DEM extraction of PRISM stereo imagery

TUTORIAL

Relatively inexpensive while at the same time offering a high spatial resolution (2.5m in the Nadir), PRISM data offers an attractive option for Stereo DEM extraction.

This tutorial is designed to give a brief overview of the ALOS PRISM sensor and its products followed by instructions to extract a DEM from PRISM stereo imagery using Geomatica Orthoengine.

ABOUT ALOS

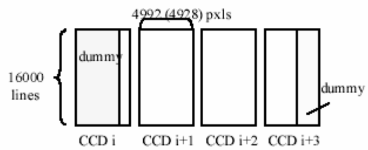
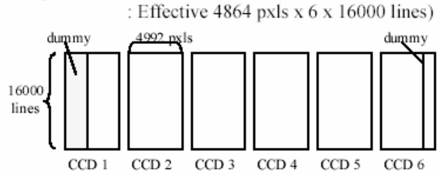
The Advanced Land Observing Satellite (ALOS) was developed by the Japan Aerospace Exploration Agency (JAXA). The sun synchronous, sub recurrent ALOS was launched by JAXA in January of 2006. ALOS is designed to provide valuable information for mapping, precise regional land coverage observation, disaster monitoring, and resource surveying. ALOS contains three sensors, commonly referred to as the "three eyes" of ALOS. These sensors are: the Panchromatic Remote-Sensing Instrument for Stereo Mapping (PRISM), the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2), and the Phased Array type L-band Synthetic Aperture Radar (PALSAR).

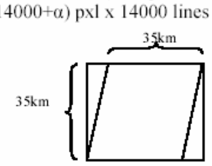
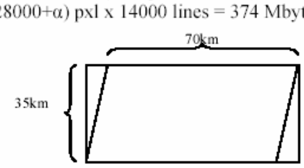
ABOUT PRISM

The PRISM sensor onboard ALOS contains three independent optical systems that allow for viewing in the Nadir direction, as well as forward and backward directions. This allows for the production of a stereoscopic image along the satellite's track. PRISM data is collected in a single band (panchromatic) with a wavelength of 0.52 to 0.77 micrometers. The spatial resolution of PRISM is 2.5m (when viewing in the Nadir direction). Swath width of PRISM is 70km when viewing in the Nadir direction, and 35km when in triplet mode. Prism's spatial resolution makes this sensor particularly desirable for mapping, urban planning, and monitoring desired areas. PRISM cannot image regions that are beyond 82 degrees North latitude and 82 degrees South latitude.

The PRISM sensor contains 6 CCDs for viewing at the Nadir, and 8 CCDs for viewing in the forward direction and backward directions. An image file is provided for each CCD when dealing with 1A and 1B1 level imagery (uncorrected imagery). Geomatica software offers support for PRISM imagery levels 1A, 1B1 and 1B2R. The following table, provided by NEC TOSHIBA Space Systems Ltd. displays the scene size and scene definition for PRISM level 1A, 1B1 and 1B2R.

PRISM PRODUCTS

Level	Observation Mode	Scene Size	Scene Definitions and Extraction method
1A, 1B1	Nadir normal mode, forward, backward view	Approximately 35 km x 35 km (4992 pxls x 16000 lines x 4 = 305 Mbyte : Nadir 4928 pxls x 16000 lines x 4 = 301 Mbyte : Forward / Backward : Effective 4864 pxls x 3 x 16000 lines) 	Scene position is defined by satellite RSP No. (Path and Frame) and scene shift distance. Calculate the scene center time corresponding to the frame number, and extract equidistant lines above and below from the calculated time. When scene shift is specified, the center time corresponding to the shifted frame number is calculated. Image file is created per CCD unit. Size of each file is 4992 pixels (nadir view) and 4928 pixels (forward, backward view), and areas with no data would be left as dummy data. Do not delete overlapped areas between CCDs. Even and odd pixel numbers have been already re-ordered. Usually there are 4 CCDs (4 files), but it may be occasionally 3 CCDs (3 files).
	Nadir 70 km Observation mode	Approximately 70 km x 35 km (4992 pxl x 16000 line x 6 = 457 Mbyte : Effective 4864 pxls x 6 x 16000 lines) 	Same as above.

