Aerial Photo Rectification

ERDAS Imagine 2016

Description: We will be using ERDAS Imagine to georeference aerial photos to a DOQ image. We will try to achieve this with a total RMS (root mean square) error of less than one half pixel.

Rectifying scanned aerial photos of southeast Minnesota using ERDAS Imagine

Objective: To rectify 1:15,840 aerial photos with a total RMS (root mean square) error of less than 0.5 pixels (0.5 meters).

Background: The color infrared aerial photos of southeast Minnesota that you will be working with were acquired by the Minnesota Department of Natural Resources at a nominal scale of 1:15,840. They were scanned at a resolution of 300dpi (dots per inch) to produce a digital image. The data are in the Imagine file format (IMG).

General Overview: Rectification is the process of transforming the data from one grid system into another grid system using a geometric transformation. It may involve correction of feature displacement in an aerial photograph in order to produce a planimetrically correct image of the landscape. The georeferencing process is accomplished by matching corresponding points from an already georeferenced image (in our case Digital Orthophoto Quads (DOQs)) with the same points on the scanned aerial photo image. This series of points will then be used to compute the best fit polynomial transformation to align the image to the correct geographic area (don't worry, the computer does this for you!).

The first goal is to locate the matching corresponding points, or **ground control points (GCPs)** of permanent objects. The best GCPs are stationary features such as road intersections and landmarks. In general, you should not choose control points in areas that may change such as shorelines, riverbanks or forested areas. If you must choose natural features, try to find small islands in lakes that appear to be similar in both sources. Select their center/centroid points (usually the highest point) in order to try to account for change in water levels. Other types of points that may be helpful are irregular areas in the shorelines along the lake that look very similar, or patches of wetlands with a centroid or unique point. Individual trees are going to be very hard to distinguish due to the pixelation of the images, but if you can find one standing alone in both images they could also be good GCPs, if necessary.

The second goal will be finding GCPs near the four corners of the image, and evenly distributed throughout the image. If you cluster control point pairs only in a certain area of the image, then your rectification is likely to be much less accurate as you move away from those points. We will find 20 or more GCPs, and correct for those which contribute the most error to the overall **root mean square (RMS)** value.

Finally, we will **"resample"** the image, which essentially fills in the geometrically correct pixels with DN values based on the values in the input image. The three possible resampling methods are nearest neighbor, bilinear interpolation and cubic convolution. We'll use nearest neighbor which assigns each corrected output pixel the value of the nearest input pixel while keeping the radiometry intact.

For further reference: Read Campbell sec. 11.6, or Lillesand, Kiefer and Chipman sec. 7-2.

Getting Set Up in ERDAS:

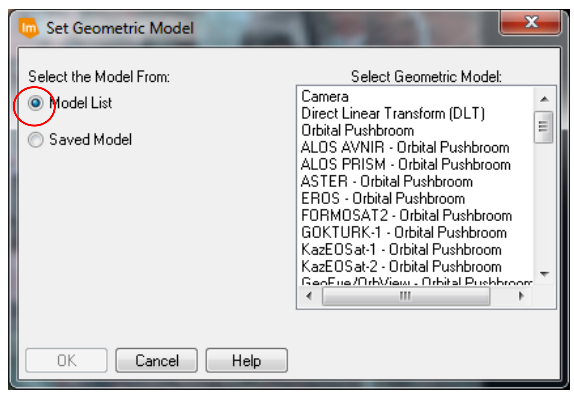
- Start **ERDAS Imagine 2016**.

- The data needed for this lab is in the S:\FR3252_5262 class folder and Lab 03. To **load the color photo**, right click on 2D View #1 and select **Open Raster Layer**. The Select Layer to Add dialog box will open. Navigate to the file **aerialphoto.img** and then click **OK**. Right click on the image and **Fit to Frame** to see the entire image. Click on the Metadata large "i" in the Home ribbon tab to view the image metadata. Note this data source is missing spatial reference information, but we will remedy that as we continue with the rectification process. Let's jump right in!

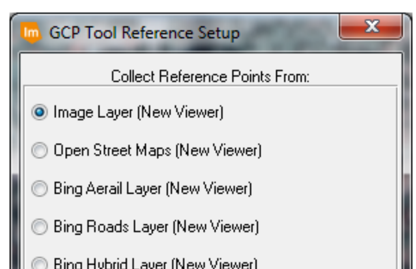
Selecting Ground Control Points

- Be sure the ERDAS window is expanded to full size using the windows controls. If it is not, some menu choices may not appear in the steps below, though you can navigate to the place via help. Close any other ERDAS windows that may be open.
- To begin georeferencing, first click on the aerialphoto.img in the **2D View #1**to select the layer. Click on the Multispectral ribbon tab and click on the **Control Points** button. It is part of the Transform & Orthocorrect group.

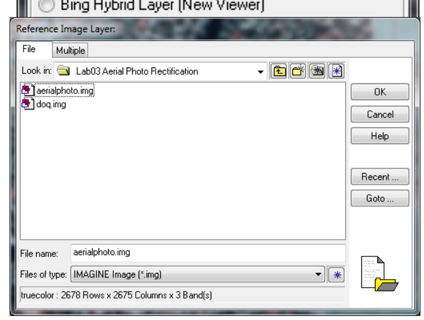
- The Set Geometric Model dialog box will appear. Make sure Model List is selected and scroll down in the Select Geometric Model listing until you can click on the Polynomial model choice and click OK. Notice there are a lot of choices here, choose two or three of them and find out more by selecting the model type and clicking on 'Help'.



- The Multipoint Geometric Correction window will open up with your uncorrected imagery and you should get the GCP Tool Reference Setup window in front of it. If the radio button is not already selected, make sure the reference points will come from Image Layer (New Viewer) and click **OK.** You will be asked to browse to your reference image.

