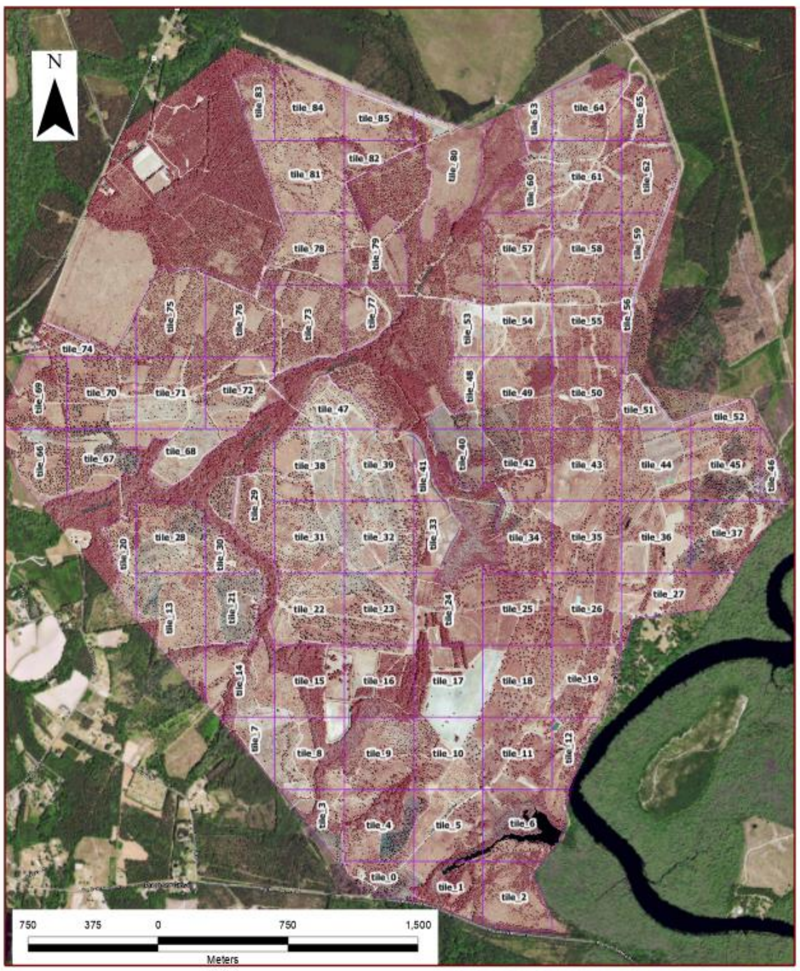
DJI MAVIC 3 Enterprise Drone Data Processing Workflow: Post-processing kinematics (PPK)



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Version: 1.0

Date: October 18, 2024

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1. General Workflow

Performing a post-processed kinetic (PPK) process with DJI drone images might seem challenging, but with proper planning and execution, it can be fairly straightforward. The process consists of several critical steps, briefly described below.

1. Mission Planning.

Before embarking on your data collection mission, thorough planning is essential. Ensure that the flight duration is sufficient to gather the necessary data. Configure specific settings within the DJI Pilot app to optimize your flight for data collection. This preparatory phase is vital to ensure that the resultant data will support accurate PPK processing. I consider preparing tiles (flight area preparation) to be also part of planning. I have created an R-package (shape2kml) to handle processing several geospatial files into the DJI pilot-accepted keyhole markup language (KML) file type. This eliminates the manual digitizing process of the route over Google Earth Pro.

2. Collecting Drone Data: Flying Drone

After finalizing a mission plan, we proceed to collect drone image data along with the Global Navigation Satellite System (GNSS) data from the drone's receiver during the flight. It is crucial to capture comprehensive GNSS data, including raw satellite navigation signals and precise timestamp information. Accumulating extensive data is the key to achieving accuracy in subsequent PPK processing. Raw GNSS data are used later to determine the precise position of image data captured during this process.

3. Collecting Reference Data

Before and after drone flight collect reflectance data using the reflectance panel. This process for DJI MAVIC 3E is not required, and the process generally takes the data from the sun sensors. Gather reference data from nearby GNSS reference stations (such as CORS or other ground-based receivers). These reference data must encompass the same GNSS signals and timing information as the drone's GNSS data. By obtaining this additional layer of data, you can significantly improve the accuracy of your PPK results.

In this project, I established the base station above the tidal benchmark; however, to improve the accuracy, I relied on CORS (CHSY) for post-processing. I will expand on this later this year with screenshots.

4. Data Alignment and PPK Processing

With all the necessary data collected, the next step is aligning the drone image data with its corresponding GNSS data based on timestamps. This alignment process is typically conducted using specialized software tools designed to synchronize image capture times with GNSS data points. After alignment, utilize PPK processing software or online services to calculate precise positioning information for each captured image, using both the drone's GNSS data and the reference station data.

As pixels from multispectral images (REDEDGE, and NIR) were not aligned with multispectral (RGB), I only processed RGB images using Emlid Studio Software. Remember, Emlid Studio, as of now, only handles *.JPEG files. DJI M3E spit out two types of data format: JPEG for RGB, and TIFF for multispectral. To process TIFF images, you can rely on the 14-day trial version of Redcatch REDtoolbox GNSS PPK postprocessing and geotagging software.

5. POS Data Overwrite

It is critical to correctly import the newly calculated Position and Orientation System (POS) data into your photogrammetry software. This step is crucial as your photogrammetric models' accuracy depends on the quality of the input data. Double-check the compatibility of the POS data with your software to ensure it is correctly overwritten, maintaining the integrity of your mapping results.

In the photogrammetry workflow, POS data are essential during the aerotriangulation process. This process aims to determine each captured image's 3D positions and orientations accurately. The basic processing steps are:

Aerotriangulation

The aerotriangulation process involves analyzing the overlaps between images and identifying the corresponding features. By calculating the relative positions and orientations of these images, it establishes a spatial framework for the entire dataset.

The POS data provide the necessary orientation information, enabling the software to determine how each image relates to others in three-dimensional space.

Generating a Sparse Point Cloud

A sparse point cloud can be generated using the orientation data derived from the POS information. This point cloud represents the surveyed area, capturing key spatial features and providing a foundation for further analysis and modeling (dense point cloud generation DSM, etc.).

Accurate Geo-Referencing

By integrating POS data with the captured images, the resulting models and maps are accurately georeferenced, allowing for precise location tracking and measurement within the mapped environment.

I will describe them in detail in my next update. Perhaps I should consider making this a separate fieldwork manual.

2. Scope and Objective

This manual describes the DJI Mavic 3E (M3M) acquired RGB and multispectral imagery processing workflow. The M3M is equipped with GNSS RTK (Real-Time Kinematic), which can be used with the D-RTK 2 or Emlid Reach base station to determine the position of the UAS with centimeter-level accuracy. This enables high georeferencing accuracy without the use of ground control points (GCP) or ground surveys. This protocol describes an approach to processing RGB and multispectral imagery using Agisoft Metashape Pro (>**Agisoft Metashape 2.0.0).**

Process:

This manual uses the Metashape Graphical User Interface (GUI) to describe the step-by-step workflow.

Output:

Co-registered RGB and multispectral orthomosaics.

Objective

The basic objective of this manual is to show the detailed processing workflow of DJI M3E acquired images using the Agisoft Metashape software version 2.0.4 or higher. Specifically, only RGB images will be processed for this manual.

Once we have a Mica-sense Altum-PT sensor, this manual will be updated to integrate the Mica-sense portion during mission planning and processing stages.

Metashape Interface

Metashape has a standard interface (**Figure 1**) with **a menu bar** (file, edit view, workflow, photo, ortho, tools, and Help), toolbar (2), and three panels (3,4 and 6).

