

TOPODRONE DJI MAVIC 2 PRO L1/L2 PPK

USER MANUAL



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1.2 Compass calibration.

As the basic model, DJI Mavic 2 Pro Topodrone PPK needs the compass calibration (CC) each time you move to the new location. CC helps your drone to adapt to local magnetic field lines. During CC, accelerometer and compass makes two rotations in different axes. After that, drone makes adjustment between values of each sensors. To make correct CC follow next steps:

1. CC makes directly before flight at the open outdoor area. Making CC indoor is useless
2. Remove gimbal holder and unfold drone's arms.
3. Turn on the drone and RC, insert and plug the mobile device.
4. Make sure, there are no large metal constructions or magnetic fields in a 50 meters.
5. Enter drone into CC mode. At least there are two ways:
 - a) In the DJI Go 4 app open MC Settings / Advanced settings / Sensors state / Compass / Calibrate compass / OK
 - b) At the right side of RC, rapidly move the slider to S and T positions not less than 4 times.
6. Ensure that rear LEDs of the drone lights solid yellow.
7. Put RC in the left arm and take drone from the in your right arm. Hold drone from the top under the battery. Do not change the orientation of the drone!
8. Rotate drone to the left side (counter-clock wise) in 380 degrees (a bit more than 360 degrees). Stop when the rear LEDs will change color from solid yellow to solid green.
9. Change orientation of the drone, turning it in 90 degrees in a longitudinal axis.
10. Rotate drone to the left side (counter-clock wise) in 380 degrees (a bit more than 360 degrees). Stop when the rear LEDs will change color from solid green to blinking green.
11. If using 5a way entering CC mode, turn the Flight Mode slider to P (central position). This is especially important!
12. Compass calibration now is complete.



Before and after CC you can check the value of magnetic interference in the DJI Go 4 App – it should be at the green zone after CC. If the app notice you compass calibration failed (rear LEDs blinks red rapidly) – recalibrate compass at another place nearby.

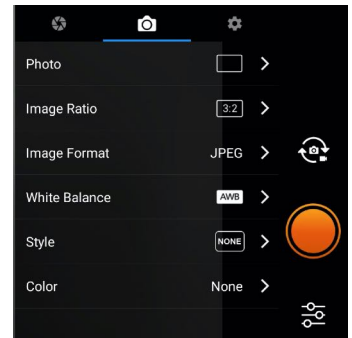
Notice 1: no magnetic or ferromagnetic objects on the body of pilot are allowed. For example: massive jewelry, metal inserts or magnets in the end of the iPad tablet etc. If you have some of these objects, even after successful CC, your drone will have “Compass Error” after taking off.

Notice 2: CC increase flight stability of the drone during the flight. But compass error can appear even after absolutely correct calibration. It usually caused by different external interferences such are metal objects, large antennas, electricity transmission lines (ETL)

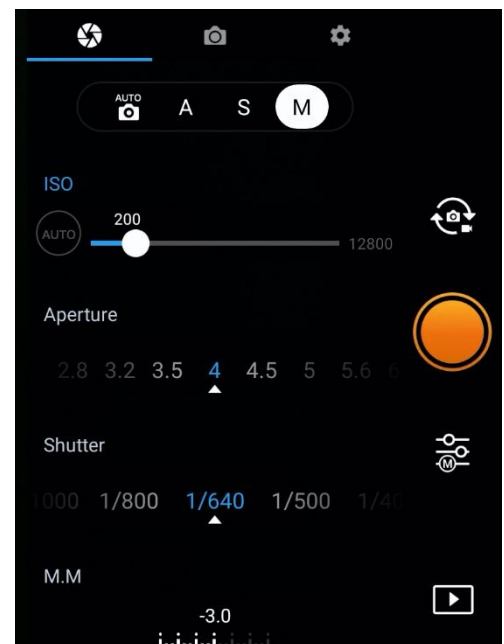
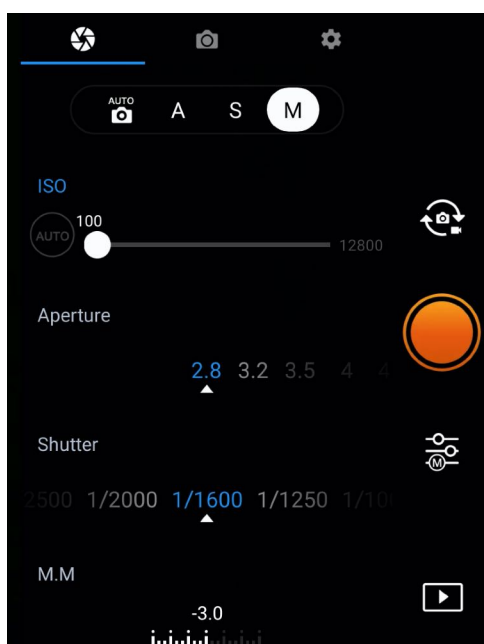
1.3. Camera calibration and settings

Before the shooting process will be started, you should calibrate focus of your DJI Mavic 2 Pro PPK camera and set optimal image settings. It is recommended to use next order.

1. You should determine drone's working altitude. This value depends on many factors: scale of the final orthophoto map, properties of the lens, height of the obstacles, features of relief, etc. Usually, working altitude is from 60 to 12 meters.
2. Set correct image ratio. Go to the image menu, tap the second tab. Use the Image Ratio 3:2 value, it allows to use all square of camera's matrix. Do not use 16:9 Ratio! Check another values of this menu – all defaults.
3. Lift off the drone to the working altitude and move gimbal to the 90 degrees (nadir). Ensure that focusing method now is in the AF value. Then tap to the center of the screen to let the camera focusing at the surface. After that change focusing method in the MF value - manual focus scale will appear. Do not touch it! Now drone's camera is focused at the selected height value. It will not change in the future.
4. Now it's time to set the best camera settings. All parameters are at auto as default. In this case, drone will change image brightness, smoothness during the flight. But this way is bad for triangulation image processing: key points at different images will be different. To get the best image quality during the flight it is strongly recommended to set image params as follows:



ISO: from 100 to 200. Upper values increase image noise, and decrease orthophoto map quality
Aperture: from 2.8 to 4. Upper values decrease stream of light, so images will be darker
Shutter: from 1/1600 to 1/640. Upper values increase image motion blur, lower ones does not allow the camera to get enough light, so images will be darker and more discolored.



1.4. IMU calibration and settings

IMU calibration needs very rarely. However some things can affect the sensor states: falls and bumps, temperature changes and long stand by time. Because of use the additional module upper the shell of DJI Mavic 2 PPK, the process of IMU calibration is not the same as the default. To calibrate IMU you need to do next:

1. Set up the props to motors
2. Fold the arms like at photo
3. Prepare your table or another flat surface: the horizon should be aligned to the bubble level
4. Start the IMU calibration process and make steps 1-4 as they are.
5. At step 5 you should place the drone head over heels. Use the edge of table to make this step. Place your drone like at the photo below



6. When the step 5 is complete, rotate drone and place it normally
7. IMU calibration now is complete

1.5.GNSS settings

Appearance and description of elements:



Green LED. Indicate power supply module.

Blue LED. Indicate quality of receive GNSS signal.

State	Description
No flash	PDOP>10
Slow blink	3<PDOP<10
Fast blink	2<PDOP<3
Solid blue	PDOP<2

Orange LED. Indicate recording data to a flash card. When recording in progress, LED rapidly blink. Each blink means that 4 kB data is recording.

Red LED. Indicate, if system have error. In case of error, check flash card. If change, or install/format microSD card not solved a problem, contact support.

Plug in microSD card.

Dual frequency (L1/L2) antenna

2. GNSS DATA POST PROCESSING AND IMAGES GEOTAGGING

2.1 Data preparation

Remove SD card with images from a drone and copy photos to your computer.

Divide a whole images dataset to separate flights and store photos from each mission in separate folders.

For example, Flight 1, Flight 2 etc.

NOTICE. *Do not delete any images.*

Remove SD card from GNSS receiver installed on the drone and copy ubx files to your computer to a folder ROVER (for example).

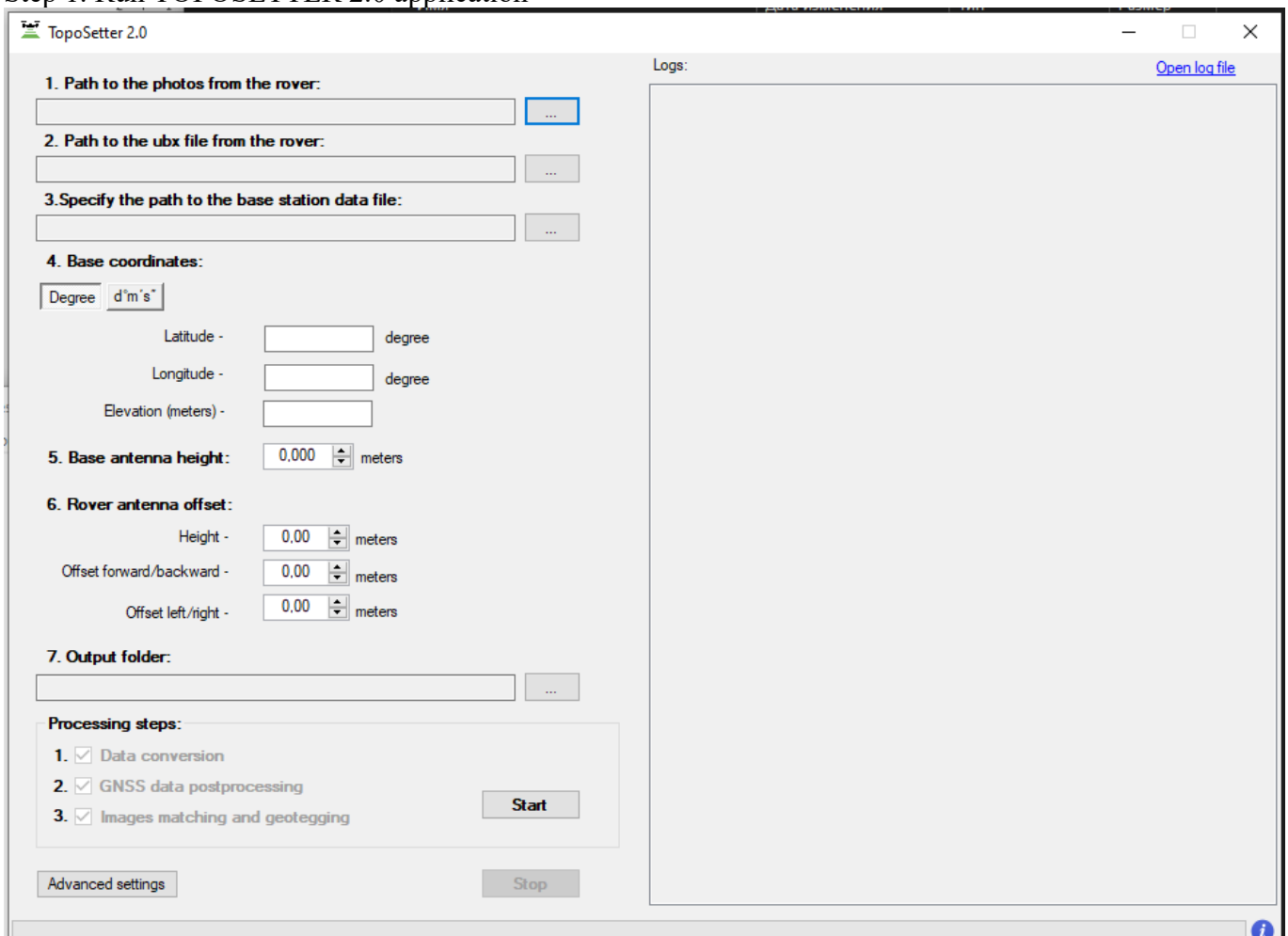
Download GNSS static logs from a base station and convert them to Rinex format. Copy Rinex files to a folder BASE (for example)

Mesure coordinates of ground control points (GCPs) and coordinates of the base station.

NOTICE. *Coordinates of the base station should be in Latitude, Longitude, Ellipsoid high, WGS 84 coordinate system.*

2.2 GNSS data post processing

Step 1. Run TOPOSETTER 2.0 application



TopoSetter 2.0

1. Path to the photos from the rover: ...

2. Path to the ubx file from the rover: ...

3. Specify the path to the base station data file: ...

4. Base coordinates:

Degree d'm's

Latitude - degree

Longitude - degree

Elevation (meters) -

5. Base antenna height: 0.000 meters

6. Rover antenna offset:

Height - 0.00 meters

Offset forward/backward - 0.00 meters

Offset left/right - 0.00 meters

7. Output folder: ...

Processing steps:

1. ☒ Data conversion

2. ☒ GNSS data postprocessing

3. ☒ Images matching and geotagging

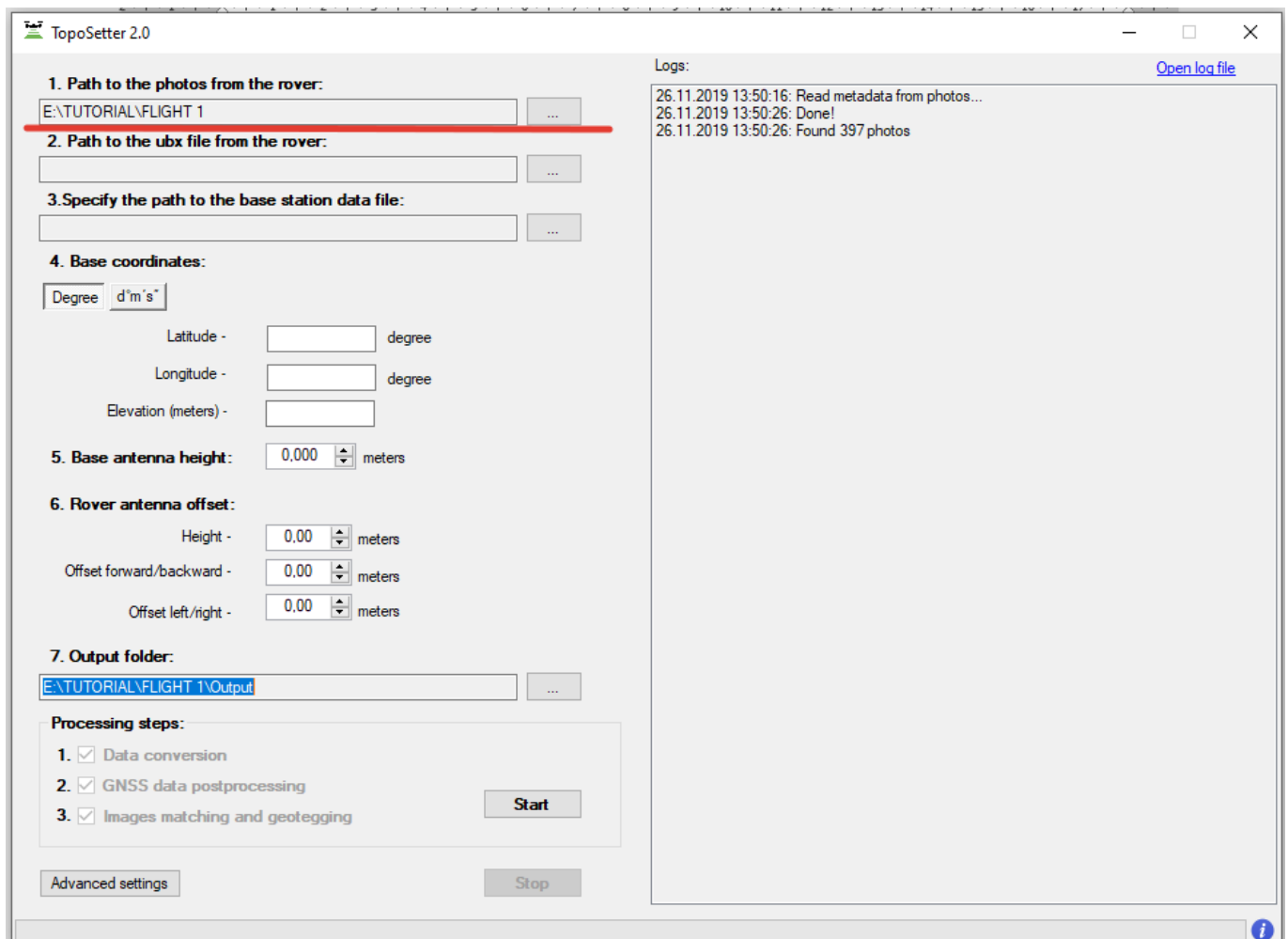
Start

Advanced settings

Stop

Logs: [Open log file](#)

Step 2. Select folder with photos



1. Path to the photos from the rover:
E:\TUTORIAL\FLIGHT 1

2. Path to the ubx file from the rover:

3. Specify the path to the base station data file:

4. Base coordinates:
Degree d'm's
Latitude - degree
Longitude - degree
Elevation (meters) -

5. Base antenna height: 0.000 meters

6. Rover antenna offset:
Height - 0.00 meters
Offset forward/backward - 0.00 meters
Offset left/right - 0.00 meters

7. Output folder:
E:\TUTORIAL\FLIGHT 1\Output

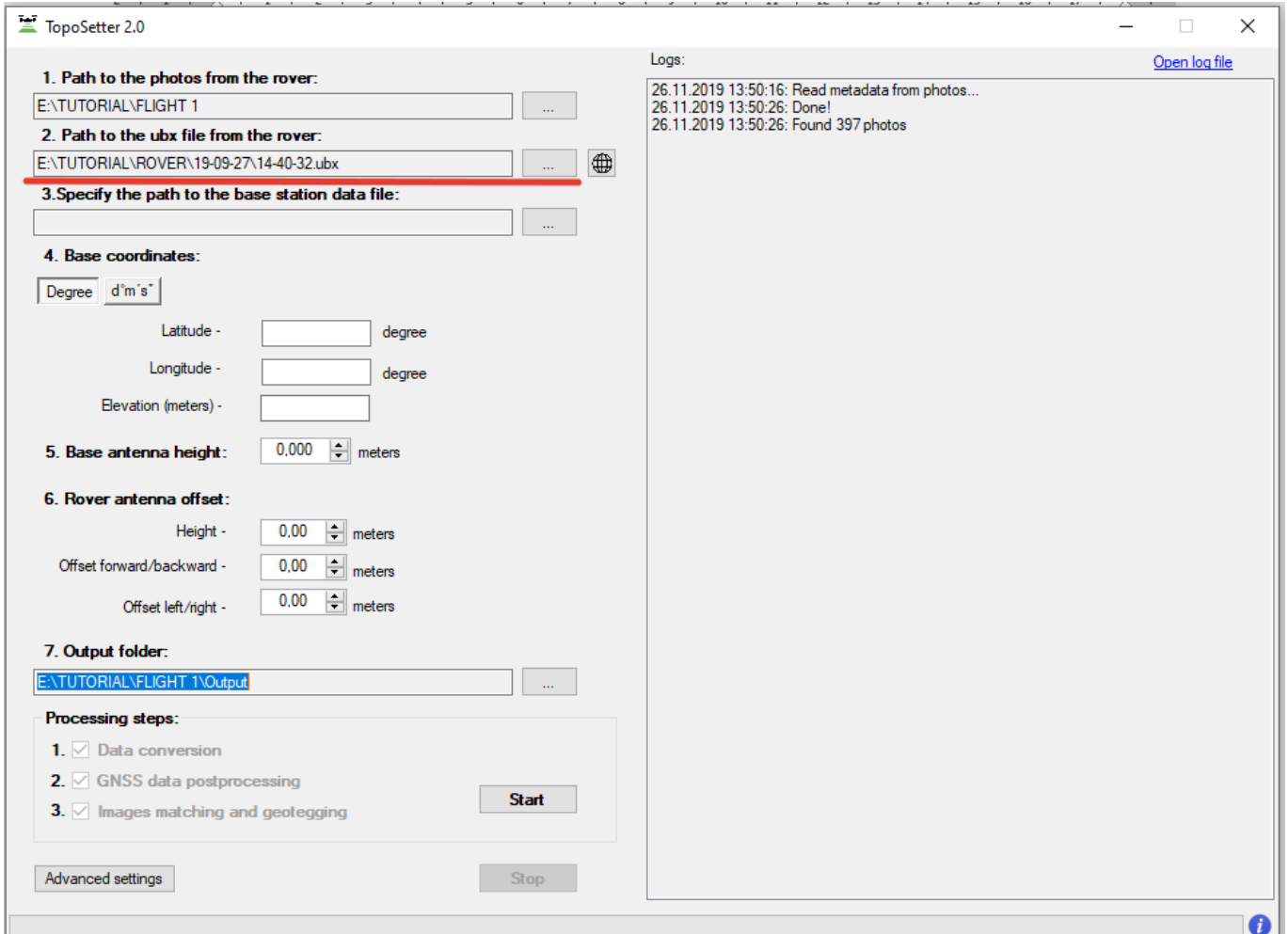
Processing steps:
1. ☒ Data conversion
2. ☒ GNSS data postprocessing
3. ☒ Images matching and geotagging

Start

Advanced settings Stop

Logs:
[Open log file](#)
26.11.2019 13:50:16: Read metadata from photos...
26.11.2019 13:50:26: Done!
26.11.2019 13:50:26: Found 397 photos

Step 3. Select UBX file from a drone



The screenshot shows the TopoSetter 2.0 software window. The interface is divided into two main sections: configuration on the left and a logs panel on the right.