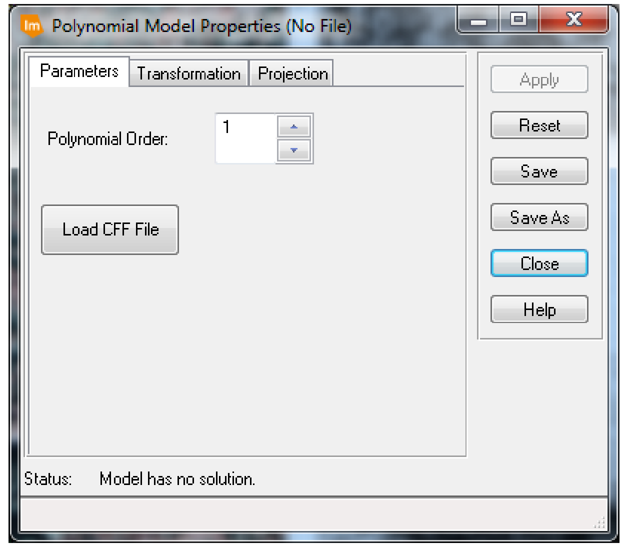


> *Tip: click the 'Recent' button to more quickly navigate to the folder where your reference DOQ is located*



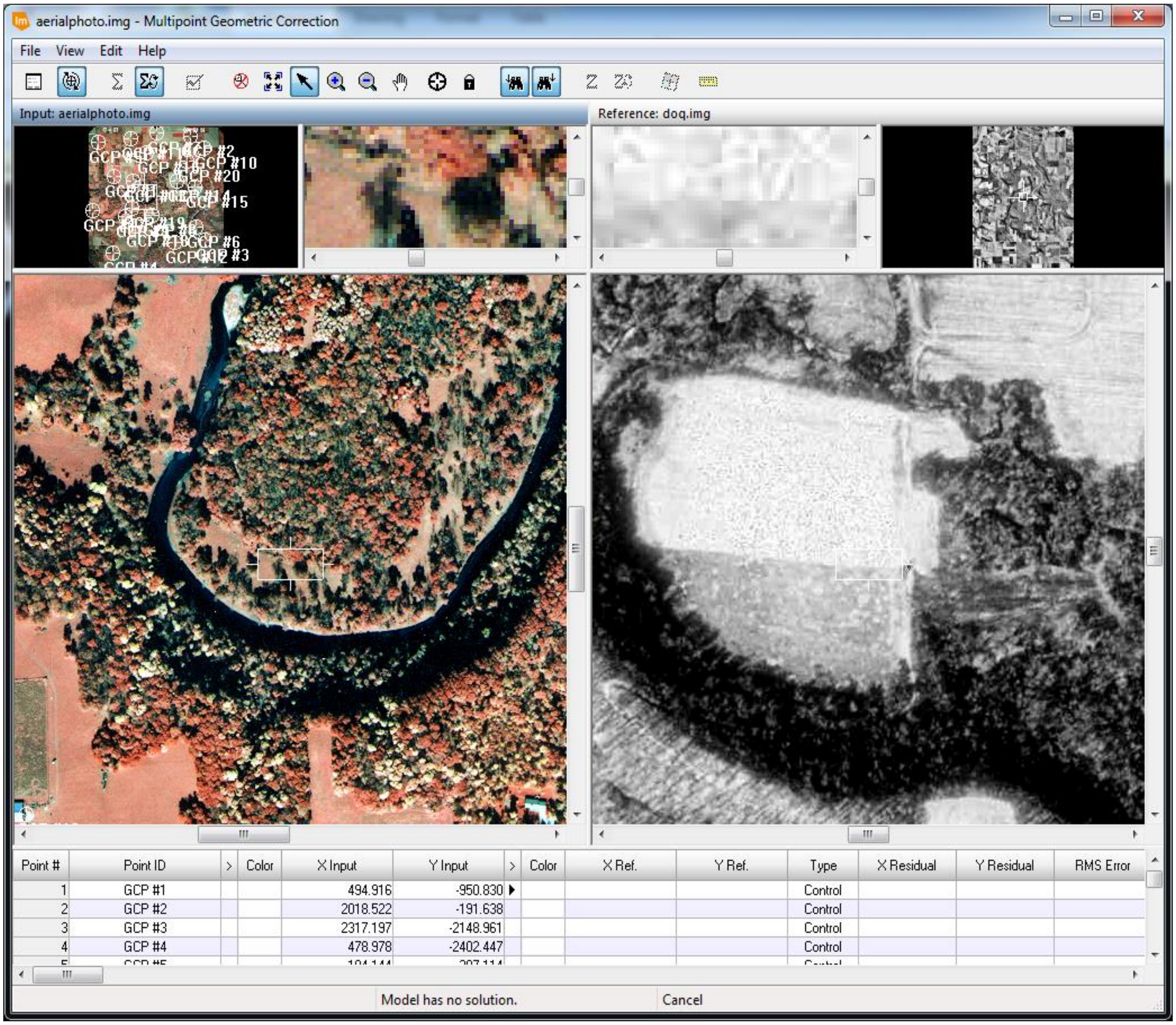
- The Reference Image Layer dialog opens up. The software is asking for the image we will use to provide our geographic reference points. Navigate to the Lab 03 folder and select **doq.img** and click OK (or just double click on doq.img

- The *Reference Map Information* dialog box opens telling us the reference is UTM Zone 15 NAD83. Just go ahead and click **OK** to continue



- The Polynomial Model Properties Box appears. Click the up arrow to move the Polynomial Order to 2 and then the down arrow to return it to 1. This should activate the Apply button so you can click **Apply.** Then click **Close** to continue. If you didn't already read the Polynomial Model help document earlier, take a look at it now so you get a general sense of what the Polynomial Order means/does.

- Your screen should now look like this: (Multipoint Geometric Correction)



