Brief Structure-From-Motion Processing Workflow
SAND Lab

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Disclaimer

The opinions expressed in this handbook are the author's own and do not reflect the view of Wingtra, DJI, Agisoft Metashape, Trimble, or The University of California-Santa Barbara.

Cover Photo: Zach Hilgendorf – WingtraOne Platform, Oceano Dunes, California – 10/2020.

Introduction

The purpose of this workflow is to provide a brief introduction to structure-from-motion processing steps in Agisoft Metashape and pre-processing steps necessary for the Wingtra One Gen II drone. In this document, we describe how to take imagery from your drone and turn it into a multispectral orthomosaic ready to use! Pre-processing steps include putting the base station location data and base station height above the survey point through NOAA's Online User Position Service (OPUS). Once you get a refined position of the base station through OPUS, you can move onto WingtraHub. WingtraHub is a native software to the Wingtra drone used to georeference the imagery to the base station location data using post-processing kinematic (PPK) technology. You then migrate your georeferenced imagery to Agisoft Metashape to generate 3D models and an orthomosaic of your data.

Useful Resources

- Introduction to Structure-From-Motion Photogrammetry playlist
    - Description: The six videos included in this playlist serve as a phenomenal primer to the conceptual basis behind a variety of SfM topics. This is highly recommended for viewing as it includes both conceptual background and Agisoft Metashape tutorials.
    - Author: OpenTopography
    - Hosting Website: YouTube
        - https://www.youtube.com/playlist?list=PLYqCeHIaz7Pi2jpqsROsk064vmOsMPz9v
- Smith, M.W., Carrivick, J.L. and Quincey, D.J., 2016. Structure from motion photogrammetry in physical geography. *Progress in physical geography*, *40*(2), pp.247-275.
- Hilgendorf, Z., Marvin, M.C., Turner, C.M. and Walker, I.J., 2021. Assessing geomorphic change in restored coastal dune ecosystems using a multi-platform aerial approach. *Remote Sensing*, *13*(3), p.354.
- Walker, I.J., Hilgendorf, Z., Gillies, J.A., Turner, C.M., Furtak‐Cole, E. and Nikolich, G., 2023. Assessing performance of a "nature‐based" foredune restoration project, Oceano Dunes, California, USA. *Earth Surface Processes and Landforms*, *48*(1), pp.143-162.
- Agisoft Metashape User Manual. Go here to find definitions of terms and learn what the software can do! https://www.agisoft.com/pdf/metashape-pro_1_8_en.pdf
- Agisoft, L. L. C. 2021. *Agisoft Metashape user manual: professional edition, version 1.8*, (https://www.agisoft.com/pdf/metashape-pro_1_8_en.pdf).
- Over, J.-S. R., A. C. Ritchie, C. J. Kranenburg, J. A. Brown, D. D. Buscombe, T. Noble, C. R. Sherwood, J. A. Warrick, and P. A. Wernette. 2021. *Processing coastal imagery with Agisoft Metashape Professional Edition, version 1.6—Structure from motion workflow documentation*. Reston, VA. http://pubs.er.usgs.gov/publication/ofr20211039.
- Singh, K. K., and A. E. Frazier. 2018. A meta-analysis and review of unmanned aircraft system (UAS) imagery for terrestrial applications. *International Journal of Remote Sensing* 39 (15–16):5078–5098, https://doi.org/10.1080/01431161.2017.1420941.