Configuration Section:

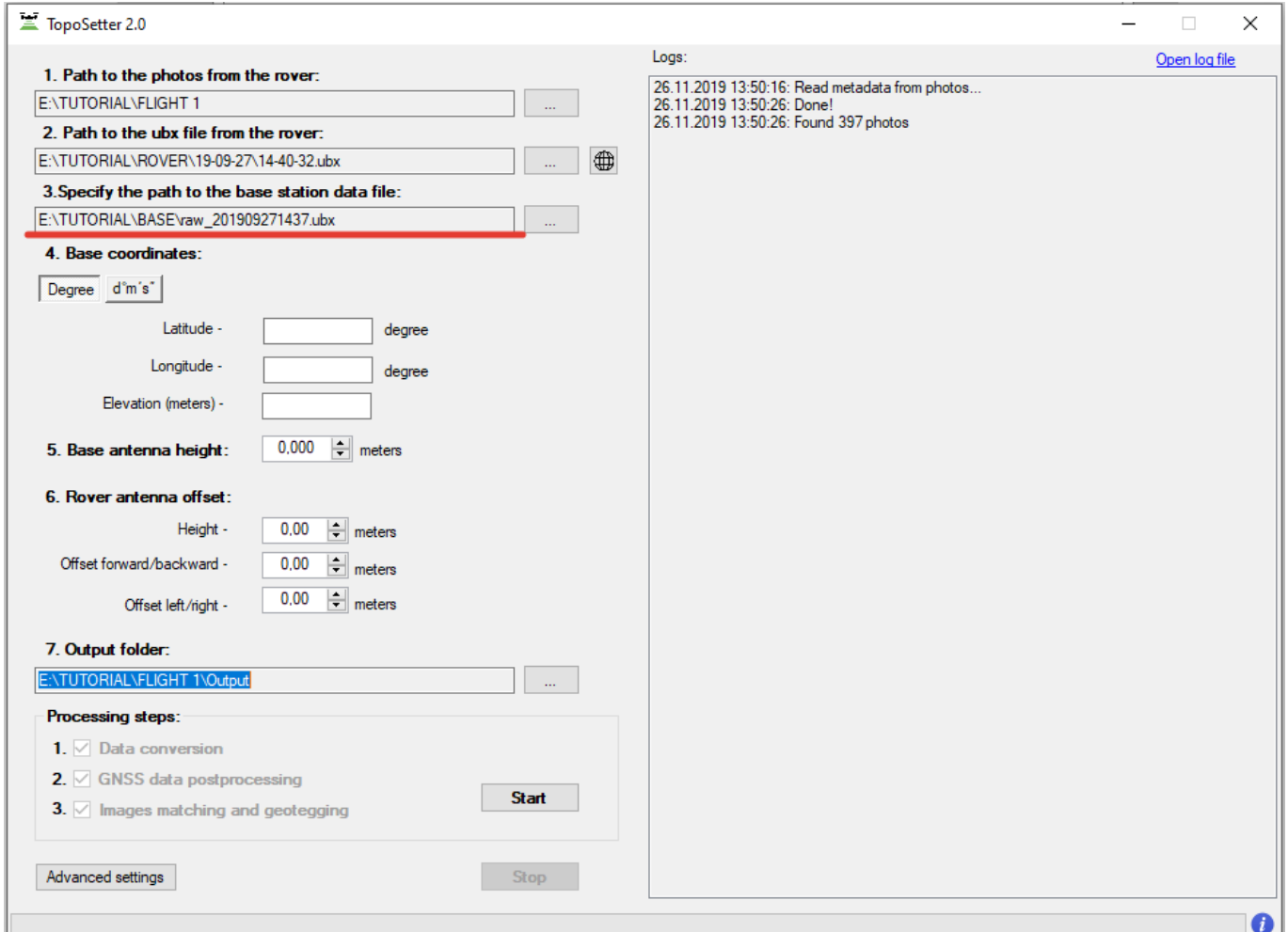
- 1. Path to the photos from the rover:** E:\TUTORIAL\FLIGHT 1
- 2. Path to the ubx file from the rover:** E:\TUTORIAL\ROVER\19-09-27\14-40-32.ubx (This path is highlighted with a red underline in the original image.)
- 3. Specify the path to the base station data file:** (Empty field)
- 4. Base coordinates:**
 - Latitude - (Empty field) degree
 - Longitude - (Empty field) degree
 - Elevation (meters) - (Empty field)
- 5. Base antenna height:** 0.000 meters
- 6. Rover antenna offset:**
 - Height - 0.00 meters
 - Offset forward/backward - 0.00 meters
 - Offset left/right - 0.00 meters
- 7. Output folder:** E:\TUTORIAL\FLIGHT 1\Output
- Processing steps:**
 - ☒ Data conversion
 - ☒ GNSS data postprocessing
 - ☒ Images matching and geotagging

Buttons: **Start** (next to processing steps), **Advanced settings**, **Stop**.

Logs Panel:

- Logs: (Link to [Open log file](#))
- 26.11.2019 13:50:16: Read metadata from photos...
- 26.11.2019 13:50:26: Done!
- 26.11.2019 13:50:26: Found 397 photos

Step 4. Select Rinex or UBX file from a base station

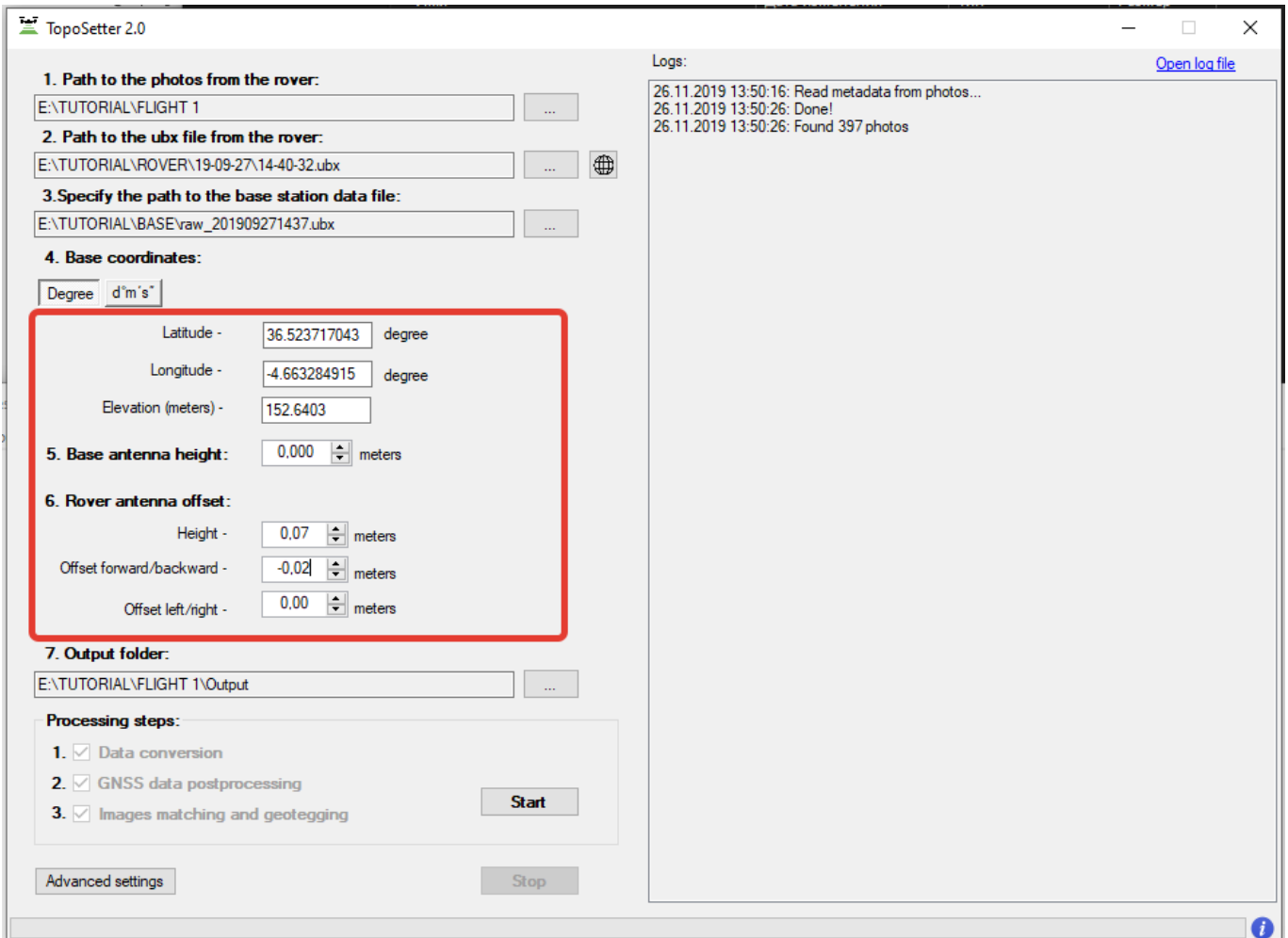


The screenshot shows the TopoSetter 2.0 software interface. The main window has a title bar with standard Windows controls. The interface is divided into several sections:

- 1. Path to the photos from the rover:** A text box containing "E:\TUTORIAL\FLIGHT 1" and a browse button (...).
- 2. Path to the ubx file from the rover:** A text box containing "E:\TUTORIAL\ROVER\19-09-27\14-40-32.ubx" and a browse button (...).
- 3. Specify the path to the base station data file:** A text box containing "E:\TUTORIAL\BASE\raw_201909271437.ubx" and a browse button (...). This section is highlighted with a red border.
- 4. Base coordinates:** A section with radio buttons for "Degree" and "d'm's". Below are input fields for Latitude, Longitude, and Elevation (meters), each with a "degree" label.
- 5. Base antenna height:** A spin box set to "0.000" with a "meters" label.
- 6. Rover antenna offset:** A section with spin boxes for Height, Offset forward/backward, and Offset left/right, each with a "meters" label.
- 7. Output folder:** A text box containing "E:\TUTORIAL\FLIGHT 1\Output" and a browse button (...).
- Processing steps:** A list of three steps, each with a checked checkbox:
 1. ☒ Data conversion
 2. ☒ GNSS data postprocessing
 3. ☒ Images matching and geotagging
- Buttons:** A "Start" button is located next to the processing steps, and a "Stop" button is at the bottom right. An "Advanced settings" button is at the bottom left.
- Logs:** A panel on the right side titled "Logs:" with a link "Open log file". It contains three log entries:


```
26.11.2019 13:50:16: Read metadata from photos...
26.11.2019 13:50:26: Done!
26.11.2019 13:50:26: Found 397 photos
```

Step 5. Impute coordinates of the base station in WGS 84.
Define antenna offset for a drone.



TopoSetter 2.0

1. Path to the photos from the rover:
E:\TUTORIAL\FLIGHT 1

2. Path to the ubx file from the rover:
E:\TUTORIAL\ROVER\19-09-27\14-40-32.ubx

3. Specify the path to the base station data file:
E:\TUTORIAL\BASE\raw_201909271437.ubx

4. Base coordinates:
Degree d'm's"
Latitude - 36.523717043 degree
Longitude - -4.663284915 degree
Elevation (meters) - 152.6403

5. Base antenna height:
0.000 meters

6. Rover antenna offset:
Height - 0.07 meters
Offset forward/backward - -0.02 meters
Offset left/right - 0.00 meters

7. Output folder:
E:\TUTORIAL\FLIGHT 1\Output

Processing steps:
1. ☒ Data conversion
2. ☒ GNSS data postprocessing
3. ☒ Images matching and geotagging

Start **Stop**

Logs:
[Open log file](#)
26.11.2019 13:50:16: Read metadata from photos...
26.11.2019 13:50:26: Done!
26.11.2019 13:50:26: Found 397 photos

NOTICE.

FOR DJI MAVIC 2 PRO PPK use the following parameters

Height: 0.07

Offset forward/backward: -0.02

FOR DJI PHANTOM 4 PRO PPK use the following parameters

Height: 0.17

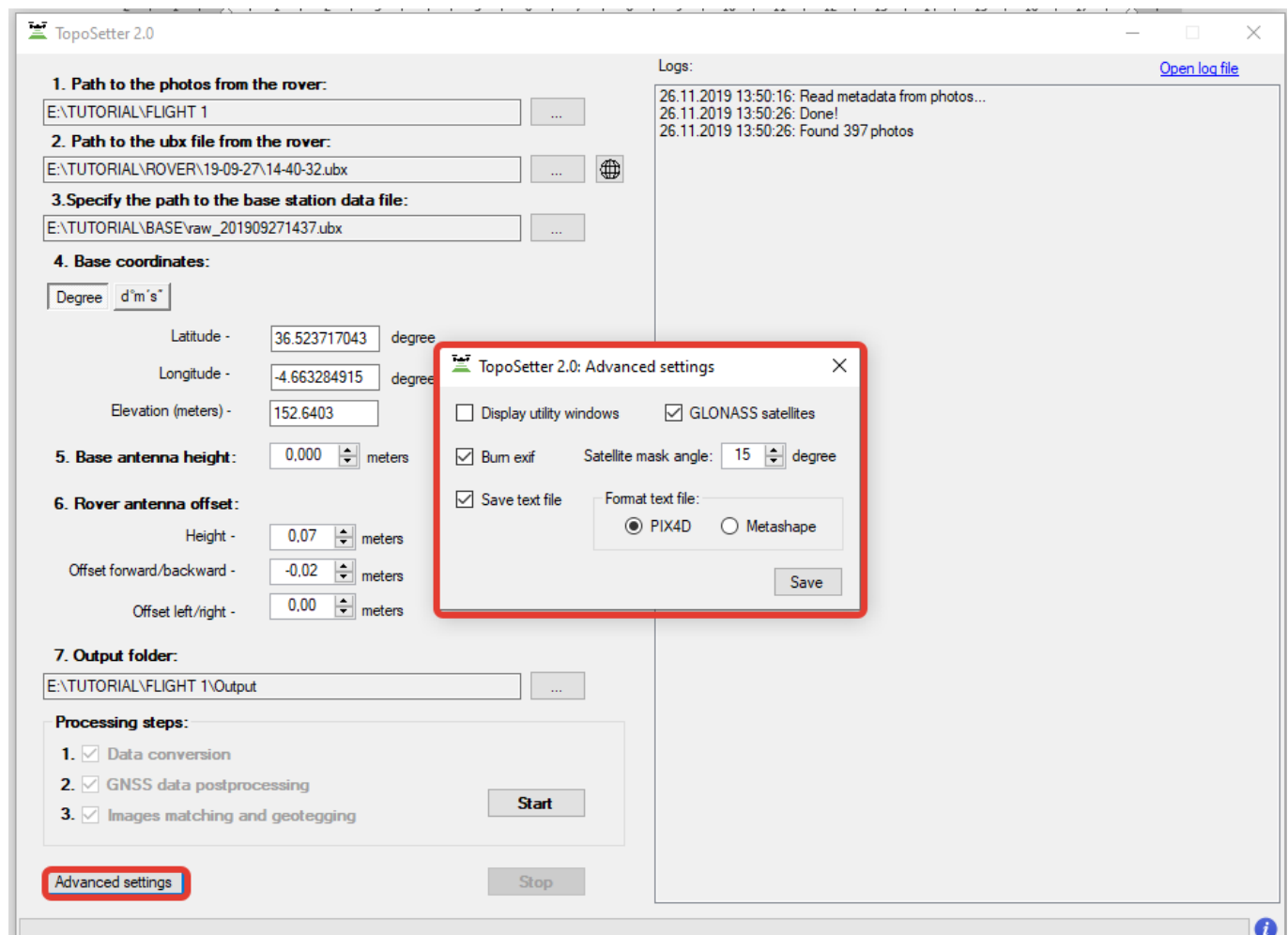
Step 6. Setup data processing setting. Click advanced setting. Advanced setting will appear.

To embed precise coordinates to photos EXIF tags check Burn exif check box. This option may lead increasing of data processing time.

To save list of coordinates check Save text file check box.

Select format of text file Pix4D or Metashape

Click Save button.



NOTICE. To look at data processing performing switch on Display utility window option.

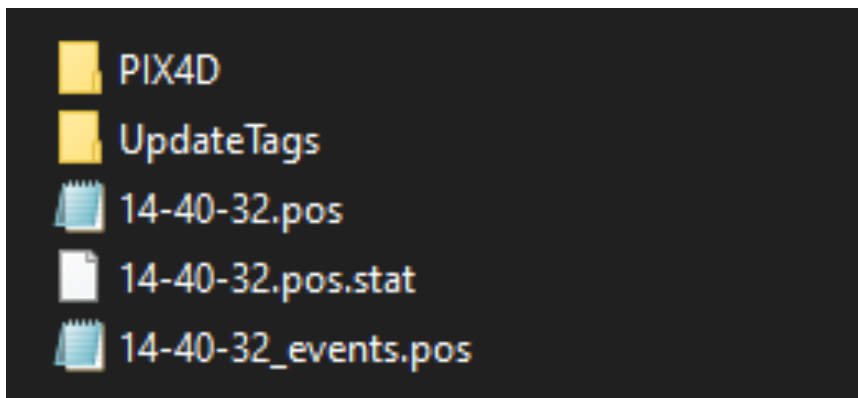
Click Start button

After finishing of all steps of data processing (data conversion, GNSS data post processing, images matching and geotagging) all results will be stored in Output folder.

File Coordinates.txt is stored in PIX4D or Metashape folder

Photos with updated EXIF tags are stored in UpdateTags folder

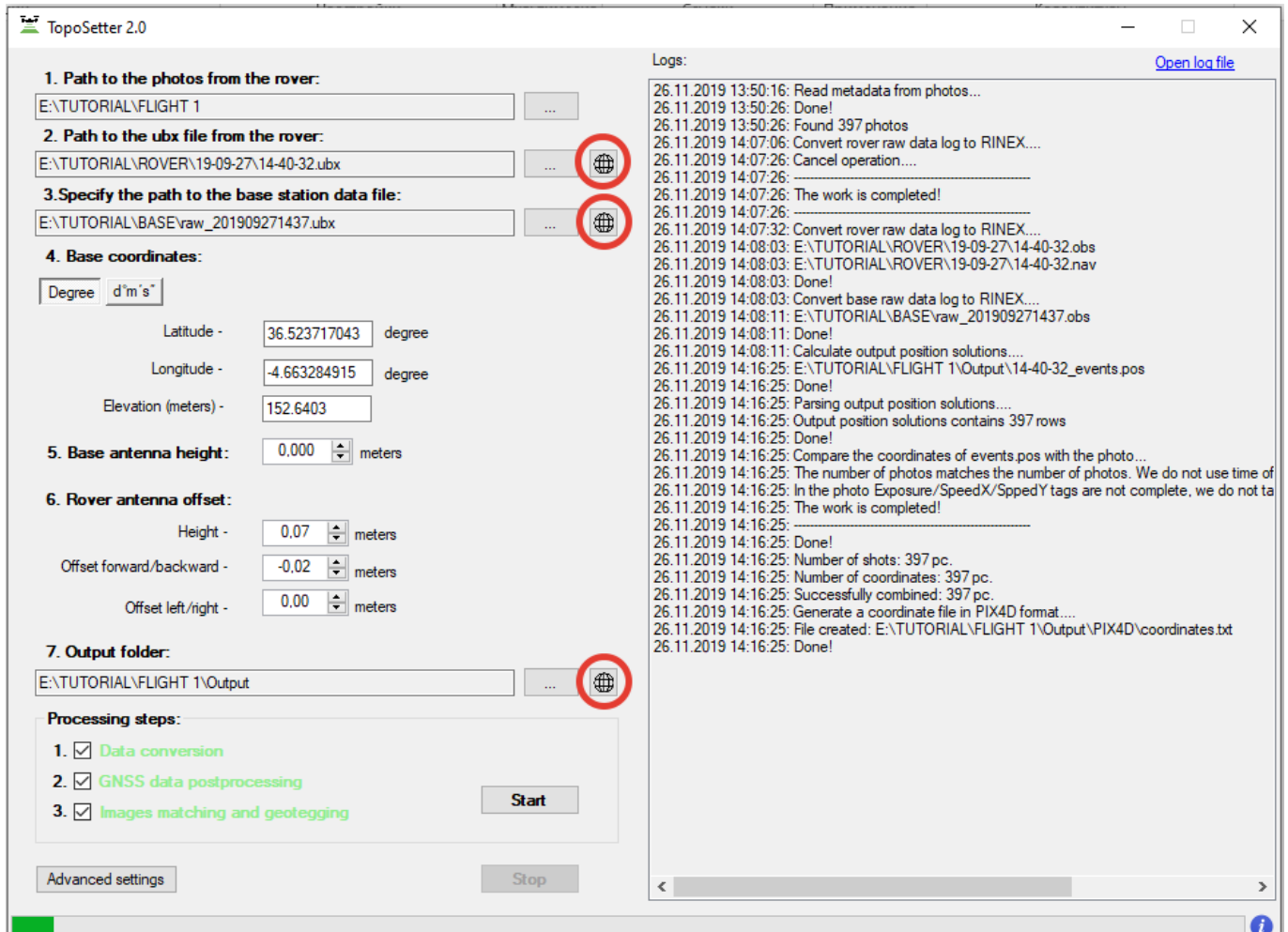
Files with .pos extension are results of GNSS data postprocessing




NOTICE. *Coordinate system is WGS84.*


Step 7. Checking processing results.

