Processing Report

Summary

Project	20200902_CTAHR
Processed	2020-09-08 08:25:11
Camera Model Name(s)	L1D-20c_10.3_5472x3648 (RGB)
Average Ground Sampling Distance (GSD)	2.95 cm / 1.16 in
Area Covered	1.654 km^2 / 165.3648 ha / 0.64 sq. mi. / 408.8369 acres
Time for Initial Processing (without report)	01h:23m:59s

Quality Check

	Images	median of 76970 keypoints per image	✓
	Dataset	1307 out of 1408 images calibrated (92%), all images enabled, 4 blocks	⚠
	Camera Optimization	5.27% relative difference between initial and optimized internal camera parameters	⚠
	Matching	median of 6427.53 matches per calibrated image	✓
	Georeferencing	yes, no 3D GCP	⚠

Preview

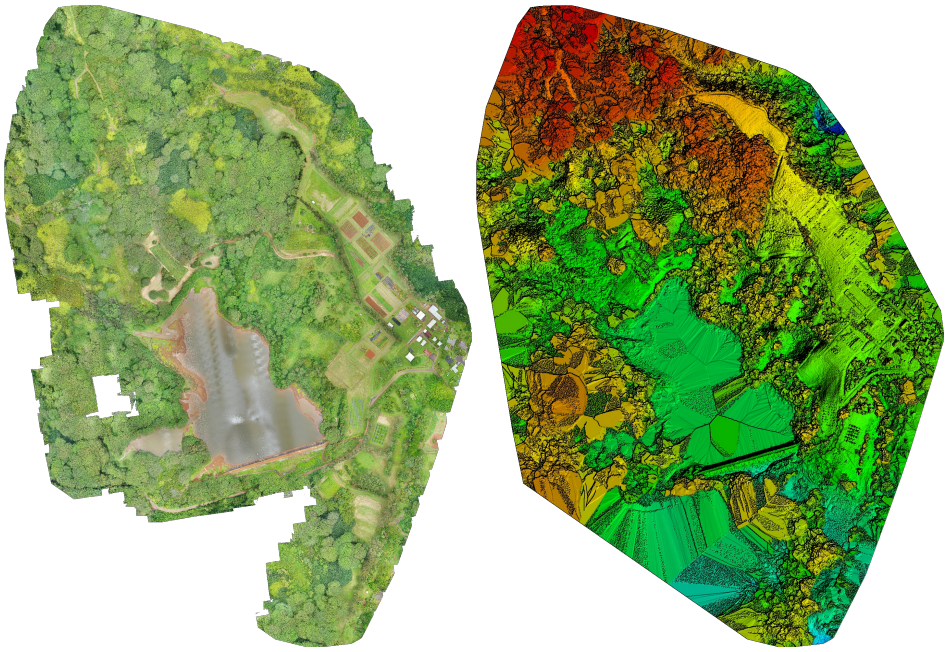


Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

Calibration Details

Number of Calibrated Images	1307 out of 1408
Number of Geolocated Images	1408 out of 1408