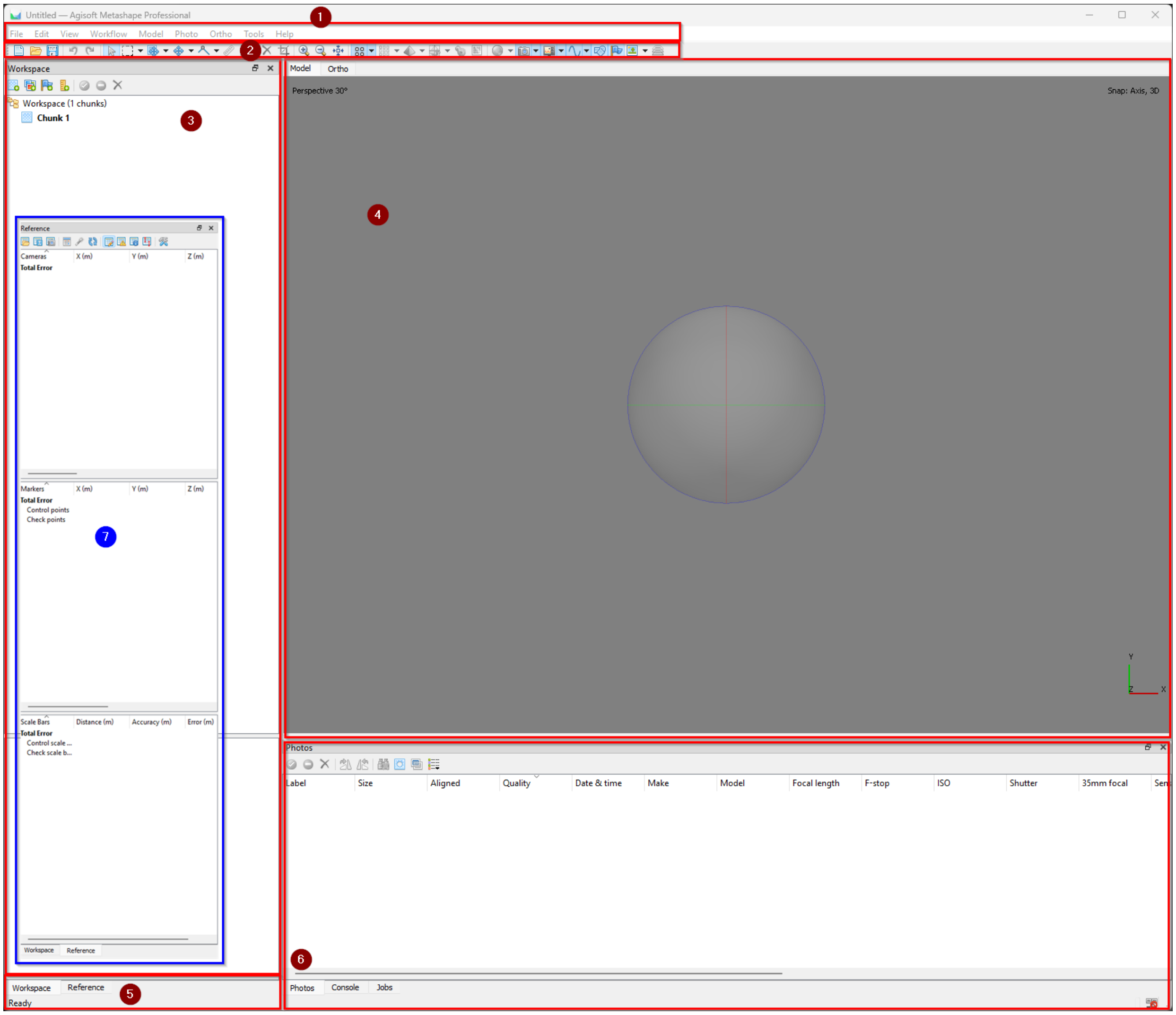


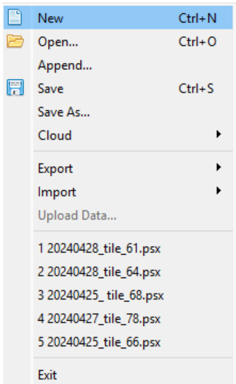
Figure 1. Metashape Standard Interface

File Menu (1)

Within the **File Menu, users have access to:**

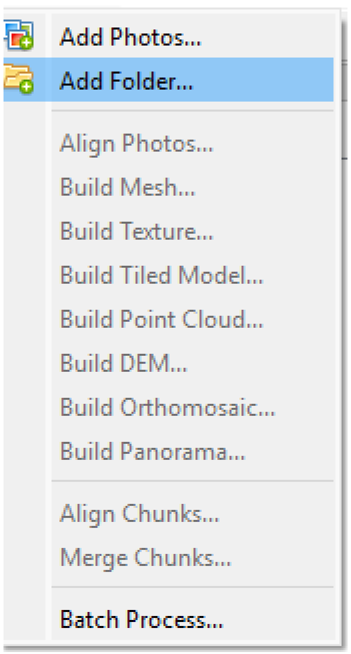
a. Create a new project
b. Open an existing project
c. Save project
d. Connect to cloud storage

e. Export and import several file types including shape files, point clouds etc.



Workflow Menu (1)

The workflow menu is used primarily to create 3D models and orthophotos. When the user opens an empty project, most of the options are disabled/grayed out-except for adding photos, adding a folder, and batch process.



Once a user adds photos or imports models, other options are available. Now let us look at the main interface.

Left panel (3)

The left panel can toggle (see 5 in Figure I) between **Workspace view** and **Reference view (7)**. These views provide information about your images and the progress of your model.

Bottom panel (6)

The bottom panel can toggle (see 6 in Figure I) between the **Photos, Console**, and **Jobs views**. In the Photos view, you can select and edit individual photos that have been added to a project. **The console** details your computer and its ability to process new processes, and **Jobs** provides a running log of processes completed during the project.

Main panel (4)

The main panel allows the user to toggle between **Model** and **Ortho.** The model pane (default) displays point clouds and models depending on which processing steps the user is in. Ortho view ortho projection is created after creating the orthomosaic or DSM. When photos are added and opened by double clicking on (Photos view), it will be opened next to ortho view.

3. Setting up Agisoft Metashape

System requirements: straight from metashape manual

Minimal configuration

Windows 7 SP 1 or later (64 bit), Windows Server 2008 R2 or later (64 bit), macOS High Sierra or later, Debian/Ubuntu with GLIBC 2.19+ (64 bit)

Intel Core 2 Duo processor or equivalent

8 GB of RAM

Recommended configuration

Windows 7 SP 1 or later (64 bit), Windows Server 2008 R2 or later (64 bit), macOS Mojave or later, Debian/Ubuntu with GLIBC 2.19+ (64 bit)

Intel Core i7 or AMD Ryzen 7 processor • Discrete NVIDIA or AMD GPU (4+ GB VRAM) • 32 GB of RAM

The number of photos that can be processed by Metashape depends on the available RAM and reconstruction parameters used. Assuming that a single photo resolution is of the order of 10 MPix, 4 GB RAM is sufficient to make a model based on 30 to 50 photos. 16 GB RAM will allow us to process up to 300-500 photographs.

General Workflow

Processing of images with Metashape includes the following main steps:

- loading data (images and laser scans) into Metashape
- inspect loaded images and laser scans and remove unnecessary images and laser scans.
- aligning images and laser scans.
- building point cloud.
- building mesh (3D polygonal model).
- generating texture.
- building tiled model.
- Building a digital elevation model (DEM).
- building orthomosaic.
- export results.

If Metashape is used in the full function (not Demo) mode, intermediate results of the image processing can be saved at any stage in the form of project files and can be used later.

