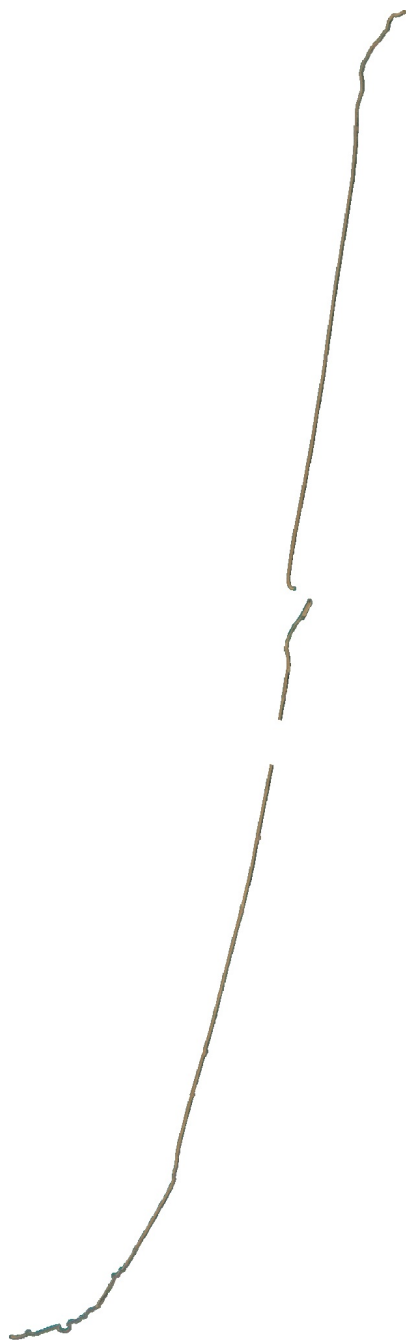


# Rapport d'aérotriangulation

BRGM - Littoral aquitain 2021

04 March 2022



# Survey Data

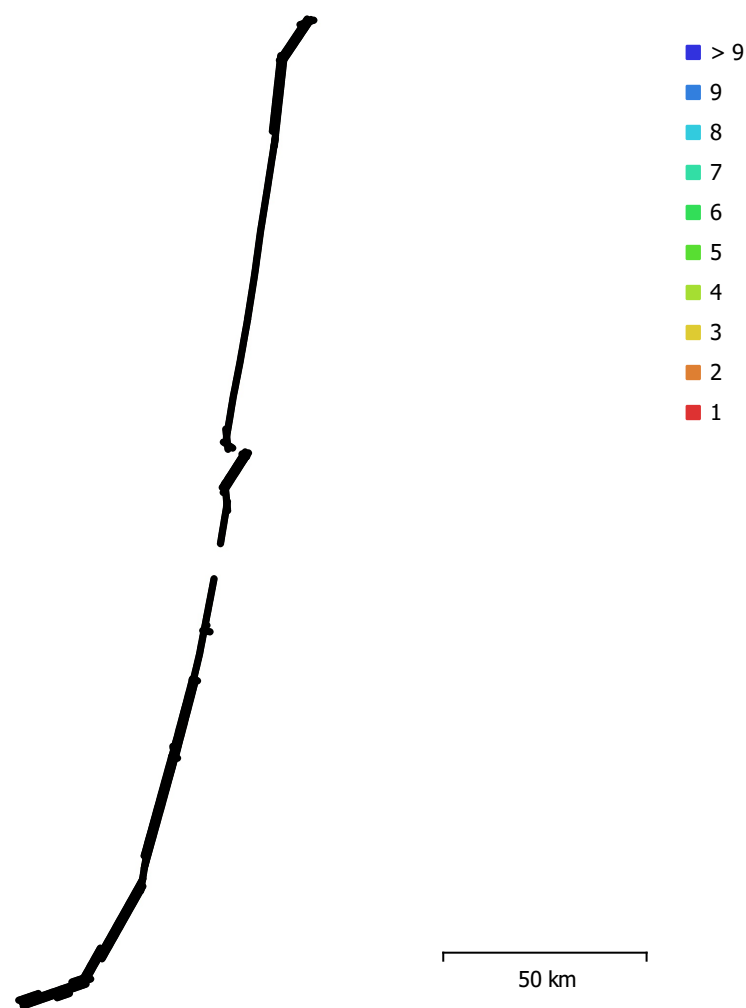


Fig. 1. Camera locations and image overlap.

Number of images:	1,029	Camera stations:	982
Flying altitude:	1.41 km	Tie points:	1,324,640
Ground resolution:	10.2 cm/pix	Projections:	3,420,918
Coverage area:	212 km <sup>2</sup>	Reprojection error:	0.951 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibration
RS150F, Rodenstock RS-50mm/Aerial (50mm)	14204 x 10652	50 mm	3.76 x 3.76 µm	Yes

Table 1. Cameras.