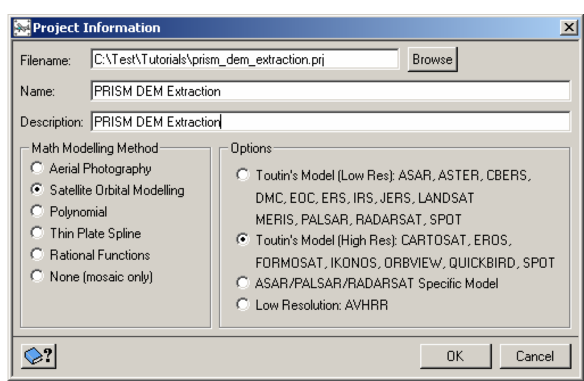
Level	Observation mode	Scene Size	Scene Definitions and Extraction method
1B2R (Geo-reference)	Nadir normal mode, forward, backward view	35 km x 35 km (Except skew area) ((14000+α) pxl x 14000 lines = 187 Mbyte) 	Scene position is defined by satellite RSP No. (Path and Frame) and scene shift distance. Calculate the scene center time corresponding to the frame number, and extract equidistant lines above and below from the calculated time. When scene shift is specified, the center time corresponding to the shifted frame number is calculated. There is only one image file in total, since each CCD was combined to make one scene.
1B2R (Geo-reference)	Nadir 70 km Observation mode	70 km x 35 km (Except skew area.) ((28000+α) pxl x 14000 lines = 374 Mbyte) 	Same as above.

STEREO DEM EXTRACTION USING GEOMATICA ORTHOENGINE

STEP 1 – Create a new project

To begin the process of extracting a DEM, we must setup a project in Orthoengine.

- In Orthoengine toolbar, select File → New to begin a new project. The Project Information Window appears.

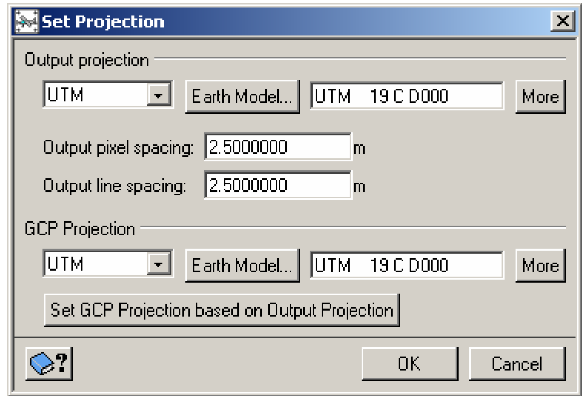


- Create a filename for the project, and give it a description.

- Select Toutin's Model (High Res).
- Click OK.

The next step is to define the Projection.

- Enter in the appropriate projection information for your PRISM dataset.
- It is recommended that you use "Set GCP Projection based on Output Projection" option for the GCP projection.
- Once the projection information is properly entered, click OK.