Update Preference settings

I. Open Agisoft Metashape Pro→Tools → Preferences.

II. In the **General tab**, update the theme to **Classic**. Select **Write log to file** and browse to enter the path and a name for the.txt file. I am saving my file to my D drive (Figure 2)

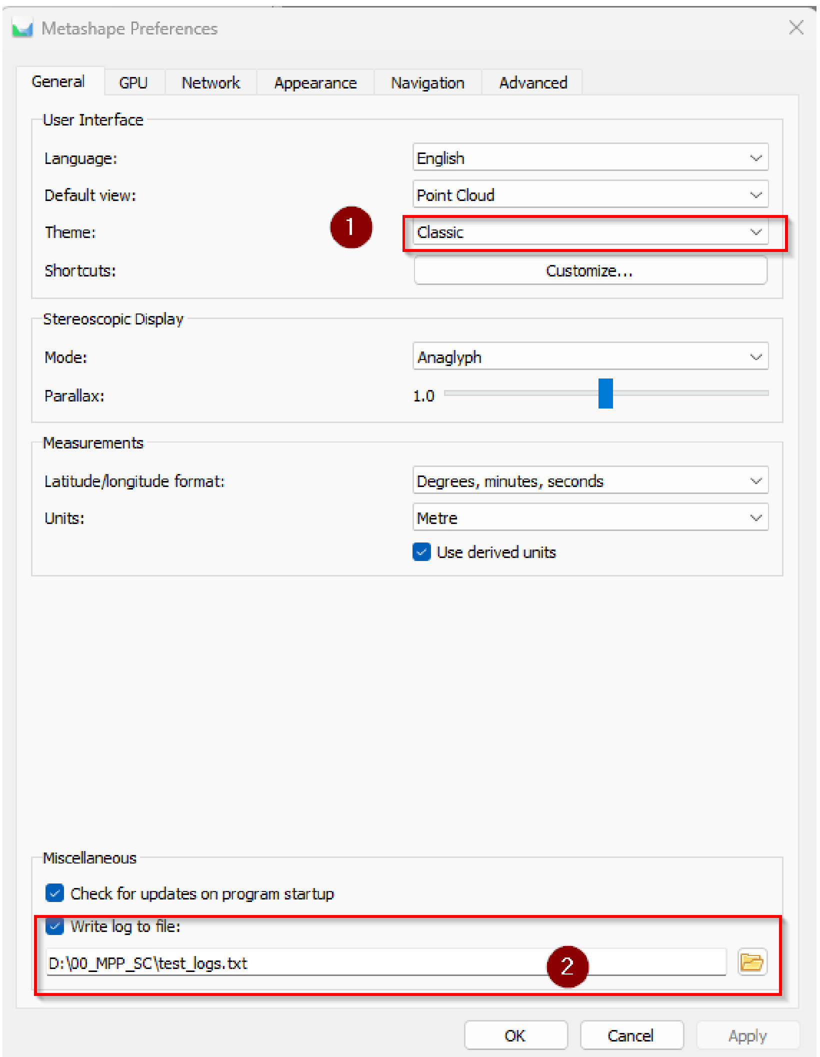


Figure 2: Update Metashape Preferences. Choose a path to save the log file.

III. In the GPU tab, make sure all GPUs are selected. Uncheck the box **Use CPU when performing GPU accelerated processing**.

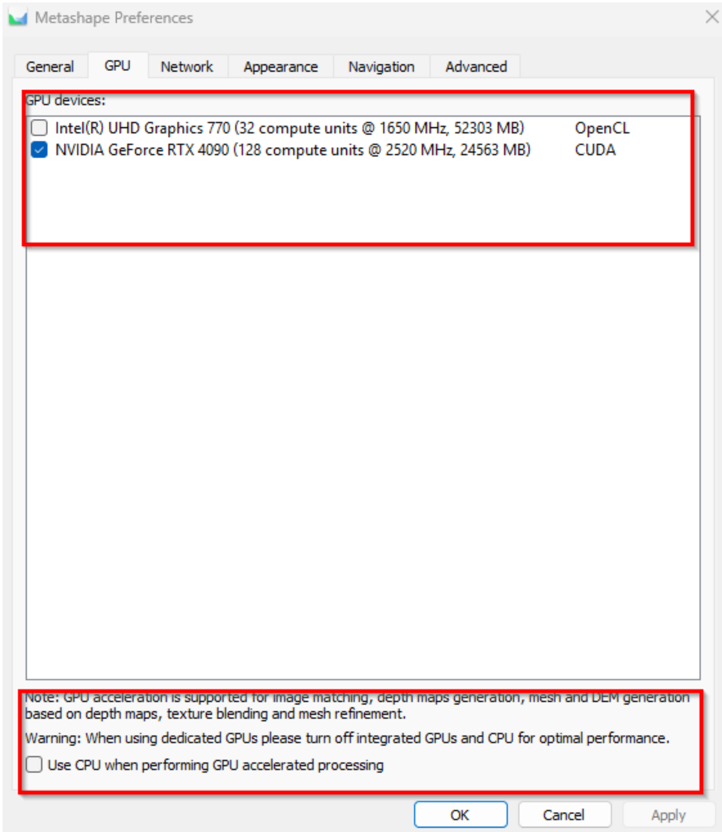


Figure 3: When using dedicated GPUs, disable integrated GPU and CPUs. In the GPU tab, disable the option Use CPU.

IV. In the Advanced tab, ensure that the following settings are checked.

Project Files:

- Keep key points
- Keep depth maps.

Depth maps are added to project file size, and if the goal is to rerun the workflow described here, this option should be enabled. However, if there is no need to re-run models (such as testing different quality settings for Point Cloud generation), an option **Keep depth maps** can be deselected **prior to starting the workflow or right after opening a metashape.**

Export/Import:

- Strip file extensions from camera labels.
- Load camera calibration from XMP meta-data
- Load camera orientation angles from XMP meta data

Miscellaneous:

- Enable rich Python console

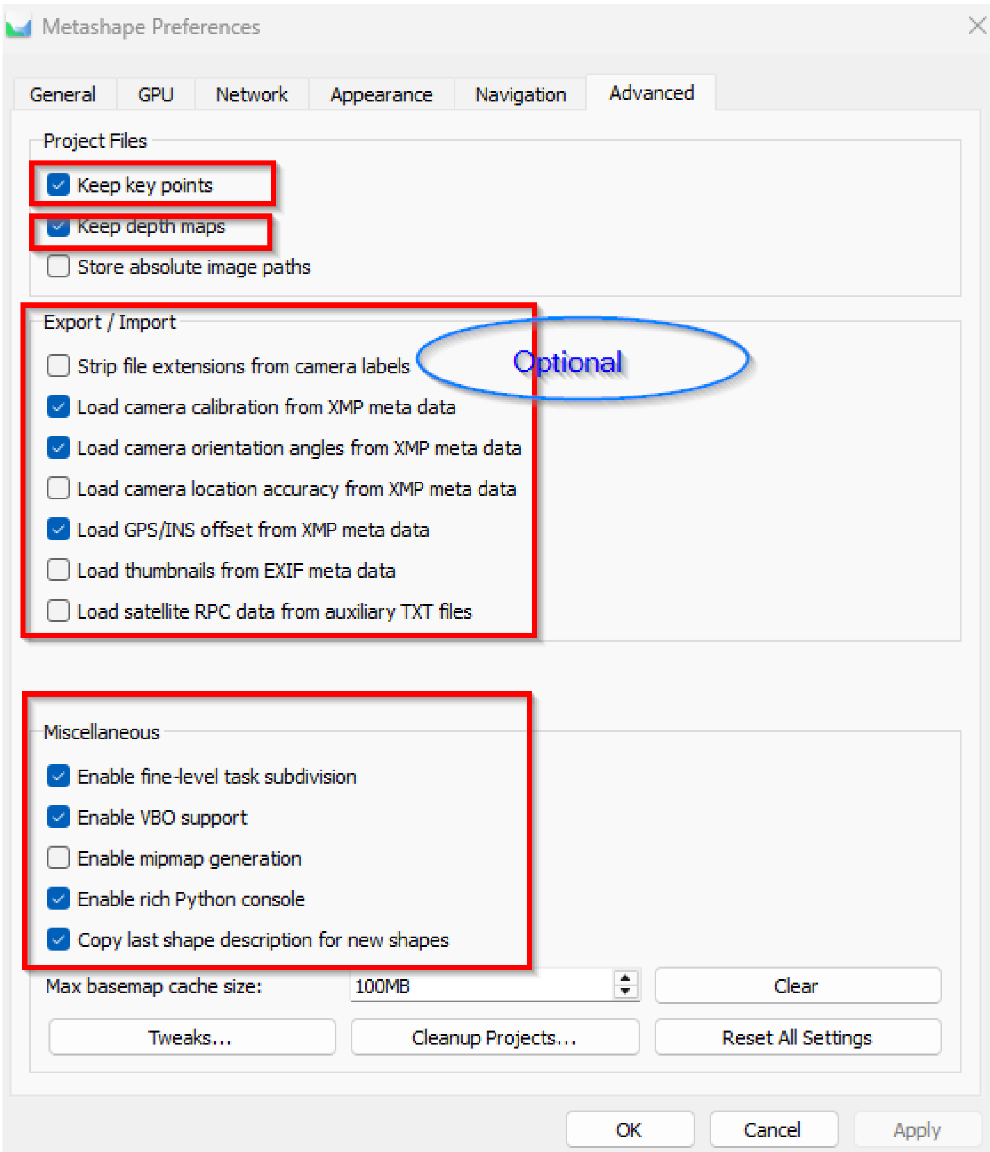


Figure 4:Update Advanced Preferences. The settings to be checked are highlighted above.

4. Processing Images in Metashape: Step-by-step process

This section describes the workflow using Metashape GUI commands.

Add images

1. Open Agisoft Metashape Pro
2. Save project in file name format **YYYYMMDD_ tile_tile#.psx** where YYYYMMDD is the date of data acquisition and tile# is the name of the plot of the project. *Example: 20240427_tile_78.psx*.
3. In the **workspace pane**[1], right-click on **Chunk 1** and rename to ***20240427_tile_78*.**
4. Choose Workflow → Add Folder and
5. In the dialog that opens next, select **Single camera** and then OK.

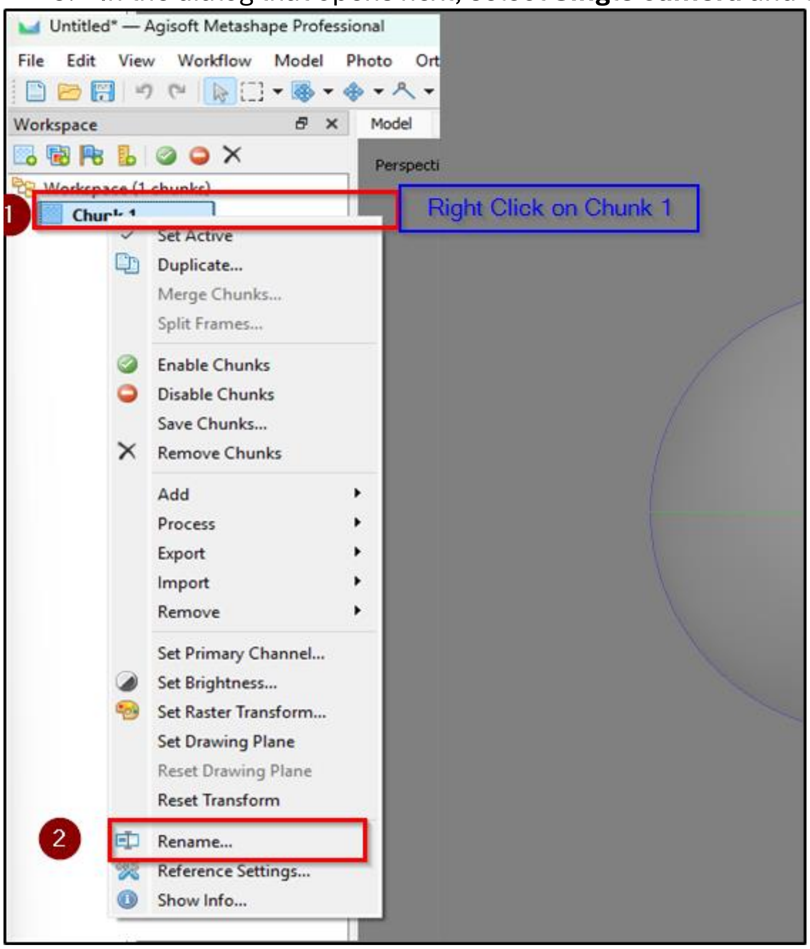


Figure 5: Using a context menu to rename default chunk 'Chunk1'

[1] Left panel has "Workspace" and "Reference pane"

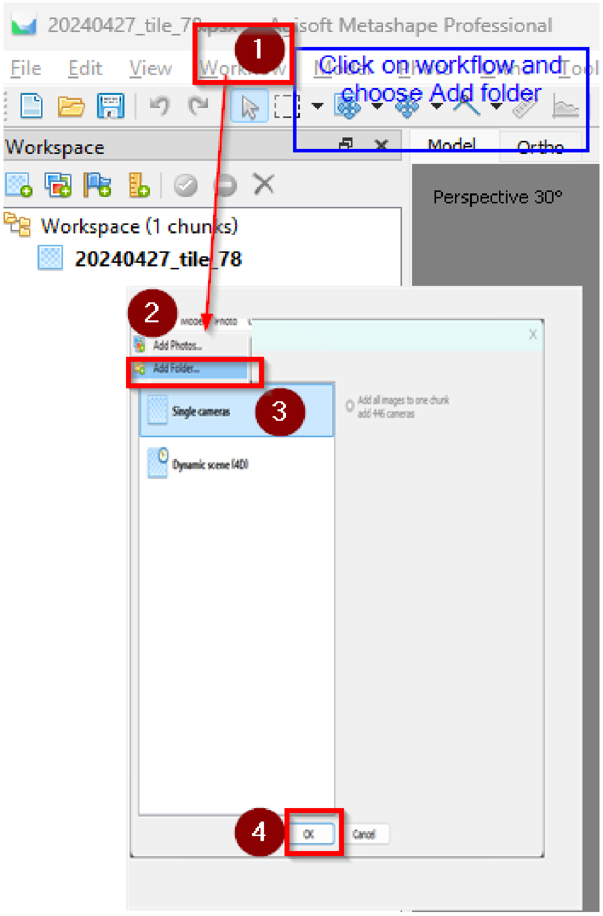


Figure 6: Workflow--> Add Folder and Select *single Cameras* to add M3M images

Note: If you add your multispectral images, there will be another option in Figure 6, called the multi-camera system, and you have to select this option. We do not have any calibration images and are not loaded.