# Camera Calibration

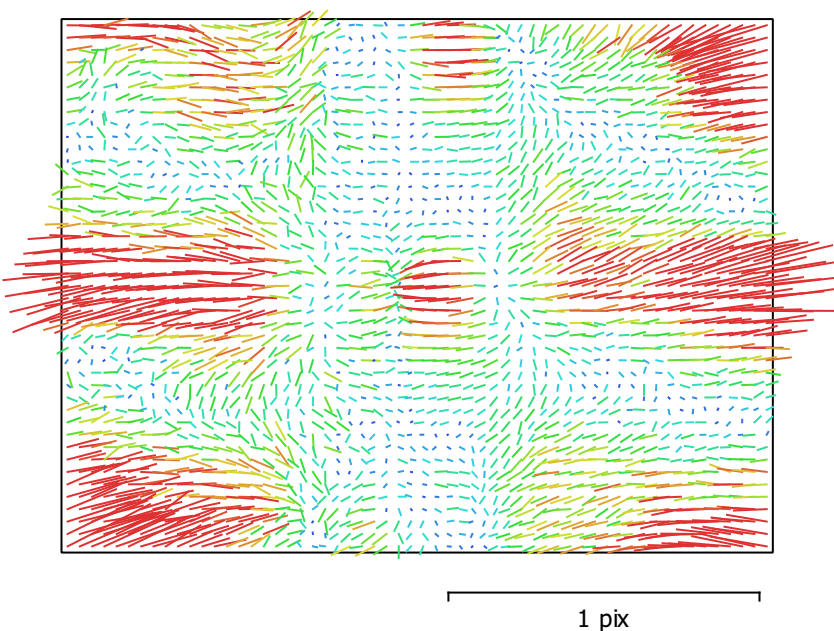


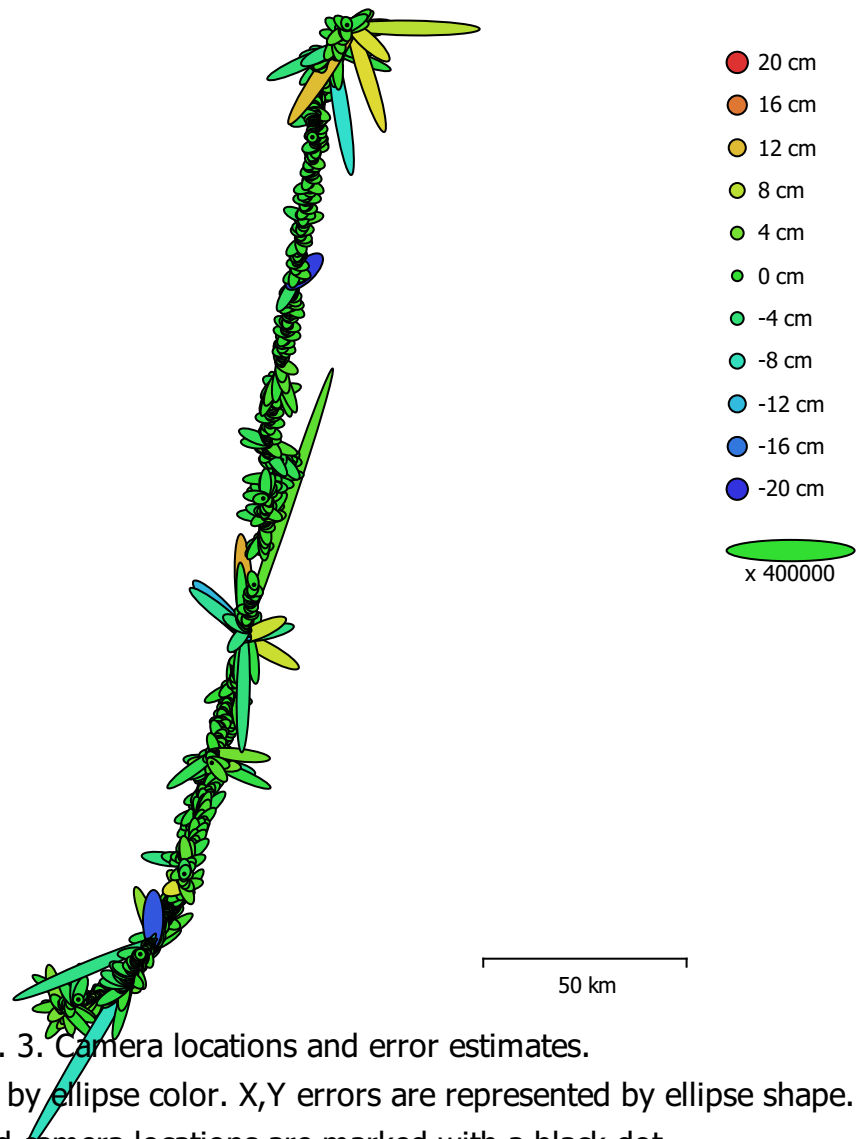
Fig. 2. Image residuals for iXM-RS150F, Rodenstock RS-50mm/Aerial (50mm).