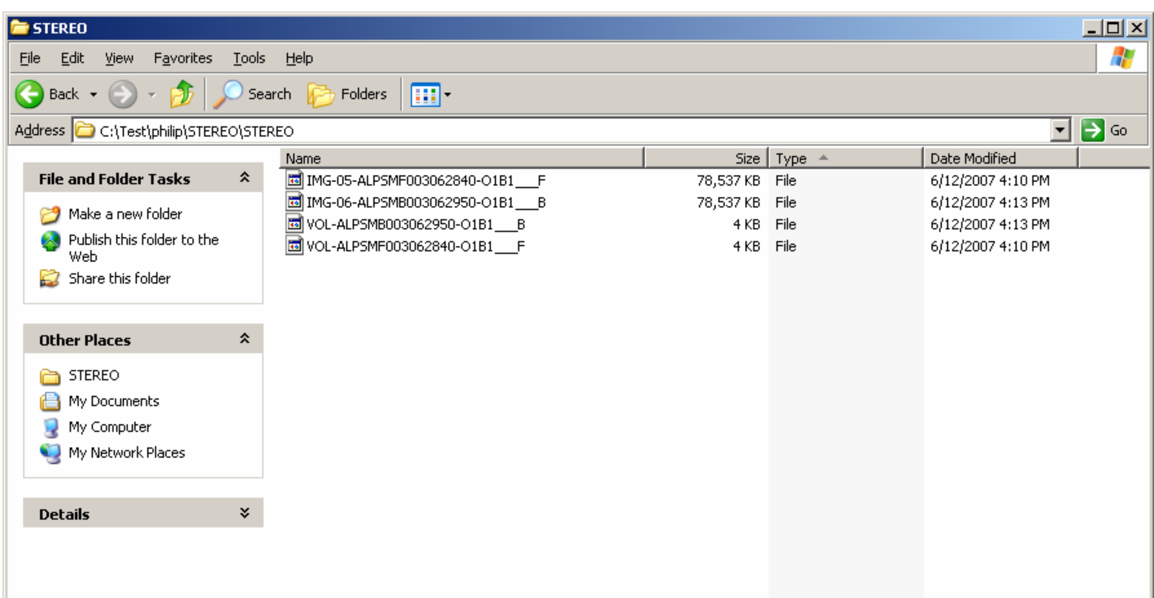


STEP 2 – Import PRISM imagery into project

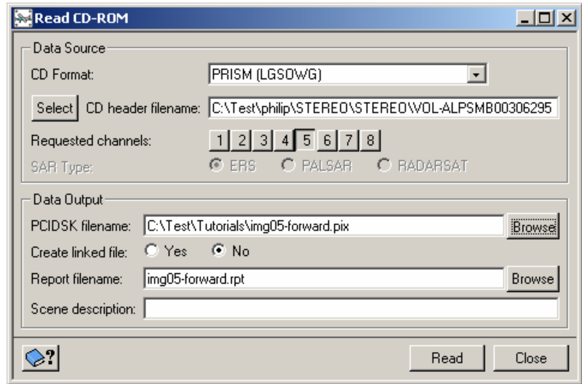
The below dataset shows stereo imagery from a single PRISM CCD, there are two types of files. One type is prefixed with the term "IMG" and the other type is prefixed with the term "VOL". The "VOL" files simply maintain information about the dataset, such as the images included in the dataset, their associated channel, and filename. The "IMG" files are the actual images in each dataset.

Note that both file types end with either "_F" or "_B". F indicates forward view, and B indicates backward view. Therefore, "VOL" files ending in "_B" maintain information about the backward view dataset, and "VOL" files ending in "_F" maintain information about the forward view dataset.

If you have data from the entire scene (i.e. all CCDs) then you will have several sets of stereo imagery to process using the following procedure. You could then stitch the DEMs from each stereo pair using the "DEM from Raster" tool in the "Import & Build DEM" processing step



To begin importing your PRISM imagery into your project:



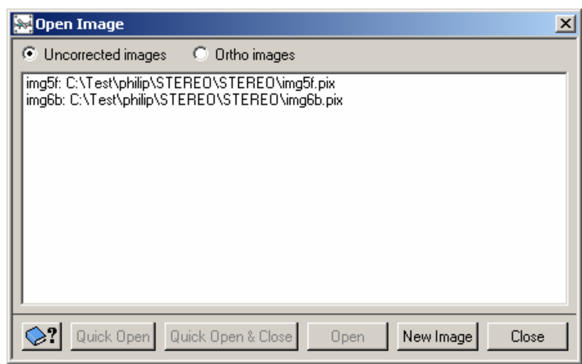
- Orthoengine select “Data Input” from the processing step, and Click “Read CD-ROM data”.
- In the Read CD-ROM data window, select “PRISM (LGSOWG)”
- Select the CD header filename (the VOLUME file).
- Select the channel to import. For example, if the imagery provided is prefixed by “IMG-05” then this would indicate that the channel is 5.
- Once the channel is selected, provide an appropriate PCIDSK filename and click READ.
- Repeat this procedure for all images in both the forward and backward views.