Initial Image Positions

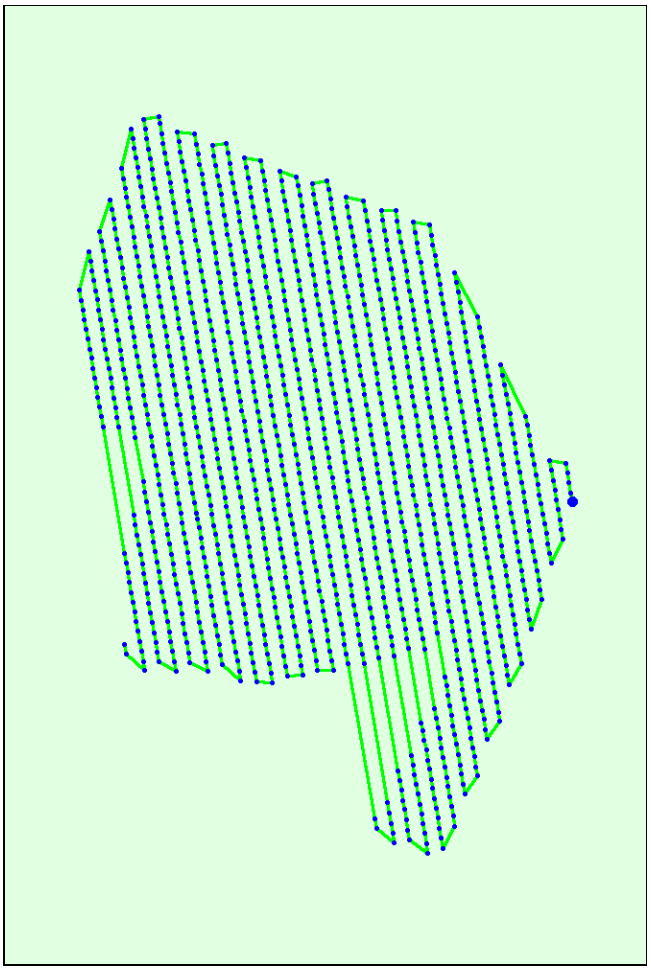


Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.