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

1029 images, precalibrated

Type	Resolution	Focal Length	Pixel Size
Frame	14204 x 10652	50 mm	3.76 x 3.76 μm
F:	13743.9		
Cx:	-6.80667	B1:	0.010349
Cy:	1.58759	B2:	0
K1:	-0.0409032	P1:	3.33309e-005
K2:	0.0398144	P2:	-0.000166522
K3:	-0.0201836	P3:	0
K4:	0.00641436	P4:	0

# Camera Locations



X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total error (cm)
0.78691	1.02369	1.78025	1.29119	2.19919

Table 2. Average camera location error.  
 X - Easting, Y - Northing, Z - Altitude.

# Camera Orientations

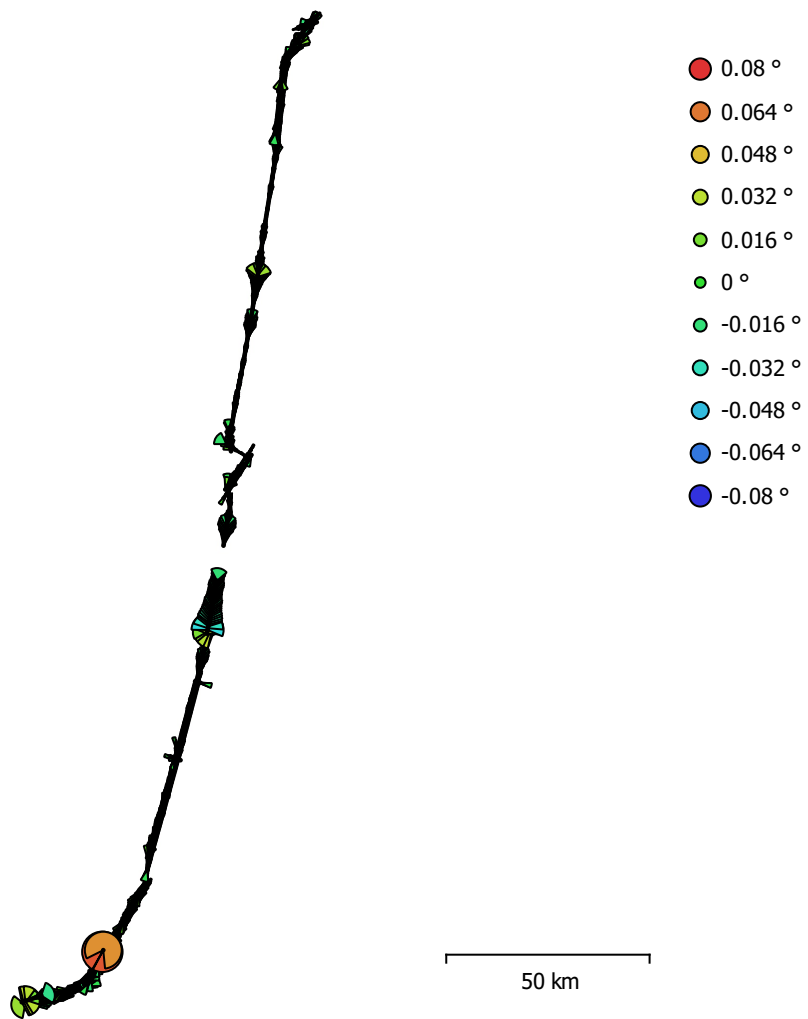


Fig. 4. Camera orientations and error estimates.  
Arcs represent kappa error estimates.

Omega error (°)	Phi error (°)	Kappa error (°)	Total error (°)
0.00708885	0.0241585	0.00780764	0.0263599

Table 3. Average camera rotation error.