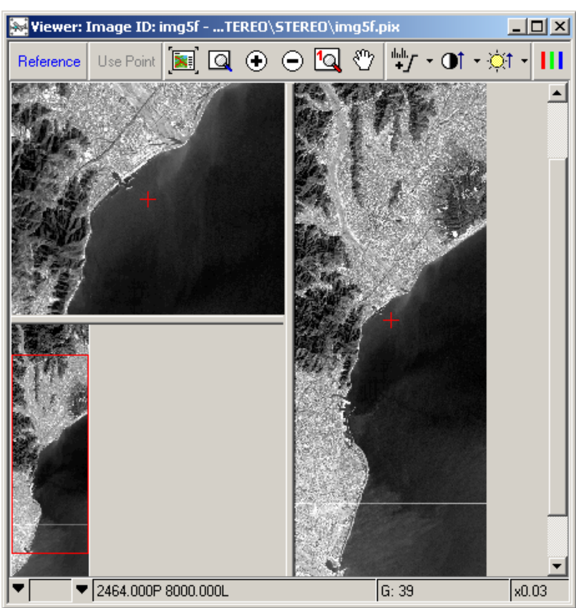
STEP 3 – Open Imagery

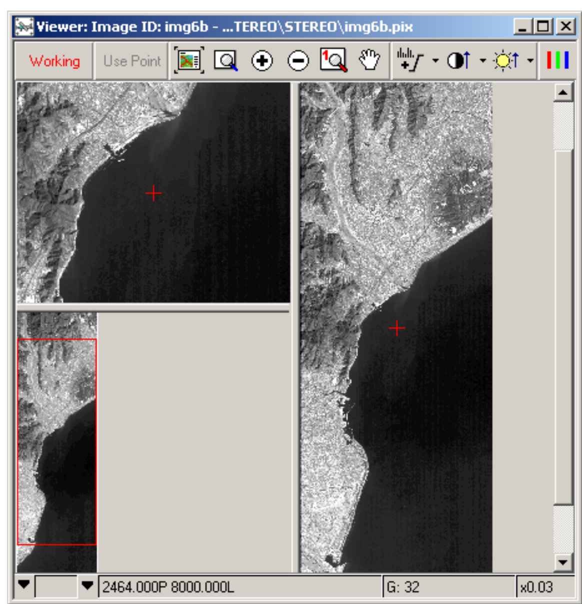
Once the imagery has been imported into PIX format, open a stereo pair.

In the processing step drop down in Orthoengine, select “GCP/TP Collection” and click the “Open a new or existing image” button.

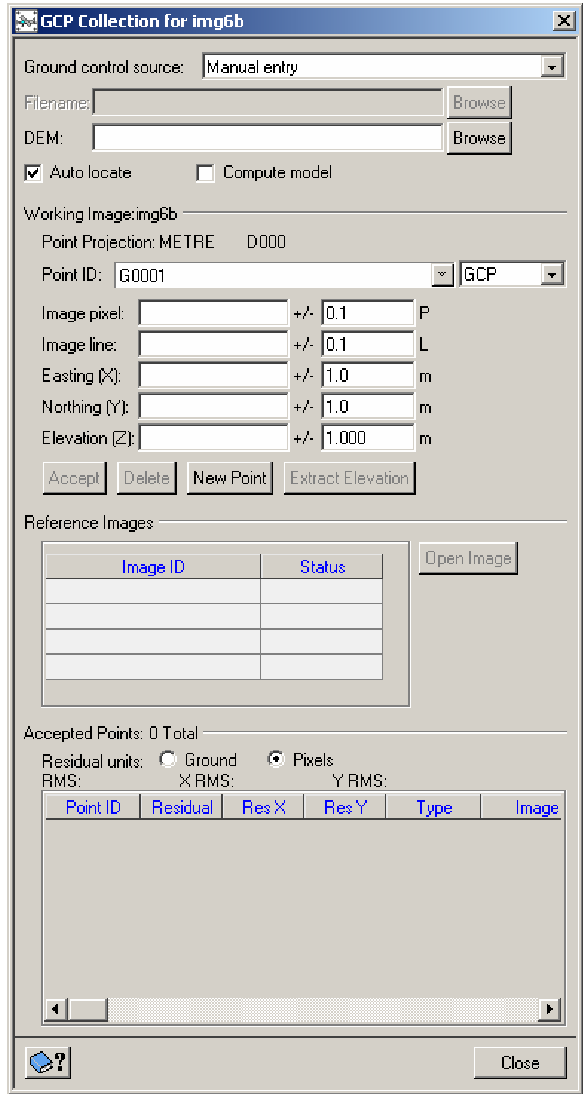
Once both images are open, one will be set to reference, and one will be set to Working.