Computed Image/GCPs/Manual Tie Points Positions

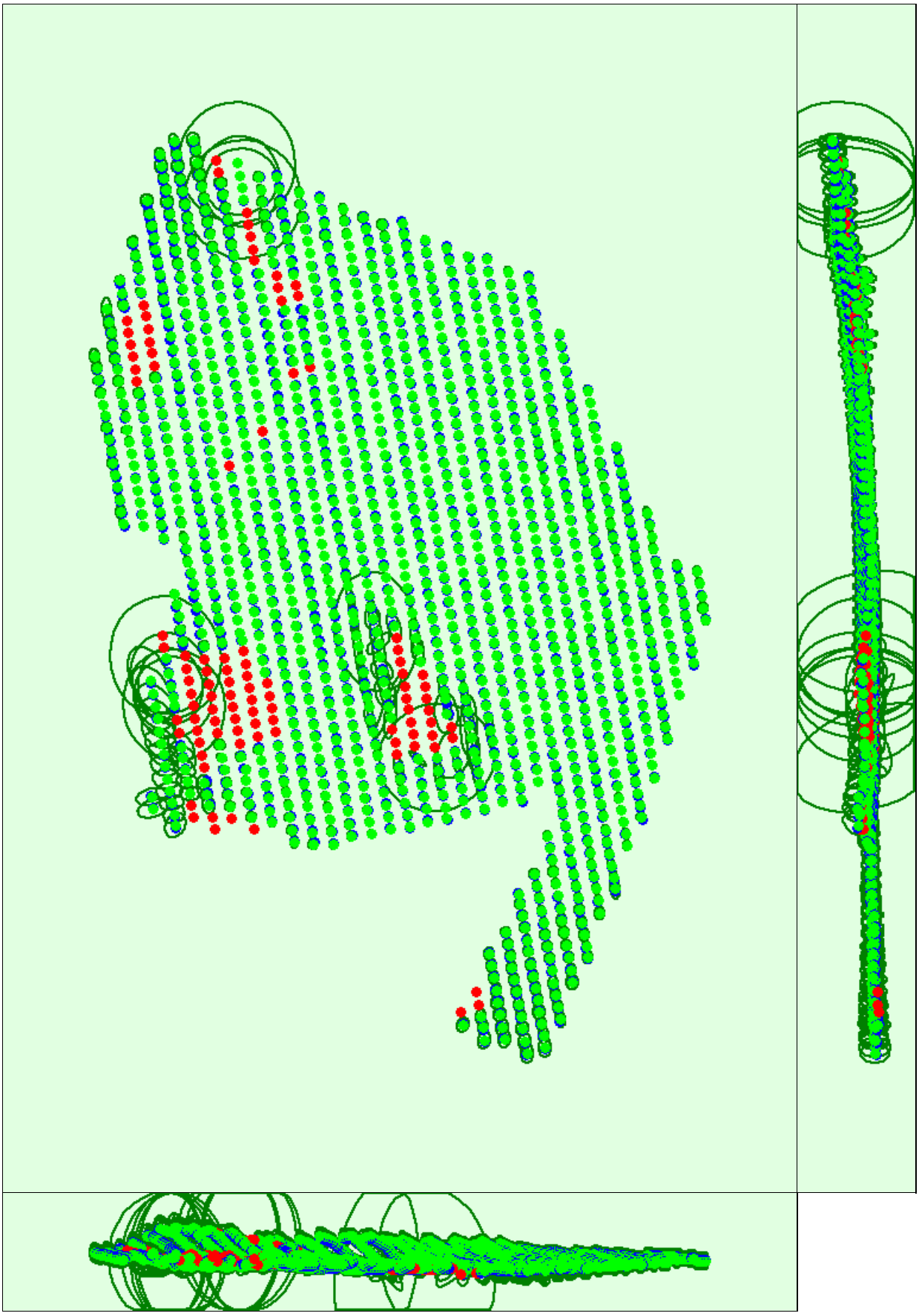


Figure 3: Offset between initial (blue dots) and computed (green dots) image positions as well as the offset between the GCPs initial positions (blue crosses) and their computed positions (green crosses) in the top-view (XY plane), front-view (XZ plane), and side-view (YZ plane). Red dots indicate disabled or uncalibrated images. Dark green ellipses indicate the absolute position uncertainty of the bundle block adjustment result.

Absolute camera position and orientation uncertainties

	X [m]	Y [m]	Z [m]	Omega [degree]	Phi [degree]	Kappa [degree]	Camera Displacement X [m]	Camera Displacement Y [m]	Camera Displacement Z [m]
Mean	0.159	0.197	0.311	0.066	0.049	0.035	0.022	0.041	0.055
Sigma	0.181	0.235	0.258	0.100	0.082	0.199	0.090	0.253	0.137

Overlap

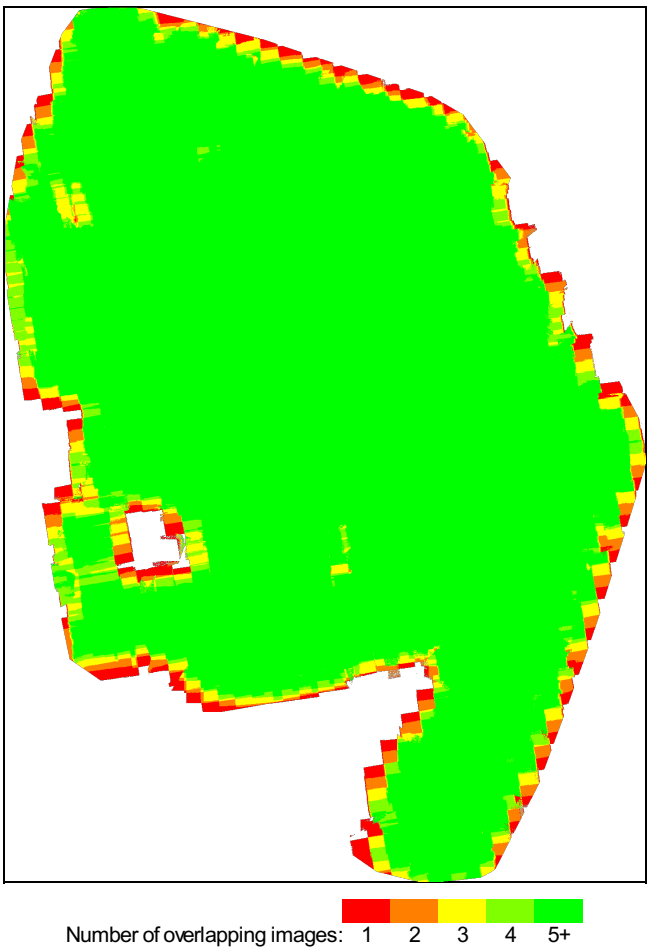


Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.
Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint matches is also sufficient for these areas (see Figure 5 for keypoint matches).

