ENVI

ENVI Tutorials: Image Georeferencing and Registration

Table of Contents

Overview of This Tutorial

This tutorial provides basic information about georeferenced images in ENVI and provides a starting point for conducting image-to-image and image-to-map registration using ENVI. It assumes that you are already familiar with general image-registration and resampling concepts. This tutorial is designed to be completed in about 1 to 2 hours.

Files Used in This Tutorial

ENVI Tutorial Data DVD: `envidata\bldr_reg`

File	Description
bldr_sp.img (.hdr)	Boulder SPOT georeferenced image subset
bldr_tm.img (.hdr)	Non-georeferenced Boulder TM data
bldr_tm.pts	GCPs for TM-SPOT image-to-image registration
bldrtm_m.pts	GCPs for TM-Map registration
bldr_rd.dlg	Boulder roads DLG
Generated Files	
bldr_tm1.wrp (.hdr)	Image-to-image result using RST and nearest neighbor
bldr_tm2.wrp (.hdr)	Image-to-image result using RST and bilinear interpolation
bldr_tm3.wrp (.hdr)	Image-to-image result using RST and cubic convolution
bldr_tm4.wrp (.hdr)	Image-to-image result using 1st degree polynomial and cubic convolution
bldr_tm5.wrp (.hdr)	Image-to-image result using Delaunay triangulation and cubic convolution
bldrtm_m.img (.hdr)	Image-to-map result using RST and cubic convolution for the Boulder TM data
bldrtmsp.img (.hdr)	Boulder TM/SPOT sharpening result using HSV sharpening, 10 meter pixels

Georeferenced Images in ENVI

ENVI provides full support for georeferenced images in numerous predefined map projections including UTM and State Plane. In addition, ENVI's user-configurable map projections allow construction of custom map projections utilizing 6 basic projection types, over 35 different ellipsoids, and more than 100 datums to suit most map requirements.

ENVI map projection parameters are stored in an ASCII text file `map_proj.txt` that you can edit or modify using ENVI map projection utilities. The information in this file is used in the ENVI header files associated with each image and allows simple association of a reference pixel location with known map projection coordinates. Selected ENVI functions can then use this information to work with the image in georeferenced data space.

ENVI's image registration and geometric correction utilities allow you to reference pixel-based images to geographic coordinates and/or correct them to match base image geometry. Ground control points (GCPs) are selected using the Image and Zoom windows for both image-to-image and image-to-map registration. Coordinates are displayed for both base and uncorrected image GCPs, along with error terms for specific warping algorithms. Next GCP point prediction allows simplified selection of GCPs.

Warping is performed using resampling, scaling and translation (RST), polynomial functions (of order 1 through n), or Delaunay triangulation. Resampling methods supported include nearest-neighbor, bilinear interpolation, and cubic convolution. Comparison of the base and warped images using ENVI's multiple dynamic overlay capabilities allows quick assessment of registration accuracy.

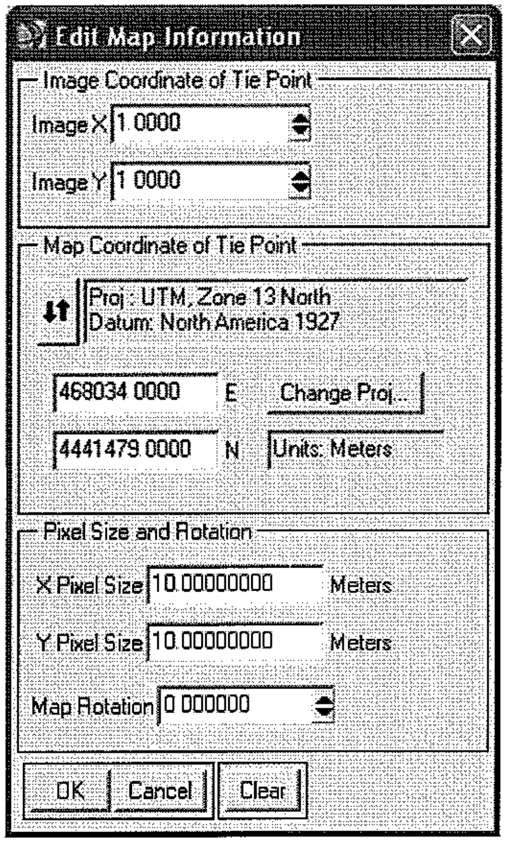
The following sections provide examples of some of the map-based capabilities built into ENVI. Consult ENVI Help for additional information.

Opening and Displaying Georeferenced Data

Before attempting to start the program, ensure that ENVI is properly installed as described in the Installation Guide that shipped with your software.

1. From the ENVI main menu bar, select **File → Open Image File**.
2. Navigate to the `envidata\bldr_reg` directory, select the file `bldr_sp.img` from the list, and click **Open**. The Available Bands List appears.
3. From the Available Bands List, select the **Georeferenced SPOT** band from the list and click **Load Band** to load the image into a new display group

Viewing Map Info in the ENVI Header



1. In the Available Bands List, right click on the **Map Info** icon and select **Edit Map Information**. The Edit Map Information dialog appears.

   This dialog lists the basic map information used by ENVI in georeferencing. The image coordinates correspond to a reference pixel used by ENVI as the starting point for the map coordinate system. Because ENVI knows the map projection, pixel size, and map projection parameters based on this header information and the map projection text file, it can calculate the geographic coordinates of any pixel in the image. You can enter coordinates in either map coordinates or geographic (latitude/longitude) coordinates.

2. Click on the projection field toggle button to display the latitude/longitude coordinates for the UTM Zone 13 North map projection. Note that ENVI makes this conversion on-the-fly.
3. Click the **DDEG** button then click the **DMS** to toggle between degrees-minutes-seconds, and decimal degrees, respectively.
4. Click **Cancel** to exit the Edit Map Information dialog.

Displaying the Cursor Location and Value

You can choose to display the location of your mouse cursor, screen value (RGB color), and the data value of the pixel underneath the crosshair cursor using the Cursor Location/Value dialog. When several display groups are open, this dialog specifies which display group's location and value are being reported.

1. To display the cursor location and value, select **Window → Cursor Location/Value** from either the ENVI main menu bar or the Display group menu bar. You can also double-click inside the Image window.
2. Move the mouse cursor over the Image, Scroll, or Zoom windows to display location and value information in the Cursor Location/Value dialog. Note that the coordinates are given in both pixels and georeferenced coordinates for this georeferenced image. Also note the relation between map coordinates and latitude/longitude.
3. From the Cursor Location/Value menu bar, select **File → Cancel** to close the dialog.
4. Keep the display group open for the next exercise.

Image to Image Registration

This section of the tutorial takes you step-by-step through Image to Image Registration. The georeferenced SPOT image will be used as the base image, and a pixel-based Landsat TM image will be warped to match the SPOT.

Opening and Displaying a Landsat TM Image File

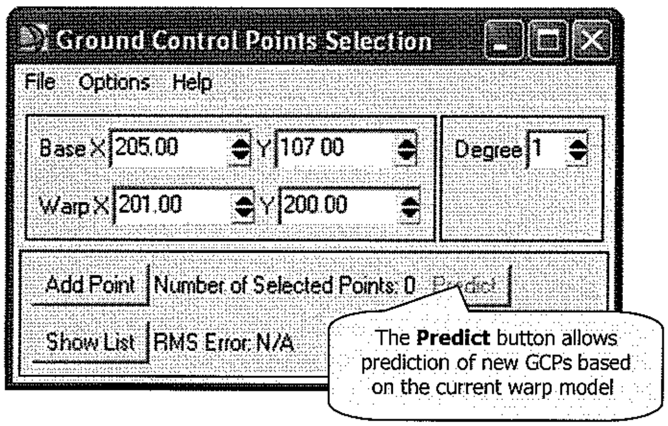
1. From the ENVI main menu bar, select **File → Open Image File**.
2. Navigate to the `envidata\bldr_reg` directory, select the file `bldr_tm.img` from the list, and click **Open**. The Available Bands List appears and the RGB image is automatically loaded into a new display group.

Displaying the Cursor Location and Value

1. Double-click in the Image window to display the Cursor Location/Value tool.
2. Move the mouse cursor over the Image, Scroll, or Zoom windows to display location and value information in the Cursor Location/Value dialog. Note that the coordinates are given in pixels since this is a pixel-based image rather than a georeferenced image like the SPOT data you used in the previous exercise.
3. From the Cursor Location/Value menu bar, select **File → Cancel** to close the dialog.

Starting Image Registration and Loading Ground Control Points

1. From the ENVI main menu bar, select **Map → Registration → Select GCPs: Image to Image**. The Image to Image Registration dialog appears.
2. In the **Base Image** field, select **Display #1** (the SPOT image). In the **Warp Image** field, select **Display #2** (the TM image).
3. Click **OK** to start the registration. The Ground Control Points Selection dialog appears.

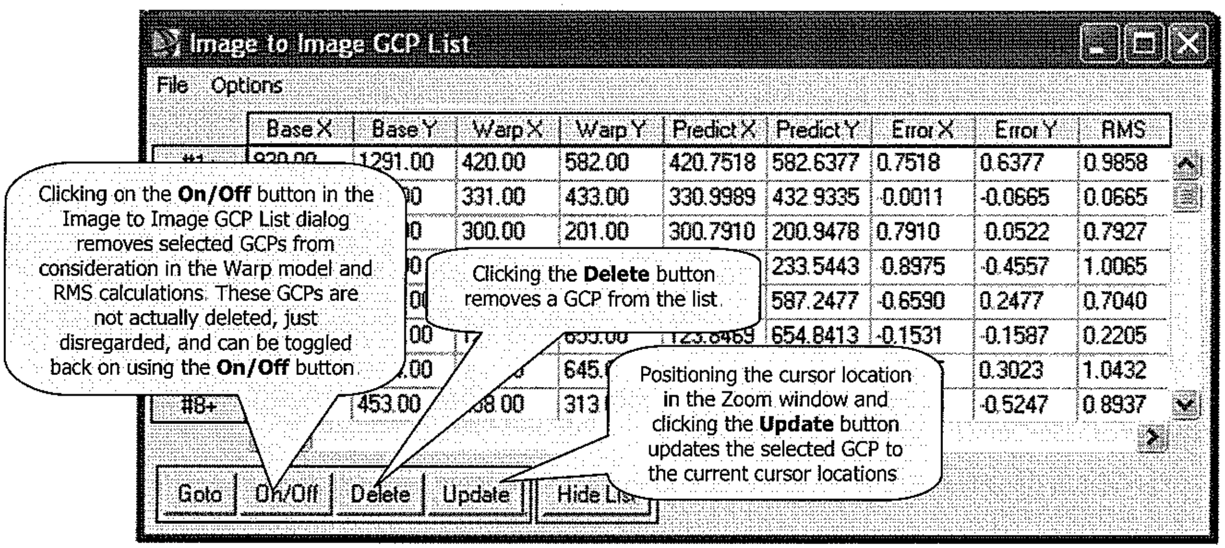


4. You can add individual ground control points (GCPs) by positioning the cursor in the two images to the same ground location. In the **Base** field, type **753** for the x location and **826** for the y location. Press the **Enter** key after typing each value, to move the cursor in the SPOT image. In the **Warp** field, type **331** for the x location and **433** for the y location to move the cursor in the TM image.
5. Examine the locations in the two Zoom windows and adjust the locations if necessary by clicking the left mouse button in each Zoom window at the desired locations. Note that sub-pixel positioning is supported in the Zoom windows. The larger the zoom factor, the finer the positioning capabilities.
6. In the Ground Control Points Selection dialog, click **Add Point** to add the GCP to the list. Click **Show List** to view the GCP list. Try this for a few points to get a feel for selecting GCPs. Note the list of actual and predicted points in the dialog. Once you have at least 4 points, the RMS error is reported.

7. From the Ground Control Points Selection dialog menu bar, select **Options → Clear All Points** to clear all of your points.
8. From the Ground Control Points Selection dialog menu bar, select **File → Restore GCPs from ASCII**.
9. Navigate to the `envidata\bldr_reg` directory, select the file `bldr_tm.pts` from the list, and click **Open**. Previously saved GCP parameters are loaded into the dialog.
10. Try positioning the cursor at a new location in the Image window containing the SPOT image. Click the **Predict** button to move the cursor position in the TM image to match its predicted location based on the warp model.
11. The exact position can now be interactively refined by moving the pixel location slightly in the TM data.
12. Click **Add Point** in the Ground Control Points Selection dialog to add the new GCP to the list.

Working with GCPs

The following image provides descriptions of the features and functions available in the Image to Image GCP List. Click **Show List** to view the GCP list. Click on individual GCPs in the Image to Image GCP List dialog and examine the locations of the points in the two images, the actual and predicted coordinates, and the RMS error. Resize the dialog to observe the total RMS Error listed in the Ground Control Points Selection dialog.



Warping Images

Images can be warped from the displayed band, or multiband images can be warped all bands at once. For this exercise you will warp only the displayed band.

1. From the Ground Control Points Selection dialog menu bar, select **Options → Warp Displayed Band**. The Registration Parameters dialog appears.
2. Click the **Method** drop-down list and select **RST**.
3. Ensure the **Resampling** drop-down list has the **Nearest Neighbor** option selected.
4. In the **Enter Output Filename** field, type `bldr_tm1.wrp` as the new filename and click **OK**. The warped image is listed in the Available Bands List when the warp is completed.
5. From the Ground Control Points Selection dialog menu bar, select **Options → Warp Displayed Band**. The Registration Parameters dialog appears.
6. Click the **Method** drop-down list and select **RST**.
7. Click the **Resampling** drop-down list and select **Bilinear**.

8. In the **Enter Output Filename** field, type `bldr_tm2.wrp` as the new filename and click **OK**. The warped image is listed in the Available Bands List when the warp is completed.
9. Repeat steps 5 – 8 using the **RST** method and **Cubic Convolution** resampling, then name the output file `bldr_tm3.wrp`.
10. Repeat steps 5 – 8 using the **Polynomial** method and **Cubic Convolution** resampling, then name the output file `bldr_tm4.wrp`.
11. Repeat steps 5 – 8 using the **Triangulation** method and **Cubic Convolution** resampling, then name the output file `bldr_tm5.wrp`.

Comparing Warp Results

Now you will use dynamic overlays to compare your warp results:

1. In the Available Bands List, click once to select the `bldr_tm.img` file, then select **File → Close Selected File** from the menu bar. In the subsequent ENVI warning dialog, click **Yes** to close the associated display group.
2. In the Available Bands List, select the `bldr_tm1.wrp` file, click the **Display #** drop-down button, select **New Display,** then click **Load Band** to load the file into the new display.
3. Right-click in the Image window and select **Link Displays**. The Link Displays dialog appears.
4. Click **OK** in the Link Displays dialog to link the SPOT and the registered TM image.
5. Compare the SPOT and the TM images using the dynamic overlay by clicking the left mouse button in the Image window of the TM image.
6. Load `bldr_tm2.wrp` and `bldr_tm3.wrp` into new displays and use the image linking and dynamic overlays to compare the effect of the three different resampling methods: nearest neighbor, bilinear interpolation, and cubic convolution.

   Note how jagged the pixels appear in the nearest neighbor resampled image. The bilinear interpolation image looks much smoother, but the cubic convolution image is the best result, smoother, but retaining fine detail.
7. Close the `bldr_tm1.wrp` and `bldr_tm2.wrp` display groups (select **File → Cancel** from the associated Display group menu bars).
8. Load `bldr_tm4.wrp` and `bldr_tm5.wrp` into new display groups, and use the image linking and dynamic overlays to compare to `bldr_tm3.wrp` (RST Warp).
9. Note the effect of the three different warping methods: RST, 1st degree Polynomial, and Delaunay Triangulation on the image geometry.
10. Use dynamic overlay to compare to the georeferenced SPOT data.
11. To display the Cursor Location/Value tool, double-click in the Image window.
12. Browse the georeferenced datasets and note the effect of the different resampling and warp methods on the data values.
13. From the Display group menu bar, select **File → Cancel** to close the dialog.
14. From the ENVI main menu bar, select **File → Close All Files** to close all of the data files. Click **Yes** on the corresponding warning dialog.

Image to Map Registration

This section of the tutorial will take you step-by-step through an Image to Map registration. Many of the procedures are similar to Image to Image registration and will not be discussed in detail. The map coordinates picked from the georeferenced SPOT image and a vector Digital Line Graph (DLG) will be used as the base image, and the pixel-based Landsat TM image will be warped to match the map data.

Opening and Displaying a SPOT Image File

1. From the ENVI main menu bar, select **File → Open Image File**.
2. Navigate to the `envidata\bldr_reg` directory, select the file `bldr_sp.img` from the list, and click **Open**. The Available Bands List appears.
3. Select **Georeferenced SPOT** under `bldr_sp.img`, and click **Load Band**. The georeferenced SPOT image appears in a new display group.

Opening and Displaying a Landsat TM Image File

1. From the ENVI main menu bar, select **File → Open Image File**.
2. Navigate to the `envidata\bldr_reg` directory, select the file `bldr_tm.img` from the list, and click **Open**. A Landsat TM RGB image is automatically loaded into a new display group.

Selecting Image-to-Map Registration and Restoring GCPs

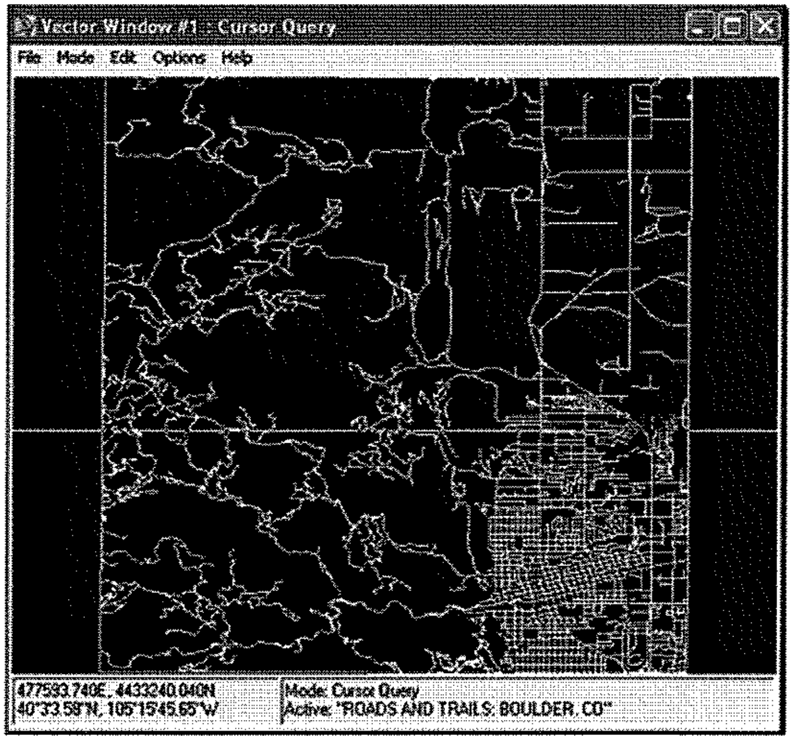
1. From the ENVI main menu bar, select **Map → Registration → Select GCPs: Image to Map**. The Image to Map Registration dialog appears.
2. From the Display #1 drop-down menu, select **Display #2**. You will warp the Landsat TM image (in Display #2) to match the georeferenced SPOT image.
3. Ensure **UTM** is selected as the projection.
4. Type **13** in the **Zone** field.
5. Enter **10.0** in the **X/Y Pixel Size** fields. SPOT data have a spatial resolution of 10m.
6. Click **OK** to start the registration. The Ground Control Points Selection dialog appears.
7. From the Ground Control Points Selection dialog menu bar, select **File → Restore GCPs from ASCII**.
8. Navigate to the `envidata\bldr_reg` directory, select the file `bldrtm_m.pts` from the list, and click **Open**. Previously saved ground control point parameters are loaded into the dialog.
9. In the Ground Control Points Selection dialog, click **Show List**. The Image to Map GCP List dialog appears. Examine the base map coordinates, the actual and predicted image coordinates, and the RMS error.

Adding Map GCPs Using Vector Display of DLGs

1. From the ENVI main menu bar, select **File → Open Vector File**.
2. From the **Files of type** drop-down list, select **USGS DLG**.
3. Navigate to the `envidata\bldr_reg` directory, select the file `bldr_rd.dlg` from the list, and click **Open**. The Import Vector Files Parameters dialog appears.
4. In the Import Vector Files Parameters dialog, click the **Memory** radio button, then click **OK** to read the DLG data. The Available Vectors List dialog appears.
5. Select the **ROADS AND TRAILS: BOULDER, CO** file, then click **Load Selected**.
6. Select **Display #1** and click **OK**. The Vector Parameters: Cursor Query dialog appears.

7. Return to the Load Vector dialog (from The Available Vectors List dialog, select the **ROADS AND TRAILS: BOULDER, CO** file then click **Load Selected**).
8. Select **New Vector Window**, and click **OK**. This loads the vectors into a new vector window.
9. Click and drag the mouse in the vector window to activate a crosshair cursor. The map coordinates of the cursor will be listed at the bottom of the vector window.
10. From the Display group menu bar in the TM image, select **Tools → Pixel Locator**.
11. Type **402** in the **Sample** field and **418** in the **Line** field then click **Apply** to place the cursor on the road intersection.

    Note that sub-pixel positioning accuracy is again available in the Zoom window.
12. In the Vector window, position the vector cursor at the road intersection at approximately 477593.74, 4433240.0 (40d 3m 3s N, -105d 15m 45s W) by clicking and dragging with the left mouse button and releasing when the circle at the crosshair intersection overlays the intersection of interest.



13. Right-click in the vector window and select **Export Map Location**. The new map coordinates will appear in the Ground Control Points Selection dialog.
14. In the Ground Control Points Selection dialog, click **Add Point** to add the map-coordinate/image pixel pair and observe the change in RMS error.

RST and Cubic Convolution Warping

1. From the Ground Control Points Selection dialog menu bar, select **Options → Warp File**. The Input Warp Image dialog appears.
2. Select the `bldr_tm.img` file, and click **OK** to select all six TM bands for warping. The Registration Parameters dialog appears.
3. Click the **Method** drop-down list, and select **RST**.
4. Click the **Resampling** drop-down list, and select **Cubic Convolution**.
5. In the **Background** field, type **255**.
6. In the **Enter Output Filename** field, type `bldrtm_m.img` as the new filename, and click **OK**. The warped image is listed in the Available Bands List and automatically loaded into a new display group when the warp is completed.

    Note the skew of the image resulting from removal of the Landsat TM orbit direction. This image is georeferenced, but at 30 meter resolution versus the 10 meter resolution provided by the SPOT image.

Displaying and Evaluating Results

1. From the ENVI main menu bar, select **File → Open Image File**.

2. Navigate to the `envidata\bldr_reg` directory, select the file `bldr_sp.img` from the list, and click **Open**. The Available Bands List appears.
3. From the Available Bands List, select the **Georeferenced SPOT** band from the list, click the **Display #** drop-down button and select **New Display**.
4. Click **Load Band** to load the SPOT image into a new display group.
5. Compare the image geometries and scale.
6. From the Ground Control Points Selection dialog menu bar, select **File → Cancel** to close that dialog. Save the GCPs if desired.

Now that you have learned how to perform Image to Image and Image to Map registration, refer to the *Map Composition* tutorial for guidance on adding grid lines and creating image maps in ENVI.

Ending the ENVI Session

You can quit your ENVI session by selecting **File → Exit** from the ENVI main menu.

ENVI

ENVI Tutorial: Classification Methods

Table of Contents

Overview of This Tutorial

This tutorial provides an introduction to classification procedures using Landsat TM data from Cañon City, Colorado. Results of both unsupervised and supervised classifications are examined and post classification processing including clump, sieve, combine classes, and accuracy assessment are discussed.

Files Used in This Tutorial

ENVI Tutorial Data DVD: `envidata\can_tm`

File	Description
can_tmr.img	Cañon City, Colorado TM reflectance image
can_tmr.hdr	ENVI header for above
can_km.img	K-meansf classification
can_km.hdr	ENVI header for above
can_iso.img	ISODATA classification
can_iso.hdr	ENVI header for above
classes.roi	Regions of interest (ROI) for supervised classification
can_pcls.img	Parallelepiped classification
can_pcls.hdr	ENVI header for above
can_bin.img	Binary encoding result
can_bin.hdr	ENVI header for above
can_sam.img	SAM classification result
can_sam.hdr	ENVI header for above
can_rul.img	Rule image for SAM classification
can_rul.hdr	ENVI header for above
can_sv.img	Sieved image
can_sv.hdr	ENVI header for above
can_clmp.img	Clump of sieved image
can_clmp.hdr	ENVI header for above
can_comb.img	Combined classes image
can_comb.hdr	ENVI header for above
can_ovr.img	Classes overlain on gray scale image
can_ovr.hdr	ENVI header for above
can_v1.evf	Vector layer generated from class #1
can_v2.evf	Vector layer generated from class #2

Examining a Landsat TM Color Image

This portion of the exercise will familiarize you with the spectral characteristics of the Landsat TM data of Cañon City, Colorado, USA. Color composite images will be used as the first step in locating and identifying unique areas for use as training sets in classification.