STEP 4 – Collect Stereo GCPs

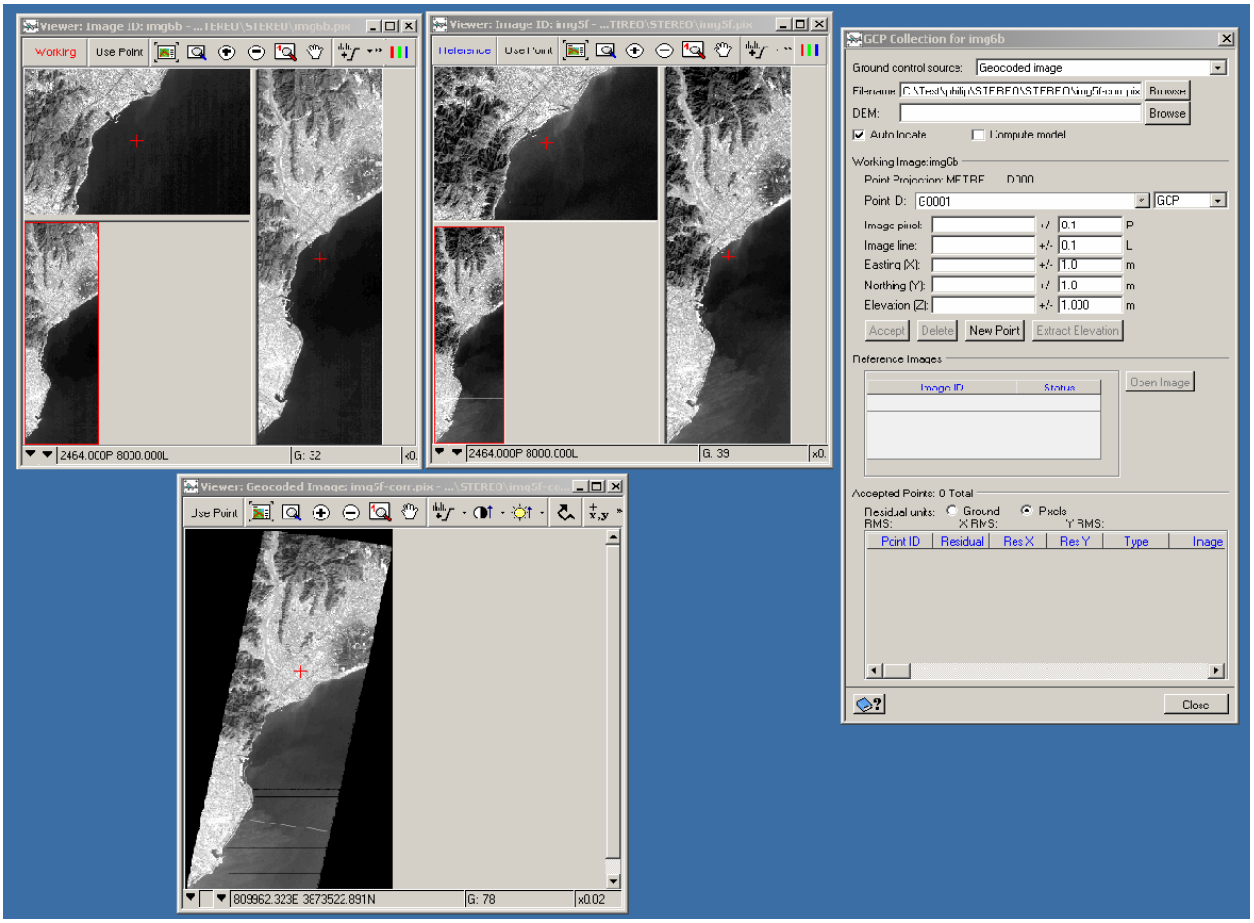


Now that the images have been opened, it's time to start collecting Stereo GCPs. Stereo GCPs are GCPs that are present in both images. These are advantageous for several reasons. Firstly, Stereo GCPs are useful because they can be used to derive elevation information from a stereo dataset. This is the result of the parallax difference which occurs between the stereo pair. Secondly, Stereo GCPs are heavily weighted in the adjustment model. It is important when collecting Stereo GCPs that the user take the utmost care to ensure that accurate and precise Stereo GCPs are chosen.

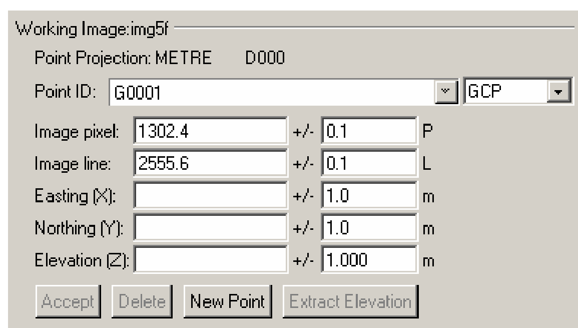
To begin collecting Stereo GCPs:

- Ensure that the "Collect GCP/TP Collection" option is chosen in the Processing Step of Orthoengine, and
- Click the "Collect GCPs Manually" button. The GCP collection panel opens.
- Select a Ground Control source that you will use to obtain control information for your Stereo GCPs. For this example, a Geocoded Image will be chosen.
- If you are going to be extracting elevation from a DEM, browse to your DEM file (note: If you do not have a DEM, you may use demworld.pix (C:\Program Files\PCI Geomatics\Geomatica_V101\etc).

Shown below is the configuration of files/windows that will now be used to collect Stereo GCPs. The bottom image is the Geocoded Source Image, and the top two images are the stereo PRISM imagery.



