A Method to Achieve High-Precision Relative Orientation of Frames Using Erdas Imagine OrthoBASE

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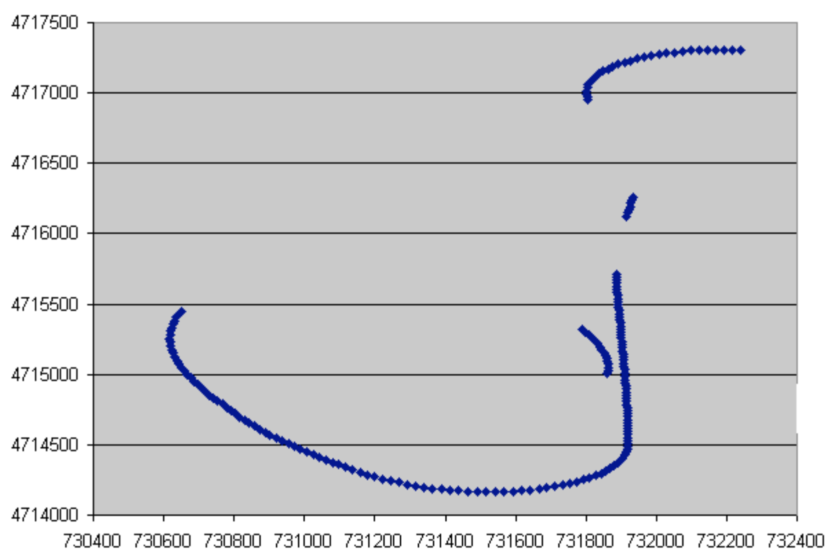
This report documents a method of achieving triangulation with low RMS error in Erdas Imagine OrthoBASE for large numbers of frames to get very precise relative orientations of frames from a strip of images. This method was developed here in the Vision Lab at UMass by Bert Rawert, Frank Stolle, and Howard Schultz, with some contributions from earlier work of Peikang Yao. As the sole purpose of this report is to document this method for purposes of "corporate memory," there is little content other than exactly how to proceed with this method.

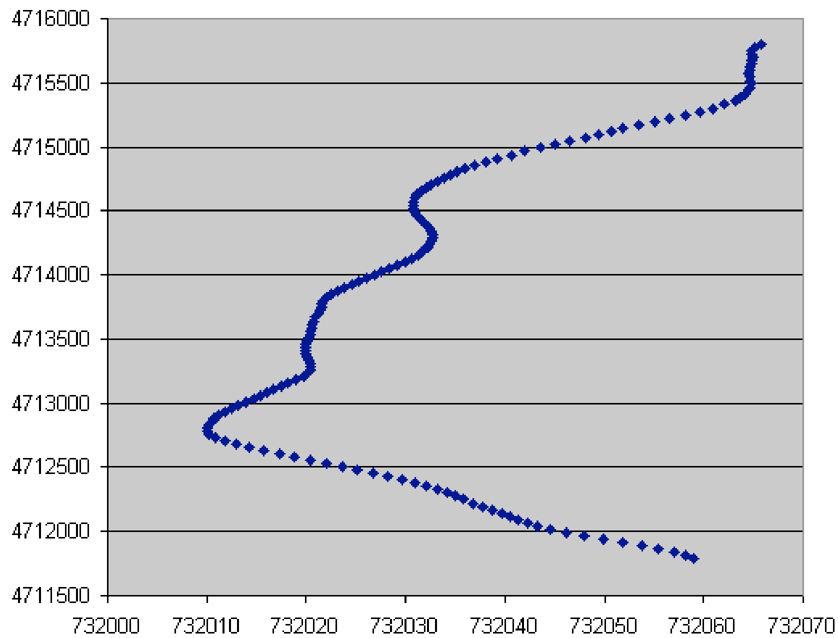
Selecting Frames

To determine which frames make up a strip, select the X and Y columns of the GPS data for your hypothesized set of frames as they appear in an Excel spreadsheet. Plot them using a scatter plot. The picture below, produced by selecting the GPS coordinates of a group of time consecutive frames, shows what the result should **not** look like.



Note the wide range of x values covering almost 2 km. This is generally bad for the Harvard Forest dataset, because flight lines were north to south, not east to west, so you should see smaller variability within a strip along the x axis. Also, note the discontinuity in the stream of frames.

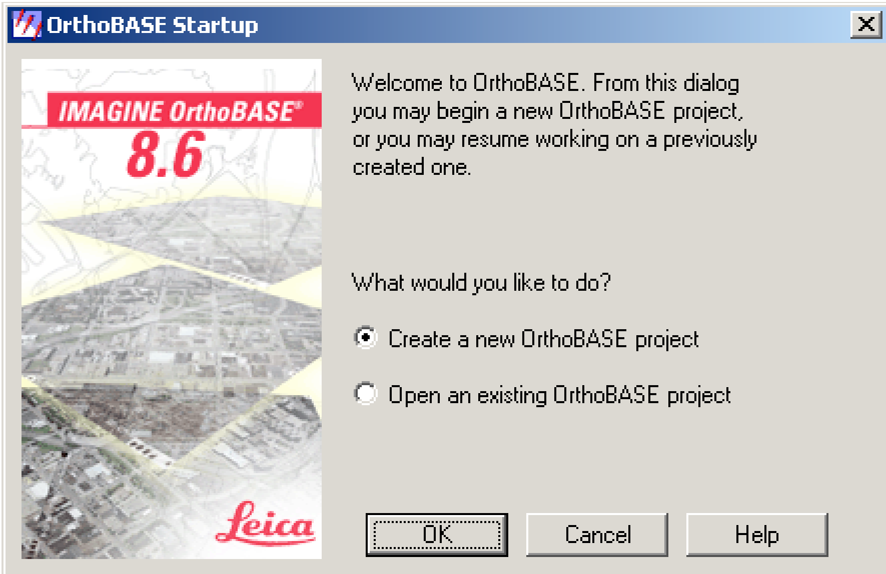
The graph below shows what you should see:



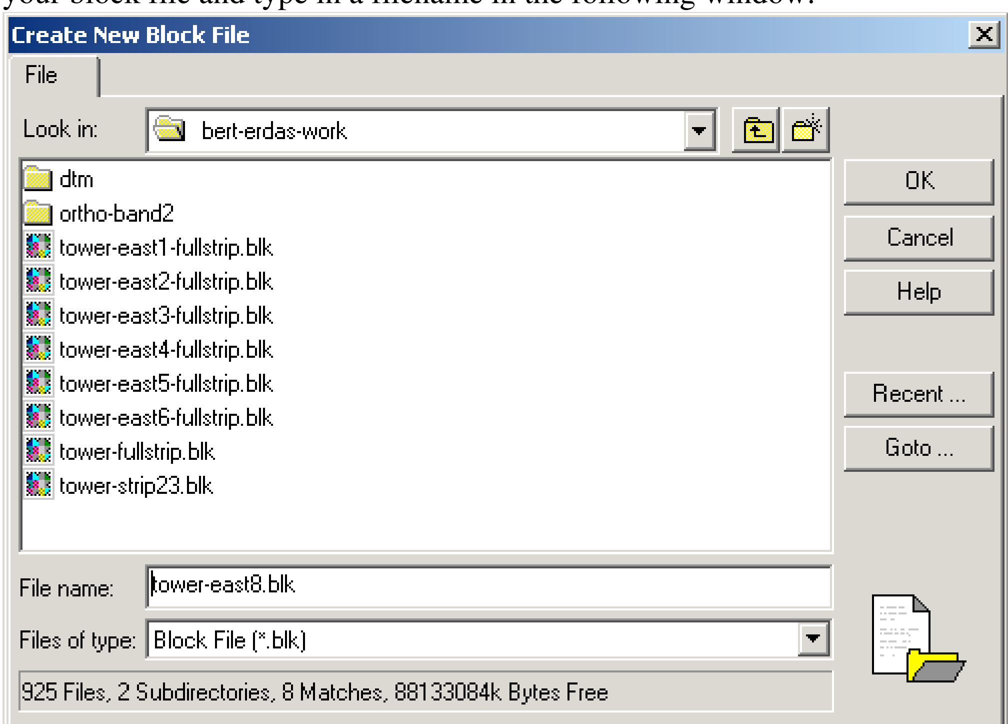
Note that the range in X is now about 70 meters, with variations in flight path most likely due to wind. This looks more realistic for a flight path. Once the images for a strip have been identified, the next step is to create a new Erdas block file.

Creating a Block File

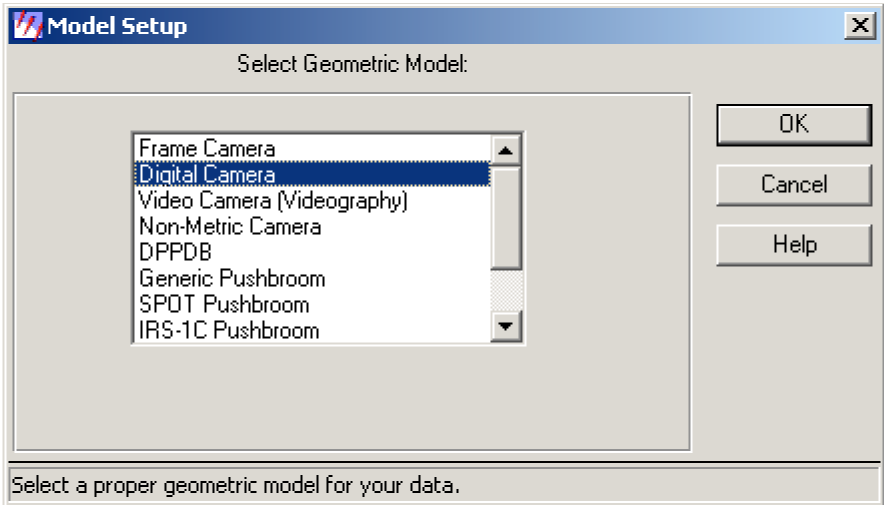
Start by clicking on the OrthoBASE icon in the Erdas Imagine tool bar. The following prompt appears:



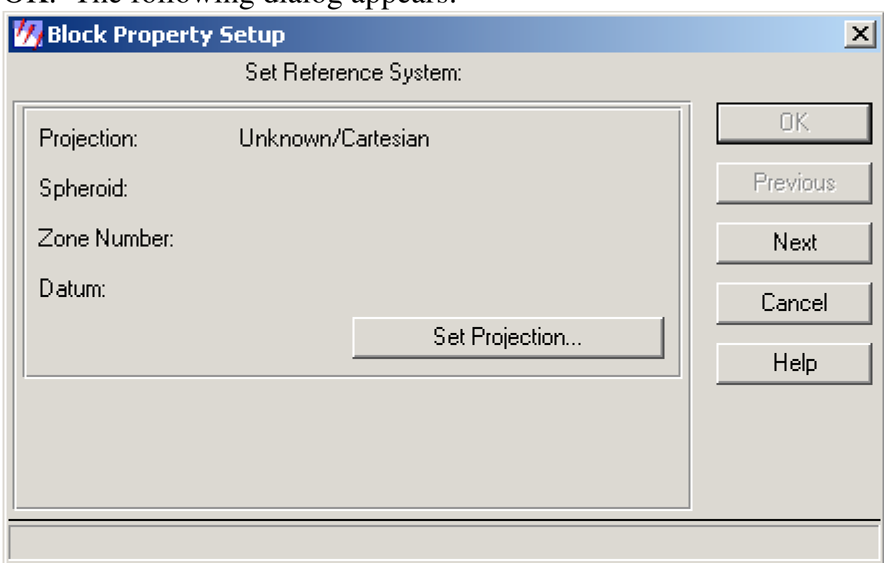
Select OK to create a new OrthoBASE Project. Navigate to the folder where you want to store your block file and type in a filename in the following window:



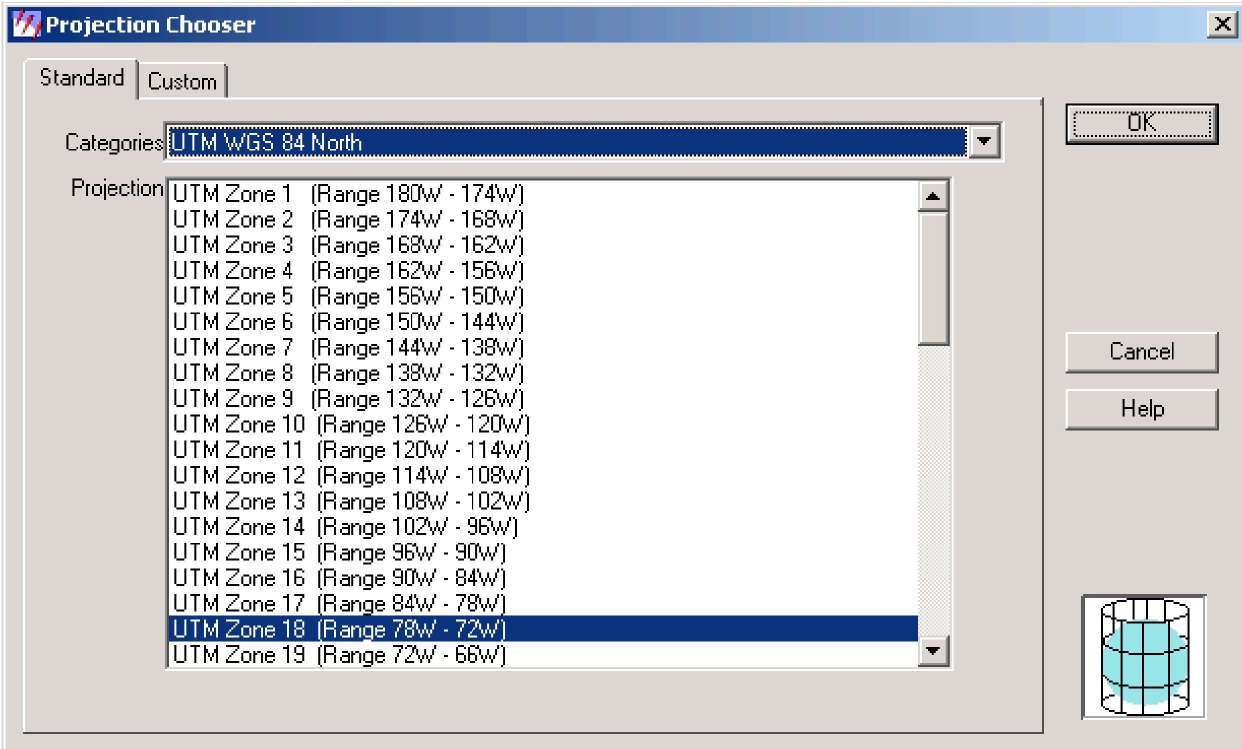
Click OK. The following window appears:



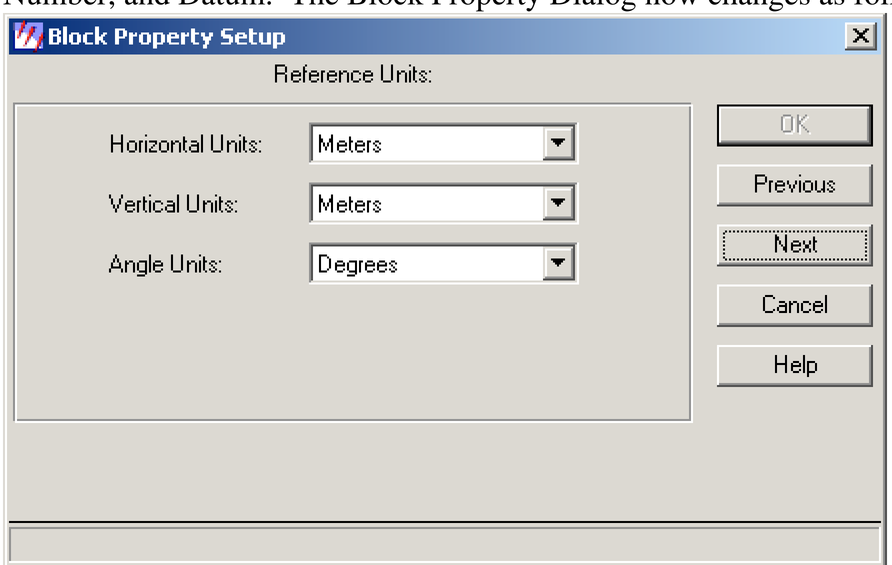
Select Digital Camera for Harvard Forest data sets (or the appropriate camera type), and click OK. The following dialog appears:



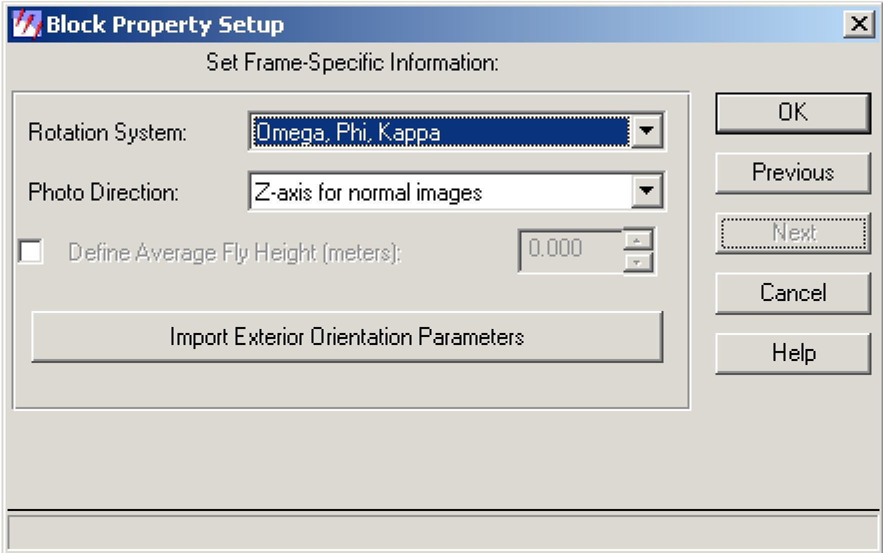
Click "Set Projection…". The following dialog appears:



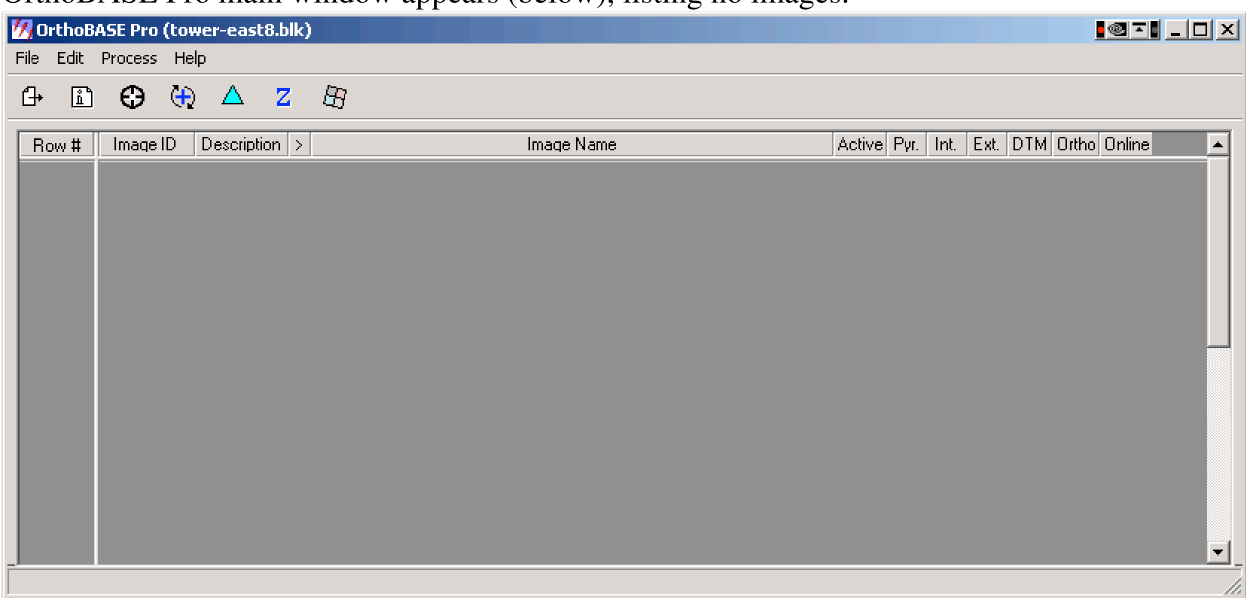
Select the appropriate Category and Projection for your project. For the Harvard Forest data, this is UTM WGS 84 North in UTM Zone 18. Click OK. Then, click "Next" in the Block Property Setup dialog (shown above) which should now display the correct Projection, Spheroid, Zone Number, and Datum. The Block Property Dialog now changes as follows:



Enter the correct horizontal, vertical, and angle units. For the Harvard Forest data the defaults are correct. Click “Next”. The Block Property Setup dialog now changes again as follows:

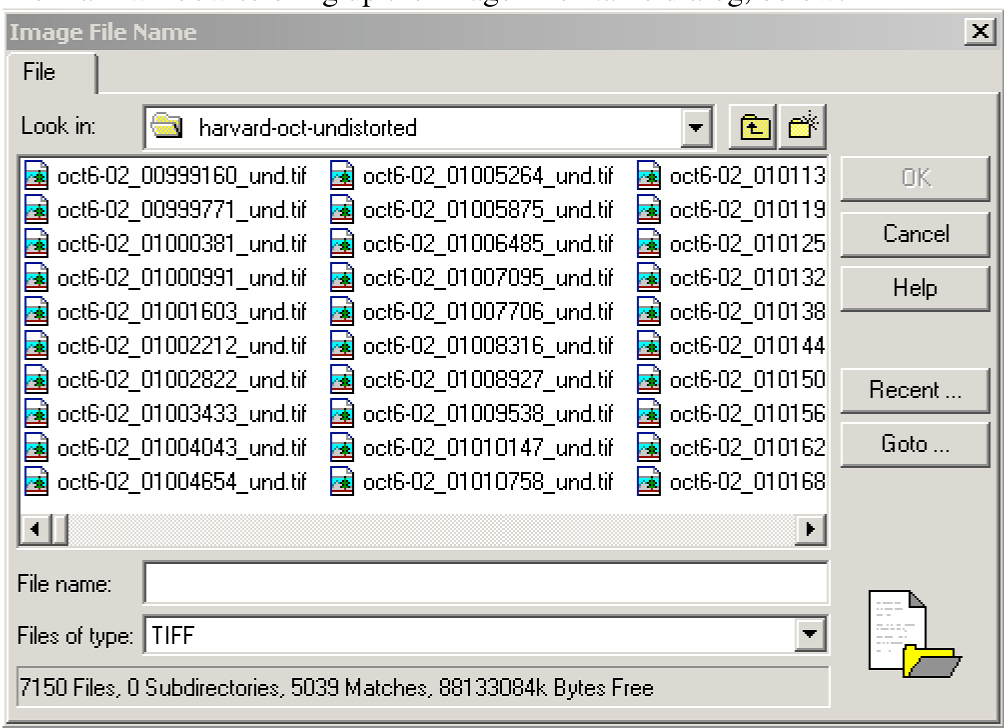


Select the appropriate rotation system and photo direction. For the Harvard Forest data the defaults are again correct. Click “OK” to complete Block Property Setup. Finally, the OrthoBASE Pro main window appears (below), listing no images.