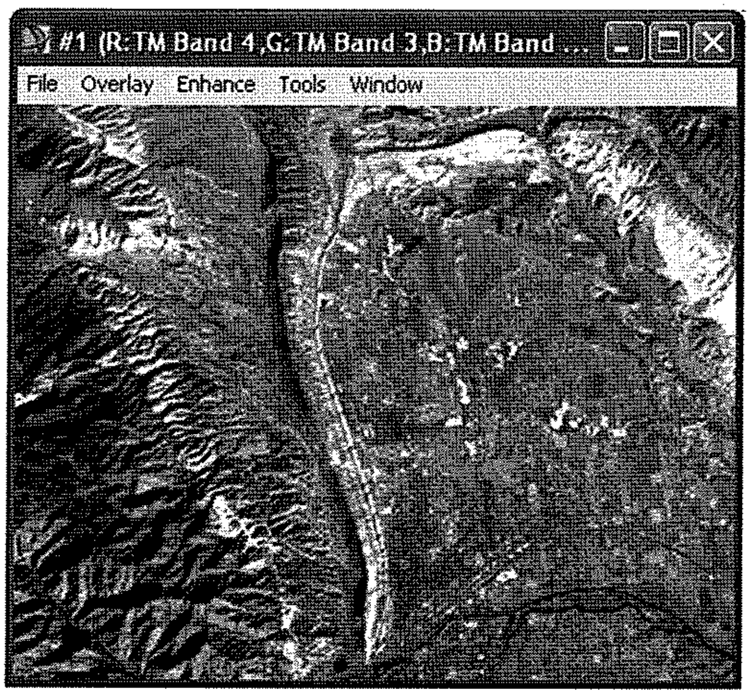
Before attempting to start the program, ensure that ENVI is properly installed as described in the Installation Guide that shipped with your software.

1. From the ENVI main menu bar, select **File → Open Image File**.
2. Navigate to the `envidata\can_tm` directory, select the file `can_tmr.img` from the list, and click **Open**. The Available Bands List appears on your screen.
3. Click on the **RGB Color** radio button in the Available Bands List. Red, Green, and Blue fields appear in the middle of the dialog.

4. Select **Band 4**, **Band 3**, and **Band 2** sequentially from the list of bands at the top of the dialog by clicking on the band names. The band names are automatically entered in the Red, Green, and Blue fields.
5. Click **Load RGB** to load the image into ENVI.
6. Examine the image in the display group.

Reviewing Image Colors

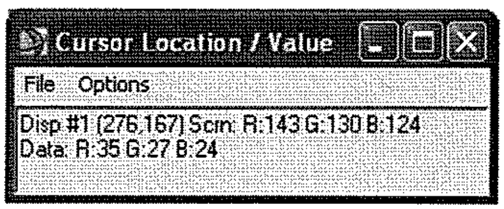
The color image displayed below can be used as a guide to classification. This image is the equivalent of a false color infrared photograph. Even in a simple three-band image, it's easy to see that there are areas that have similar spectral characteristics. Bright red areas on the image represent high infrared reflectance, usually corresponding to healthy vegetation, either under cultivation, or along rivers. Slightly darker red areas typically represent native vegetation, in this case in slightly more rugged terrain, primarily corresponding to coniferous trees. Several distinct geologic and urbanization classes are also readily apparent.



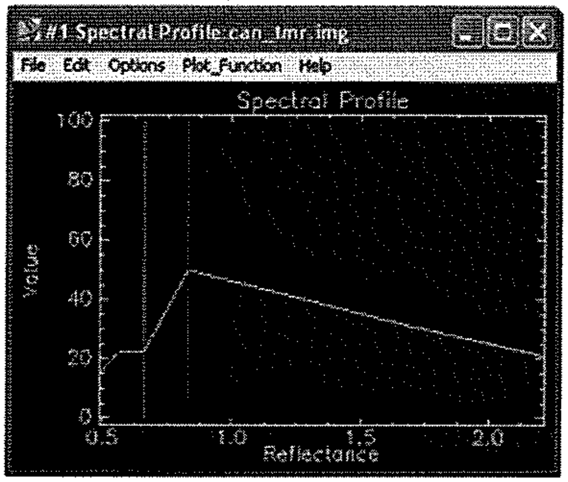
Using the Cursor Location/Value

Use ENVI's Cursor Location/Value option to preview image values in the displayed spectral bands.

1. From the Display group menu bar, select **Tools → Cursor Location/Value**. Alternatively, double-click the left mouse button in the Image window to toggle the Cursor Location/Value dialog on and off.
2. Move the cursor around the image and examine the data values in the dialog for specific locations. Also note the relation between image color and data value.
3. From the Cursor Location/Value dialog, select **Files → Cancel**.



Examining Spectral Plots



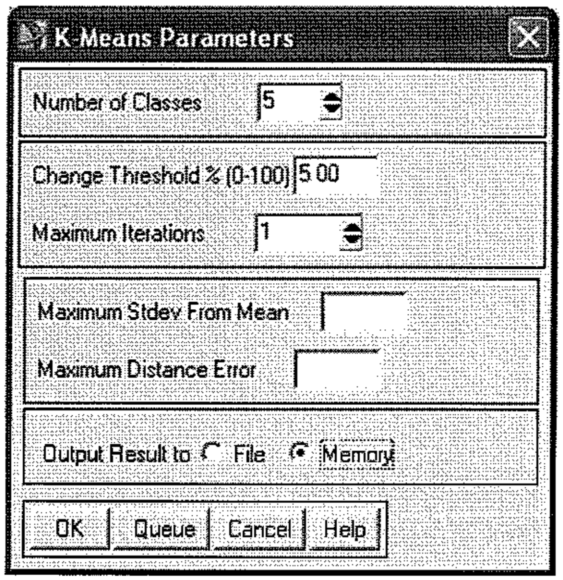
Use ENVI's integrated spectral profiling capabilities to examine the spectral characteristics of the data.

1. From the Display group menu bar, select **Tools → Profiles → Z Profile (Spectrum)** to begin extracting spectral profiles.
2. Examine the spectra for areas that you previewed above using color images and the Cursor/Location Value dialog by clicking the left mouse button in any of the display group windows. Note the relations between image color and spectral shape. Pay attention to the location of the image bands in the spectral profile, marked by the red, green, and blue bars in the plot.
3. From the Spectral Profile dialog menu bar, select **File → Cancel**.

Exploring Unsupervised Classification Methods

Unsupervised classification can be used to cluster pixels in a dataset based on statistics only, without any user-defined training classes. The available unsupervised classification techniques are K-Means and ISODATA.

Applying K-Means Classification



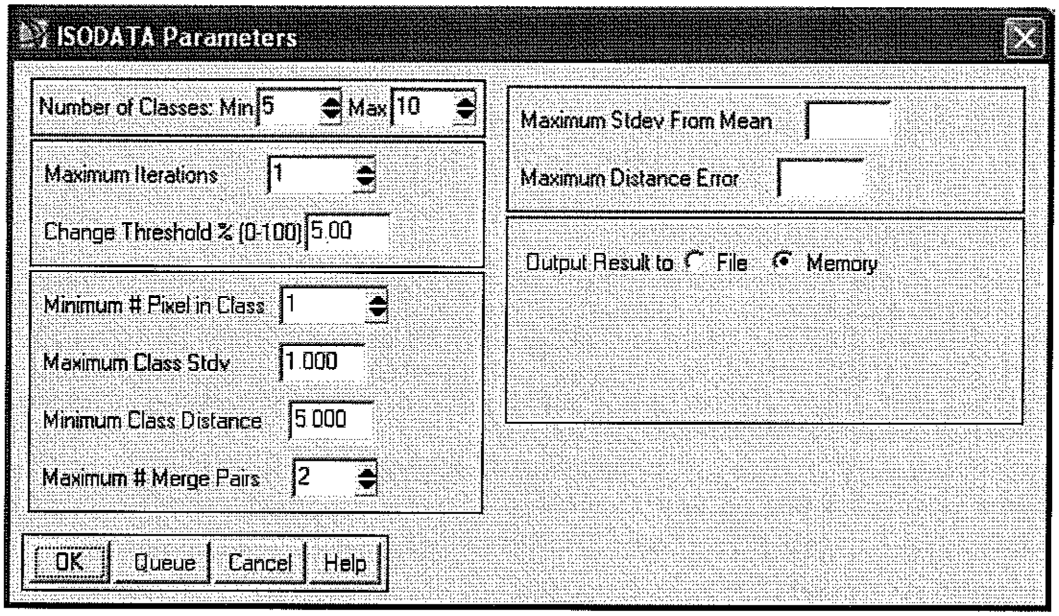
K-Means unsupervised classification calculates initial class means evenly distributed in the data space, then iteratively clusters the pixels into the nearest class using a minimum-distance technique. Each iteration recalculates class means and reclassifies pixels with respect to the new means. All pixels are classified to the nearest class unless a standard deviation or distance threshold is specified, in which case some pixels may be unclassified if they do not meet the selected criteria. This process continues until the number of pixels in each class changes by less than the selected pixel change threshold or the maximum number of iterations is reached.

1. From the ENVI main menu bar, select **Classification → Unsupervised → K-Means** or review the pre-calculated results of classifying the image by opening the `can_km.img` file in the `can_tm` directory.
2. Select the `can_tmr.img` file and click **OK**. The K-Means Parameters dialog appears.
3. Accept the default values, select the **Memory** radio button, and click **OK**. The new band is loaded into the Available Bands List.
4. From the Available Bands List, click the **Display #1** button and select **New Display**.
5. From the Available Bands List, select the **K-Means** band and click **Load Band**.
6. From the Display group menu bar, select **Tools → Link → Link Displays** then click **OK** to link the images.
7. Compare the K-Means classification result to the color-composite image using the dynamic overlay feature in ENVI (click using the left mouse button in the Image window).
8. From the Display group menu bar, select **Tools → Link → Unlink Display** to remove the link and turn off the dynamic overlay feature.
9. If desired, experiment with different numbers of classes, change thresholds, standard deviations, and maximum distance error values to determine their effect on the classification.

Applying ISODATA Classification

ISODATA unsupervised classification calculates class means evenly distributed in the data space then iteratively clusters the remaining pixels using minimum distance techniques. Each iteration recalculates means and reclassifies pixels with respect to the new means. This process continues until the number of pixels in each class changes by less than the selected pixel change threshold or the maximum number of iterations is reached.

1. From the ENVI main menu bar, select **Classification → Unsupervised → IsoData**, or review the pre-calculated results of classifying the image by opening the `can_iso.img` file in the `can_tm` directory.
2. Select the `can_tmr.img` file and click **OK**. The ISODATA Parameters dialog appears.
3. Accept the default values, select the **Memory** radio button, and click **OK**. The new band is loaded into the Available Bands List.



4. From the Available Bands List, click the **Display #2** button and select **New Display**.
5. Select the **ISODATA** band and click **Load Band**.
6. From the Display group menu bar, select **Tools → Link → Link Displays**. The Link Displays dialog appears.
7. Click the **Display #2** toggle button to select **No**, and click the **Display #3** toggle button to select **Yes**. Click **OK** to link the images.
8. Compare the ISODATA classification result to the color-composite image using the dynamic overlay feature in ENVI (click using the left mouse button in the Image window).
9. From the Display group menu bar, select **Tools → Unlink Displays.**
10. From the Display group menu bar, select **Tools → Link → Link Displays**. The Link Displays dialog appears.
11. Click the **Display #1** toggle button to select **No**, and ensure that the **Display #2** and **Display #3** toggle buttons say **Yes**. Click **OK** to link and compare the K-means and ISODATA images.
12. If desired, experiment with different numbers of classes, change thresholds, standard deviations, maximum distance error, and class pixel characteristic values to determine their effect on the classification.
13. From the Display group menu bar on the K-Means Image window, select **File → Cancel** to close the display group. Close the ISODATA display group using the same technique.

Exploring Supervised Classification Methods

Supervised classification can be used to cluster pixels in a dataset into classes corresponding to user-defined training classes. This classification type requires that you select training areas for use as the basis for classification. Various comparison methods are then used to determine if a specific pixel qualifies as a class member. ENVI provides a broad range of different classification methods, including Parallelepiped, Minimum Distance, Mahalanobis Distance, Maximum Likelihood, Spectral Angle Mapper, Binary Encoding, and Neural Net. In this tutorial, you will experiment with two methods for selecting training areas, also known as regions of interest (ROIs).

Selecting Training Sets Using Regions of Interest (ROI)

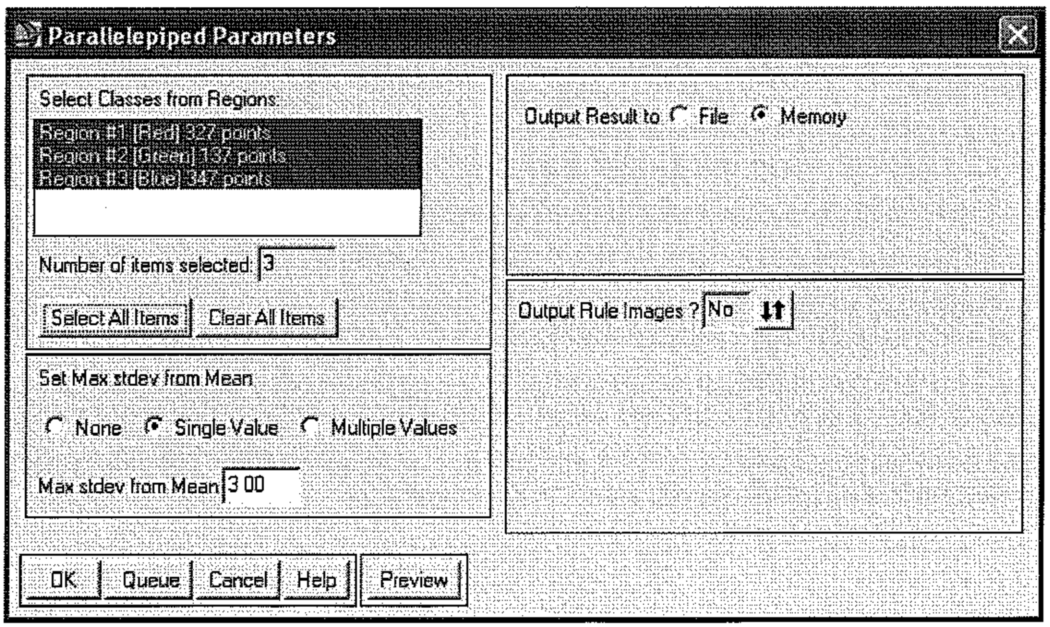
As described in the tutorial, "An Introduction to ENVI" and summarized here, ENVI lets you define regions of interest (ROIs) typically used to extract statistics for classification, masking, and other operations. For the purposes of this exercise, you can either use predefined ROIs, or create your own. In this exercise, you will restore predefined ROIs.

1. From the #1 Display group menu bar, select **Tools → Region of Interest → ROI Tool**. The ROI Tool dialog appears.
2. From the ROI Tool dialog menu bar, select **File → Restore ROIs**. The Enter ROI Filenames dialog appears.
3. Select the `classes.roi` file and click **Open**. Click **OK**. The ROIs appear in the Image window.

Applying Parallelepiped Classification

Parallelepiped classification uses a simple decision rule to classify multispectral data. The decision boundaries form an n-dimensional parallelepiped classification in the image data space. The dimensions of the parallelepiped classification are defined based upon a standard deviation threshold from the mean of each selected class. If a pixel value lies above the low threshold and below the high threshold for all n bands being classified, it is assigned to that class. If the pixel value falls in multiple classes, ENVI assigns the pixel to the last class matched. Areas that do not fall within any of the parallelepiped classifications are designated as unclassified.

1. From the ENVI main menu bar, select **Classification → Supervised → Parallelepiped,** or review the pre-calculated results of classifying the image by opening the `can_pcls.img` file in the `can_tm` directory.
2. Select the `can_tmr.img` file and click **OK**. The Parallelepiped Parameters dialog appears.
3. Click the **Select All Items** button to select the ROIs.
4. Select to output the result to **Memory** using the radio button provided.
5. Click the **Output Rule Images** toggle button to select **No**, then click **OK**. The new band is loaded into the Available Bands List.



6. From the Available Bands List, click the **Display #1** button and select **New Display**.
7. Select the **Parallel** band and click **Load Band**.
8. From the Display group menu bar, select **Tools → Link → Link Displays** and click **OK** in the dialog to link the images.
9. Use image linking and dynamic overlay to compare this classification to the color composite image.

Applying Maximum Likelihood Classification

Maximum likelihood classification assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Unless a probability threshold is selected, all pixels are classified. Each pixel is assigned to the class that has the highest probability (i.e., the maximum likelihood).

1. Using the steps above as a guide, perform a **Maximum Likelihood** classification.
2. Try using the default parameters and various probability thresholds.
3. Use image linking and dynamic overlay to compare this classification to the color composite image and previous unsupervised and supervised classifications.

Applying Minimum Distance Classification

The minimum distance classification uses the mean vectors of each ROI and calculates the Euclidean distance from each unknown pixel to the mean vector for each class. All pixels are classified to the closest ROI class unless the user specifies standard deviation or distance thresholds, in which case some pixels may be unclassified if they do not meet the selected criteria.

1. Using the steps above as a guide, perform a **Minimum Distance** classification.
2. Try using the default parameters and various standard deviations and maximum distance errors.
3. Use image linking and dynamic overlay to compare this classification to the color composite image and previous unsupervised and supervised classifications.

Applying Mahalanobis Distance Classification

The Mahalanobis Distance classification is a direction sensitive distance classifier that uses statistics for each class. It is similar to the Maximum Likelihood classification but assumes all class covariances are equal and therefore is a faster method. All pixels are classified to the closest ROI class unless you specify a distance threshold, in which case some pixels may be unclassified if they do not meet the threshold.

1. Using the steps above as a guide, perform a **Mahalanobis Distance** classification.
2. Try using the default parameters and various maximum distance errors.
3. Use image linking and dynamic overlay to compare this classification to the color composite image and previous unsupervised and supervised classifications.
4. When you are finished, close all classification display groups.

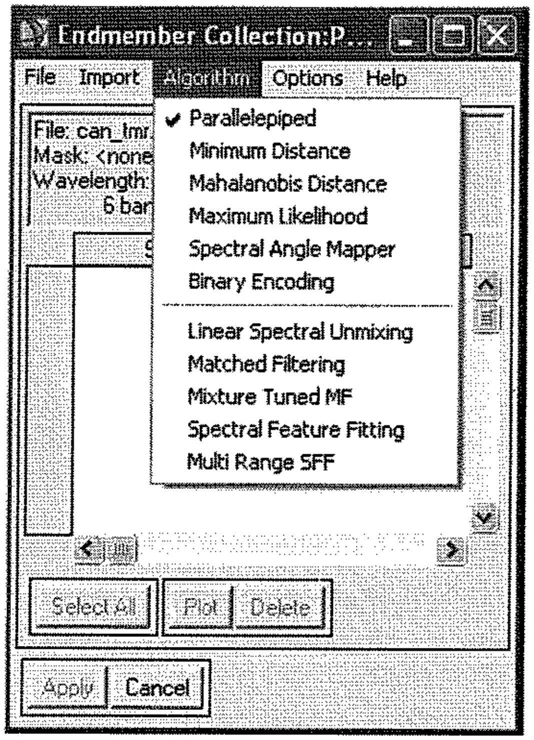
Exploring Spectral Classification Methods

The following methods are described in the ENVI User's Guide. These were developed specifically for use on hyperspectral data, but they provide an alternative method for classifying multispectral data, often with improved results that can easily be compared to spectral properties of materials. They typically are used from the Endmember Collection dialog using image or library spectra; however, they can also be started from the **Classification → Supervised** menu option.

Collecting Endmember Spectra

The Endmember Collection:Parallel dialog is a standardized means of collecting spectra for supervised classification from ASCII files, ROIs, spectral libraries, and statistics files.

1. From the ENVI main menu bar, select **Classification → Endmember Collection**. The Classification Input File dialog appears.
2. Select the `can_tmr.img` file and click **OK**.
3. The Endmember Collection dialog appears with the Parallelepiped classification method selected by default. The available classification and mapping methods are listed under the **Algorithm** menu. You will use this dialog in the following exercises.

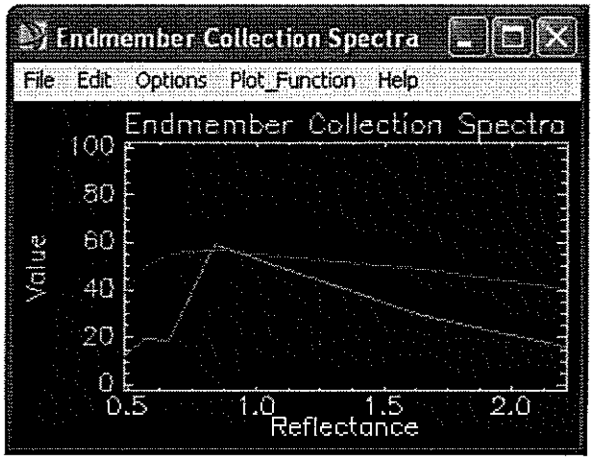


Applying Binary Encoding Classification

The binary encoding classification technique encodes the data and endmember spectra into zeros and ones, based on whether a band falls below or above the spectrum mean. An exclusive OR function compares each encoded reference spectrum with the encoded data spectra, and ENVI produces a classification image. All pixels are classified to the endmember with the greatest number of bands that match unless the user specifies a minimum match threshold, in which case some pixels may be unclassified if they do not meet the criteria.

1. From the Endmember Collection:Parallel dialog menu bar, select **Algorithm → Binary Encoding** or review the pre-calculated results of classifying the image by opening the `can_bin.img` file in the `can_tm` directory. These results were created using a minimum encoding threshold of 75%.

2. For this exercise, you will use the predefined ROIs in the `classes.roi` file that you used on page 6. From the Endmember Collection:Parallel dialog menu bar, select **Import → from ROI/EVF from input file**. The Select Regions for Stats dialog appears.



3. Click the **Select All Items** button, and click **OK**.
4. In the Endmember Collection:Parallel dialog, click **Select All** then click **Plot** to view the endmember spectral plots for the ROIs collected in the Endmember Collections dialog.
5. In the Endmember Collections dialog click **Apply**. The Binary Encoding Parameters dialog appears.
6. In the Binary Encoding Parameters dialog, select to output the result to **Memory** using the radio button provided.
7. Toggle the Output Rule Images to **No**, then click **OK** to start the classification. The new band is loaded into the Available Bands List.
8. From the Available Bands List, select the **Bin Encode** band, and click **Load Band**.
9. Use image linking and dynamic overlay to compare this classification to the color composite image and previous unsupervised and supervised classifications.

Applying Spectral Angle Mapper Classification

The Spectral Angle Mapper (SAM) is a physically-based spectral classification that uses an n-dimensional angle to match pixels to reference spectra. The algorithm determines the spectral similarity between two spectra by calculating the angle between the spectra, treating them as vectors in a space with dimensionality equal to the number of bands. SAM compares the angle between the endmember spectrum vector and each pixel vector in n-dimensional space. Smaller angles represent closer matches to the reference spectrum. Pixels further away than the specified maximum angle threshold in radians are not classified.

1. Using the steps in the last exercise as a guide, perform a **Spectral Angle Mapper** classification, or review the pre-calculated results of classifying the image by opening the `can_sam.img` file in the `can_tm` directory.
2. Use image linking and dynamic overlay to compare this classification to the color composite image and previous unsupervised and supervised classifications.
3. When you are finished, close all classification display groups, plots, and the Endmember Collection dialog.

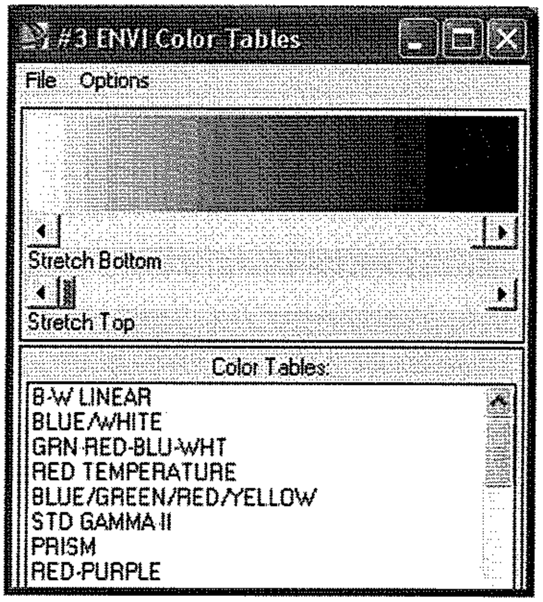
Exploring Rule Images

ENVI creates images that show the pixel values used to create the classified image. These optional images allow users to evaluate classification results and to reclassify if desired based on thresholds. These are gray scale images: one for each ROI or endmember spectrum used in the classification.

