Photogrammetry with Historic Aerial Photographs

Up to now we have mostly focused on digital photogrammetry with current (or very recent) photographs taken from drones (i.e., UAS). But the concepts of photogrammetric mapping can be applied to any overlapping photos taken from a camera with a single-focal-point lens.

The first aerial photographs were taken in the 1860’s, and aerial photography was an important application of this developing camera technology.

Starting in 1927 and continuing through the early 1940’s, the Washington National Guard, operating out of Spokane, WA, collected a lot of aerial photographs over eastern Washington and northern Idaho. The University of Idaho’s library hosts an online database of many of these photographs (Information about the UI historic aerial photography collection is available at https://www.lib.uidaho.edu/digital/aerial/about.html).

I personally find these photographs fascinating to look at. What’s even cooler is that many of these photos were taken along overlapping flight lines and we can use the same techniques that we’ve learned with drone imagery to create orthomosaics (and even elevation models) from photos from the 1930’s!

Objectives

The objectives of this lab are to:

- Explore historic aerial photographs from the Moscow, Idaho region from 1934.
- Use Agisoft Metashape to align the historic aerial photographs and create a digital elevation model and orthomosaic.
- Use current features as ground control to add spatial reference information to the historic orthomosaic.
- Evaluate how well the historic orthomosaic aligns with modern orthomosaics and examine changes in the landscape over a period of almost 90 years!

Deliverables

After completing the steps in the lab, answer the questions below and upload screenshots of your historic aerial photo orthomosaic.

Steps

1. Download the 1934 historic aerial photographs from the region east of Moscow, Idaho. These photos cover an area starting on the eastern edge of Moscow and continuing east toward Troy, Idaho just north of Highway 8 (Figure 1). These are the only aerial photos I found in the UI historic aerial photography collection from this 1934 series that cover the Moscow region.

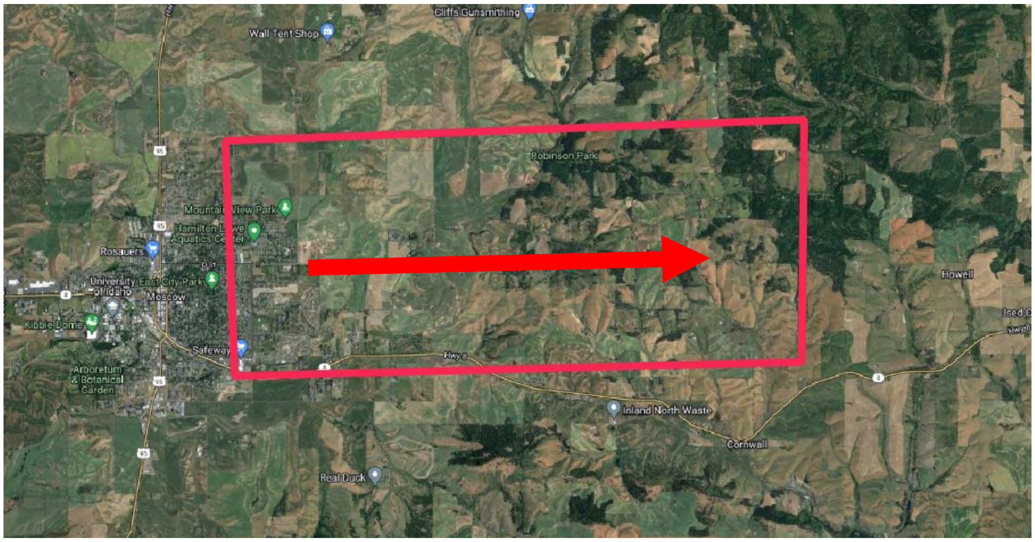


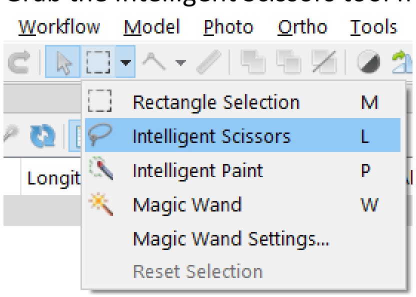
Figure 1. The general flight area covered by the 1934 aerial photographs extends east from Moscow, Idaho north of Highway 8. Flight direction (arrow) was heading east.

