophotos, survey data, camera locations, and digital elevation models.

1. Longyearbreen July/August 2021
2. Larsbreen July/August 2021
3. Upper Middle Longyearelva July/August 2021
4. Lower Longyearelva July/August 2021
5. Longyearbreen September 2021
6. Larsbreen September 2021
7. Upper Middle Longyearelva September 2021
8. Lower Longyearelva September 2021

C Roundness analysis in Longyeardalen: Tables of measurements and calculations

Quaternary Map of Upper Longyeardalen



Legend

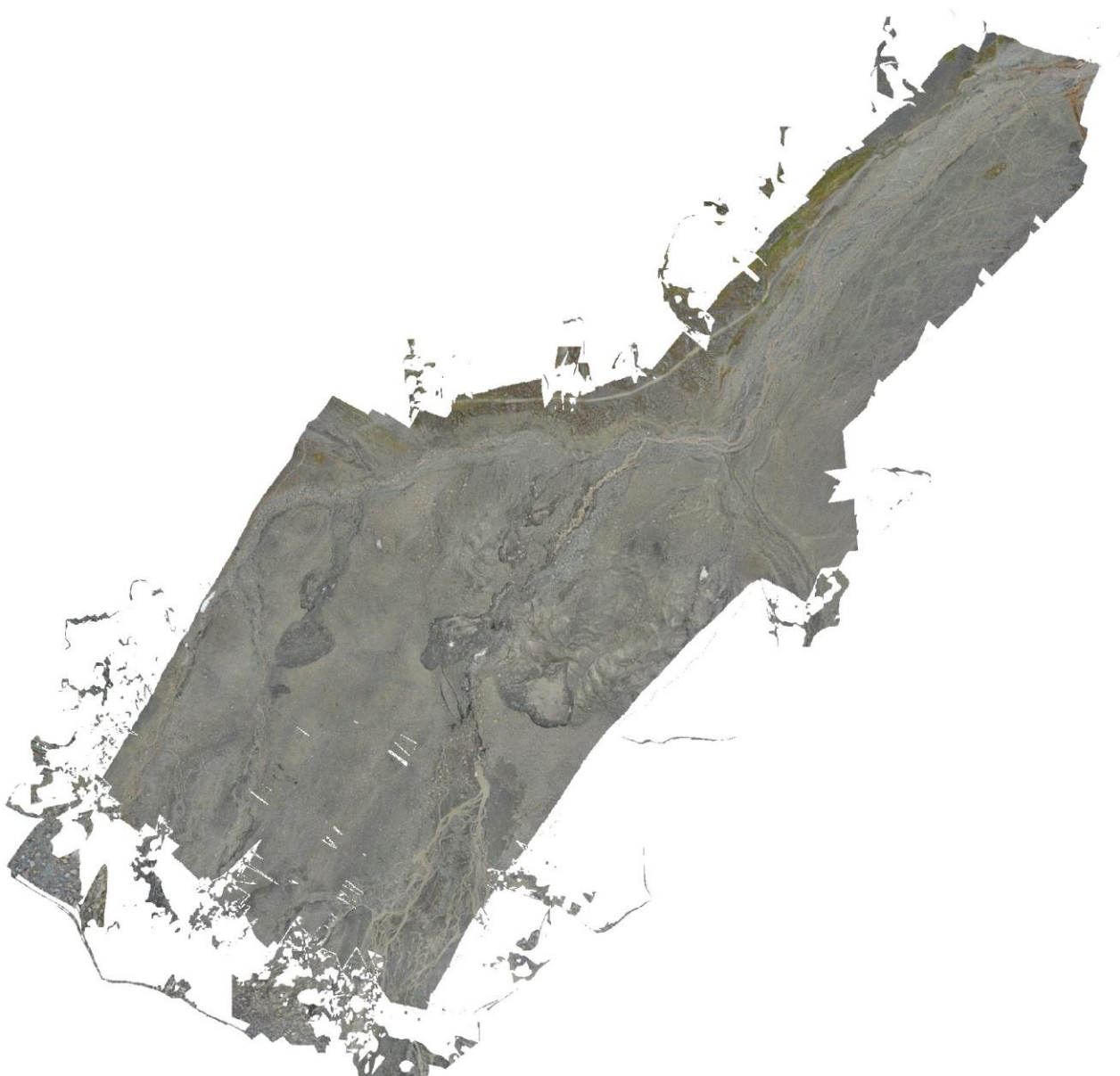
011-Till	z Anthropogenically added sediment
015-Marginal moraine	~ Solifluction lobe
014-Supra-glacial till	* Patterned ground
021-Glaciofluvial deposit, active channel	Ss Small snow avalanche deposit
020-Glaciofluvial deposit, inactive channel	Glaciofluvial erosion scarp
071-Weathering material	Glaciofluvial channel
072-Weathering material, thin cover	Subsurface glaciofluvial channel
088-Rock glacier	Inactive glaciofluvial erosion scarp
130-Bare bedrock	Inactive glaciofluvial channel
321-Stone-rich solifluction material	Water channel from slump
320-Solifluction material	Back-scarp of slump/slide
120-Anthropogenic fill mass	Previous/stabilised backscarp
121-Mining dump	Edge of slump scar
122-Anthropogenically disturbed sediment	Collapse edge
307-Rock fall deposit	Edge of avalanche fan
308-Rock fall deposit, thin cover	General avalanche track
309-Snow avalanche deposit	Debris flow track
310-Snow avalanche deposit, thin cover	Ridge
301-Debris flow deposit	Nivation scarp
311-Inactive slush avalanche/debris flood deposit	Contour, 10m
313-Snow avalanche and debris flow deposit	Hillshade generated from 2021 DEMs and NPI 2009 DEM (NW light source)
314-Snow avalanche and debris flow deposit, thin cover	Scale 1:7,000
317-Snow avalanche and rock fall deposit	
318-Snow avalanche and rock fall deposit, thin cover	
081-Mixed avalanche deposit	
082-Mixed avalanche deposit, thin cover	
111-Glacier	

Appendix B – Drone modelling in Longyeardalen 2021: Processing reports from Agisoft metashape Pro

1. Longyearbreen July/August 2021

Agisoft Metashape Processing Report

Orthophoto



Survey Data

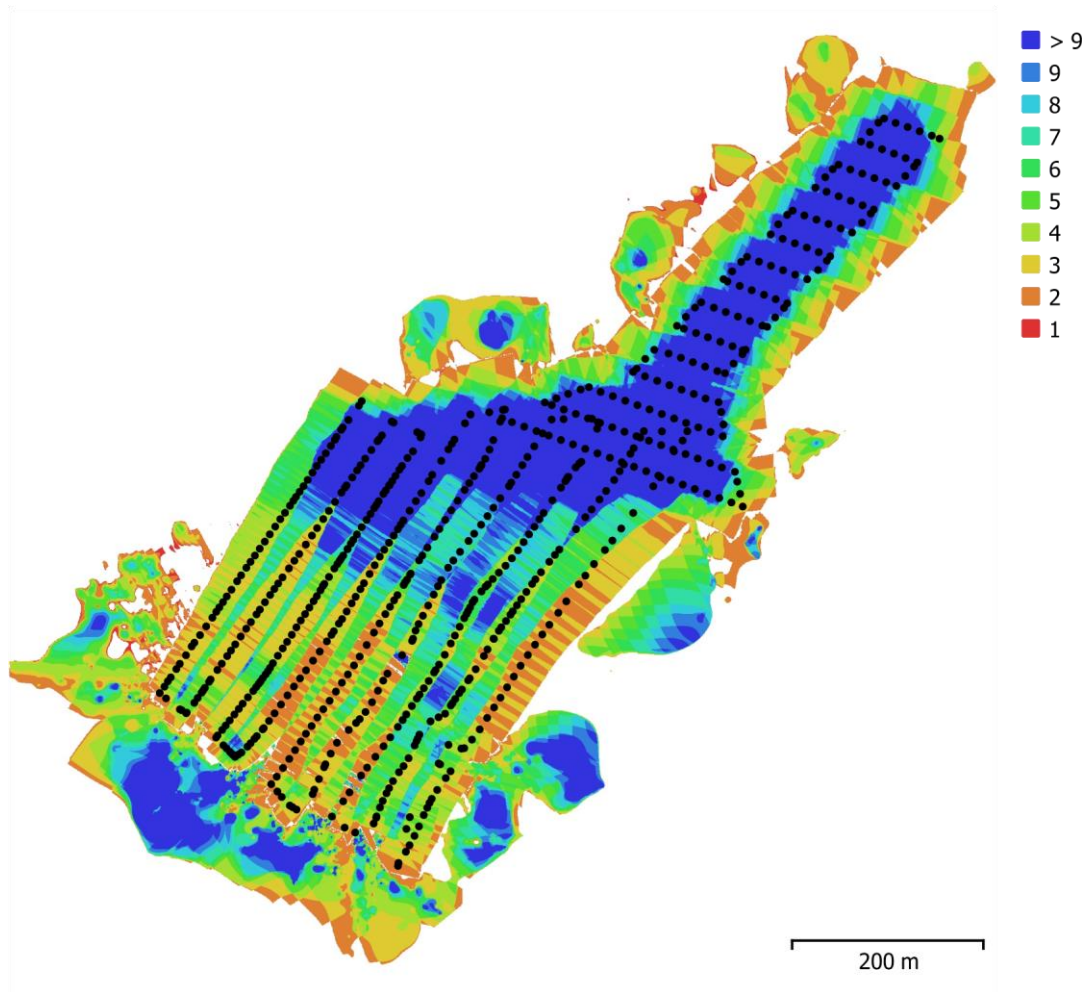


Fig. 1. Camera locations and image overlap.

Number of images:	629	Camera stations:	628
Flying altitude:	63.6 m	Tie points:	1,327,922
Ground resolution:	1.33 cm/pix	Projections:	4,345,304
Coverage area:	0.369 km ²	Reprojection error:	0.493 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
Test_Pro (10.26mm)	5472 x 3078	10.26 mm	2.53 x 2.53 μm	No

Table 1. Cameras.

Camera Locations

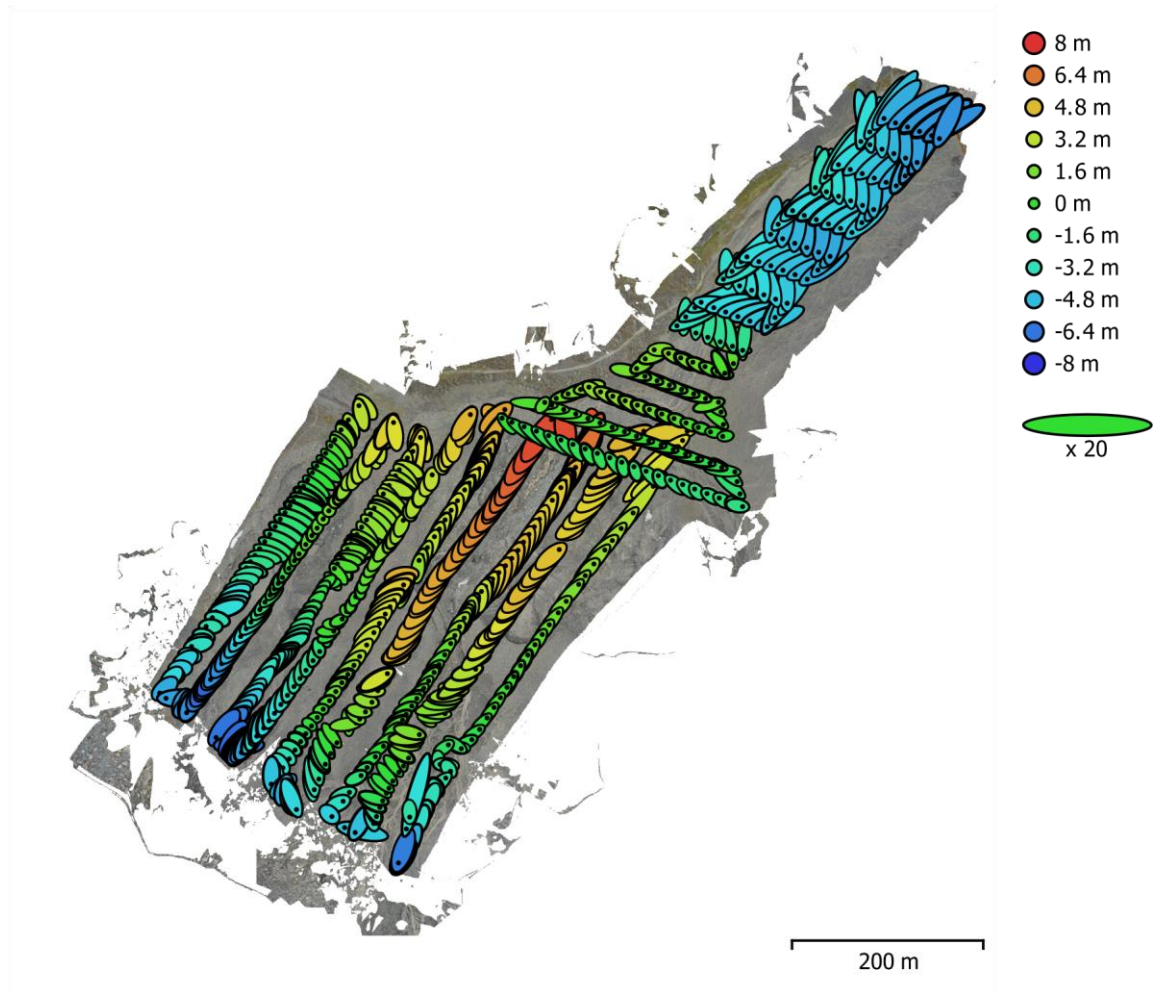


Fig. 3. Camera locations and error estimates.