The rule image pixel values represent different things for different types of classifications, for example:

Classification Method	Rule Image Values
Parallelepiped	Number of bands satisfying the parallelepiped criteria
Minimum Distance	Sum of the distances from the class means
Maximum Likelihood	Probability of pixel belonging to class
Mahalanobis Distance	Distances from the class means
Binary Encoding	Binary match in percent
Spectral Angle Mapper	Spectral angle in radians (smaller angles indicate closer match to the reference spectrum)

1. From the ENVI main menu bar, select **File → Open Image File**.
2. Navigate to the `envidata\can_tm` directory, select the file `can_rul.img` from the list, and click **Open**. The Available Bands List appears on your screen.
3. Click on the **Gray Scale** radio button in the Available Bands List and open each **Rule** band into its own image window (use the **Display → New Display** button).
4. Use image linking and dynamic overlay to compare the color composite image to the rule images.
5. From the Display group menu bar, select **Tools → Color Mapping → ENVI Color Tables** and drag the Stretch Bottom and Stretch Top sliders to opposite ends of the dialog. Areas with low spectral angles (more similar spectra) appear bright.



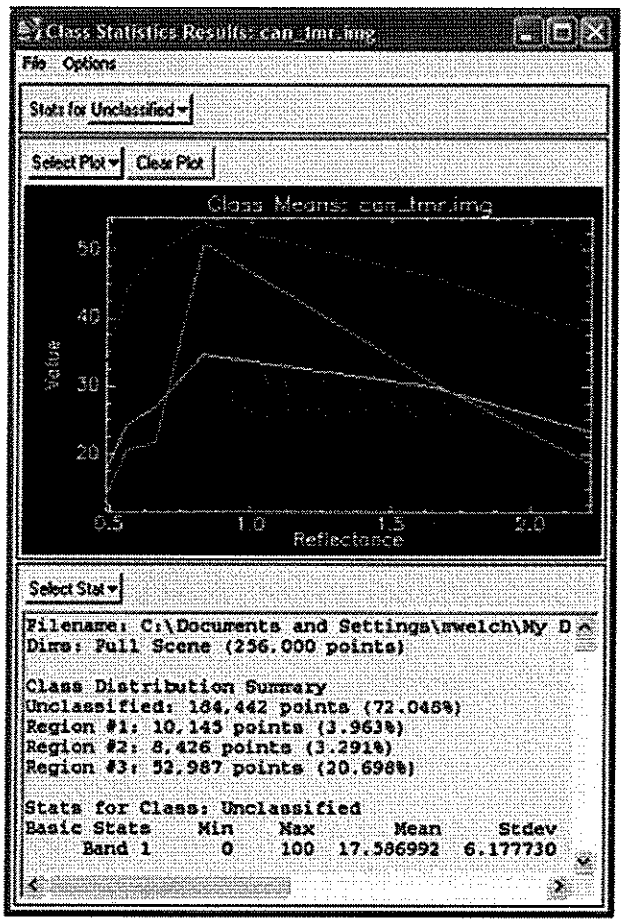
Post Classification Processing

Classified images require post-processing to evaluate classification accuracy and to generalize classes for export to image-maps and vector GIS. Post Classification can be used to classify rule images; to calculate class statistics and confusion matrices; to apply majority or minority analysis to classification images; to clump, sieve, and combine classes; to overlay classes on an image; to calculate buffer zone images; to calculate segmentation images; and to output classes to vector layers. ENVI provides a series of tools to satisfy these requirements.

Extracting Class Statistics

This function allows you to extract statistics from the image used to produce the classification. Separate statistics consisting of basic statistics, histograms, and average spectra are calculated for each class selected.

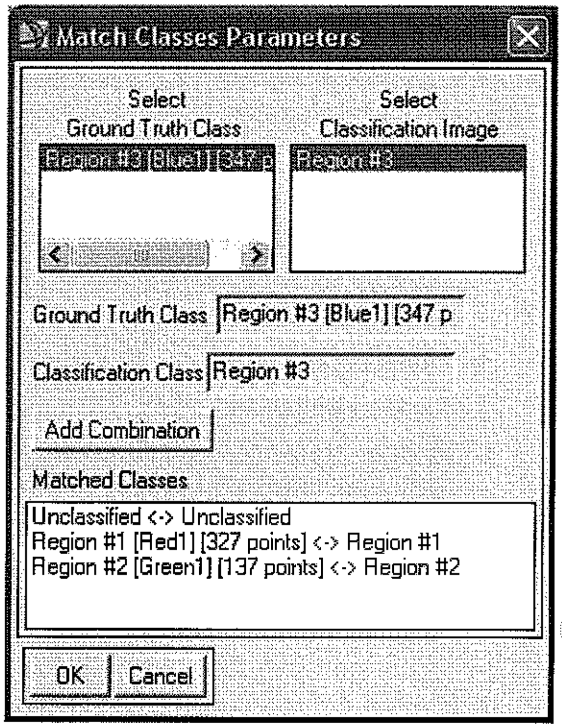
1. From the ENVI main menu bar, select **Classification → Post Classification → Class Statistics**. The Classification Input File dialog appears.
2. Click the **Open** drop-down button and select **New File**.
3. Navigate to the `envidata\can_tm` directory, select the file `can_pcls.img` from the list, and click **Open**. The Statistics Input File appears.
4. Select the `can_tmr.img` file and click **OK**. The Class Selection dialog appears.
5. Click the **Select All Items** button and click **OK**. The Compute Statistics Parameters dialog appears.
6. Click the **Basic Stats, Histograms, Covariance,** and **Covariance Image** check boxes in the Compute Statistics Parameters dialog to calculate all the possible statistics.
7. Click **OK** to compute the statistics. The Class Statistics Results dialog appears.



Generating a Confusion Matrix

ENVI's confusion matrix function allows comparison of two classified images (the classification and the "truth" image), or a classified image and ROIs. The truth image can be another classified image, or an image created from actual ground truth measurements. In this exercise, you will compare the Parallelepiped and SAM classification images using the Parallelepiped classification image as the ground truth.

1. From the ENVI main menu bar, select **Classification → Post Classification → Confusion Matrix → Using Ground Truth Image**. The Classification Input File dialog appears.
2. Select the `can_pcls.img` file and click **OK**. The Ground Truth Input File appears.
3. Click the **Open** drop-down button and select **New File**.
4. Navigate to the `envidata\can_tm` directory, select the file `can_sam.img` from the list, and click **Open**.
5. Select the `can_sam.img` file in the Ground Truth Input File dialog and click **OK**. The Match Classes Parameters dialog appears.
6. Select **Region #1** from both fields and click **Add Combination**. Continue to pair corresponding classes from the two images in this way, then click **OK**. The Confusion Matrix Parameters dialog appears.
7. Click the Output Result to **Memory** radio button then click **OK**.
8. Examine the confusion matrix and confusion images (in the Available Bands List). Determine sources of error by comparing the classified image to the original reflectance image using dynamic overlays, spectral profiles, and Cursor Location/Value.



Clumping and Sieving

Clump and **Sieve** are used to generalize classification images. Sieve is usually run first to remove the isolated pixels based on a size (number of pixels) threshold, then clump is run to add spatial coherency to existing classes by combining adjacent similar classified areas.

1. From the ENVI main menu bar, select **Classification → Post Classification → Sieve Classes**. The Classification Input File dialog appears.
2. Select the `can_sam.img` file within the Select Input File section of this dialog and click **OK**. The Sieve Parameters dialog appears.
3. Click the Output Result to **Memory** radio button, then click **OK**. The image is loaded into the Available Bands List.
4. You will now use the output of the sieve operation as the input for clumping. From the ENVI main menu bar, select **Classification → Post Classification → Clump Classes**. The Classification Input File dialog appears.
5. Select the previously created image file from memory, and click **OK**. The Sieve Parameters dialog appears.
6. Click the Output Result to **Memory** radio button, then click **OK**. The image is loaded into the Available Bands List.
7. Compare the three images (`can_sam.img`, **Clump**, and **Sieve**) and reiterate if necessary to produce a generalized classification image.
8. Optional: compare the pre-calculated results in the files `can_tm\can_sv.img` (sieve) and `can_clmp.img` (clump of the sieve result) to the classified image `can_pcls.img` (parallelepiped classification) or calculate your own images and compare to one of the classifications.

Combining Classes

The Combine Classes function provides an alternative method for classification generalization. Similar classes can be combined to form one or more generalized classes.

1. From the ENVI main menu bar, select **Classification → Post Classification → Combine Classes** or review the pre-calculated results of classifying the image by opening the `can_comb.img` file in the `can_tm` directory. The Classification Input File dialog appears.
2. Select the `can_sam.img` file and click **OK**. The Combine Classes Parameters dialog appears.
3. Select **Region #3** from the Select Input Class field, click **Unclassified** from the Select Output Class field, click **Add Combination**, then click **OK**. The Combine Classes Output dialog appears.
4. Click the Output Result to **Memory** radio button then click **OK**. The image is loaded into the Available Bands List.
5. Using image linking and dynamic overlays, compare the combined class image to the classified images and the generalized classification image.

Overlaying Classes

Overlay classes allow you to place the key elements of a classified image as a color overlay on a gray scale or RGB image.

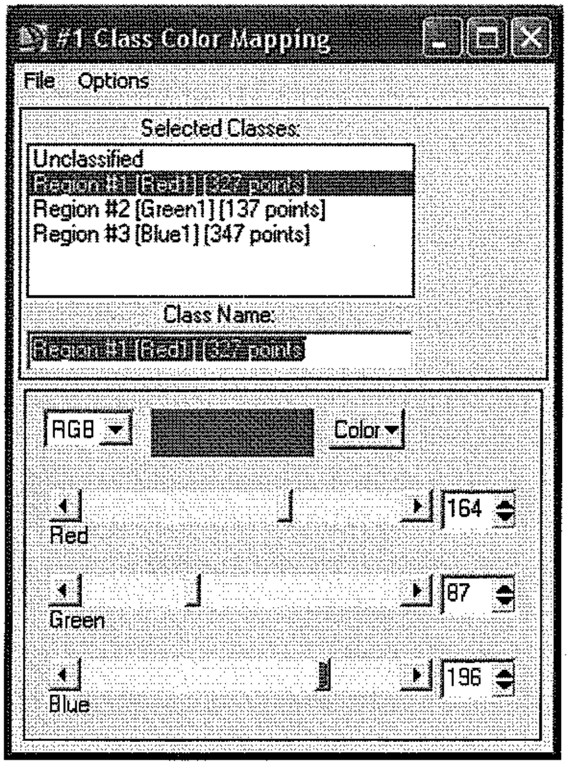
You can examine the pre-calculated image `can_tm\can_ovr.img` or create your own overlay(s) from the `can_tmr.img` reflectance image and one of the classified images.

1. From the ENVI main menu bar, select **Classification → Post Classification → Overlay Classes** or review the pre-calculated results of classifying the image by opening the `can_comb.img` file in the `can_tm` directory. The Input Overlay RGB Image Input Bands dialog appears.
2. Under `can_tmr.img` in the Available Bands List, select **Band 3** for each RGB band (Band 3 for the *R* band, Band 3 for the *G* band, and Band 3 for the *B* band) and click **OK**. The Classification Input File dialog appears.
3. Click **Open**, and select **New File**. A file selection dialog appears.
4. Open `can_tm\can_comb.img`, and click **Open**.
5. Click **OK** in the Classification Input File dialog.
6. Using the **Shift** key on your keyboard, select **Region #1** and **Region #2** in the Class Overlay to RGB Parameters dialog.
7. Click the Output Result to **Memory** radio button, then click **OK**. The image is loaded into the Available Bands List.
8. Load the overlay image to a new display group.
9. Using image linking and dynamic overlays, compare this image to the classified image and the reflectance image.

Editing Class Colors

When a classification image is displayed, you can change the color associated with a specific class by editing the class colors.

1. From the Display group menu bar, select **Tools → Color Mapping → Class Color Mapping**. The Class Color Mapping dialog appears.
2. Click on one of the class names in the Class Color Mapping dialog and change the color by dragging the appropriate color sliders or entering the desired data values. Changes are applied to the classified image immediately.
3. To make the changes permanent, select **Options → Save Changes** from the menu bar in this the dialog.



Working with Interactive Classification Overlays

In addition to the methods above for working with classified data, ENVI also provides an interactive classification overlay tool. This tool allows you to interactively toggle classes on and off as overlays on a displayed image, to edit classes, get class statistics, merge classes, and edit class colors.

1. From the Available Bands List, load **Band 4** of `can_tmr.img` as a gray scale image.
2. From the Display group menu bar, select **Overlay → Classification**. The Interactive Class Tool Input File dialog appears.
3. Select the `can_sam.img` file and click **OK**. The Interactive Class Tool appears with each class listed along with its corresponding colors.
4. Click each **On** check box to change the display of each class as an overlay on the gray scale image.
5. Explore the various options for assessing the classification using the Interactive Class Tool **Options** menu.
6. Interactively change the contents of specific classes using the Interactive Class Tool **Edit** menu.
7. From the Display group menu bar, select **File → Save Image As → Image File** to burn in the classes and output to a new file.
8. From the Interactive Class Tool menu bar, select **File → Cancel** to exit the interactive tool.

Overlaying Vector Layers

You can load pre-calculated vector layers onto a gray scale reflectance image for comparison to raster classified images, or convert one of the classification images to vector layers.

1. Load the `can_clmp.img` into a display group.
2. From the Display group menu bar, select **Overlay → Vectors**. The Vector Parameters: Cursor Query dialog appears.
3. From the Vector Parameters: Cursor Query dialog menu bar, select **File → Open Vector File**.
4. Navigate to the `envidata\can_tm` directory, and use the **Shift** key on your keyboard to select the files `can_v1.evf` and `can_v2.evf`. Click **Open**. The vectors derived from the classification polygons will outline the raster classified pixels.

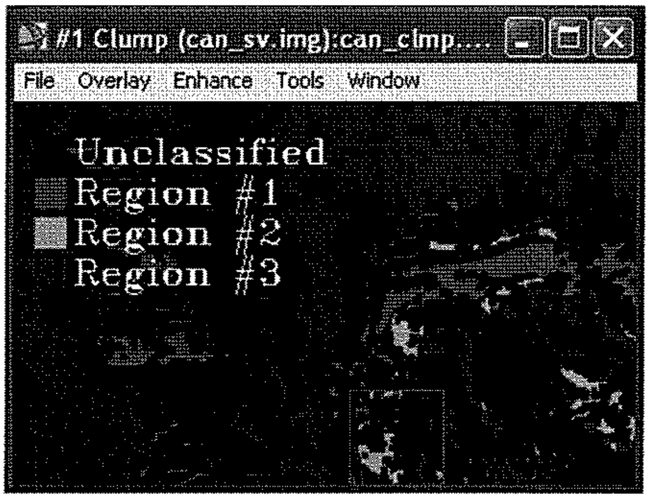
Converting a Classification to a Vector

1. From the ENVI main menu bar, select **Classification → Post Classification → Classification to Vector**. The Raster to Vector Input Band dialog appears.
2. Select the `can_clmp.img` file **Clump** result within the Select Input File section of this dialog and click **OK**. The Raster to Vector Parameters dialog appears.
3. Using the **Shift** key on your keyboard, select **Region #1** and **Region #2** from the Select Input Class field.
4. In the **Enter Output Filename** field, type `canrty` and click **OK** to begin the conversion. The layers are loaded into the Available Vectors List.
5. Select **Region #1** and **Region #2**s in the Available Vectors List dialog then click **Load Selected**.
6. Select a display number from the Load Vector dialog and click **OK**.
7. From the Vector Parameters dialog menu bar, select **Edit → Edit Layer Properties** to change the colors and fill of the vector layers to make them more visible.
8. Using image linking and dynamic overlays, compare the combined class image to the classified images and the Select

Adding Classification Keys Using Annotation

ENVI provides annotation tools to put classification keys on images and in map layouts. The classification keys are automatically generated.

1. From the Display group menu bar, select **Overlay → Annotation** for either one of the classified images, or for the image with the vector overlay.
2. From the Annotation menu bar, select **Object → Map Key** to start annotating the image. You can edit the key characteristics by clicking the **Edit Map Key Items** button in the dialog and changing the desired characteristics.
3. Click once with the left mouse button in the Image window to place the map key in the image window.
4. Click and drag the map key using the left mouse button in the display to place the key.
5. Click in the display with the right mouse button to finalize the position of the key. For more information about image annotation, please see the ENVI User's Guide.



Ending the ENVI Session

You can quit your ENVI session by selecting **File → Exit** from the ENVI main menu.

ENVI

ENVI Tutorial: Introduction to ENVI

Table of Contents

Overview of This Tutorial

This tutorial is designed to introduce you to the basic concepts of the ENVI software and some of its key features. It assumes that you are already familiar with general image-processing concepts.

In order to run this tutorial, you must have ENVI installed on your computer.

Files Used in This Tutorial

ENVI Tutorial Data DVD: `envidata\can_tm`

File	Description
`can_tmr.img`	Cañon City, CO, TM Data
`can_tmr.hdr`	ENVI Header for Above

Getting Started with ENVI

Starting ENVI

Before attempting to start the program, ensure that ENVI is properly installed as described in the Installation Guide that shipped with your software.

Starting ENVI on Windows Machines

- Select **Start → Programs → ENVI *x.x* → ENVI**.
  (where *x.x* is the version number)

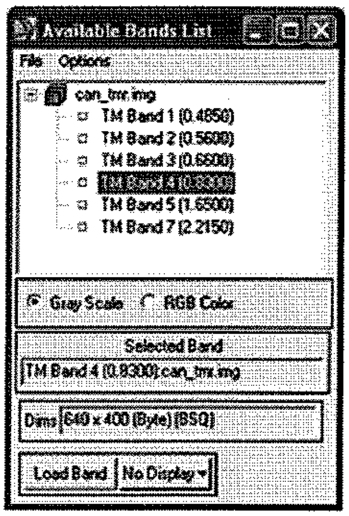
Starting ENVI in UNIX

- For ENVI, enter **`envi_rt`** at the UNIX command line.
- For ENVI+IDL, enter **`envi`** at the UNIX command line.

Starting ENVI on Macintosh Machines

1. Display an OSX, UNIX X-window.
2. Do either of the following:
   - For ENVI, type **`envi_rt`** at the UNIX command prompt.
   - For ENVI +IDL, type **`envi`** at the UNIX command prompt.

Loading a Gray Scale Image



Open a multispectral Landsat Thematic Mapper (TM) data file representing Cañon City, Colorado, USA.

Opening an Image File

1. From the ENVI main menu bar, select **File → Open Image File**.
2. Navigate to the `envidata\can_tm` directory, select the file `can_tmr.img` from the list, and click **Open**.

The Available Bands List

ENVI provides access to both image files and to the individual spectral bands in these files. The Available Bands List is a special ENVI dialog containing a list of all the available image bands in all open files, as well as any associated map information. You can use the Available Bands List to load both color and gray scale images into a display.

The **File** menu at the top of the Available Bands List dialog provides access to file opening and closing, file information, and canceling the Available Bands List. The **Options** menu provides a way to find the band closest to a specific wavelength, shows the currently displayed bands, allows toggling between full and shortened band names in the list, and provides the capability to fold all of the bands in a single open image into just the

image name. Folding and unfolding the bands into single image names or lists of bands can also be accomplished by clicking on the + (plus) or – (minus) symbols to the left of the filename in the Available Bands List.
Right-clicking in the Available Bands List displays a menu with access to different functions. The right-click menu selections will differ depending on what item is currently selected in the Available Bands List.

1. Select **TM Band 4**. The band you have chosen is displayed in the field marked *Selected Band*.
2. Click the **Gray Scale** radio button then click **Load Band** to load the image into a new display. Band 4 will be loaded as a gray scale image.

ENVI File Formats

ENVI uses a generalized raster data format consisting of a simple flat-binary file and a small associated ASCII (text) header file. This file format permits ENVI to use nearly any image file, including those that contain their own embedded header information. ENVI also supports a variety of data types: byte, integer, unsigned integer, long integer, unsigned long integer, floating-point, double-precision floating-point, complex, double-precision complex, 64-bit integer, and unsigned 64-bit integer.

Generalized raster data are stored as a binary stream of bytes in either **Band Sequential (BSQ)**, **Band Interleaved by Pixel (BIP)**, or **Band Interleaved by Line (BIL)** format.

- **BSQ** is the simplest format, with each line of data followed immediately by the next line of the same spectral band. BSQ format is optimal for spatial (x,y) access to any part of a single spectral band.
- **BIP** format provides optimal spectral processing performance. Images stored in BIP format have the first pixel for all bands in sequential order, followed by the second pixel for all bands, followed by the third pixel for all bands, etc., interleaved up to the number of pixels. This format provides optimum performance for spectral (z) access of the image data.
- **BIL** format provides a compromise in performance between spatial and spectral processing and is the recommended file format for most ENVI processing tasks. Images stored in BIL format have the first line of the first band followed by the first line of the second band, followed by the first line of the third band, interleaved up to the number of bands. Subsequent lines for each band are interleaved in similar fashion.

Exploring the ENVI Header File

The separate text header file provides information to ENVI about the dimensions of the image, any embedded header that may be present, the data format, and other pertinent information. The header file is normally created (sometimes with your input) the first time a particular data file is read by ENVI. It can also be created outside of ENVI using a text editor.

1. From the ENVI main menu bar, select **File → Edit ENVI Header**.
2. Click once on `can_tmr.img` to view the ENVI header file for this image.
3. Click the **Cancel** button to close the header file.
4. Right-click on an image name in the Available Bands List and select **Edit Header** as an alternate way to view the ENVI header file. Close the header file.

ENVI Windows and Displays

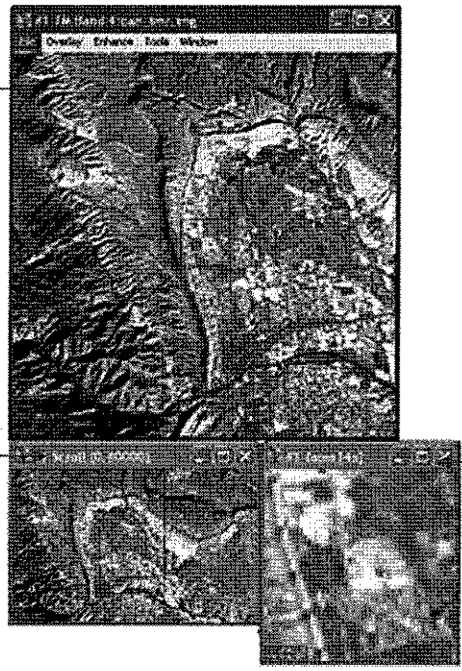
The ENVI Main Menu Bar

In ENVI, activities are initiated by using the menus in the ENVI main menu bar, which may be oriented horizontally as shown below, or vertically (as set via the option on the **File → Preferences → Miscellaneous** tab).

The Display Group

As you work with ENVI, a group of windows will appear on your screen allowing you to manipulate and analyze your image. This group of windows is collectively referred to as the "display group" and the default setup consists of an Image window, a Scroll window, and a Zoom window.

Image window



Scroll Window

Zoom Window

You can choose which combinations of windows appear on the screen by right-clicking on any image window to display the right-click menu and selecting a style from the **Display Window Style** submenu. Use the ENVI main menu bar **File → Preferences → Display Defaults** tab to change the default settings for which windows you wish to display and where you wish to position them.

You may have many display groups open on the screen at any time. A wide variety of other types of ENVI windows may also be displayed, such as scatter plots, spectral profiles, spectral plots, and vector windows.

All windows can be resized by grabbing and dragging a window corner with the left mouse button.

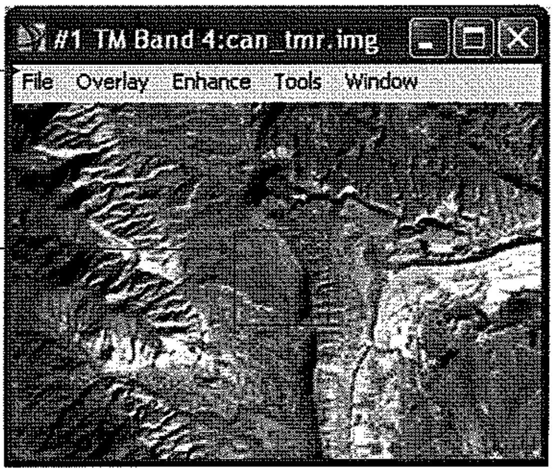
1. Resize the Image window to be as large as possible (until the Scroll window disappears).
2. Now, make the Image window smaller than the full extent of the image data (the Scroll window will reappear).
3. Resize the Zoom window and notice how the outlining box changes in the Image window.

The Image Window

The Image window shows a portion of the image at full resolution.