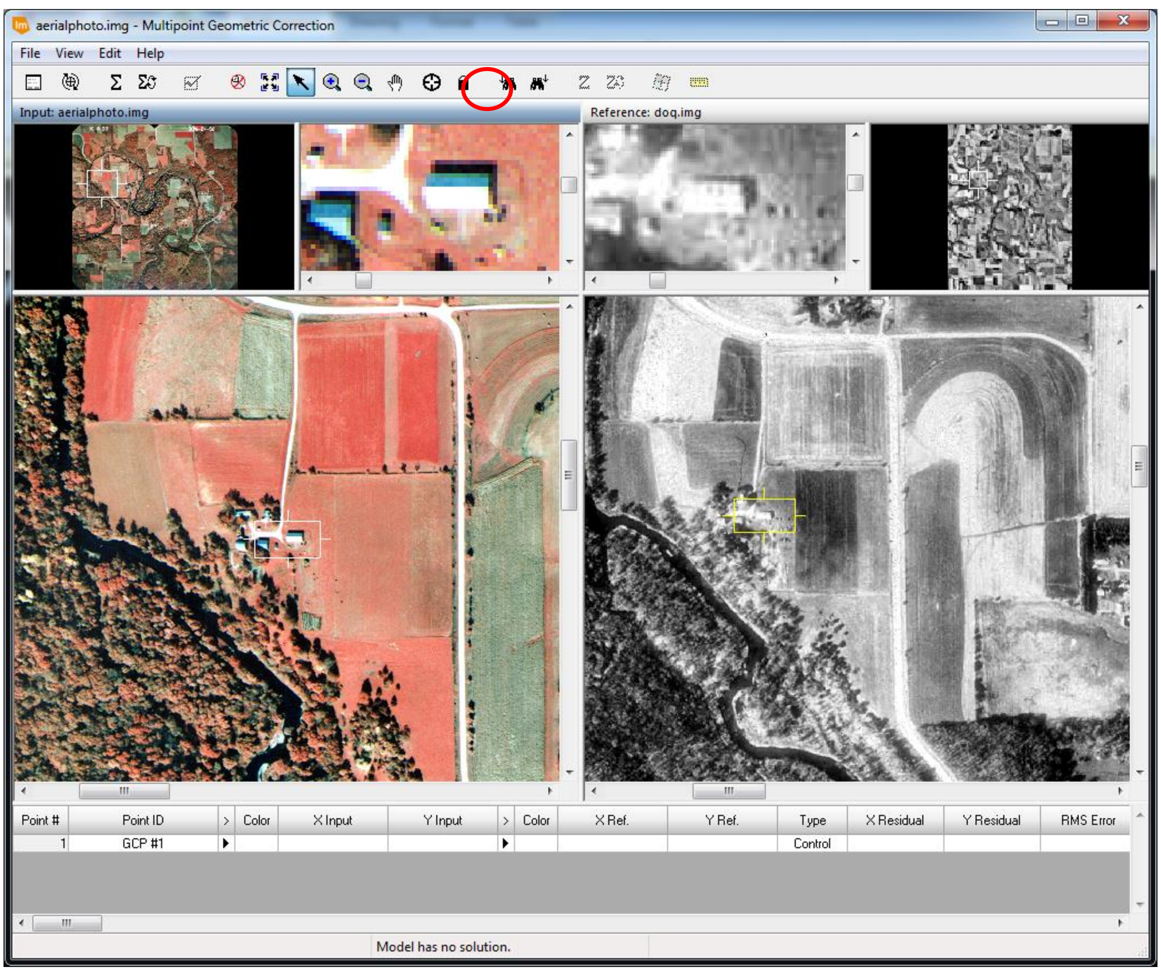
- The Multipoint Geometric Correction (MGC) window is now our master work area for the rest of the lab. In the left half you have various views of the uncorrected aerial image that we want to rectify. In the right half are views of the black and white DOQ image that contains our reference geographic information. As we pick matching points in each photo, coordinate information of the points will appear in the table at the bottom of the screen.

- You may find that there are GCP points that appear in the color image on the left and in the table below the images, which is an interesting bug in ERDAS that makes it difficult to run a lab lesson like this. You can take a look at these points to see what the general distribution should look like, but do not keep them - the main task for this lab is for you to **create your own points**! Select the rows in the table by dragging your mouse from top to bottom (or right click and choose Select All) and then Right click to delete.

- Click on the "Toggle Fully Automatic GCP Editing Mode" icon  in the Multipoint Geometric Correction window so it is **NOT** depressed (look in the help documentation to find out what this button does).

- You will notice in the aerial image in the upper left pane (the least zoomed in pane) there is a square white box. If you position your mouse over it the cursor becomes a 4-headed arrow. If you click and drag, notice what you see in the larger pane below. Move the 4-headed cursor around until an easily identifiable object appears in the lower pane (like a farm house). Now move the white box in the lower pane until it is directly over the farmhouse and notice that in the upper right pane the farmhouse will appear enlarged. Take some time to orient yourself to how the various levels of zoom and pointers work together. You can change the overall zoom level by right clicking in the lower pane. As you do this you will see how the upper left square box changes size to match the view of the lower pane. You can also click on the edges of either of the white squares to change the relative scene of the pane it represents.

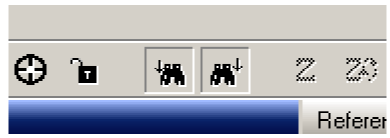
- Try to find some geographical landmarks in the aerial photo. Now, right click on your DOQ and select **Fit Image to Window**. Find the same landmarks on the DOQ that you found in the photo. Use the zoom and pan tools to help you. Take some time to set up your window so both the input and reference windows are of similar scale. There are tools at the top of the viewer windows and you can also right click in the viewer and left click on "Zoom" to select the level of zoom desired. Here's a sample of how the two should look:



If you find that the link boxes are difficult to see, you can change their color by right clicking on the box and selecting **Link Box Color…**

- Click the Create GCP  in the GCP tool window. In the highest zoom pane of the aerial image, carefully click on an object. GCP#1 will be created. Now Click Create GCP  again and Click on the matching object in the DOQ image pane with the highest zoom. GCP#1 will be created in that image as well.

Helpful Hint: If the two Binocular icons are depressed any time you click on a row containing the GCPs, the main screen will display the corresponding Input and Reference point

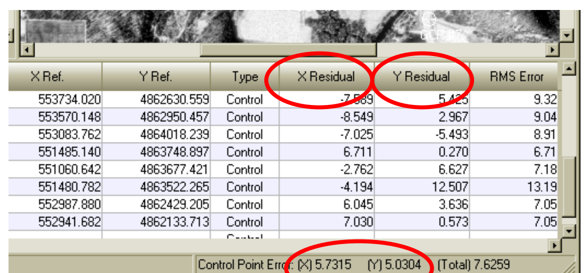


Another Helpful Hint: ERDAS has been known to occasionally crash during this lab! You should consider saving your points periodically. In the File menu, select **Save Input As...** to save points in the left side of the screen to your student drive and select **Save Reference As**... to save the points on the right side of the screen.

- By now you should have GCP #1 listed in the GCP Tool window. You should have data for the X Input and Y Input (the photo location of the GCP) and X Ref. and Y Ref. (the location on the DOQ). Repeat this process for at least six more GCPs.

- Once you have at least six GCPs, you can click on the summation icon  to solve for your model (this is where the Polynomial Model is doing it's 'behind the scenes work').

