

# ENVI Tutorial: Orthorectifying Imagery using Rational Polynomial Coefficients (RPCs)

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# Orthorectifying Using Rational Polynomial Coefficients (RPCs)

This tutorial demonstrates ENVI's orthorectification tools that use rational polynomial coefficients (RPCs). You will orthorectify an IKONOS image of La Jolla, California, USA, courtesy of Space Imaging. You will then compare the orthorectified image to the uncorrected image and examine the differences.

## Files Used in This Tutorial

ENVI Resource DVD: Data\ortho

File	Description
conus_usgs.dem	USGS digital elevation model (DEM) for the area of the IKONOS image
po_101515_metadata.txt	Metadata file for the IKONOS image
po_101515_pan_0000000_rpc.txt	Text file containing RPCs
po_101515_pan_0000000.tfw	TIFF world file containing initial georeferencing information
po_101515_pan_0000000.tif (.hdr)	IKONOS image data in TIFF format

## Introduction to RPC Orthorectification

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.

ENVI's orthorectification tools rectify data from specific pushbroom sensors (currently ASTER, CARTOSAT-1, FORMOSAT-2, GeoEye-1, IKONOS, OrbView-3, QuickBird, RapidEye, SPOT, and WorldView-1), using an RPC model. Data from each of these sensors typically include an ancillary RPC file generated from ephemeris data, which ENVI uses to perform the orthorectification.

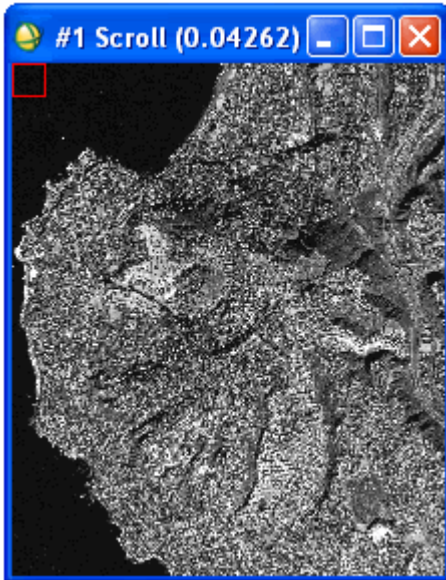
The following are required input for RPC orthorectification:

- The image to rectify
- RPC model (not required for SPOT data)
- Elevation information
- Offset between mean sea level and the gravitational potential surface (known as the geoid), so the elevation can be correctly interpreted
- If approximate geolocation information is not available for the source image, the rough location of the image on the earth's surface must be computed to provide a location base needed for the RPC transformation.

The input image must be linked to the RPC coefficients contained in an ancillary text file. These coefficients are required for the rational function expansion to convert ground coordinates into sensor coordinates. In the case of opening an IKONOS image, which you will use for the following exercise, ENVI searches for an RPC filename consisting of the root name of the source image plus `_rpc.txt`.

## View Images

1. From the ENVI main menu bar, select **File > Open Image File**. A file selection dialog appears.
2. Navigate to `Data\ortho` and select `po_101515_pan_0000000.tif`. Click **Open**.
3. In the Available Bands List, select the **Gray Scale** radio button, select **Band 1**, and click **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.



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**.
5. Select `conus_usgs.dem` and click **Open**. A USGS DEM Input Parameters dialog appears.
6. Enter `ortho_dem.dat` for the output filename and click **OK**.
7. In the Available Bands List, click **Display #1** and select **New Display**.
8. In the Available Bands List, select **DEM Image** and click **Load Band**.

The elevation for this area ranges from sea level to 245 m. This significant topographic variation is sure to introduce geometric inaccuracies into the IKONOS image. The DEM and the IKONOS 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 > IKONOS > Orthorectify IKONOS**. A file selection dialog appears.
2. Select `po_101515_pan_0000000.tif` and click **OK**. An Orthorectification Parameters dialog appears.
3. Image Resampling is the method for determining pixel values in the IKONOS 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, 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**.
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 IKONOS 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.

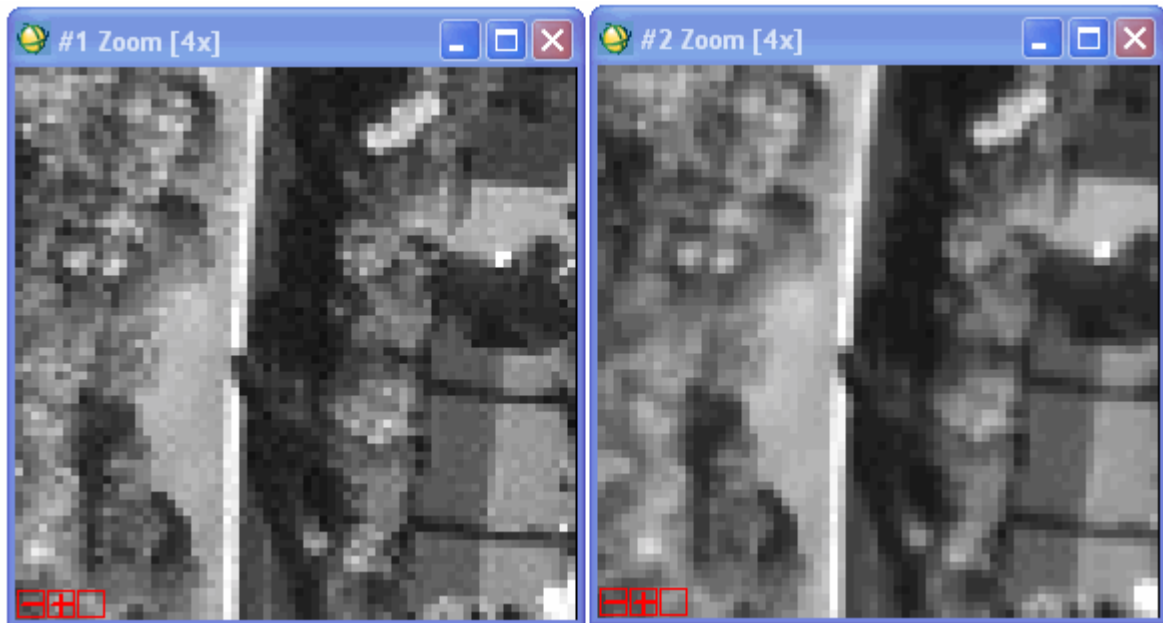
Enter a **Geoid offset** value of **-35**. This means the ellipsoid is about 35 m above mean sea level in this area. Many institutions that perform photogrammetry have their own software for determining geoid heights, or you can obtain software from NOAA, the National Geospatial Intelligence Agency (NGA), 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](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 IKONOS 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 `ikonos_ortho.dat` in 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 IKONOS 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. Notice the subtle difference in geometry, especially in the upper-right corner of the two images:



4. When you are finished, select **File > Exit** from the ENVI main menu bar.