Display Group Menu Bar

Zoom Box



The Display group menu bar provides access to many ENVI features related to the images in the display group. By default, it appears at the top of the Image window. If you have chosen to display only the Scroll and Zoom windows or just the Zoom window, the menu bar will appear at the top of the Zoom window.

The Zoom box (the colored box in the Image window) indicates the region that is displayed in the Zoom window.

1. Place the mouse cursor in the Zoom box in the Image window, hold down the left mouse button, and move the mouse. The Zoom window is updated automatically when the mouse button is released.
2. Place the cursor anywhere in the Image window (outside of the Zoom box) and click the left mouse button to move the magnified area instantly. If you click, hold, and drag the left mouse button in this fashion, the Zoom window is updated as you drag.
3. Click once in the Zoom box in the Image window and use the arrow keys on your keyboard to move the box. To move several pixels at a time, hold down the **Shift** key while using the arrow keys.

You can choose to have scroll bars displayed in the Image window. These scroll bars provide a way to move through the Scroll window, allowing you to select which portion of the image appears in the Image window.

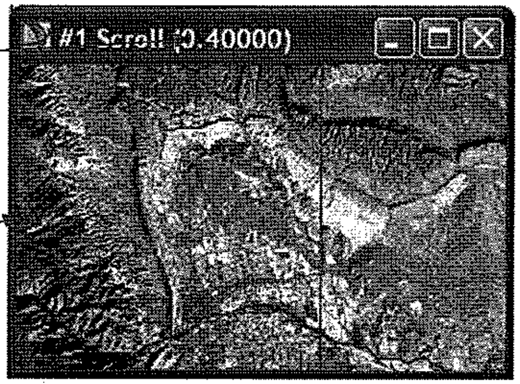
1. Right-click in the Image window and select **Toggle → Display Scroll Bars**.
2. To have scroll bars appear in the Image window by default, use the ENVI main menu bar to select the **File → Preferences → Display Defaults** tab. Set the **Image Window Scroll Bars** toggle to **Yes**.

The Scroll Window

The Scroll window displays the entire image at reduced resolution (subsampled). The subsampling factor is listed in parentheses in the window Title Bar at the top of the image. The highlighted Image box (red by default) indicates the area shown at full resolution in the Image window.

Subsampling Factor

Image Box



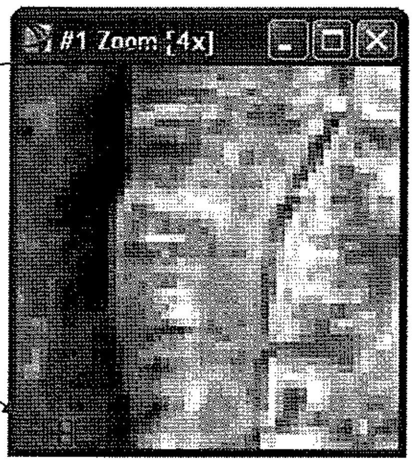
1. Place the mouse cursor inside the Image box, hold down the left mouse button, drag to the desired location, and release to reposition the portion of the image shown in the Image window. The Image window is updated automatically when the mouse button is released.
2. Click anywhere within the Scroll window using the left mouse button to instantly move the selected Image window area. If you click, hold, and drag the left mouse button in this fashion, the Image window will be updated as you drag (the speed depends on your computer resources).
3. Click in the Image box and press the arrow keys on your keyboard. To move the image in larger increments, hold down the **Shift** key while using the arrow keys.

The Zoom Window

The Zoom window shows a portion of the image magnified the number of times indicated by the number shown in parentheses in the Title Bar of the window. The zoom area is indicated by a highlighted box (the Zoom box) in the Image window.

Zoom Level

Zoom controls



There are three Zoom controls (red by default) in the lower left corner of the Zoom window. These control the zoom factor and the crosshair cursor in both the Zoom and Image windows.

1. Place the mouse cursor in the Zoom window and click the left mouse button to reposition the magnified area (displayed in the Zoom box in the Image window) by centering the zoomed area on the selected pixel.
2. Click and hold the left mouse button in the Zoom window while dragging. This causes the Zoom window to pan within the Image window.

3. Click the left mouse button on the ⊟ graphic in the lower left corner of the Zoom window to zoom out by a factor of 1.
4. Using a three button mouse, click the middle mouse button on the ⊟ graphic to zoom out by a factor of 2.
5. Click the right mouse button on the ⊟ graphic to return the Zoom window to the default zoom factor.
6. Click the left mouse button on the ⊞ graphic to zoom in by a factor of 1.
7. Click the middle mouse button on the ⊞ graphic to zoom in by a factor of 2.
8. Click the right mouse button on the ⊞ graphic to return the Zoom window to the default zoom factor.
9. Click the left mouse button on the □ graphic to toggle the crosshair cursor in the Zoom window on or off.
10. Click the middle mouse button on the □ graphic to toggle the crosshair cursor in the Image window on or off.
11. Click the right mouse button on the □ graphic to toggle the Zoom box in the Image window on or off.
12. The Zoom window can also have optional scroll bars, which provide an alternate method for moving through the Zoom window. Right-click in the Zoom window and select **Toggle → Zoom Scroll Bars.** To have scroll bars appear on the Zoom window by default, use the ENVI main menu bar to select the **File → Preferences → Display Defaults** tab. Set the Zoom window **Scroll Bars** toggle to **Yes**.

The Mouse Button Descriptions Dialog

ENVI has many interactive functions, and the mouse button combinations and actions are different for each one. The Mouse Button Descriptions dialog is available to assist you in understanding what the mouse buttons do in each graphics window. Start the Mouse Button Descriptions dialog by performing either of these methods:

- From the Display group menu bar, select **Window → Mouse Button Descriptions**.
- From the ENVI main menu bar, select **Window → Mouse Button Descriptions** and place your cursor over the Image window.

When the Mouse Button Descriptions dialog is open, the mouse button assignments for each ENVI display or graphics window are shown in the dialog when the cursor is poised over a display group window. In the dialog, MB1 is the left mouse button, MB2 is the middle mouse button, and MB3 is the right mouse button.

Basic ENVI Functions

This section of the tutorial takes you on a step-by-step tour of ENVI's basic functions.

Displaying the Cursor Location and Value

You can choose to display the location of your mouse cursor, screen value (RGB color), and the actual data value of the pixel underneath the crosshair cursor using the Cursor Location/Value dialog. When several display groups are open, this dialog specifies which display group's location and value are being reported.

1. To display the cursor location and value, select **Window → Cursor Location/Value** from either the ENVI main menu bar or the Display group menu bar. You can also right-click in the Image window and select **Cursor Location/Value**.
2. Move the mouse cursor over the Image, Scroll, or Zoom windows to display location and value information in the Cursor Location/Value dialog.
3. Double-click in the Image window to hide the Cursor Location/Value dialog. Double-click again to show the Cursor Location/Value dialog.
4. From the Cursor Location/Value menu bar, select **File → Cancel** to close the dialog.

Displaying Image Profiles

X (horizontal), Y (vertical), and Z (spectral) profile plots can be selected and displayed interactively. These profiles show the data values across an image line (X), column (Y), or spectral bands (Z). To display these profiles, perform the following steps.

1. From the Display group menu bar, select **Tools → Profiles → X Profile** to display a window plotting data values versus sample number for a selected line in the image.
2. From the Display group menu bar, select **Tools → Profiles → Y Profile** to display a plot of data value versus line number.
3. From the Display group menu bar, select **Tools → Profiles → Z Profile** to display a spectral plot. You can also open a Z profile from the right-click menu in any **Image** window.
4. From the Display group menu bar, select **Window → Mouse Button Descriptions** to view the descriptions of the mouse button actions in the Profile displays.
5. A red crosshair extends to the top and bottom and to the sides of the Image window. The red lines indicate the line or sample locations for the vertical or horizontal profiles. Move the crosshair around the image (just as you move the Zoom box) to see the three image profile plots update to display data on the new location.
6. Close the profile plots by selecting **File → Cancel** from the menu bar within each window.

Performing Quick Contrast Stretching

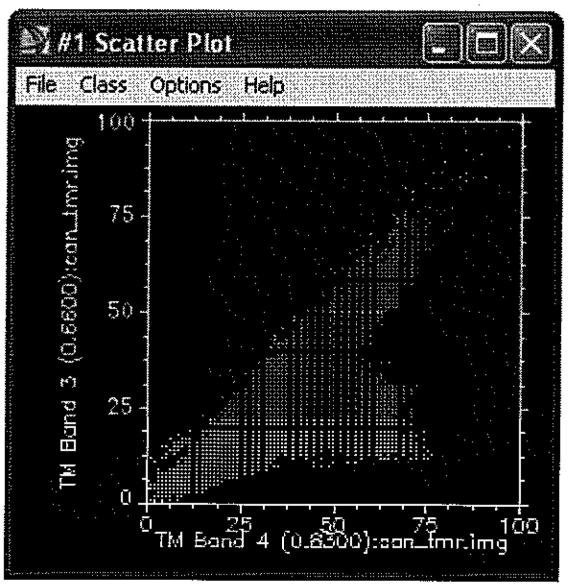
You can perform quick contrast stretches using default parameters and data from either the Image window, the Zoom window, or the Scroll window.

1. From the Display group menu bar, select **Enhance** and apply various contrast stretches (Linear, Linear 0-255, Linear 2%, Gaussian, Equalization, and Square Root).
2. Compare the effects of the various stretches on the display group.

Displaying Interactive Scatter Plots

You can plot the data values of two selected image bands versus each other in a scatter plot to graphically display the overlapping values.

1. From the Display group menu bar, select **Tools → 2D Scatter Plots**. The Scatter Plot Band Choice dialog appears, allowing you to choose the two image bands to compare.
2. Select one band for the x axis and another band for the y axis and click **OK**. It may take a few seconds for ENVI to extract and tabulate the data values.
3. Once the scatter plot has appeared (see image right), position the mouse cursor anywhere in the Image window and drag with the left mouse button pressed. Pixel values contained in a ten-pixel by ten-pixel box surrounding the crosshair will be highlighted in red on the scatter plot.
4. From the Display group menu bar, select **Window → Mouse Button Descriptions** to display the functions of the different mouse button actions when applied in the Scatter Plot display.



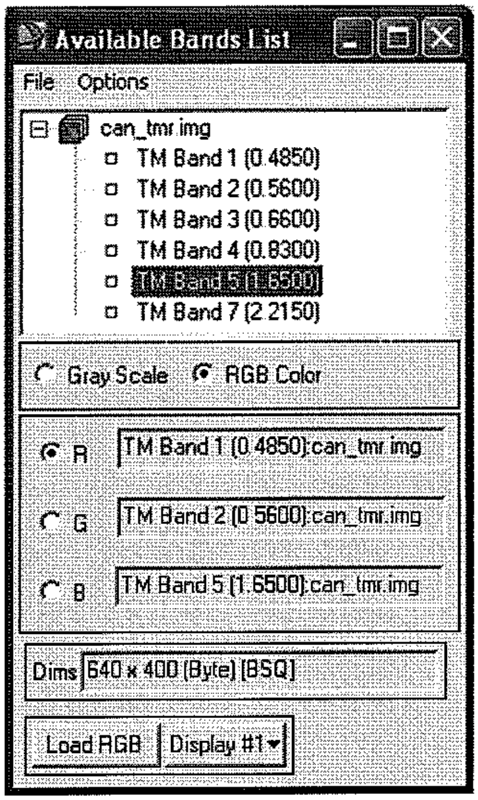
5. Click and drag the cursor around in the Image window to observe the dancing pixels effect.

You can also use the scatter plot to highlight specific data values in the Image window.

1. Place the mouse cursor in the Scatter Plot window and click and drag with the middle mouse button. Pixel values contained in a ten-pixel by ten-pixel box surrounding the crosshair will be highlighted in red on the scatter plot Pixels with the values contained in the box are highlighted in the Image window and appear to dance.
2. From the Scatter Plot menu bar, select **File → Cancel** to close the Scatter Plot window.

Loading a Color Image

Previously, you opened and were working with Band 4 of `can_tmr.img`. You opened that image using the Gray Scale option. Now you will open three bands of the image using the RGB Color option.



1. If the Available Bands List dialog is not displayed, select **Window → Available Bands List** from the ENVI main menu bar.
2. Click the **RGB Color** radio button, then select **TM Band 1** under can_tmr.img. The band you have chosen is displayed in the field marked *R*.
3. Select **TM Band 2**. The band you have chosen is displayed in the field marked *G*.
4. Select **TM Band 5**. The band you have chosen is displayed in the field marked *B*.
5. Click **Display #1** and select **New Display**.
6. Click **Load RGB** to load the image into a new display.

Linking Two Displays

Link the two displays together for comparison. When you link two displays, any action you perform on one display (scrolling, zooming, etc.) is echoed in the linked display. To link the two displays on your screen, do the following.

1. From the Display group menu bar, select **Tools → Link → Link Displays**. You can also right-click in the Image window and select **Link Displays**.
2. Click **OK** in the Link Displays dialog to establish the link.
3. Scroll and zoom in one display group and observe as your changes are mirrored in the second display.

Dynamic Overlays

ENVI's multiple dynamic overlay feature allows you to dynamically superimpose parts of one or more linked images onto another image. Dynamic overlays are turned on automatically when you link two displays, and may appear in either the Image window or the Zoom window.

1. Click the left mouse button in one of the Image windows to see the image displays overlaid on one another.
2. To create a smaller overlay area, position the mouse cursor anywhere in either Image window (or Zoom window) and hold down and drag with the **middle mouse button**. Upon button release, the smaller overlay area is set and a small portion of the linked image will be superimposed on the current Image window.
3. Click the left mouse button in the Image window and drag the small overlay window around the image to see the overlay effects.
4. Resize the overlay area at by clicking and dragging the middle mouse button until the overlay area is the desired size.

Selecting Regions of Interest

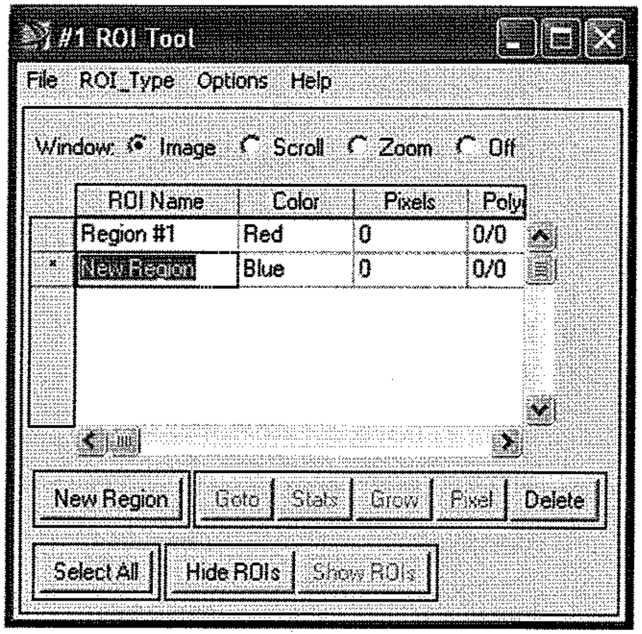
ENVI lets you define regions of interest (ROIs) in your images. ROIs are typically used to extract statistics for classification, masking, and other operations.

1. From the Display group menu bar, select **Overlay → Region of Interest**, or right-click in the Image window and select **ROI Tool**.
2. Draw a polygon that represents the region of interest by clicking the left mouse button in the Image window to establish the first point of the ROI polygon, then selecting further border points in sequence by clicking the left button again. Close the polygon by clicking the right mouse button, then accept the polygon by clicking the right mouse button again. The middle mouse button deletes the most recent point, or (if you have closed the polygon) the entire polygon.

   ROIs can also be defined in the Zoom and Scroll windows by selecting the appropriate window radio button in the ROI Tool dialog.

   When you have finished defining an ROI, it is shown in the dialog table, with the name, region color, number of pixels enclosed, and other ROI properties.

   ROIs can also be defined as polylines or as a collection of individual pixels by selecting the desired ROI type from the ROI_Type pull-down menu in the ROI Tool.



3. Click the **New Region** button.
4. Select an ROI by clicking in a cell of the far left column of the ROI Tool table. An ROI is selected when its entire row is highlighted. An asterisk next to the row also signifies the currently active ROI. Multiple ROIs can be selected by using **Shift**-click or **Ctrl**-click. All the ROIs can be selected by clicking the **Select All** button. Click and type to edit the values in the cells of the ROI Tool table. Change the name for the region and select a new color.
5. Hide ROIs by selecting them in the table and clicking the **Hide ROIs** button. Use the **Show ROIs** button to re-display these hidden ROIs.
6. Go to an ROI in the ENVI display by selecting it and clicking the **Goto** button.
7. View the statistics for one or more ROIs by selecting them in the table and clicking the **Stats** button.
8. Grow an ROI to its neighboring pixels within a specified threshold by selecting it and clicking the **Grow** button.
9. Pixelate polygon and polyline ROIs by selecting them in the table and clicking the **Pixel** button. Pixelated objects become a collection of editable points.
10. Delete ROIs by selecting them in the table and clicking the **Delete** button.

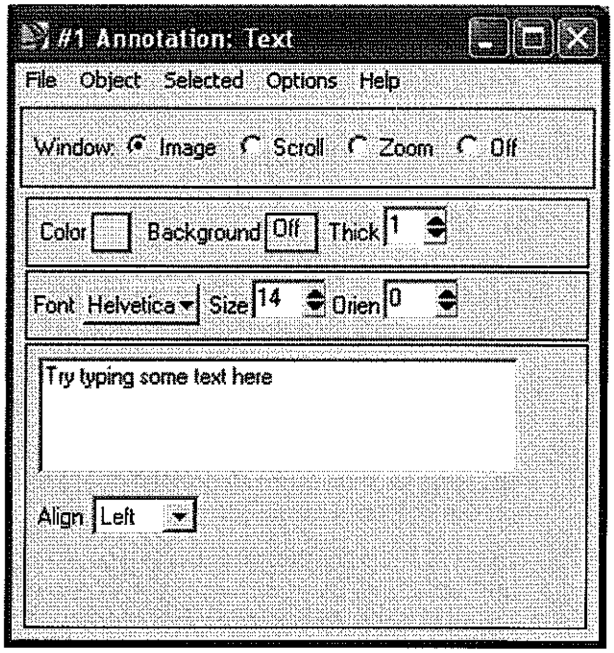
    The ROI Tool table also allows you to view and edit various ROI properties, such as name, color, and fill pattern. Menu options available at the top of the ROI Tool dialog let you perform other various tasks, such as calculate ROI means, save your ROI definitions, and load saved definitions. ROI definitions are retained in memory after the ROI Tool dialog is closed, unless you explicitly delete them. ROIs are available to other ENVI functions even if they are not displayed.

11. Close the ROI Tool using the menu at the top of the table, select **File → Cancel**.

Annotating the Image

ENVI's flexible annotation features allow you to add text, polygons, color bars, and other symbols to your plots and images.

The Annotation Text dialog allows you to choose from a variety of annotation types. Different types are selected from the **Object** menu and include Text, Symbols, Rectangles, Ellipses, Polygons, Polylines, Arrows, Map Scale Bars and Declination Diagrams, Map Keys, Color Table Ramps, and Images. By default, the Annotation dialog starts up with Text selected. Other fields in the dialog let you control the size, color, placement, and angle of the annotation text. When you select different annotation types from the **Object** menu, the fields in the dialog change to display options appropriate to the new type.



1. From the Display group menu bar, select **Overlay → Annotation**.
2. Type some text in the text field of the Annotation Text dialog.
3. Select a font, font size, and color using the fields provided in the dialog, then position the mouse pointer in the Image window and click the left mouse button. Your text is displayed in the window at the point you clicked.

   Remember, you can view the mouse button descriptions using the Display group menu bar **Window → Mouse Button Descriptions** option.
4. Using the left mouse button, drag the handle (displayed in the image below as a diamond shape to the left, bottom of the text) to position the text in the window.

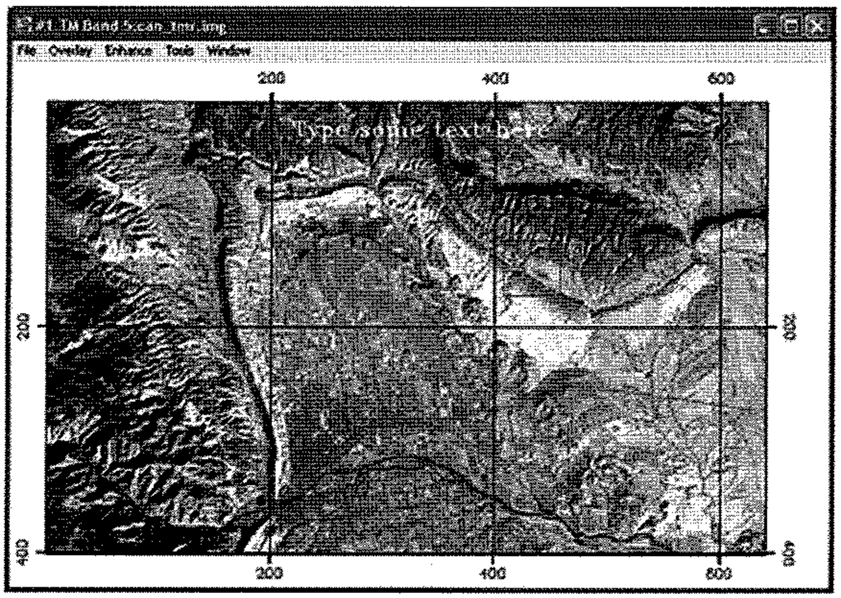
5. You can continue to change the annotation's properties and position by changing the fields in the dialog box or dragging the text or symbol while holding down the left mouse button. When you are satisfied with the annotation, click the <u>right</u> mouse button to fix the annotation in position.
6. You can save your image annotation by selecting **File → Save Annotation** from the Annotation Text dialog menu bar. If you do not save your annotation in a file, it will be lost when you close the Annotation Text dialog (you will be prompted to save the annotation if you close without first saving). You can also restore saved annotation files by selecting **File → Restore Annotation** from the Annotation Text dialog menu bar.

7. To edit an annotation element that has already been set in the image, select **Object → Selection/Edit** from the Annotation Text dialog menu bar.
8. Draw a box around the annotation you wish to edit by clicking and dragging with the left mouse button. When the handle reappears, click and drag the handle and annotation to move and configure the item just as you would a new annotation.
9. To suspend annotation operations and return to normal ENVI functionality temporarily, select the **Off** radio button at the top of the Annotation Text dialog. This allows you to use the scroll and zoom features in your display without losing your annotations. To return to the annotation function, select the radio button in the Annotation Text dialog for the window you are annotating.
10. Leave your annotation on the Image window as you complete this tutorial.

Adding Grid Lines

You can use grid lines to overlay one or more grids on an image. Grids can be pixel-based or map-coordinate and/or latitude/longitude based (for georeferenced images). Each image display can have its own set of grids, which are displayed in the Image, Scroll, and Zoom windows.

1. From the Display group menu bar, select **Overlay → Grid Lines** to open the Grid Line Parameters dialog box. As soon as you choose this option, an image border is automatically added.
2. You can adjust the grid line attributes by setting the line thickness and color and the grid spacing by selecting **Options → Edit Pixel Grid Attributes** from the Grid Lines Parameters dialog menu bar. This selection brings up the Edit Pixel Attributes dialog box.
3. In the Edit Pixel Attributes dialog, you can change the color, thickness and grid spacing for the labels, lines, box and corners of the grid. When the attributes are set up to your satisfaction, click **OK** in the Edit Pixel Attributes dialog to apply the changes to the grid on the images.
4. When you have added a satisfactory grid, click **Apply** in the Grid Line Parameters dialog.



Saving and Outputting an Image

ENVI gives you several options for saving and outputting your filtered, annotated, gridded images. You can save your work in ENVI's image file format, or in several popular graphics formats (including Postscript) for printing or importing into other software packages. You can also output directly to a printer.

1. From the Display group menu bar, select **File → Save Image As → Image File** to save your work in ENVI's native format (as an RGB file). The Output Display to Image File dialog appears.

2. Select **24-Bit Color** or **8-bit (gray scale)** output.
3. Click the **Change Graphic Overlay Selections** button to select graphics options (including annotation and gridlines)
4. Set border options.
5. Select output to **Memory** or **File** using the desired radio button. If output to **File** is selected, enter an output filename.
6. If you select other graphics file formats from the **Output File Type** drop-down which, by default is set to ENVI, your choices will be slightly different.
7. Click **OK** to save the image. This process saves the current display values for the image, not the actual data values.

Exiting ENVI

End the ENVI session by selecting **File → Exit** from the ENVI main menu, then click **OK** to terminate ENVI when prompted.

ENVI

ENVI Tutorial: Vector Overlay and GIS Analysis

Table of Contents

Overview of This Tutorial

This tutorial introduces ENVI's vector overlay and GIS analysis capabilities using vector data from ESRI's Maps and Data CD-ROM; a simulated 4 m resolution Space Imaging/EOSAT multispectral dataset; and associated vector data of Gonzales, California, USA.