Pre-Processing

- Download your imagery from your sensor SD card. Download any flight information data from the drone SD card.
- Download your base station .T04 file from the Trimble Receiver
- Use Convert to Rinex software to convert the .T04 file into readable location files (.o, .n, .g). Find more information on these files here: introduction-to-rinex-file-and-how-is-it-used-by-wingtra
- Import your .o file (observation file), base station height, and time spent occupying the benchmark point to OPUS. Read more about OPUS here: https://www.ngs.noaa.gov/OPUS/about.jsp
  - Submit your files here: https://www.ngs.noaa.gov/OPUS/index.jsp
- In WingtraHub, direct the software to your file folder where you have your imagery and flight data stored. Import your base station files. Use the NOAA OPUS latitude, longitude, and orthometric elevations to refine the location data of your imagery. Once you have processed your data in WingtraHub, your imagery will be georeferenced with centimeter level uncertainty!
- Your imagery is georeferenced and has an associated .csv metadata file with latitudes, longitudes, and altitudes for each image. Correct your altitude as necessary based on the difference between the orthogonal and ellipsoid heights.
- Want to know more? Check out Dr. Hilgendorf's Youtube Video to visualize these steps! https://www.youtube.com/watch?v=qbmU8ozX_I8&t=716s
- Now you are ready to bring your images into and metadata files to Agisoft Metashape.

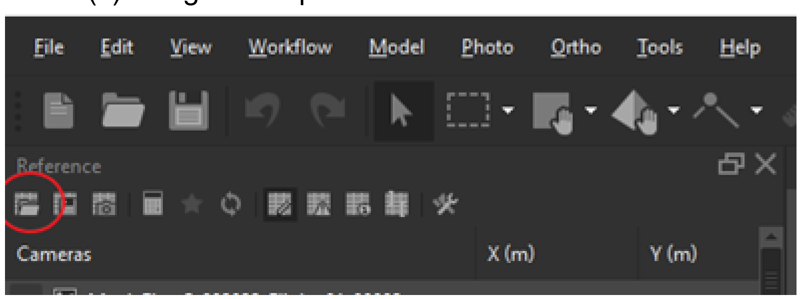
Agisoft Metashape Processing (Structure-from-Motion)*

**See the separate WingtraKnowledgeBase.PDF for a brief, proper workflow on how to process multispectral (MicaSense RedEdge-P) data in Agisoft Metashape. Read that document side-by-side to follow along in the workflow. The written sections here briefly describe the steps taken to process the data from North Campus Open Space (NCOS). Agisoft is a powerful tool for structure-from-motion reconstruction of surfaces that provide output 3D models and orthomosaics. It is important to understand the parameters you use. Please refer to the Agisoft Metashape User Manual (linked above) for details on processing parameters.*