- Now you will see X Residual, Y Residual and RMS Error information. You will also see Control Point Error for (X) and (Y) and a (Total) about your GCP list. *What do these numbers represent?*



X Ref.	Y Ref.	Type	X Residual	Y Residual	RMS Error
553734.020	4862630.559	Control	-7.589	5.425	9.32
553570.148	4862950.457	Control	-8.549	2.967	9.04
553083.762	4864018.239	Control	-7.025	-5.493	8.91
551485.140	4863748.897	Control	6.711	0.270	6.71
551060.642	4863677.421	Control	-2.762	6.627	7.18
551480.782	4863522.265	Control	-4.194	12.507	13.19
552987.880	4862429.205	Control	6.045	3.636	7.05
552941.682	4862133.713	Control	7.030	0.573	7.05

Control Point Error: (X) 5.7315 (Y) 5.0304 (Total) 7.6259

- Continue finding control points with this method until you have a minimum of 20. More GCPs are better, so try using 30 if you can.

- Also, you can try to use the automatic GCP  and automatic solving buttons . *What do these applications do for you?*

- Cover the photo thoroughly in selecting your GCPs! **It is important to distribute the ground control point pairs over the entire aerial photo, extending all the way to the corners.** Try to get a GCP close to each of the four corners. This may be challenging if you are on top of a bluff in a field where there are few roads and other permanent features.

Minimizing the Root Mean Square Error

- The RMSE is important because it is a measure of the spatial error in the photo. We seek the smallest RMSE we can achieve.

- The residual columns give a measure of how much each point contributes to the total positional error. The X and Y residual will help you understand the contribution to the error by direction. To achieve the best possible RMSE (less than 0.5 pixels at a minimum - you need to know the pixel size of your image to translate your total error, which is measured in meters), we require careful placement of the GCP points. In the screen shot above for example, you might start by examining the row that contributed 13.19 to the RMS Error. Make certain that the two GCPs are placed on the exactly on the same location. Move one of them if necessary. Often error can be reduced by deleting control points and then recreating them, being a bit more precise with their location. While it is tempting, a control points with a high residual should not just be deleted. It may likely be telling us there is something "going on" in that part of the image that may require other actions such as clipping that portion of the image out and processing it separately.

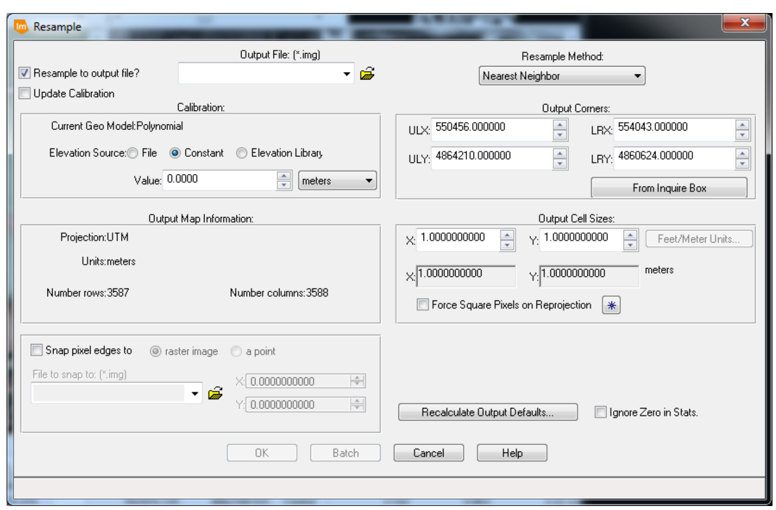
> *Don't Fudge the Points! You can reduce the overall RMSE by deleting "bad" points or artificially moving GCPs to where they no longer match optically but lower RMSE. You will end up with a low RMSE but when you overlay your final image the pixels will not align well. The proof of THIS pudding is in the alignment!*

- Often error can be reduced by deleting control points and then recreating them, being a bit more precise with their location. It is often a good idea to delete and re-create the first few of your points.

- Another method is to zoom in tightly to the area you are trying to match. You can move the points at this zoomed level and it may be easier for you to align the points.

- Once you have achieved the lowest RMS error you can achieve (**0.5 pixels** [(Total) < 0.5]) is an excellent but difficult to achieve goal) and **you have twenty GCPs evenly spaced throughout the image**, you are ready to resample the aerial photo pixels into geographic space.

- In the Multipoint Geometric window, click on the <u>Display Resample Image Dialog…</u> button



- The Resample dialog box will appear similar to the screen at right.

- Be sure to save your file as a **JPEG2000 (JP2)** file type or it will be too large to upload to Moodle

- Keep the default values for Output Cell Size and as well as the Output Corners. Make sure the Resampling Method is Nearest Neighbor and save your rectified photo to your preferred personal location and give it an appropriate name.

- To see your rectified image, open a new viewer and add your image. Your image is now ready for further analysis. Well done!

- Import your saved photo into ArcGIS. Load some imagery using File > Add Data > Add Basemap > Imagery

- Perform the following steps

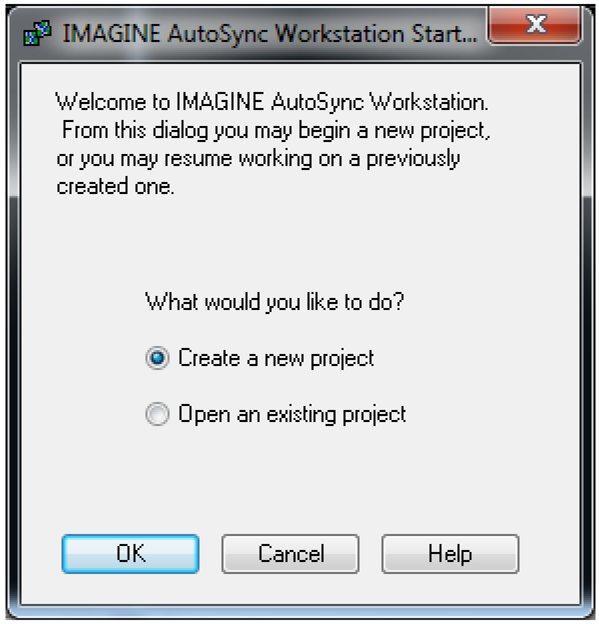
    1. Right click on your rectified image in the table of contents and select Properties
    2. Select the Display tab and set the transparency to 50%
    3. Right click anywhere in the menu bar area that is plain gray at the top of the screen and make certain the Effects menu is clicked
    4. In the Effects menu bar that opens, select your rectified image from the drop down and click the  icon . Your cursor should change to a triangular arrow
    5. Right click on the layer with your image and Zoom to the Layer
    6. Click and drag the arrow across your screen horizontally or vertically to swipe the image over the basemap.
    7. To really examine how well the pixels align you will likely need to be around 1:700 zoom level