After processing accomplishing, the following buttons will appear.



NOTICE.

Click  buttons in front of Rover or Base fields to open GNSS observation files to check the quality of GNSS signal.

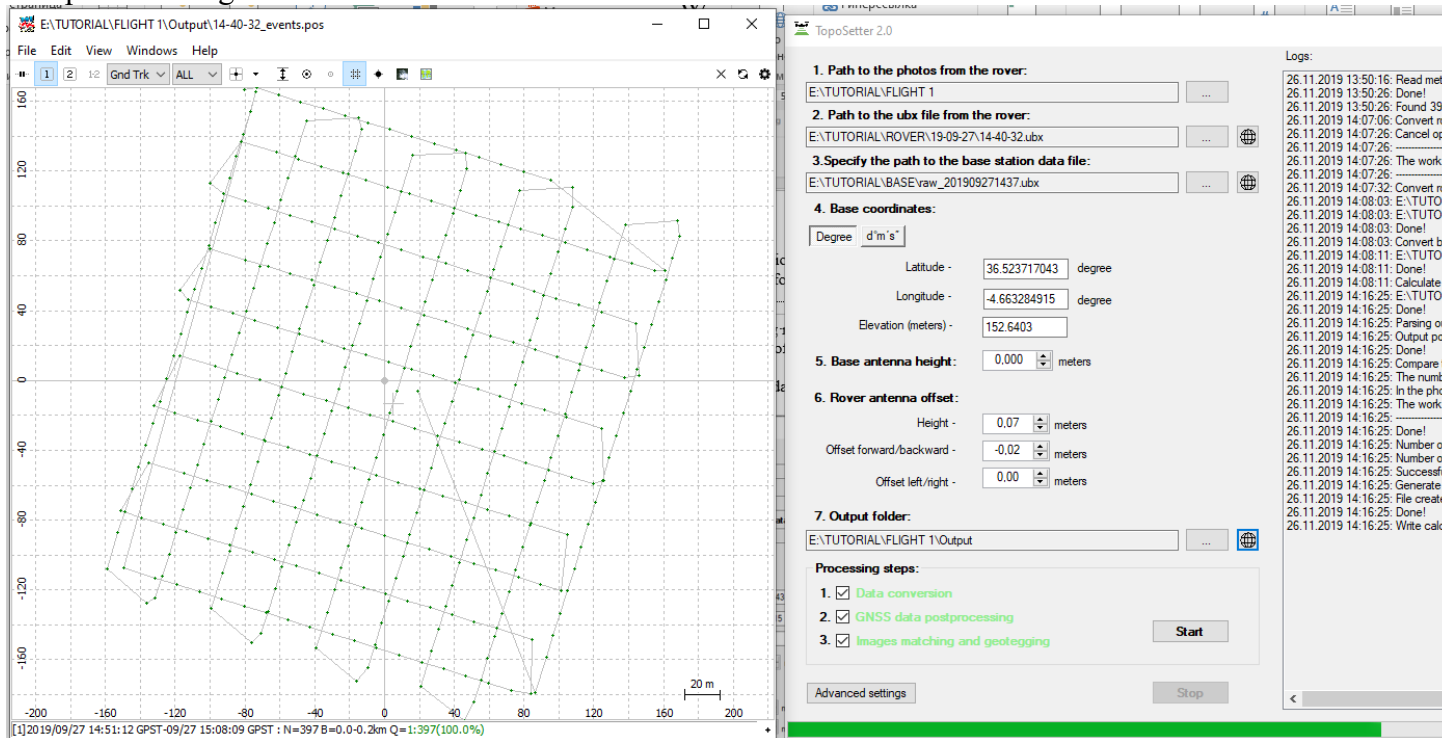
To check quality of GNSS data postprocessing click  button in front of output results.

On the map you can see results of GNSS data postprocessing.

Green points of photos events – Fixed solution

Yellow points – Float solution

Red points – Single solution



NOTICE.

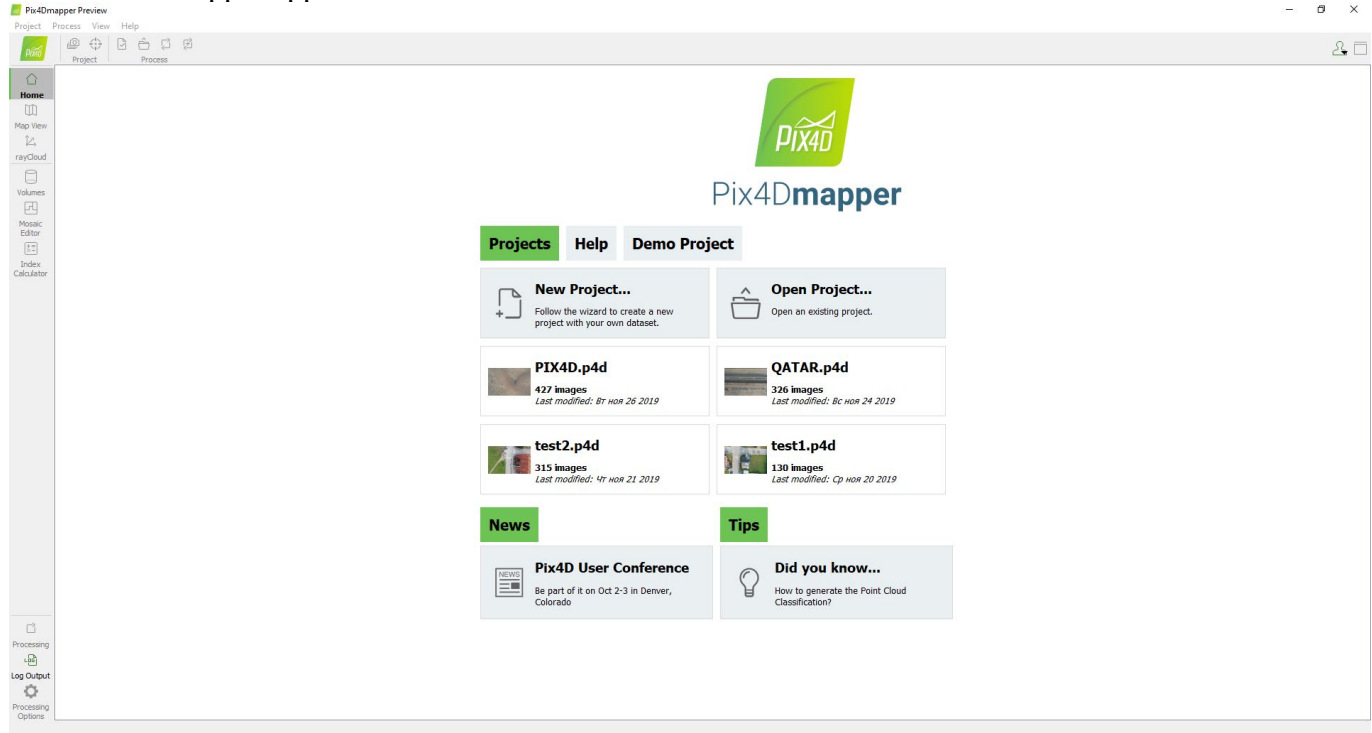
If there are only red points on the map it means, that GNSS data from a drone and a base station were not collected at the same time.

If there are only yellow points (float solution) you should check coordinates of a base station or quality of the signal. To remove noisy GNSS signal try to increase satellite mask angle or exclude GLONASS satellite in Advanced setting menu.

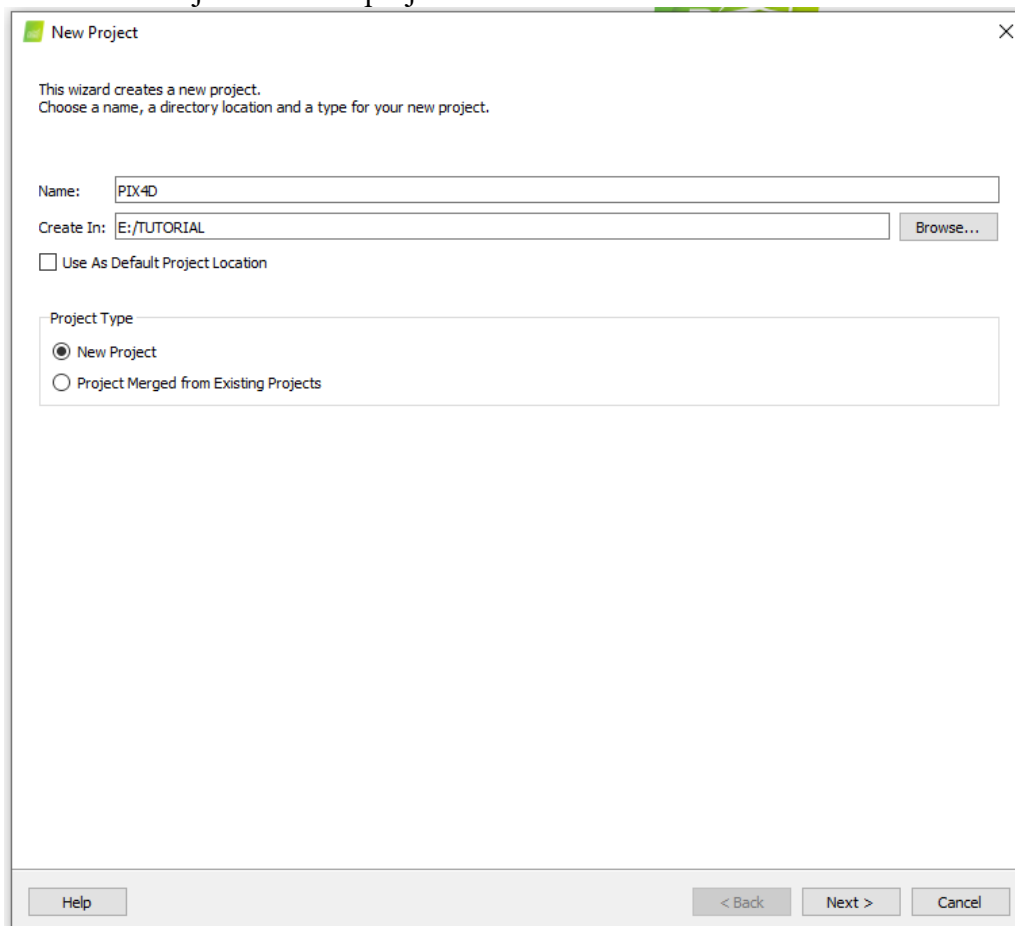
3. PHOTOGRAMMETRY PROCESSING IN PIX4D MAPPER SOFTWARE

3.1 Creating pix4d mapper project

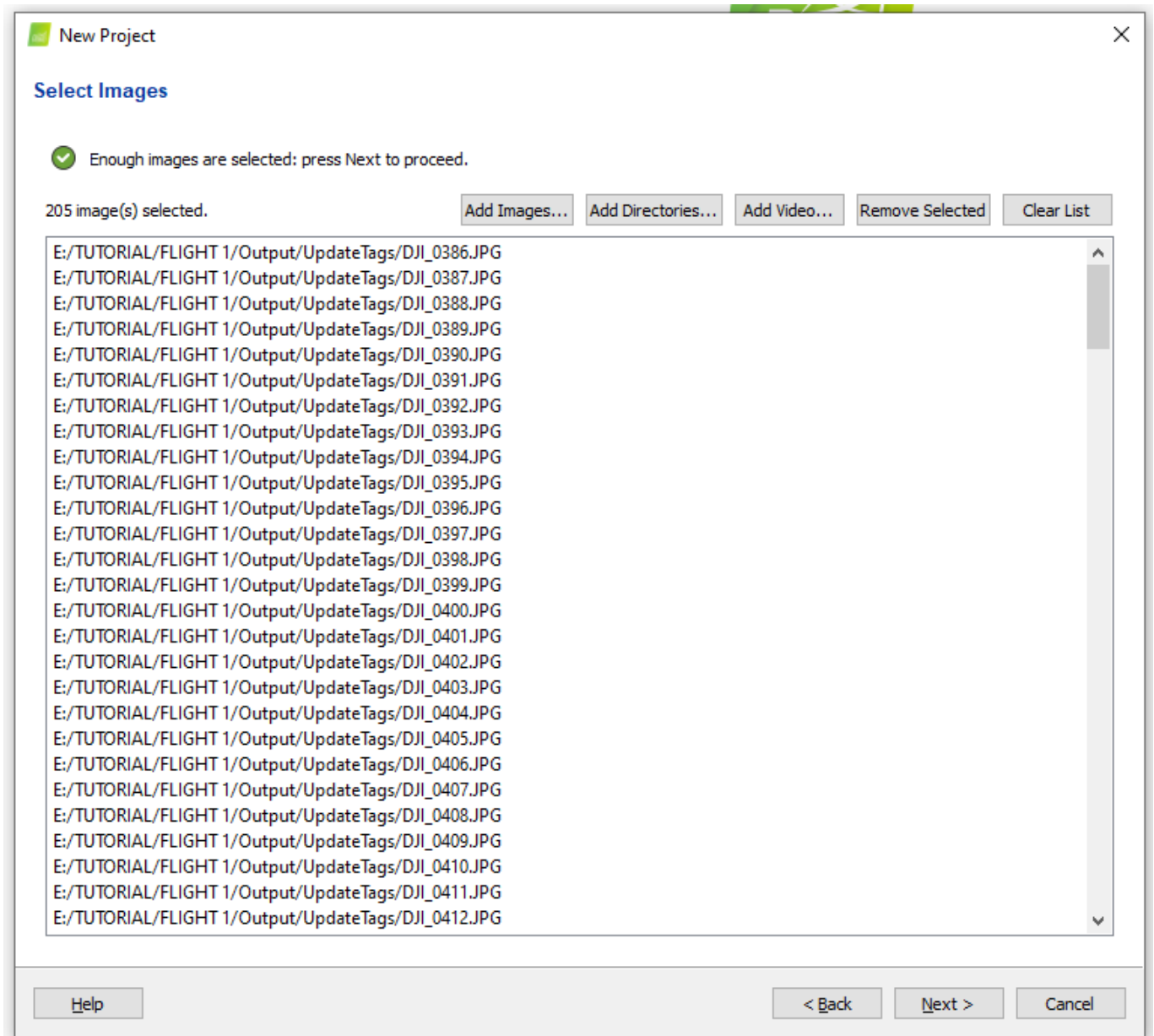
Run PIX4D mapper application.



Click New Project. Select a project folder location. Click next



Select images to be processed from output\UpdateTags folder. Click next




Software will read precise coordinates of images and accuracy setting automatically. Click Next.

New Project

Image Properties

Image Geolocation

Coordinate System

☒  Datum: World Geodetic System 1984; Coordinate System: WGS 84

Edit...

Geolocation and Orientation

☒ Geolocated Images: 203 out of 203

Clear


From EXIF

From File...

To File...

Geolocation Accuracy: ☐ Standard ☐ Low ☒ Custom

Selected Camera Model

☒  L1D-20c_10.3_5472x3648 (0K8TG740120251) (RGB)

Edit...

Enabled	Image	Group	Latitude [degree]	Longitude [degree]	Altitude [m]	Accuracy Horz [m]	Accuracy Vert [m]
<input checked="" type="checkbox"/>	DJI_0389.JPG	group1	36.52239990	-4.66220570	221.339	0.003	0.006
<input checked="" type="checkbox"/>	DJI_0390.JPG	group1	36.52251434	-4.66216040	221.160	0.003	0.006
<input checked="" type="checkbox"/>	DJI_0391.JPG	group1	36.52263260	-4.66211557	221.198	0.003	0.006
<input checked="" type="checkbox"/>	DJI_0392.JPG	group1	36.52274323	-4.66207075	221.162	0.003	0.006
<input checked="" type="checkbox"/>	DJI_0393.JPG	group1	36.52285767	-4.66202545	221.005	0.003	0.006
<input checked="" type="checkbox"/>	DJI_0394.JPG	group1	36.52297211	-4.66197968	220.971	0.003	0.006
<input checked="" type="checkbox"/>	DJI_0395.JPG	group1	36.52308655	-4.66193438	220.926	0.003	0.006
<input checked="" type="checkbox"/>	DJI_0396.JPG	group1	36.52320099	-4.66189003	220.824	0.003	0.006

Help

< Back

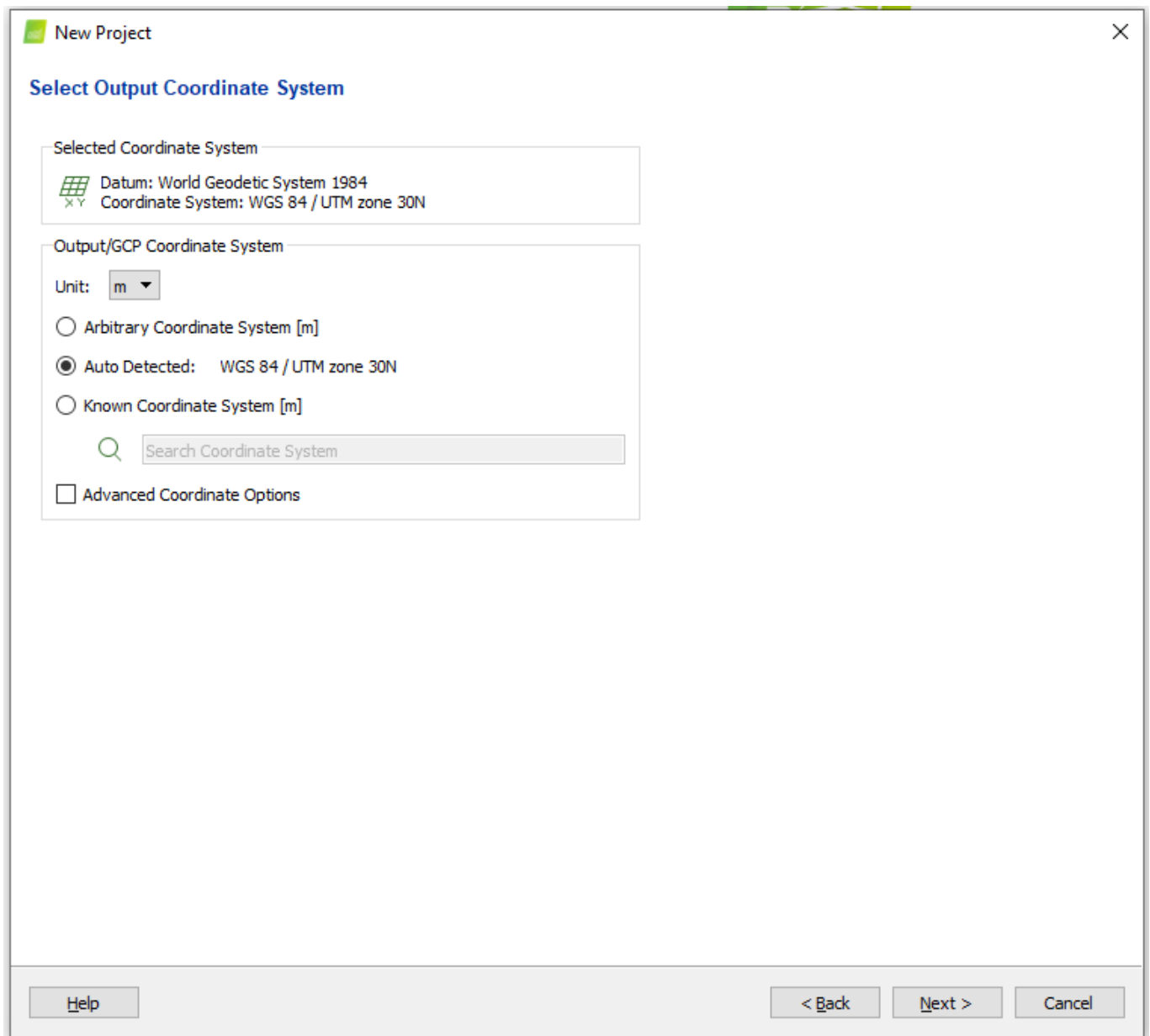
Next >

Cancel

NOTICE. It is possible to upload coordinates from txt file. Click From File button and select coordinates.txt file

It is recommended to check camera settings. Click Edit button and check if Linear rolling shutter camera model is enabled in case if DJI MAVIC 2 PRO was used for survey.