# Ground Control Points

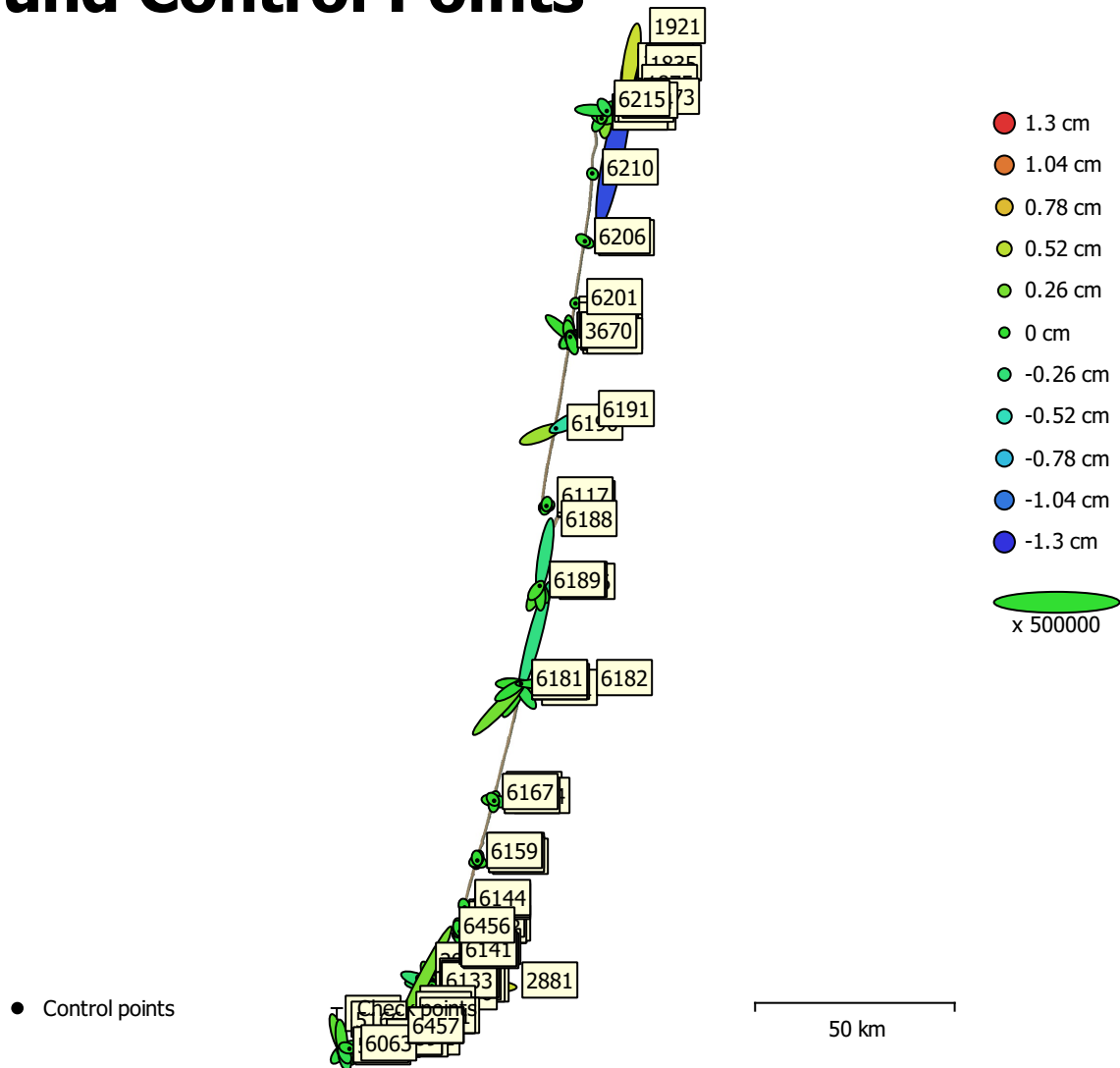


Fig. 5. GCP locations and error estimates.

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)
177	0.608538	0.895789	0.144774	1.08294	1.09257