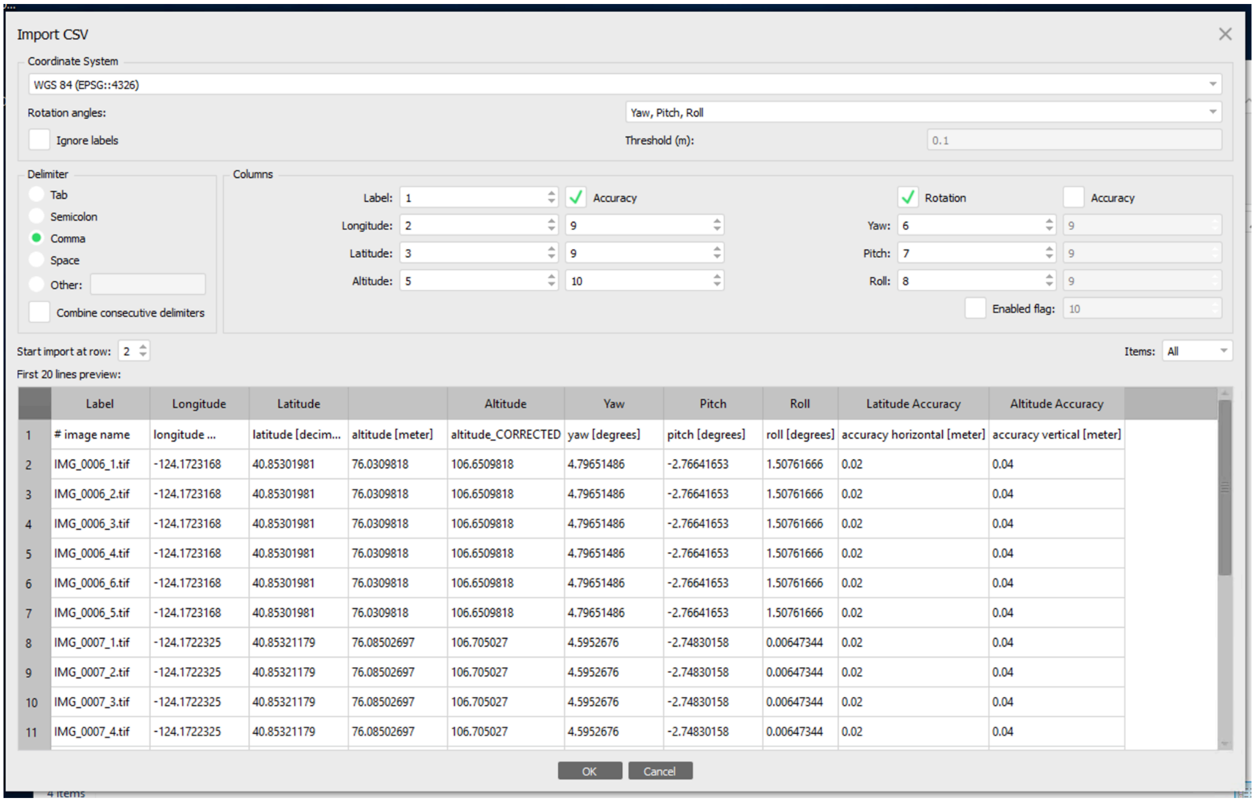
1) Add Photos

If you are using a WingtraOne PPK dataset with a concurrently collected static base station survey, you will need to import the image coordinate data prior to aligning photos. This is the .csv file generated by pre-processing in WingtraHub.

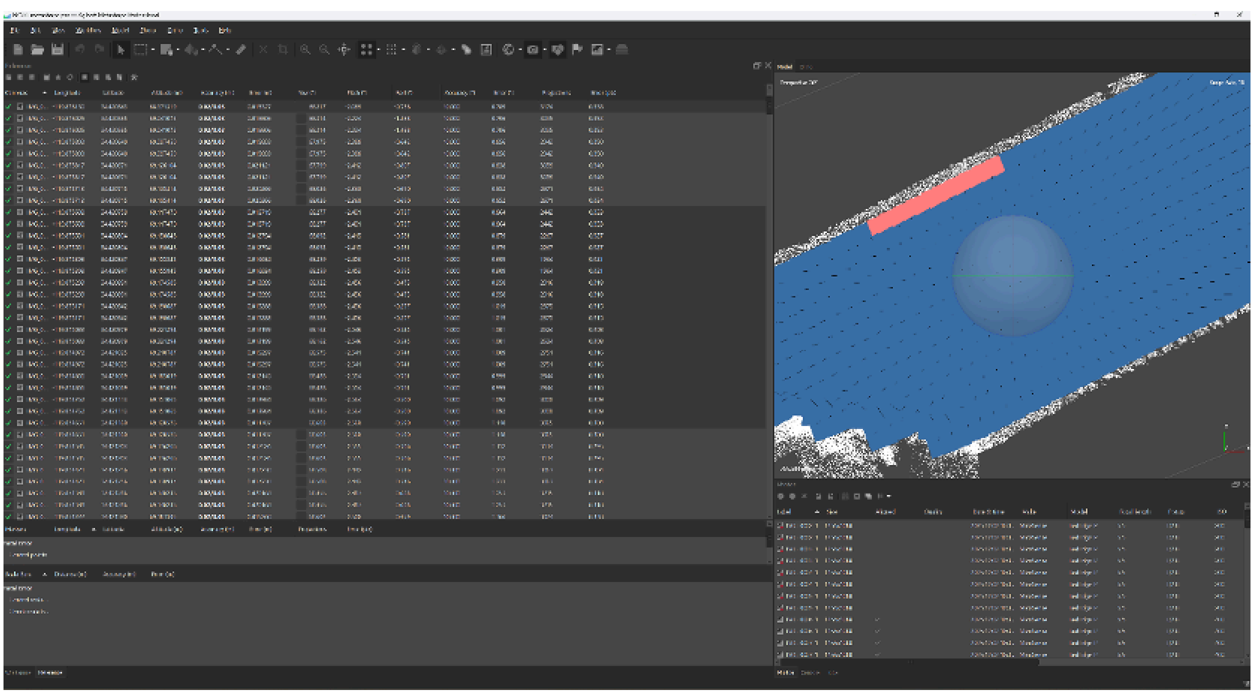
- Import modified .csv(s) using the “Import Reference” tool