Autosync Workstation

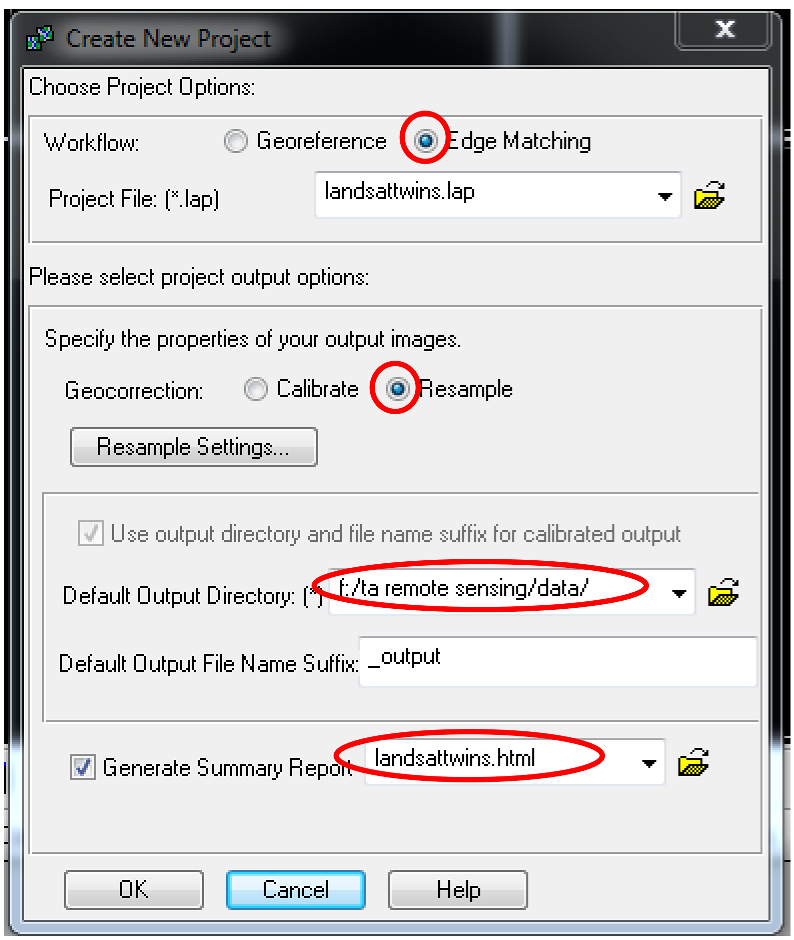
As you work with Landsat you may find that two images from different time frames of the same geographic area may not align accurately. This can be a result of the automated processing that is done by USGS on the level 1 prodect. ERDAS Imagine has a functionality called Autosync which is similar to the georeferencing we did in the first part of the lab. In this case, you pick one image to be the reference, and the other the input. Points are placed across both images and when the model is run, the input is adjusted to match the model created by the points you have placed.

Assuming both images are georeferenced but slightly off, we can easily resolve this using the Edge Matching model of Autosync

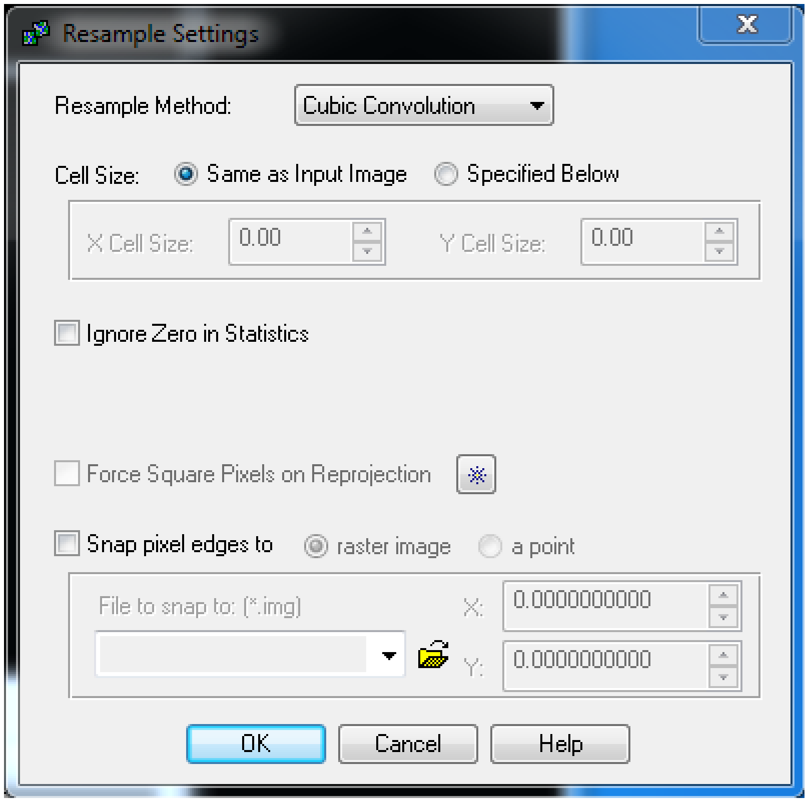
Prior to starting Autosycn, your images should both be in stacks. Begin Autosync. You should see:


IMAGINE AutoSync Workstation Start...
Welcome to IMAGINE AutoSync Workstation. From this dialog you may begin a new project, or you may resume working on a previously created one.
What would you like to do?
Create a new project
Open an existing project
OK
Cancel
Help