2. Add the photos into Metashape and add masks to remove black margins of photos.

   Masks are used to exclude portions of photos from processing in Metashape. In the case of these historic aerial photographs, we need to mask out the black margins on each photo.

   a. Double click on a photo in the Photos tray to open it.

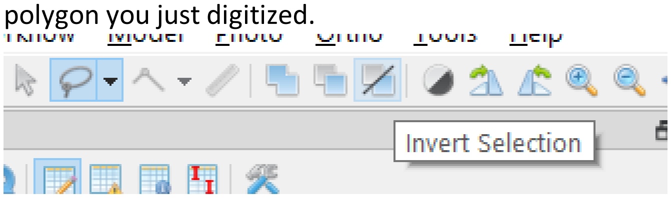
   b. Grab the Intelligent Scissors tool from the main toolbar



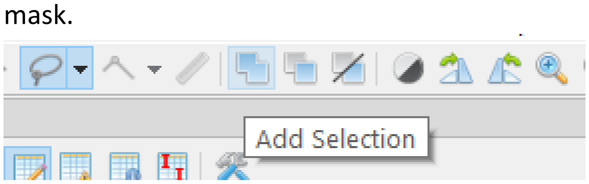
   We will first select the area we want to preserve (opposite of the mask) and then invert the selection to make the mask (easier for photos that may have multiple parts that need to be masked out).

   c. Use the Intelligent Scissors tool to digitize a box or polygon that includes all the areas you want to keep. Double-click to close and accept the selection polygon.

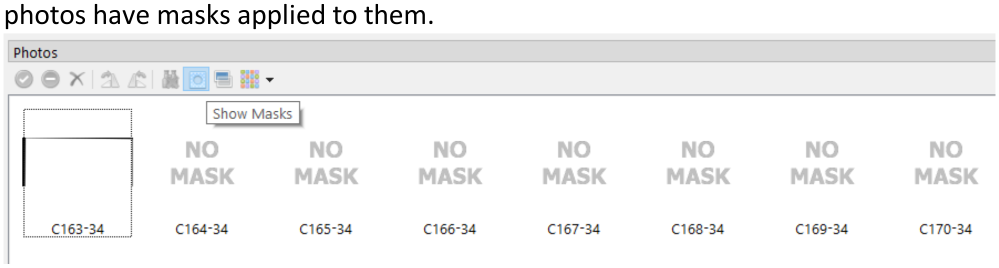
d. Click the Invert Selection button to change the selection to those areas outside the polygon you just digitized.



e. Then click the Add Selection button on the main toolbar to add the selection to the mask.



f. In the Photos tray at the bottom, you can toggle on and off the masks to see which photos have masks applied to them.



g. Repeat this process for all the photos.