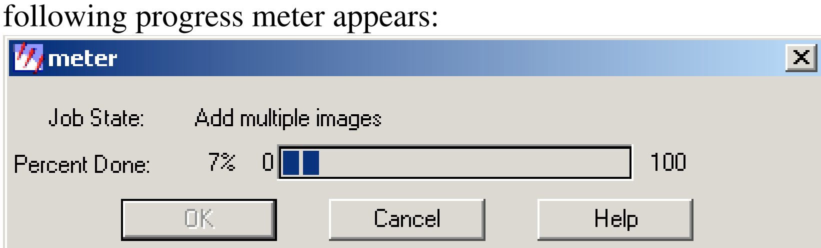


Adding Images

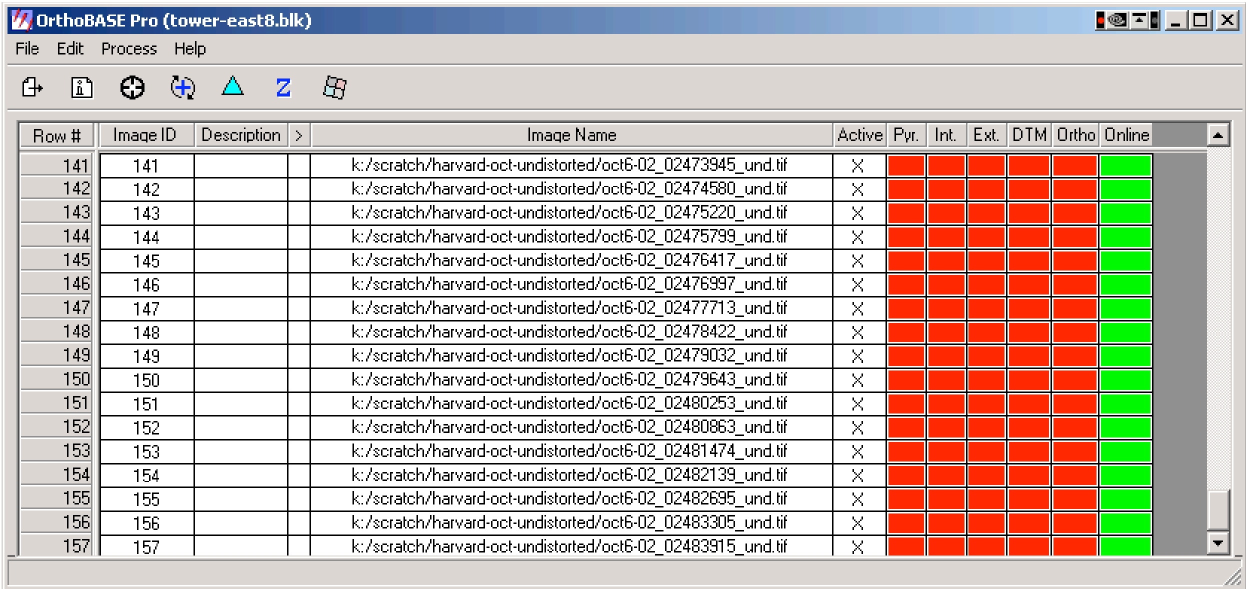
It is now time to select images. To do this, click the (add images) icon in the OrthoBASE Pro main window to bring up the Image File Name dialog, below:



Navigate to the directory where your undistorted images are stored (k:\scratch\harvard-oct-undistorted\ for the Harvard Forest data). Make sure to select the correct image format at the bottom where it says "Files of type: ," which is TIF for Harvard Forest. Select the images from your strip by selecting the first one, then, while holding down the SHIFT key on the keyboard, click the last one. This selects all the frames. To add them to the block file, click OK. The following progress meter appears:

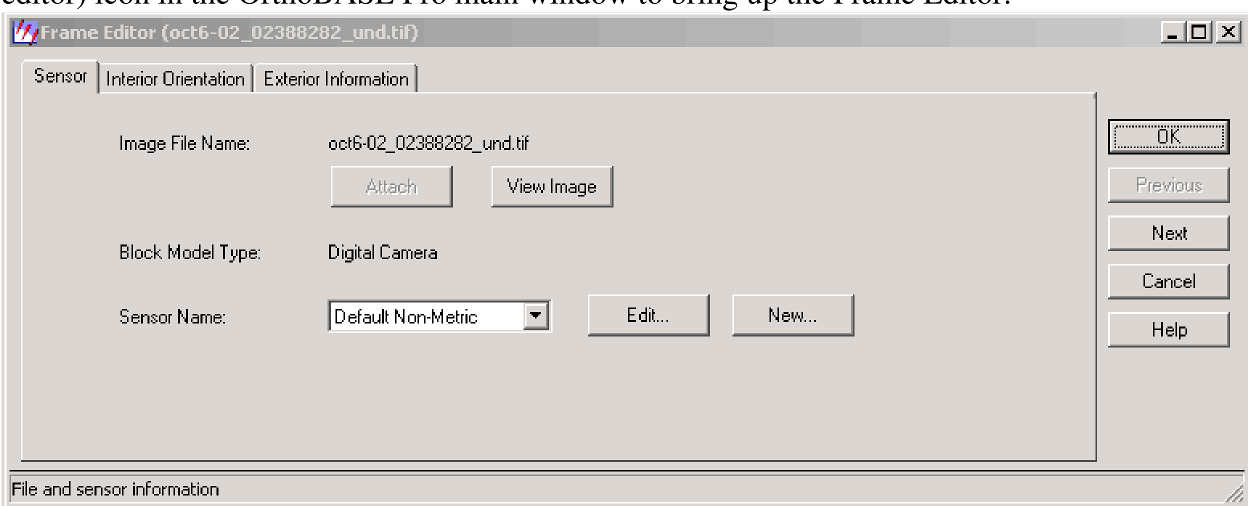


When it reaches 100%, the images appear in the OrthoBASE Pro main window:

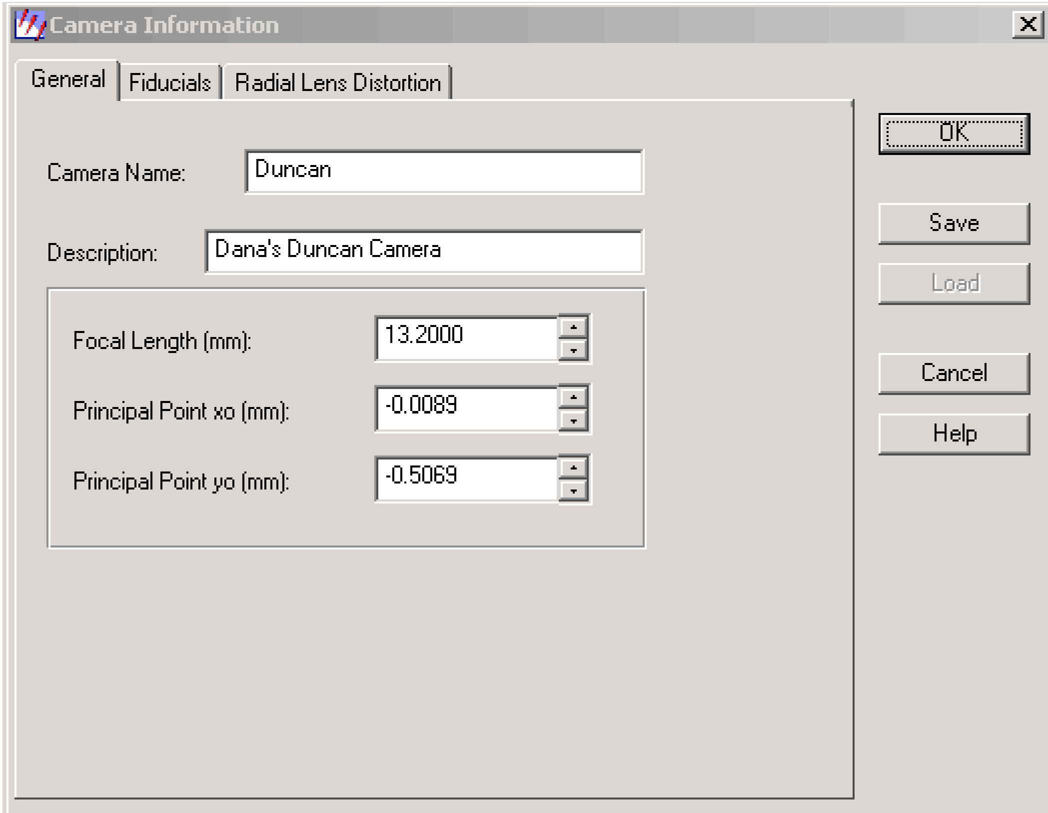


Interior Orientation and Exterior Information

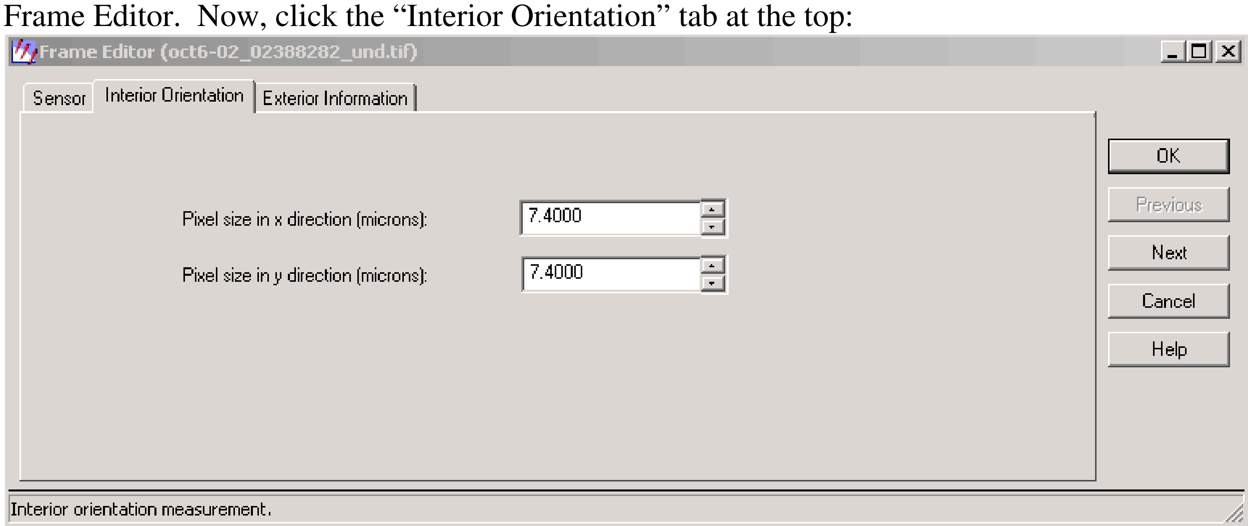
Now it is time to enter the interior (camera) parameters for the frames. Click the (frame editor) icon in the OrthoBASE Pro main window to bring up the Frame Editor:



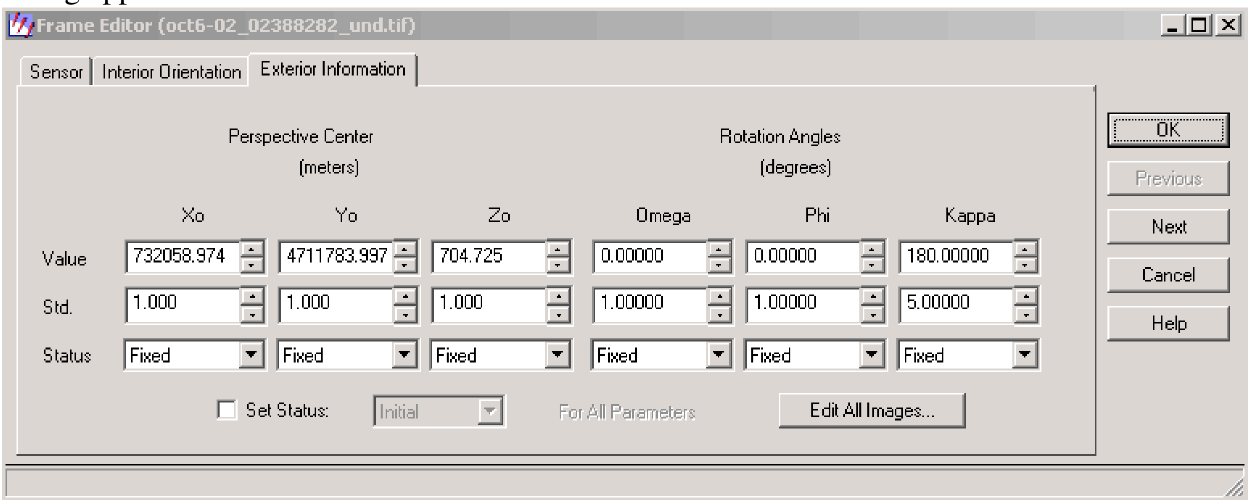
Now, click "Edit" under the "Sensor" tab to enter some information about the camera that was obtained from calibrating the camera that was used to capture the frames. This can be done on a frame-by-frame basis, however, for the Harvard Forest data, the same camera was used for all frames. The following dialog appears:



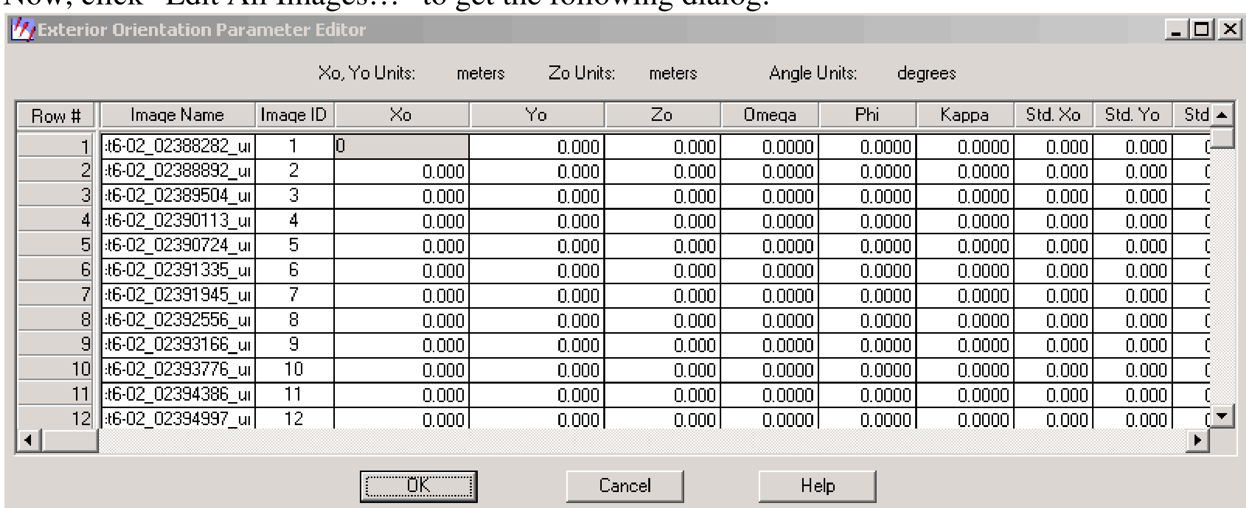
Enter the correct camera information. The correct information for the Duncan camera used to capture the Harvard Forest data is shown in the above screen shot. Click OK to return to the Frame Editor. Now, click the "Interior Orientation" tab at the top:



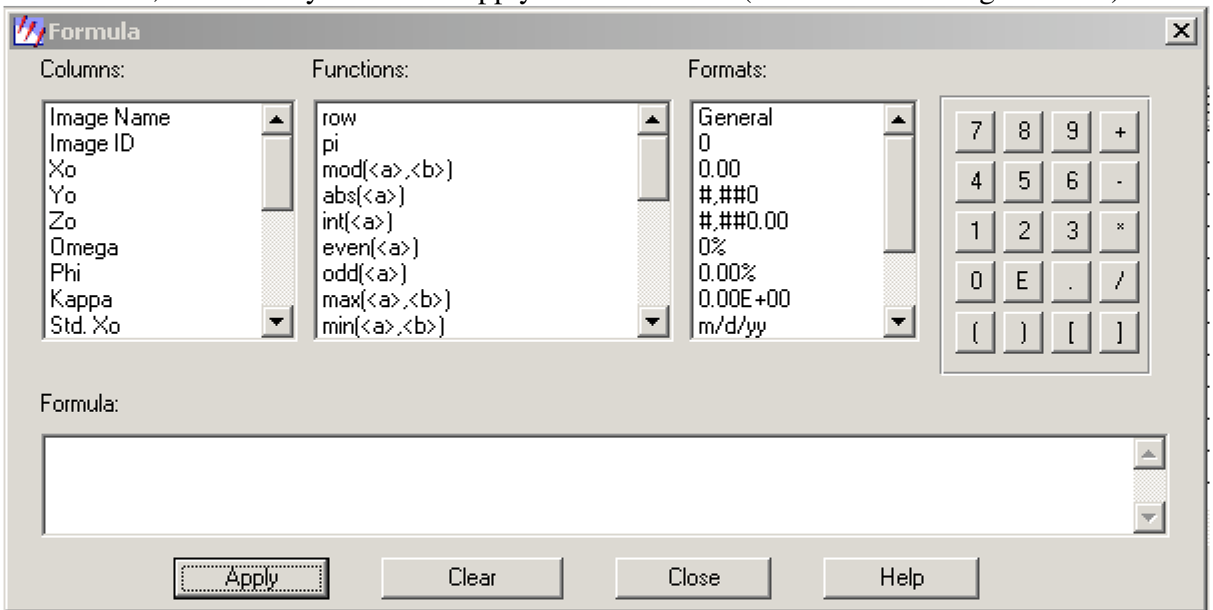
Enter the correct pixel size for the camera used. In the case of the Harvard Forest data, this is 7.4 microns for both the x and y directions. Due to a bug in OrthoBASE, you should now click "Next" once for each image in your block file to apply these interior parameters to all the frames. Click "OK" to store all the camera parameters, and then click (frame editor) icon again to re-enter the Frame Editor. Now click the "Exterior Information" tab at the top. The following dialog appears:



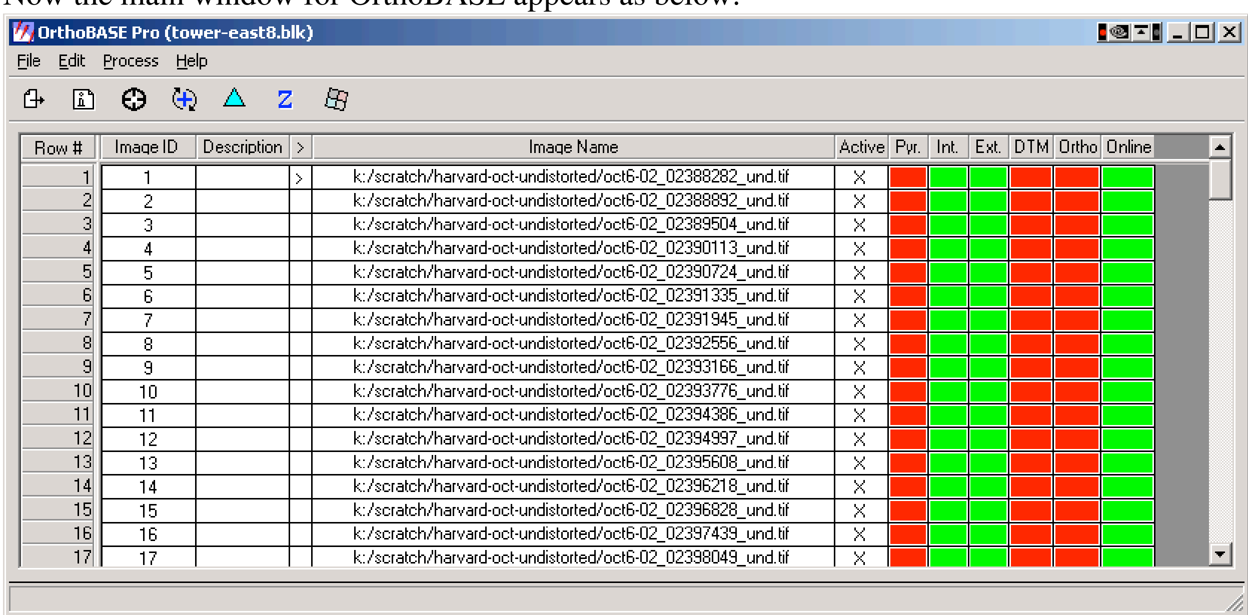
Now, click "Edit All Images…" to get the following dialog:



Select the Xo, Yo, and Zo columns by clicking on the Xo column header and dragging to Zo. Right-click and select Paste to paste in the xyz GPS data copied from an Excel spreadsheet. Enter in estimates for Omega, Phi, and Kappa (0, 0, for Omega and Phi, and either 0 or 180 for Kappa is used in the Harvard Forest data processing, depending on the flight direction) by selecting the column, right-clicking, selecting “Formula”, and entering the appropriate value in the formula, followed by a click to Apply and then Close (the Formula dialog is below):