- Select the first image you would like to collect a GCP in by setting it to the working image. The working image chosen for this example is the forward view image (img5f.pix)



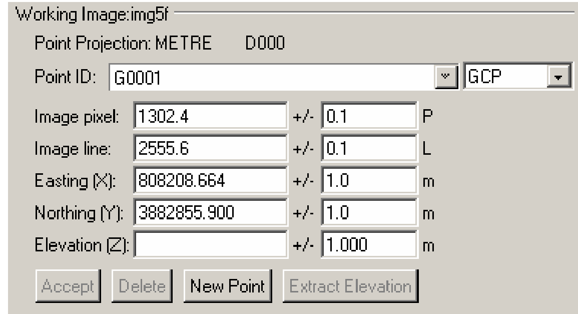
- In your working image viewer, locate a clearly identifiable point you would like to use as a GCP and click "Use Point".

- To ensure better results, make sure that the GCP you choose is a well defined location in your image (such as an intersection of two roads). Also ensure that the GCP is identifiable in both images in the stereo pair, and the control source image.

- Notice that after you click "Use Point" the GCP Collection Window updates with the pixel and line location of the GCP.

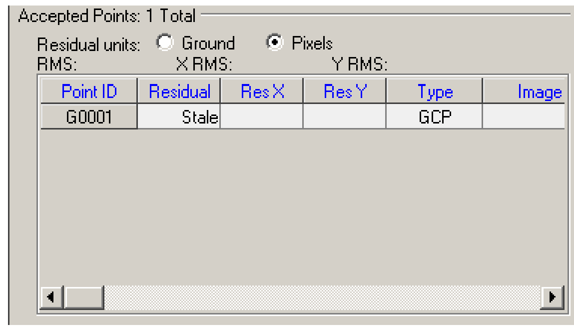
- Now locate the same location (in this case, G0001) in the geocoded image. Be sure to get as close as possible to the same location as that in your working image.

- Once you have found the same point, click "Use Point" in the control source image window. Notice that the Eastings and Northings information is added to the GCP collection Window.



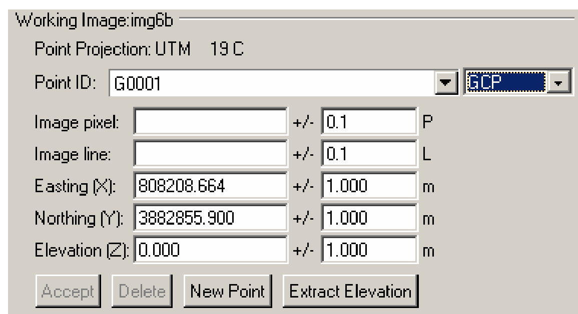
- Enter the elevation of your GCP (if it is known), or use "Extract Elevation" to extract the elevation value for this GCP from your DEM.

- In the GCP Collection Window, Click Accept. Notice that the new GCP (in this case, G0001) is now added to the Accepted Points section



- Now the same GCP must be collected in the other image in the stereo pair. Change the Viewer Window Status of the second image in the stereo pair from Reference to Working.

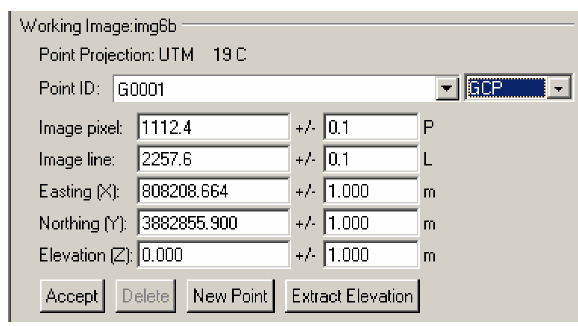
- In the GCP collection window, change the Point ID to the same Point ID just collected in the other image. In this example, the Point ID just collected was G0001. Therefore, in the current working image, we change the Point ID to G0001 as well. This allows Orthoengine to reference the same Easting, Northings and Elevation information from the previous image. The Easting and Northing information is updated as shown here:



- Click "Use Point" for this Working Image and notice that the pixel and line coordinates of the GCP are added to the GCP collection window.

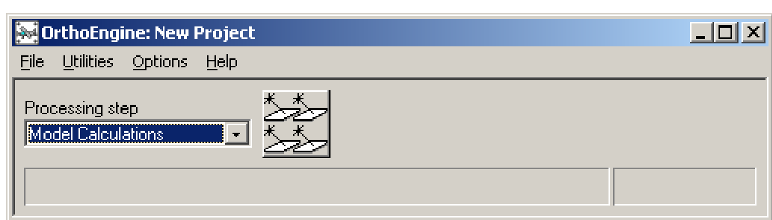
- Click "Accept" in the GCP Collection Window to add the Stereo GCP.