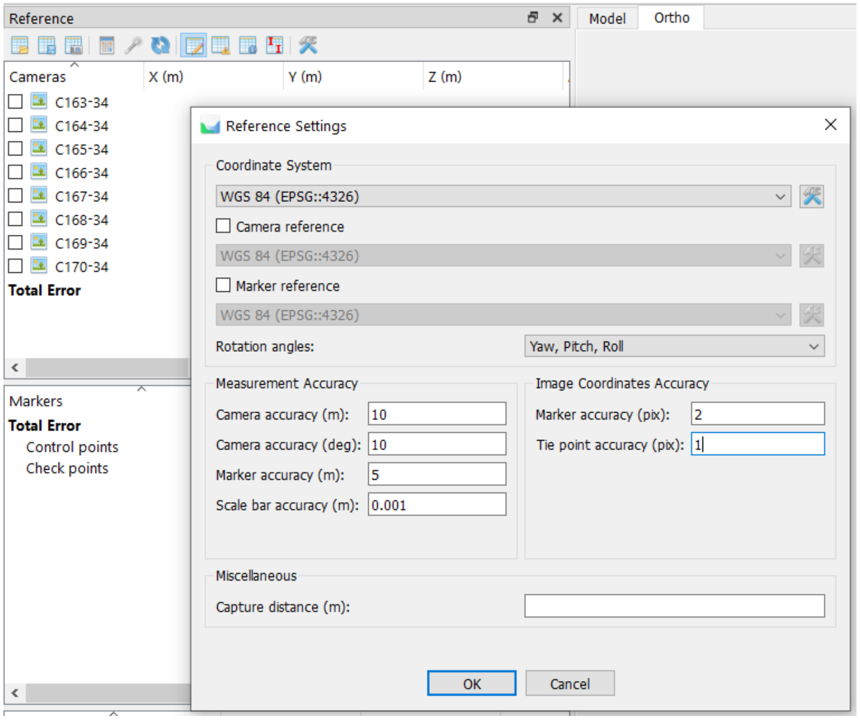
3. Set the coordinate system in Reference Settings
    a. Click on the Hammer and Wrench icon in the Reference window to open the Reference Settings dialog box.

    Because there is no geographic information associated with the photos, Metashape will default to Local Coordinates (m) for the coordinate system.

b. Change the Coordinate System to WGS 84 (EPSG::4326).

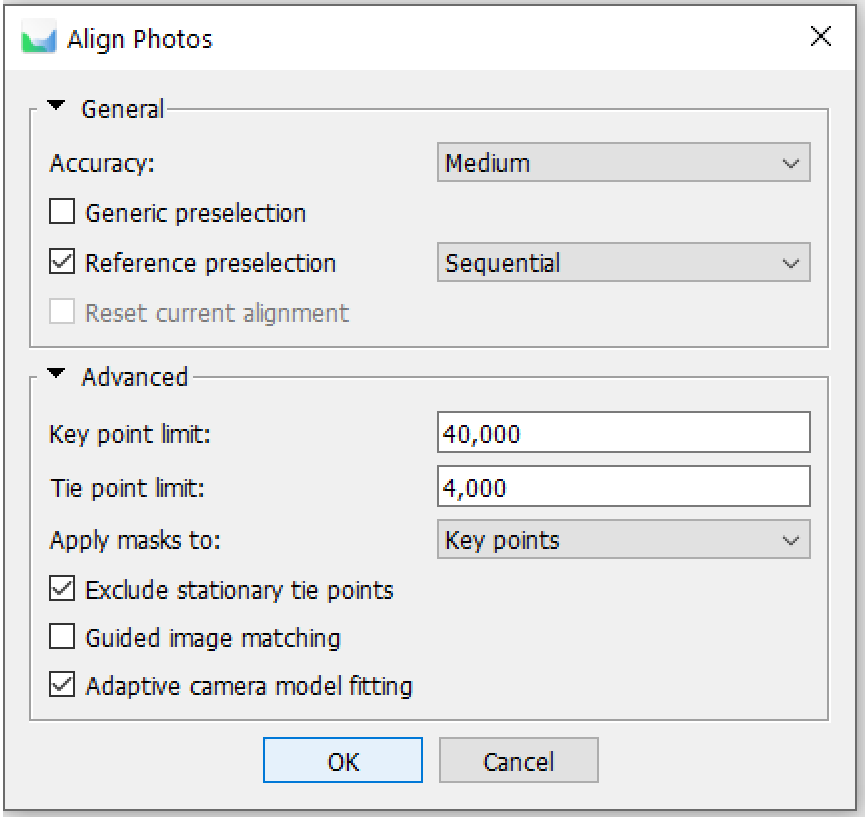
These historic aerial photographs are fairly coarse in resolution and quality compared to modern aerial photography. As such, it can be difficult to accurately place the ground control markers, and we need to change the marker accuracy settings.

c. Change the Marker Accuracy (m) under Measurement Accuracy to 5m.
d. Change the Marker Accuracy (pix) to 2 under Image Coordinates Accuracy.