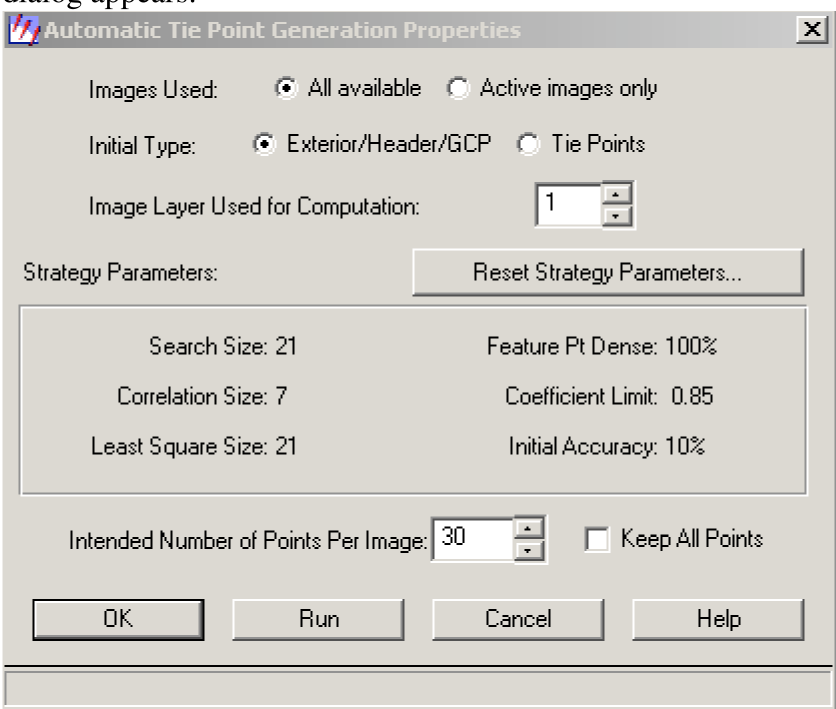
Using the same strategy, enter defaults for the standard deviations of Xo, Yo, Zo, Omega, Phi, and Kappa (values used on Harvard Forest data are 1, 1, 1, 1, 1, and 5, respectively). Finally, use the same strategy again to change the status on all images from “Unknown” to “Fixed.” Click “OK” in the “Exterior Orientation Parameter Editor”, followed by “OK” in the “Frame Editor”. Now the main window for OrthoBASE appears as below:

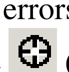


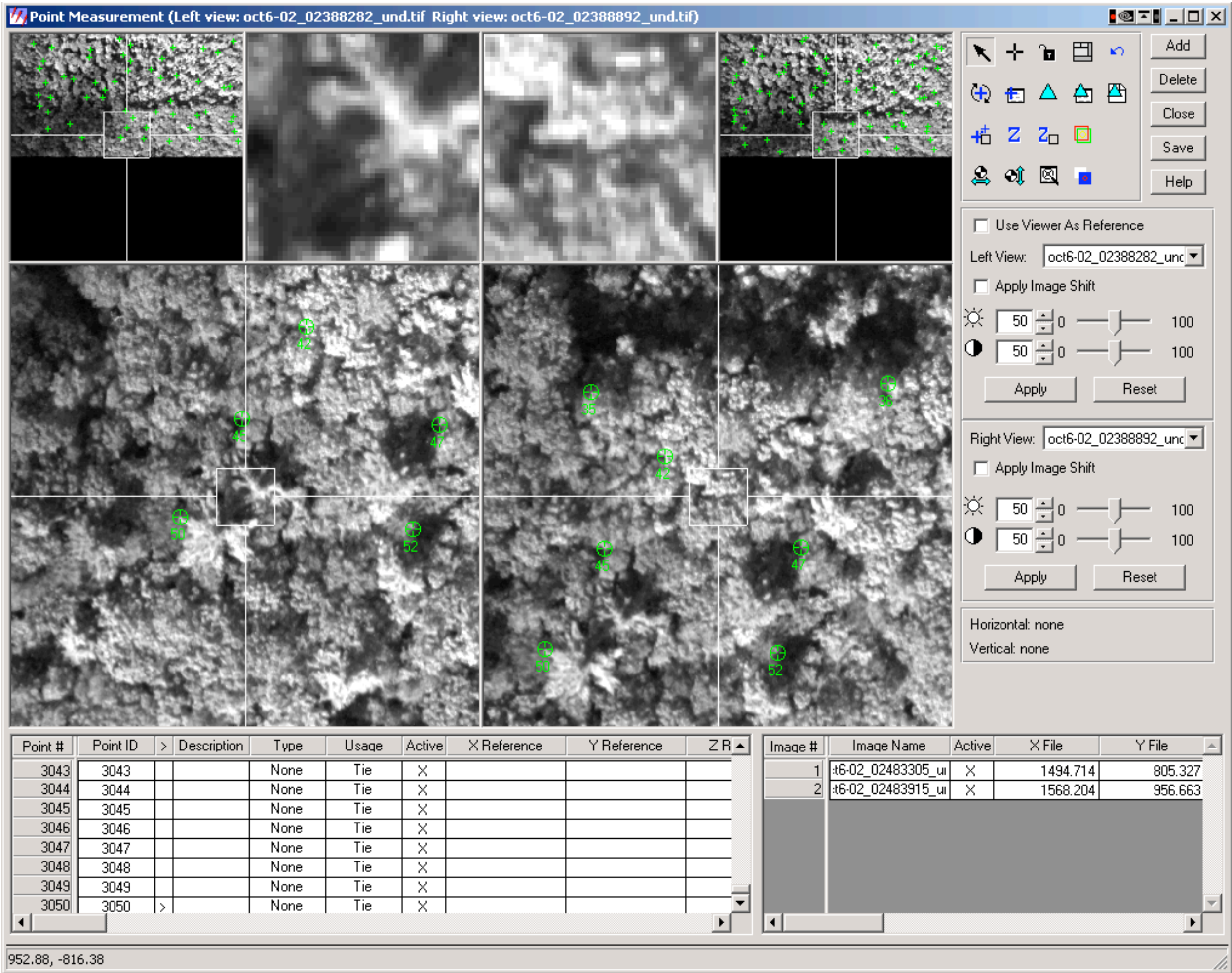
Note that the Int. and Ext. columns are now green, indicating these steps in the process of orthorectification are now complete. Now is probably a good time to save the block file by clicking File and then Save.

Automatic Tie-Point Generation

The next step is to gather tie-points to more correctly align the images. OrthoBASE can do this automatically. Click Edit and go to "Auto. Tie Point Generation Properties…" The following dialog appears:



Select 30 Points Per Image. The rest of the defaults work well for the Harvard Forest data. Click "OK". Now click the  (auto tie point collection) icon in the main OrthoBASE window. This performs the automatic tie point generation. If you have not yet computed the pyramid layers for all the images, Erdas automatically does this first. Then, the tie points are automatically generated. This process may take up to an hour for block files with many images. Upon completion of finding tie points, Erdas may give a message saying that the tie points may contain "gross errors." If this is the case, then you should manually review the tie-points by clicking on the  (point measurement) icon to bring up the Point Measurement Tool, as seen below:

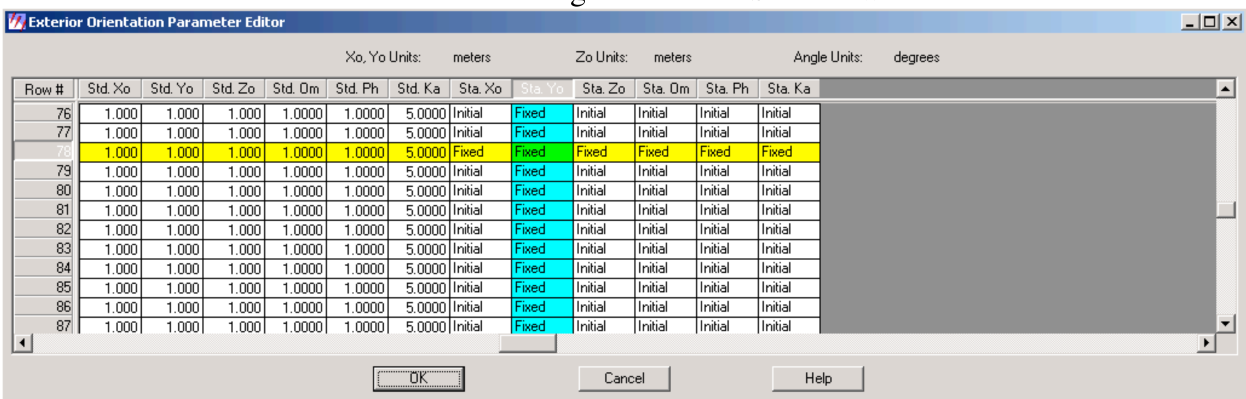


If all the tie points make sense, then click Save. You can use the Point Measurement Tool to fix erroneous points, too.

If the automatic tie point generation generated too many errors, then manually checking and editing the points may not be practical. This may be the result of accidentally entering the wrong exterior information in the Frame Editor above, or of entering incorrect estimates of Omega, Phi, or, most likely, Kappa. Try deleting all the tie points, changing the correct exterior information, and re-running the auto tie point generation.

Triangulation

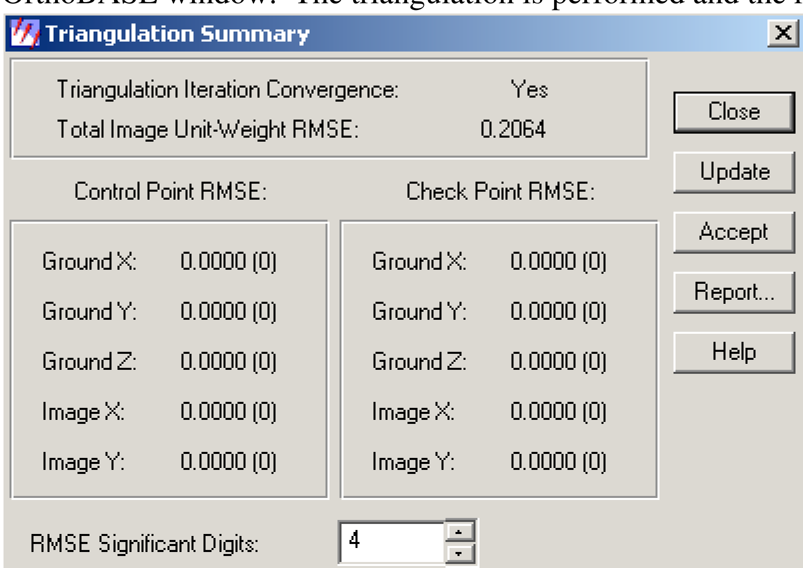
At this point, there is enough information to perform the triangulation, or bundle block adjustment to more precisely fix the location and orientation of the camera at the capture of each frame. First, we must specify which exterior information values are allowed to float. To do this, enter the frame editor again by clicking (frame editor) icon. Click Edit all Images again to see the Exterior Orientation Parameter Editor. Now, change all the values in all the status columns on the right to be “Initial”, but set the Y column values to “fixed” for a flight which primarily traverses a north-to-south direction (kappa in (315, 45) or (135, 225)) or set the X column values to “fixed” instead for a flight which primarily traverses an east-to-west direction (kappa in (45,135) or (225, 315)). Then, set all the values for a particular frame to “fixed”. The “center” frame or one of the end frames is a good choice. See below:



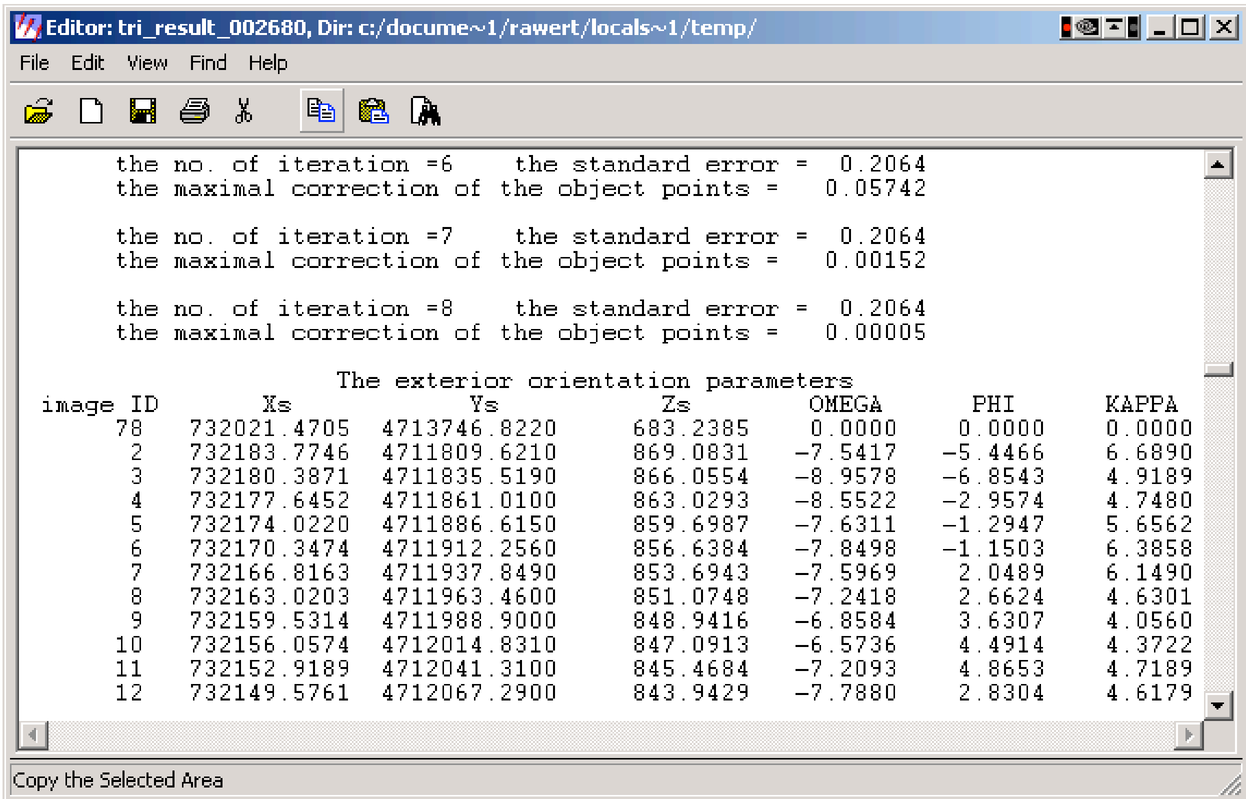
Row #	Std. Xo	Std. Yo	Std. Zo	Std. Om	Std. Ph	Std. Ka	Sta. Xo	Sta. Yo	Sta. Zo	Sta. Om	Sta. Ph	Sta. Ka
76	1.000	1.000	1.000	1.0000	1.0000	5.0000	Initial	Fixed	Initial	Initial	Initial	Initial
77	1.000	1.000	1.000	1.0000	1.0000	5.0000	Initial	Fixed	Initial	Initial	Initial	Initial
78	1.000	1.000	1.000	1.0000	1.0000	5.0000	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
79	1.000	1.000	1.000	1.0000	1.0000	5.0000	Initial	Fixed	Initial	Initial	Initial	Initial
80	1.000	1.000	1.000	1.0000	1.0000	5.0000	Initial	Fixed	Initial	Initial	Initial	Initial
81	1.000	1.000	1.000	1.0000	1.0000	5.0000	Initial	Fixed	Initial	Initial	Initial	Initial
82	1.000	1.000	1.000	1.0000	1.0000	5.0000	Initial	Fixed	Initial	Initial	Initial	Initial
83	1.000	1.000	1.000	1.0000	1.0000	5.0000	Initial	Fixed	Initial	Initial	Initial	Initial
84	1.000	1.000	1.000	1.0000	1.0000	5.0000	Initial	Fixed	Initial	Initial	Initial	Initial
85	1.000	1.000	1.000	1.0000	1.0000	5.0000	Initial	Fixed	Initial	Initial	Initial	Initial
86	1.000	1.000	1.000	1.0000	1.0000	5.0000	Initial	Fixed	Initial	Initial	Initial	Initial
87	1.000	1.000	1.000	1.0000	1.0000	5.0000	Initial	Fixed	Initial	Initial	Initial	Initial

Now, click OK in the Exterior Orientation Parameter Editor dialog, and then OK again in the Frame Editor to return to the main OrthoBASE window.

We can now perform triangulation by clicking the (triangulation) icon in the main OrthoBASE window. The triangulation is performed and the resulting dialog appears:



Check to make sure the iteration converged and that the RMSE is low enough for your requirements. Click “Report” to view the report and verify that the image orientations make sense.



the no. of iteration =6 the standard error = 0.2064
the maximal correction of the object points = 0.05742

the no. of iteration =7 the standard error = 0.2064
the maximal correction of the object points = 0.00152

the no. of iteration =8 the standard error = 0.2064
the maximal correction of the object points = 0.00005

The exterior orientation parameters

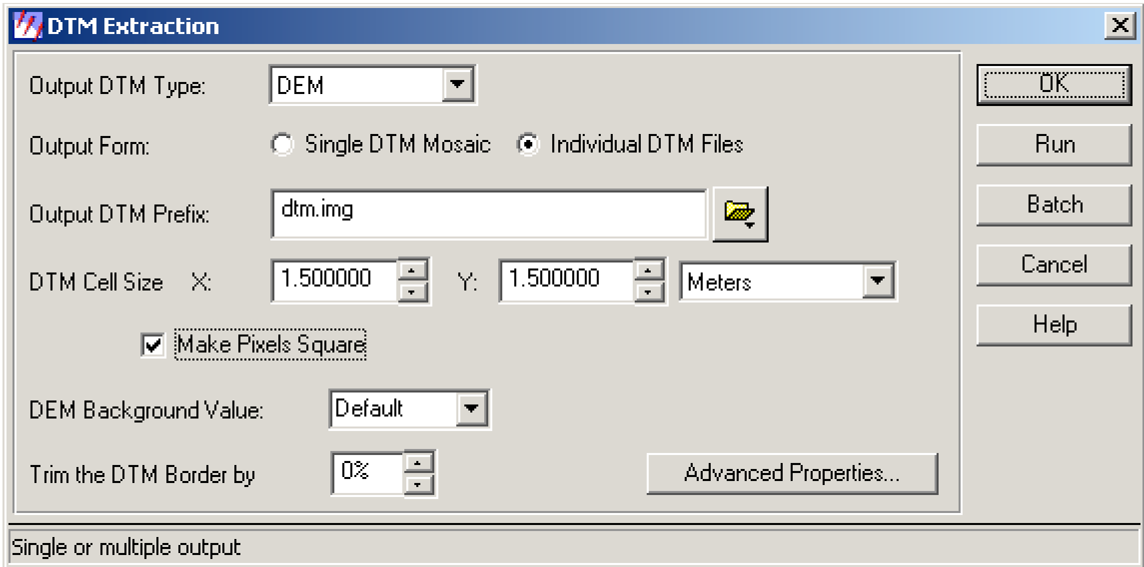
image ID	Xs	Ys	Zs	OMEGA	PHI	KAPPA
78	732021.4705	4713746.8220	683.2385	0.0000	0.0000	0.0000
2	732183.7746	4711809.6210	869.0831	-7.5417	-5.4466	6.6890
3	732180.3871	4711835.5190	866.0554	-8.9578	-6.8543	4.9189
4	732177.6452	4711861.0100	863.0293	-8.5522	-2.9574	4.7480
5	732174.0220	4711886.6150	859.6987	-7.6311	-1.2947	5.6562
6	732170.3474	4711912.2560	856.6384	-7.8498	-1.1503	6.3858
7	732166.8163	4711937.8490	853.6943	-7.5969	2.0489	6.1490
8	732163.0203	4711963.4600	851.0748	-7.2418	2.6624	4.6301
9	732159.5314	4711988.9000	848.9416	-6.8584	3.6307	4.0560
10	732156.0574	4712014.8310	847.0913	-6.5736	4.4914	4.3722
11	732152.9189	4712041.3100	845.4684	-7.2093	4.8653	4.7189
12	732149.5761	4712067.2900	843.9429	-7.7880	2.8304	4.6179

If all looks reasonable, close the report and then click “Update” followed by “Accept”, and then “Close” in the “Triangulation Summary” window.

Now is another good time to save work in the block file.

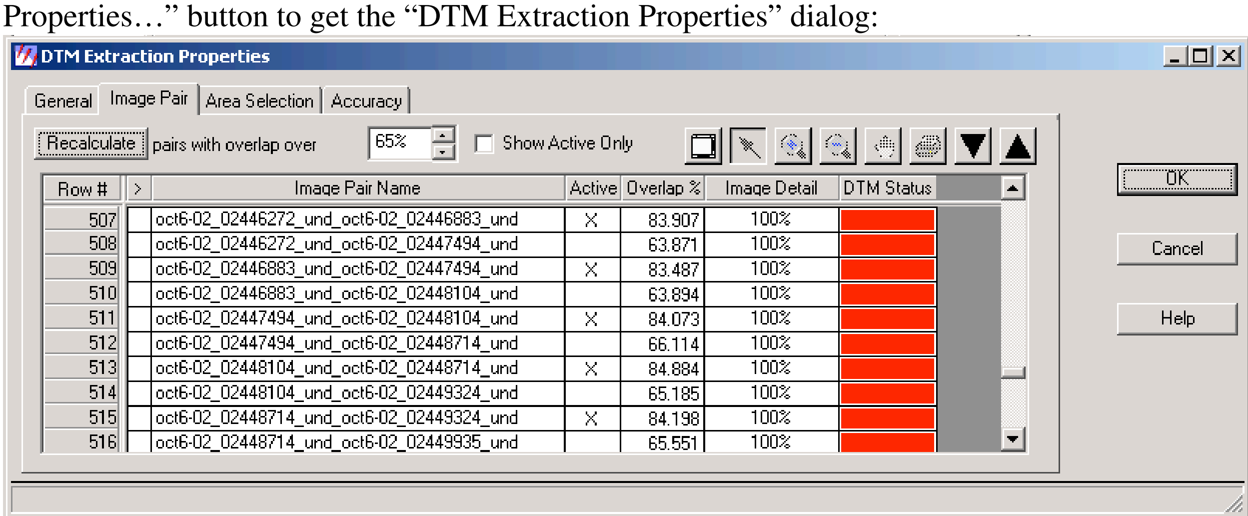
DTM Extraction

Now we can extract the DTM’s for enough pair’s of frames to cover the whole area reliably. To start, click the Z (dtm extraction) icon in the main OrthoBASE window. This brings up the following dialog:



It seems that OrthoBASE crashes whenever we try to produce a single DTM mosaic for long strips. As a result we will output “Individual DTM Files”. Make sure these individual files go into the correct directory by clicking the file folder next to the “Output DTM Prefix” text box and navigating to the correct folder. Now, set the DTM Cell Size in the X and Y directions. For the Harvard Forest Data, 1.5m provides close to the best accuracy possible given the DTM extraction process and the resolution of the images.