Part 1 of this tutorial demonstrates the following:

- Stand-alone vector GIS analysis, including input of shapefiles and associated DBF attribute files
- Display in vector windows
- Viewing and editing attribute data
- Point-and-click spatial query
- Math and logical query operations

Part 2 of this tutorial demonstrates the following:

- ENVI's combined image display/vector overlay and analysis capabilities
  - Cursor tracking with attribute information
  - Point-and-click spatial query
  - Heads-up digitizing and vector layer editing
- Generation of new vector layers using math and logical query operations
- Raster-to-vector conversion of ENVI regions of interest (ROIs) and classification images
- ENVI's vector-to-raster conversion, using vector query results to generate ROIs for extraction of image statistics and area calculations

Sources and Files Used in this Tutorial

The data used in this tutorial are provided courtesy of the Environmental Systems Research Institute Inc. and Space Imaging/EOSAT and may not be redistributed without explicit permission from those organizations.

ESRI Data and Maps Version 1 CD-ROM

Example data used in Part 1 of this tutorial come from the ESRI Data and Maps Version 1 CD-ROM distributed with ArcView Version 3.0. ITT Visual Information Solutions strives to maintain import/export compatibility with ESRI GIS products and data formats, including ArcView shapefiles, ArcGRID files, and ArcInfo export files (`.e00`, non-compressed).

Space Imaging/EOSAT CarterraTM Agriculture Sampler Data

Example images and vector data used in Part 2 of this tutorial come from the Space Imaging/EOSAT Carterra Agriculture Sampler CD-ROM (Copyright © 1997, Space Imaging/EOSAT) and are used with their explicit permission. This sample dataset covers an agricultural area near Gonzales, California, USA–the north-central portion of the Palo Escrito Peak, CA USGS 7.5 minute quadrangle. The digital imagery are simulated data products designed to be similar to the space-based image data products collected and distributed by Space Imaging/EOSAT in early 1998. Space Imaging/EOSAT provides these simulated data products as examples of information extracted from their imagery products. The simulated imagery datasets were generated from digital image data collected by an airborne multispectral scanner. The airborne data were geometrically rectified, corrected for solar effects, and mosaicked at a spatial resolution simulating the Carterra data products. However, radiometric and geometric differences exist between these data and satellite-based products planned for delivery. Please see the Carterra Sampler `readme.txt` file included in the `si_eosat` subdirectory for additional information.

Required Files

ENVI Tutorial Data DVD:

Paths: `envidata/esri_gis` (Part 1 of this tutorial)
`envidata/si_eosat` (Parts 1 and 2 of this tutorial)
`envidata/can_tm` (Part 2 of this tutorial)

Required vector GIS files for Part 1 (envidata\esri_gis)

File	Description
cities.shp (.shx, .dbf)	USA cities (points)
states.shp (.shx, .dbf)	USA states (polygons)

Optional vector GIS files for Part 1 (envidata\esri_gis)

File	Description
counties.shp (.shx, .dbf)	USA counties (polygons)
drainage.shp (.shx, .dbf)	USA states (polygons)
lakes.shp (.shx, .dbf)	USA lakes (polygons)
rivers.shp (.shx, .dbf)	USA rivers (polylines)
roads.shp (.shx, .dbf)	USA roads (polylines)

Required image files for Part 2 (envidata\si_eosat)

File	Description
0826_ms.img (.hdr)	4 m multispectral data and ENVI header

Required image files for Part 2 (envidata\can_tm)

File	Description
can_tmr.img (.hdr)	Cañon City TM data and ENVI header
can_sam.img (.hdr)	Cañon City SAM classification and ENVI header
can_pcls.img (.hdr)	Cañon City parallelepiped classification and ENVI header
can_sv.img (.hdr)	Sieved classification (threshold = 5) and ENVI header
can_clmp.img (.hdr)	Clumped (5 x 5) after sieve and ENVI header
can_tm1.roi	Cañon City TM ROI #1
can_tm2.roi	Cañon City TM ROI #2

Required vector GIS files for Part 2 (envidata\si_eosat)

File	Description
vectors.shp (.shx, .dbf)	Field outlines (polygons)

Optional vector GIS files for Part 2 (envidata\si_eosat)

File	Description
gloria.evf (.dbf)	Query results (polygons)
lanini.evf (.dbf)	Query results (polygons)
sharpe.evf (.dbf)	Query results (polylines)
si_eosat.vec	ENVI vector template for the above three vectors

Vector Overlay and GIS Concepts

Capabilities

ENVI provides extensive vector overlay and GIS analysis capabilities. These include the following:

Import support for **industry-standard GIS file formats**, including shapefiles and associated DBF attribute files, ArcInfo interchange files (`.e00`, uncompressed), MapInfo vector files (`.mif`) and attributes from associated `.mid` files, Microstation DGN vector files, DXF, and USGS DLG and SDTS formats. ENVI uses an internal ENVI Vector Format (EVF) to maximize performance.

Vector and image/vector display groups provide a stand-alone **vector plot window** for displaying vector data and composing vector maps. More importantly, ENVI provides **vector overlays** in display groups (Image windows, Scroll windows, and Zoom windows).

You can generate world boundary **vector layers**, including low- and high-resolution political boundaries, coastlines, and rivers, and USA state boundaries. You can display all of these in vector windows or overlay them in image display groups.

You can perform **heads-up (on-screen) digitizing** in a vector or raster display group. Heads-up digitizing provides an easy means of creating new vector layers by adding polygons, lines, or points.

Image- and vector window-based **vector editing** allows you to modify individual polygons, polylines, and points in vector layers using standard editing tools, taking full advantage of the image backdrop provided by raster images in ENVI.

ROIs, specific image contour values, classification images, and other **raster processing results can be converted to vector format** for use in GIS analysis.

Latitude/longitude and map coordinate information can be displayed and exported for image-to-map registration. Attribute information can be displayed in real-time as each vector is selected.

ENVI supports **linked vectors and attribute tables** with point-and-click query for both vector and raster displays. Click on a vector in the display group, and the corresponding vector and its associated information is highlighted in the attribute table. Click on an attribute in the table, and the display scrolls to and highlights the corresponding vector.

Scroll and pan through rows and columns of vector **attribute data**. Edit existing information or replace attributes with constant values, or with data imported from ASCII files. Add or delete attribute columns. Sort column information in either forward or reverse order. Export attribute records as ASCII text.

Query vector database attributes directly to extract information that meets specific search criteria. You can perform GIS analysis using simple mathematical functions and logical operators to produce new information and layers. Results can either be output to memory or to a file for later access.

You can set **vector layer display characteristics** and modify line types, fill types, colors, and symbols. Use attributes to control labels and symbol sizes. Add custom vector symbols.

You can **reproject** vector data from any map projection to another.

You can **convert vector data to raster ROIs** for extraction of statistics, calculation of areas, and use in ENVI's many raster analysis functions.

Generate maps using ENVI annotation in either vector or image windows. Set border widths and background colors, and configure graphics colors. Automatically generate vector layer map keys. Insert objects such as rectangles, ellipses, lines, arrows, symbols, text, and image insets. Select and modify existing annotation objects. Save and restore annotation templates for specific map compositions.

Create shapefiles and associated DBF attribute files and indices, or DXF files, from the internal ENVI Vector Format (EVF). New vector layers generated using ENVI's robust image processing capabilities, and changes made to vector layers in ENVI are exported to industry-standard GIS formats.

Use ENVI's direct **printing** capabilities to output to printers and plotters.

Concepts

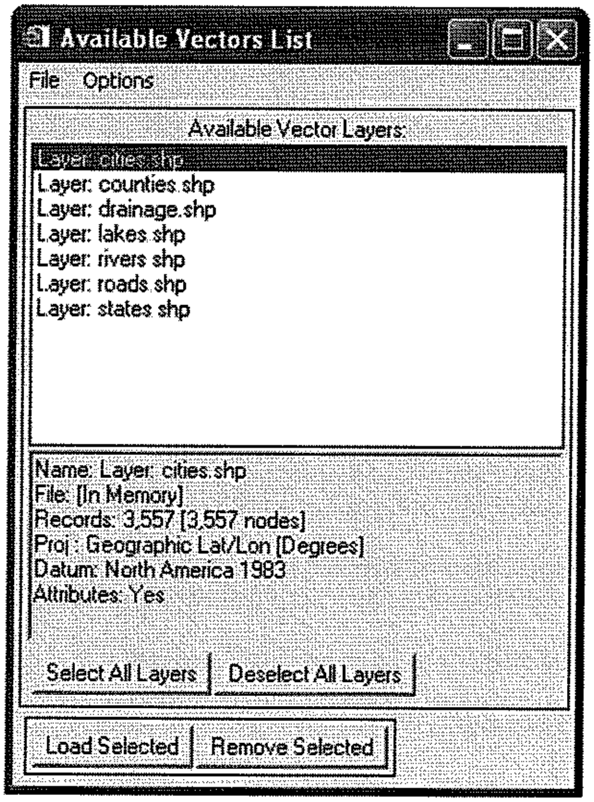
ENVI's vector overlay and GIS analysis functions generally follow the same paradigms as ENVI's raster processing routines, including the same procedures for opening files and the use of standard dialogs for output to memory or file. The following sections describe some of the basic concepts.

ENVI Vector Files (.evf)

External vector files imported into ENVI are automatically converted into EVF, with the default file extension `.evf`. The EVF format speeds processing and optimizes data storage. When you select output to memory (instead of to a file), ENVI retains the external vector format without creating an EVF file.

The Available Vectors List

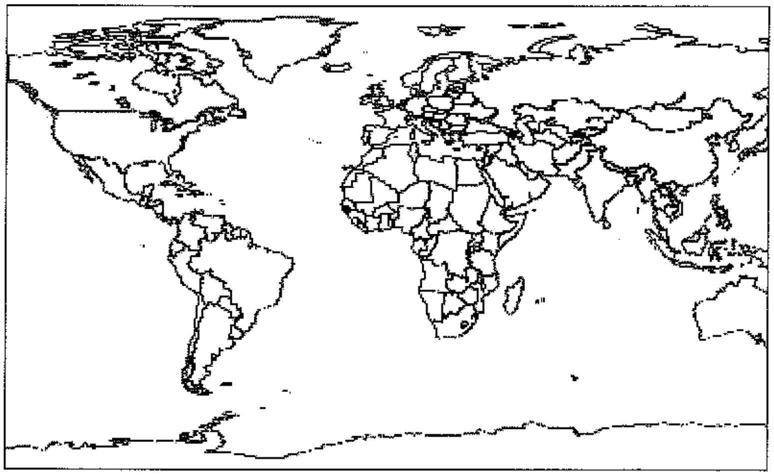
Much like the Available Bands List used to list and load image bands, the Available Vectors List provides access to all vector files open in ENVI. It appears when needed, or you can invoke it by selecting **Window → Available Vectors List** from the ENVI main menu bar. Vectors are loaded to either vector or image display groups when you select them from the Available Vectors List and click **Load Selected**. If you have an image display group open, you can load the vectors to that display group, or to a new vector window. In addition to listing and loading vector layers, the Available Vectors List provides utilities to open vector files, to start new vector windows, to create world boundaries and new vector layers, and to export analysis results to ROIs (through raster-to-vector conversion), shapefiles, and ancillary files.



Create World Boundaries

ENVI uses IDL map sets to generate low- and high-resolution world boundaries in EVF. Select **Options → Create World Boundaries** from the Available Vectors List, or **Vector → Create World Boundaries** from the ENVI main menu bar. You can also generate political boundaries, coastlines, rivers, and USA state boundaries.

High-resolution format is available only if the IDL high-resolution maps are installed. If these are not currently installed on your system, you can install them using the ENVI Installation CD, modifying your installation to include the high-resolution maps.

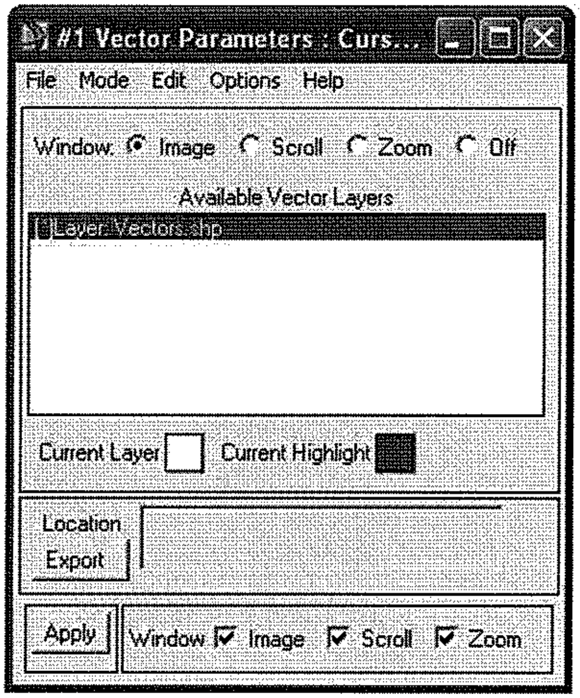


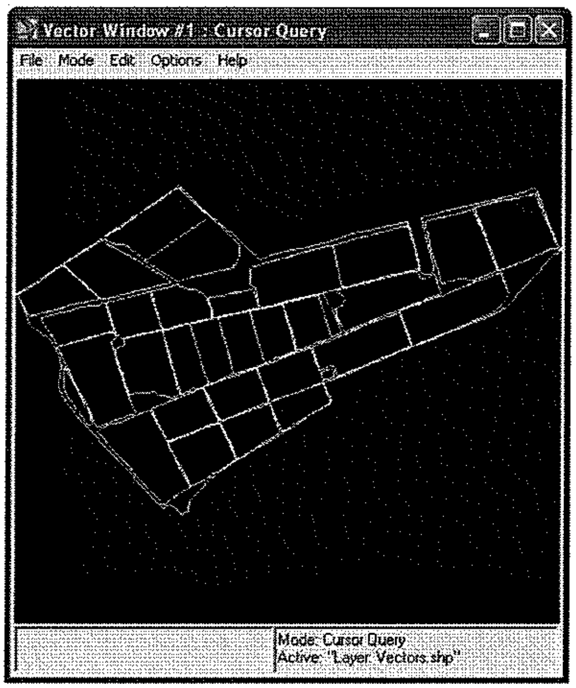
The Vector Parameters Dialog and Vector Window Menu

When vectors are overlaid on an image, the Vector Parameters dialog appears to let you control the way vectors are displayed and the functions that are available for vector processing and analysis.

When vectors are loaded into a vector window (not in an image display group), the vector window has the same menu functions available in the Vector Parameters dialog.

The Vector Parameters dialog and the vector window menu bar allow you to open vector files, import vector layers from the Available Vectors List, arrange vector layer precedence, set plot parameters, and annotate plots. They also control the mode of operation in the vector window or image display group, toggling between cursor query and heads-up digitizing and editing. The Vector Parameters dialog or the vector window menu initiate ENVI's GIS analysis functions, including real-time vector information, attribute viewing and editing, and vector query operations. Finally, the Vector Parameters dialog and the vector window menu bar provide utilities for exporting analysis results to shapefiles and ancillary attribute files, or to ROIs (through vector-to-raster conversion). You can also save the current configuration of vector overlays to a template, so you can later restore them.



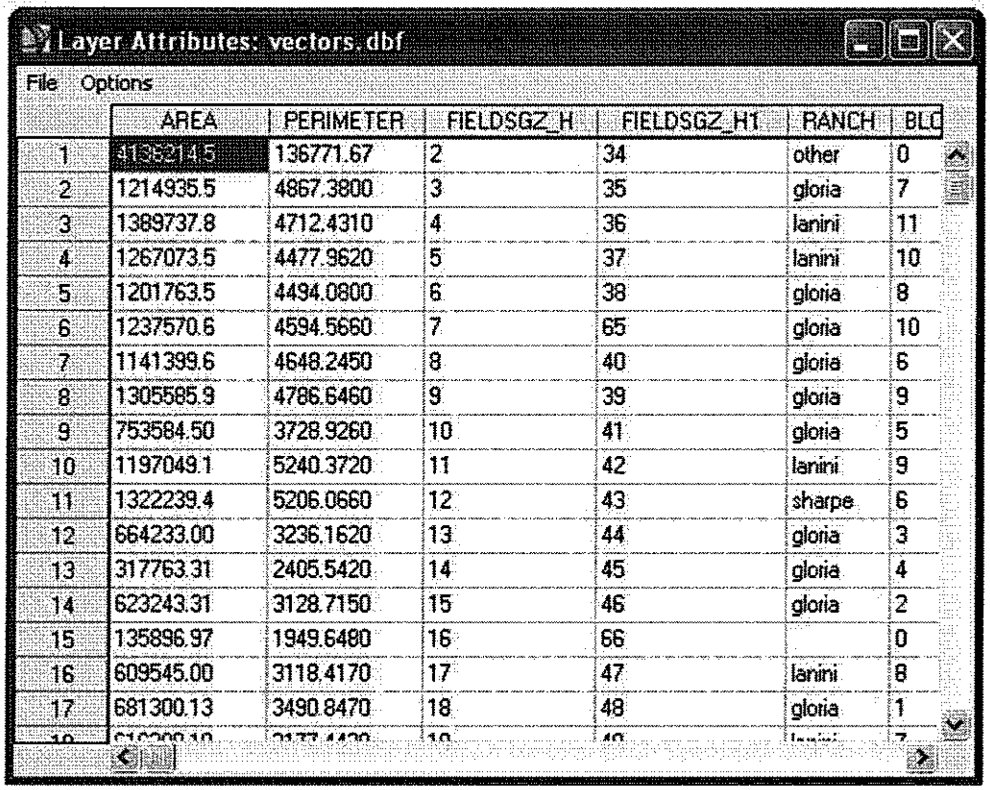


ENVI Attributes

ENVI provides access to fully attributed GIS data in a shapefile DBF format. Attributes are listed in an editable table, allowing point-and-click selection and editing.

Double-clicking in a particular cell selects that cell for editing. The table also supports full column substitution using a uniform value and replacement with values from an ASCII file. Options include adding and deleting individual columns and sorting data forward and backward based on information within a column. You can save attributes to an ASCII file or to a DBF file.

Point-and-click spatial query is supported in ENVI attribute tables to help you locate key features in images or in a vector window. Select specific records by clicking the label at the left edge of the table for a specific row in the table. The corresponding vector is highlighted in a contrasting color in the image display group or vector window. You can select multiple records, including non-adjacent records, by holding down the **<Ctrl>** key as you click the additional row labels.



	AREA	PERIMETER	FIELDSGZ_H	FIELDSGZ_H1	RANCH	BLC
1	[illegible]	136771.67	2	34	other	0
2	1214935.5	4867.3800	3	35	gloria	7
3	1389737.8	4712.4310	4	36	lanini	11
4	1267073.5	4477.9620	5	37	lanini	10
5	1201763.5	4494.0800	6	38	gloria	8
6	1237570.6	4594.5660	7	65	gloria	10
7	1141399.6	4648.2450	8	40	gloria	6
8	1305585.9	4786.6460	9	39	gloria	9
9	753584.50	3728.9260	10	41	gloria	5
10	1197049.1	5240.3720	11	42	lanini	9
11	1322239.4	5206.0660	12	43	sharpe	6
12	664233.00	3236.1620	13	44	gloria	3
13	317763.31	2405.5420	14	45	gloria	4
14	623243.31	3128.7150	15	46	gloria	2
15	135896.97	1949.6480	16	66		0
16	609545.00	3118.4170	17	47	lanini	8
17	681300.13	3490.8470	18	48	gloria	1

Part 1: Stand-Alone Vector GIS

This part of the tutorial demonstrates how to use ENVI as a simple stand-alone vector processing and analysis system for GIS data. You will use data from the ESRI Data and Maps 1 CD-ROM, which are provided on the ENVI Tutorial Data DVD.

Before attempting to start the program, ensure ENVI is properly installed as described in the installation guide.

Open a Shapefile

1. From the ENVI main menu bar, select **File → Open Vector File**. A Select Vector Filenames dialog appears.
2. Navigate to `envidata\esri_gis`. Click the **Files of type** drop-down list in the Select Vector Filenames dialog, and select **Shapefile**.
3. Select `cities.shp`. Click **Open**. The Import Vector Files Parameters dialog appears. This dialog allows you to select file or memory output, enter an output filename for the ENVI `.evf` file, and enter projection information if ENVI is unable to find the projection information automatically.
4. Click the **Memory** radio button. Accept the default values by clicking **OK**. A status window indicates the number of vector vertices being read, and the Available Vectors List appears when the data have been converted.
5. Select `cities.shp` in the Available Vectors List and click **Load Selected**. The Vector Window #1 dialog appears with USA cities plotted. The default mode (shown in the title bar or in the lower-right corner of the dialog) is Cursor Query.

Work with Vector Point Data

1. Click and drag the cursor around in Vector Window #1. Latitudes and longitudes are displayed in the lower-left corner of the dialog.
2. Zoom into the contiguous 48 states by positioning the cursor in the far northwest part of the U.S. and clicking and dragging the middle mouse button to define a box covering the desired region. Release the middle mouse button in the far southeast part of the U.S.

   Multiple levels of zoom are possible. Click the middle mouse button while holding the <Shift> key to zoom into the display centered on the cursor. Right click in the Vector Window #1 dialog and select Previous Range to step backward through the previous zoom levels. Right-click and select Reset Range, or click the middle mouse button in the Vector Window #1 dialog to reset the zoom level and to set the vector display back to the original range.
3. Change the symbol used to mark the cities. From the Vector Window #1 menu bar, select **Edit → Edit Layer Properties**. An Edit Vector Layers dialog appears. Click the **Point Symbol** drop-down list and select **Flag**. Click **OK**. You can add your own symbols by defining them in the file `usersym.txt` in the menu directory of your ENVI installation.
4. Experiment with changing the color, symbol, and size. Click **Preview** to view your changes as you go.

Create USA State Boundaries Using IDL Map Sets

1. From the Available Vectors List menu bar, select **Options → Create World Boundaries**. The Create Boundaries dialog appears.
2. Select the **USA States** check box, select the **Memory** radio button, and click **OK** to create the USA States boundaries, which is loaded into the Available Vectors List.
3. In the Available Vectors List, select **USA States [full range]** and click **Load Selected**. The Load Vector dialog appears.

4. Select **Vector Window #1** as the location to load the vector. Click **OK**. The cities and the state boundaries both appear in the Vector Window #1 dialog. The state boundaries are polylines, which are not true polygons because of the way they were digitized and stored.

5. From the Vector Window #1 dialog menu bar, select **Edit → Edit Layer Properties**. The Edit Vector Layers dialog appears.

6. Select **USA States [full range].** Change parameters for the state boundaries, including color, line style, and thickness. To change the color, click on the colored box until you see the color you want, or right-click on the colored box and select a color from the menu that appears. Click **OK** when you are finished.

7. Clear the state boundaries by clicking **USA States [full range]** in the Available Vectors List, then clicking **Remove Selected**.

Work with Vector Polygon Data

1. From the Vector Window #1 dialog menu bar, select **File → Open Vector File**. A Select Vector Filenames dialog appears.

2. Click the **Files of type** drop-down list in the Select Vector Filenames dialog, and select **Shapefile**. Select `states.shp` and click **Open**. A Import Vector Files Parameters dialog appears.

3. Select the **Memory** radio button, and accept the default values by clicking **OK**.

4. A status window reports the number of vector vertices being read, and the Available Vectors List appears when the data have been converted. The vector layer `states.shp` is loaded into the Available Vectors List.

5. In the Available Vectors List, select **states.ship** and click **Load Selected**. The Load Vector dialog appears.

6. Select **Vector Window #1** as the location to load the vector. Click **OK**. The cities and the state boundaries both appear in the Vector Window #1 dialog. The state boundaries are polylines, which are not true polygons because of the way they were digitized and stored.

7. From the Vector Window #1 dialog menu bar, select **Edit → Edit Layer Properties**. The Edit Vector Layers dialog appears.

8. Select **Layer:states.shp** and change the color to green. Click the **Polygon Fill** drop-down list and select **Line**. Click **OK**.

Retrieve Vector Information and Attributes

1. Right-click in the Vector Window #1 dialog and select **Select Active Layer → Layer: cities.shp.** From the Vector Window #1 dialog menu bar, select **Options → Vector Information** to open the Vector Information dialog. Click and drag over the city flags in the Vector Window #1 dialog to see the basic attribute information (from `cities.dbf`) in the Vector Information dialog.

2. Find your hometown or a nearest city by examining the AREANAME attribute in the Vector Information window. The latitude and longitude appear at the bottom of the Vector Window #1 dialog.

View Attributes and Use Point-and-Click Query

1. While `cities.shp` is still the active layer and Cursor Query is the active mode, select **Edit → View/Edit/Query Attributes** from the Vector Window #1 dialog menu bar. A Layer Attributes table appears. This is a fully editable table of the attributes for the selected layer.