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)
0.910257	0.975309	3.51388	1.33409	3.75861

Table 3. Average camera location error.

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

Digital Elevation Model

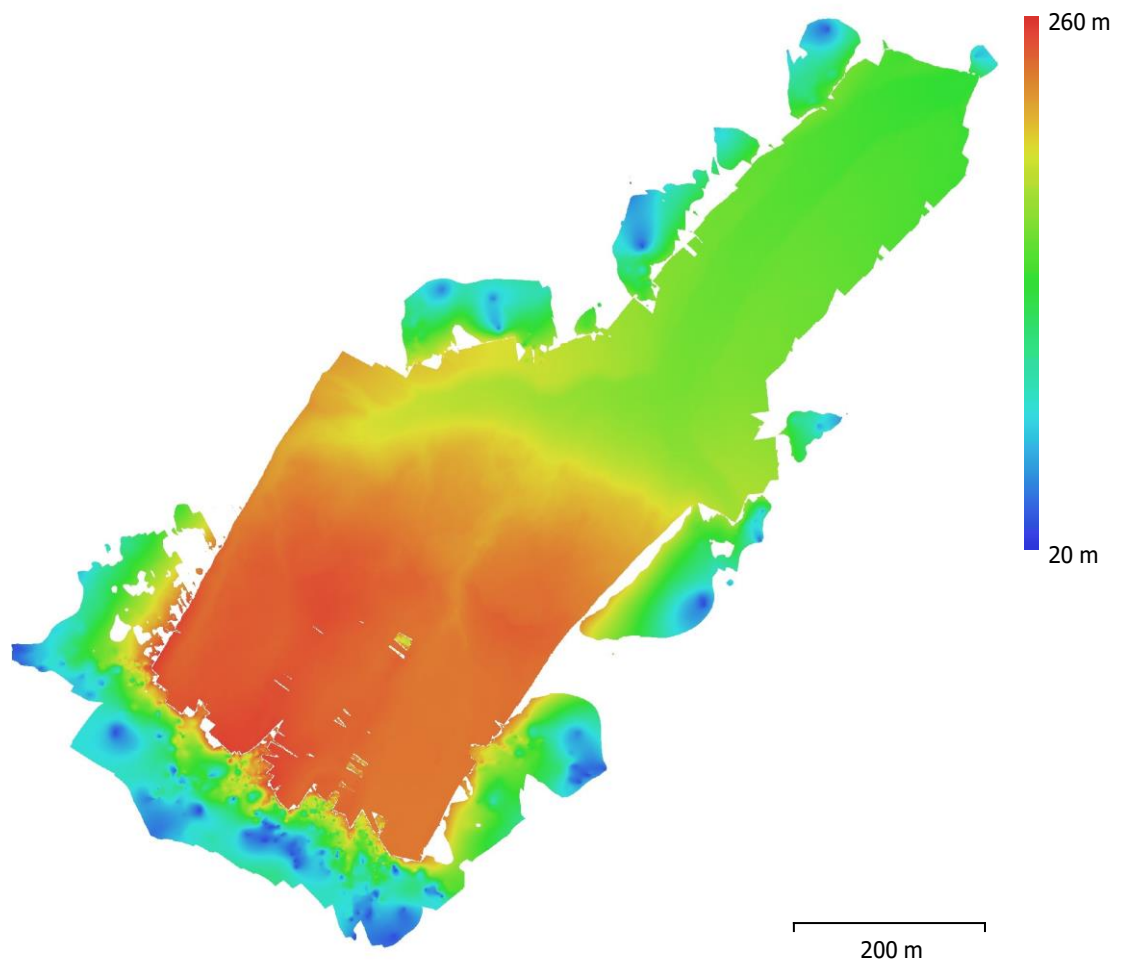


Fig. 4. Reconstructed digital elevation model.

Resolution: 2.67 cm/pix
Point density: 0.141 points/cm²

2. Larsbreen July/August 2021

Agisoft Metashape Processing Report

Orthophoto



Survey Data

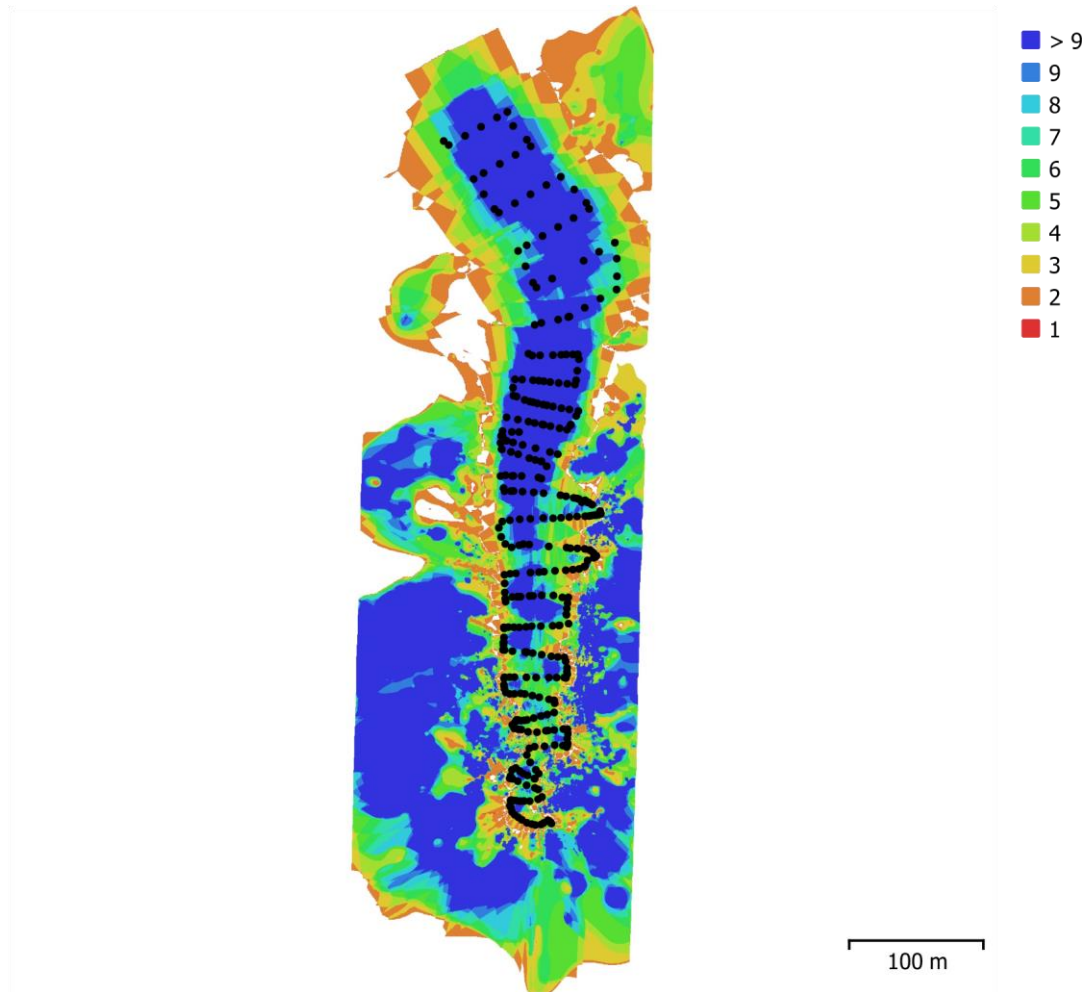


Fig. 1. Camera locations and image overlap.

Number of images:	333	Camera stations:	333
Flying altitude:	34.8 m	Tie points:	814,302
Ground resolution:	7.76 mm/pix	Projections:	2,268,712
Coverage area:	0.125 km ²	Reprojection error:	0.7 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
Test_Pro (10.26mm)	5472 x 3078	10.26 mm	2.53 x 2.53 μm	No

Table 1. Cameras.

Camera Locations

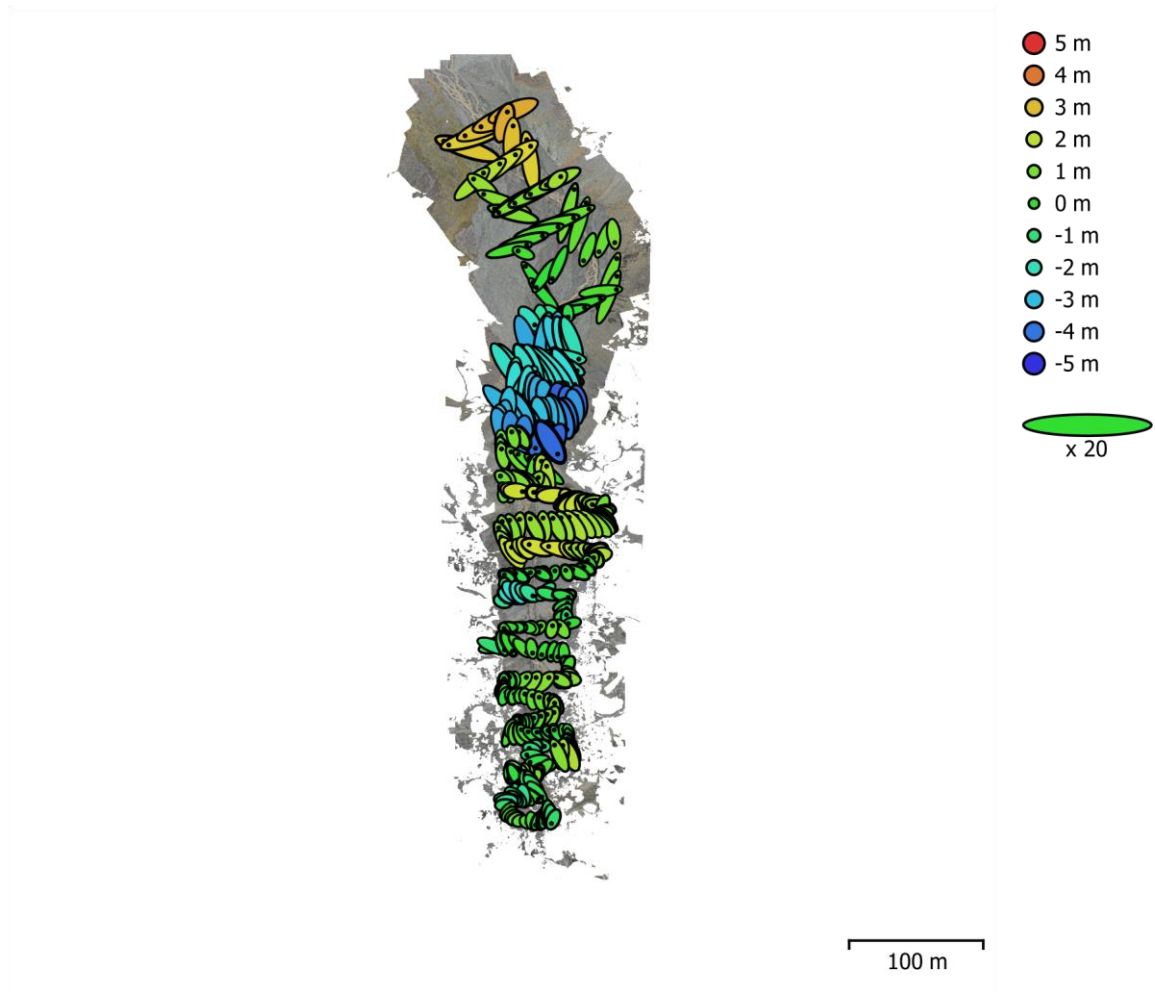


Fig. 3. Camera locations and error estimates.

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)
0.503709	0.550805	1.65258	0.746397	1.81332

Table 3. Average camera location error.