6. In the main **Model** window, check that the flight path layout is expected.

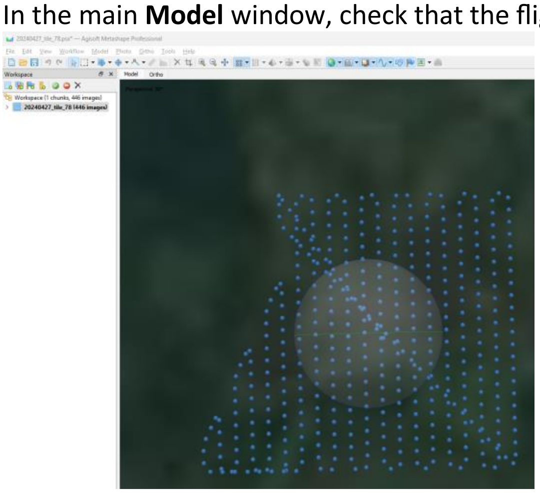
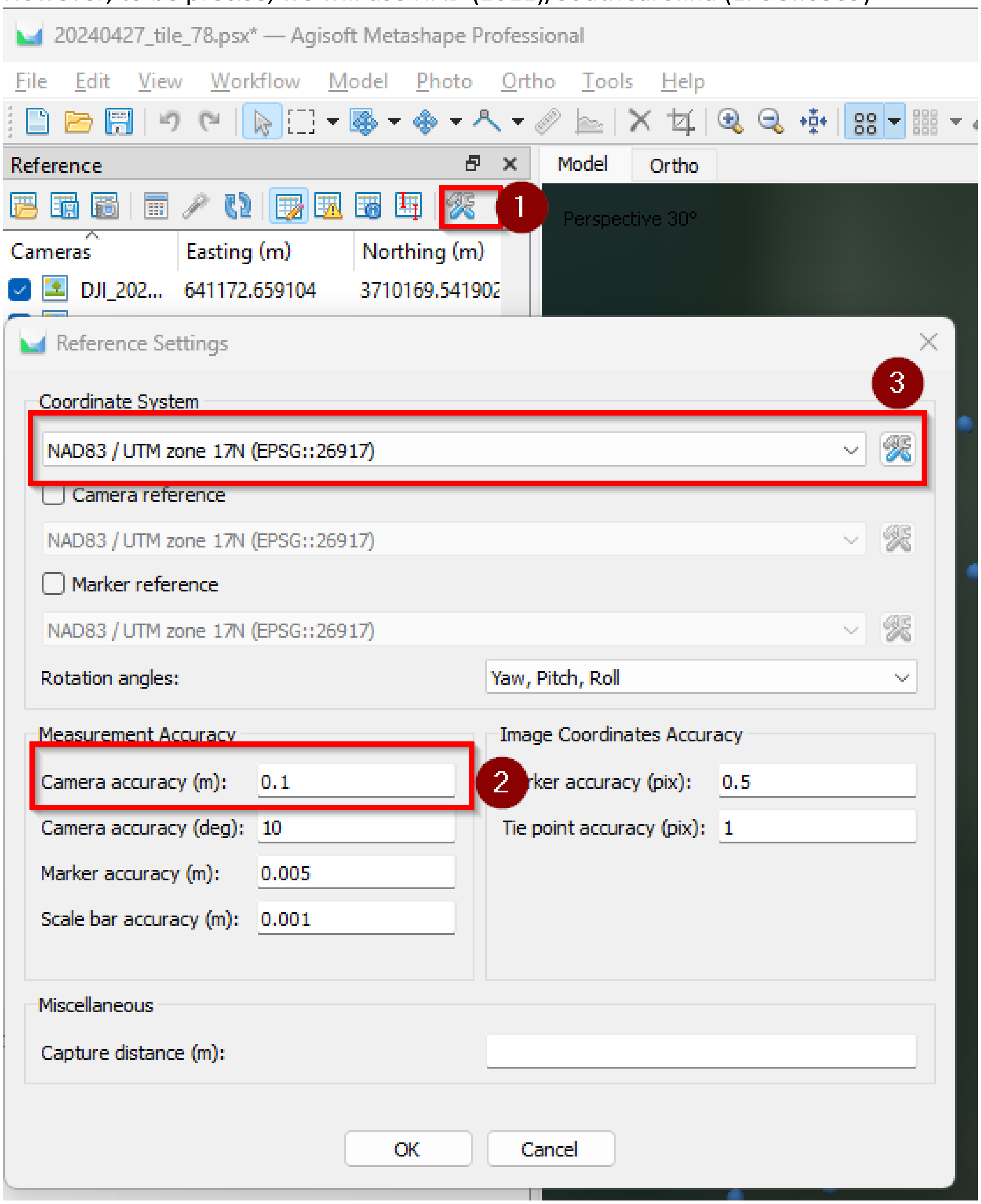


Figure 7: Flight layout. Each point indicates the photo taken by DJI M3E

Inspect camera settings

7. On the left panel (below workspace, click on **Reference** panel).
8. Click on **the Settings** icon. Update the camera accuracy to **0.1m**. This is the expected accuracy for Mavic3E when GNSS RTK is enabled. You can change the coordinate system to your designed projection system. North American Datum (NAD) 83 UTM Zone 17N. However, to be precise, we will use NAD (2011)/SouthCarolina (EPSG::6569)



Disable Cameras with Low Image Quality.

Metashape calculates image quality based on the sharpness in the most focused part of the image (usually, the center of the image); remember the vignette effect. Low-quality images can be removed/disabled in Metashape. Metashape recommends removing low-quality images.

9. In the **Photos** tab, select the **Details view**. Right-click on any image to **estimate image quality.** In the **Analyze Photos** dialog, select Apply to **All cameras.**
10. When this step is complete, sort the photos according to the **Quality** column. Inspect images with quality less than 0.75. Right-click on these image(s) to **disable cameras**.

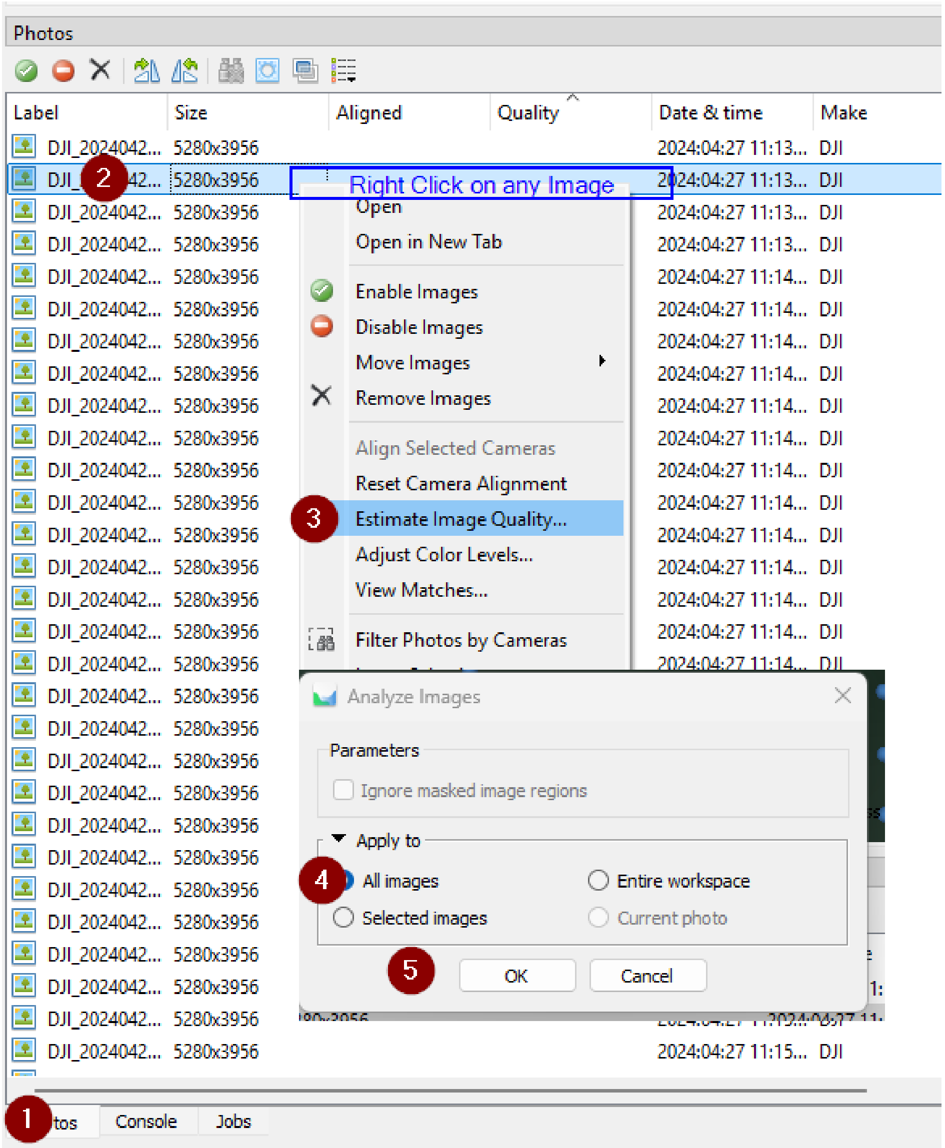


Figure 8: Estimate Image Quality and disable low-quality images

Align Photos

Image alignment is done to estimate the exterior and interior orientation parameters based on bundle block adjustment.