4. Align the photos
   a. There is no spatial reference information associated with the photos, and the photos are not very high resolution. So, we need to change some settings for the photo alignment.
   b. In the Align Photos dialog do the following:
      i. set the accuracy to “Medium” – This will both speed up the alignment and help with alignment of lower-resolution photos.
      ii. Check “Reference preselection” and change the drop-down option to “Sequential.” Because there is no spatial information we cannot use “Source,” but the photos were collected along a flight line, so “Sequential” will help with photo alignment.
      iii. Under the Advanced options, set the Apply masks to option to Key Points. This will prevent Metashape from creating key points in the masked portions of the photos.

iv. Leave the other options as defaults and click OK to start the photo alignment.



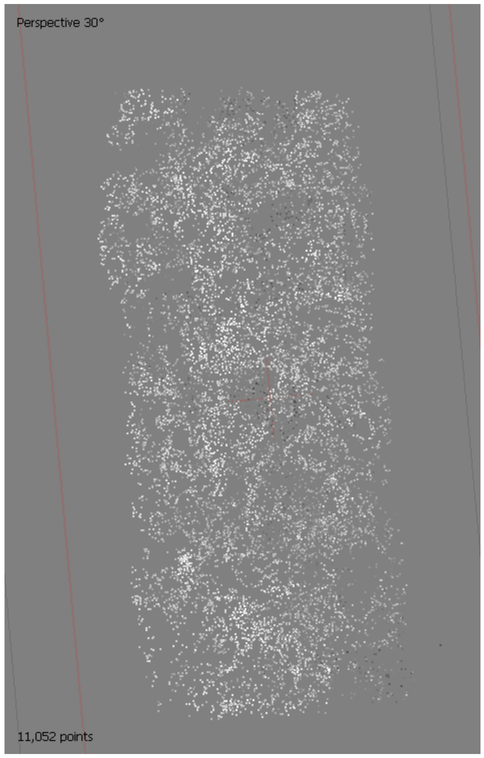
c. Examine the sparse point cloud once the photo alignment is complete.

i. You should see green check marks next to all the photos indicating they successfully aligned.

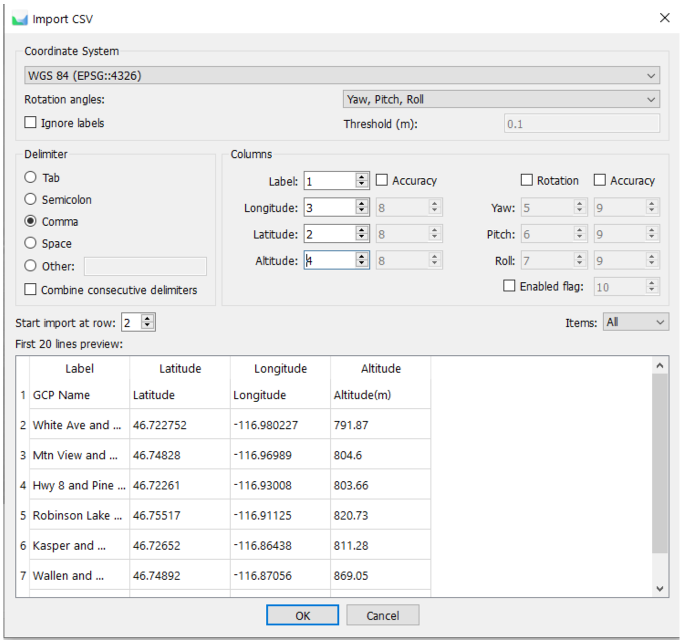
ii. Your sparse point cloud should have around 11,000 points. That is sufficient but is lower than we are used to seeing with drone imagery because of the lower resolution of the historic aerial photos.

iii. The colors of the sparse point cloud look all white because of the overall light color (i.e., overexposure) of the original photos.