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

Digital Elevation Model

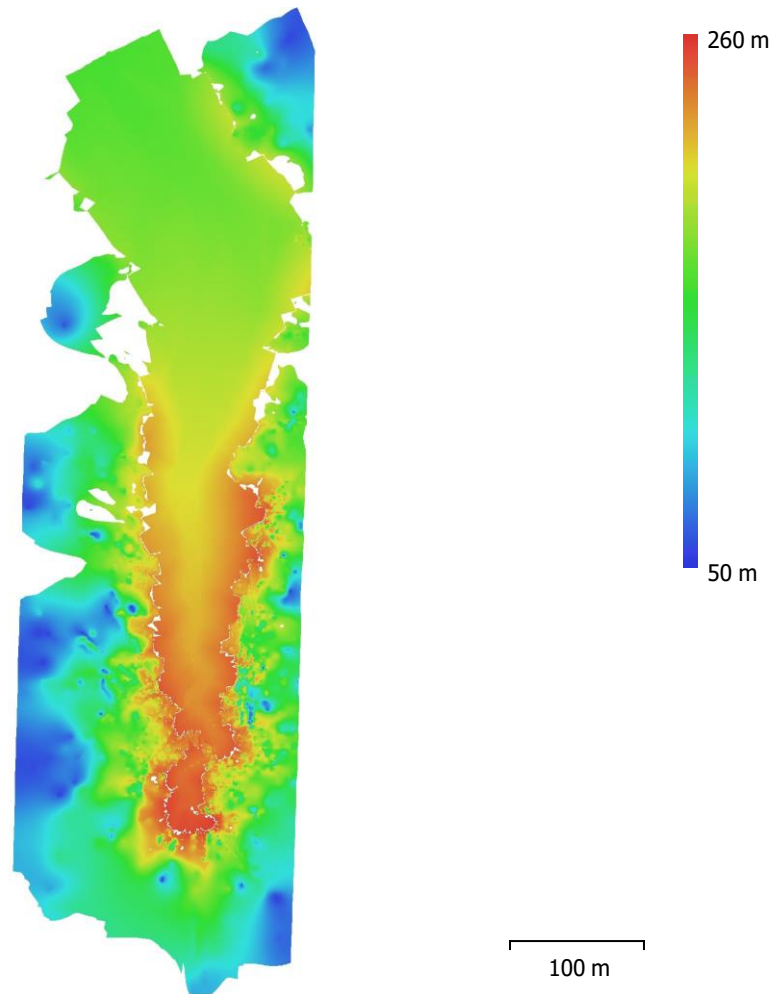
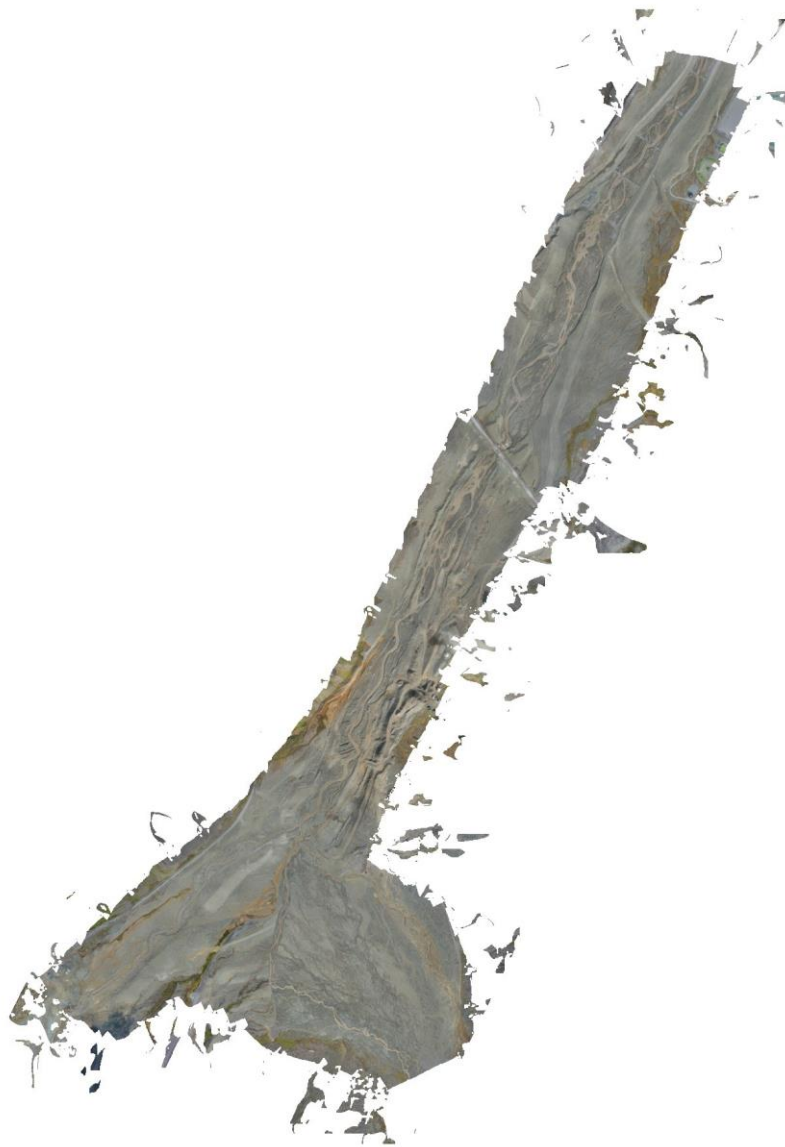


Fig. 4. Reconstructed digital elevation model.

Resolution: 1.55 cm/pix
Point density: 0.416 points/cm²

3. Upper Middle Longyearelva July/August 2021

**Agisoft Metashape Processing Report
Orthophoto**



Survey Data

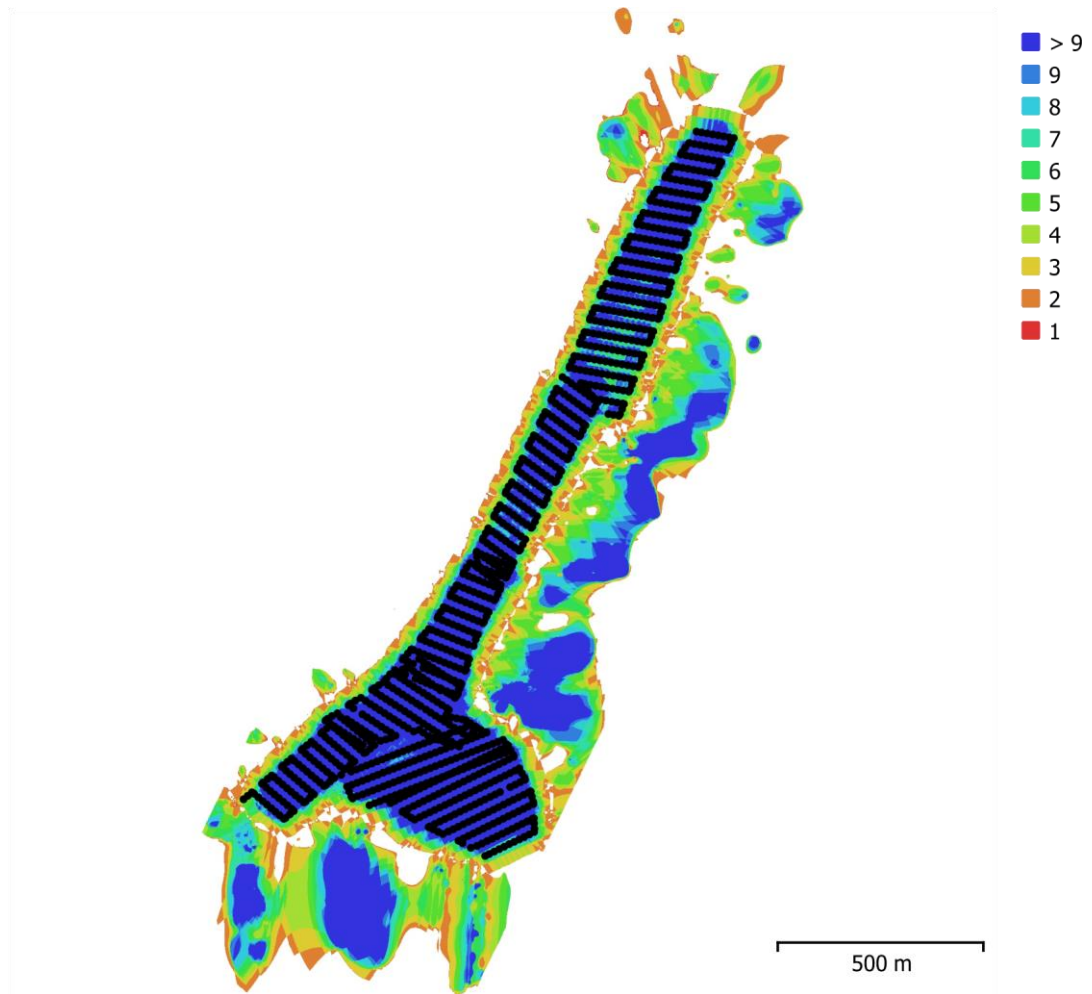


Fig. 1. Camera locations and image overlap.

Number of images:	1,155	Camera stations:	1,155
Flying altitude:	83.2 m	Tie points:	1,250,733
Ground resolution:	1.79 cm/pix	Projections:	7,402,183
Coverage area:	1.08 km ²	Reprojection error:	0.908 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
Test_Pro (10.26mm)	5472 x 3078	10.26 mm	2.53 x 2.53 μm	No

Table 1. Cameras.

Camera Locations

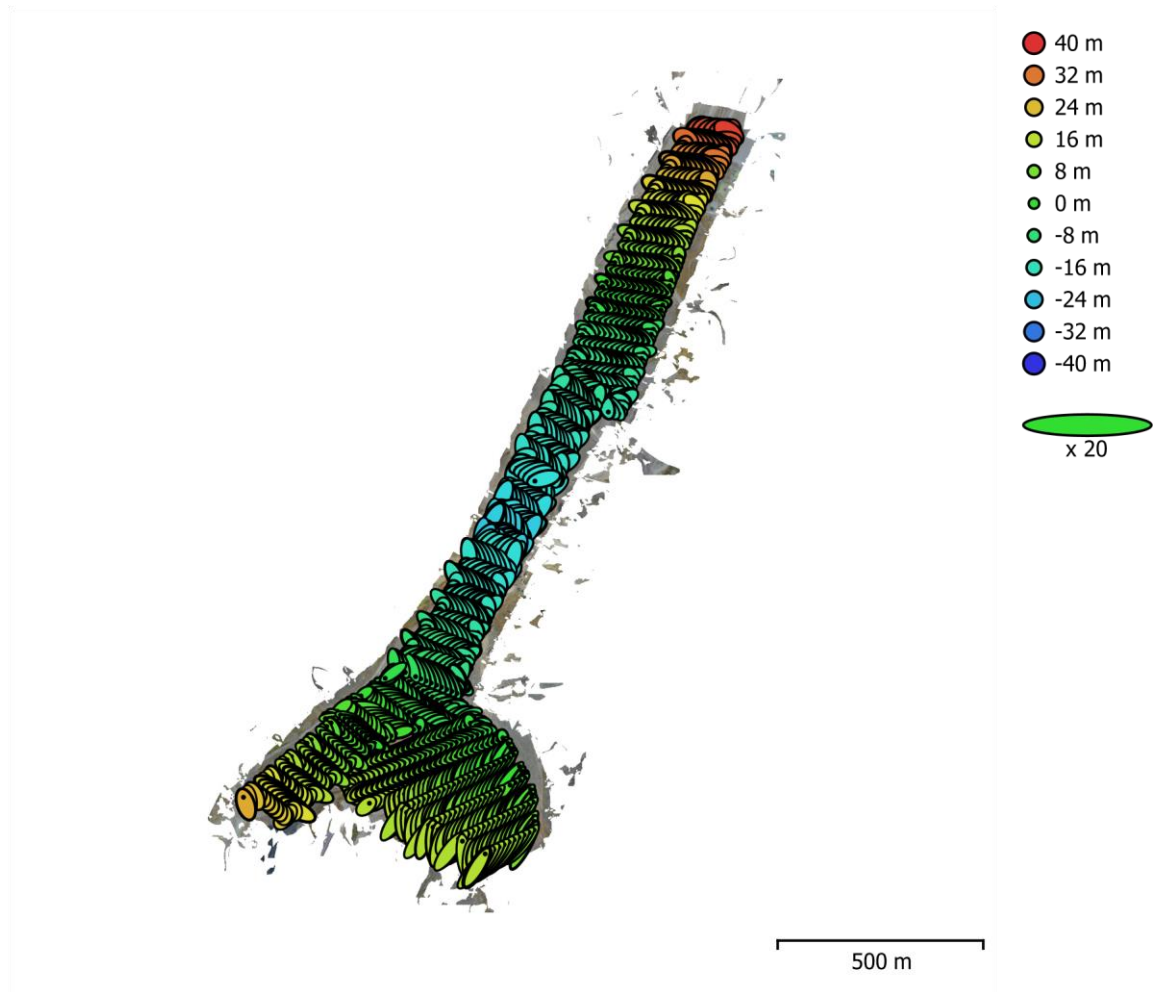


Fig. 3. Camera locations and error estimates.

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)
1.44357	1.50219	13.4678	2.08338	13.628

Table 3. Average camera location error.