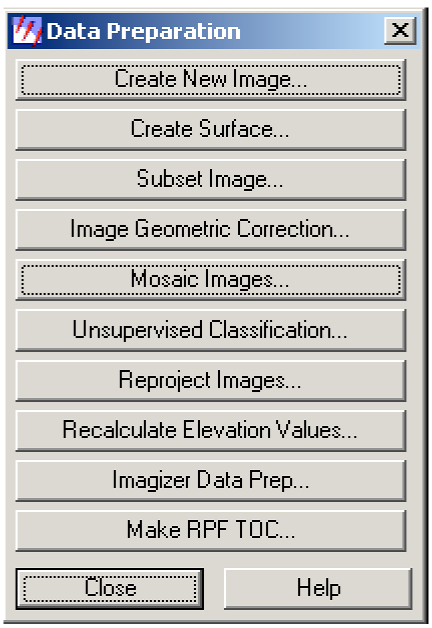
Now, to select which image pairs are used to compute the DTM, click the “Advanced Properties…” button to get the “DTM Extraction Properties” dialog:



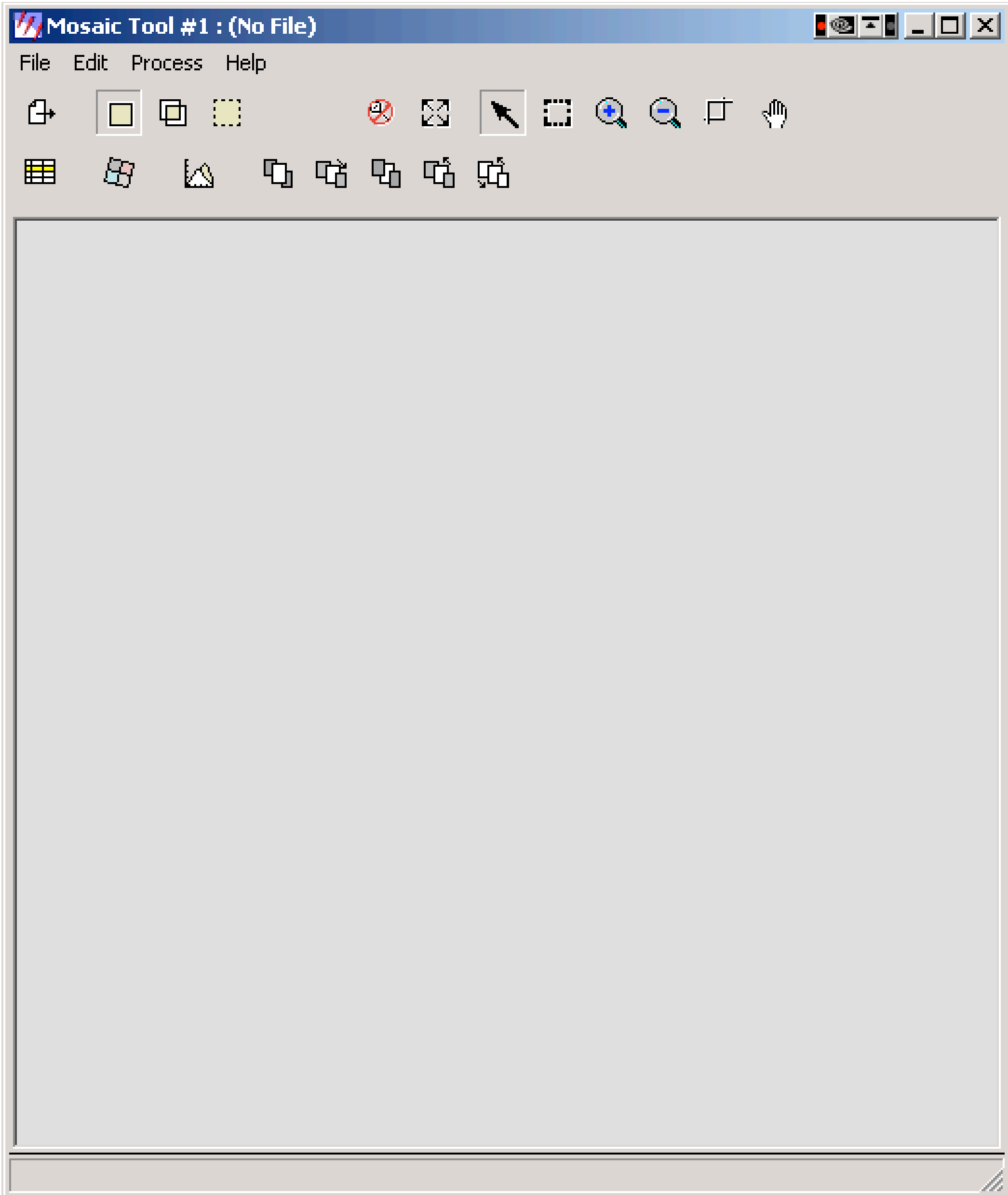
Select the “Image Pair” tab at the top. With the Harvard Forest data, there are enough frames to set the overlap threshold to 65% and still get more than enough coverage. After “recalculating” the pairs, go through and de-activate any pairs with 100% overlap because OrthoBASE can't seem to handle these. It's also a good idea to thin out the active pairs so that there aren't too many unnecessary DTM's computed. Now click OK to close the DTM Extraction Properties dialog. Now click "Run" in the DTM Extraction dialog. Wait while OrthoBASE computes the DTM frames. This is another good time to save the block file. Note that by now, all the columns to the right in the main OrthoBASE window are green except the "Ortho" column. Orthorectification is the last step in processing a block of images; we will get to this later. First, we need a unified DTM.

DTM Mosaic Generation

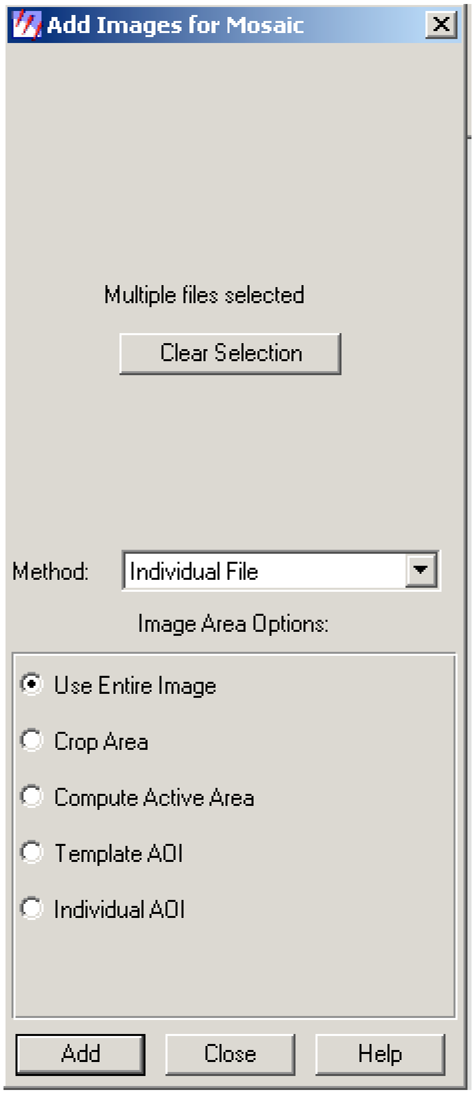
Once the individual DTM's have been generated, we can assemble them into a mosaic. To do this, click the "Data Prep" button in the main Erdas Imagine tool bar. This yields the following box:



Click "Mosaic Images…" to get the following dialog:

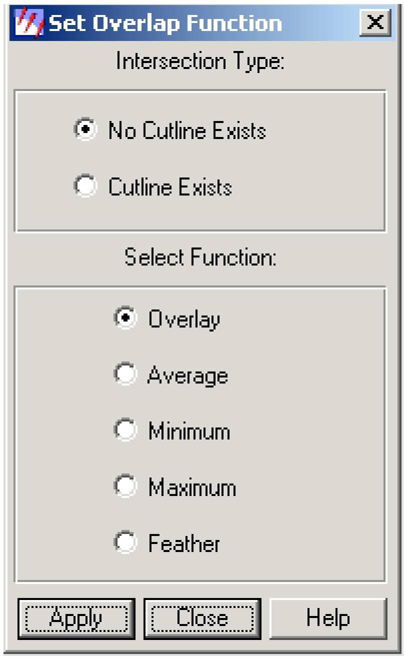


First, we must add all the DTM frames as images into this mosaic. To do this, click the (add images) button near the top. This yields the following dialog:

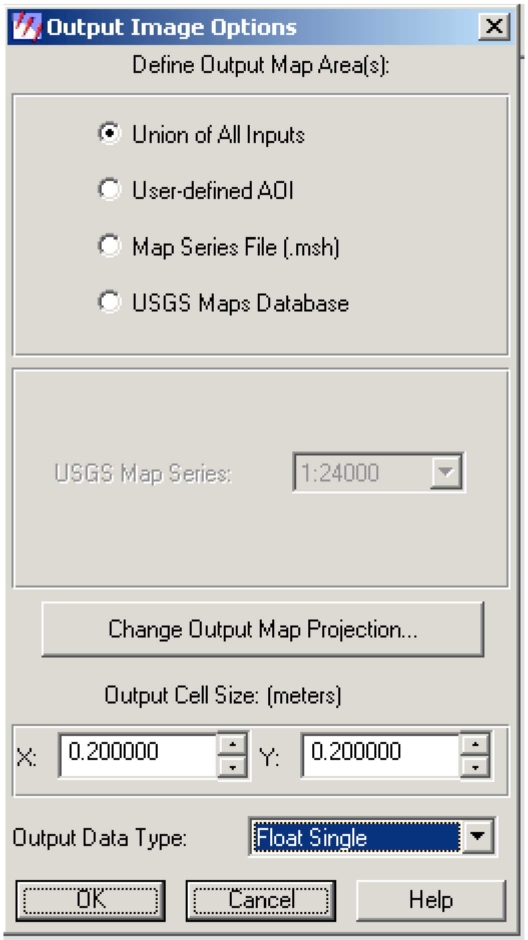


You can navigate to the appropriate directory and select all the DTM's at once. The result after doing that is what you see above. Now, select "Compute Active Area", and then click add. After some processing, this gives the following:

Now, we need to set the overlap functions and the resolution of the resulting mosaic. To set the overlap function, click “Edit” and select “Set Overlap Function”. This presents the following dialog:

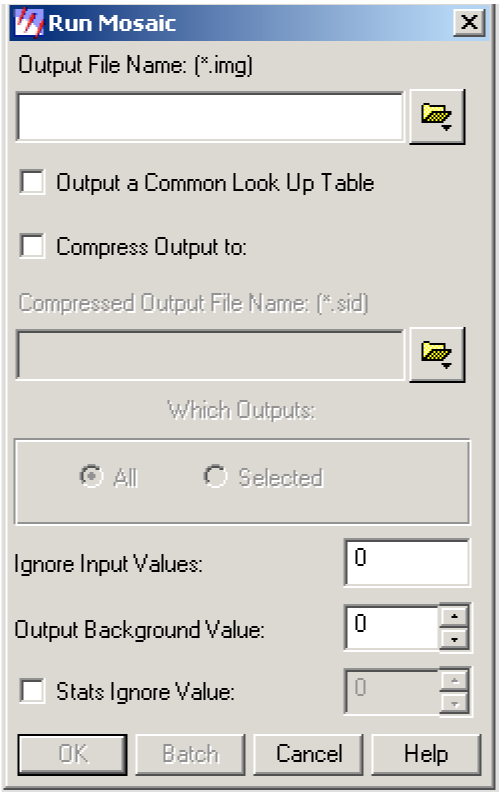


Select the "Feather" option and then click "Apply", then "Close". Now, to set the resolution, click Edit, then "Output Options" to get:

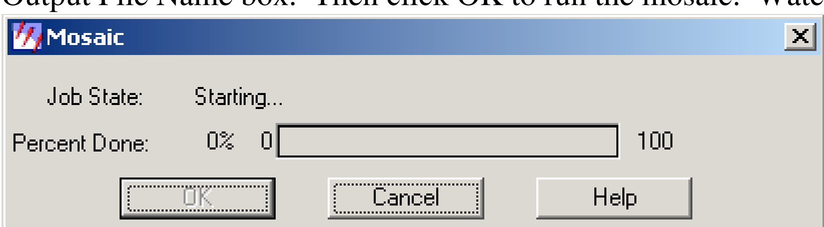


Set the output cell sizes appropriately. For the Harvard forest data, 0.2 is probably a much higher resolution than is needed. Click OK. Now, we need to compute the mosaic.