Select output coordinate system and click Next.



The screenshot shows a software window titled "New Project" with a close button (X) in the top right corner. The main heading is "Select Output Coordinate System".

Under "Selected Coordinate System", there is a grid icon and the text: "Datum: World Geodetic System 1984" and "Coordinate System: WGS 84 / UTM zone 30N".

Under "Output/GCP Coordinate System", there is a "Unit:" dropdown menu set to "m". Below it are three radio button options: "Arbitrary Coordinate System [m]", "Auto Detected: WGS 84 / UTM zone 30N" (which is selected), and "Known Coordinate System [m]".

Below the radio buttons is a search icon and a text input field labeled "Search Coordinate System".

At the bottom left of the main area is a checkbox labeled "Advanced Coordinate Options", which is currently unchecked.

The bottom of the window contains three buttons: "Help", "< Back", and "Next >", followed by a "Cancel" button.

Select type of data processing options. Click Finish.

New Project

Processing Options Template

Standard

3D Maps

3D Models

Ag Multispectral

Rapid

3D Maps - Rapid/Low Res

3D Models - Rapid/Low Res

Ag Modified Camera - Rapid/Low Res

Ag RGB - Rapid/Low Res

Advanced

Ag Modified Camera

Ag RGB

Thermal Camera

ThermoMAP Camera

3D Models

Generate a 3D Model from any set of overlapping images.

Image Acquisition

oblique flight terrestrial

Outputs Quality/Reliability

Low High

Processing Speed

Slow Fast

Input Image Recommendations

Any images with a high amount of overlap such as images taken from the ground or oblique aerial images (free flight).

Outputs Generated

3D Mesh

Point Cloud

Start Processing Now

Help

< Back

Finish

Cancel

3.2 Initial aerial triangulation

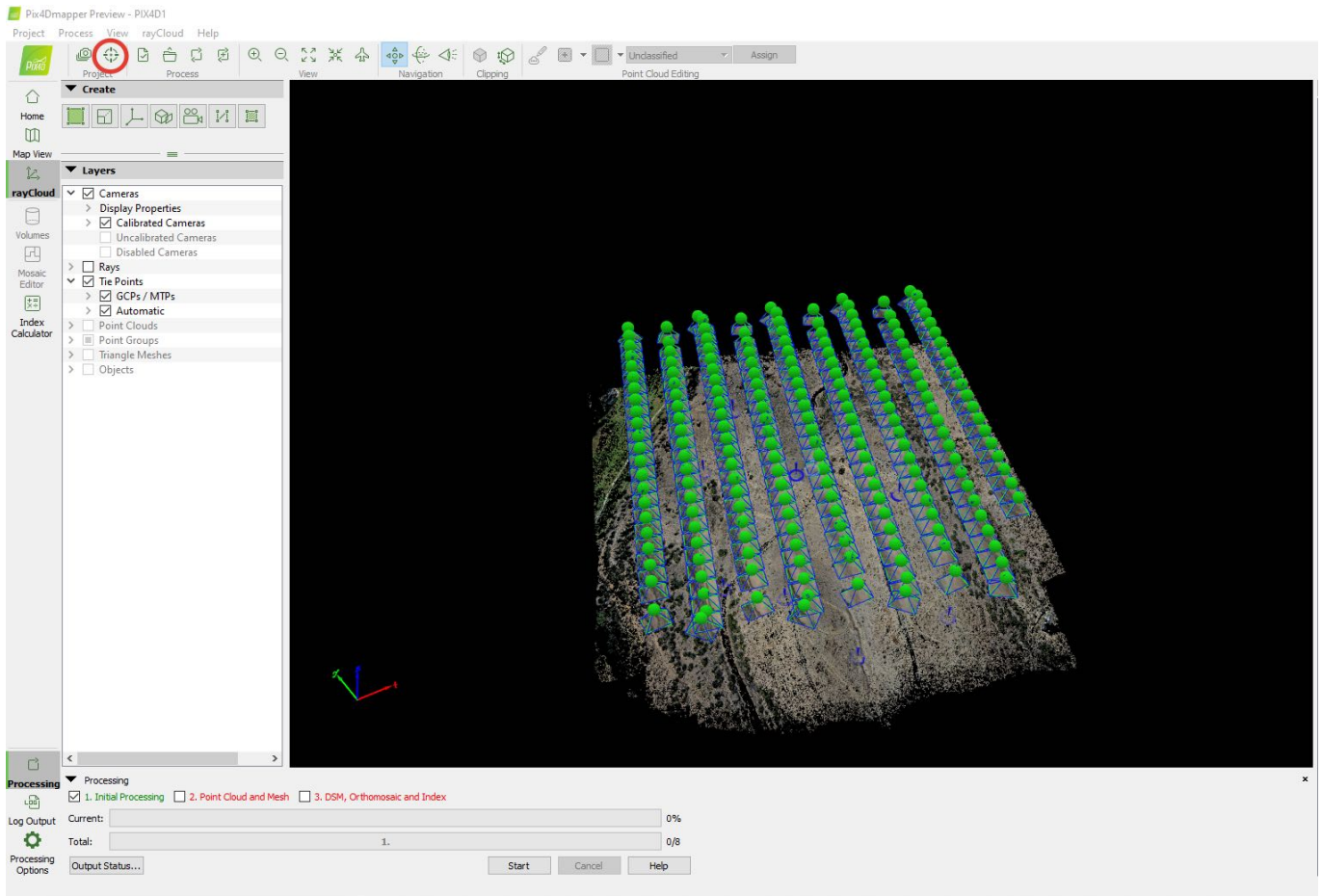
As soon as images with precise coordinates were loaded to the project, we can start initial aerial triangulation. Select initial processing checkbox and start processing.



3.3. Camera calibration

In order to calibrate focal length of the camera you need at list one GCP.

Click GCP/MTP button.



Select coordinate system of ground control points and import GCPs. Click OK.

GCP/MTP Manager

GCP Coordinate System
 Datum: World Geodetic System 1984; Coordinate System: WGS 84 Edit...

GCP/MTP Table

	Label	Type	Latitude [degree]	Longitude [degree]	Altitude [m]	Accuracy Horz [m]	Accuracy Vert [m]
0	Base	3D GCP	36.52371704	-4.66328492	152.506	0.020	0.020
14	Point 1	3D GCP	36.52372766	-4.66311001	148.133	0.020	0.020
0	Point 2	3D GCP	36.52377147	-4.66264965	153.482	0.020	0.020
0	Point 3	3D GCP	36.52340747	-4.66240828	153.772	0.020	0.020
0	Point 4	3D GCP	36.52320690	-4.66257781	149.481	0.020	0.020
0	Point 5	3D GCP	36.52224430	-4.66288253	138.133	0.020	0.020

1/12 GCPs with enough image marks Import Marks... Export Marks...

GCP/MTP Editor

In order to compute the 3D position of a GCP/MTP, it needs to be marked on at least two images.
 In order to take GCPs into account for georeferencing the project, at least 3 GCPs need to be marked.
 Marking GCPs/MTPs after step 1. Initial Processing requires the user to run Process > Reoptimize.
 The GCPs/MTP accuracy can be verified in the Quality Report or in the rayCloud Editor.

(Recommended) Use the rayCloud Editor after step 1. Initial Processing is done. This allows a fast and precise point marking.

rayCloud Editor... Basic Editor...

Use the Basic Editor either
 1) before running step 1. Initial Processing, or
 2) when using non-geolocated images, or
 3) when using an arbitrary coordinate system.

OK Cancel Help

Change GCPs type to Check point.

GCP/MTP Manager

GCP Coordinate System
 Datum: World Geodetic System 1984; Coordinate System: WGS 84 Edit...

GCP/MTP Table

	Label	Type	Latitude [degree]	Longitude [degree]	Altitude [m]	Accuracy Horz [m]	Accuracy Vert [m]
0	Base	Check Point	36.52371704	-4.66328492	152.506		
14	Point 1	Check Point	36.52372766	-4.66311001	148.133		
0	Point 2	Check Point	36.52377147	-4.66264965	153.482		
0	Point 3	Check Point	36.52340747	-4.66240828	153.772		
0	Point 4	Check Point	36.52320690	-4.66257781	149.481		
0	Point 5	Check Point	36.52224430	-4.66288253	138.133		

Import Marks... Export Marks...

GCP/MTP Editor

In order to compute the 3D position of a GCP/MTP, it needs to be marked on at least two images.
 In order to take GCPs into account for georeferencing the project, at least 3 GCPs need to be marked.
 Marking GCPs/MTPs after step 1. Initial Processing requires the user to run Process > Reoptimize.
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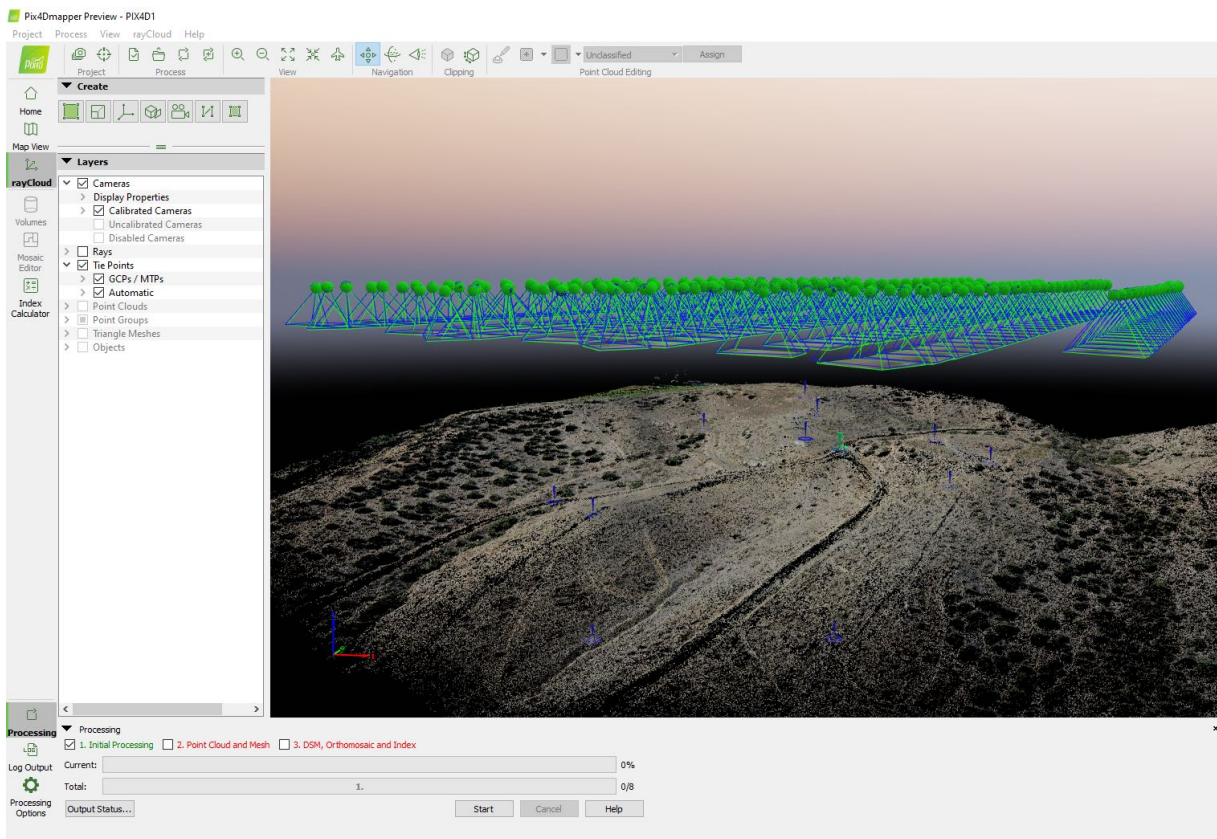
(Recommended) Use the rayCloud Editor after step 1. Initial Processing is done. This allows a fast and precise point marking.

rayCloud Editor... Basic Editor...

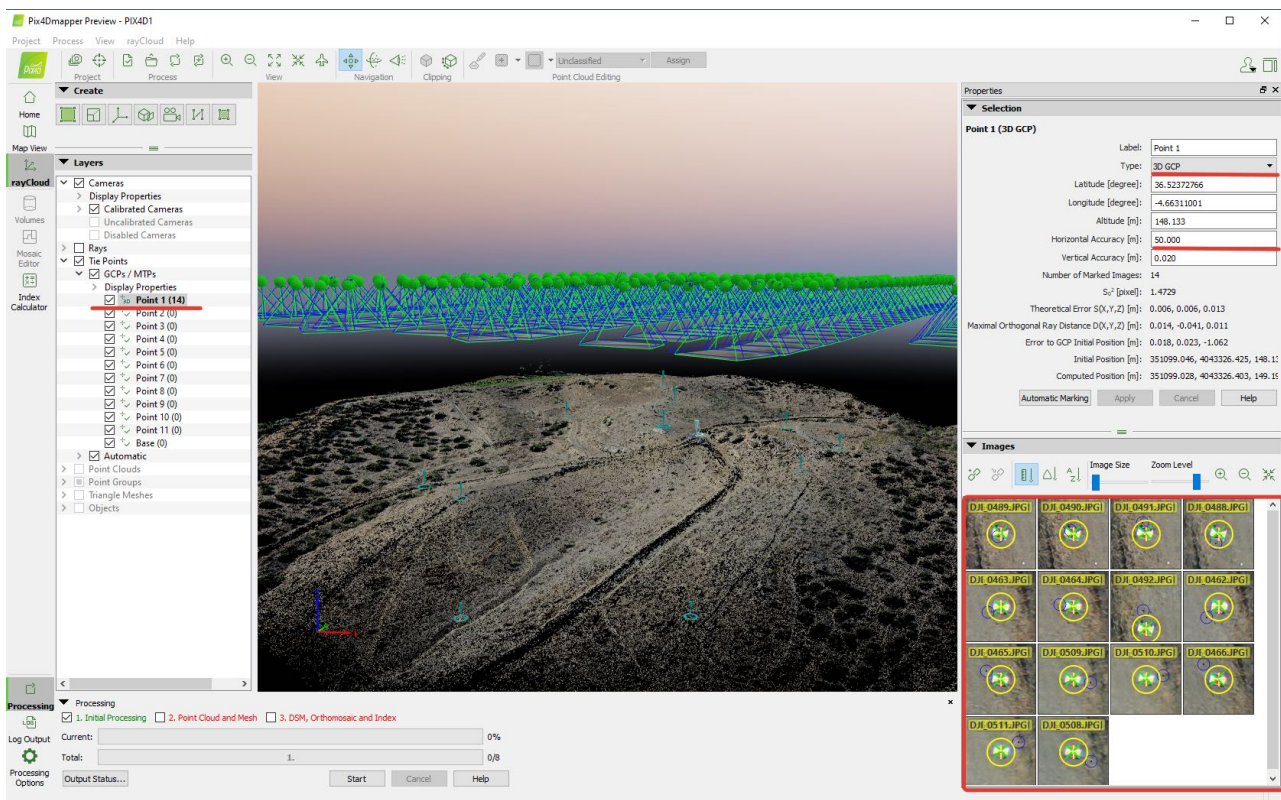
Use the Basic Editor either
 1) before running step 1. Initial Processing, or
 2) when using non-geolocated images, or
 3) when using an arbitrary coordinate system.

OK Cancel Help

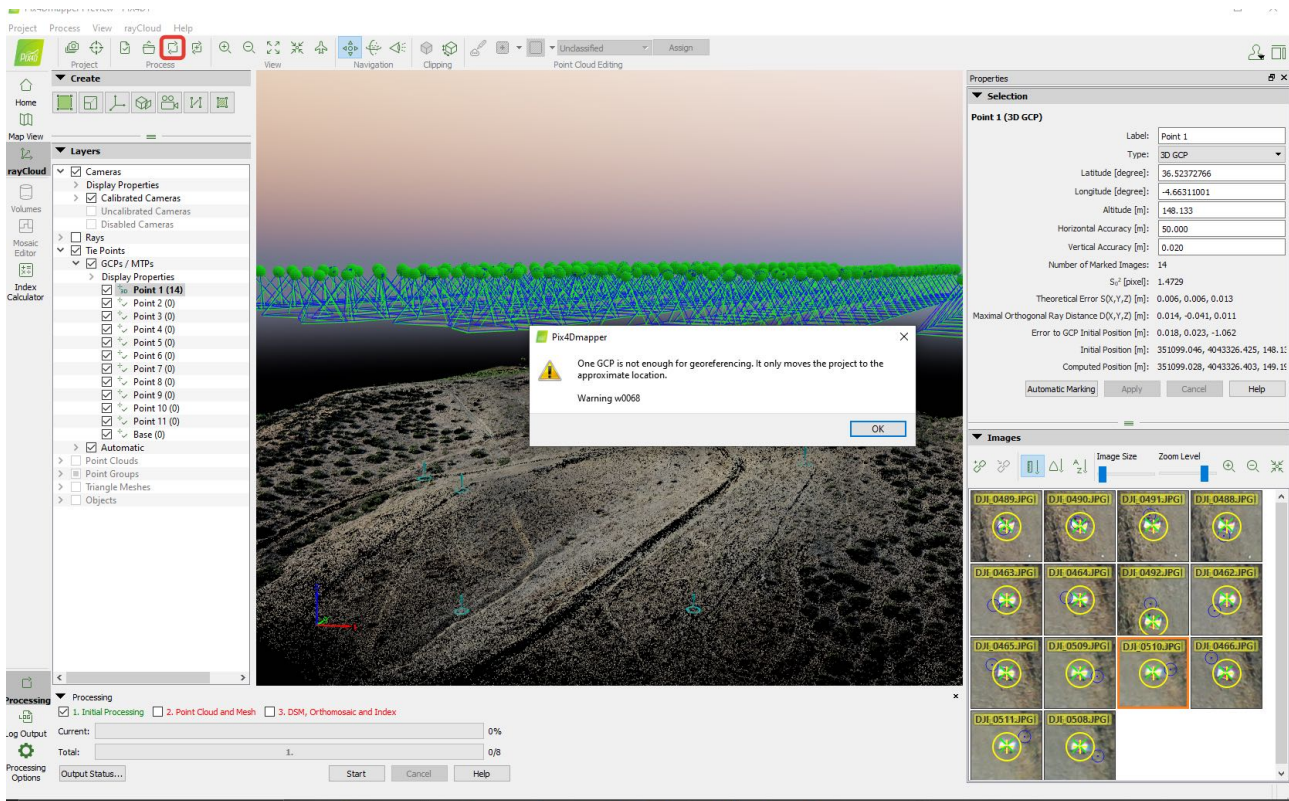
All GCPs will be shown on the map.