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

Digital Elevation Model

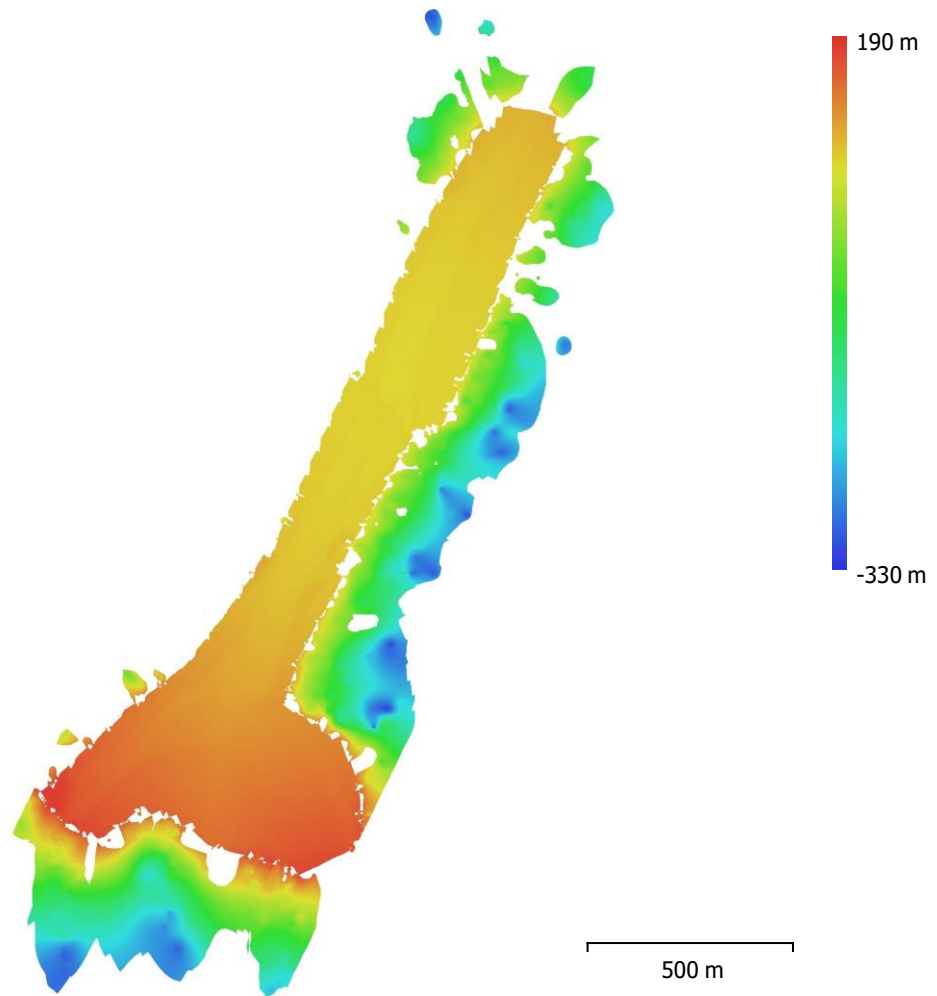


Fig. 4. Reconstructed digital elevation model.

Resolution: 3.58 cm/pix
Point density: 779 ints/m²

4. Lower Longyearelva

July/August 2021

Agisoft Metashape Processing Report
Orthophoto



Survey Data

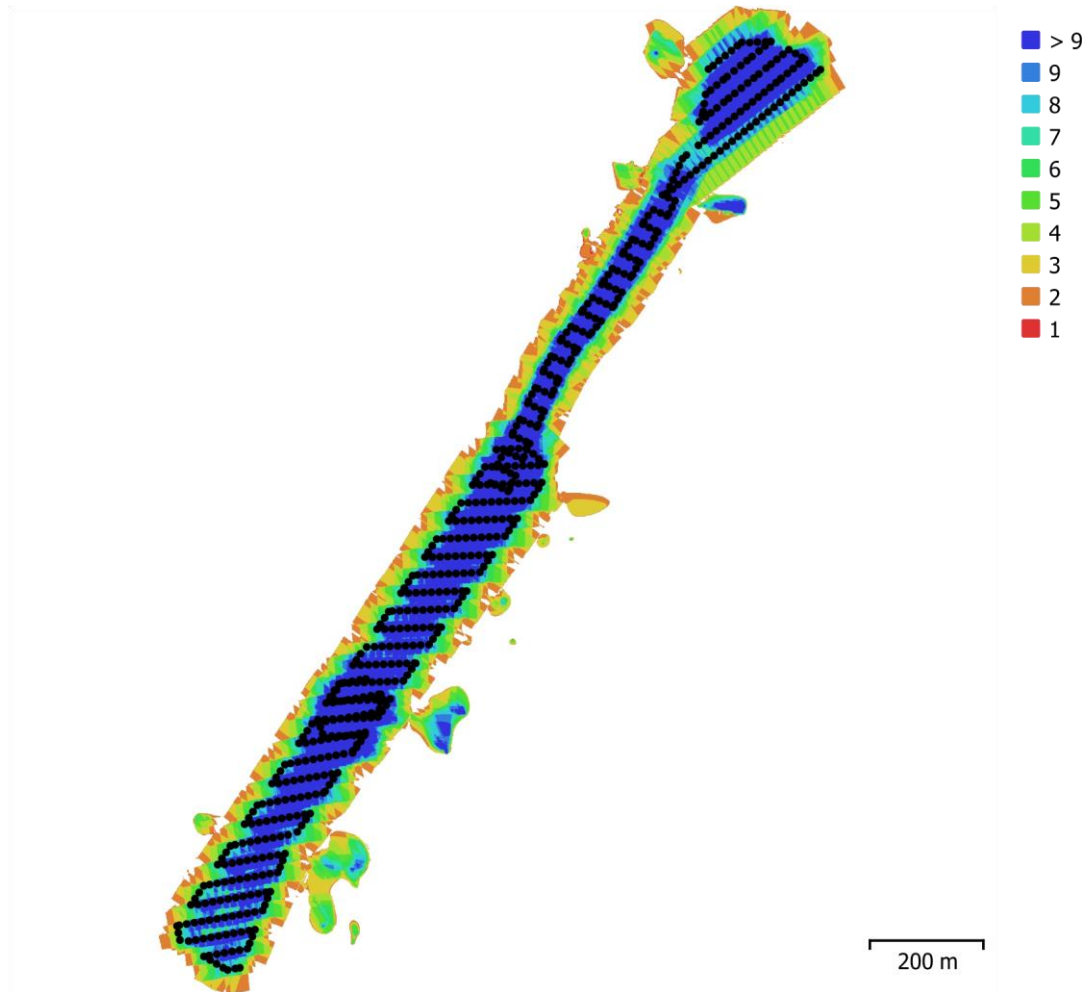


Fig. 1. Camera locations and image overlap.

Number of images:	586	Camera stations:	586
Flying altitude:	78.1 m	Tie points:	882,376
Ground resolution:	1.71 cm/pix	Projections:	4,673,644
Coverage area:	0.364 km ²	Reprojection error:	1.4 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
L1D-20c (10.26mm)	5472 x 3078	10.26 mm	2.53 x 2.53 μm	No

Table 1. Cameras.

Camera Locations

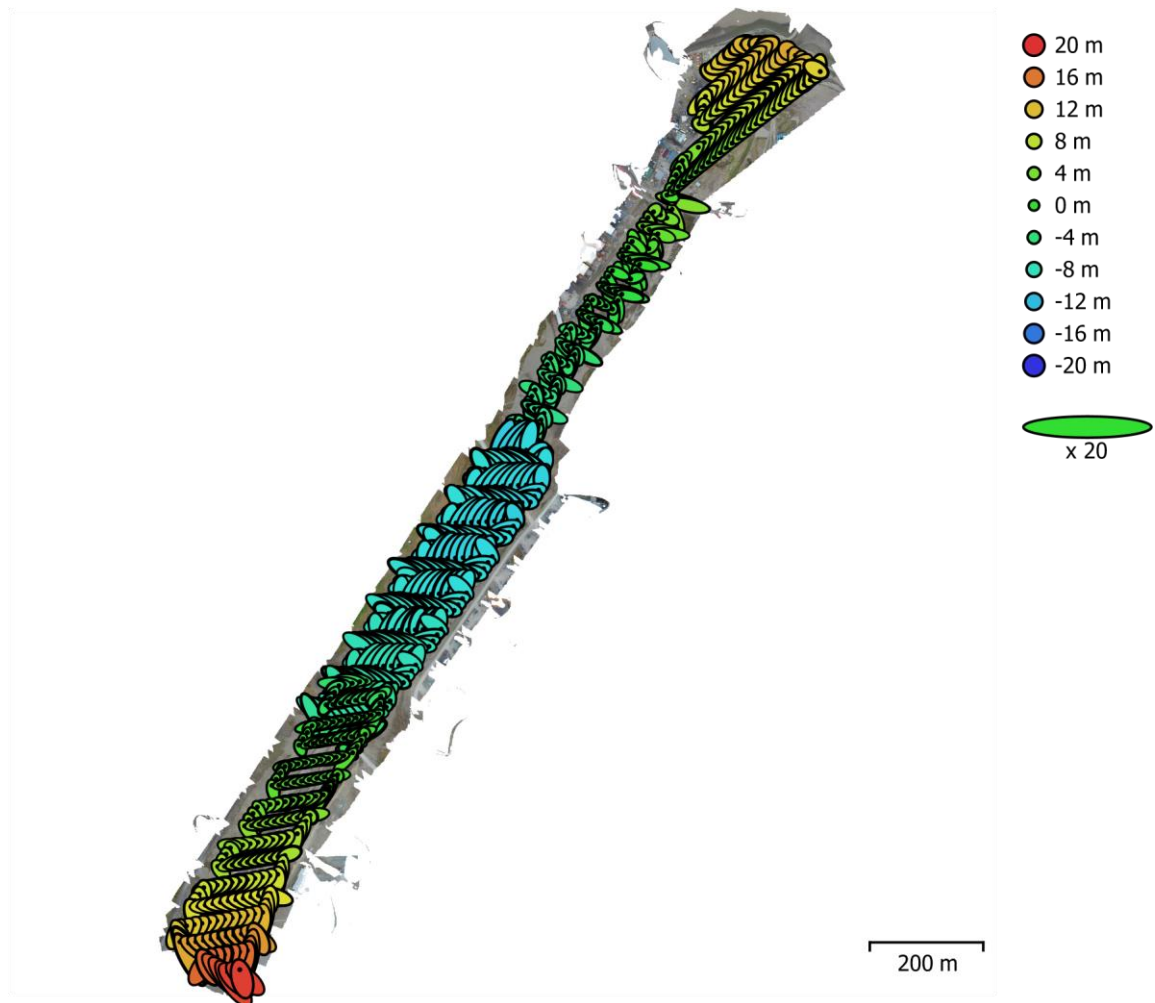


Fig. 3. Camera locations and error estimates.

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)
1.2936	1.11211	7.944	1.70593	8.12511

Table 3. Average camera location error.

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

Digital Elevation Model

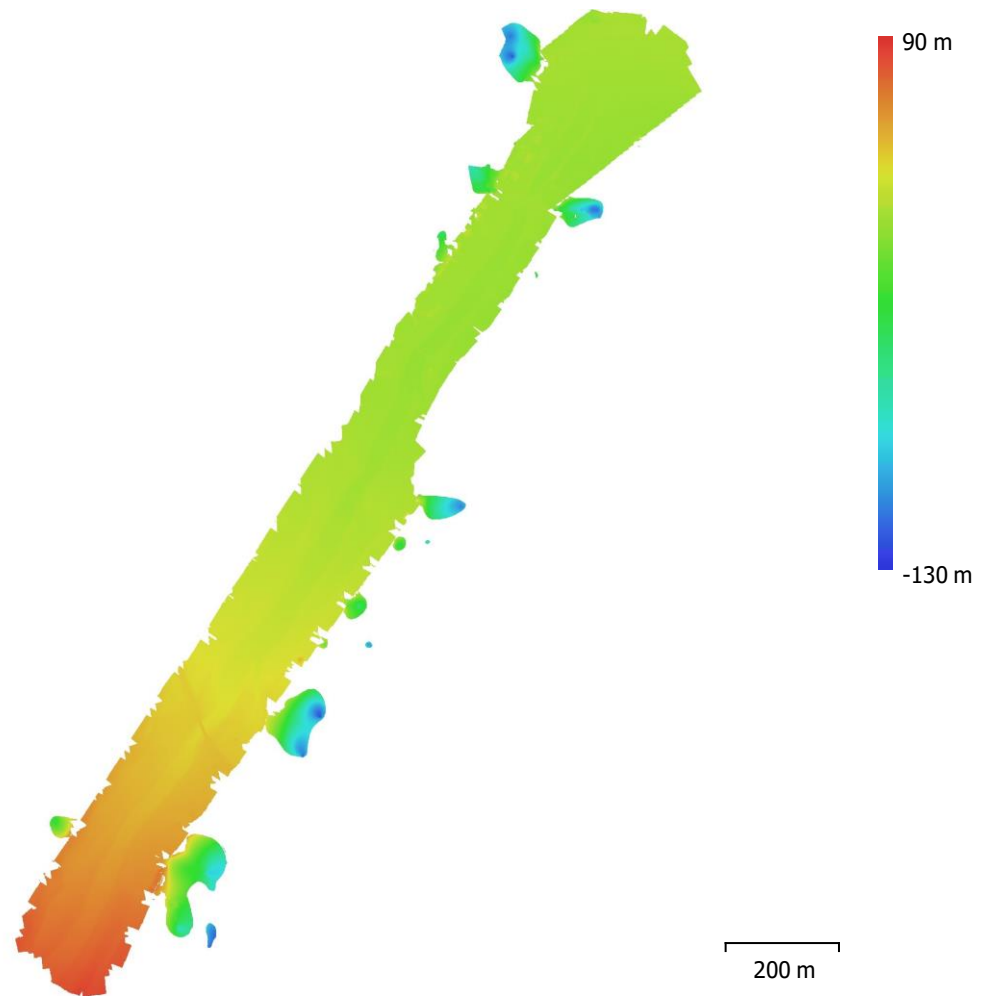


Fig. 4. Reconstructed digital elevation model.