2. Click in the left column (on the record number) to do a spatial query on a selected city. The corresponding city flag is highlighted in the Vector Window #1 dialog. If desired, zoom to the selected city by clicking and dragging a box around it with the middle mouse button. Zoom back out by clicking the middle mouse button in the Vector Window #1 dialog.

3. Verify that you have selected the correct city by clicking the city flag in the Vector Window #1 dialog and observing the attributes in the Vector Information window.

4. Edit the AREALAND value for the selected city by scrolling to the right in the Layer Attributes table until you see the AREALAND column. Double-click in the corresponding AREALAND table cell. Enter a new value and press **<Enter>** to change the value.

5. Perform a map-based query by clicking a city flag. The corresponding record is highlighted in the Layer Attributes table. In the Vector Window #1 dialog, drag the vector cursor from one city flag to another, and note how the Layer Attributes table scrolls to follow the selected cities.

Query Attributes

1. Ensure that `cities.shp` is still the active layer. From the Vector Window #1 dialog menu bar, select **Options** → **Select Active Layer** → **Layer:cities.shp**.

2. From the Vector Window #1 dialog menu bar, select **Edit** → **Query Attributes**. A Layer Attribute Query dialog appears.

3. In the **Query Layer Name** field, enter **Where State==California**. Click **Start**. A Query Expression section appears at the top of the Layer Attribute Query dialog.

4. Click the **AREANAME** drop-down list and select **ST**.

5. Click the **>** drop-down list and select **==**.

6. In the **String** field, enter **CA** (be sure to match this case).

7. Click the **Memory** radio button and click **OK**. ENVI creates a new vector layer and associated DBF file based on the results of the query. The new layer appears in the Available Vectors List and is loaded into Vector Window #1. Zoom to the selected vectors using the middle mouse button to draw a box around the state of California.

8. Right-click in the Vector Window #1 dialog and select **Select Active Layer** → **Layer:Where State==California**. Open the DBF attribute file by selecting **Edit** → **View/Edit/Query Attributes** from the Vector Window #1 dialog menu bar. The Layer Attributes table appears.

9. Perform some point-and-click query operations as described in the previous section to see the association between the selected cities, their locations in the vector window, and their attributes. You can select multiple cities from the attribute table by holding down the <Ctrl> key while you click on the record labels on the left side of the table.

10. Click the AREANAME column name at the top of the table to highlight the entire set of attributes. From the Layer Attributes table menu bar, select **Options** → **Sort by selected column forward** to sort the column alphabetically. Scroll down the column and click the **Sacramento** row (record 334) to highlight the location of California's capital in a different color in the Vector Window #1 dialog.

Add a Map Key in Vector Window

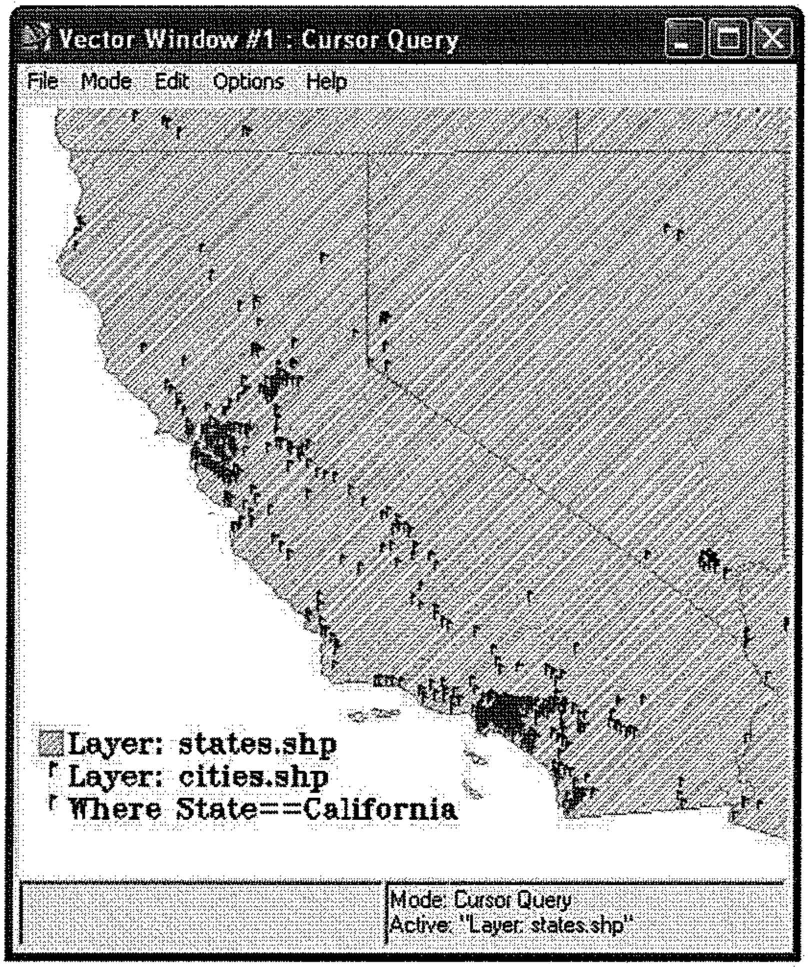
You can generate a vector map from the Vector Window dialog, using annotation tools. See the *Map Composition* tutorial or ENVI Help for further details. The following exercise shows you how to add a map key.

1. From the Vector Window #1 dialog menu bar, select **Options** → **Annotate Plot**. An Annotation dialog appears.

2. From the Annotation dialog menu bar, select **Object → Map Key** to automatically create a map key for the vector layers. Click once inside the Vector Window #1 dialog to show the map key, and click and drag the red diamond handle to move it. To change the characteristics of the map key, click **Edit Map Key Items** in the Annotations dialog and change the settings in the Map Key Object Definition dialog.

3. Right-click in the Vector Window #1 dialog to lock the map key in place. Annotation in the vector window behaves the same way as annotation in display groups. See the *Map Composition* tutorial or ENVI Help for further details.

   The following image shows the results of the attribute queries and annotations; your results may be slightly different.



Close all Windows and Files

1. In the Available Vectors List, click **Select All Layers**. Click **Remove Selected**. From the Available Vectors List menu bar, select **File → Cancel**.

2. Close the vector window and all associate dialogs and attribute tables by selecting **File → Cancel** from the Vector Window #1 dialog menu bar.

Part 2: Raster and Vector Processing

This section of the tutorial demonstrates how to use vector overlays and GIS data and attributes in combination with raster images from Space Imaging/EOSAT.

Load Image Data to Combined Image/Vector Display

Open an image file to use as a backdrop for vector layers.

1. From the ENVI main menu bar, select **File → Open Image File**. A file selection dialog appears.
2. Navigate to `envidata\si_eosat` and select `0826_ms.img`. Click **Open**.

The Available Bands List appears with four spectral bands listed. The data simulate a 4 m Space Imaging/EOSAT multispectral dataset with spectral band coverage similar to the first four spectral bands of Landsat Thematic Mapper data. A true-color image is automatically loaded into a new display group.

Open a Vector Layer and Load to Image Display

1. From the Display group menu bar, select **Overlay → Vectors**. A Vector Parameters dialog appears.
2. From the Vector Parameters dialog menu bar, select **File → Open Vector File**. This menu option is also accessible from the ENVI main menu bar. A Select Vector Filenames dialog appears.
3. Click the **Files of type:** drop-down list and select **Shapefile**. Select `vectors.shp` and click **Open**. An Import Vector Files Parameters dialog appears.
4. Select **File** or **Memory** output, and enter an output filename for the ENVI `.evf` file if you selected File.
5. In the **Native Projection** list, select **State Plane (NAD 83)**. Click **Set Zone**. A Select State Plane Zone dialog appears.
6. Select **(404, 3351) California IV** and click **OK**.
7. Select **Memory** output and click **OK**. A status window reports the number of vector vertices being read. When the data have been converted, they are automatically loaded into the Vector Parameters dialog and displayed in white on the image. The vectors.shp layer should be highlighted in the Vector Parameters dialog.
8. Click the **Current Layer** colored box to select a more visible color for the vector layer or right-click on the box and select from the menu. Click **Apply** to update the vector color.

Track Attributes with the Cursor

1. In the Vector Parameters dialog, select **Options → Vector Information**. A Vector Information dialog appears.
2. Click and drag inside the image to view the attribute information for the vectors. Also observe the latitude and longitude listed in the Vector Parameters dialog. Select the **Scroll** or **Zoom** radio button in the Vector Parameters dialog to allow vector tracking in the corresponding window. Select the **Off** radio button to allow normal scrolling in the Scroll and Main windows and zooming in the Zoom window. Try different zoom factors in the Zoom window to assess the accuracy of the vectors.
3. Ensure that you are in Cursor Query mode by selecting **Mode** from the Vector Parameter dialog menu bar.
4. From the Vector Parameters dialog menu bar, select **Edit → View/Edit/Query Attributes**. A Layer Attributes table appears. Select random records by clicking the numbered columns to highlight specific polygons on the

image. You may want to change the Current Highlight color in the Vector Parameters dialog to something that is more visible in your display group.

Heads-up (On-screen) Digitizing

ENVI provides vector editing routines for adding your own vectors to an existing vector layer or for creating new vector layers. These vector editing routines are similar in function to ENVI's annotation polygons, polylines, and points. ENVI heads-up vector digitizing allows you to create new polygons, polylines, points, rectangles, and ellipses.

1. Create a new vector layer by selecting **File → Create New Layer** from the Vector Parameters dialog. A New Vector Layer Parameters dialog appears.

2. Enter a **Layer Name**. Click the **Memory** radio button, and click **OK**.

3. In the Vector Parameters dialog, click the new layer name to initialize a new DBF file.

4. From the Vector Parameters dialog menu bar, select **Mode → Add New Vectors**.

5. For this exercise, you will create a polygon vector. From the Vector Parameters dialog menu bar, select **Mode → Polygon**.

   Since the Image radio button is selected by default in the Vector Parameters dialog, you will define the new polygon in the Image window. You can specify which display group window you want to edit your vectors in, by selecting the appropriate radio button in the Vector Parameters dialog.

   You may want to change the new vector layer color from white to something more visible before drawing new polygons.

6. Draw a few polygons using field outlines on the image as guides. In the Image window, use the mouse to define the new polygon area as follows:

   Click the left mouse button to draw polygon segments.
   Click the middle mouse button to erase polygon segments.
   Click the right mouse button to fix the polygon. Right-click again and select **Accept New Polygon** to accept the polygon.
   To move the Image box in the Scroll window to a new location, you must click the **Off** radio button in the Vector Parameters dialog. When you are finished moving around the image, click the **Image** radio button to resume adding new vectors.

7. To add attributes to the new polygons, select **Edit → Add Attributes** from the Vector Parameters dialog menu bar. An Add Attributes Choice dialog appears.

8. Select **Define new attributes interactively**. Click **OK**. An Attribute Initialization dialog appears.

9. In the **Name** field, type **Field_ID**.

10. Click the **Type** drop-down list and select **Character**.

11. Click **Add Field**.

12. For the second attribute, type **Field_Area** in the **Name** field.

13. Click the **Type** drop-down list and select **Numeric**.

14. Click **OK** to create the attribute table. A Layer Attributes table appears.

15. Double-click in a field, enter the value, and press the **<Enter>** key. To see which rows are associated with which fields, select **Mode → Cursor Query** from the Vector Parameters dialog, and click the row labels in the Layer Attributes table. The corresponding polygon is highlighted in the Image window.

16. From the Layer Attributes dialog menu bar, select **File → Cancel**. When you are prompted to save the attribute table, click **Yes**.

Edit Vector Layers

1. In the Vector Parameters dialog, select the new vector layer and select **Mode → Edit Existing Vectors**.

2. In the Image window, click one of the polygons you created in the last section. The polygon is highlighted and its nodes are marked with diamonds. When the vector is selected, you can make the following changes:

   Delete the entire polygon by right-clicking it and selecting **Delete Selected Vector**.

   To move a node, click and drag it to a new location.

   After making changes to a polygon, right-click it and select **Accept Changes**.

   Exit the editing function without making any changes by clicking the middle mouse button, or right-click and select **Clear Selection**.

   To add or remove nodes from a polygon, right-click to display the shortcut menu and select from the following options:

   - To add a node, right-click and select **Add Node**, then drag the node to a new location.
   - To remove a node, right-click it and select **Delete Node** from the shortcut menu.
   - To change the number of nodes added at one time, right-click and select **Number of Nodes to Add**. Enter the number of nodes in the dialog that appears.
   - To remove a range of nodes, right-click on the first node and select **Mark Node**. Right-click on the last node and select **Mark Node** again. Right-click again and select **Delete Marked Nodes**.

3. To finish this section, select **Window → Available Vectors List** from the ENVI main menu bar to display the Available Vectors List. Delete any new layers you have created by selecting them in the Available Vectors List and clicking **Remove Selected**. Do not remove the `vectors.shp` layer.

Query Operations

1. From the Vector Parameters dialog menu bar, select **Mode → Cursor Query**.

2. In the Vector Parameters dialog, highlight `vectors.shp`. Select **Edit → View/Edit/Query Attributes**. A Layer Attributes table appears.

3. Examine the RANCH column and note the predominance of three owners "gloria", "lanini", and "sharpe". Close the attribute table by selecting **File → Cancel**.

4. From the Vector Parameters dialog menu bar, select **Edit → Query Attributes**. A Layer Attribute Query dialog appears.

5. In the **Query Layer Name** field, type **Gloria Ranch**. Click **Start**.

6. In the Query Expression section that appears at the top of the Vector Parameters dialog, click the **AREA** drop-down list and select **RANCH**.

7. Click the **>** drop-down list and select **==**.
8. In the **Value** field, type **gloria**. (Be sure to match the case in the attribute table).
9. Select the **Memory** radio button and click **OK**. The Gloria Ranch layer generated by the query appears in the Vector Parameters dialog.
10. In the Vector Parameters dialog, select the **Gloria Ranch** layer and select **Edit → Edit Layer Properties** from the menu bar to change layer parameters. An Edit Vector Layers dialog appears.
11. Click the **Polygon Fill** drop-down list and select **Line**. Click **OK**. The Gloria Ranch polygons are highlighted as a new layer.
12. To examine the attributes for this layer, select **Gloria Ranch** in the Vector Parameters dialog, and select **Edit → View/Edit/Query Attributes** from the menu bar. A Layer Attributes table appears. Examine the query results.
13. Close the Layer Attributes table and repeat the query for the "lanini" and "sharpe" ranches, highlighting each in a different color or pattern.
14. Try other queries on combinations of attributes by choosing one of the logical operators in the Layer Attribute Query dialog.

Convert Vectors to ROIs

ENVI provides several important links between vector analysis and raster image processing. This portion of the exercise describes how to create ROIs from vector processing results and extract ROI statistics.

1. From the Display group menu bar, select **Overlay → Region of Interest**. The ROI Tool dialog appears.
2. In the Vector Parameters dialog, highlight a layer name and select **File → Export Active Layer to ROIs**. An Export EVF Layers to ROI dialog appears.
3. Select **Convert all records of an EVF layer to one ROI**, and click **OK**.
4. Repeat Steps 2-3 for each layer you created earlier from the query operations. The layers appear in the ROI Tool dialog.
5. In the ROI Tool dialog, select the **Gloria Ranch** ROI by clicking in the far left column of its row. Click **Stats**. An ROI Statistics Results dialog appears with image statistics for the Gloria Ranch polygons and multispectral data.

Now that you have converted these vector polygons to ROIs, you can use ENVI's raster processing capabilities to analyze the image data, with respect to the ROIs. This includes masking, statistics, contrast stretching, and supervised classification.

Display Image Map Results

ENVI provides tools to generate image maps from the combined raster/vector data in a display group. These include annotation tools used for image and plot annotation, as well as QuickMap tools. The following example shows you how to add a map key to the display group. See the *Map Composition* tutorial or ENVI Help for further details on annotation.

1. From the Display group menu bar, select **Overlay → Annotation**. An Annotation dialog appears.
2. From the Annotation dialog menu bar, select **Object → Map Key**.
3. Click once inside the Image window to show the map key. Click and drag the diamond handle to move the map key.

4. Click **Edit Map Key Items** in the Annotation dialog. A Map Key Object Definition dialog appears. Change the map key characteristics as desired and click **OK**.

5. Once you have placed the map key where you want it, right-click in the Image window to lock it in place.

Close Windows and Files

1. In the Available Vectors List, click **Select All Layers**, followed by **Remove Selected**. From the Available Vectors List menu bar, select **File → Cancel**.

2. From the ENVI main menu bar, select **File → Close All Files**.

Export ROI to Vector Layer

ENVI can convert raster processing results (such as ROIs) for use in ENVI vector processing and analysis and for export to external GIS software such as ArcGIS. The following exercises illustrate the export of raster information to vector GIS.

Open and Display an Image

Open a Landsat TM image of Cañon City, Colorado, USA, to use as background for ROI definition and export to vector:

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

2. Navigate to `envidata\can_tm` and select `can_tmr.img`. Click **Open**.

3. In the Available Bands List, select **TM Band 4**, select the **Gray Scale** radio button, and click **Load Band**.

Load Predefined ROIs

1. From the Display group menu bar, select **Overlay → Region of Interest**. An ROI Tool dialog appears.

2. From the ROI Tool dialog menu bar, select **File → Restore ROIs**.

3. Navigate to `envidata\can_tm` and select `can_tm1.roi`. Click **Open**. An ENVI Message dialog reports what regions have been restored. Click **OK**. The predefined ROI is loaded into the ROI Tool dialog and plotted on the image.

4. Repeat Step 3 for the file `can_tm2.roi`.

Convert ROIs to Vectors

1. To convert these ROIs to vector polygons, select **File → Export ROIs to EVF** from the ROI Tool dialog menu bar. An Export Region to EVF dialog appears.

2. Select a region from the **Select ROIs to Export field**.

3. Select **All points as one record**.

4. Enter an **Output Layer Name**, click **Memory**, and click **OK** to convert the first ROI.

5. Repeat Steps 1-4 for the second ROI. The layers appear in the Available Vectors List.

6. In the Available Vectors List, click **Select All Layers**, followed by **Load Selected**. A Load Vector dialog appears.

7. Select **New Vector Window** and click **OK**. The vectors are loaded as polygons into the Vector Window #1 dialog.

8. From the Vector Window #1 dialog menu bar, select **Edit → Add Attributes**.

9. Add attributes as described in Steps 8-15 on page 12.

You can now use these polygons with query operations and GIS analysis with other vector data, or you can export them to shapefiles by selecting **File → Export Active Layer to Shapefile** from the Vector Window Parameters dialog.

Close All Windows and Files

1. In the Available Vectors List, click **Select All Layers**, followed by **Remove Selected**.

2. From the Available Vectors List menu bar, select **File → Cancel**.

3. From the Vector Window #1 dialog menu bar, select **File → Cancel**.

4. From the ENVI main menu bar, select **File → Close All Files**.

Export a Classification Image to Vector Polygons

You can export classes from a classification image to one or more vector layers, and you can select individual image brightness levels for export as a vector layer.

Load and Display a Classification Image

Open a parallelepiped classification image of Cañon City TM data (with three classes) to use as a background for ROI definition and export to vector:

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

2. Navigate to `envidata\can_tm` and select `can_pcls.img`. Click **Open**.

3. In the Available Bands List, click **Load Band**.

Generalize the Classification Image

To conduct successful raster-to-vector conversions, you should typically generalize the results of raster processing. If you do not generalize, you will have vector polygons around individual pixels and small groups of pixels. To demonstrate the results of generalizing the classification image, load and display the results of a 5-pixel sieve operation, followed by a 5 x 5 clump operation as follows:

1. Open and display `can_sv.img` (the sieve results) in Display #1, replacing `can_pcls.img`.

2. Open and display `can_clmp.img` (the clump results) in Display #1, replacing `can_sv.img`.

Convert the Generalized Classification Image to Vector Polygons

1. From the ENVI main menu bar, select **Classification → Post Classification → Classification to Vector**. A Raster to Vector Input Band dialog appears.

2. Select **Clump** under `can_clmp.img` and click **OK**. A Raster to Vector Parameters dialog appears.

3. Select **Region #1**, press the **<Shift>** key, and select **Region #2** (to select both).

4. Click the Output toggle button to select **One Layer per Class**.

5. Select **Memory** and click **OK**. The new vector layers appear in the Available Vectors List.

6. In the Available Vectors List, select **Region #1**, press the **<Shift>** key, and select **Region #2** (to select both).

7. Click **Load Selected**. A Load Vectors dialog appears.

8. Select **Display #1** and click **OK**. A Vector Parameters dialog appears.

9. In the Vector Parameters dialog, select **Region #1**. Select **Edit → Edit Layer Properties** from the Vector Parameters menu bar. An Edit Vectors Layers dialog appears.

10. Right-click the **Color** box and select Items **1:20 → White**. Click the **Polygon Fill** drop-down list and select **Line**. Click **OK**.

11. In the Vector Parameters dialog, select **Region #2**. Select **Edit → Edit Layer Properties** from the Vector Parameters menu bar. An Edit Vectors Layers dialog appears.

12. Right-click the **Color** box and select Items **1:20 → Yellow**. Click the **Polygon Fill** drop-down list and select **Line**. Click **OK.**

13. Examine the results in Display #1. You can also overlay the vectors onto a gray scale image of `can_tmr.img` Band 3 if desired. This overlay is show in the following figure.

14. From the ENVI main menu bar, select **File → Exit**.

ENVI

ENVI Tutorial: Map Composition

Table of Contents

Overview of This Tutorial

This tutorial is designed to give you a working knowledge of ENVI's map composition capabilities. You can use ENVI's QuickMap utility to generate a basic map template and add more information using ENVI's annotation capabilities. For additional information on map composition, see ENVI Help.

Files Used in This Tutorial

ENVI Tutorial Data DVD: `envidata/ys_tmsub`

File	Description
`ysratio.img (.hdr)`	Yellowstone National Park TM Ratio Subset Image
`ysratio.ann`	Saved annotation result for above
`ysratio.grd`	Saved grid parameters for above
`ys_loc.tif`	Location image for above

Map Composition in ENVI

Map composition should be a simple, quick process of creating an image-based map from a remote sensing image and interactively adding key map components. In ENVI, the map composition process usually consists of basic template generation (or restoring a saved template) using the QuickMap utility, followed by interactive customization (if required) using ENVI annotation or other image overlays.

QuickMap allows you to set the map scale and the output page size and orientation; to select the image spatial subset to use for the map; and to add basic map components such as map grids, scale bars, map titles, logos, projection information, and other basic map annotation. Other custom annotation types include map keys, declination diagrams, arrows, images or plots, and additional text. Using annotation or grid line overlays means you can modify QuickMap default overlays and place all map elements in a custom manner.

You can save your map composition in a display group and restore it for future modification or printing. Using annotation, you can build and save individual templates of common map objects.

Open and Display Landsat TM Data

Before attempting to start the program, ensure that ENVI is properly installed as described in the installation guide.