Bundle Block Adjustment Details

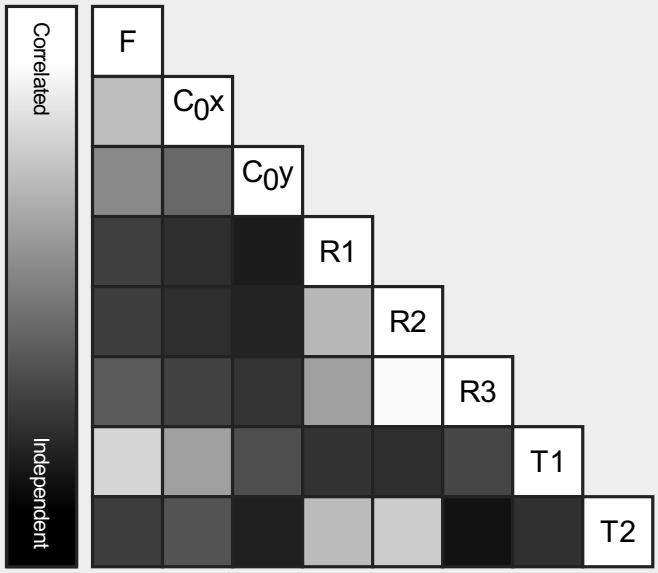
Number of 2D Keypoint Observations for Bundle Block Adjustment	8589221
Number of 3D Points for Bundle Block Adjustment	2933592
Mean Reprojection Error [pixels]	0.174

Internal Camera Parameters

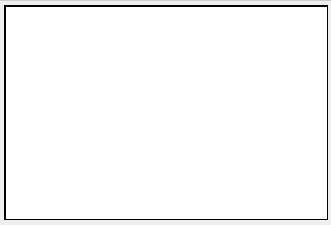
L1D-20c_10.3_5472x3648 (RGB). Sensor Dimensions: 12.825 [mm] x 8.550 [mm]

EXIF ID: L1D-20c_10.3_5472x3648

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	4470.830 [pixel] 10.479 [mm]	2770.870 [pixel] 6.494 [mm]	1698.700 [pixel] 3.981 [mm]	0.009	0.040	-0.050	-0.003	0.002
Optimized Values	4706.784 [pixel] 11.032 [mm]	2746.344 [pixel] 6.437 [mm]	1751.657 [pixel] 4.105 [mm]	0.008	0.019	-0.027	-0.006	0.001
Uncertainties (Sigma)	8.825 [pixel] 0.021 [mm]	0.169 [pixel] 0.000 [mm]	0.490 [pixel] 0.001 [mm]	0.000	0.001	0.001	0.000	0.000



The correlation between camera internal parameters determined by the bundle adjustment. White indicates a full correlation between the parameters, ie. any change in one can be fully compensated by the other. Black indicates that the parameter is completely independent, and is not affected by other parameters.



The number of Automatic Tie Points (ATPs) per pixel, averaged over all images of the camera model, is color coded between black and white. White indicates that, on average, more than 16 ATPs have been extracted at the pixel location. Black indicates that, on average, 0 ATPs have been extracted at the pixel location. Click on the image to the see the average direction and magnitude of the re-projection error for each pixel. Note that the vectors are scaled for better visualization. The scale bar indicates the magnitude of 1 pixel error.

2D Keypoints Table

	Number of 2D Keypoints per Image	Number of Matched 2D Keypoints per Image
Median	76970	6428
Min	16955	40
Max	91880	29966
Mean	71984	6572

3D Points from 2D Keypoint Matches

	Number of 3D Points Observed
In 2 Images	2015255
In 3 Images	429279
In 4 Images	167433
In 5 Images	88738
In 6 Images	56077
In 7 Images	39452
In 8 Images	29287
In 9 Images	22259
In 10 Images	17444
In 11 Images	14319
In 12 Images	12102
In 13 Images	10149
In 14 Images	8288
In 15 Images	7344
In 16 Images	7029
In 17 Images	5162
In 18 Images	2215
In 19 Images	966
In 20 Images	400
In 21 Images	247
In 22 Images	113
In 23 Images	34