Resolution: 3.41 cm/pix
Point density: 858 points/m²

5. Longyearbreen September 2021

Agisoft Metashape Processing Report

Orthophoto



Survey Data

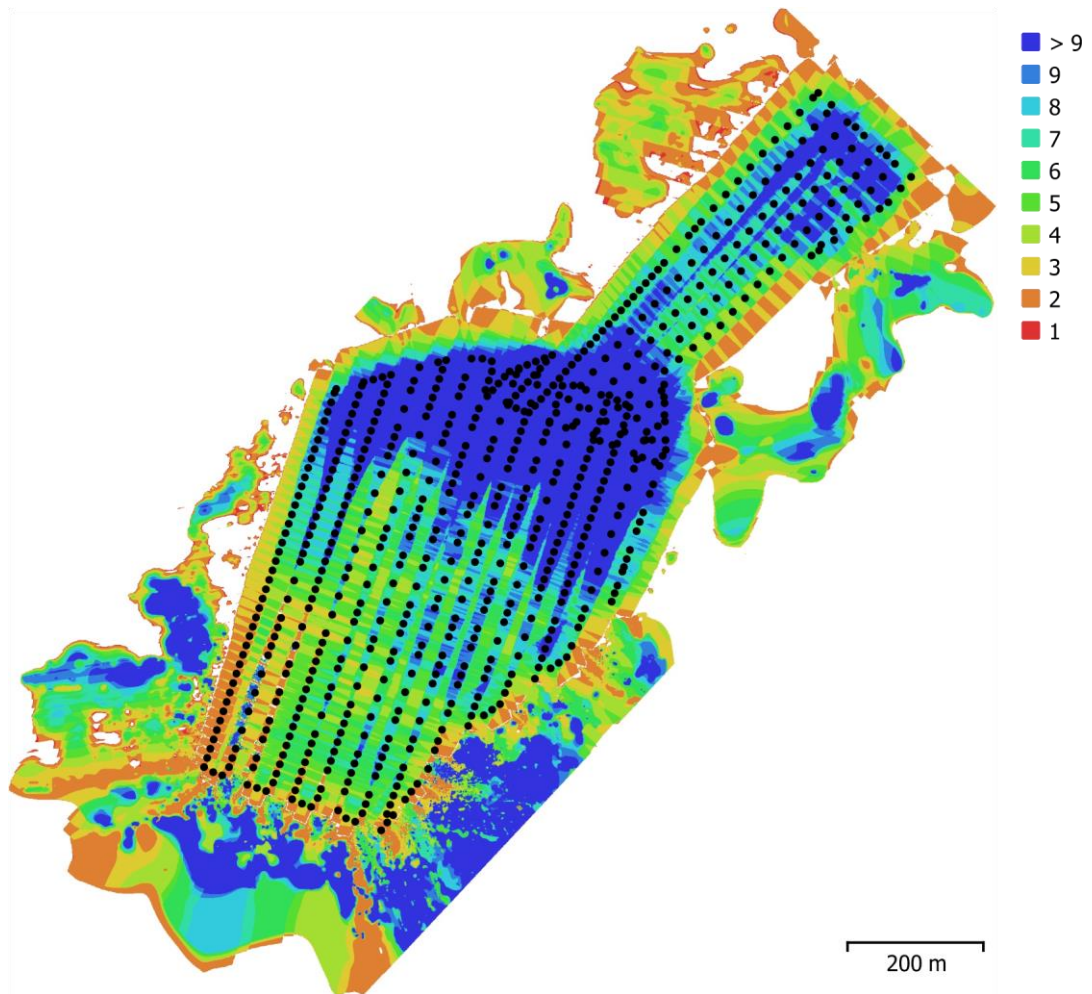


Fig. 1. Camera locations and image overlap.

Number of images:	675	Camera stations:	675
Flying altitude:	79.5 m	Tie points:	1,367,858
Ground resolution:	1.73 cm/pix	Projections:	5,136,245
Coverage area:	0.869 km ²	Reprojection error:	0.411 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
Test_Pro (10.26mm)	5472 x 3648	10.26 mm	2.41 x 2.41 μm	No

Table 1. Cameras.

Camera Locations

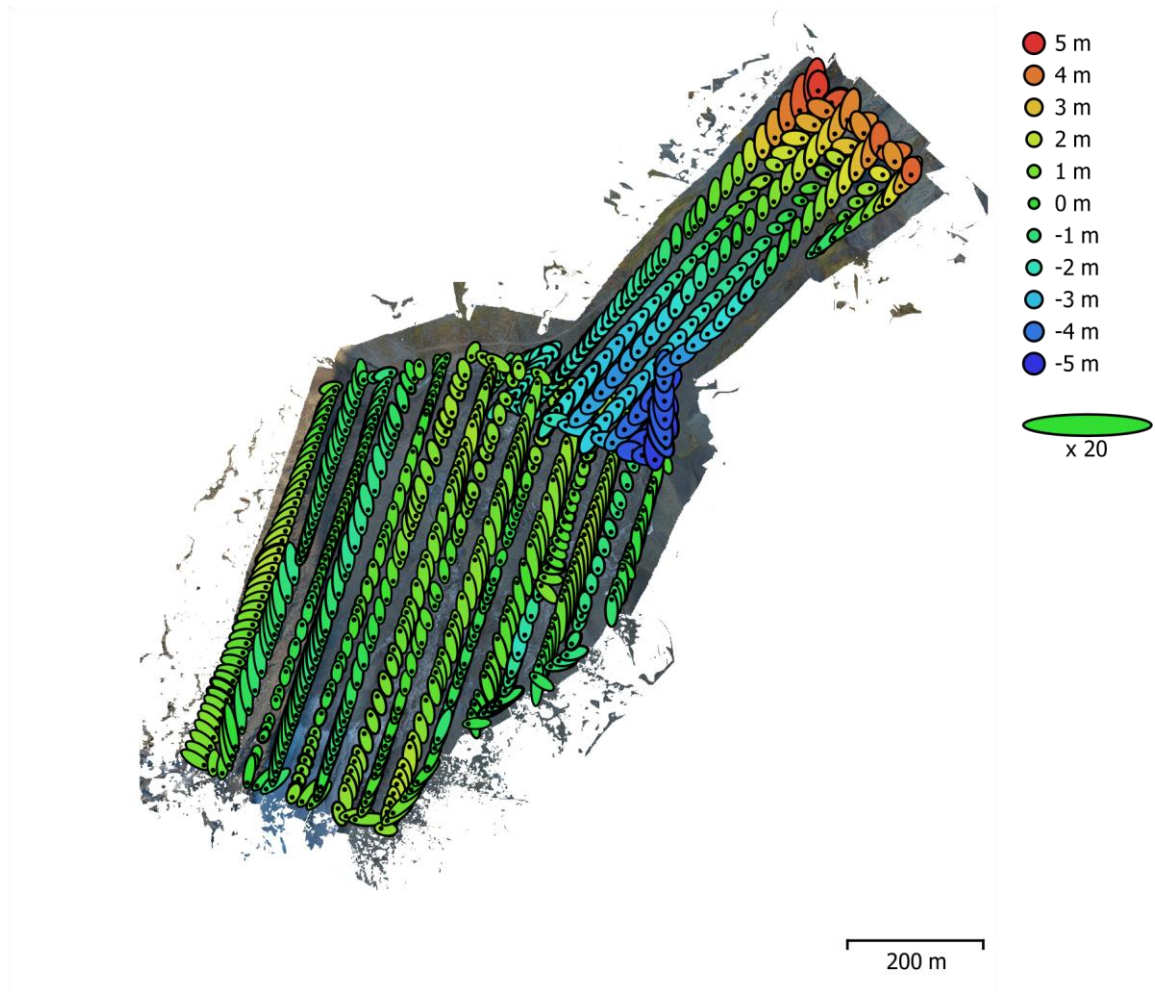


Fig. 3. Camera locations and error estimates.

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)
0.562391	1.40889	1.53441	1.51699	2.1577

Table 3. Average camera location error.

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

Digital Elevation Model

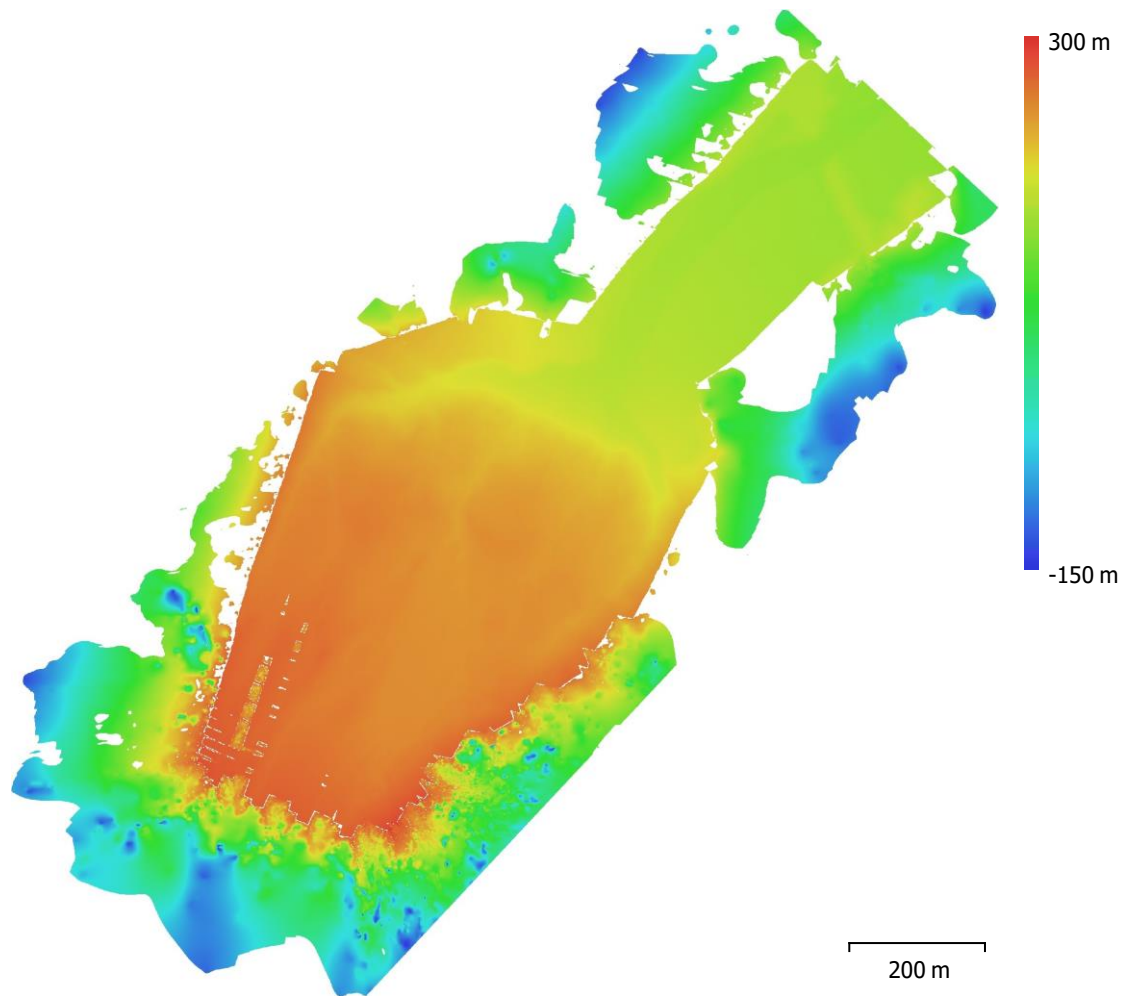


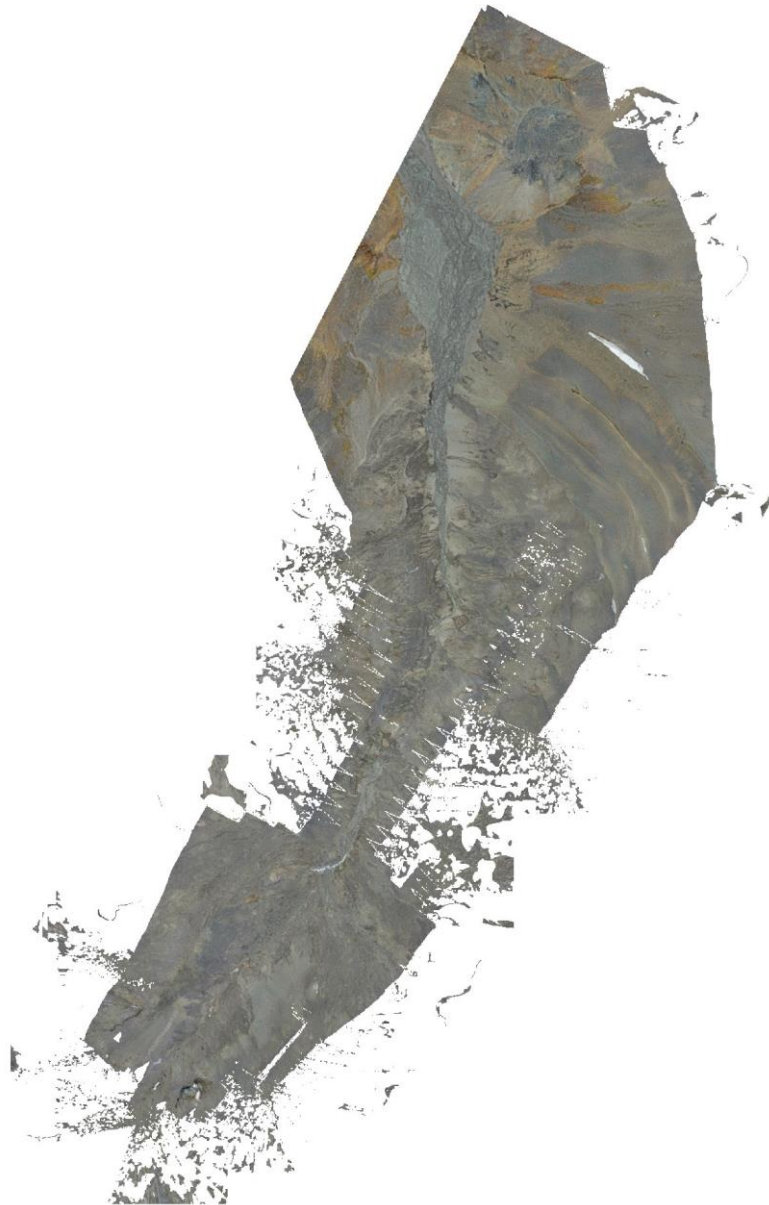
Fig. 4. Reconstructed digital elevation model.