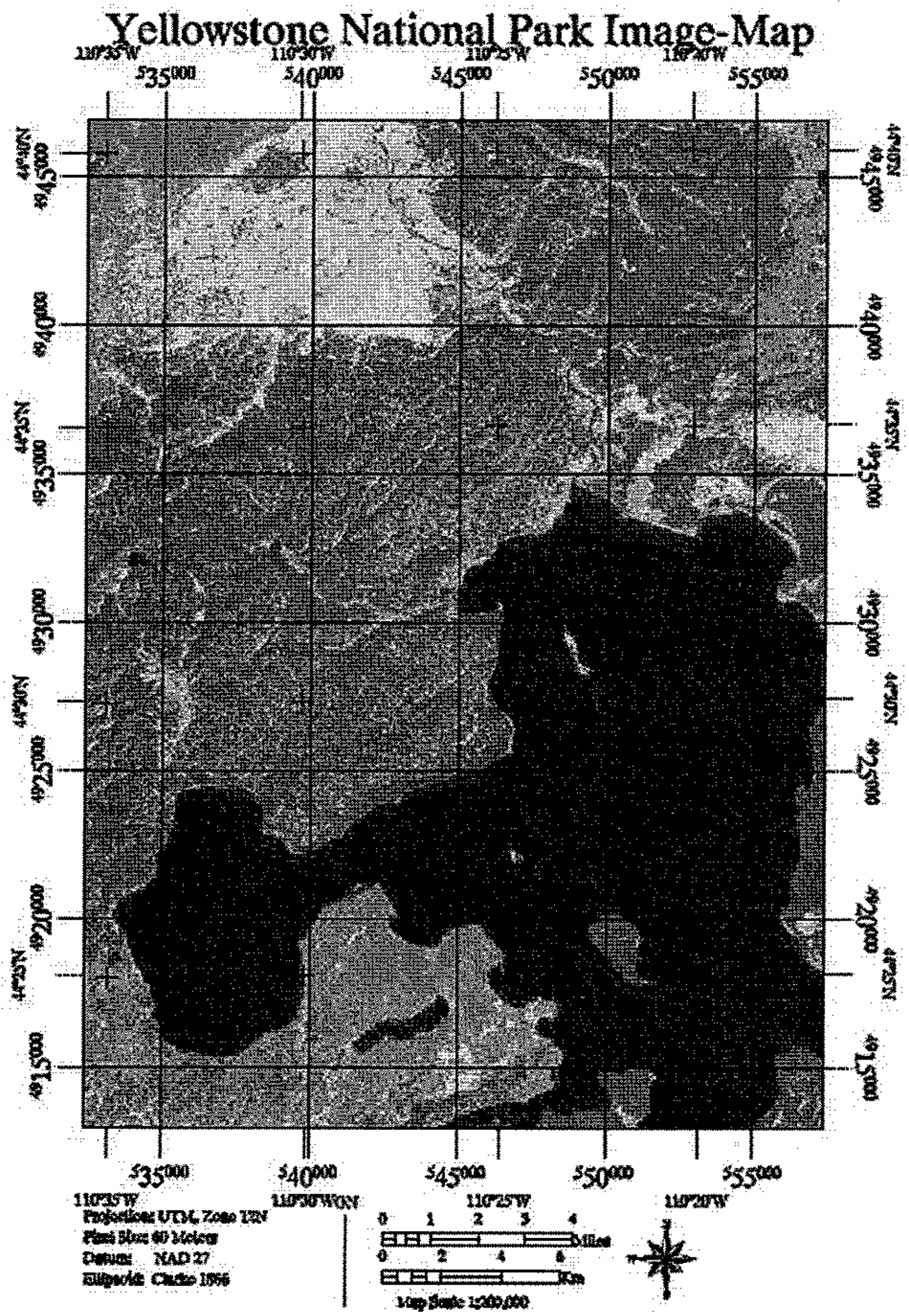
1. From the ENVI main menu bar, select **File → Open Image File**. A file selection dialog appears.
2. Navigate to `envidata\ys_tmsub` and select `ysratio.img`. Click **Open**. The 5/7, 3/1, and 3/4 ratio bands are automatically loaded into the R, G, and B fields of the Available Bands List, respectively.
3. Click **Load RGB**. Once the image appears in a display group, complete the following steps to build a QuickMap template and to add individual map components.

Build the QuickMap Template

1. From the Display group menu bar, select **File → QuickMap → New QuickMap.** The QuickMap Default Layout dialog appears. This dialog allows you modify the output page size, page orientation, and map scale.
2. For this exercise, accept the default values but change the **Map Scale** to **200000**. Click **OK**. A QuickMap Image Selection dialog appears.
3. Use the full image for this exercise. Click and drag the lower-right corner of the red box downward so that the whole image is selected. Click **OK**. The QuickMap Parameters dialog appears.
4. Click inside the **Main Title** field and type **Yellowstone National Park Image-Map.**
5. Right-click inside the **Lower Left Text** field and select **Load Projection Info** to load the image map projection information from the ENVI header.
6. For this exercise, you should leave the Scale Bars, Grid Lines, and North Arrow check boxes selected.
7. Click the **Declination Diagram** check box to select it.
8. Click **Save Template** at the bottom of the dialog. A Save QuickMap Template to File dialog appears.
9. In the **Enter Output Filename** field, enter `ysratio.qm`. Click **OK** to save the QuickMap results as a QuickMap template file. You can recall this template later and use it with any image of the same pixel size by displaying the desired image and selecting File → QuickMap → from Previous Template from the Display group menu bar.
10. Click **Apply** in the QuickMap Parameter dialog to display the QuickMap results in a display group. If desired, you can modify the settings in the QuickMap Parameters dialog and click **Apply** to change the displayed QuickMap.

11. At this stage, you can output the QuickMap to a printer or a Postscript file. See "Save the Results" and "Printing" on page 14 for more information. Save or print a copy if desired. Otherwise, continue with the next step.

12. Review the QuickMap results and observe the map grids, scale bars, north arrow, and positioning of the default text.



Map Elements

ENVI offers many options for customizing your map composition. Options include virtual borders, text annotation, grid lines, contour lines, plot insets, vector overlays, and classification overlays. You can use the display group (Image window, Scroll window, or Zoom window) to perform additional, custom map composition. (If you are working in the Scroll window, you may want to enlarge it by dragging one of the corners to resize the display.) The following sections describe the different elements and provide general instructions.

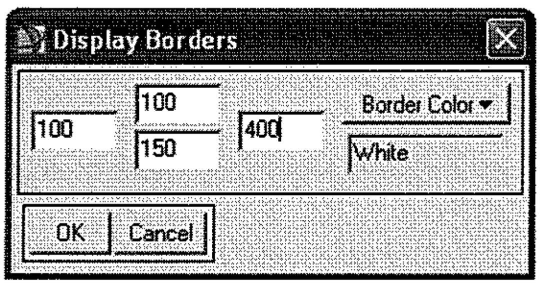
Adding Virtual Borders

Default display groups contain only the image, with no surrounding blank space. Map composition typically requires some map objects to reside outside the image. ENVI provides a virtual border capability that allows annotation in the image borders without creating a new image. You can add virtual borders to an image in several ways, which are described in the following sections.

Automatically

When you generate a QuickMap, ENVI automatically adds a virtual border to all sides of the image to accommodate the QuickMap grid, and it displays a default grid.

1. To change the default border, select **Overlay → Grid Lines** from the Display group menu bar associated with the QuickMap. A Grid Line Parameters dialog appears.
2. From the Grid Line Parameters dialog menu bar, select **Options → Set Display Borders**. A Display Borders dialog appears.
3. Enter values as shown in the following figure.



4. Click **OK**. The new virtual border characteristics are immediately applied to the image. If you select **File → Save Setup** from the Grid Line Parameters dialog menu bar, the border information will be saved with the grid and will be restored when you restore the grid parameters file later.

Using the Display Preferences

You can also change virtual borders and other display settings using the Display Preferences dialog.

1. From the Display group menu bar associated with the QuickMap, select **File → Preferences**. A Display Parameters dialog appears with a Display Border section similar to the above figure.
2. Enter the desired values and select the desired color for the border.
3. Click **OK**. The new borders are immediately applied to the image.

Using the Annotation Function

You can also control virtual borders in the Annotation dialog.

1. From the Display group menu bar associated with the QuickMap, select **Overlay → Annotation**. An Annotation dialog appears.

2. From the Annotation dialog menu bar, select **Options** → **Set Display Borders**. A Display Borders dialog appears.

3. Enter the desired border characteristics and click **OK**. The new virtual border characteristics are immediately applied to the image. If you save an annotation to a file, the border information is also saved and restored when you restore the annotation file later.

Adding Grid Lines

ENVI supports simultaneous pixel, map coordinate, and geographic (latitude/longitude) grids. A 100-pixel virtual border (which can be adjusted as described in "Adding Virtual Borders" on page 6) is automatically appended to the image to accommodate grid labels when grids are applied. To add or modify image grids, follow these steps:

1. From the Display group menu bar associated with the QuickMap, select **Overlay** → **Grid Lines**. A Grid Line Parameters dialog appears and a default grid is displayed with default grid spacings.

2. In the **Grid Spacing** field, enter **4000**.

3. To change line and label characteristics for the grid, select **Options** → **Edit Map Grid Attributes** or **Edit Geographic Grid Attributes** from the Grid Line Parameters dialog menu bar. Alternatively, you can access grid line parameters by clicking Additional Properties in the QuickMap Parameters dialog.

4. Click **OK** to apply the selected attributes.

5. In the Grid Line Parameters dialog, click **Apply** to post the new grid to the displayed image.

6. To save grid parameters for later use, select **File** → **Save Setup** from the Grid Parameters dialog menu bar and select an output file. This saves a template of the grid parameters, which you can recall later and use with another map composition (select **File** → **Restore Setup** from the Grid Parameters dialog menu bar).

Working with Annotation

ENVI's annotation utility provides a way to insert and position map objects in an ENVI display group for map composition. Several classes of map objects are available.

1. From the Display group menu bar associated with the QuickMap, select **Overlay** → **Annotation**. An Annotation dialog appears.

2. From the Annotation dialog menu bar, select **Object** and choose the desired annotation object.

3. In the Annotation dialog, select the **Image**, **Scroll**, or **Zoom** radio button to indicate where the annotation will appear.

4. Drag the object to a preferred location, then right-click to lock it in place.

5. To reselect and modify an existing annotation object, select **Object** → **Selection/Edit** from the Annotation dialog menu bar. Then select the object by drawing a box around it. You can move the selected object by clicking the associated handle and dragging the object to a new location. You can delete or duplicate an object by choosing the appropriate option from the selected menu. Right-click to relock the annotation in place.

6. Remember to select the **Off** radio button in the Annotation dialog before attempting non-annotation mouse functions in the display group.

7. Keep the Annotation dialog open for the following exercises.

Text and Symbol Annotation

ENVI currently has a wide variety of text fonts and different standard symbol sets. In addition, ENVI can use TrueType fonts installed on your system. This provides access to a wide range of different text fonts and symbols. You can interactively scale and rotate these fonts and symbols, and you can set different colors and thickness.

ENVI provides some useful symbols (including special north arrows) as a custom TrueType font. To modify the font characteristics, click Font and select ENVI Symbols in the Annotation dialog. Following are some examples of ENVI Symbols:

Text:
1. Select **Object → Text** from the Annotation dialog menu bar.

2. Click **Font** and select a font.

3. Select the font size, color, and orientation using the appropriate buttons and fields in the Annotation dialog. For information on adding additional fonts, see "Using Other TrueType Fonts with ENVI" in ENVI Help. TrueType fonts provide more flexibility. Select one of the TrueType fonts available on your system by clicking **Font,** selecting a **True Type** option, and selecting the desired font.

4. Type your text in the empty field in the Annotation dialog.

5. Drag the text object to a preferred location in the image and right-click to lock it in place.

Symbols:
1. Select **Object → Symbol** from the Annotation dialog menu bar.

2. Select the desired symbol from the table of symbols that appears in the Annotation dialog.

3. Drag the text object to a preferred location in the image and right-click to lock it in place.

Polygon and Shape Annotation

You can draw rectangles, squares, ellipses, circles, and free-form polygons in an image. These can be an outline only, or filled with a solid color or a pattern. Placement is interactive, with easy rotation and scaling.

1. Select **Object → Rectangle, Ellipse**, or **Polygon** from the Annotation dialog menu bar.

2. Enter object parameters as desired in the Annotation dialog.

3. Drag the shapes to a preferred location in the image and right-click to lock them in place. For polygons, use the left mouse button to define polygon vertices and the right mouse button to close the polygon.

Line and Arrow Annotation

You can draw polylines (lines) and arrows in an image. You have full control over the color, thickness and line type, and the fill and head characteristics for arrows.

Arrows:
1. Select **Object → Arrow** from the Annotation dialog menu bar.

2. Enter object parameters as desired in the Annotation dialog.

3. To draw an arrow, click and hold the left mouse button and drag the cursor in the image to define the length and orientation of the arrow. Release the left mouse button to complete the arrow. You can move it by dragging the red diamond handle. Right-click to lock the arrow in place.

Lines:

1. Select **Object → Polyline** from the Annotation dialog menu bar.

2. Enter object parameters as desired in the Annotation dialog.

3. To draw a free-form line, click and hold the left mouse button as you are drawing. To draw a straight line, click repeatedly (without holding the left mouse button) to define the vertices. Right-click to complete the line. You can move it by dragging the red diamond handle. Right-click again to lock the line in place.

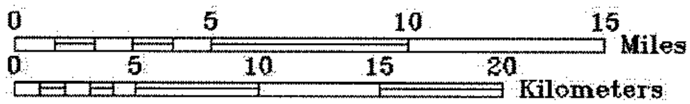
Scale Bar Annotation

ENVI automatically generates map scales based on the pixel size of the image in the map composition. Units include feet, miles, meters, or kilometers. You can place map scales individually, or in groups. You can configure the number of major and minor divisions, and the font and character size.

1. Select **Object → Scale Bar** from the Annotation dialog menu bar.

2. Enter object parameters as desired in the Annotation dialog.

3. Click once in the image to show the scale bar. Move it to a preferred location by dragging the red diamond handle. Right-click to lock the scale bar in place.



Declination Diagrams

ENVI generates declination diagrams based on your preferences. You can specify the size of the diagram and enter azimuths for true north, grid north, and magnetic north in decimal degrees.

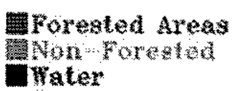
1. Select **Object → Declination** from the Annotation dialog menu bar.

2. Enter object parameters as desired in the Annotation dialog.

3. Click once in the image to show the declination diagram. Move it to a preferred location by dragging the red diamond handle. Right-click to lock the diagram.

Map Key Annotation

Map keys are automatically generated for classification images and vector layers, but you can manually add them for all other images. Following is an example of a map key:

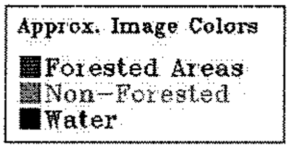


1. Select **Object → Map Key** from the Annotation dialog menu bar.

2. Click **Edit Map Key Items** to add, delete, or modify individual map key items.

3. Click once in the image to show the map key. Move it to a preferred location by dragging the red diamond handle. Right-click to lock the map key in place.

4. If you want a border and title for the map key, you must add these separately as polygon and text annotations, respectively:



Color Ramp Annotation

You can create gray scale ramps and color bars for gray scale and color-coded images, respectively. This option is not available with RGB images.

1. Select **Object → Color Ramp** from the Annotation dialog menu bar.

2. In the Annotation dialog, enter minimum and maximum values and intervals as desired. Also set vertical or horizontal orientation.

3. Click once in the image to show the color ramp. Move it to a preferred location by dragging the red diamond handle. Right-click to lock the color ramp in place.

Image Insets as Annotation

While mosaicking provides one way to inset an image into another, you can also inset images while composing and annotating maps.

1. Ensure that the image to be inset is listed in the Available Bands List.

2. Select **Object → Image** from the Annotation dialog menu bar.

3. Click **Select New Image**. An Annotation Image Input Bands dialog appears.

4. Select the image from the Available Bands List in the Annotation Image Input Bands dialog and perform optional spatial subsetting. Click **OK**.

5. Click once in the image to show the inset. Drag the green diamond handle to resize the inset as desired. Right-click to lock the inset in place.

Because 8-bit displays cannot easily assign a new color table to the inset image, ENVI only shows a gray scale image in the display group. If your display has 24-bit color, a color image will be displayed.

Plot Insets as Annotation

You can easily inset ENVI plots into an image during the map composition/annotation process. These vector plots maintain their vector character (meaning they will not be rasterized) when output to the printer or to a Postscript file. They will not appear when output to an image.

1. You must have a plot window open, such as an X Profile, Y Profile, Z Profile, spectral plot, or arbitrary profile.

2. Select **Object → Plot** from the Annotation dialog menu bar.

3. Click **Select New Plot**. A Select Plot Window dialog appears.

4. Select the plot and enter the desired dimensions to set the plot size. Click **OK**.

5. Click once in the image to show the plot. Right-click to lock the plot in place.

Because 8-bit displays cannot easily assign a new color table to the inset plot, ENVI only shows a representation of the plot in the display group. The actual plot is placed when the image is output directly to the printer or to a Postscript file, and the annotation is burned in. Again, this option does not produce a vector plot when output to "Image."

Overlaying Classification Images

ENVI classification images can be used as overlays during map composition. First, classify the image (see ENVI Help for procedures) or open an existing ENVI classification image. Once the classified image is listed in the Available Bands List, then you can use it as an overlay.

1. From the Display group menu bar associated with the map composition, select **Overlay → Classification**. A file selection dialog appears.

2. Select an ENVI classification image and click **OK**. An Interactive Class Tool dialog appears.

3. Turn on specific classes to appear in the map composition by selecting the corresponding **On** check boxes. The selected classes will appear in the appropriate color as an overlay on the image.

4. You can change class colors and names by selecting **Options → Edit class colors/names** from the Interactive Class Tool dialog menu bar.

Overlaying Contour Lines

You can contour Z values of images and overlay the contour lines as vectors on an image background. Digital elevation models (DEMs) work best. Add contours to a map composition as follows:

1. From the Display group menu bar associated with the map composition, select **Overlay → Contour Lines**. A Contour Band Choice dialog appears.

2. Select the desired image to contour and click **OK**. A Contour Plot dialog appears.

3. To use the default contour values, click **Apply**. Otherwise, you can add new contour levels, edit contours, and change colors and line types using the Contour Plot dialog. See ENVI Help for details.

Incorporating Regions of Interest

You can incorporate Regions of interest (ROIs) into ENVI map compositions. Generate ROIs by drawing them, by thresholding specific image bands, by utilizing 2D or *n*-D scatter plots, or by performing vector-to-raster conversions. See ENVI Help for details. Display an ROI in a map composition as follows:

1. From the Display group menu bar associated with the map composition, select **Overlay → Region of Interest**. An ROI Tool dialog appears, listing any existing ROIs having the same dimensions as the displayed image. These ROIs appear in the image.

2. Add or modify ROIs as desired. See ENVI Help for further details.

Overlaying Vector Layers

ENVI can import shapefiles, MapInfo files, Microstation DGN files, DXF files, ArcInfo interchange files, USGS DLG files, or ENVI vector files (`.evf`).

1. From the Display group menu bar associated with the map composition, select **Overlay → Vectors**. A Vector Parameters dialog appears.

2. From the Vector Parameters dialog menu bar, select **File → Open Vector File**. A file selection dialog appears.

3. Select a file and click **Open**. An Import Vector Files Parameters dialog appears.

4. Select the appropriate map projection, datum, and units for the vector layer.

5. Click **OK**. ENVI converts the input vectors into an ENVI vector format (`.evf`).

6. Load the vectors into the map composition by clicking **Apply** in the Vector Parameters dialog.

7. In the Vector Parameters dialog, adjust the vector attributes to obtain the desired colors, thickness, and line types. See the *Vector Overlay and GIS Analysis* tutorial or see ENVI Help for additional information.

Customize the Map Layout

This section uses several map elements described in the previous sections to demonstrate some of ENVI's custom map composition capabilities.

The QuickMap you created earlier (see pages 2-4) will be used in the following exercises. If you already closed `ysratio.img`, redisplay it as follows.

1. From the ENVI main menu bar, select **File → Open Image File**. A file selection dialog appears.
2. Navigate to `envidata\ys_tmsub` and select `ysratio.img`. Click **Open**. The 5/7, 3/1, and 3/4 ratio bands are automatically loaded into the R, G, and B fields of the Available Bands List, respectively.
3. Click **Load RGB**.

Load the QuickMap Template

Once the image is displayed, follow these steps to load the previously saved QuickMap template and to add individual map components:

1. From the Display group menu bar, select **File → QuickMap → from Previous Template**. The Enter QuickMapTemplate Filename dialog appears.
2. Navigate to your output directory, select `ysratio.qm`, and click **Open**. A QuickMap Parameters dialog appears.
3. Click **Apply** to generate the QuickMap image. The Load To: Current Display button is selected by default, so the QuickMap parameters are applied to the display group from which you started QuickMap.
4. Restore saved grid parameters by selecting **Overlay → Grid Lines** from the Display group menu bar associated with the QuickMap. A Grid Line Parameters dialog appears.
5. From the Grid Line Parameters dialog menu bar, select **File → Restore Setup**. A file selection dialog appears.
6. Navigate to `envidata\ys_tmsub` and select the saved grid parameters file `ysratio.grd`. Click **Open**, followed by **Apply**.
7. Modify some of the grid line parameters and click **Apply** to show your changes on the image. Be sure to save any changes by selecting **File → Save Setup** from the Grid Line Parameters dialog menu bar.
8. Restore saved ENVI annotation by selecting **Overlay → Annotation** from the Display group menu bar associated with the QuickMap. The Annotation dialog appears.
9. Select **File → Restore Annotation** from the Annotation dialog menu bar.
10. Navigate to `envidata\ys_tmsub` and select the saved annotation file `ysratio.ann`. Click **Open**.
11. In the Annotation dialog, click the **Image** radio button, select **Object → Selection/Edit** from the menu bar, and click and drag a box around the annotation objects in the QuickMap image window. A red diamond handle appears for the selected objects.
12. Click and drag the handles to move the annotation objects. Modify some parameters for the selected objects. Right-click the objects to lock them in place. Be sure to save any changes by selecting **File → Save Annotation** from the Annotation dialog menu bar. See ENVI Help for further details.

Save the Results

You can save a map composition for future modification as a display group, or with the map composition "burned in" to an image.

Saving for Future Modification

This is the most flexible option.

1. From the Display group menu bar associated with the map composition, select **File → Save as Display Group**.
2. Enter an output filename and click **OK**.
3. To restore this map composition, select **File → Restore Display Group** from the ENVI main menu bar.

Saving as a "Burned-in" Image

1. From the Display group menu bar associated with the map composition, select **File → Save Image As → Postscript File**. An ENVI QuickMap Print Option dialog appears.

    Select **Standard Printing** and click **OK** to output a Postscript file. An Output Display to Postscript File dialog appears. Change the page size and scaling parameters as desired. This option provides additional control, but it may produce a map that does not fit well with the originally selected QuickMap scale.

    Select **Output QuickMap to Postscript**, select an output filename, and click **OK** to output a Postscript file with the specified QuickMap page size and scaling. If your additional annotation enlarged the image so it will not fit in the specified page size, ENVI asks if you want to output to multiple pages. If so, click **Yes**, and ENVI automatically creates multiple Postscript files.

Saving as an Image File

You can save your map composition as an image file. Output formats include ENVI (binary) image, BMP, HDF, JPEG, PICT, PNG, SRF, TIFF/GeoTIFF, and XWD, as well as common image processing system formats such as ERDAS (.lan), ERMAPPER, PCI, and ArcView Raster.

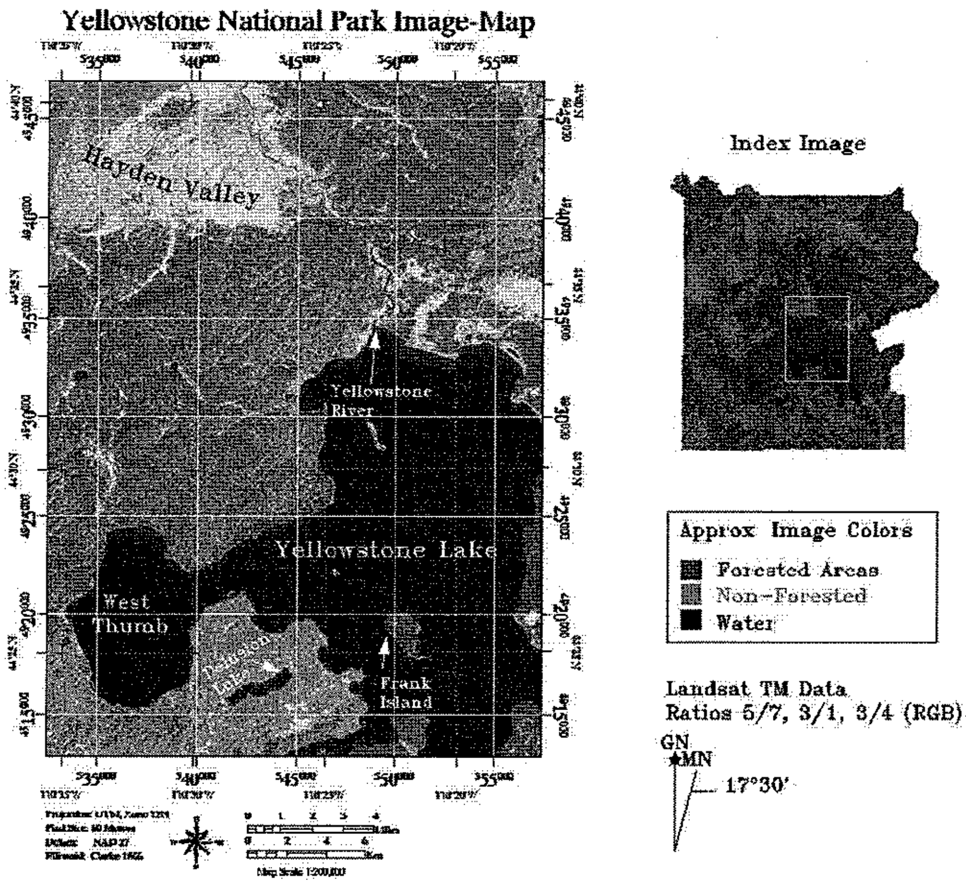
1. From the Display group menu bar associated with the map composition, select **File → Save Image As → Image File**.
2. Set the resolution, output file type, and other parameters as described in ENVI Help; enter an output filename; and click **OK**.

Printing

You can also select direct printing of the ENVI map composition, in which case, the map composition will be printed directly to your printer using system software drivers.