- Now repeat the same process to collect other Stereo GCPs. Try to collect GCPs such that they are evenly distributed across both the spatial extent and elevation range of the scene. Remember to ensure a good RMS (Root Mean Square) error.



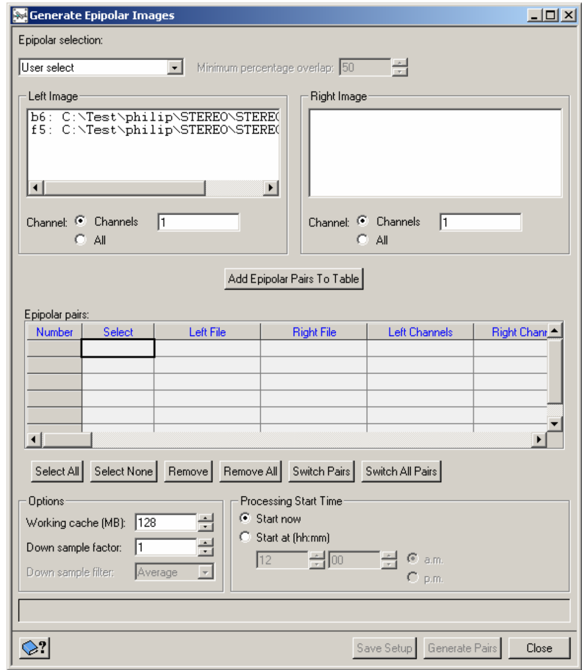
STEP 5 – Compute Model

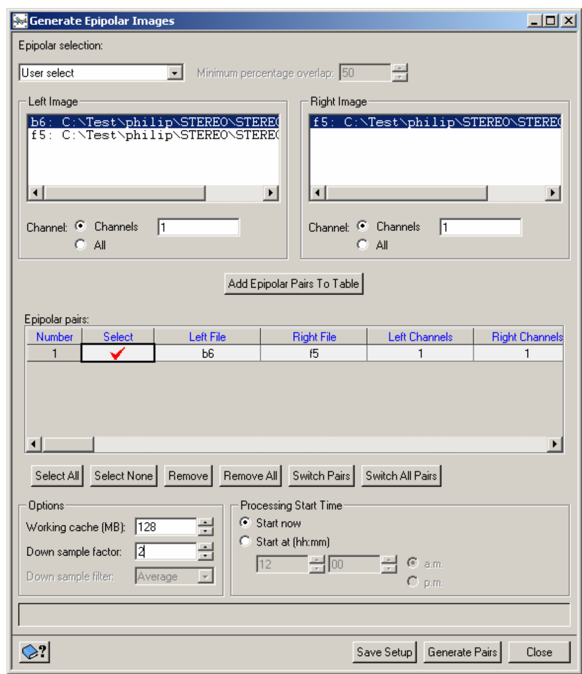
- Now that all stereo GCPs have been collected, switch to "Model Calculations" in the processing step of Orthoengine and click the "Compute Model" button.