Resolution: 3.46 cm/pix
Point density: 833 points/m²

6. Larsbreen September 2021

Agisoft Metashape Processing Report

Orthophoto



Survey Data

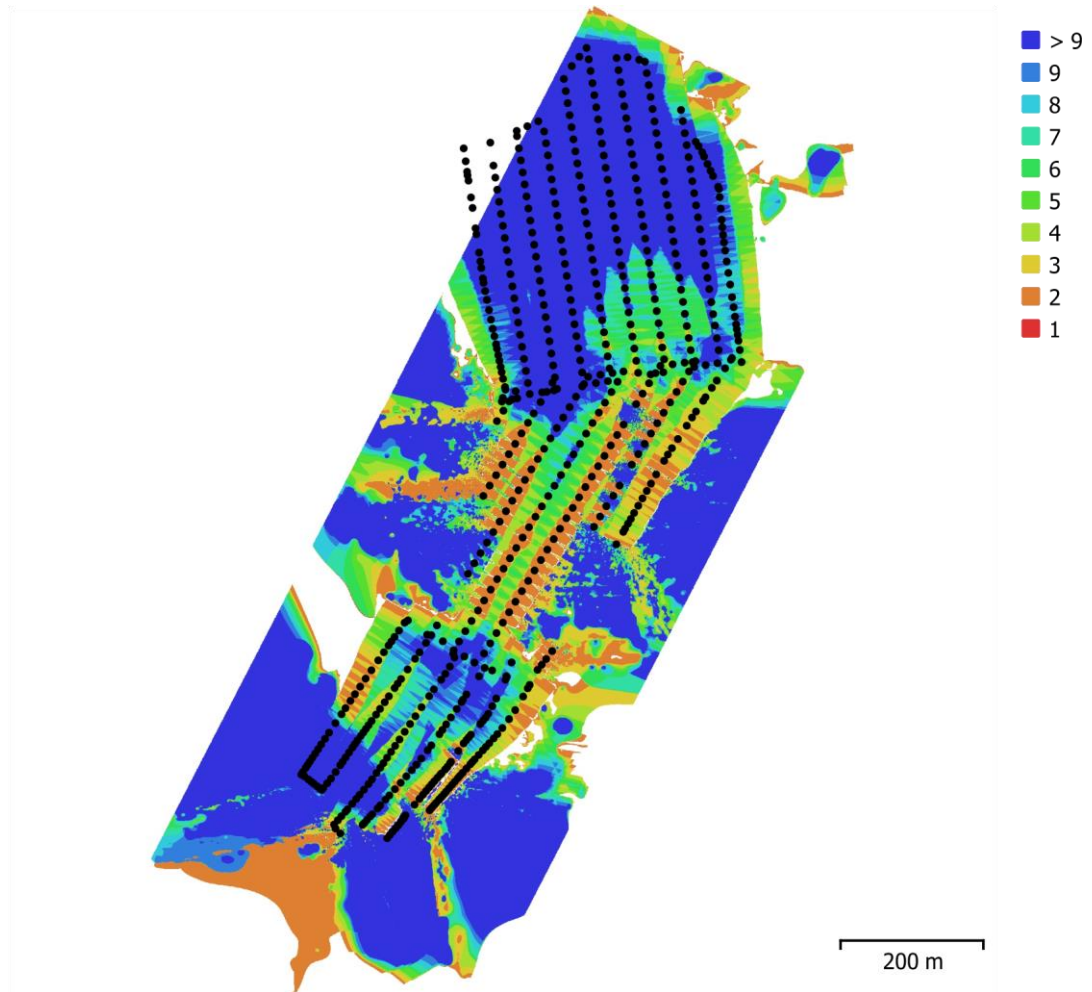


Fig. 1. Camera locations and image overlap.

Number of images:	688	Camera stations:	605
Flying altitude:	68.4 m	Tie points:	1,377,256
Ground resolution:	1.55 cm/pix	Projections:	4,114,197
Coverage area:	0.591 km ²	Reprojection error:	0.358 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
Test_Pro (10.26mm)	5472 x 3648	10.26 mm	2.41 x 2.41 μm	No

Table 1. Cameras.

Camera Locations

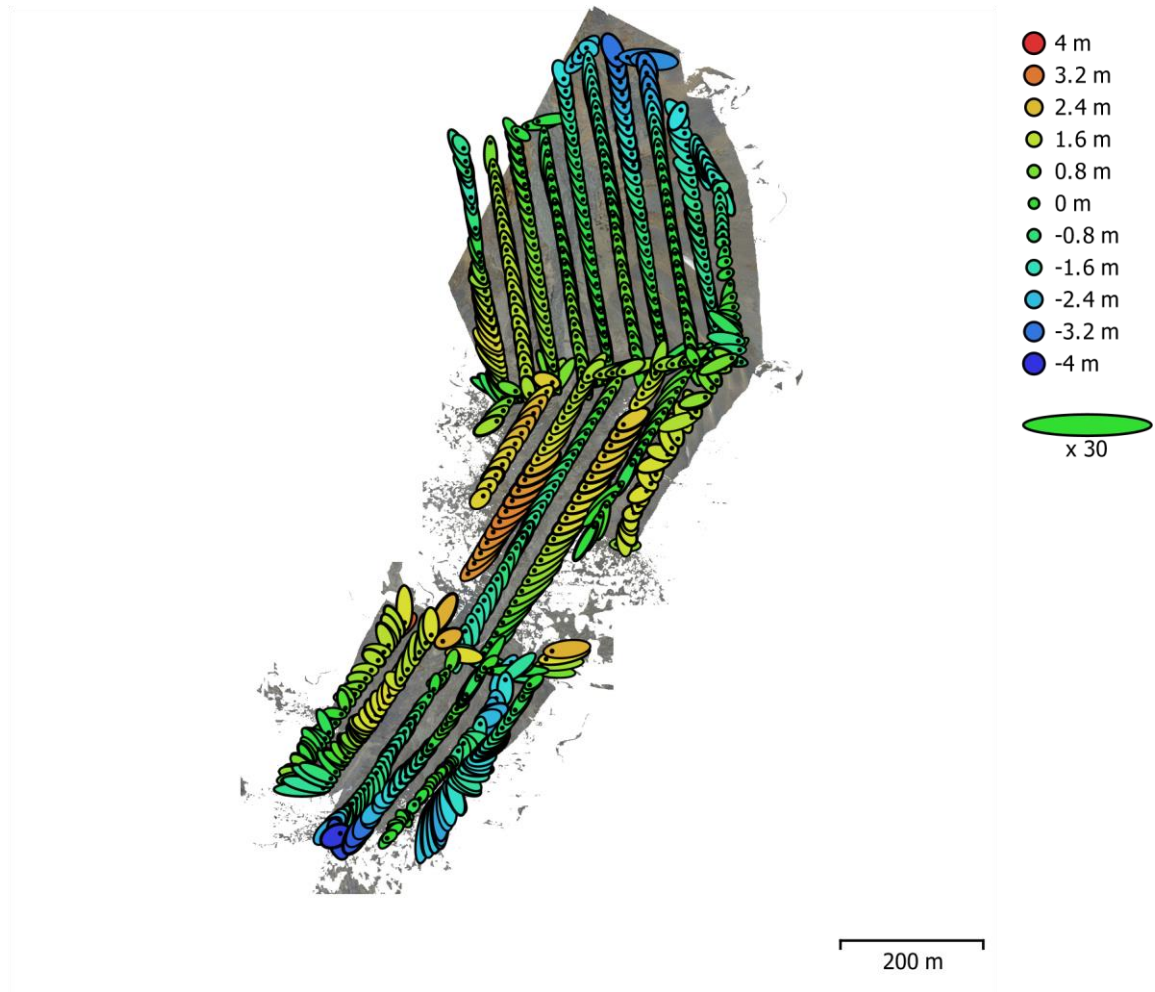


Fig. 3. Camera locations and error estimates.

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)
0.656276	0.956281	1.37719	1.15982	1.80051

Table 3. Average camera location error.

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

Digital Elevation Model

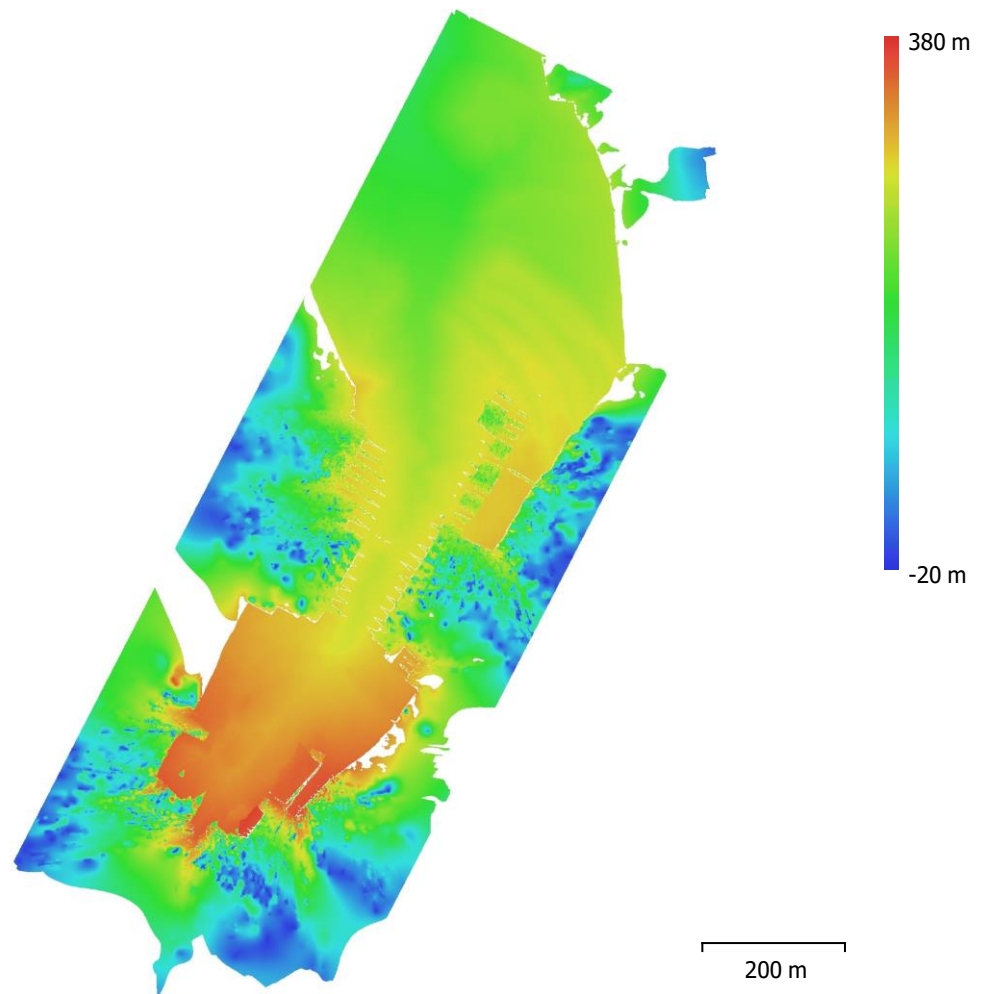
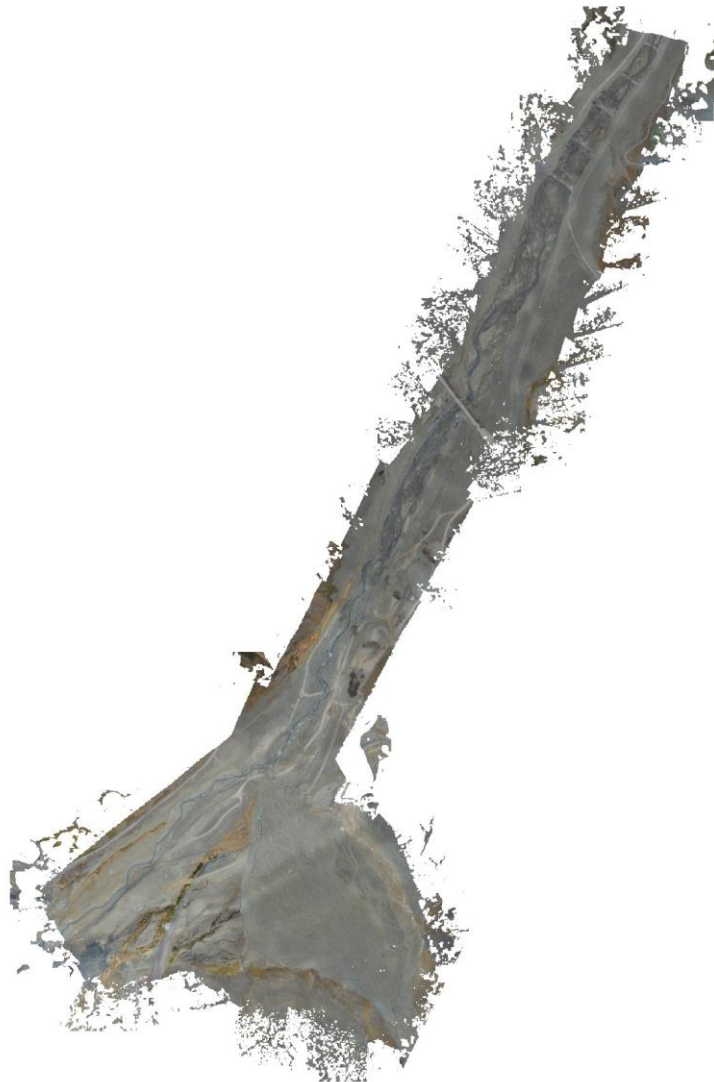