Click "Process" and then "Run Mosaic" to get the following dialog:



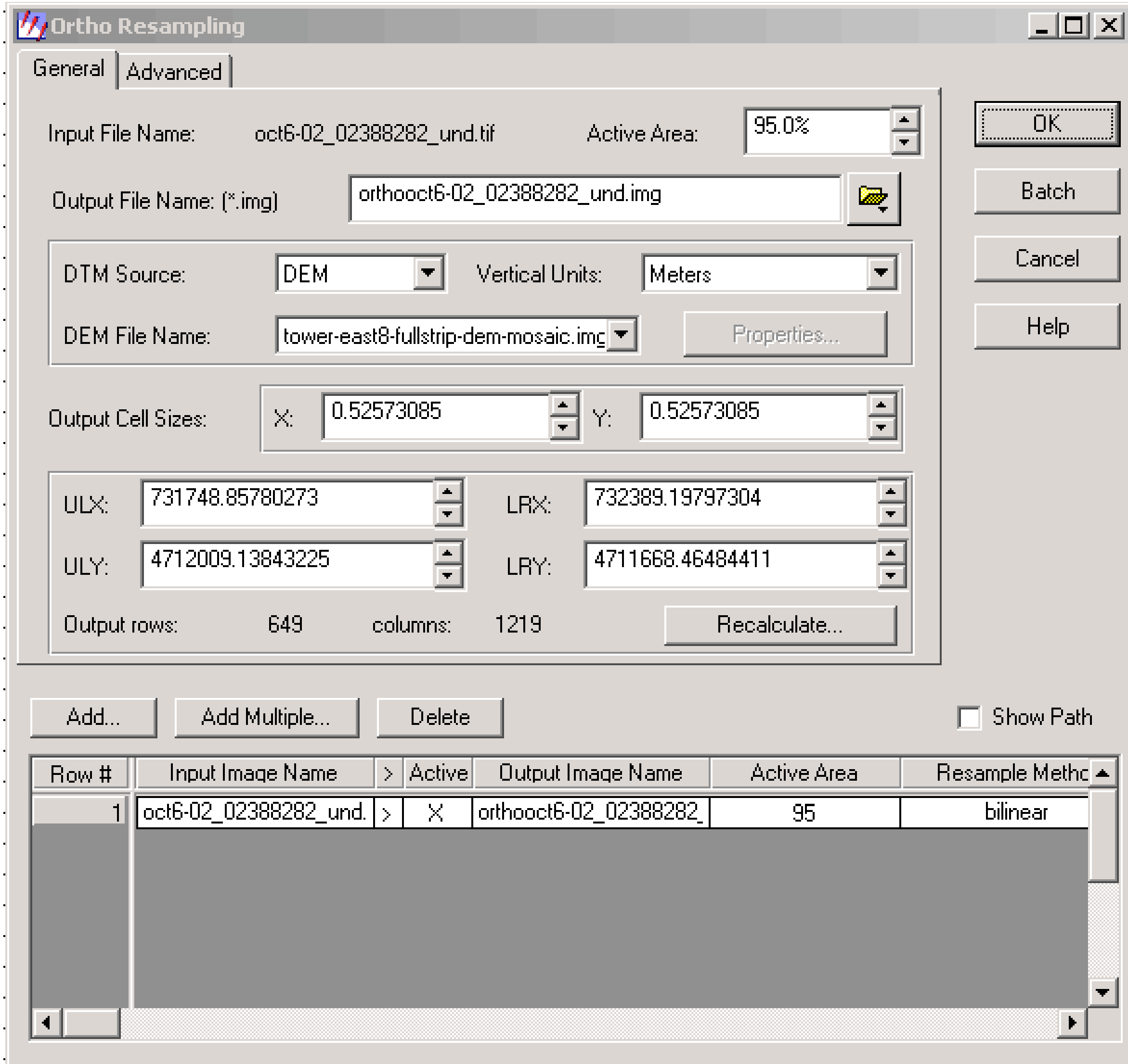
Enter the appropriate filename and location (by clicking on the folder and navigating) in the Output File Name box. Then click OK to run the mosaic. Watch the progress bar:



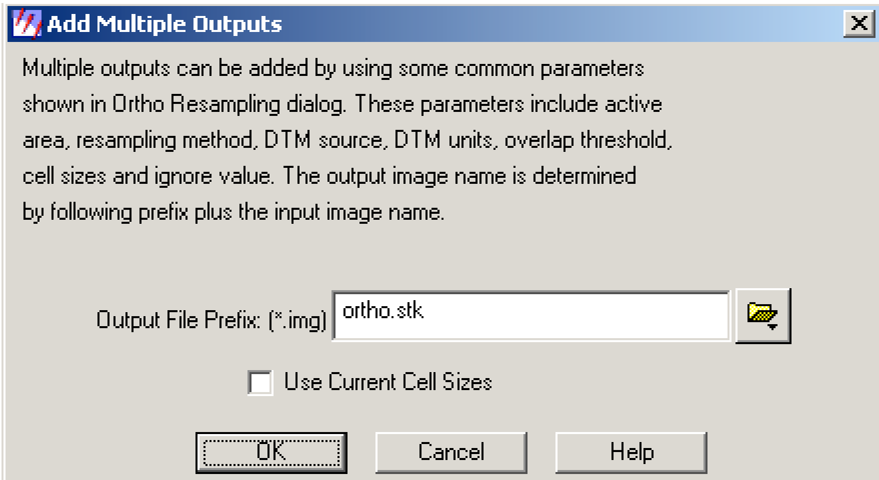
When finished, we can close all the mosaic tool windows, and return to OrthoBASE to continue working on our block file. You may view the newly created DTM mosaic by opening it in a viewer.

Orthorectification

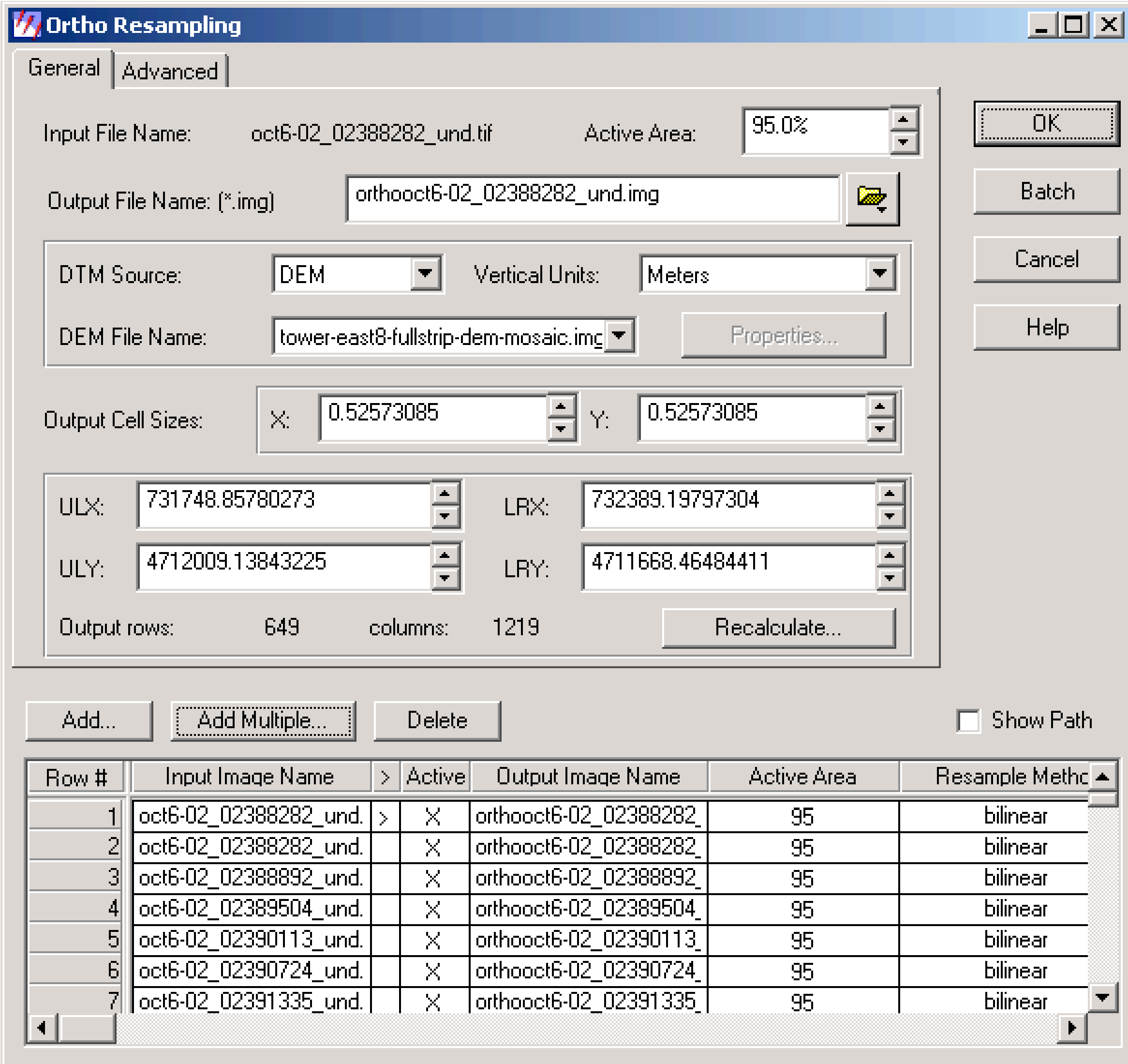
To begin the orthorectification process, click the (ortho resampling) button in the OrthoBASE main window. This presents the following dialog:



Remember to change the "Active Area" percentage to 95. Next to DTM source, click the down arrow and select DEM. Then, click the DEM File Name down arrow and select "Find DEM…", then navigate to the DEM mosaic just created, and select this file. Next, click the "Add Multiple…" button near the bottom. The following dialog appears:



Click the folder icon to the right of the text box labeled "Output File Prefix". Navigate to the directory where you want to store the individual orthorectified frames, change "Files of Type" to "IMAGINE image (*.img)", and then enter "ortho.img" in the "file name" box, then click OK. You then see the above dialog again. Check the "Use Current Cell Sizes" box, and click OK. Now the Ortho Resampling dialog reappears as this:



Notice that the first row is the same as the second row in the table at the bottom. We should delete the ***first*** row because it actually will place the orthoresampled image in the wrong place, leaving two copies of it. To do this, click the “1” on the left side of the table to select that row. Then, right-click, and choose “delete selection”. Now you can perform the orthorectification (or orthoresampling) by clicking “OK”. The process may take up to an hour or more for large block files. When complete, all the columns on the right side of the main OrthoBASE window should be green. Now, let’s create the orthomosaic.

Orthomosaic

To create the orthomosaic, we follow the same process as we did in mosaicking the DEM's. See the section labeled DTM Mosaic Generation. This time, however, select the orthorectified frames for mosaicking instead of the DTM's. Also, set the output cell size to 0.1 m. Run the mosaic as before, and it can be viewed in the viewer. Now the process is complete.