Table 4. Control 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>
1816	-0.232247	-0.744984	-0.0926148	0.785823	2.238 (4)
1825	-0.0100441	-0.808647	0.122786	0.817978	2.071 (4)
1826	-0.0258508	-1.09381	0.182527	1.10923	2.827 (4)
1835	-0.373804	-0.945363	-0.0832305	1.01998	2.780 (4)
1875	1.27953	6.39067	-1.20178	6.62738	12.753 (5)
1921	-0.47815	-2.9191	0.573807	3.01314	5.831 (5)
2005	0.0444617	-0.91517	-0.00593546	0.916269	4.542 (2)
2006	0.0973889	-0.532548	0.0332479	0.5424	2.646 (2)
2011	0.110608	0.0313375	0.0838551	0.142295	2.802 (2)
2016	-0.15754	0.130214	0.0376991	0.207836	1.744 (2)
2021	-0.0887613	0.296525	-0.0200202	0.310171	1.660 (2)
2022	-0.191229	0.243463	-0.0521217	0.313942	2.138 (2)
2026	-0.157479	0.18533	-0.0534666	0.249009	2.029 (2)
2027	-0.237102	0.0078822	-0.00804361	0.237369	1.411 (2)
2032	0.0613789	-0.079065	0.00452574	0.100195	0.639 (2)
2033	-0.019718	0.251492	0.0291544	0.253943	1.572 (2)
2045	0.0157809	-0.0756322	0.0474133	0.0906493	1.401 (2)
2048	0.124507	-0.139471	0.0373631	0.190657	1.561 (2)
2050	-0.00451608	0.199669	-0.121718	0.233887	1.386 (5)
2051	-0.453369	0.260287	0.128585	0.538356	1.565 (6)
2066	-1.31472	-4.96769	-0.300262	5.14748	16.665 (3)
2086	0.754989	-0.203894	0.30393	0.83902	1.907 (6)
2087	0.748321	1.2284	0.0653321	1.43987	2.576 (6)
2135	-0.583057	0.837802	-0.122469	1.02804	2.526 (5)
2137	2.1244	2.16004	0.24501	3.03955	11.471 (5)
2399	-0.283595	0.293042	-0.28408	0.496992	1.566 (5)
2415	-0.0126031	0.17578	-0.0642927	0.187592	0.649 (4)
2418	0.0570785	0.495038	-0.110336	0.510387	1.359 (4)
2496	0.0930581	-0.117421	-0.101445	0.180938	0.958 (4)
2503	-0.0685239	0.124026	0.045331	0.148771	0.463 (4)
2509	-0.0466452	-0.025886	-0.00515689	0.0535953	1.172 (4)

<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>
2515	0.000373555	-0.0602507	0.0107834	0.0612092	0.486 (4)
2516	-0.810453	-0.38078	0.00647535	0.895472	2.195 (4)
2523	0.200116	0.158463	0.100566	0.274354	0.969 (4)
2526	-0.129069	0.223856	0.000807614	0.258401	1.253 (4)
2532	0.608171	0.194388	-0.0677368	0.642064	1.741 (4)
2537	-0.123079	-0.0241561	-0.0374806	0.130907	0.437 (4)
2547	0.532905	0.0543282	0.0470203	0.537726	1.392 (4)
2551	-0.512704	0.00844887	-0.00578952	0.512806	1.286 (4)
2734	0.0507515	-0.239931	0.106195	0.267245	0.815 (4)
2739	-0.0692604	0.193007	-0.157638	0.258648	1.000 (4)
2877	0.551478	-0.120435	-0.0260767	0.565077	2.147 (3)
2881	-4.00725	0.142556	0.590214	4.05299	12.860 (3)
2883	0.910193	-0.0545338	-0.163165	0.926309	3.062 (3)
2886	1.10345	-0.413686	-0.238782	1.2024	3.838 (3)
2923	0.197546	0.107263	0.00624341	0.224875	0.867 (4)
2925	0.113887	-0.316437	0.00229109	0.336315	0.860 (4)
2926	-0.249738	-0.189545	-0.0513892	0.317706	1.022 (4)
2928	0.0271654	-0.170675	-0.00370262	0.172863	0.723 (4)
2932	0.0510387	-0.167018	0.0399023	0.179143	0.842 (4)
2934	-0.452895	0.268868	-0.0441072	0.528535	1.444 (4)
2938	0.0384347	-0.0724291	-0.0344479	0.0889373	0.548 (4)
2941	-0.290683	0.287109	-0.0492556	0.411527	1.200 (4)
2946	0.271759	0.323415	0.118896	0.438846	1.436 (4)
2948	0.393439	-0.878349	0.131291	0.971354	2.358 (4)
2950	0.158434	0.00600596	0.0475663	0.165529	0.546 (4)
2951	0.560803	-0.268467	0.136328	0.636522	1.608 (4)
3270	0.0512197	1.01805	0.313481	1.06645	2.300 (5)
3273	-1.33112	-0.421965	0.227467	1.41481	3.278 (5)
3429	-0.401425	0.0271006	0.0790471	0.41003	0.936 (5)
3432	0.252478	0.398235	-0.0441967	0.473593	0.980 (5)
3435	0.252313	-0.15012	-0.0482611	0.297535	0.670 (5)
3490	-0.122302	-0.444432	0.0654007	0.46557	1.079 (5)