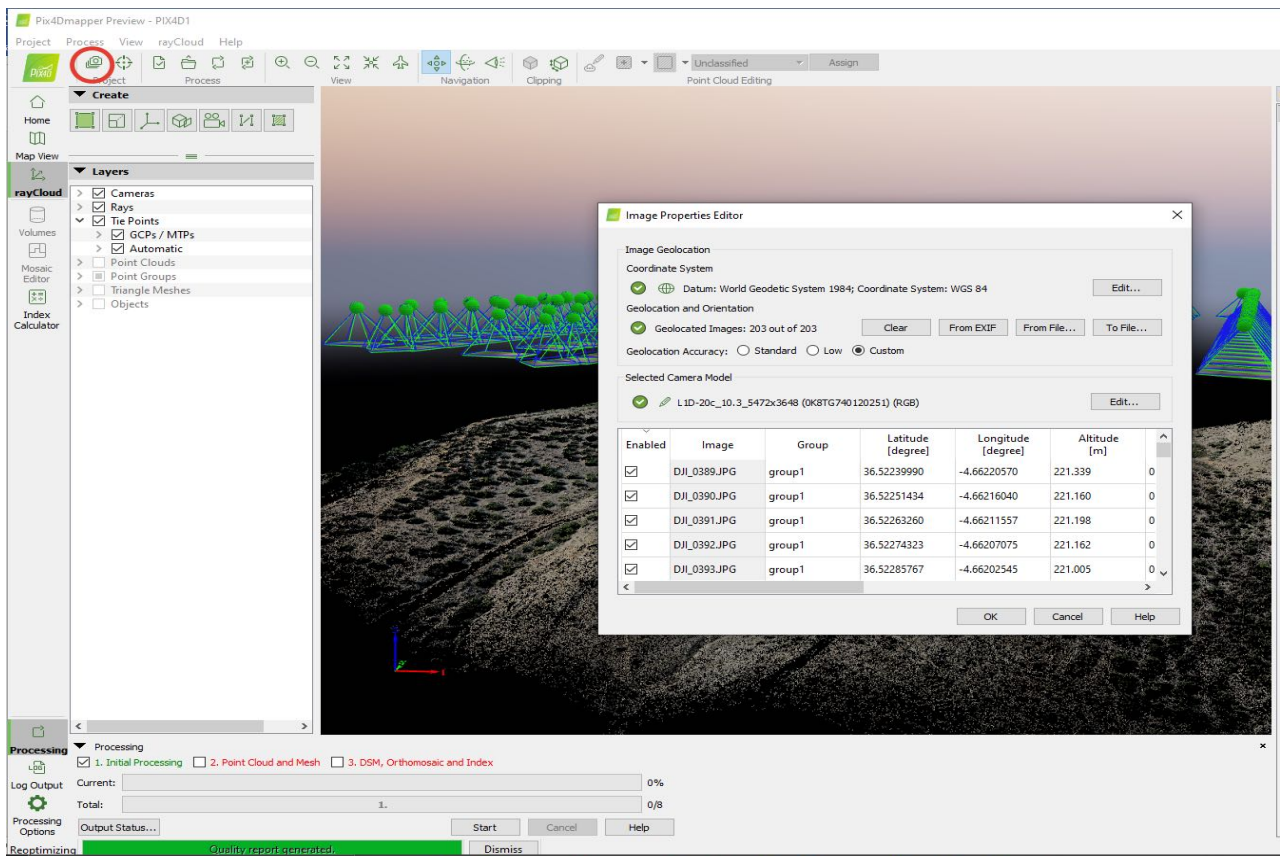
Select one GCP, define position of ground control point at each image, change type of GCP to 3D and setup horizontal accuracy to 50 meters.



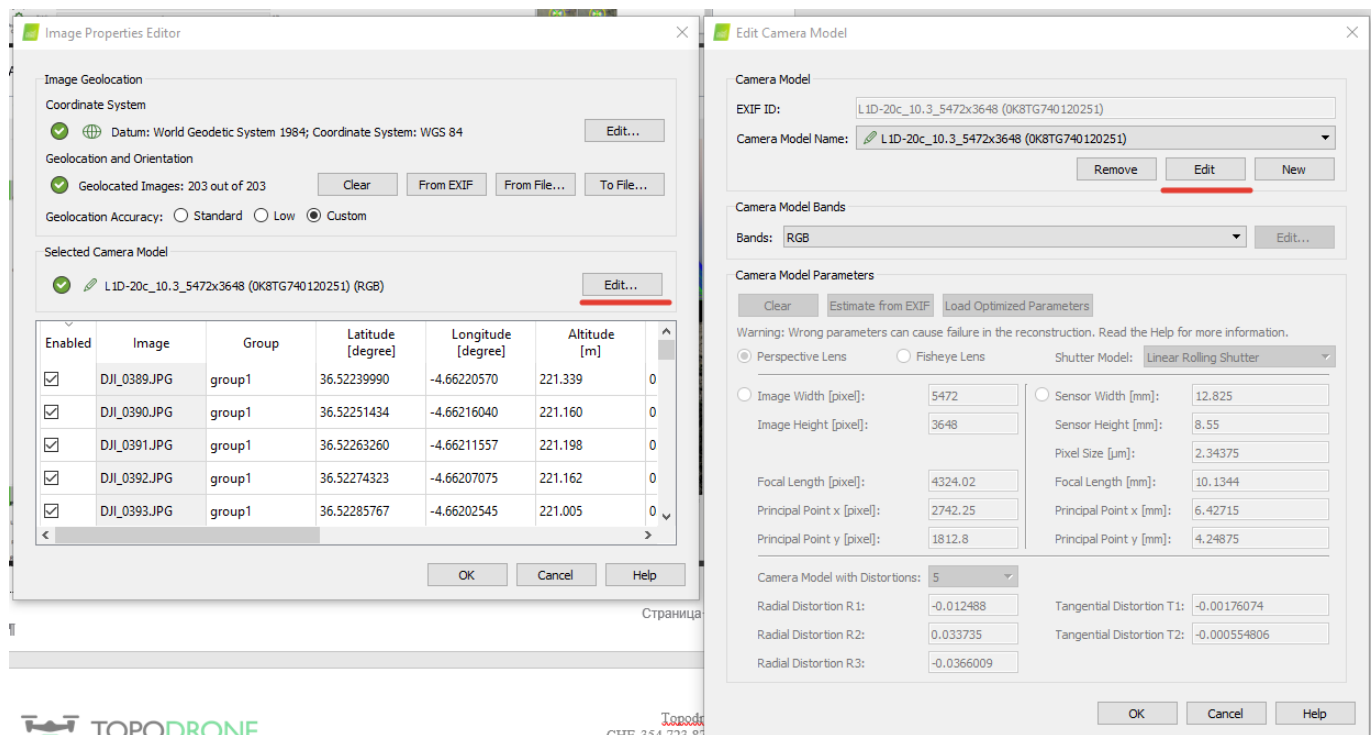
Click Reoptimize button. Click Ok on warning messages.



After finishing of reoptimizing process click Image property editor button.



Click Edit camera model buttons in Image Properties Editor window and in Edit Camera Model window



Click Load Optimiezed parameters. Copy Focal Length value for future work.

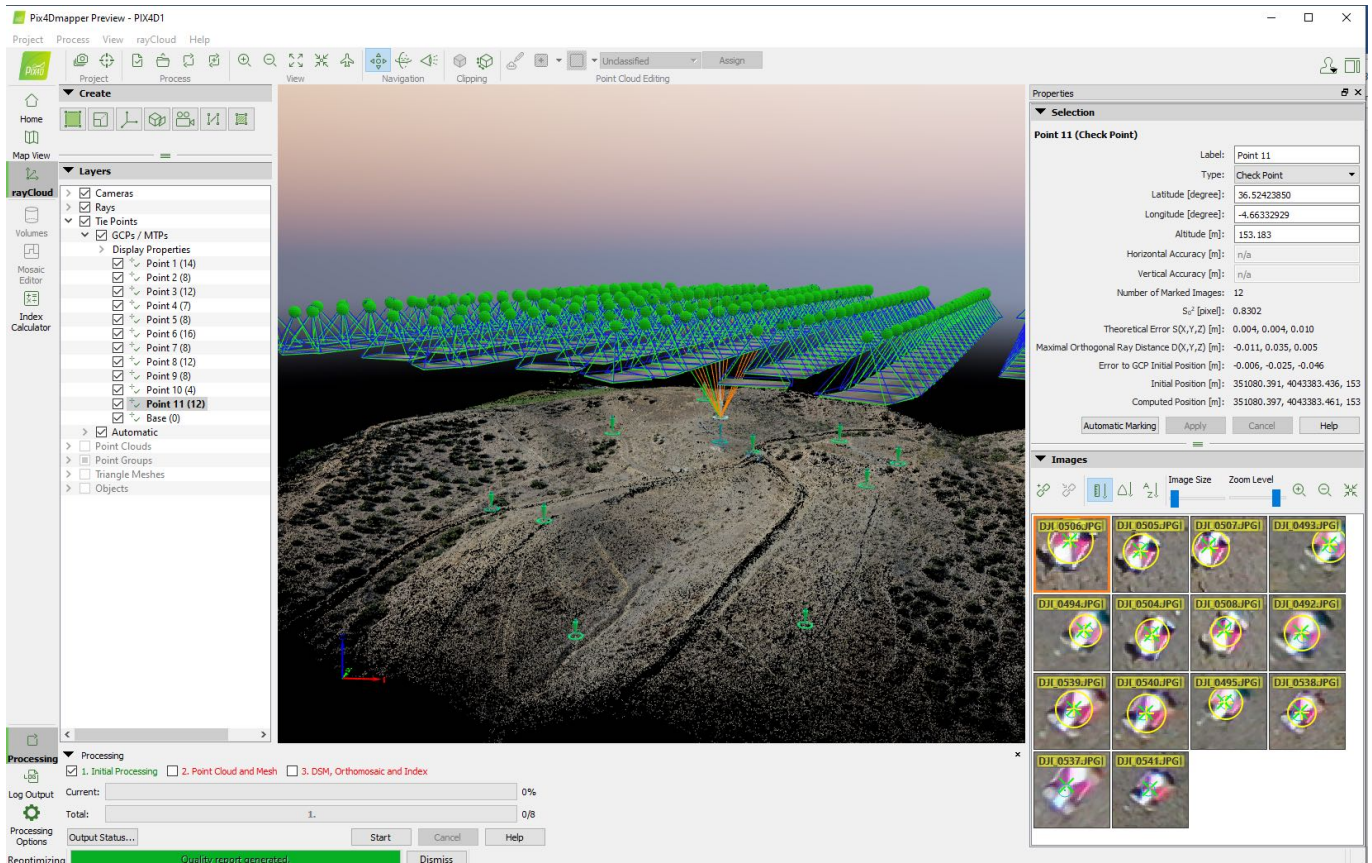
NOTICE. It is possible to use the calibrated value of focal length for the processing If you don't change focus settings for future flights.

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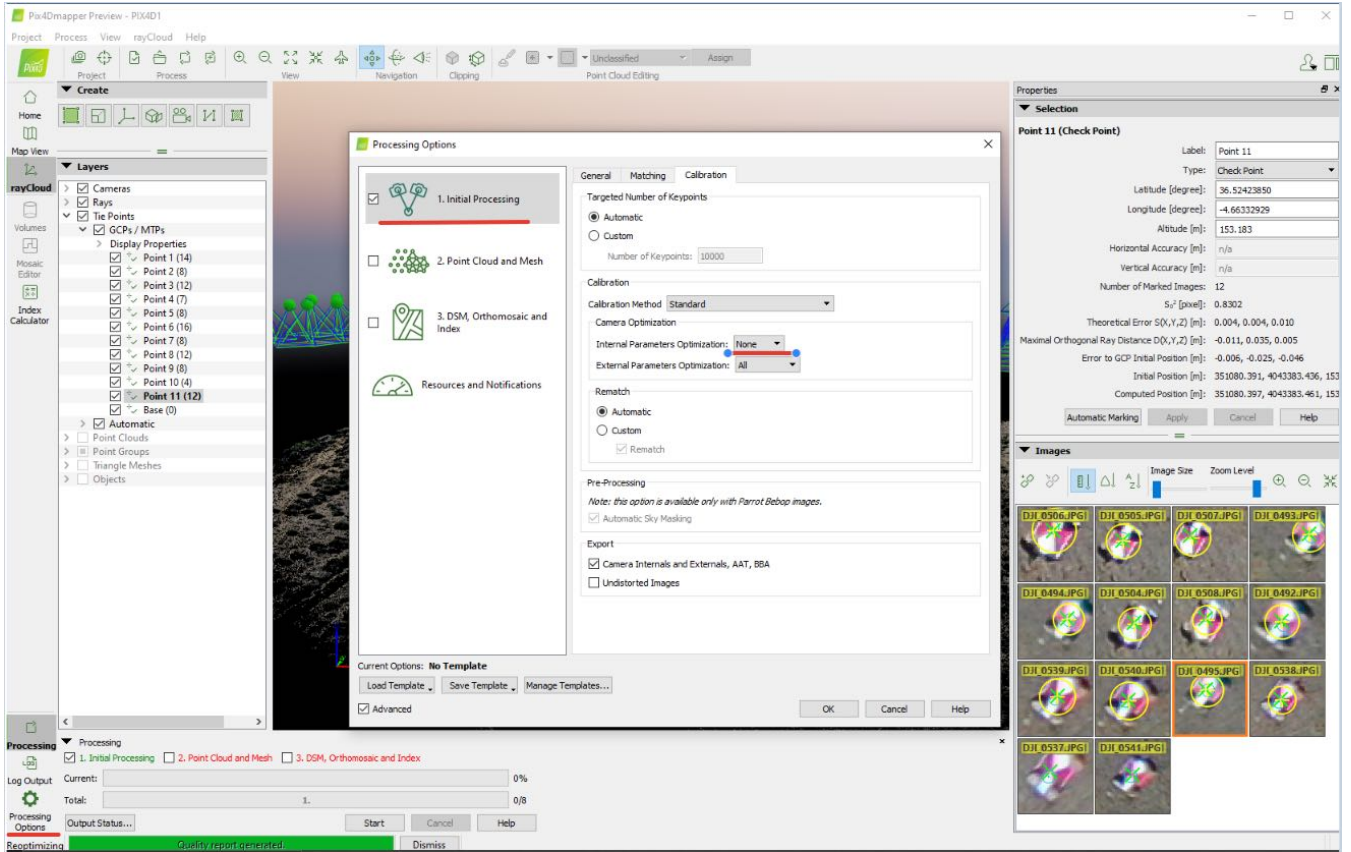
3.4 Accuracy estimating

Load ground control points. Set up as check points.

Select position of all check points at images to check accuracy.



Go to Processing option. Select None for Internal Parameters Optimization. Click Ok.
Click Reoptimize.



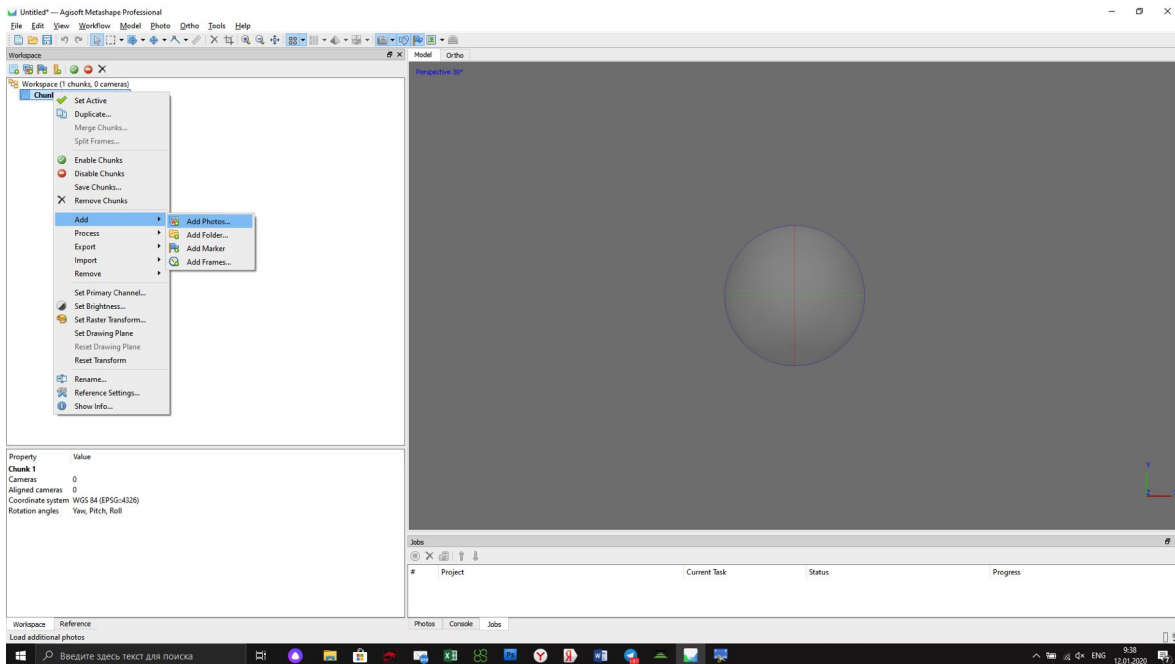
Data processing report will be generated. Go to Geolocation Details to estimate accuracy of the project.

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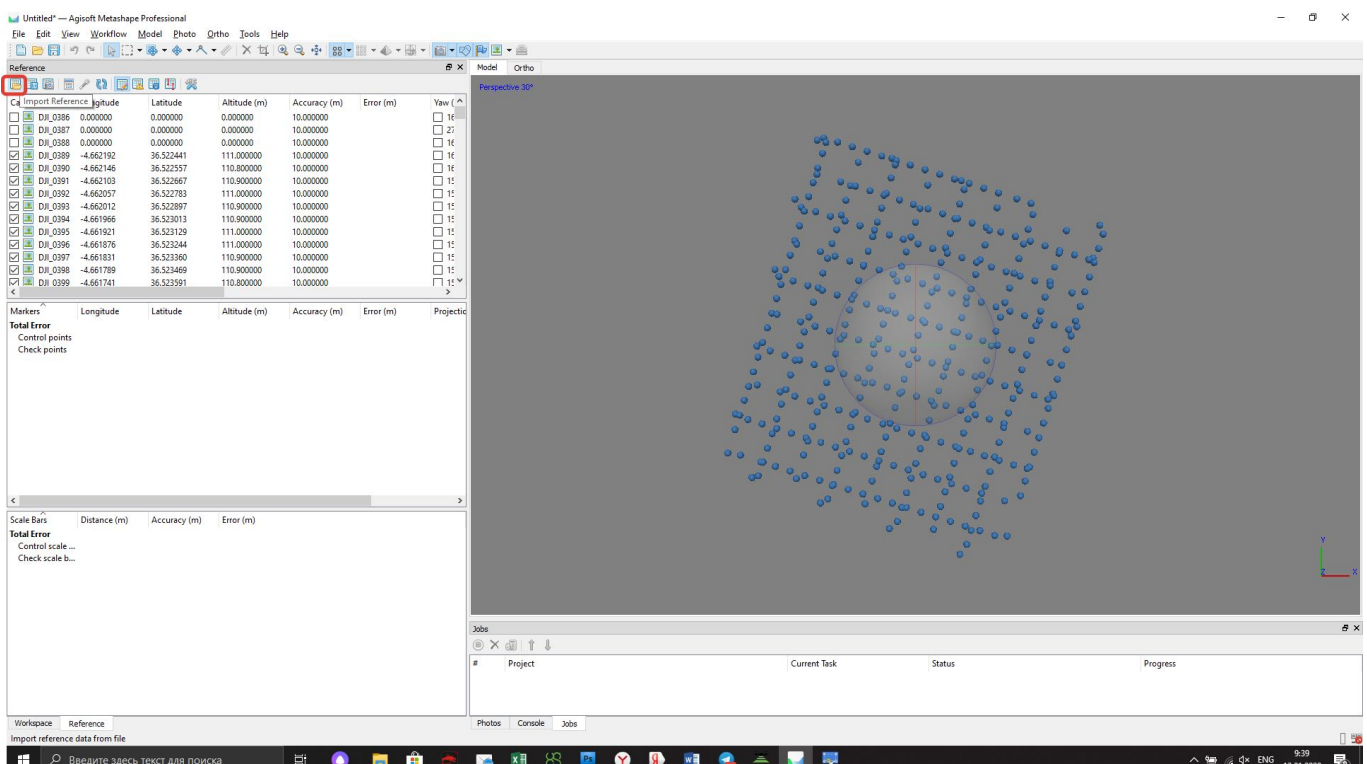
4. PHOTOGRAMMETRY PROCESSING IN AGISOFT METASHAPE SOFTWARE