2D Keypoint Matches

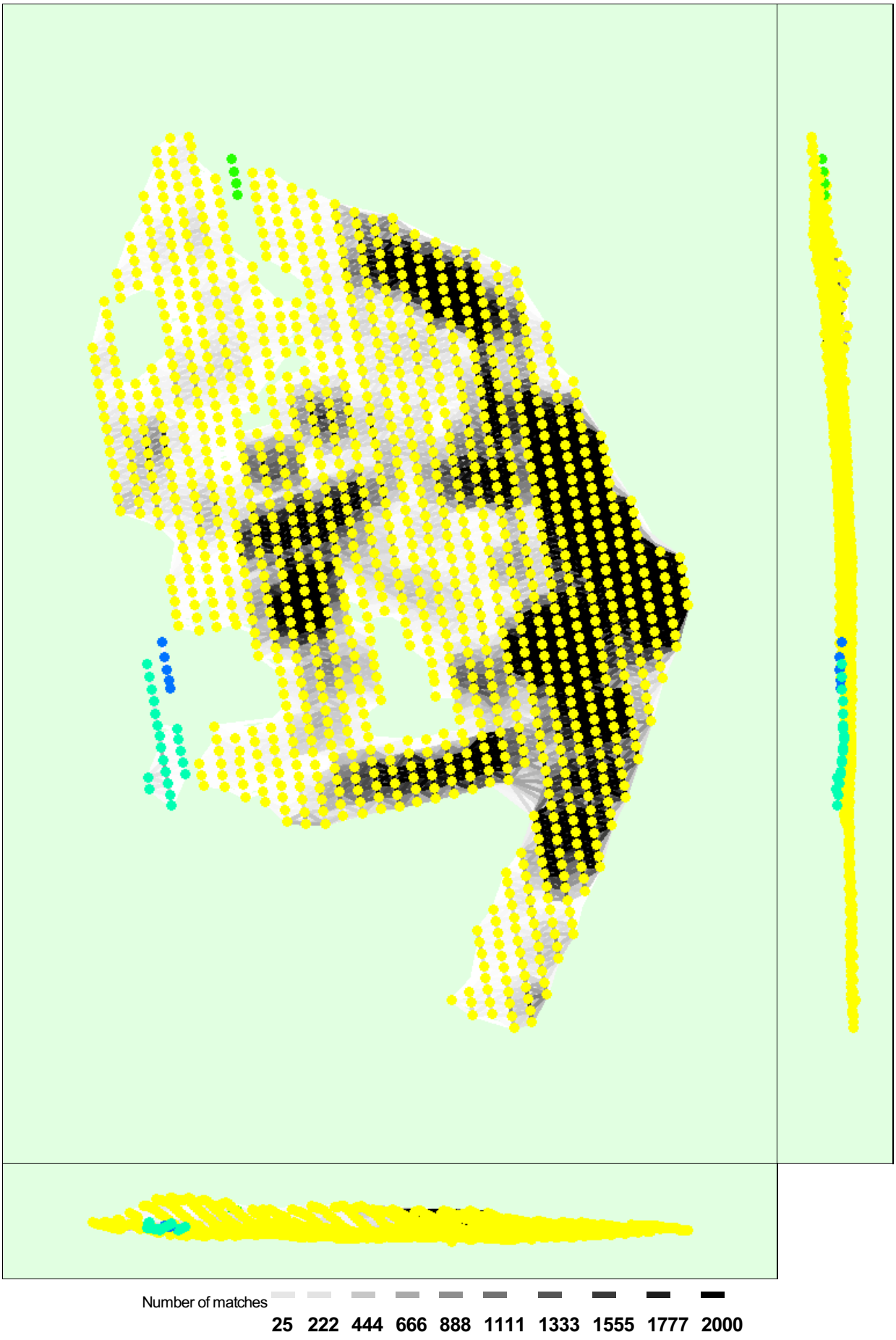


Figure 5: Computed image positions with links between matched images. The darkness of the links indicates the number of matched 2D keypoints between the images. Bright links indicate weak links and require manual tie points or more images.

