Orthorectifying WorldView-1 Imagery using Rational Polynomial Coefficients (RPCs) in ENVI 4.8

Introduction

DigitalGlobe's QuickBird, WorldView-1, and WorldView-2 images are comprised of groups of scan lines acquired as the satellites move forward in its orbit. As a result, different parts of the same image are acquired from different sensor positions. In order to rigorously describe the transformation from image coordinates to Earth surface coordinates, a mathematical sensor model that incorporates all of the physical elements of the imaging system can be exceedingly long and complex. **Rational Polynomial Coefficients (RPCs)** are simpler empirical mathematical models relating image space (line and column position) to latitude, longitude, and surface elevation. The name Rational Polynomial derives from the fact that the model is expressed as the ratio of two cubic polynomial expressions. Actually, a single image involves two such rational polynomials, one for computing line position and one for the column position. The coefficients of these two rational polynomials are computed by DigitalGlobe from the satellite's orbital position and orientation and the rigorous physical sensor model.* Using the georeferenced satellite image, its rational polynomial coefficients, and a DEM to supply the elevation values, ENVI 4.8 can compute the proper geographic position for each image cell, producing an **Orthorectified** image.

Orthorectification is a process of making the geometry of an image planimetric, or map-accurate, by modeling the nature and magnitude of geometric distortions in the imagery. These distortions are caused by topography, camera geometry, and sensor-related errors. Orthorectification is a logical step when precise positional accuracy and uniform scale are required throughout an image. After orthorectifying an image, you can measure or precisely locate features in the image, collect information for a GIS, or combine the image with other orthorectified images for sophisticated analyses.

It's important to note that using the RPCs is just one way to transform from image coordinates to Earth surface coordinates. This process can also be completed using the Rigorous Sensor Model; although not all 3rd party remote sensing software packages have access to DigitalGlobe's Rigorous Sensor Model for its satellites.

This tutorial demonstrates ENVI's orthorectification tools that use rational polynomial coefficients (RPCs). The example used for orthorectification using the RPCs is a WorldView-1 Ortho Ready Standard product. **

**RPC files are available for all DigitalGlobe sensors (QuickBird, WorldView-1 and WorldView-2) and accompany Basic (1B) Products as well as Ortho Ready Standard (2A) products.*

***This process can also be performed on QuickBird and WorldView-2 imagery files that contain RPCs*

View Images

1. From the ENVI main menu bar, select **File > Open Image File**. A file selection dialog appears.

2. Navigate to the folder where your image files resideand select the file with the .TIF or .NTF extension. In this example, we will open a WorldView-1 image called 10SEP12175936-P2AS-052582771010_01_P001. Click **Open**.

3. In the Available Bands List, select the **Gray Scale** radio button, select **Band 1** and then **Load Band**. Although the image has map information associated with it, orthorectification is still required since the coordinates reported for any given point in the image are likely to have significant positional inaccuracy.

Fig.1. Scroll Window

4. A DEM is optional input, but it enhances the accuracy of the orthorectification. From the main ENVI menu bar, select **File > Open External File > Digital Elevation > USGS DEM**. *Note: If you have your own DEM that coincides with your DigitalGlobe image you can bypass this part. In this example we used a DEM that accompanies the ENVI 4.8 software.*

5. Select conus_usgs.demand click **Open**. A USGS DEM Input Parameters dialog appears.

6. Enter ortho_dem.datfor the output filename and click **OK**.

7. In the Available Bands List, select **Display #1** and then **New Display**.

8. In the Available Bands List, select **DEM Image** and then **Load Band**.

The elevation for this area ranges from 1,800 meters to 2,900 meters. This significant topographic variation is sure to introduce geometric inaccuracies into the WorldView-1 image. The DEM and the WorldView-1 image do not have the same map projection or pixel size. However, you do not have to reproject or resample the two images; ENVI's orthorectification tool accounts for their differences.

Run the Orthorectification

1. From the ENVI main menu bar, select **Map > Orthorectification >WorldView > Orthorectify WorldView**. A file selection dialog appears.
2. In this example we'll select 10SEP12175936-P2AS-052582771010_01_P001.tifand click **OK**. An Orthorectification Parameters dialog appears.