<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>
3622	0.315839	0.326708	-0.0282176	0.455289	2.242 (2)
3626	0.995991	-0.890624	0.0330361	1.33653	6.437 (2)
3628	-0.218945	-0.126237	0.0504143	0.25771	1.841 (2)
3632	0.105049	-0.571452	0.0564361	0.583762	2.913 (2)
3636	-0.0285243	-0.0806724	0.0155526	0.0869687	0.530 (2)
3638	-0.349563	0.0396523	0.0424076	0.354352	2.160 (2)
3652	-0.124755	-0.0486184	-0.0258941	0.136375	1.037 (2)
3655	0.0301933	-0.00214736	-0.00742841	0.0311677	0.443 (2)
3659	0.054228	0.359741	0.00377046	0.363824	1.820 (2)
3660	-0.172463	0.272457	0.0242568	0.323364	1.871 (2)
3661	0.291046	0.355707	-0.0288441	0.460508	2.364 (2)
3663	-0.285892	0.218861	-0.0138335	0.360313	1.766 (2)
3664	-0.0201179	0.107275	0.0241396	0.111783	1.133 (2)
3670	-0.19283	0.621316	-0.00571343	0.650576	3.116 (2)
4490	0.0947726	-0.238461	-0.0390954	0.259565	0.670 (4)
4491	0.116689	0.0235569	-0.0265387	0.121965	0.400 (4)
4498	-0.109046	0.124125	0.00761511	0.165397	0.453 (4)
4499	-0.104393	-0.214879	-0.0220134	0.239907	0.626 (4)
4641	-0.0218715	-0.00897281	-0.00346266	0.0238928	0.349 (4)
4642	0.036916	-0.0465825	0.00230081	0.0594812	0.477 (4)
4643	0.126713	0.155628	-0.00589111	0.200776	0.851 (4)
4644	-0.0864054	0.221297	-0.00572744	0.237636	0.771 (4)
4645	0.037765	0.350944	-0.04252	0.355521	0.970 (4)
4646	-0.253085	-0.153131	-0.00492167	0.295847	1.265 (4)
4647	0.0534232	0.0547081	-0.00583898	0.0766883	0.324 (3)
4648	0.0976854	-0.29133	-0.0309851	0.308829	1.794 (3)
4834	-0.161572	0.314695	0.00414689	0.353773	0.730 (5)
4835	0.0135442	0.06827	0.0218905	0.0729619	0.476 (5)
4836	-0.205406	0.0468977	0.0145673	0.211195	0.692 (5)
4837	-0.113823	-0.0809687	-0.00261151	0.139708	0.539 (5)
4838	0.405649	0.147444	-0.0090015	0.431708	0.933 (5)
4894	-0.0277022	-0.0592591	0.0119553	0.066498	0.459 (4)

<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>
4895	0.285179	0.080179	0.0219193	0.297045	0.761 (4)
4896	-0.260875	0.0244268	-0.0611886	0.269065	0.801 (4)
5049	-0.120807	0.511643	0.00664533	0.525753	1.346 (4)
5064	0.323166	0.423884	-0.0666294	0.537172	1.403 (4)
5065	-0.117503	0.114445	-0.0390701	0.168616	0.709 (3)
5151	-0.36554	0.490526	0.0446013	0.613372	1.274 (5)
5152	-0.178533	0.74759	-0.148227	0.782775	1.727 (5)
5165	0.471926	-1.51403	0.168711	1.59482	3.161 (5)
5166	0.134443	-1.24679	0.0902586	1.25727	2.513 (5)
5177	-0.19658	0.40442	-0.1046	0.461671	1.005 (5)
5586	-0.0333852	0.0506201	0.0162446	0.0627762	0.580 (2)
5587	0.0154546	-0.0639997	0.0217746	0.0693466	0.682 (2)
5588	0.116207	-0.0321964	-0.0248259	0.123114	0.823 (2)
5589	-0.0560557	0.0932264	-0.00289433	0.10882	0.615 (2)
6063	0.264645	-0.0924977	-0.0167662	0.280845	1.402 (2)
6111	0.113547	0.0364336	-0.0010643	0.119254	0.989 (2)
6112	-0.128411	0.00179311	-0.0159401	0.129409	0.757 (2)
6113	0.124101	0.0869999	0.010977	0.151955	0.780 (2)
6114	-0.141994	-0.062417	-0.00441186	0.15517	0.800 (2)
6115	0.077506	0.178892	0.0131338	0.195402	0.995 (2)
6116	0.000133129	-0.0560834	0.00385122	0.0562156	0.382 (2)
6117	-0.0323897	-0.200932	-0.00245625	0.203541	1.009 (2)
6129	0.0914365	-0.198379	0.0406082	0.22218	0.728 (4)
6130	0.0561137	-0.092429	-0.0041053	0.108207	0.398 (4)
6131	-0.0799941	0.151991	-0.0157657	0.172479	0.572 (4)
6132	0.562911	0.135241	0.119042	0.591042	1.604 (4)
6133	0.210961	0.0836912	0.0137788	0.227373	0.786 (4)
6134	0.138422	0.0770286	0.00561107	0.15851	0.856 (2)
6135	-0.118536	0.150408	-0.0009728	0.191505	1.015 (2)
6136	-0.187354	-0.129687	-0.0173229	0.228518	1.185 (2)
6137	0.113058	-0.160261	-0.00605612	0.19622	0.985 (2)
6138	-0.136994	0.0694438	-0.00759836	0.153778	0.795 (2)