4.1 Creating project, photos alignment

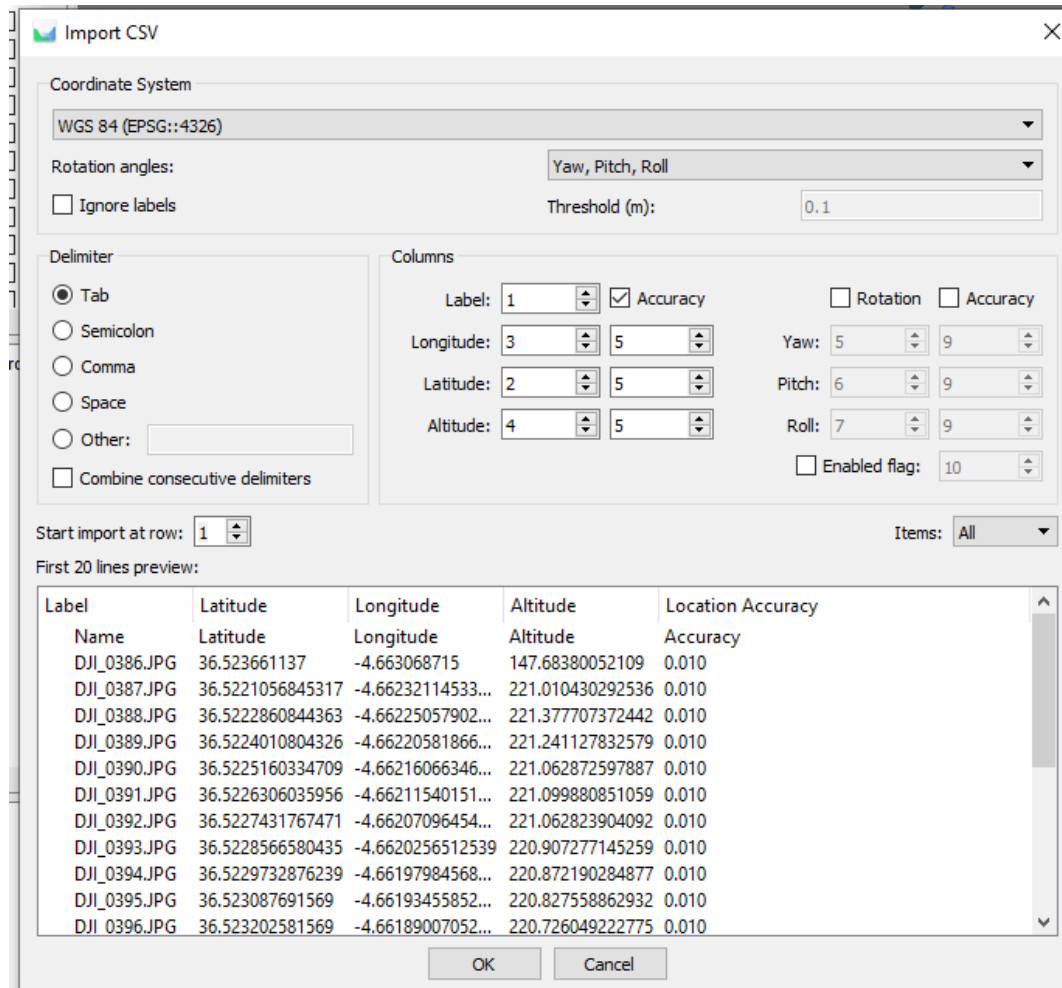
The following process should be performed in Agisoft Metashape. Add photos to the project



Import positions from file coordinates.txt. Go to Reference. Click Import button, select coordinates.txt file from folder with photos



Select WGS 84 coordinate system, setup columns order 1,3,2,4, click Accuracy checkbox, select field 5, click OK



Import CSV

Coordinate System: **WGS 84 (EPSG::4326)**

Rotation angles: **Yaw, Pitch, Roll**

☐ Ignore labels

Threshold (m): **0.1**

Delimiter: **Tab**

Columns:

Label	1	3	2	4	5	6	7	8	9	10
Longitude										
Latitude										
Altitude										

☒ Accuracy

☐ Rotation ☐ Accuracy

Yaw: 5 9

Pitch: 6 9

Roll: 7 9

☐ Enabled flag: 10

Start import at row: **1**

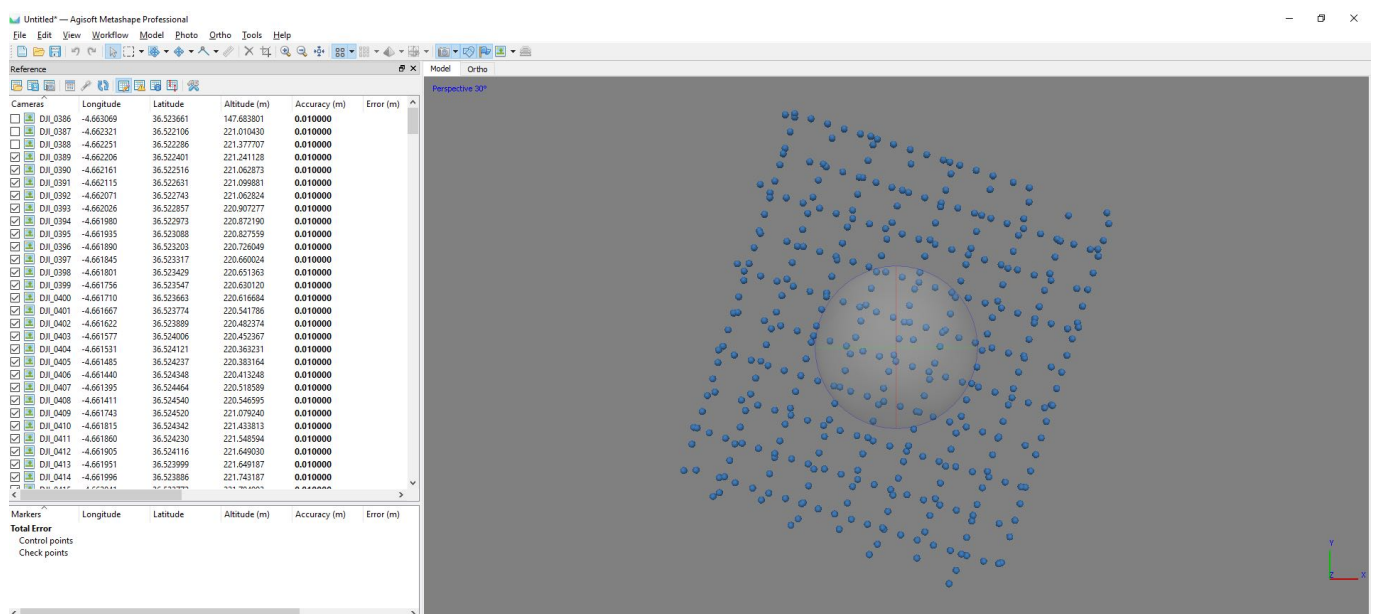
Items: **All**

First 20 lines preview:

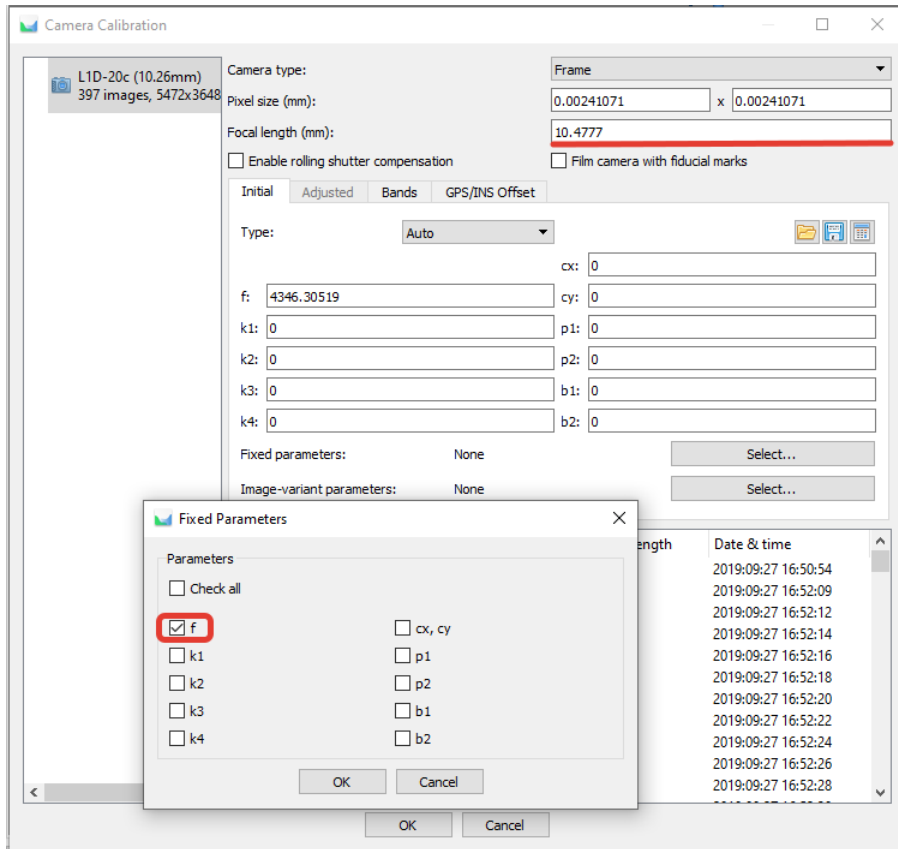
Label	Latitude	Longitude	Altitude	Location Accuracy
DJI_0386.JPG	36.523661137	-4.663068715	147.68380052109	0.010
DJI_0387.JPG	36.5221056845317	-4.66232114533...	221.010430292536	0.010
DJI_0388.JPG	36.5222860844363	-4.66225057902...	221.377707372442	0.010
DJI_0389.JPG	36.5224010804326	-4.66220581866...	221.241127832579	0.010
DJI_0390.JPG	36.5225160334709	-4.66216066346...	221.062872597887	0.010
DJI_0391.JPG	36.5226306035956	-4.66211540151...	221.099880851059	0.010
DJI_0392.JPG	36.5227431767471	-4.66207096454...	221.062823904092	0.010
DJI_0393.JPG	36.5228566580435	-4.6620256512539	220.907277145259	0.010
DJI_0394.JPG	36.5229732876239	-4.66197984568...	220.872190284877	0.010
DJI_0395.JPG	36.523087691569	-4.66193455852...	220.827558862932	0.010
DJI_0396.JPG	36.523202581569	-4.66189007052...	220.726049222775	0.010

OK Cancel

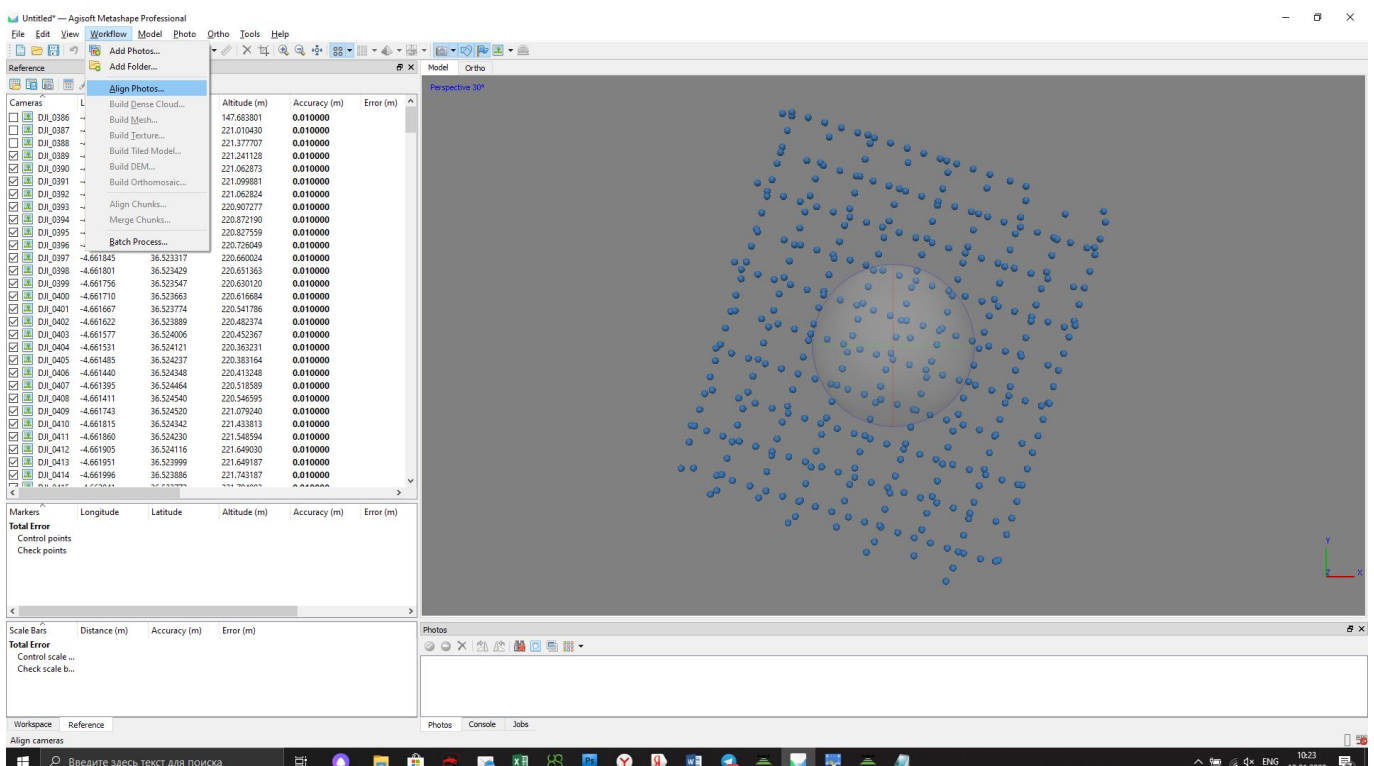
Accurate X,Y,Z coordinates and accuracy values will appear in Reference window



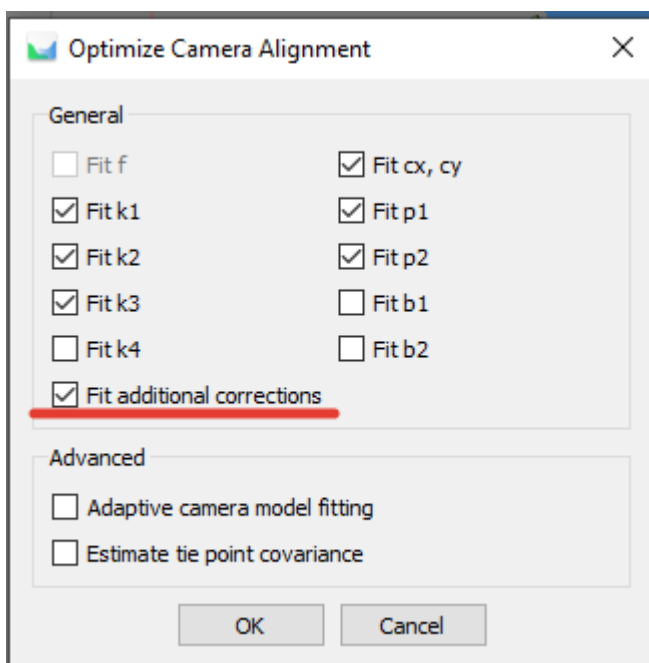
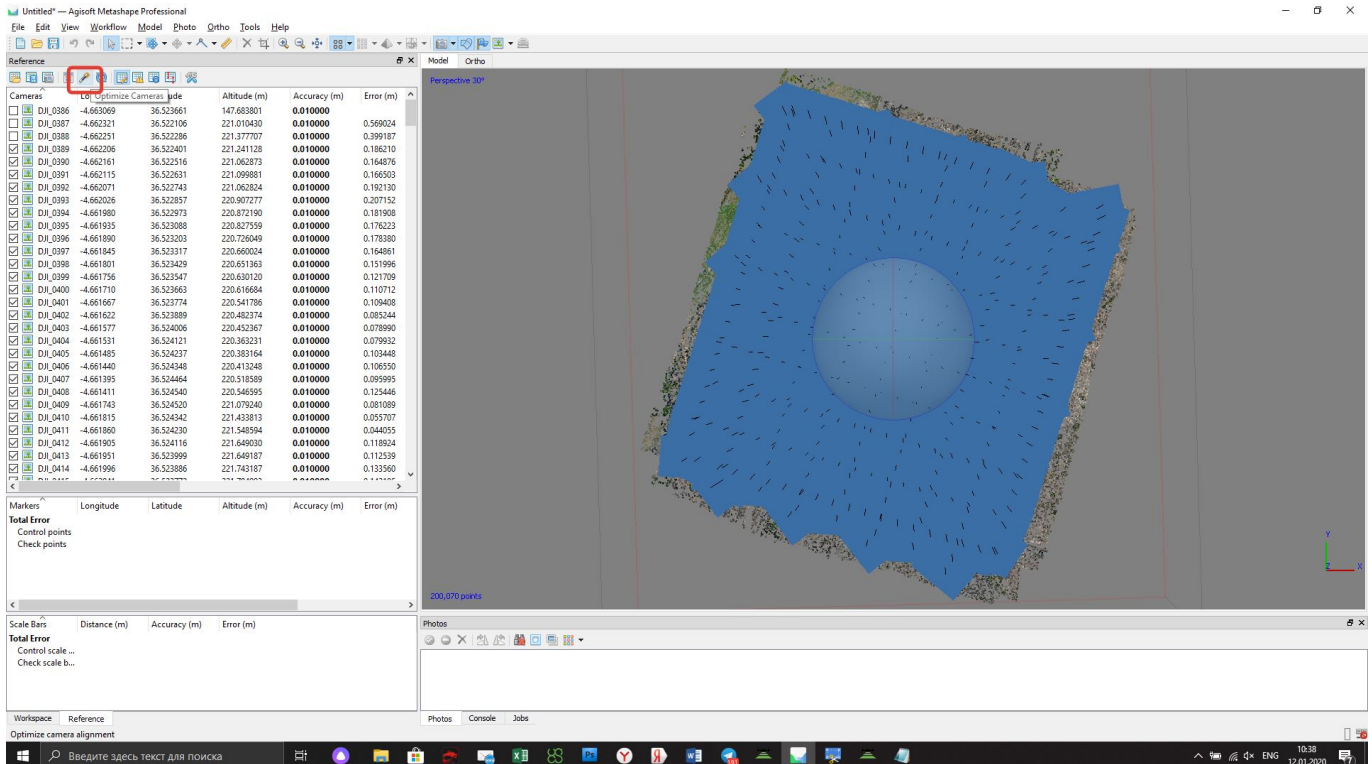
.Go to Tools, click Camera calibration and input calibrated parameter for focal length 10.4777, select fixed F parameter