Fig. 4. Reconstructed digital elevation model.

Resolution: 3.1 cm/pix
Point density: 0.104 points/cm²

7. Upper Middle Longyearelva September 2021

Agisoft Metashape Processing Report
Orthophoto



Survey Data

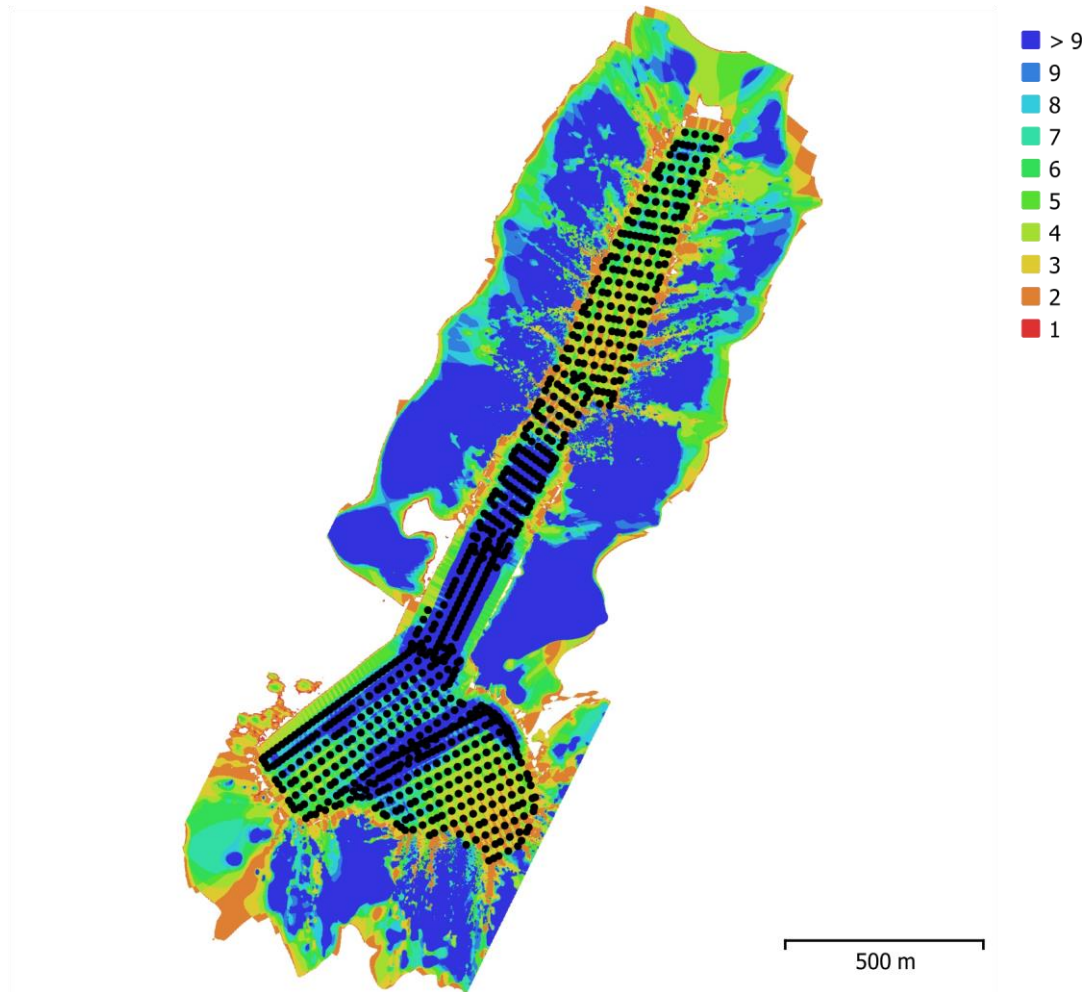


Fig. 1. Camera locations and image overlap.

Number of images:	801	Camera stations:	788
Flying altitude:	69.4 m	Tie points:	3,050,199
Ground resolution:	1.56 cm/pix	Projections:	8,965,757
Coverage area:	1.68 km ²	Reprojection error:	0.404 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
Test_Pro (10.26mm)	5472 x 3648	10.26 mm	2.41 x 2.41 μm	No

Table 1. Cameras.

Camera Locations

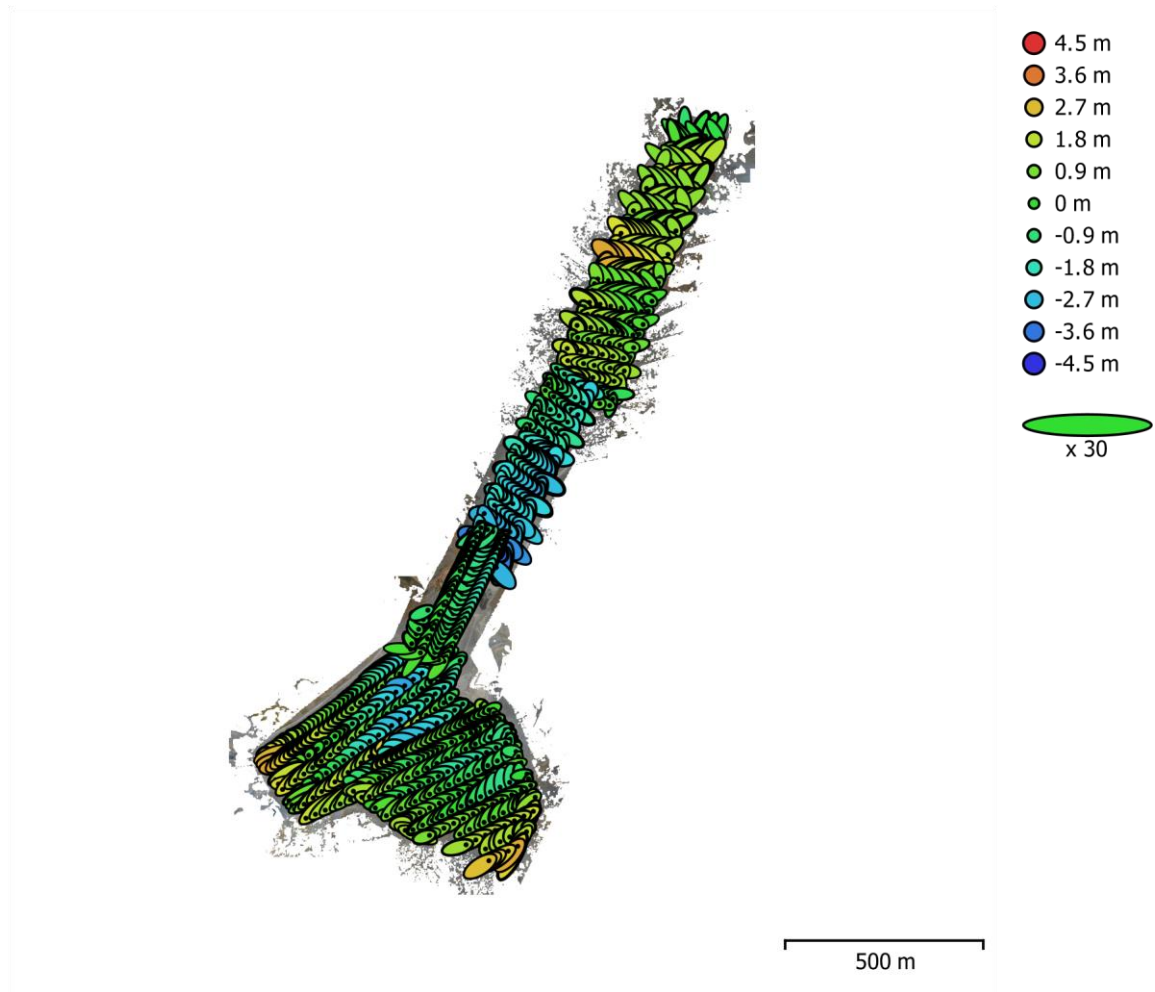


Fig. 3. Camera locations and error estimates.

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)
1.18864	1.00451	1.43666	1.55625	2.11799

Table 3. Average camera location error.

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

Digital Elevation Model

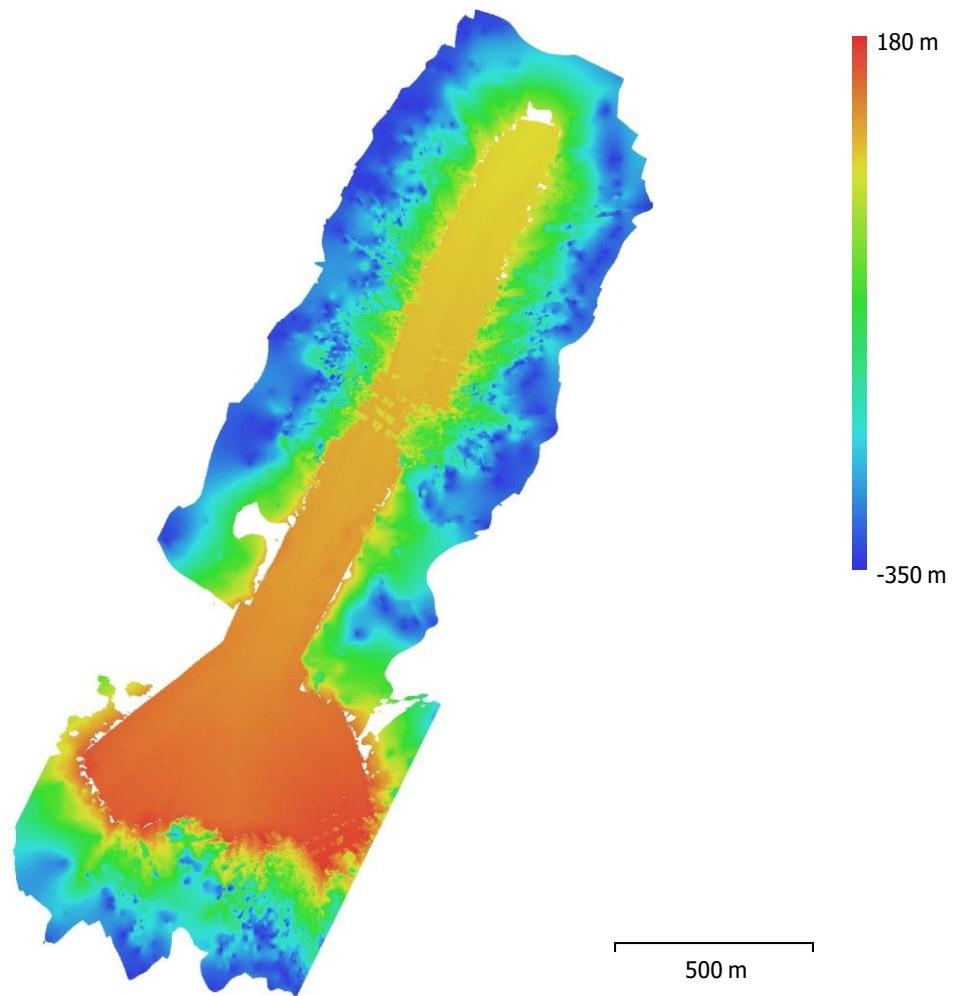


Fig. 4. Reconstructed digital elevation model.