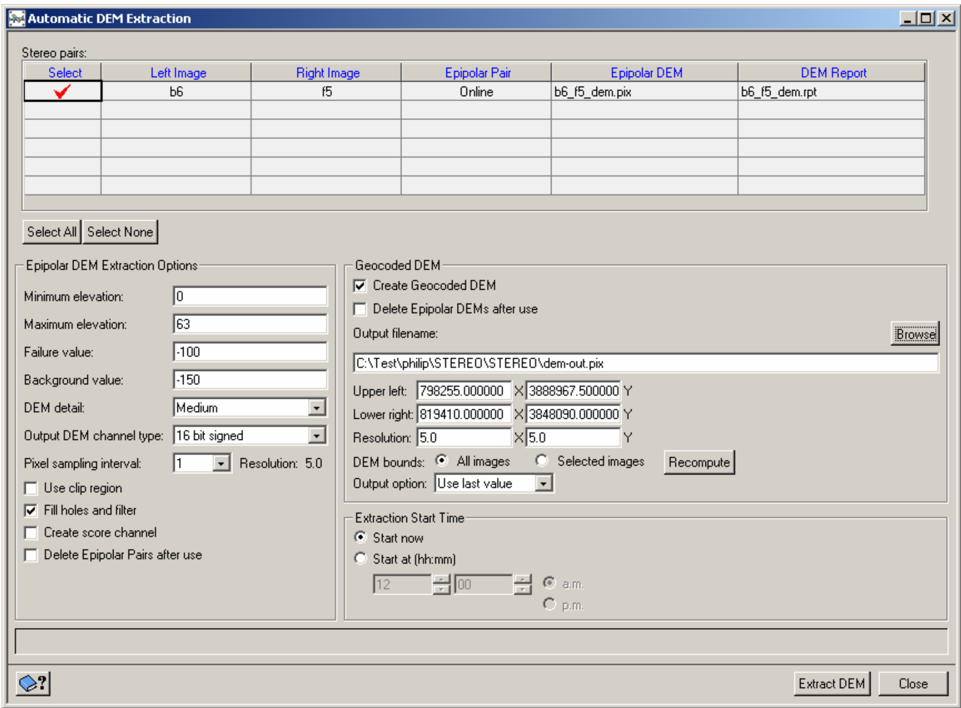
STEP 6 – Extract DEM from Stereo

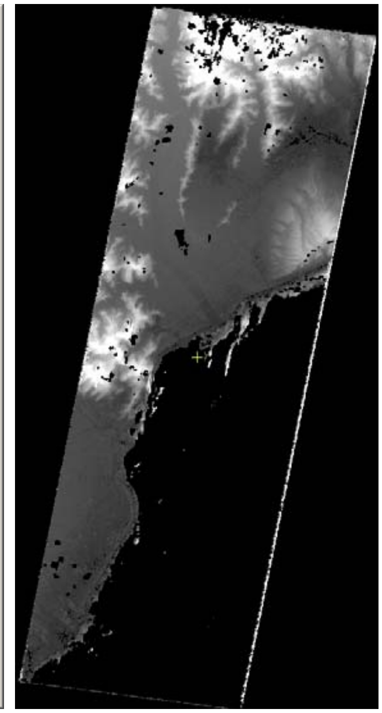
- In Orthoengine, switch to the “DEM From Stereo” option in the Processing Step. Then click the “Create Epipolar Image” button. The Generate Epipolar Images Window appears.
- In the Generate Epipolar Images window, select a left image and right image. Then click Add Epipolars to Table. The Epipolar pairs are then added to the Epipolar Pairs table. For PRISM data, it is also recommended that the user set a down sample factor greater then 1 to obtain a more smooth DEM. For this example, we will use a down sample factor of 2. A value of 4 may also be good.
- Now click Generate Pairs to generate the Epipolar images. (This may take some time depending on file size).
- Now that the Epipolar Pairs have been generated, click the “Extract DEM automatically” button in Orthoengine (Processing Step: DEM From Stereo)



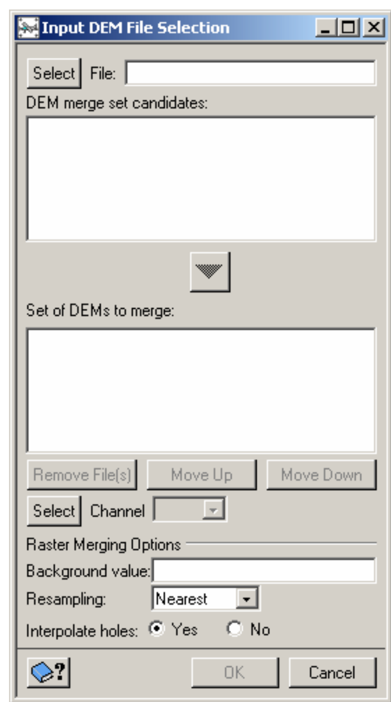


- In the Automatic DEM Extraction Window, put a checkmark next to the stereo pair you are working with and set a pixel sampling interval of 1. Select the option "Create Geocoded DEM" and choose an output filename for your DEM.





- Now click Extract DEM. (Note: This may take some time to process, depending on file size). The DEM extracted from the sample data used in this tutorial is shown below:



STEP 7 – Extract DEM for additional stereo pairs and merge

- In order to completely build a DEM for the entire scene of interest, the user must repeat Steps 1 through 6 for the stereo pair from each CCD in the scene.

- Once a DEM has been extracted for each CCD, the user can then use the "Build DEM from Raster File" module in Orthoengine under processing step "Import and Build DEM". The following window appears.

- The user then uses the "Select" button to import each DEM generated for each CCD, and uses the arrow button to add all DEMs to "Set of DEMs to merge". Click Ok to proceed to the "Define Output DEM File" window, where the user will define the DEM Region and Resolution, then choose "Generate DEM" to generate the DEM of the entire scene.