- Pay attention that the Accuracy boxes are checked, and that the columns are properly assigned.
  a. Horizontal Accuracy is applied to the Latitude/Longitude or Northing/Easting
  b. Vertical Accuracy is applied to the Altitude

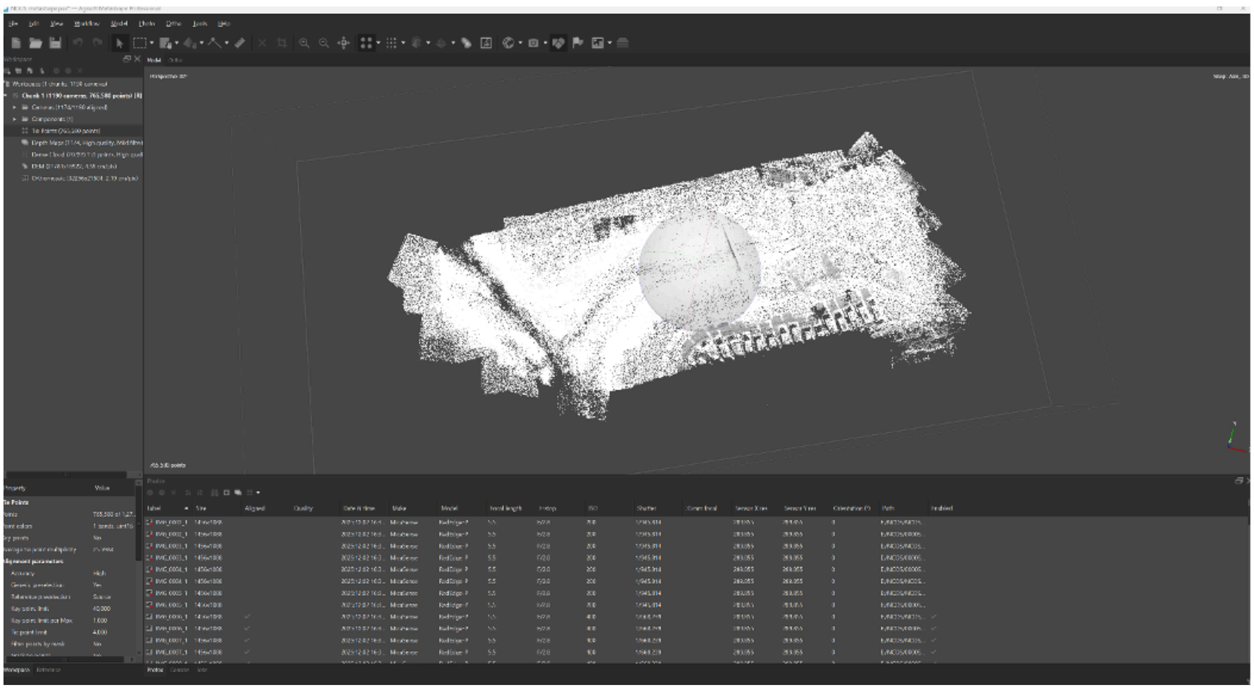


- Image metadata is populated for NCOS as shown below



2) Align Photos

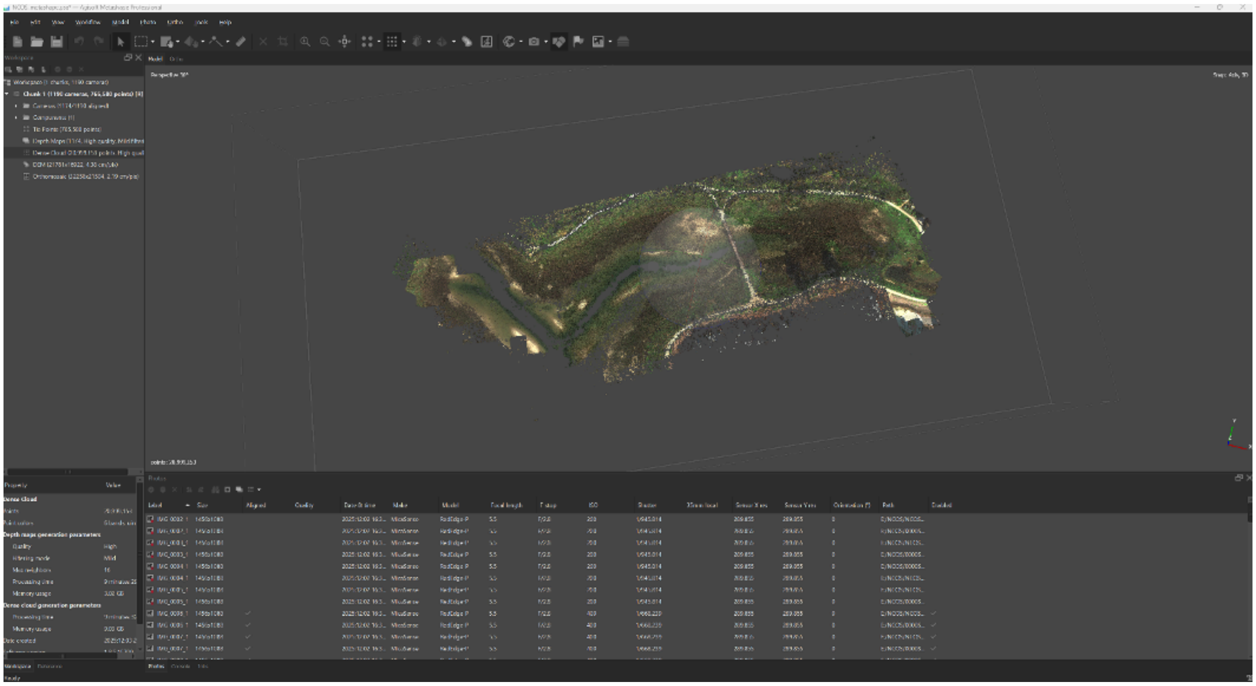
- Align photos by setting key and tie point parameters. At this stage we tell Agisoft to use the image metadata and matching features seen in each overlapping image to produce a 3D reconstruction of the surface (the sparse cloud). This is generated using structure-from-motion technology.
- Sparse Cloud
  - Once your data is aligned you will get a sparse point cloud! See picture below of the one at NCOS. Delete spurious points above and below the surface, and any extras on the outside of your study area.



Dense Cloud

Make sure you manually inspect and clean your sparse point cloud. This will ensure the data used to construct your dense cloud is as accurate as possible.