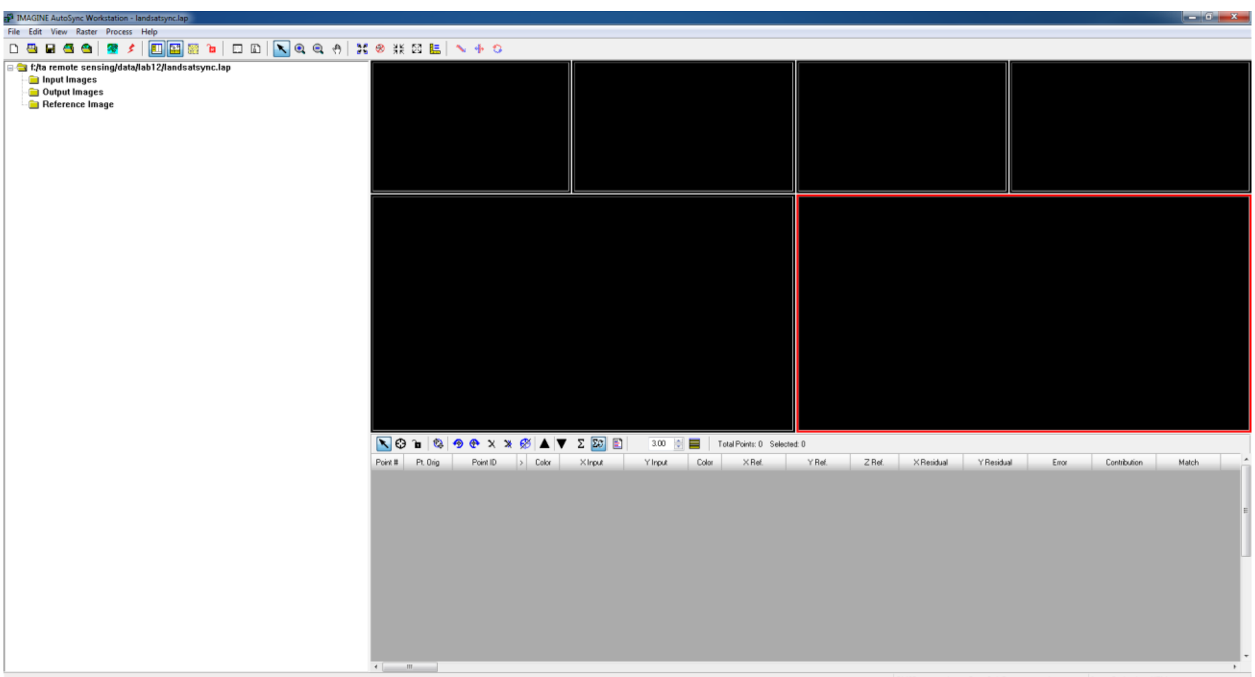
Click OK


Create New Project
Choose Project Options:
Workflow:
Georeference
Edge Matching
Project File: (*.lap)
landsattwins.lap
Please select project output options:
Specify the properties of your output images.
Geocorrection:
Calibrate
Resample
Resample Settings...
Use output directory and file name suffix for calibrated output
Default Output Directory: (*)
f:/ta remote sensing/data/
Default Output File Name Suffix:
_output
Generate Summary Report
landsattwins.html
OK
Cancel
Help

Make the above changes using your student drive as the directory and whatever name you want for the summary report. Click Resample Settings and verify that the screen is as below:

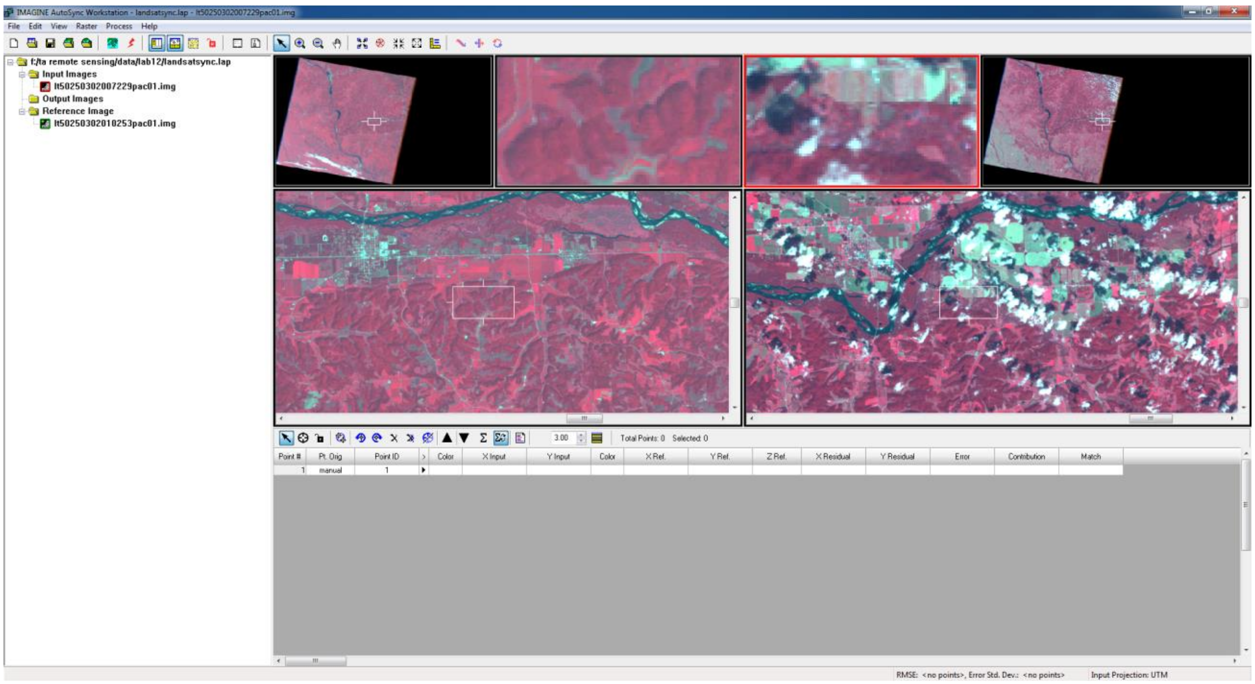


Click **OK** to this dialog box as well as the Create New Project dialog.