<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>
6139	0.187366	-0.0199002	0.0170469	0.189189	0.968 (2)
6140	0.00823503	0.0967481	0.0141132	0.0981183	0.605 (2)
6141	-0.00542923	-0.0617701	-0.00588096	0.0622865	0.376 (2)
6142	-0.0930116	0.255398	0.0264621	0.273093	0.809 (4)
6143	0.0116908	-0.0636855	-0.0278006	0.0704655	0.407 (4)
6144	0.0510578	-0.171529	-0.0259389	0.180837	0.595 (4)
6152	-0.0727546	-0.0670698	-0.00328388	0.0990069	0.302 (5)
6153	0.03596	0.168803	-0.0143171	0.173183	0.426 (5)
6154	0.0163572	0.113057	-0.0155698	0.11529	0.482 (5)
6155	-0.207799	0.114209	0.0311947	0.23916	0.609 (5)
6156	-0.0699061	-0.23528	-0.0250766	0.246723	0.566 (5)
6157	0.102172	0.0890345	0.0622586	0.149139	0.538 (5)
6158	0.148588	0.0792532	-0.0187492	0.169443	0.468 (5)
6159	0.0301639	-0.233467	-0.00114327	0.23541	0.536 (5)
6162	0.355641	-0.053661	0.0624531	0.365049	0.805 (5)
6163	-0.0590915	-0.220175	0.00583068	0.228042	0.632 (5)
6164	-0.441992	0.0856162	-0.104524	0.462182	0.994 (5)
6165	0.0335387	0.312437	-0.00706773	0.314312	0.702 (5)
6167	0.129042	-0.147905	0.0324077	0.198942	0.545 (5)
6180	0.999101	-0.00134461	0.0321913	0.999621	4.858 (2)
6181	1.05975	0.671762	-0.0344105	1.2552	6.070 (2)
6182	-3.29691	0.0384627	-0.0619962	3.29772	15.890 (2)
6184	0.455454	0.97876	0.129526	1.08728	5.270 (2)
6185	-0.266809	0.606747	-0.00661144	0.662852	3.237 (2)
6186	-0.0370337	0.965183	0.053206	0.967358	4.712 (2)
6188	-0.515218	-3.0673	-0.292225	3.12397	15.178 (2)
6189	0.348073	0.462316	0.0840901	0.584775	2.910 (2)
6190	1.47829	0.586759	0.402691	1.64066	7.733 (2)
6191	-1.49306	-0.715765	-0.425565	1.70957	8.063 (2)
6201	-0.00526724	-0.0238116	0.000467146	0.0243917	0.121 (2)
6204	0.000537516	0.0115113	-0.0200569	0.0231318	0.392 (3)
6205	-0.182678	0.102123	-0.0182351	0.210078	0.743 (3)

<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>
6206	0.18289	-0.118794	0.032207	0.22045	0.842 (3)
6210	-0.0349867	0.0611838	-0.0429388	0.0825304	0.635 (6)
6213	1.30517	-0.0727532	-0.0851832	1.30997	2.647 (5)
6214	-0.22865	-0.237528	-0.0710429	0.337264	1.075 (4)
6215	0.221722	-0.346122	-0.129839	0.431068	1.335 (4)
6334	-0.0671988	0.119508	0.0361616	0.141794	0.391 (5)
6335	-0.0271686	-0.525621	-0.00226538	0.526328	1.071 (5)
6336	-0.173553	0.521511	0.0252551	0.550211	1.144 (5)
6428	0.0715214	0.0391599	-0.00347465	0.0816142	0.353 (3)
6429	-0.184115	-0.0202517	-0.0376415	0.189011	0.703 (3)
6430	0.200036	-0.292546	0.0121238	0.354604	1.139 (3)
6431	0.104358	0.071571	0.0231887	0.128649	0.590 (3)
6452	0.708098	1.24435	-0.0881097	1.43442	2.826 (5)
6453	0.936239	0.951022	-0.0816057	1.33703	2.625 (5)
6454	0.204464	0.614907	-0.0154227	0.648193	1.347 (5)
6455	-0.0820455	0.890071	-0.00269943	0.893849	1.778 (5)
6456	-2.55281	-4.96854	0.265587	5.59229	10.989 (5)
6457	0.615927	1.18096	-0.084443	1.3346	2.631 (5)
<b>Total</b>	<b>0.608538</b>	<b>0.895789</b>	<b>0.144774</b>	<b>1.09257</b>	<b>3.176</b>