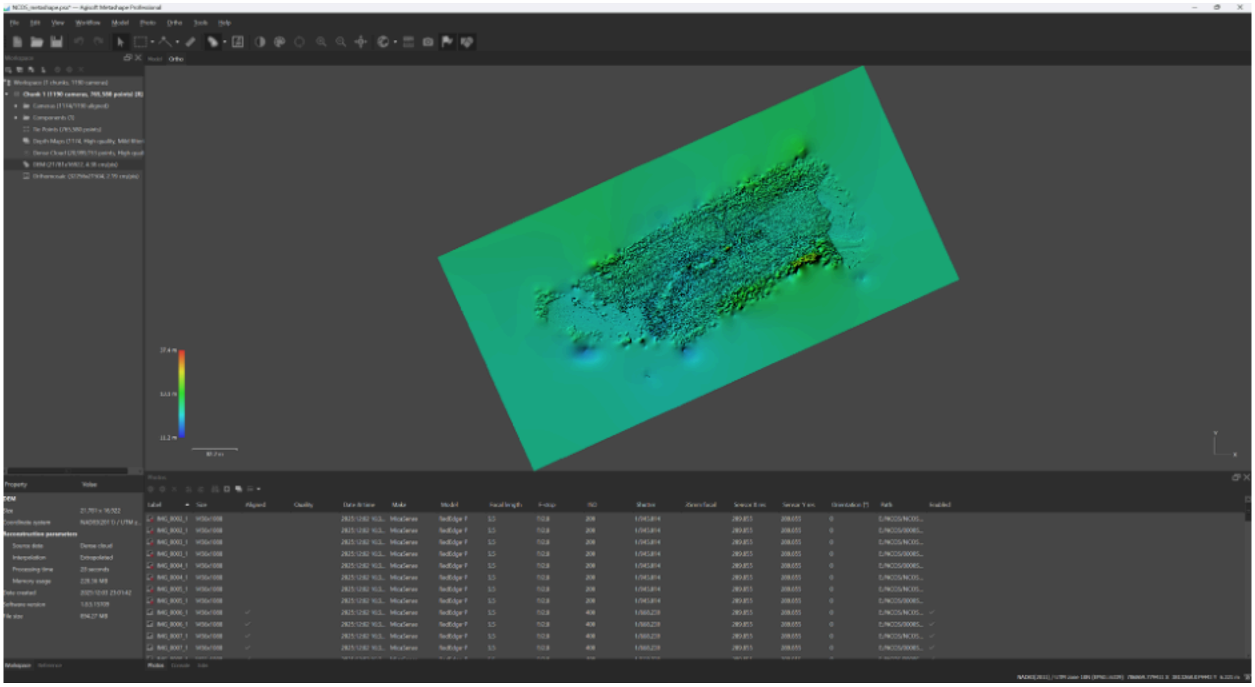
- Build Dense Cloud
- Once hitting OK, this can be a rather time-consuming step (HOURS TO DAYS)
- See the dense cloud from NCOS below



- Cleaning the Dense Cloud
    - Confidence Filtering
        - The dense cloud needs to be filtered in order to remove poor quality points. This is the primary purpose of the “Calculate Point Confidence” step during the construction of the dense cloud.
        - Deleting low confidence points can remove noise.
    - Manual Filtering
        - It is also necessary to manually inspect point clouds for “flyers” and “sinkers”, which are unrealistically high and low points when viewing point clouds horizontally (Over et al., 2021).