11. Select **Workflow**→Align Photos. Use the settings as shown in the image below:

Accuracy: High

Reference preselection: **Source**. Select overlapping pairs of images on the measured camera coordinates. This is recommended, as camera locations georeferenced with high accuracy are available. (For detail information, please refer to Metashape reference manual: The information in the following is from the Manual).

Accuracy

Higher accuracy settings help to obtain more accurate camera position estimates. Lower accuracy settings can be used to obtain a rough estimation of camera positions in a shorter period of time.

While in the High-accuracy setting the software works with the photos of the original size, the Medium setting causes image downscaling by a factor of 4 (2 times by each side), in the Low-accuracy source files are downscaled by a factor of 16, and the Lowest value means further downscaling by 4 times more. The highest accuracy setting upscales the image by a factor of 4. Since tie-point positions are estimated on the basis of feature spots found on the source images, it may be meaningful to upscale a source photo to accurately localize a tie point. However, the highest accuracy setting is recommended only for very sharp image data and mostly for research purposes, because the corresponding processing is quite time consuming.

Generic preselection

The alignment process of large photo sets can take a long time. A significant portion of this time period is spent on matching detected features across the photos. The image pair preselection option may speed up this process due to selection of a subset of image pairs to be matched.

In the Generic preselection mode, the overlapping pairs of photos are selected by matching photos using the lower accuracy setting first.

Reference preselection

In the source preselection mode, the overlapping pairs of photos are selected based on the measured camera locations (if present). For oblique imagery, it is necessary to set

Capture distance value (average ground height in the same coordinate system which is set for camera coordinates data) in the Settings dialog of the Reference pane to make the preselection procedure work efficiently. Capture distance information must be accompanied with yaw, pitch, roll/omega, phi, kappa data for cameras. Rotation parameters should be input into the Reference Pane. Then the preselection based on the new 3D points is calculated as the original 3D point and vector in the direction of the camera view with the length equal to the input capture distance value.

The Estimated preselection mode takes into account the calculated exterior orientation parameters for the aligned cameras. That is, if the alignment operation has been already completed for the project, the estimated camera locations will be considered when the Align Photos procedure is run again with the estimated preselection selected.

When using Sequential preselection mode, the correspondence between the images is determined according to the sequence of photos (the sequence number of the image); it is worth noting that with this adjustment, the first with the last images in the sequence will also be compared.

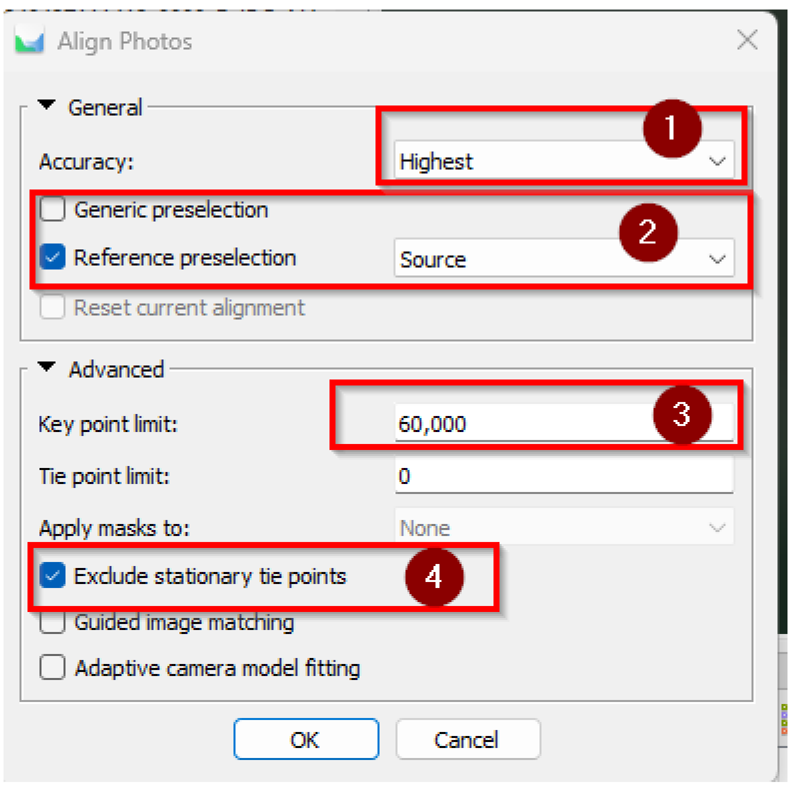


Figure 9: Align Photos: Accuracy, Generic, and Reference preselection

Optimize Camera Alignment

To optimize camera alignment, set the marker and/or camera coordinates to be used for optimization (if not done yet).

12. **Click Settings** toolbar button on the **Reference pane** and set the coordinate system (if not done yet).

In the Reference Settings dialog box specify the assumed accuracy of measured values as well as the assumed accuracy of marker projections on the source images.

Click the **OK** button.

Indicate relative GPS device and/or INS to camera coordinates (if info is available) on GPS/INS Offset tab of Camera Calibration dialog available from Tools menu.

Check the Adjust GPS/INS offset box.

Click the **OK** button.

Click Optimize toolbar button on the Reference pane.

In the Optimize Camera Alignment dialog box, check additional camera parameters to be optimized.

Fit additional corrections

With this option enabled Metashape estimates additional coefficients that are necessary to achieve better accuracy. There are different corrections that allow one to compensate the distortions that cannot be described by the Brown model (see Appendix D, Camera models section). This option may be helpful for the datasets acquired drone with RTK/PPK, when no GCPs are used.

Click the **OK** button to start optimization.

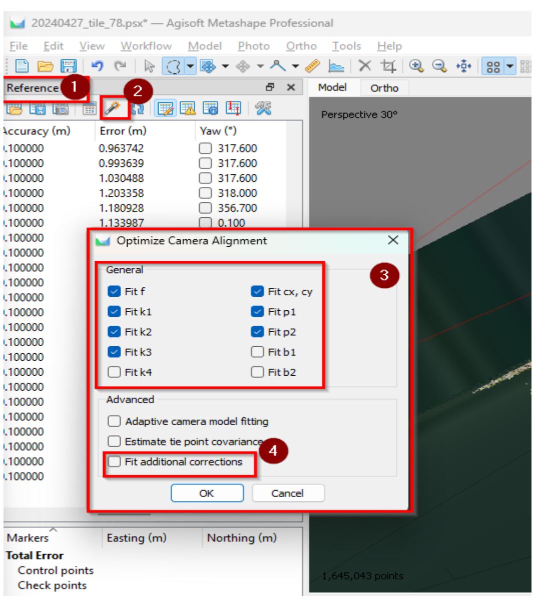


Figure 10: Optimize Camera Alignment dialog box in the Reference pane.