Resolution: 3.13 cm/pix
Point density: 0.102 ints/cm²

8. Lower Longyearelva

September 2021

Agisoft Metashape Processing Report
Orthophoto



Survey Data

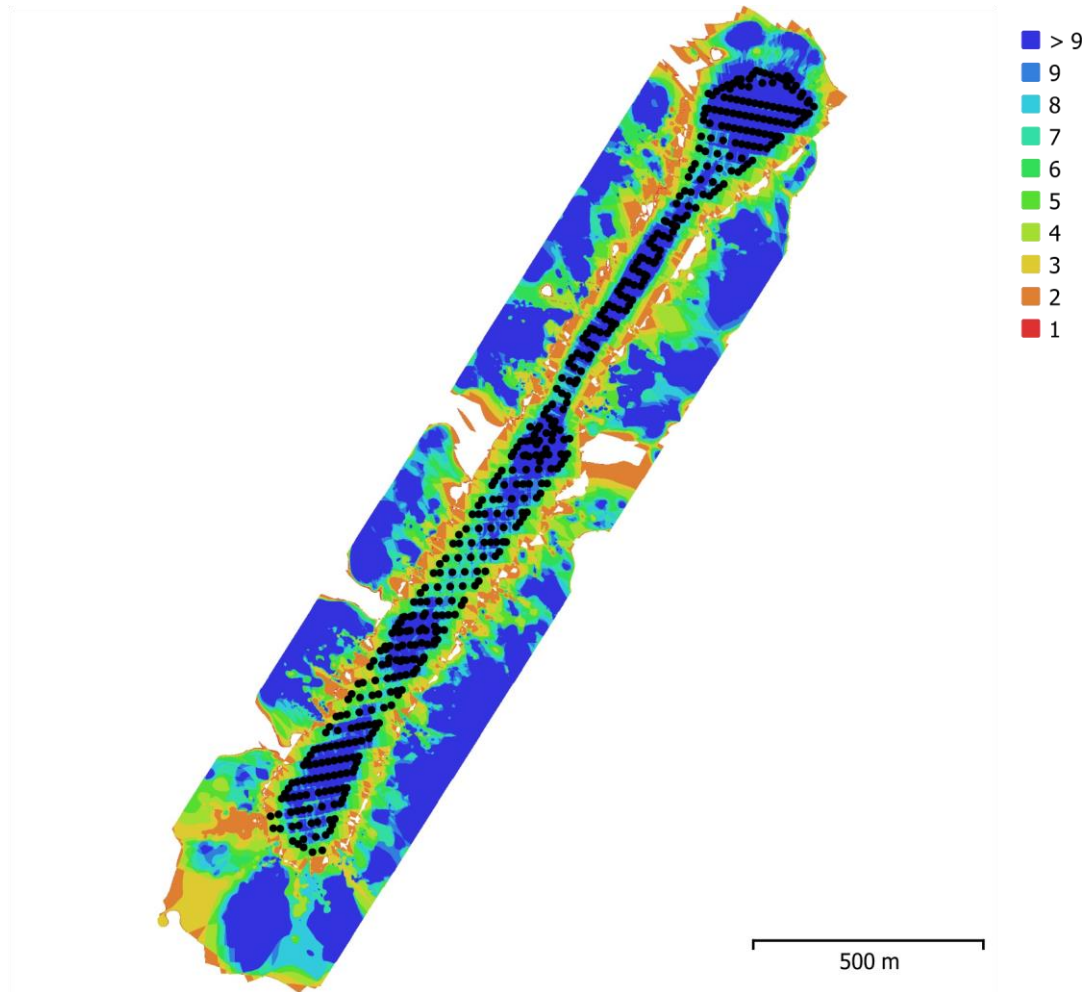


Fig. 1. Camera locations and image overlap.

Number of images:	476	Camera stations:	476
Flying altitude:	81 m	Tie points:	976,475
Ground resolution:	1.65 cm/pix	Projections:	3,399,392
Coverage area:	0.967 km ²	Reprojection error:	1.08 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
Test_Pro (10.26mm)	5472 x 3648	10.26 mm	2.41 x 2.41 μm	No

Table 1. Cameras.

Camera Locations

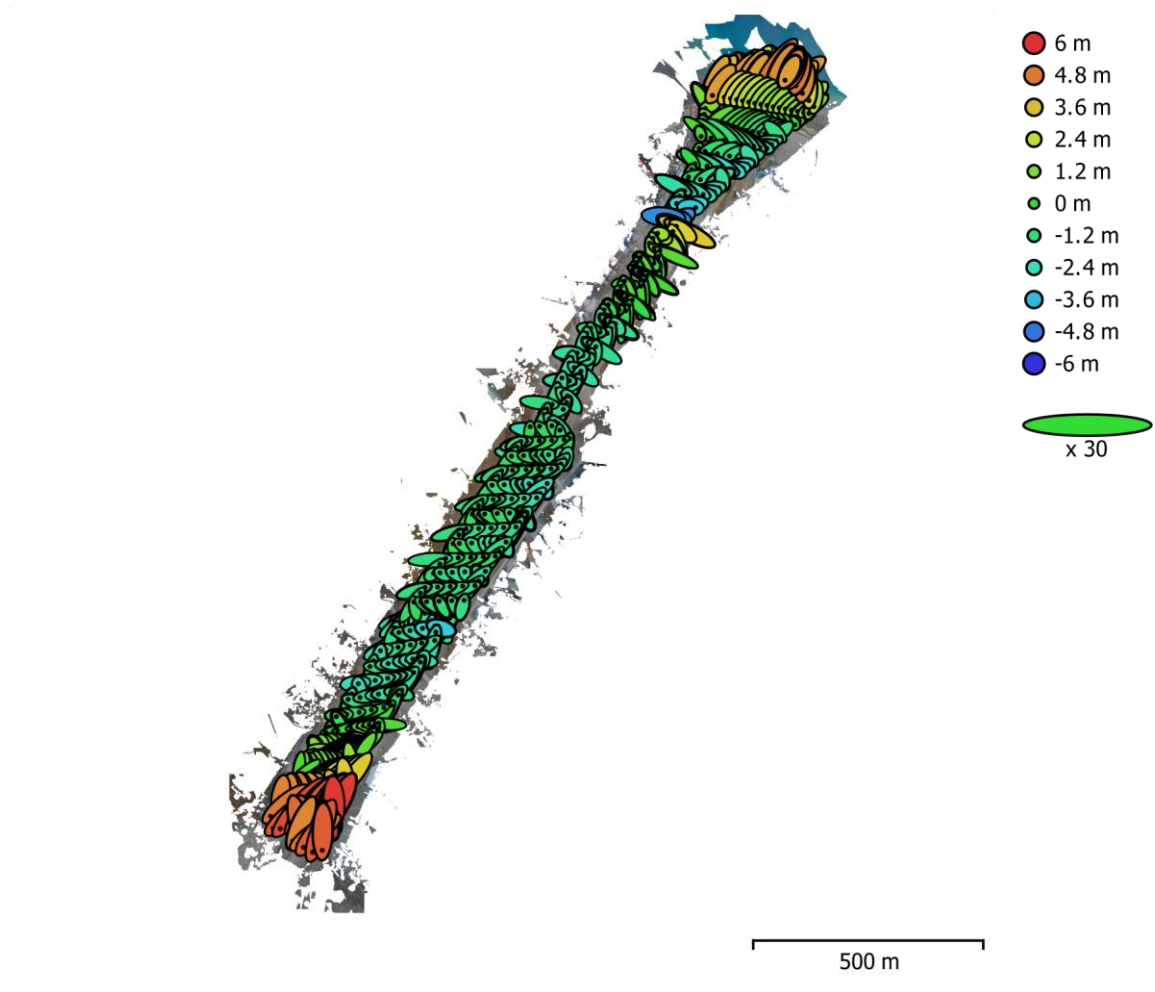


Fig. 3. Camera locations and error estimates.

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)
1.30492	1.23828	2.22957	1.79893	2.8648

Table 3. Average camera location error.

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

Digital Elevation Model

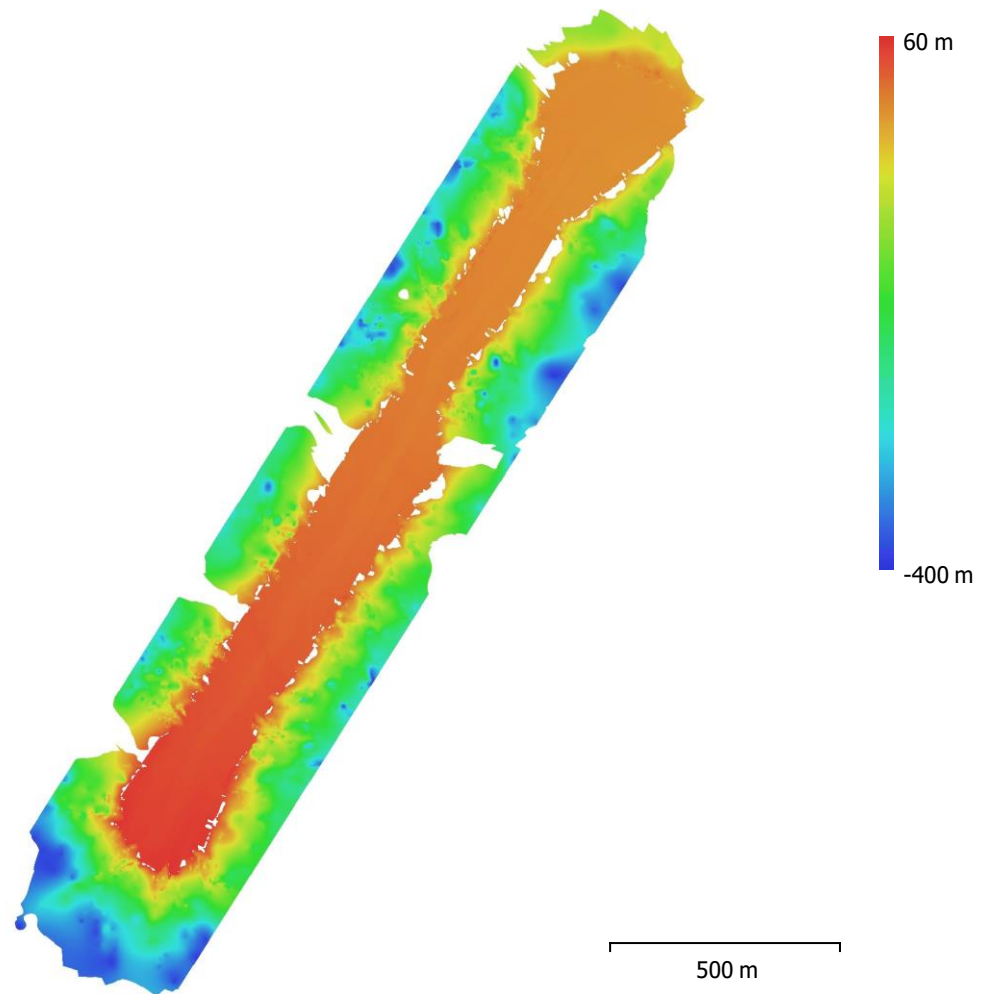


Fig. 4. Reconstructed digital elevation model.

Resolution: 3.3 cm/pix
Point density: 919 points/m²

Appendix C

Roundness analysis in Longyeardalen

KEY

1	VA	very angular
2	A	angular
3	SA	subangular
4	SR	subrounded
5	R	rounded
6	WR	well rounded

Method 1 - Profiles

	Locality	No. of rocks analysed
1	Longyearbre upper river	10 rocks every 5m
2	Longyearbre lower river	10 rocks every 3m
3	Larsbre upper river	10 rocks every 3m
4	Larsbre lower river	7 rocks every 5m
5	Longyearelva mid river	10 rocks every 4m
6	Longyearelva lower river delta	10 rocks every 2m

	LOC. 1	LOC. 2	LOC. 3	LOC. 4	LOC. 5	LOC. 6
1	5	0	0	0	0	0
2	6	1	9	3	0	0
3	20	6	42	32	0	3
4	44	51	33	68	20	12
5	22	36	14	23	53	50
6	3	6	2	0	27	35
SUM ROCKS	100	100	100	126	100	100
AVERAGE	3.81	4.4	3.58	3.88	5.07	5.17
	SA-SR	SR-R	SA-SR	SR	R	R

Method 2 - Squares

	EAST OF RIVER						WEST OF RIVER					
ROUNDNESS NO	1	2	3	4	5	TOTAL 1-5	6	7	8	9	10	TOTAL 6-10
1	2	5	0	1	0	8	0	0	1	2	1	4
2	4	5	0	6	4	19	2	3	4	3	1	13
3	8	5	8	9	9	39	7	7	6	4	11	35
4	6	5	11	2	7	31	11	5	8	9	6	39
5	0	0	1	2	0	3	0	5	1	2	1	9
6	0	0	0	0	0	0	0	0	0	0	0	0
SUM ROCKS	20	20	20	20	20	100	20	20	20	20	20	100
AVERAGE	2.9	2.5	3.65	2.9	3.15	3.02	3.45	3.6	3.2	3.3	3.25	3.36