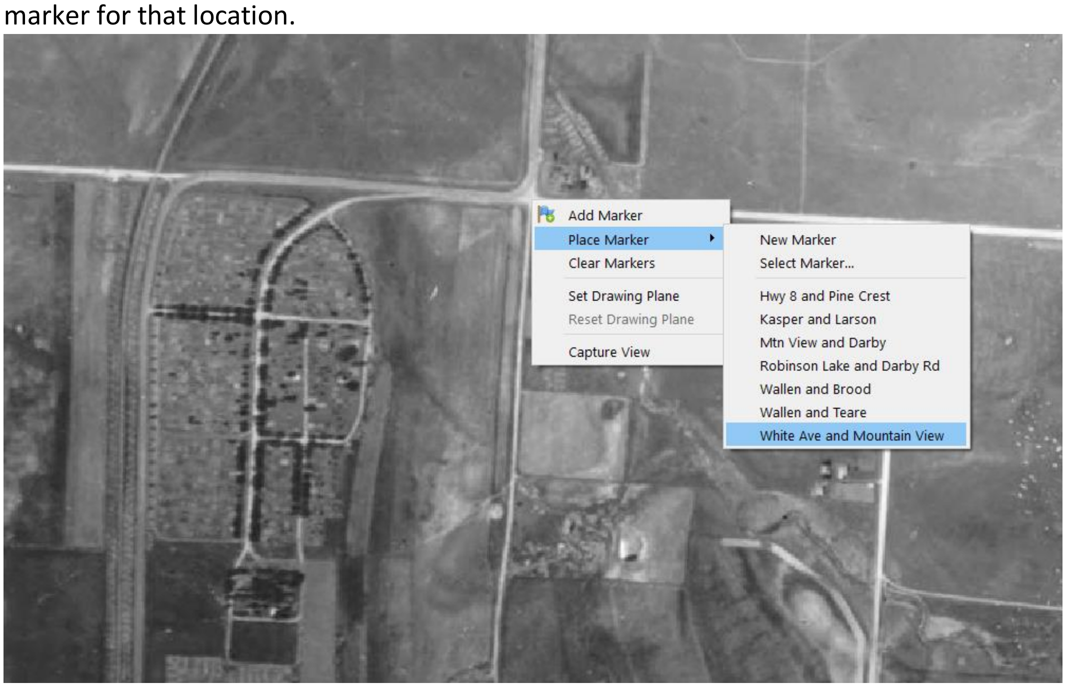
iv. Not also that the model is oriented with the long edge going north-to-south. It is rotated 90 degrees from what it should be because there is no geographic reference information yet.



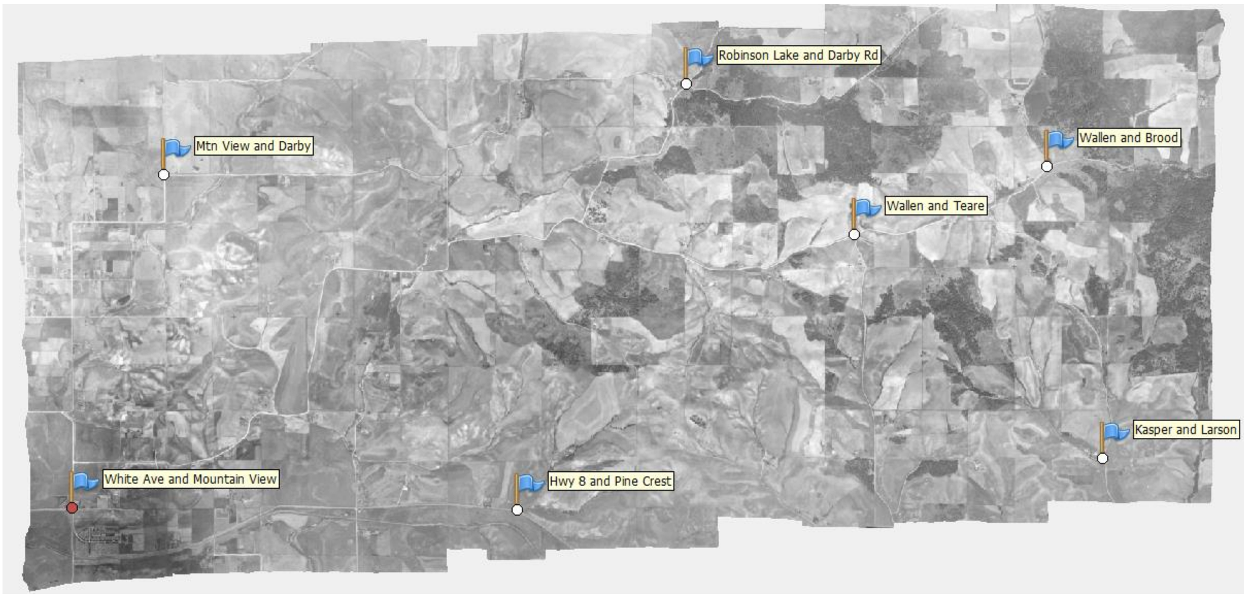
5. For a project like this, we're going to need some ground control information to get our final products to line up with other spatial data. The ground control aspect of this project, however, is probably the trickiest part. We have to find some locations on the map that exist today – almost 90 years later! This can be difficult, especially if you don't know the area. To help things along, I've pre-selected some ground control locations and pulled the coordinate values for them. These are saved in a CSV file that you can import like we normally do with ground control points.