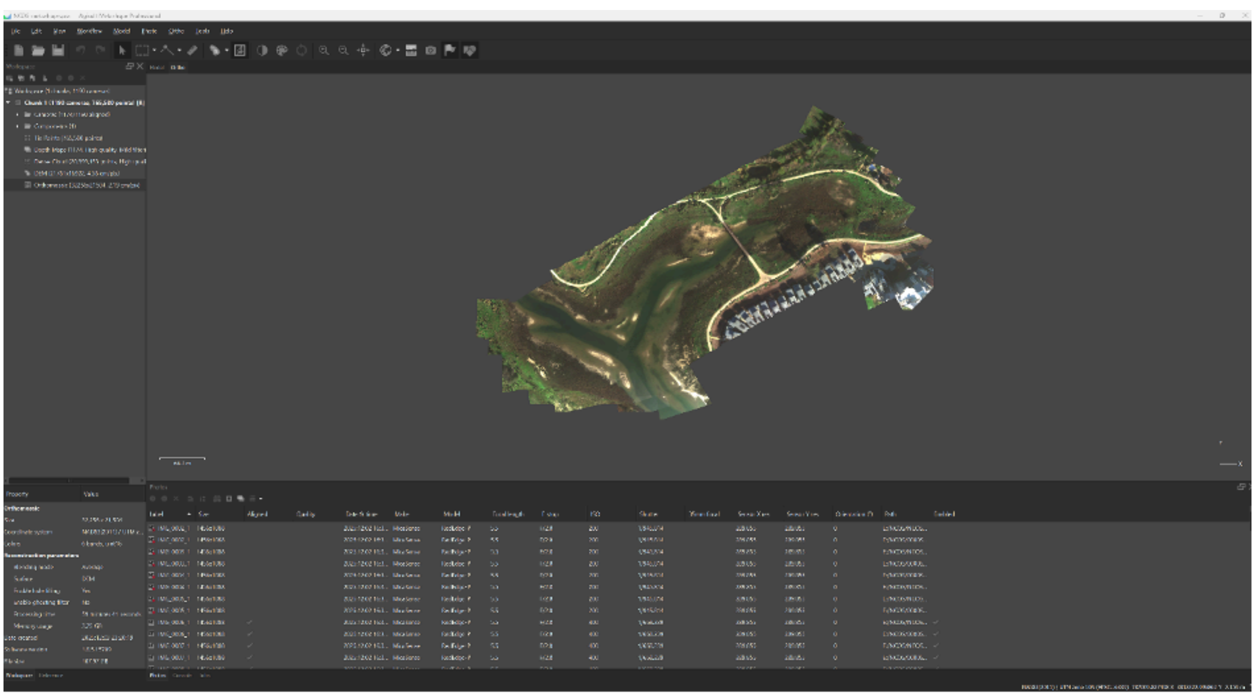
Digital Elevation Model

- Build DEM. This is an intermediate elevation surface created to orthorectify the orthomosaic.
- Here you define your coordinate system from WGS84 to NAD83(2011) UTM Zone 10N
- The resolution and total size varies on the size of the project.
- See the DEM for NCOS below (it is a bit noisy)



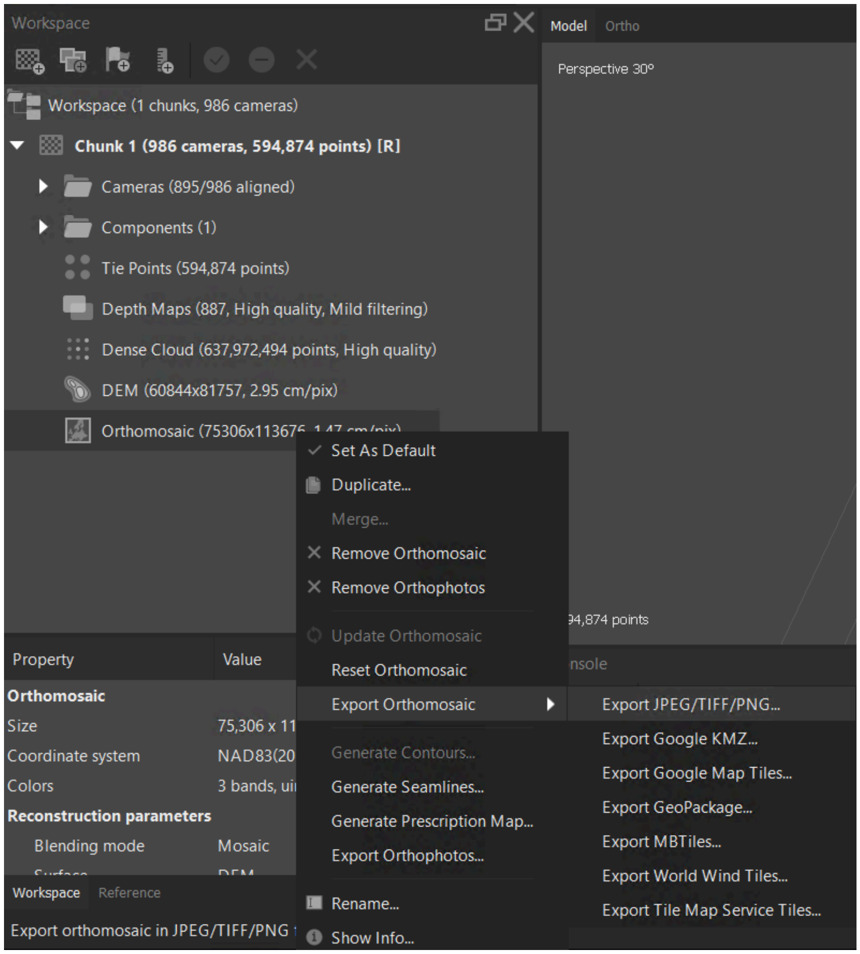
Orthomosaic (your final product)