Geolocation Details

Absolute Geolocation Variance

Min Error [m]	Max Error [m]	Geolocation Error X [%]	Geolocation Error Y [%]	Geolocation Error Z [%]
-	-15.00	0.00	0.00	0.00
-15.00	-12.00	0.00	0.00	0.00
-12.00	-9.00	0.00	0.23	0.00
-9.00	-6.00	0.08	1.38	0.00
-6.00	-3.00	1.45	12.47	1.91
-3.00	0.00	44.91	35.81	49.89
0.00	3.00	53.25	33.82	45.60
3.00	6.00	0.31	16.14	2.37
6.00	9.00	0.00	0.15	0.23
9.00	12.00	0.00	0.00	0.00
12.00	15.00	0.00	0.00	0.00
15.00	-	0.00	0.00	0.00
Mean [m]		-0.000000	-0.000000	-0.000000
Sigma [m]		1.031122	2.803667	1.443741
RMS Error [m]		1.031122	2.803667	1.443741

Min Error and Max Error represent geolocation error intervals between -1.5 and 1.5 times the maximum accuracy of all the images. Columns X, Y, Z show the percentage of images with geolocation errors within the predefined error intervals. The geolocation error is the difference between the initial and computed image positions. Note that the image geolocation errors do not correspond to the accuracy of the observed 3D points.

Relative Geolocation Variance

Relative Geolocation Error	Images X [%]	Images Y [%]	Images Z [%]
[-1.00, 1.00]	99.85	95.41	100.00
[-2.00, 2.00]	100.00	100.00	100.00
[-3.00, 3.00]	100.00	100.00	100.00
Mean of Geolocation Accuracy [m]	5.000000	5.000000	10.000000
Sigma of Geolocation Accuracy [m]	0.000000	0.000000	0.000000

Images X, Y, Z represent the percentage of images with a relative geolocation error in X, Y, Z.

Geolocation Orientational Variance	RMS [degree]
Omega	1.187
Phi	0.637
Kappa	120.447

Geolocation RMS error of the orientation angles given by the difference between the initial and computed image orientation angles.