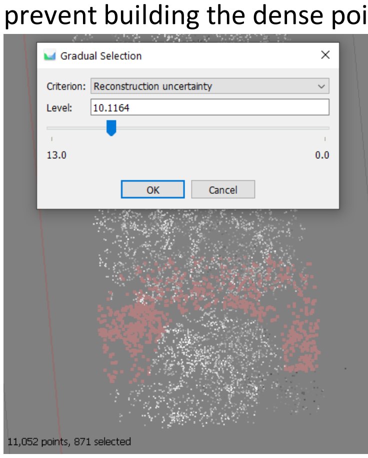
6. Because the photos and the sparse cloud do not have any real-world coordinates, Metashape won't know where to put the ground control points on the model or photos. So we're going to have to find these locations in the individual photos and add the markers manually. I've included a table below that lists which markers go in which photos and gives a thumbnail of where the marker should go (Table 1). The general process is to:
   a. Open the photo by double-clicking on it in the photo tray
   b. Zoom into the correct location for a ground control marker on the photo
   c. Right-click on that location in the photo, choose Place Marker, and select the correct marker for that location.



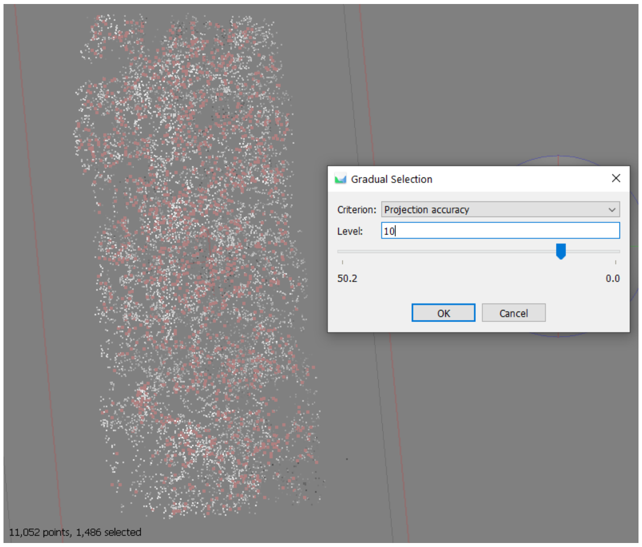
7. When you are done, your overall distribution of ground control points should look like below (NOTE this is displayed on the final orthomosaic, yours will display on the sparse cloud).