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

# Digital Elevation Model

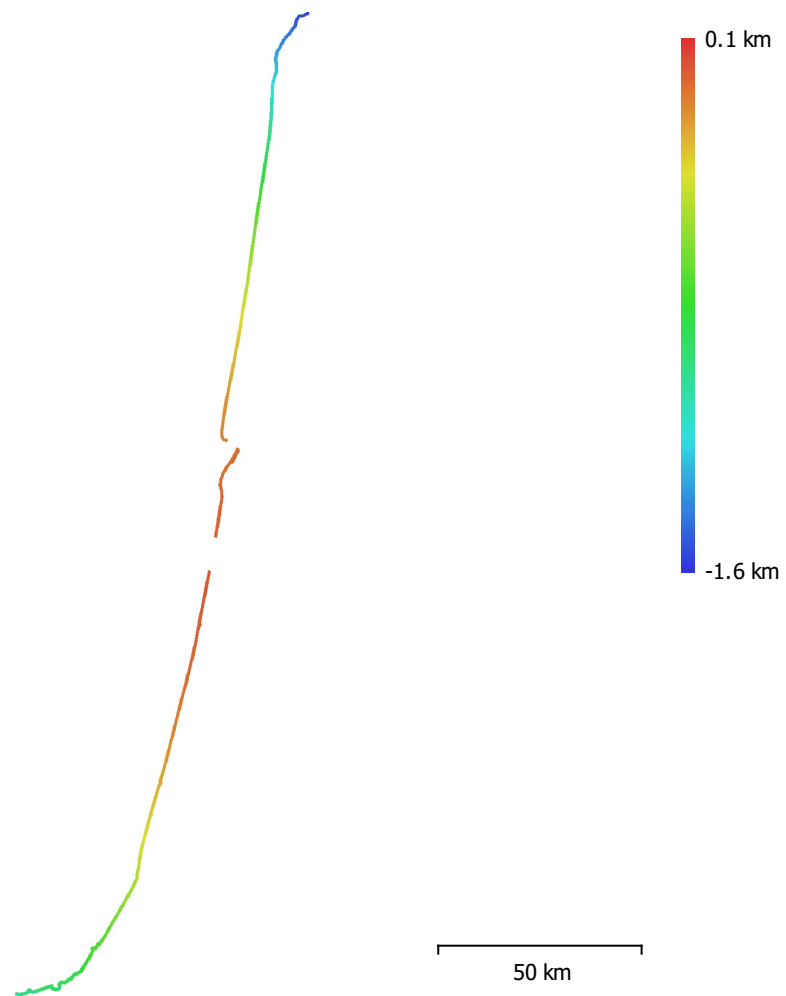


Fig. 6. Reconstructed digital elevation model.

Resolution: 1 m/pix  
Point density: 0.999 points/m<sup>2</sup>

# Processing Parameters

## General

Cameras	1029
Aligned cameras	982
Markers	179

## Shapes

Polygons	2
Coordinate system	RGF93_Lambert_93
Coordinate system	RGF93 / Lambert-93 (EPSG::2154)
Rotation angles	Omega, Phi, Kappa

## Point Cloud

Points	1,324,640 of 1,466,517
RMS reprojection error	0.0806889 (0.951233 pix)
Max reprojection error	1.05404 (51.8445 pix)
Mean key point size	7.98433 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	2.62111

## Alignment parameters

Accuracy	Medium
Key point limit	40,000
Tie point limit	4,000
Adaptive camera model fitting	No
Matching time	45 minutes 23 seconds
Alignment time	5 minutes 27 seconds

## Optimization parameters

Adaptive camera model fitting	No
Optimization time	8 seconds
Software version	1.7.5.13229

## DEM

Size	72,247 x 241,633
Coordinate system	RGF93 / Lambert-93 (EPSG::2154)

## Orthomosaic

Size	722,470 x 2,416,330
Coordinate system	RGF93 / Lambert-93 (EPSG::2154)
Colors	3 bands, uint8

## Reconstruction parameters

Blending mode	Mosaic
Surface	DEM
Enable hole filling	Yes
Processing time	5 hours 1 minutes
Software version	1.5.5.9097

## Software

Version	1.5.5 build 9097
Platform	Windows 64