Rolling Shutter Statistics

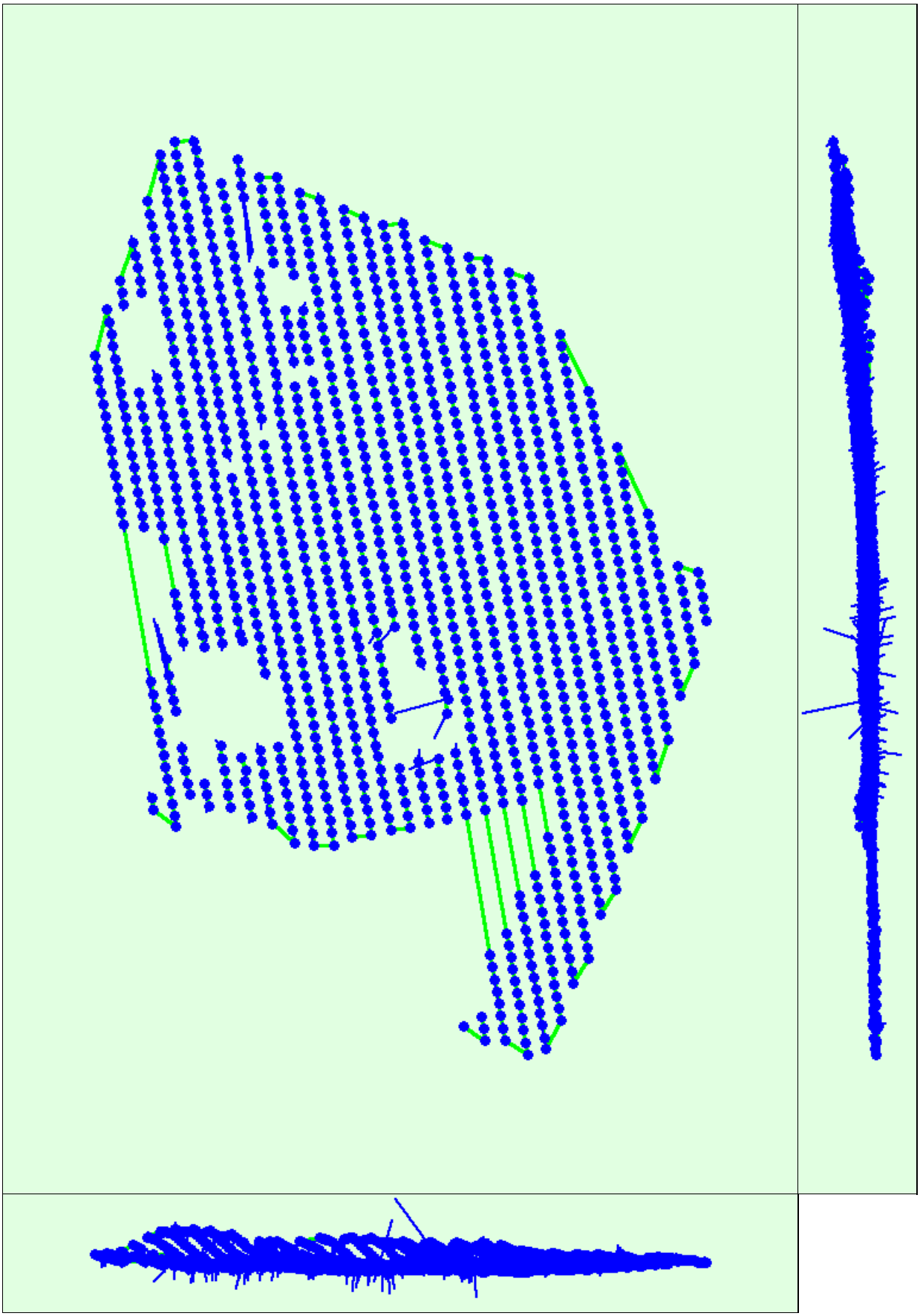


Figure 6: Camera movement estimated by the rolling shutter camera model. The green line follows the computed image positions. The blue dots represent the camera position at the start of the exposure. The blue lines represent the camera motion during the rolling shutter readout, re-scaled by a project dependant scaling factor for better visibility.

Median Camera Speed	12.0527 [m/s]
Median Camera Displacement During Sensor Readout)	0.8626 [m]
Median Rolling Shutter Readout Time	87.4262 [ms]

Initial Processing Details

System Information

Hardware	CPU: Intel(R) Core(TM) i9-9900 CPU @ 3.10GHz RAM: 64GB GPU: Intel(R) UHD Graphics 630 (Driver: 26.20.100.7262), NVIDIA GeForce RTX 2080 SUPER (Driver: 26.21.14.4223)
Operating System	Windows 10 Pro, 64-bit

Coordinate Systems

Image Coordinate System	GCS_WGS_1984 (EGM96 Geoid)
Output Coordinate System	WGS_1984_UTM_Zone_4N (EGM96 Geoid)

Processing Options

Detected Template	2D Full
Keypoints Image Scale	Full, Image Scale: 1
Advanced: Matching Image Pairs	Aerial Grid or Corridor
Advanced: Matching Strategy	Use Geometrically Verified Matching: no
Advanced: Keypoint Extraction	Targeted Number of Keypoints: Automatic
Advanced: Calibration	Calibration Method: Standard Internal Parameters Optimization: All External Parameters Optimization: All Rematch: Auto, yes

Point Cloud Densification details

Processing Options

Image Scale	multiscale, 1/2 (Half image size, Default)
Point Density	Optimal
Minimum Number of Matches	3
3D Textured Mesh Generation	no
LOD	Generated: no
Advanced: Image Groups	group1
Advanced: Use Processing Area	yes
Advanced: Use Annotations	yes
Time for Point Cloud Densification	09h:23m:33s
Time for Point Cloud Classification	27m:20s
Time for 3D Textured Mesh Generation	NA

Results

Number of Generated Tiles	6
Number of 3D Densified Points	162826362
Average Density (per m^3)	99.16