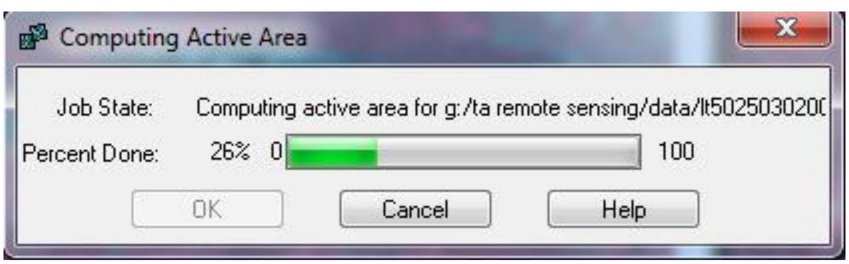
File > Add Images > Input Images …

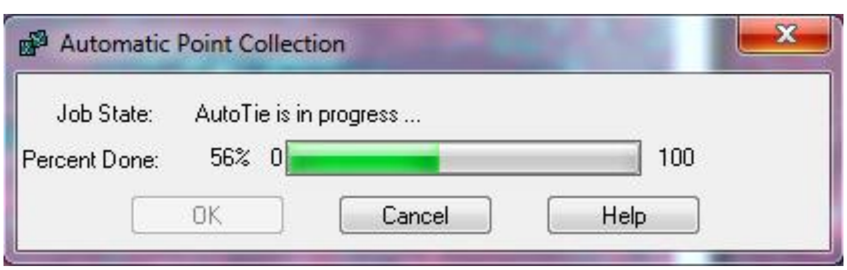
Browse to the image you would like to adjust
Click ok and it will appear in the left half of the workspace
File > Add Images > Input Images … again
Browse to the second image you would like to use and click OK
Screen should look like:



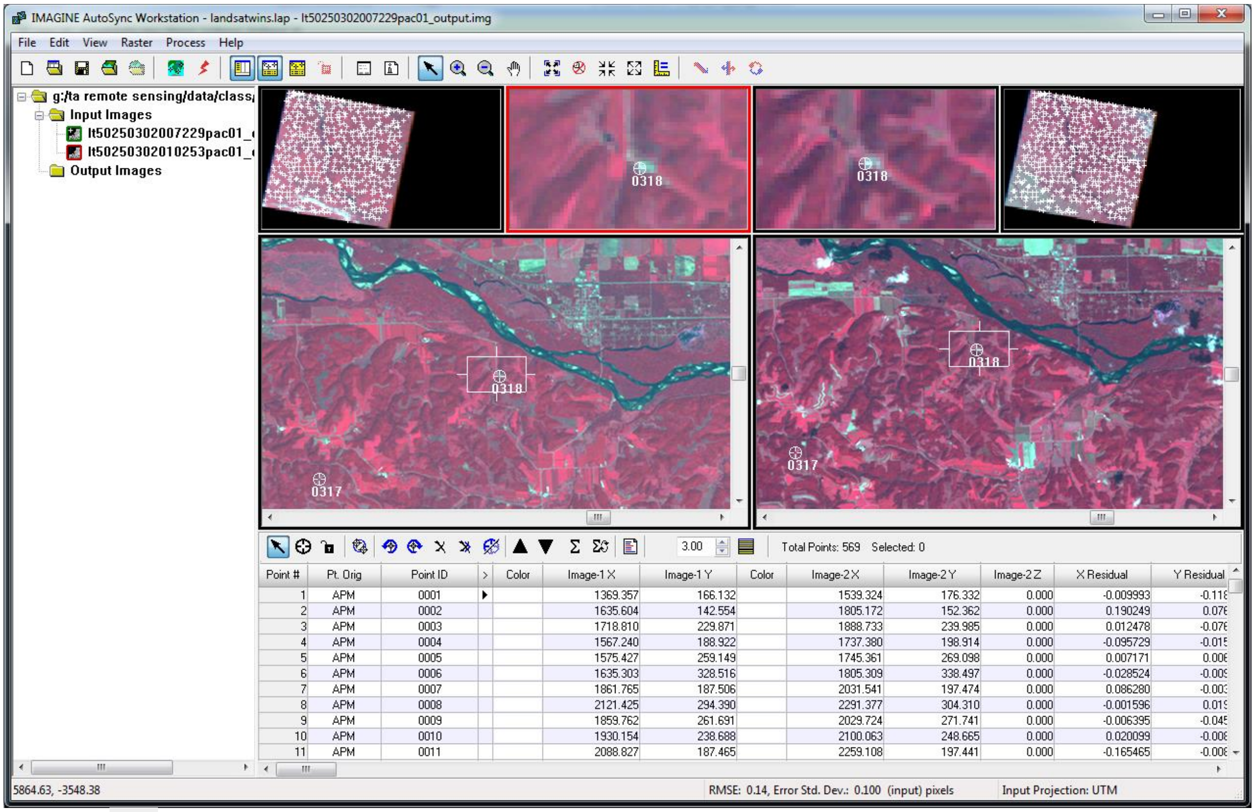
Run APM Model by clicking on Process > Run APM Model

Run time about 20 minutes. Sample of dialogs while running:



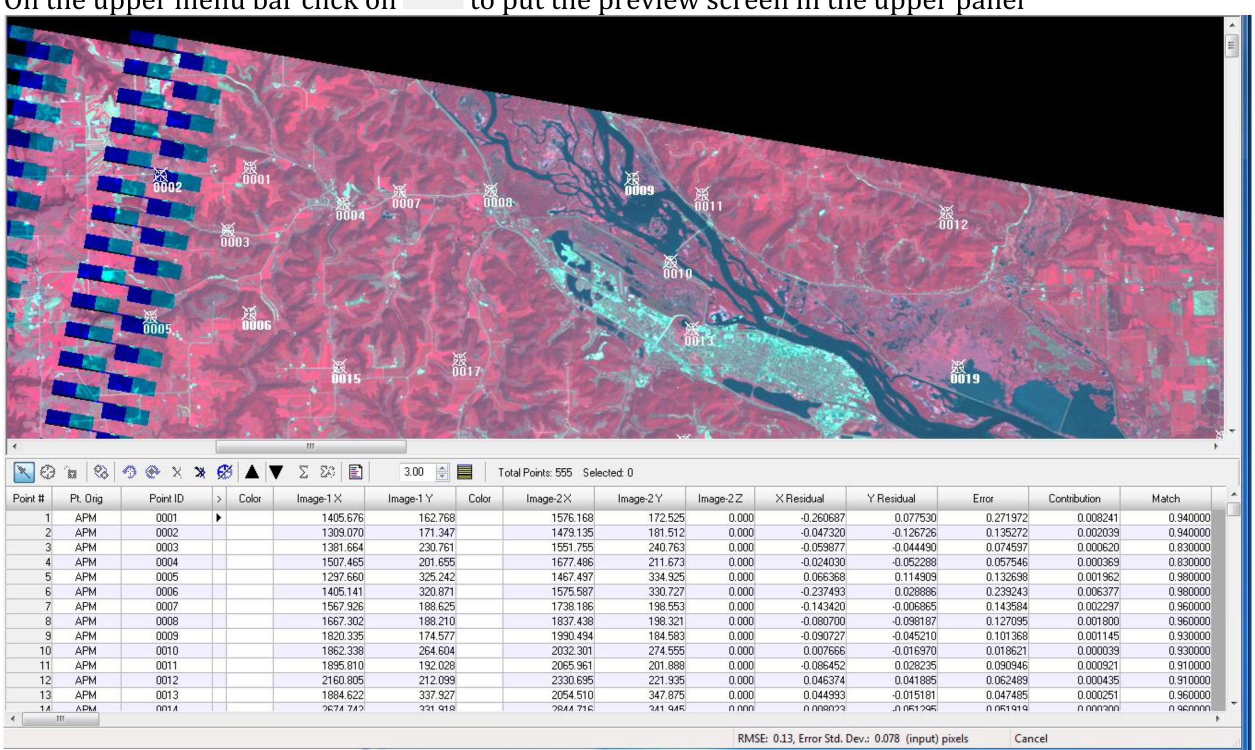


Hundreds of points will automatically be placed for you and the screen will appear as:

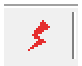


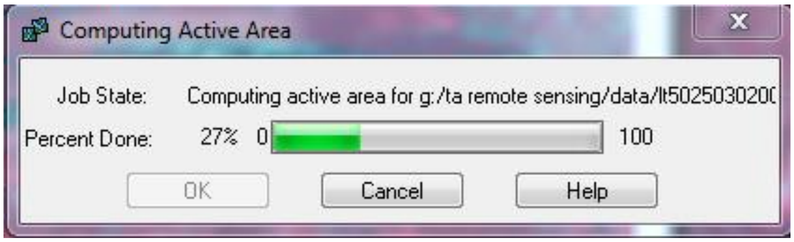
Clicking  will display a copy of the report indicating overall error

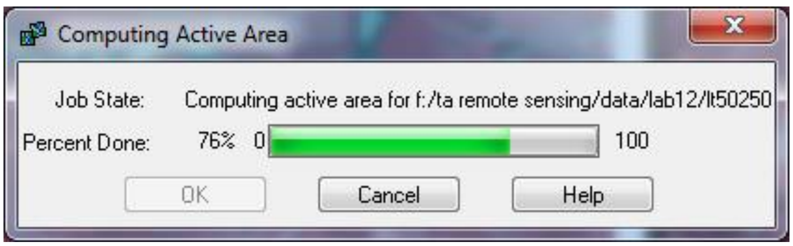
On the upper menu bar click on  to put the preview screen in the upper panel



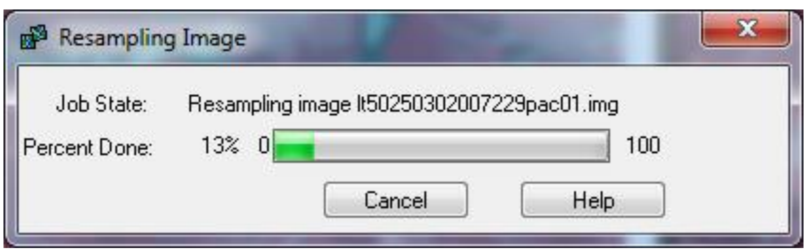
Click on  to put the preview screen in Swipe mode. Review your image to assure you are satisfied with the fit. A Blend and Flicker tool is also available. If you want to adjust GSPs click on the  again to toggle back to the review points mode

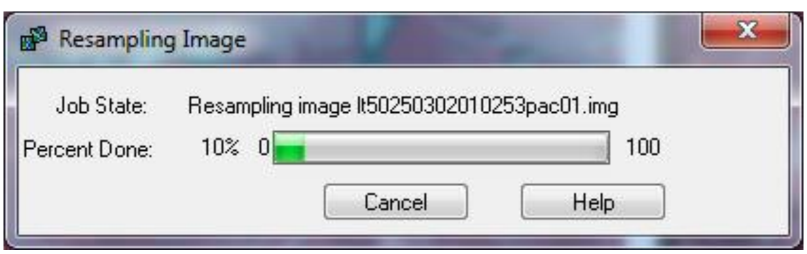
Click on  to create resampled output for all input images. The output images will have whatever suffix you placed in the Project dialog and be placed in the input folder. Statuses will be displaced:



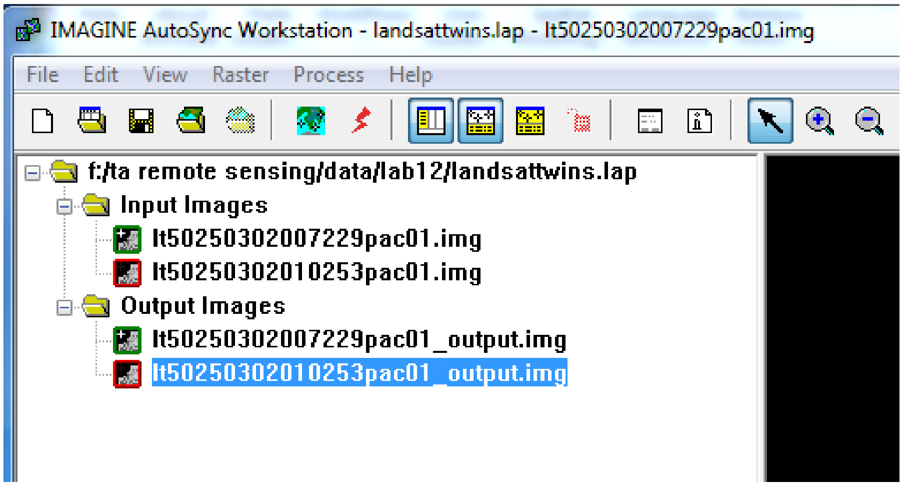


Each image will be resampled





The above may take a while since both images will need to be resampled and have new pyramid layers created. The output files will now show in the table of contents:



After completion the images should exactly overly so image differences can more easily be evaluated.

Lesson 03 Outcomes

By completing Lesson 03 you should be able to:

1. Open ERDAS Imagine and load image files.
2. Fit images to the viewer and zoom to various levels.
3. Identify features that can be used as ground control points.
4. Apply the georeferencing tool to an unrectified image.
5. Identify which ground control points are contributing the most error and delete them.
6. Minimize the RMS error.
7. Be comfortable in maneuvering around the photo using the tools available in ERDAS Imagine.