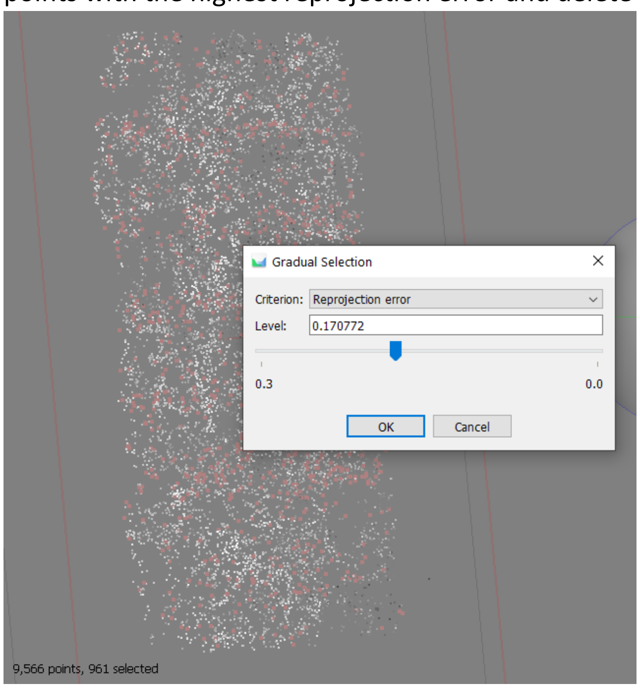
8. The next step is to do some optimization of the sparse point cloud. Because we have only a few photos and not many tie points, we will do only a light optimization. Removing too many points at this stage could degrade the overall stereo model and cause problems for building the dense point cloud.
    a. From the main menu, select Model, Gradual Selection
    b. We would normally start with Reconstruction Uncertainty, but the low overlap of the photos causes even slight changes in reconstruction uncertainty to select tie points all in one region. Deleting all these points would leave a hole in the model which would prevent building the dense point cloud.



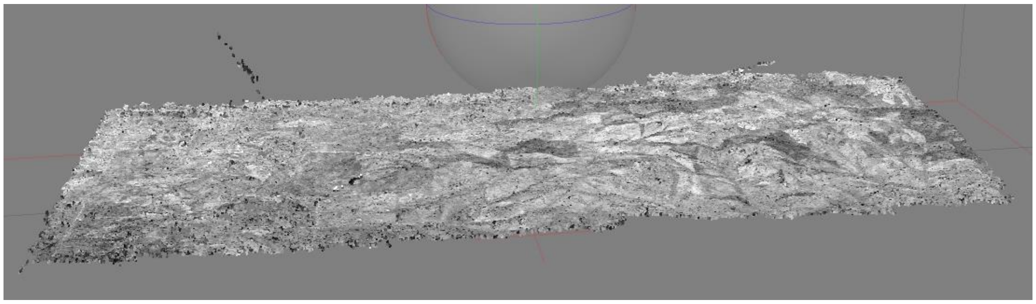
    c. Instead, choose Projection Accuracy and gradually decrease the amount until approximately 10% of the points are selected. Delete these points and then reoptimize the model using the adaptive camera model fitting option.



d. Repeat the gradual selection for Reprojection Error selecting approximately 10% of the points with the highest reprojection error and delete them. Reoptimize the model.



9. Build the Dense Point Cloud with medium accuracy once the model has been optimized.
    a. Take some time to explore the dense point cloud. By looking at the dense point cloud from the side, you may still see some aberrations from the black margins of some of the input photos or other defects in the photos.



b. Select the aberrant points using the Rectangle Selection tool from the toolbar and delete them. Rotate the model as needed to select all the points you wish to delete. Make sure you do not select and accidently delete any valid points in the model.

10. Once you have removed all the invalid points from the dense point cloud, build a DEM for the area. Select a projected coordinate system (e.g., UTM Zone 11, WGS 1984).

11. Finally, you can build the orthomosaic. I just used the default options.

12. You can do a quick evaluation of how well your model aligns with modern imagery by toggling the background imagery (globe icon in the toolbar, blue circle below) in the Ortho window. You can turn the orthomosaic on and off using the ortho button (shown in red circle below).