Go to Workflow and click Align Photos for aerial triangulations



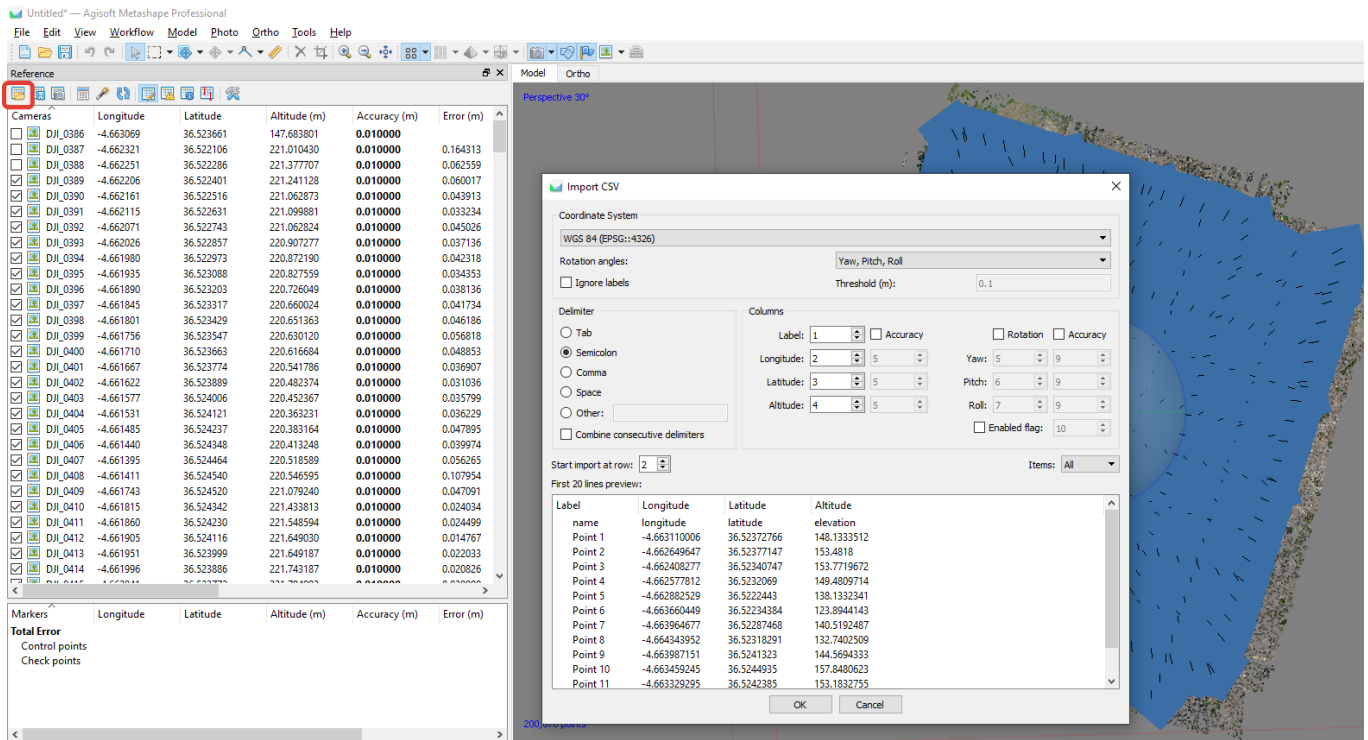
After finishing aerial triangulation go to Reference, click "Optimize Camera Alignment" and click on Fit additional corrections check box. Click OK



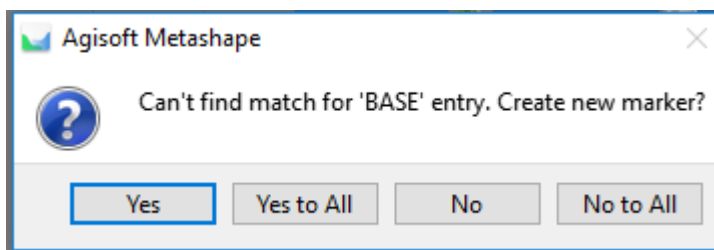
4.2 Accuracy estimating

After finishing aerial triangulation go to Reference, click "Import" and load GCP.txt file

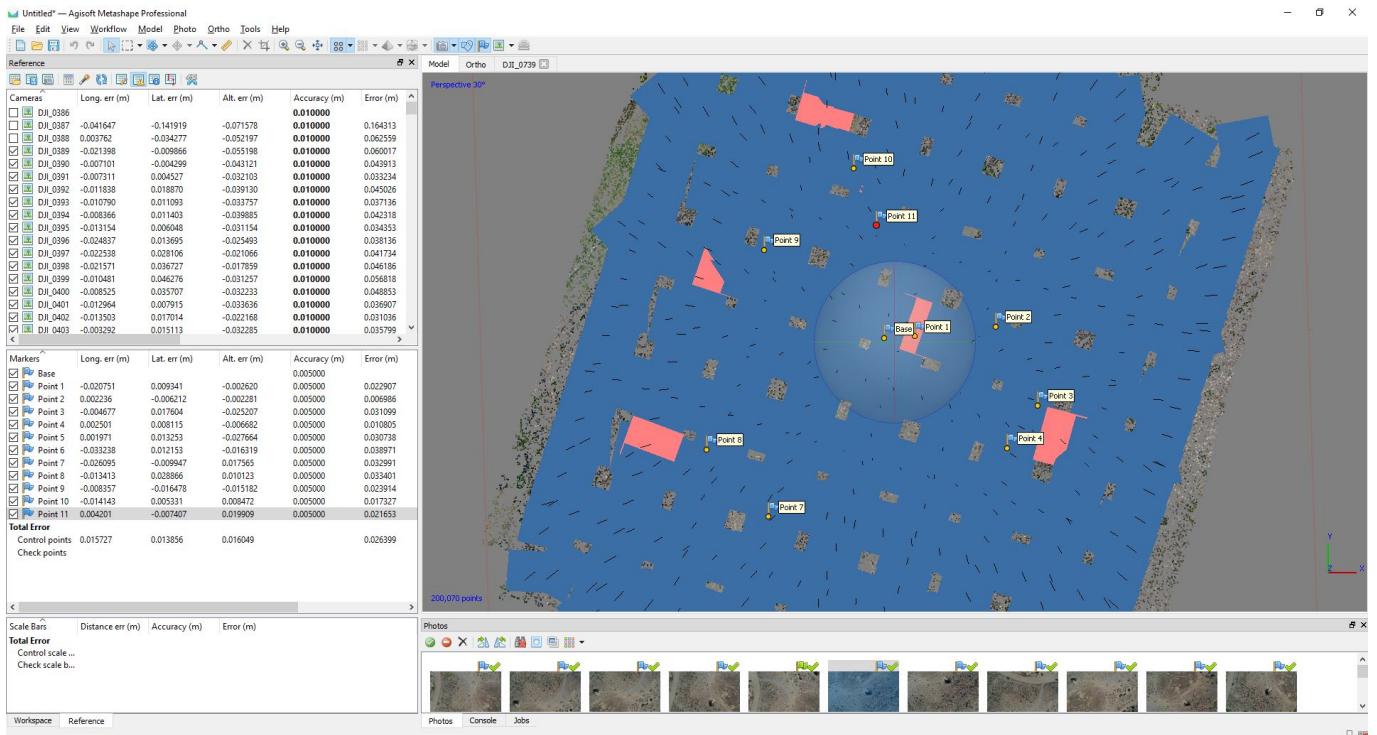
Use the following settings and click OK



Click «Yes to All» button. GCPs will be shown at Model window.



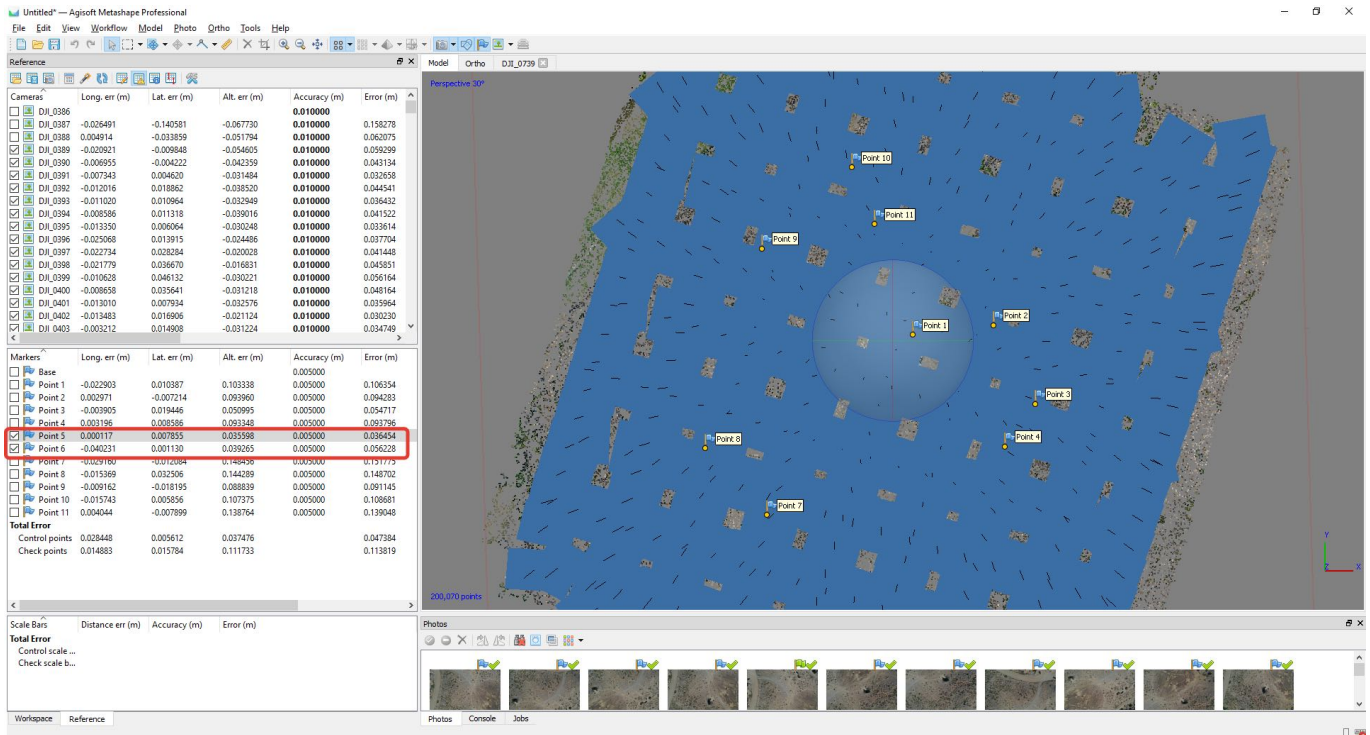
Select locations of each GCP on photos and look at accuracy report



Markers	Long. err (m)	Lat. err (m)	Alt. err (m)	Accuracy (m)	Error (m)
<input checked="" type="checkbox"/> Base				0.005000	
<input checked="" type="checkbox"/> Point 1	-0.020751	0.009341	-0.002620	0.005000	0.022907
<input checked="" type="checkbox"/> Point 2	0.002236	-0.006212	-0.002281	0.005000	0.006986
<input checked="" type="checkbox"/> Point 3	-0.004677	0.017604	-0.025207	0.005000	0.031099
<input checked="" type="checkbox"/> Point 4	0.002501	0.008115	-0.006682	0.005000	0.010805
<input checked="" type="checkbox"/> Point 5	0.001971	0.013253	-0.027664	0.005000	0.030738
<input checked="" type="checkbox"/> Point 6	-0.033238	0.012153	-0.016319	0.005000	0.038971
<input checked="" type="checkbox"/> Point 7	-0.026095	-0.009947	0.017565	0.005000	0.032991
<input checked="" type="checkbox"/> Point 8	-0.013413	0.028866	0.010123	0.005000	0.033401
<input checked="" type="checkbox"/> Point 9	-0.008357	-0.016478	-0.015182	0.005000	0.023914
<input checked="" type="checkbox"/> Point 10	-0.014143	0.005331	0.008472	0.005000	0.017327
<input checked="" type="checkbox"/> Point 11	0.004201	-0.007407	0.019909	0.005000	0.021653
Total Error					
Control points	0.015727	0.013856	0.016049		0.026399
Check points					

4.3. Camera calibration

To calibrate camera focal length, load images, import accurate coordinates of photos, perform photos alignment (don't fix F parameter) and import GCPs. Define position of markers on each photo. Select 2-3 markers

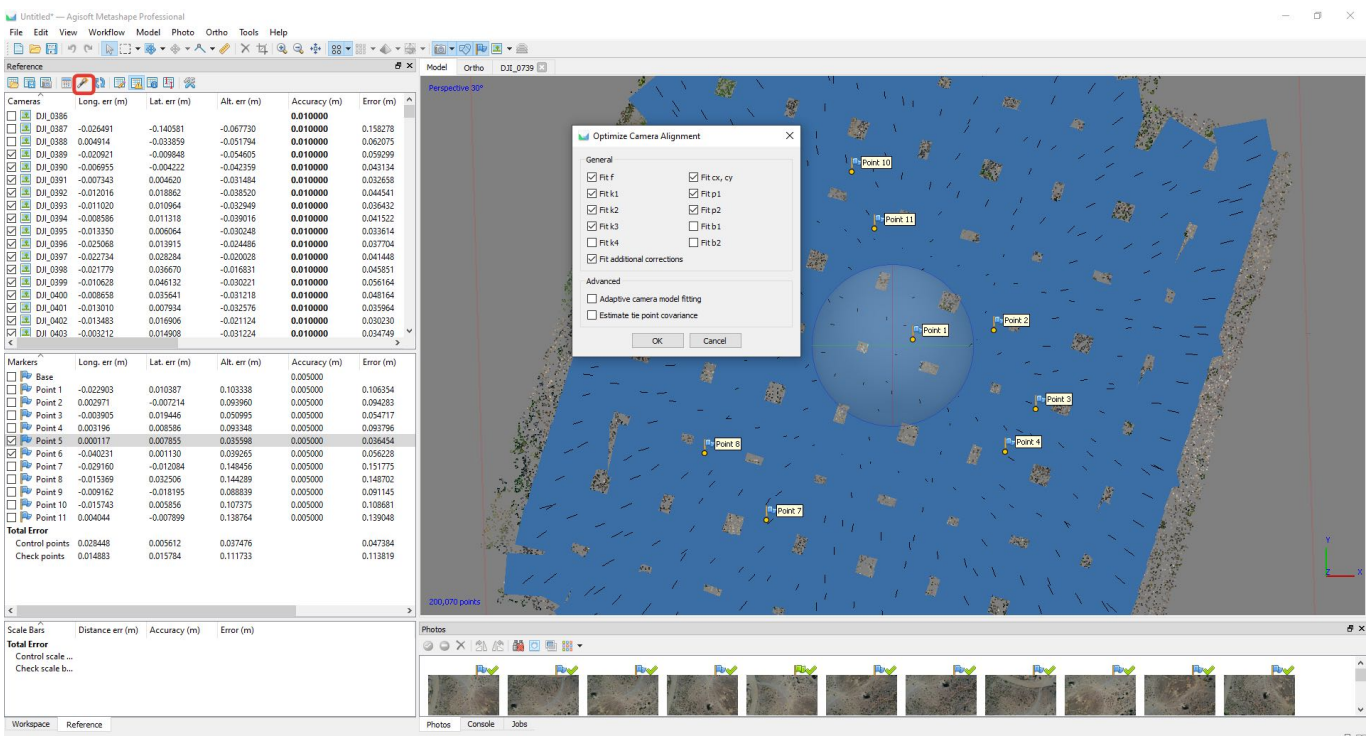


The screenshot shows the Agisoft Metashape Professional interface. On the left, the 'Cameras' list displays data for 11 cameras (DJI_0386 to DJI_0403). The 'Markers' list shows 11 points (Point 1 to Point 11) with their coordinates and errors. The main 3D view shows a blue mesh of a field with 11 yellow markers labeled Point 1 to Point 11. The 'Photos' panel at the bottom shows a sequence of 11 photos.

Cameras	Long. err (m)	Lat. err (m)	Alt. err (m)	Accuracy (m)	Error (m)
DJI_0386	-0.026491	-0.140581	-0.067730	0.010000	0.158278
DJI_0388	0.004914	-0.033859	-0.051794	0.010000	0.062075
DJI_0389	-0.020921	-0.009848	-0.054605	0.010000	0.059299
DJI_0390	-0.006955	-0.004222	-0.042359	0.010000	0.043134
DJI_0391	-0.007343	0.004620	-0.031484	0.010000	0.032658
DJI_0392	-0.012016	0.018862	-0.038520	0.010000	0.044541
DJI_0393	-0.011020	0.010954	-0.032949	0.010000	0.035432
DJI_0394	-0.005856	0.011318	-0.039016	0.010000	0.041522
DJI_0395	-0.013350	0.006064	-0.030248	0.010000	0.033614
DJI_0396	-0.025068	0.013915	-0.024486	0.010000	0.037704
DJI_0397	-0.022734	0.028284	-0.020028	0.010000	0.041448
DJI_0398	-0.021779	0.036670	-0.016831	0.010000	0.045851
DJI_0399	-0.010628	0.046132	-0.030221	0.010000	0.056164
DJI_0400	-0.008658	0.035641	-0.031218	0.010000	0.048164
DJI_0401	-0.013010	0.007934	-0.032576	0.010000	0.035964
DJI_0402	-0.013483	0.016906	-0.021124	0.010000	0.030230
DJI_0403	-0.003212	0.014908	-0.031224	0.010000	0.034749

Markers	Long. err (m)	Lat. err (m)	Alt. err (m)	Accuracy (m)	Error (m)
Base	-0.022903	0.010387	0.103338	0.005000	0.106354
Point 1	0.002971	-0.007214	0.093960	0.005000	0.094283
Point 2	-0.003905	0.019446	0.050995	0.005000	0.054717
Point 3	0.003196	0.005586	0.093348	0.005000	0.093796
Point 4	0.000117	0.007855	0.035598	0.005000	0.036454
Point 5	-0.040231	0.001130	0.039265	0.005000	0.056228
Point 6	-0.029160	-0.012084	0.148456	0.005000	0.151775
Point 7	-0.015389	0.023256	0.140289	0.005000	0.146702
Point 8	-0.009162	-0.018195	0.088839	0.005000	0.091145
Point 9	-0.015743	0.005856	0.107375	0.005000	0.108681
Point 10	0.004044	-0.007899	0.138764	0.005000	0.139048
Point 11					
Total Error	0.028448	0.005612	0.037476		0.047384
Control points	0.014883	0.015784	0.111733		0.113819

Click Optimize camera Alignment, use the following settings and click OK

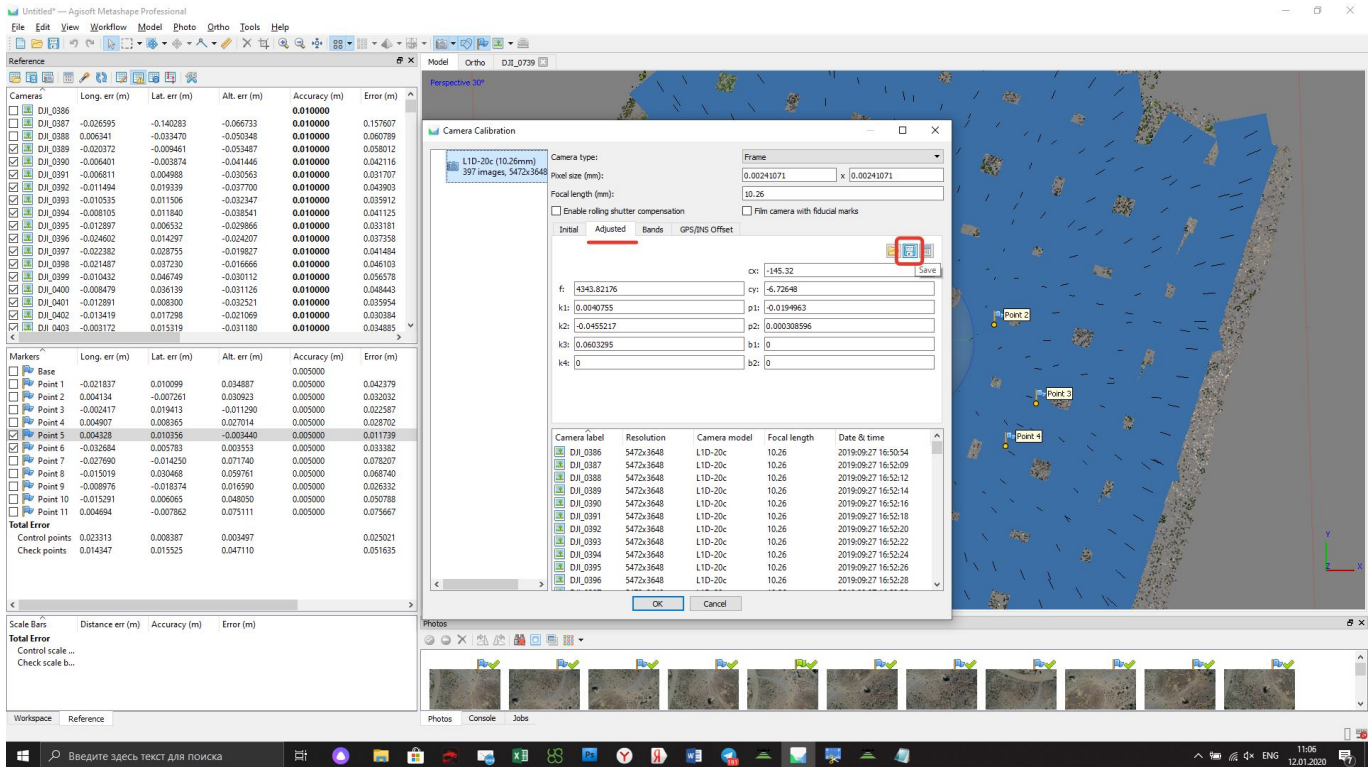


The screenshot shows the same Agisoft Metashape Professional interface as before, but with the 'Optimize Camera Alignment' dialog box open. The dialog box has two tabs: 'General' and 'Advanced'. The 'General' tab is active, showing the following settings:

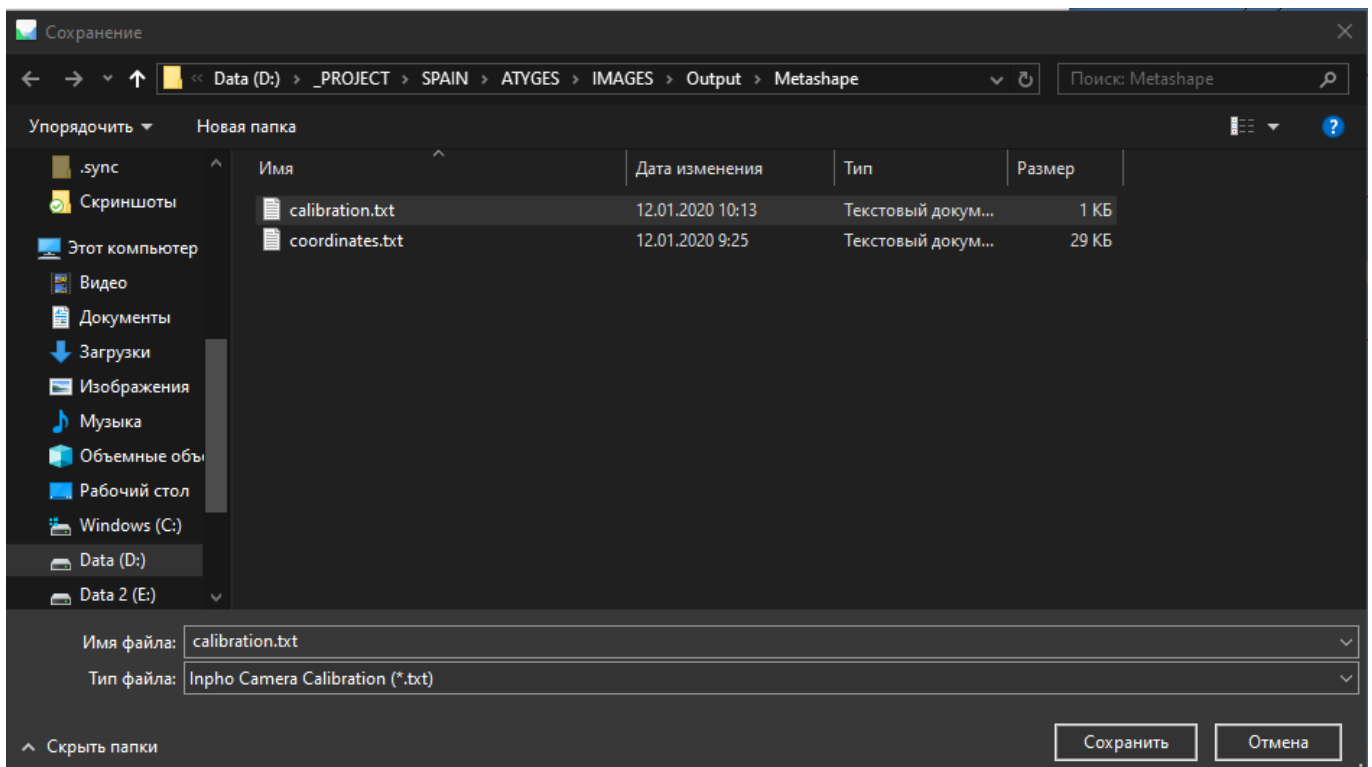
- ☒ Fit F
- ☒ Fit K1
- ☒ Fit K2
- ☒ Fit K3
- ☒ Fit K4
- ☒ Fit cx, cy
- ☒ Fit p1
- ☒ Fit p2
- ☐ Fit b1
- ☐ Fit b2
- ☒ Fit additional corrections
- ☐ Adaptive camera model fitting
- ☐ Estimate tie point covariance

The 'OK' button is highlighted.

After finishing aerial triangulation, go to Tools, click Camera calibration. Select adjusted and Save button.



Select Info Camera Calibration format and save file.



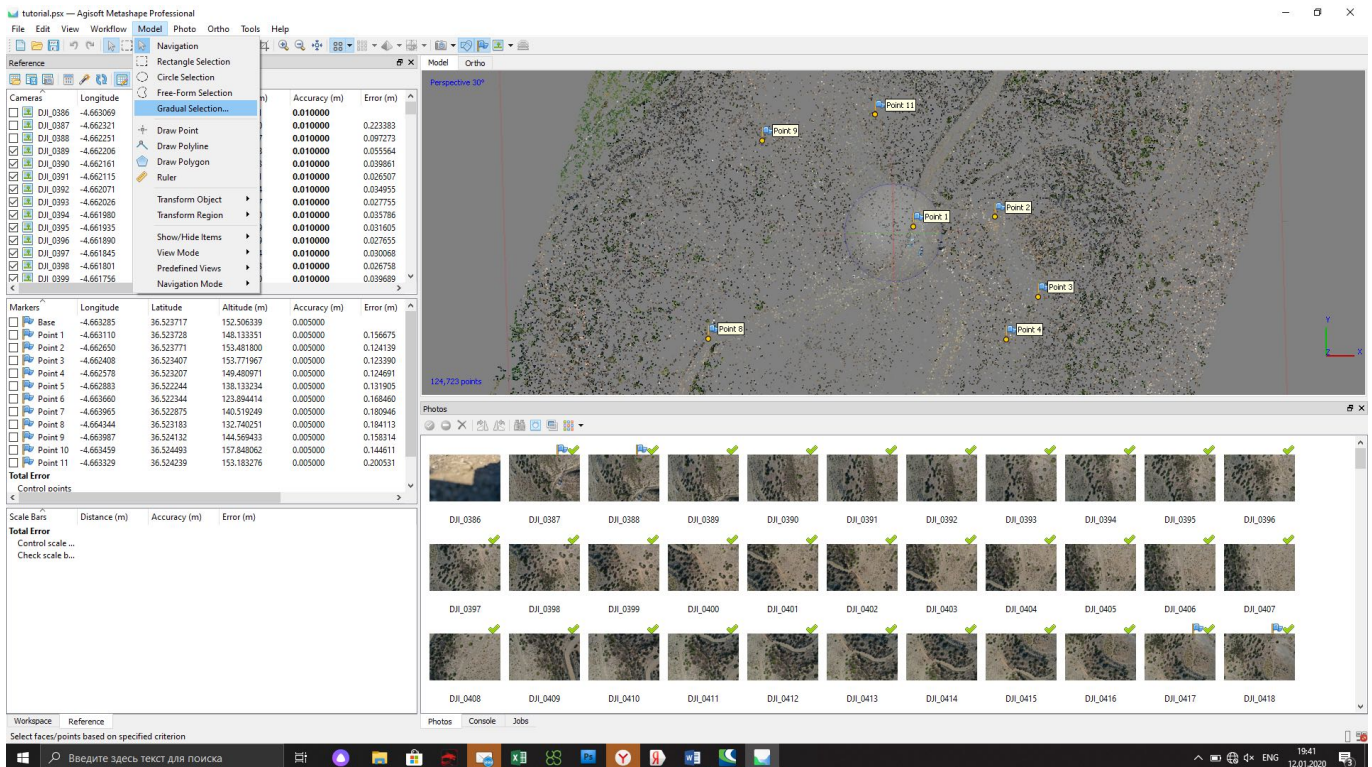
Open txt file and copy focal length value

```
$CAMERA
$TYPE : L1D-20c_(10.26mm)
$DATE : 11:09:31 12/01/2020
$BRAND : Custom
$KIND : CCDFrame
$CCD_INTERIOR_ORIENTATION :
    412.893      -0      2580.68
    0.0000000000 -414.547  1817.54
$CCD_COLUMNS : 5472
$CCD_ROWS : 3648
$PIXEL_REFERENCE : CenterTopLeft
$FOCAL_LENGTH : 10.4717
$PRINCIPAL_POINT_PPA : 0.000000 0.000000
$DISTORTION_TYPE : Polynomial
$RADIAL_COEFFS :
    0      -1.53934e-05      -2.12222e-06      8.19425e-08
    -7.31114e-10      0      0      0
$DECENTRE_COEFFS :
    -0.00140953      2.44127e-05      0      0
$GPS_ANTENNA_OFFSET : 0.000000 0.000000 0.000000
$CAMERA_MOUNT_ROTATION : 0.000000
```

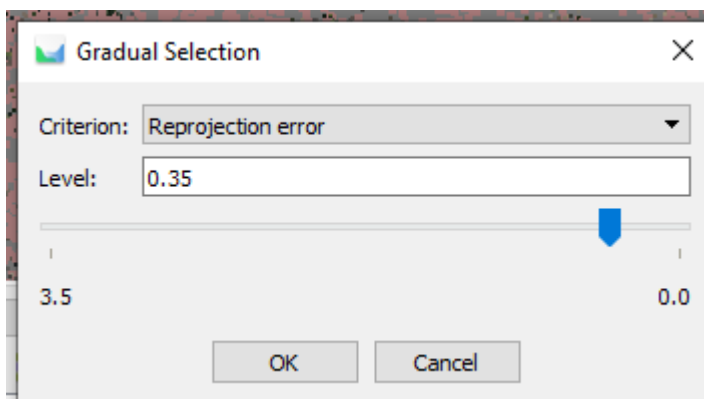
NOTICE. It is possible to use the calibrated value of focal length for the processing If you don't change focus settings for future flights.

4.4. Aerial triangulation accuracy improvement. Tie points filtering

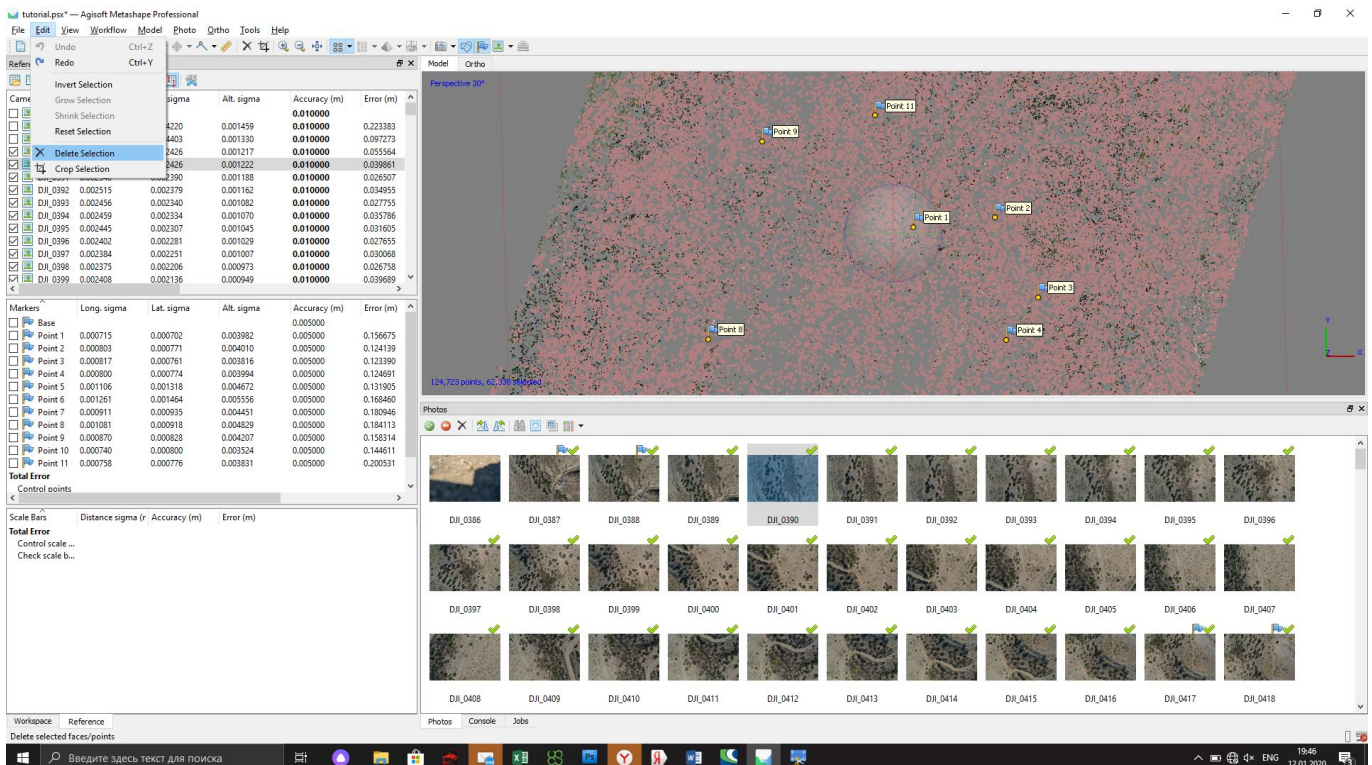
In order to increase an accuracy of your model, we would suggest to filter tie points using Gradual Selection tool. Open Model menu, click Gradual Selection.



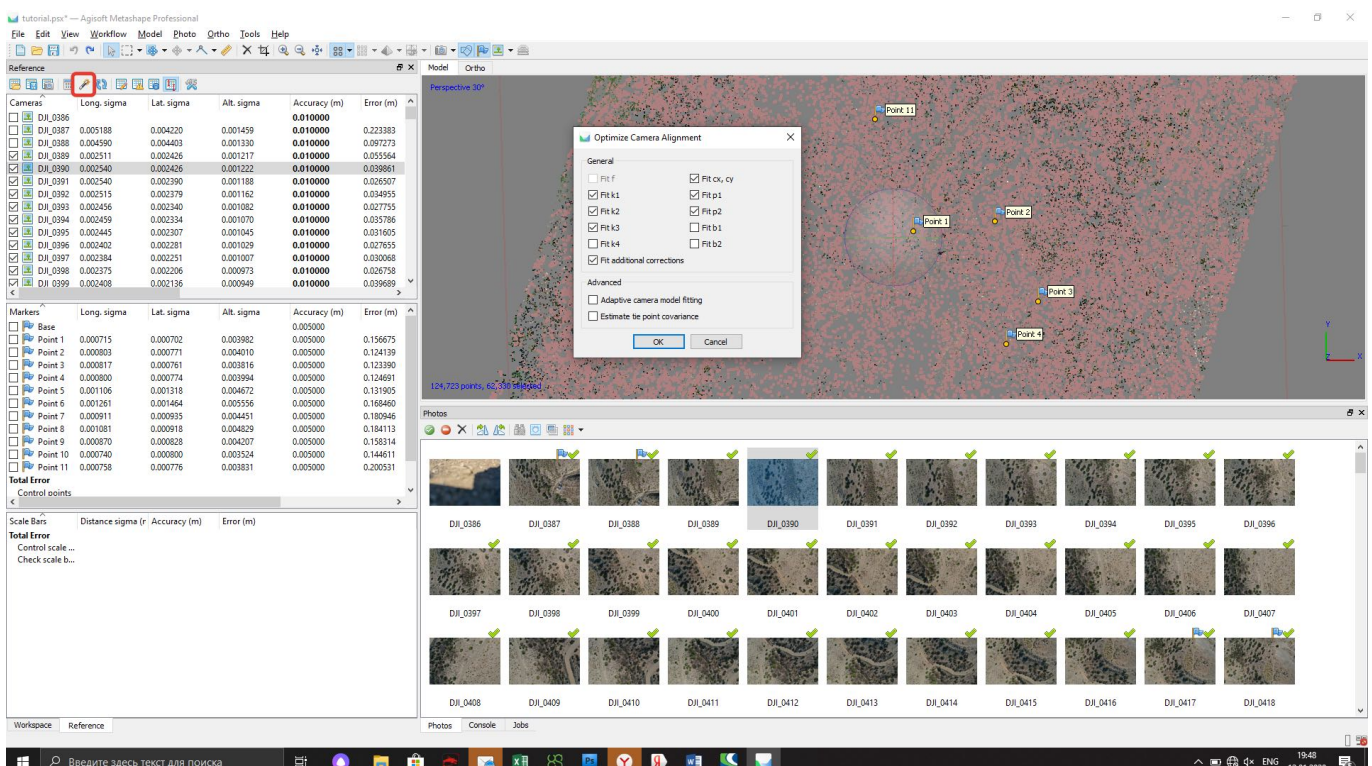
Select Gradual selection and input 0.35 value



Go to Edit menu and delete selected points



Click "Optimize Camera Alignment"

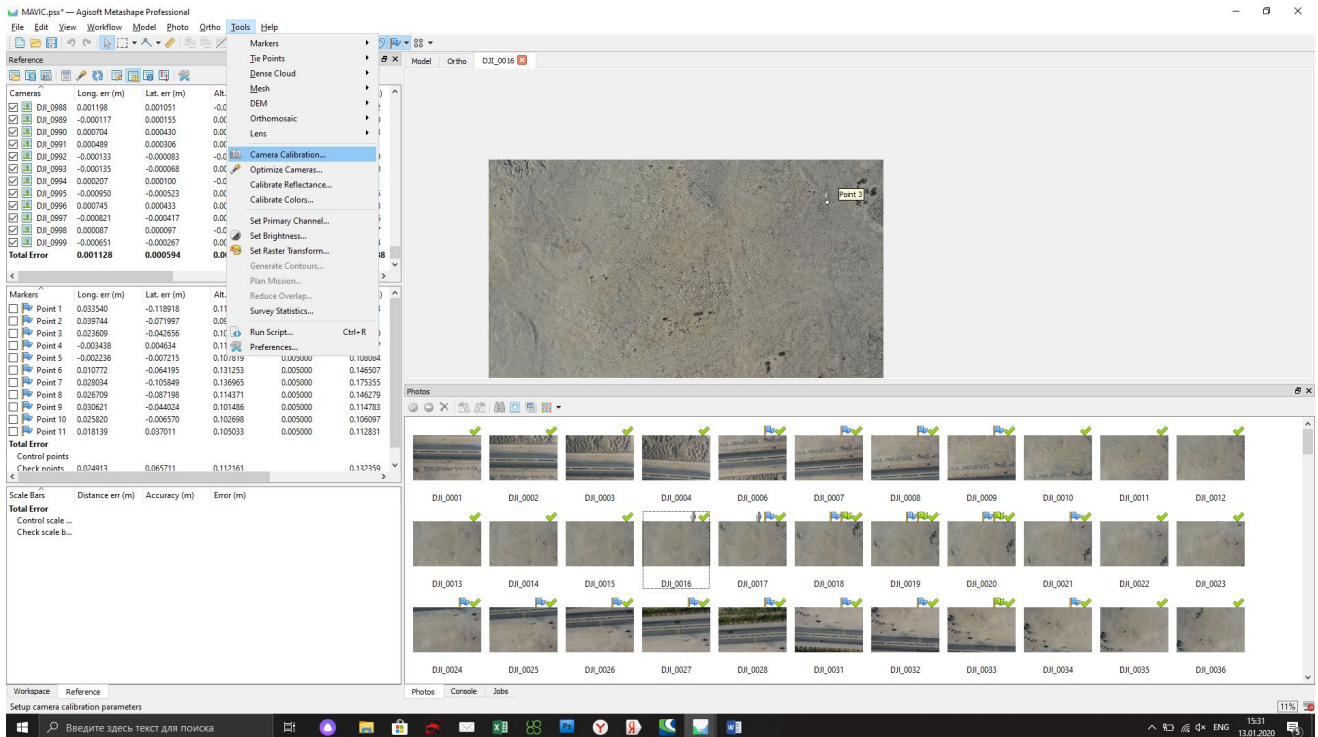


Check accuracy and repeat described above steps until Reprojection error reach 0.65-0.35 value.

4.5. Removing rolling shutter distortion

If photos acquisition was made with a low shutter speed or high flight speed we would suggest to remove rolling shutter distortion.

Open Tools, Camera Calibration



Enable rolling shutter compensation. Reoptimize cameras. Check accuracy.