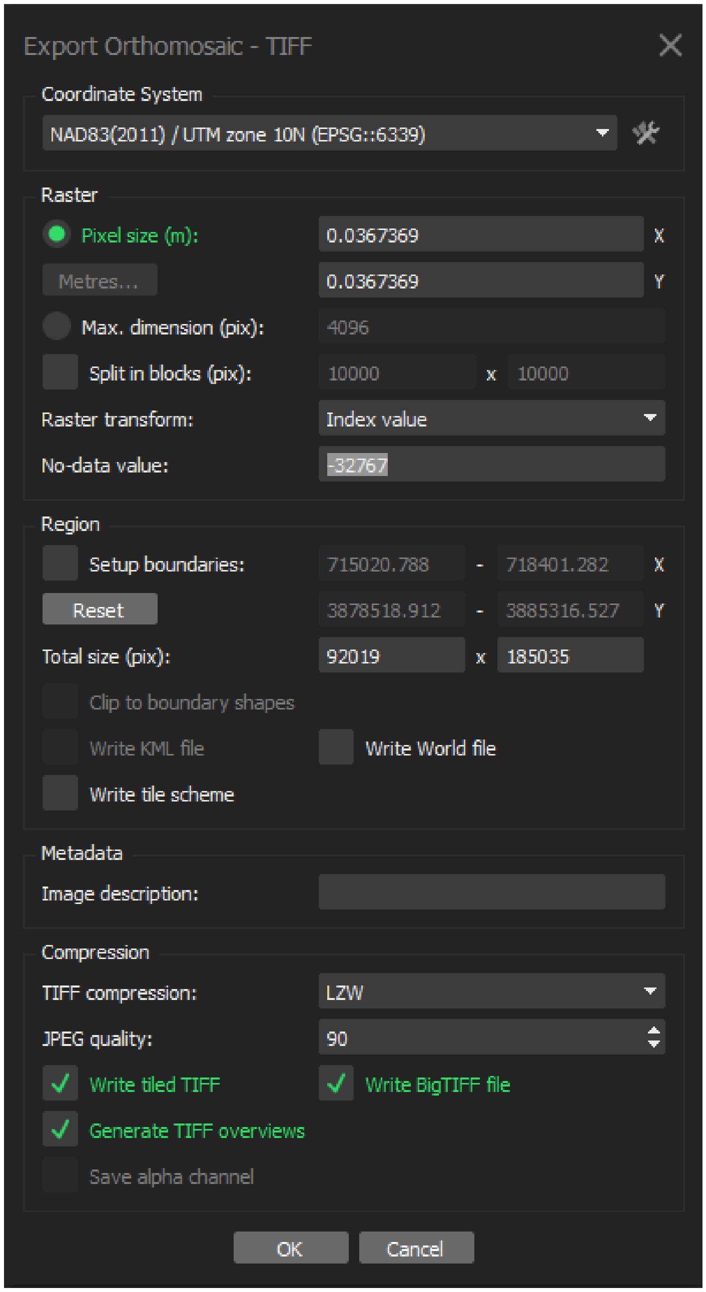
- Build Orthomosaic
- See the orthomosaic from NCOS below



Export Orthomosaic (the data you have for your lab!)

- You have a .tif file for the lab.





- Once exported, the orthomosaic is available for use in most popular GIS platforms (ESRI; QGIS; GRASS; etc.)
    - RedEdge-P (After Pansharpening): Band 1 - Blue; Band 2 - Green; Band 3 - Red; Band 4 - Red-Edge; Band 5 - Near Infrared

Generate Report

- Be sure to generate a processing report so the specification of the project are easily accessible, should you need to reference it further, without opening the project.
- Your report has information about error/uncertainty in your dataset, as well as processing parameters.