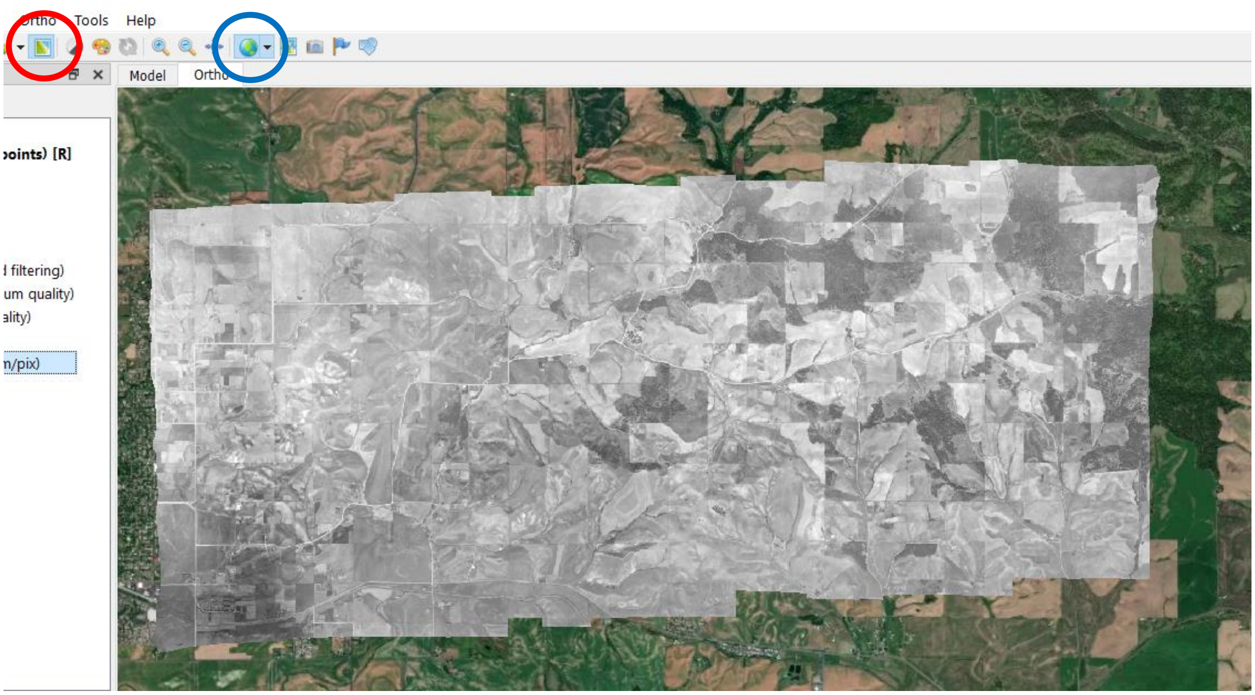


Table 1. Ground Control locations and information

GCP Name	Latitude	Longitude	Altitude (m)	Photos	Snapshot

White Ave and Mountain View	46.72275	-116.98	791.87	C163-34, C164-34	
Mtn View and Darby	46.74828	-116.97	804.6	C164-34, C165-34	
Hwy 8 and Pine Crest	46.72261	-116.93	803.66	C165-34, C166-34, C167-34	
Robinson Lake and Darby Rd	46.75517	-116.911	820.73	C166-34, C167-34, C168-34	

Wallen and Teare	46.72652	-116.864	811.28	C167-34, C168-34, C169-34	
Wallen and Brood	46.74892	-116.871	869.05	C168-34, C169-34, C170-34	
Kasper and Larson	46.74371	-116.892	900.88	C169-34, C170-34	

Lab Questions to Answer

Please answer the following questions and where appropriate provide justification for your answers.

1. Include a screenshot of your final orthomosaic.

2. Check out the DEM that you created from the historic aerial photos. What do you notice about the features that DEM captures and the overall properties of it? What would be the value of a DEM like this (aside from orthorectifying the historic photos)?

3. How well did your orthomosaic line up with current imagery? What might you do to improve the overall fit?