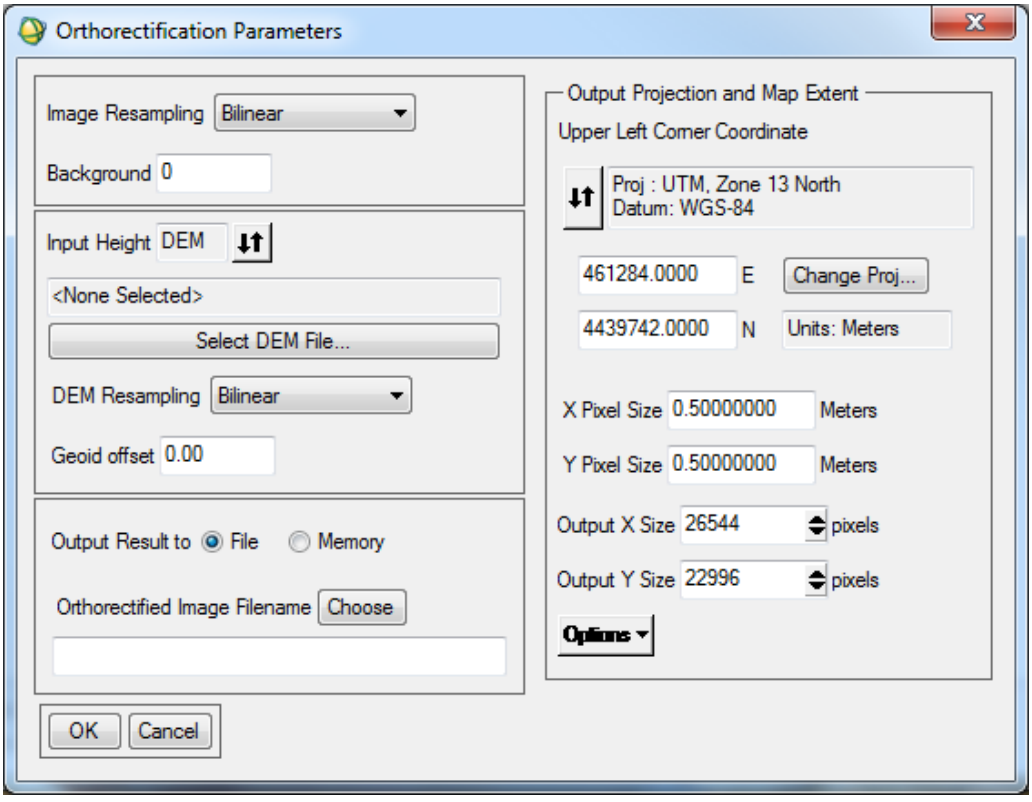

Fig.2. Orthorectification Parameters

3. Image Resampling is the method for determining pixel values in the WorldView-1 image during the orientation. The default method is Bilinear, which provides moderately smooth results. The Cubic Convolution option provides smoother results,

while the Nearest Neighbor option does change the original pixel values. The Nearest Neighbor option leads to a relatively choppy appearance, but it is the only valid option if you intend to perform analyses on the orthorectified image. For this tutorial, we will select **Bilinear**.

4. Background refers to the value assigned to the border pixels in the orthorectified image. Leave the value at **0**.
5. Input Height specifies whether a DEM or a fixed elevation value will be used for the entire image. Because you have a DEM (the more accurate option), leave the DEM option selected.
6. Click **Select DEM**. A Select Input DEM Band dialog appears.
7. Select **DEM Image** under ortho_dem.dat and click **OK**. *Note: If you have a DEM that you would prefer to use in this step you can click on **Open** and select **New File.** This will take you to an explorer window. Navigate to the folder with the DEM you would like to use and select it with your cursor. Once selected click **Open***
8. DEM Resampling is the method used to determine pixel values for an internally calculated version of the DEM image with the same orientation and pixel size as the WorldView-1 image. Again, use the default **Bilinear** method.
9. Geoid offset is the height of the geoid above mean sea level in the geographic area covered by the image. Most DEM images provide information about the elevation above mean sea level for each pixel. Orthorectification, however, requires information about the height above the ellipsoid for each pixel. To convert from the DEM mean sea level values to height above the ellipsoid, you must add the geoid height to the DEM.

   Enter a **Geoid offset** value of **-13**. This means the ellipsoid is about 13 meters above mean sea level in this area. Many institutions that perform photogrammetry have their own software for determining geoid heights, or you can obtain software from NOAA, the National Geospatial Intelligence Agency (NGA), USGS, or other sources.

   See the following URL for a geoid height calculator: http://www.ngs.noaa.gov/cgi-bin/GEOID_ STUFF/geoid99_prompt1.prl .
10. The right side of the dialog has parameters related to the extent and pixel size of the output image. The default values are calculated from the georeferencing information in the original WorldView-1 image. These values are appropriate for this example. You could also optionally change the projection for the output orthorectified image by clicking **Change Proj**.
11. Enter WorldView_ortho.datin the **Orthorectified Image Filename** field.
12. Click **OK** to begin the orthorectification process, which can take several minutes. After processing is complete, the orthorectified image is added to the Available Bands List.

Examine the Orthorectification Results

1. Display the orthorectified image in Display #2, which currently contains the DEM image.

2. Compare the original WorldView-1 image to the orthorectified image by selecting **Tools > Link > Link Displays** from a Display group menu bar and clicking **OK** in the Link Displays dialog.

3. Click inside an Image window to toggle between the two images. Pay notice to the subtle difference in geometry

For more information on ExelisVis ENVI 4.8 product please visit
http://www.exelisvis.com/ProductsServices/ENVI/Capabilities.aspx

For more technical information on DigitalGlobe Products and Services please visit
http://www.digitalglobe.com/resources
Additional Documents and Imagery Product Samples may be downloaded from here.