Build Point Cloud

A dense cloud can be built using the estimated camera positions. Depth maps calculated for the overlapping image pairs are used to generate a dense point cloud.
Select Workflow → **Build Point Cloud** and enter settings as follows:

Quality: **Ultra high**. Higher-quality settings result in a more detailed geometry but require longer processing times.
Depth filtering: **Mild. The depth** filtering mode sets the level of noise filtering; Mild or Moderate are useful for these datasets. Whereas Aggressive could remove more points than intended, and disabled will result in a very noisy point cloud.

Depth filtering modes (from metashape manual)

At the stage of point-cloud generation reconstruction Metashape calculates depth maps for every image. Due to some factors, such as noisy or badly focused images, there may be some outliers among the points. To sort out the outliers, Metashape has several built-in filtering algorithms that answer the challenges of different projects.

If there are important small details which are spatially distinguished in the scene to be reconstructed, then it is recommended to set a mild depth filtering mode, for important features not to be sorted out as outliers. This value of the parameter may also be useful for aerial projects, for example, in the case that the area contains poorly textured roofs. Mild depth filtering mode is also required for the depth-map-based mesh reconstruction.

If the area to be reconstructed does not contain meaningful small details, then it is reasonable to choose aggressive depth filtering mode to sort out most of the outliers. This value of the parameter is normally recommended for aerial data processing; however, mild filtering may be useful in some projects as well (see the comment on poorly textured roofs in the mild parameter value description above). Moderate depth filtering mode brings results that are in between the Mild and Aggressive approaches. You can experiment with the setting in case you have doubts about which mode to choose. Additionally, depth filtering can be disabled. But this option is not recommended as the resulting point cloud could be extremely noisy.

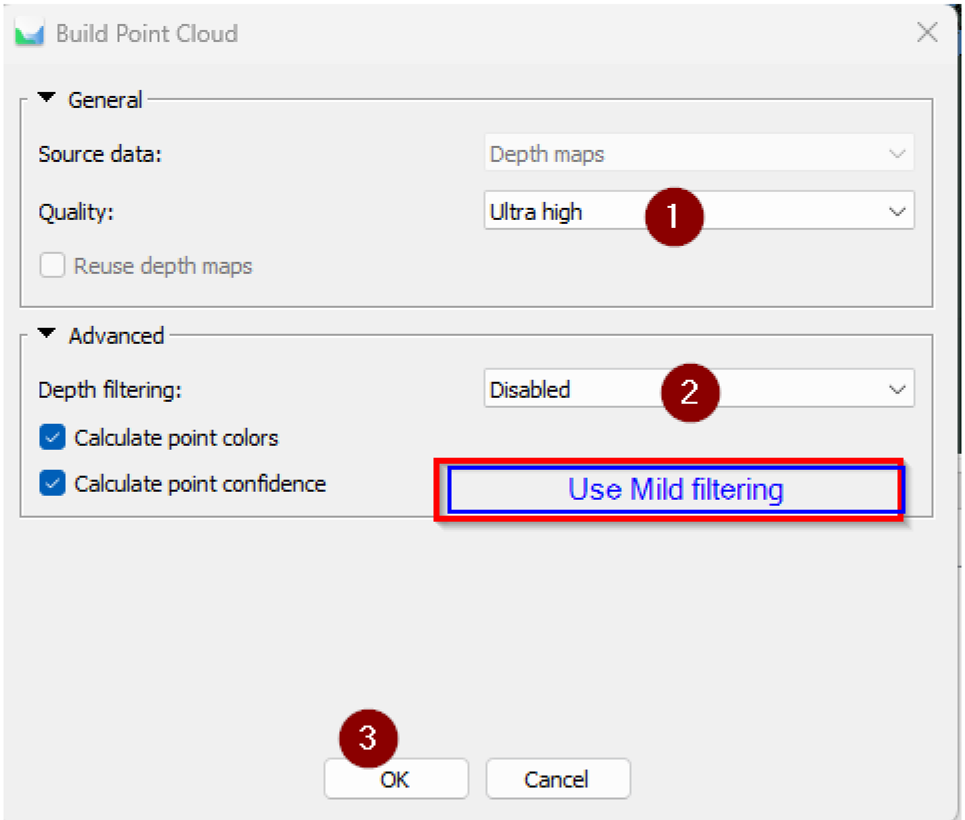


Figure 11: Build point cloud dialog box

Mesh building

Metashape can reconstruct polygonal mesh model based on the point cloud information (Point Cloud, Tie Points imported from external source) or based on the depth maps data.

Select workflow→Build Mesh

In the Build Mesh pop-up menu, select desired reconstruction parameter as follows:

Source data: Point cloud
Surface type: Height field (2.5D). The surface type is optimized to model a planar surface rather than arbitrary object.
Face count: Maximum.
Use default values for other settings.
In Metashape Pro version 2.x, in the dialog box that appears next, click on ‘Yes’ to build the mesh from the point cloud.

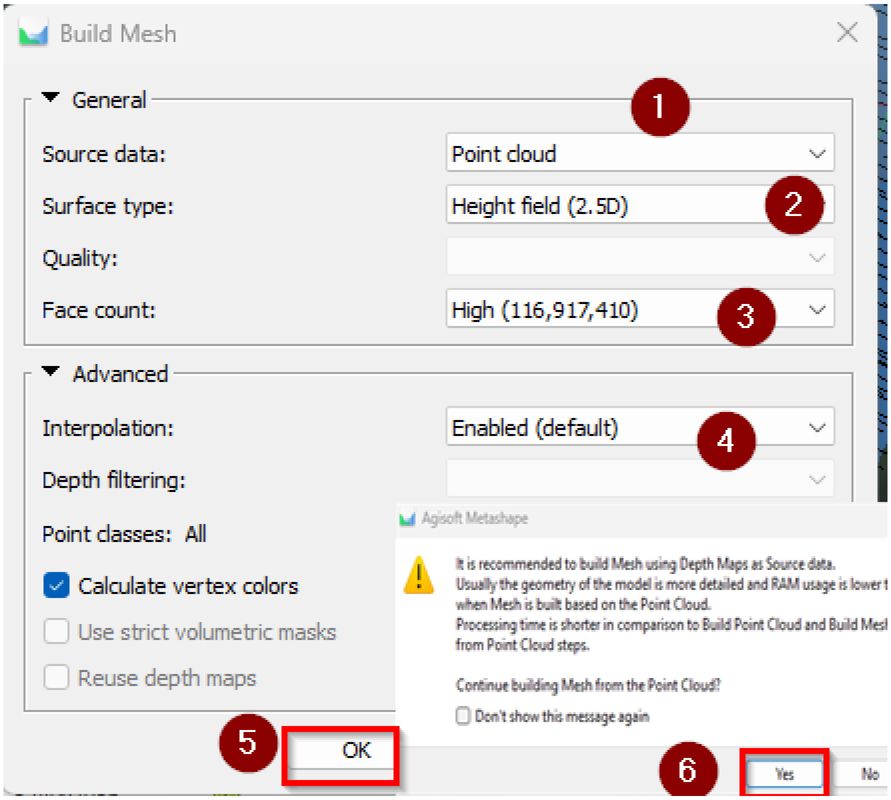


Figure 12: Building Mesh using point-cloud data

Orthomosaic Generation

Orthomosaics can be built using different orthorectification surfaces, for example:

1. Ground surface generated from lidar point cloud.

2. Ground points classified in the photogrammetric point cloud in Metashape, and the resulting surface built from ground points can be used as the orthorectification surface.

3. The dense photogrammetric point cloud can be used to reconstruct a 3D polygonal mesh model that can be used as the surface.

4. The surface model as above was smoothed to remove artifacts due to sharp differences in height, e.g., canopy edges.

To build Orthomosaic

Select the Build go to Workflow → Orthomosaic

In the Build Orthomosaic dialog box, select Coordinate system in which the orthomosaic will be generated or select projection type.

Select type of surface data that will be used to build the orthophoto.

Click the OK button when done.

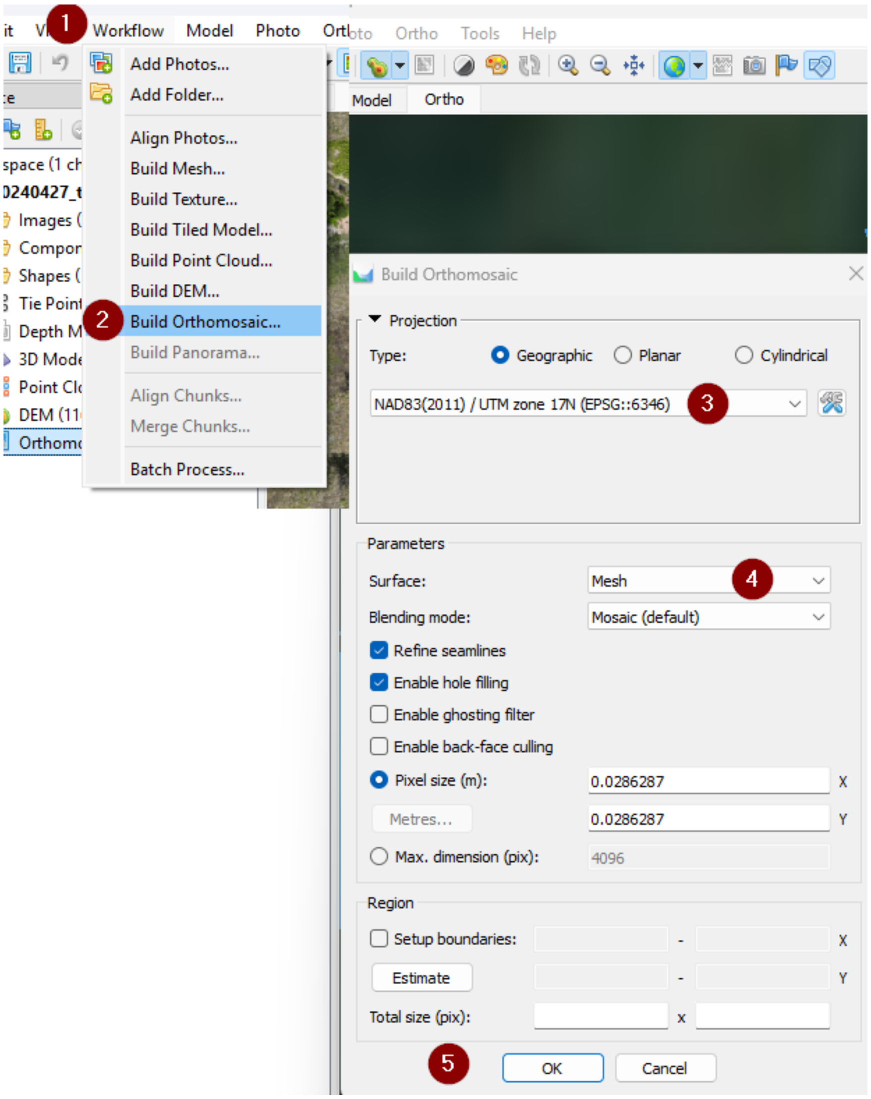


Figure 13: Orthomosaic construction using mesh

Export Orthomosaic

After the Orthomosaic is generated:

Export Orthomosaic

1. Select File→Export Orthomosaic command. OR

   In the workspace pane, select Orthomosaic and right click on it. Select Export Orthomosaic → Export JPEG/TIFF/PNG

2. The Save As dialog box opens, browse the destination folder, choose the file type, and type the file name. Click the Save button: (use the naming convention of **YYYMMDD-tile-tile #.tif)**
3. In the Export Orthomosaic dialog box, specify the coordinate system for the Orthomosaic to be saved in (NAD83(2011) UTM Zone 17N) (#3 in Figure 14).
4. Check the Write KML file and / or Write World file options to create files needed to georeference the orthomosaic in the Google Earth and / or a GIS.
5. Click OK (#4) button to start exporting your orthomosaic

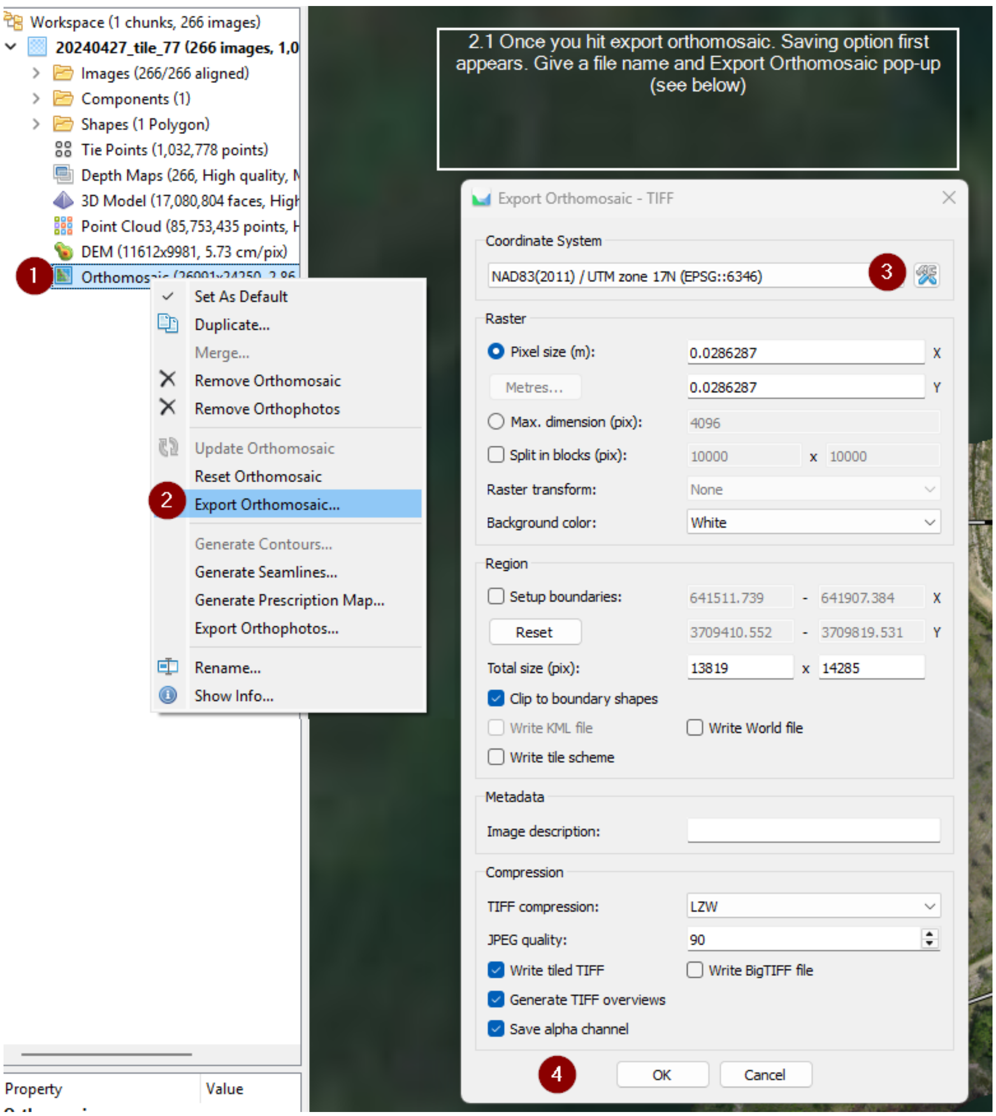


Figure 14: Export Ortho mosaic as a tiff file.

#-- THE END --#