1. From the Display group menu bar associated with the map composition, select **File → Print**. An ENVI QuickMap Print Preferences dialog appears.
2. Select **Standard Printing** or **Output QuickMap to Printer** as described above.
3. Choose your printer, then click **OK**.

In all of the output options listed above, graphics and map composition objects are burned into the image on output. The following figure shows an example of a final map composition produced in ENVI using QuickMap and custom map composition.


Yellowstone National Park Image-Map
Hayden Valley
Yellowstone River
Yellowstone Lake
West Thumb
Frank Island
Index Image
Approx Image Colors
Forested Areas
Non-Forested
Water
Landsat TM Data
Ratios 5/7, 3/1, 3/4 (RGB)
GN
MN
17°30'

ENVI

ENVI Tutorial: Mosaicking in ENVI

Table of Contents

Overview of This Tutorial

This tutorial is designed to give you a working knowledge of ENVI's image mosaicking capabilities. For additional details, please see *ENVI Help*.

Files Used in this Tutorial

ENVI Tutorial Data DVD: `envidata/avmosaic`

File	Description
Pixel-based mosaicking	
`dv06_2.img (.hdr)`	AVIRIS Scene 02
`dv06_3.img (.hdr)`	AVIRIS Scene 03
`dv06a.mos`	Mosaic template for end-to-end AVIRIS mosaic
`dv06b.mos`	Mosaic template for feathered overlapping AVIRIS mosaic
`dv06_fea.img (.hdr)`	Feathered mosaic
Georeferenced mosaicking	
`lch_01w.img (.hdr)`	Warped, histogram-matched image
`lch_01w.ann`	Cut-line feathering annotation for above
`lch_02w.img (.hdr)`	Warped, histogram matched image
`lch_a.mos`	Mosaic template for georeferenced image mosaicking
`lch_mos1.img (.hdr)`	Georeferenced mosaic result
Color balancing during mosaicking	
`mosaic1_equal.dat (.hdr)`	Subset of a Landsat-7 ETM image with a histogram equalization stretch independently applied to each band
`mosaic_2.dat (.hdr)`	Another subset from the same Landsat-7 ETM image, without any stretching applied

Mosaicking in ENVI

Mosaicking involves combining multiple images into a single composite image. ENVI provides interactive capabilities for placing non-georeferenced images within a mosaic, and automated placement of georeferenced images within a georeferenced output mosaic. ENVI also provides transparency, histogram matching, and automated color balancing. ENVI's Virtual Mosaic allows you to create and display mosaics without creating large output files.

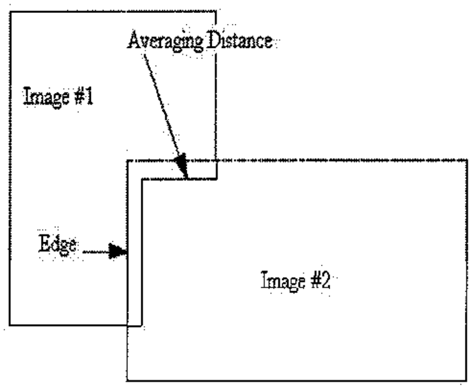
The following sections provide useful information about mosaics in ENVI before you start the exercises. The actual exercises begin with the section "Pixel-Based Mosaicking Example" on page 4.

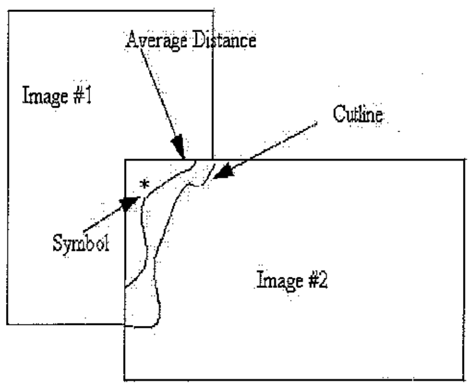
Feathering

To blend or blur the seams between mosaicked images, you can feather the edges of overlapping areas using either edge feathering or cut-line feathering over a specified distance. To use feathering when mosaicking images, import the bottom image without feathering. Then import the overlapping images with edge or cut-line feathering.

Edge Feathering

Edge Feathering uses a pixel distance you specify to blend the seams along the edges of the mosaicked image. The edge is blended using a linear ramp that averages the two images across the specified distance. For example, if the specified distance is 20 pixels, 0% of the top image is used in the blending at the edge and 100% of the bottom image is used to make the output image. At 20 pixels from the edge, 100% of the top image is used to make the output image and 0% of the bottom image is used. At 10 pixels from the edge, 50% of each image is used to make the output image.





Cut-line Feathering

Cut-line Feathering uses a pixel distance and annotation file you specify to blend the image boundaries. You must define cut-lines using the annotation tools prior to mosaicking. The annotation file must contain a polyline defining the cut-line that is drawn from edge-to-edge, and you must place a symbol in the region of the image that will be cut off. The cut-line distance is used to create a linear ramp that averages the two images across that distance from the cut-line outwards. For example, if the specified distance is 20 pixels, 100% of the top image is used in the blending at the cut-line and 0% of the bottom image is used to make the output image. At 20 pixels from the cutline, 0% of the top image is used to make the output image and 100% of the bottom image is used. At 10 pixels from the cutline, 50% of each image is used to make the output image.

Virtual Mosaics

You can use a mosaic template file to construct a "Virtual Mosaic," one that can be displayed and used by ENVI without actually creating a mosaic output file. You cannot use feathering when creating a Virtual Mosaic in ENVI.

After creating a mosaic, save the template file by selecting **File → Save Template** from the Image Mosaicking dialog menu bar. This creates a small text file describing the mosaic layout.

To use the Virtual Mosaic, select **File → Open Image File** from the ENVI main menu bar and open the mosaic template file. All of the images used in the mosaic are opened and their bands are listed in the Available Bands List. Display or process any of the bands in the Virtual Mosaic, and ENVI treats the individual images as if they were an actual mosaic output file. The new processed file has the specified size of the mosaic, and the input files are in their specified positions within the mosaic.

Pixel-Based Mosaicking Example

Before attempting to start the program, ensure that ENVI is properly installed as described in the Installation Guide that shipped with your software.

Import and Position Images

1. From the ENVI main menu bar, select **Map → Mosaicking → Pixel Based**. The Pixel Based Mosaic dialog appears.

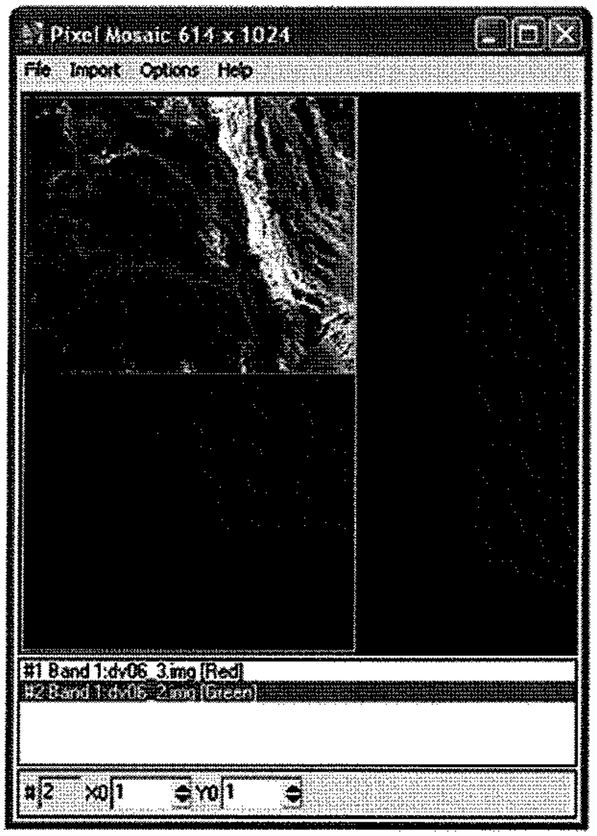
2. From the Pixel Based Mosaic dialog menu bar, select **Import→ Import Files**. The Mosaic Input Files dialog appears.

3. Select **Open → New File**. Navigate to `envidata\avmosaic` and select `dv06_2.img`. Click **Open**.

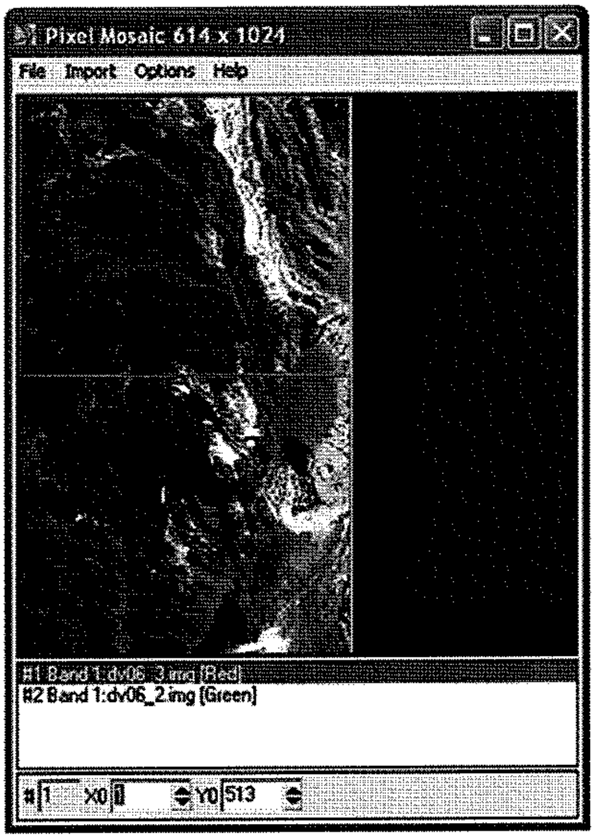
4. Repeat Step 3 for `dv06_3.img`.

5. In the Mosaic Input Files dialog, click **<Shift>** to select both images. Click **OK**. The Select Mosaic Size dialog appears.

6. In the **Mosaic Xsize** field, enter **614**. In the **Mosaic Ysize** field, enter **1024**. Click **OK**. A Pixel Mosaic dialog appears:



7. The bottom of the Pixel Mosaic dialog lists the current position of the images. Select `dv06_3.img`, enter **513** in the **Y0** field, and press **<Enter>**. The file `dv06_3.img` is placed directly below `dv06_2.img`.



8. From the Pixel Mosaic dialog menu bar, select **File → Apply**. A Mosaic Parameters dialog appears.

9. In the **Enter Output Filename** field, enter `dv06.img` and click **OK** to create the mosaic.

10. To create a Virtual Mosaic instead of a new mosaic file, select **File → Save Template** from the Pixel Based Mosaic dialog menu bar. When the Output Mosaic Template dialog appears, enter the output filename `dv06a.mos`.

11. In the Available Bands List, select **Mosaic (Band 1)** under `dv06.mos` (or `dv06a.mos` from Step 9) and click **Load Band**.

More on Positioning Images

The second part of this example shows you how to position the two images into a composite mosaic image by entering X0 and Y0 values, or by dragging the images to the desired locations within the Pixel Mosaic dialog. The example also includes edge feathering.

1. In the Pixel Mosaic dialog, select **Options → Change Mosaic Size**. The Select Mosaic Size dialog appears.

2. In the **Mosaic Xsize** and **Mosaic Ysize** fields, enter **768**. Click **OK**.

3. In the Pixel Mosaic dialog, click the image surrounded by a green box (`dv06_2.img`) and drag it to the lower-right corner of the dialog.

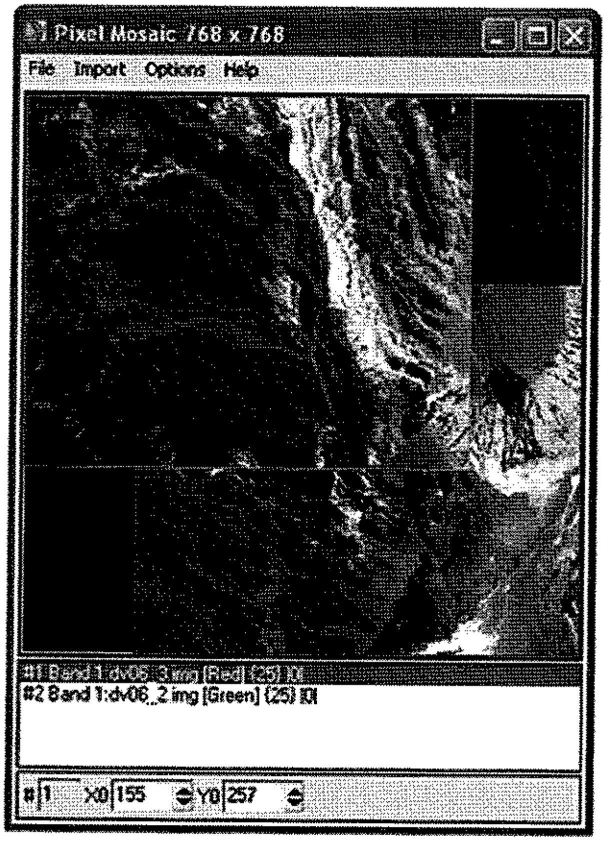
4. Right-click inside this image and select **Edit Entry**. An Entry: dialog appears.

5. In the **Data Value to Ignore** field, enter **0**.

6. In the **Feathering Distance** field, enter **25**.

7. Leave the default values for other fields and click **OK**.

8. Click the image surrounded by a red box (`dv06_3.img`) and drag it to the upper-left corner of the dialog. Then, repeat steps 4-7 for this image.



9. From the Pixel Mosaic menu bar, select **File → Save Template**. An Output Mosaic Template dialog appears.

10. In the **Enter Output Filename** field, enter `dv06b.mos`. Click **OK**.

11. In the Available Bands List, select **Virtual Mosaic (Band 1)** and click **Load Band**. No feathering is performed with a Virtual Mosaic.

12. Make the same image as a feathered mosaic by creating an output file. From the Pixel Mosaic dialog menu bar, select **File → Apply**. A Mosaic Parameters dialog appears.

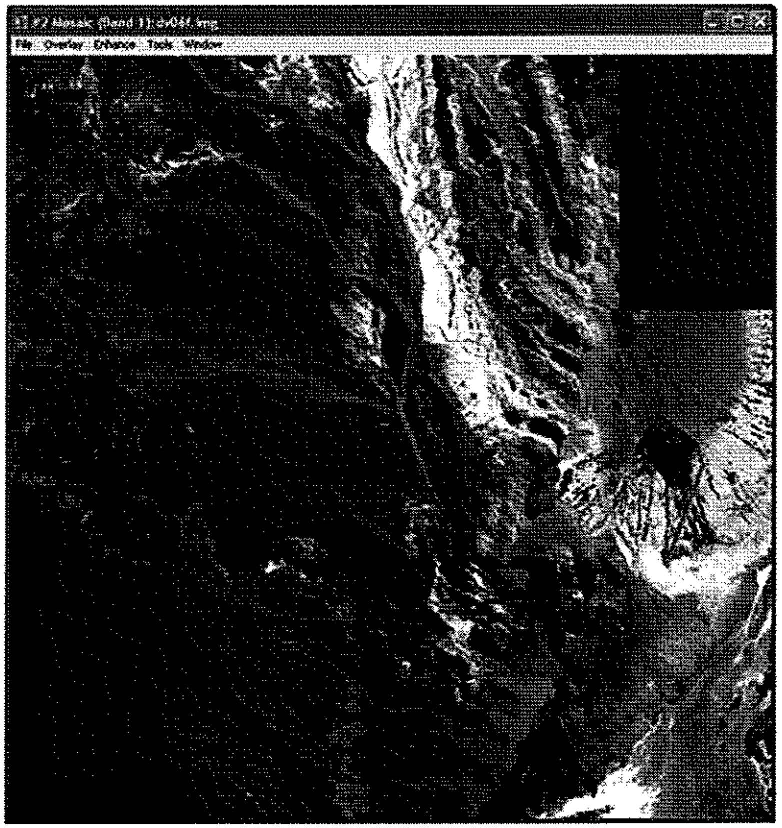
13. In the **Enter Output Filename** field, enter `dv06f.img`.

14. In the **Background Value** field, enter **255**. Click **OK**.

15. In the Available Bands List, click **Display #1** and select **New Display**.

16. Select **Mosaic (Band 1)** under `dv06f.img` and click **Load Band**. If you cannot see the entire image in the Image window, click and drag a corner of the Image window to resize it.

17. Compare the Virtual Mosaic and the feathered mosaic using image linking and dynamic overlays. The following figure shows the feathered output mosaic produced by overlapping the two AVIRIS scenes.



18. From the Available Bands List menu bar, select **File → Close All Files**.
19. Close the Pixel Mosaic dialog and all display groups.

Map Based Mosaicking Example

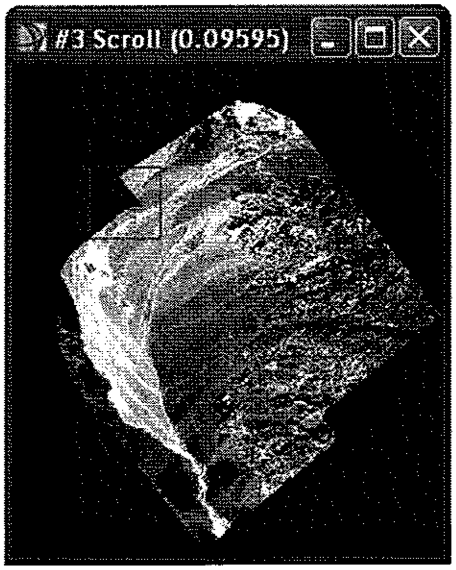
Create the Map Based Mosaic Image

1. From the ENVI main menu bar, select **Map** → **Mosaicking** → **Georeferenced**. A Map Based Mosaic dialog appears.
2. From the Map Based Mosaic dialog menu bar, select **File** → **Restore Template**. A file selection dialog appears.
3. Navigate to `envidata\avmosaic` and select `lch_a.mos`. Click **Open**. This opens the files associated with the mosaic template and restores the mosaic parameters necessary for a georeferenced, feathered mosaic.

   You can also individually import georeferenced images and set the feathering options by selecting **Import** → **Import Files** from the Map Based Mosaic dialog menu bar. Images will automatically be placed in their correct geographic locations. The location and size of the georeferenced images will determine the size of the output mosaic.

View the Top Image, Cut-line and Virtual, Non-Feathered Mosaic

1. In the Available Bands List, select **Warp** under `lch_01w.img` and click **Load Band**.
2. Right-click in the Image window and select **Toggle** → **Display Scroll Bars**. Click the horizontal scroll bar until a good portion of the image is visible.
3. From the Display group menu bar, select **Overlay**→ **Annotation**. An Annotation dialog appears.
4. From the Annotation dialog menu bar, select **File** → **Restore Annotation**. A file selection dialog appears.
5. Select `lch_01w.ann` and click **OK**. The display group shows a red cut-line used to blend the two images in this mosaic.
6. In the Available Bands List, click **Display #1** and select **New Display**.
7. Select **Warp** under `lch_02w.img` and click **Load Band**.
8. Can you identify the relationship between the cut-line and this image?
9. From the ENVI main menu bar, select **File** → **Open Image File**. A file selection dialog appears.
10. Select `lch_a.mos` and click **Open**.
11. In the Available Bands List, click **Display #2** and select **New Display**.
12. Select **Virtual Mosaic** under `lch_a.mos` and click **Load Band**.
13. Examine the non-feathered edge between the two images that were used to create the mosaic:



Create the Output Feathered Mosaic

1. From the Mosaic dialog menu bar, select **File** → **Apply**. A Mosaic Parameters dialog appears.
2. In the **Enter Output Filename** field, enter `lch_mos.img` and click **OK** to create the feathered mosaic.
3. Close Display #1 (`lch_01w.img`) and Display #2 (`lch_02w.img`).
4. In the Available Bands List, click **Display #3** and select **New Display**.
5. Select Warp under `lch_01w.img` and click **Load Band**.
6. Compare the feathered mosaic to the non-feathered mosaic using image linking and dynamic overlays.

Color Balancing During Mosaicking

This tutorial describes the procedure for creating a georeferenced mosaic using automated color balancing. For this exercise, you will use two overlapping subsets from a Landsat-7 ETM image.

Create the Mosaic Image without Color Balancing

First, you will create a mosaic without color balancing. You will start by importing both of the images without any feathering so you can clearly see the seams between the images.

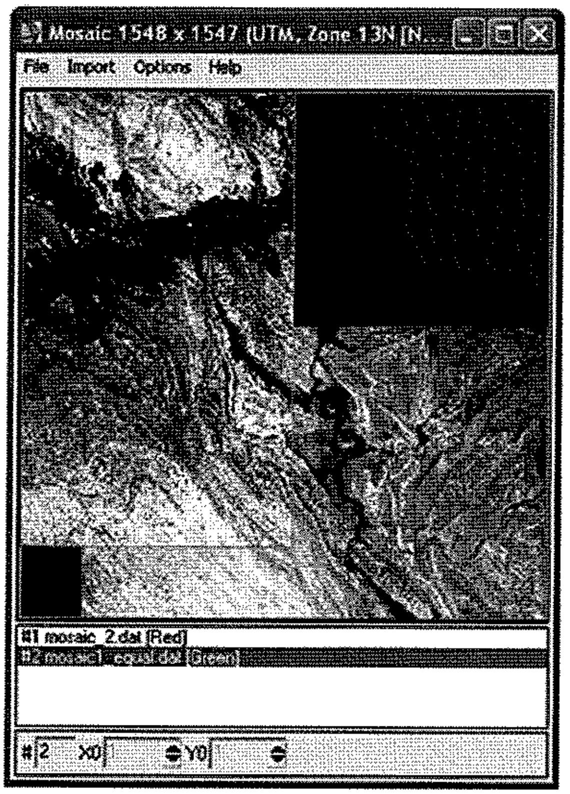
1. From the ENVI main menu bar, select **Map** → **Mosaicking** → **Georeferenced**. A Map Based Mosaic dialog appears.

2. From the Map Based Mosaic dialog menu bar, select **Import** → **Import Files**. A Mosaic Input Files dialog appears.

3. In the Mosaic Input Files dialog, click **Open** and select **New File**. Navigate to `envidata\avmosaic` and select `mosaic1_equal.dat`. Click **Open**. A histogram equalization stretch was independently applied to each band in this image.

4. Repeat Step 3 for `mosaic_2.dat`.

5. In the Mosaic Input Files dialog, Click **<Shift>** to select `mosaic_2.dat` and `mosaic1_equal.dat`. Click **OK**. The two images are automatically placed in their correct geographic locations in the Mosaic dialog. By default, a 2% contrast stretch is applied to the images.



RGB Mosaic Preview

1. Right-click inside the image surrounded by a green box (`mosaic1_equal.dat`) and select **Edit Entry**. An Entry: dialog appears.

2. Click the Mosaic Display toggle button to select **RGB**.

3. In the **Red** field, enter **1**. In the **Green** field, enter **2**. In the **Blue** field, enter **3**.

4. Click **OK**. The file `mosaic1_equal.dat` is now displayed in color in the Mosaic dialog.

5. Repeat steps 1 through 4 for the other file in the mosaic (`mosaic_2.dat`).

By default, ENVI automatically creates an RGB composite in the Mosaic dialog using the first band as red, the second band as green, and the third band as blue. If an image has more than three bands, the Mosaic dialog only shows a gray scale version of Band 1.

Output the Mosaic Without Color Balancing

You should remember that what you see in the Mosaic dialog is not necessarily what you will see in the final mosaic. In the Mosaic dialog, the two images are stretched independently. If the images are mosaicked into one image and displayed, ENVI calculates a contrast stretch from the two images combined.

1. From the Mosaic menu bar, select **File → Apply**. A Mosaic Parameters dialog appears.

2. In the **Enter Output Filename** field, enter `mosaic_unbalanced.dat` and click **OK**.

3. In the Available Bands List, click RGB Color. Select **Band 1, Band 2**, and **Band 3**, and click **Load RGB**. The seams between the two images are quite obvious.

Output the Mosaic With Color Balancing

You will now apply the mosaic again, this time using color balancing to minimize the contrast between the two images in the final mosaic.

1. In the Mosaic dialog, right-click inside the image surrounded by a green box (`mosaic1_equal.dat`) and select **Edit Entry**. An Entry: dialog appears.

2. Click the **Adjust** radio button. The contrast of this image will be adjusted to match the other image. Click **OK**.

3. In the Mosaic dialog, right-click inside the image surrounded by a red box (`mosaic_2.dat`) and select **Edit Entry**. An Entry: dialog appears.

4. Click the **Fixed** radio button. The contrast of this image will not change. The other image will be adjusted to match this image. Click **OK**.

5. From the Mosaic dialog menu bar, select **File → Apply**. A Mosaic Parameters dialog appears with a Color Balance option near the bottom. Leave the default value "stats from overlapping regions." Color balancing is usually better when based on statistics calculated from only the overlapping regions. The other option (stats from complete files) is used when the mosaicked images have little or no overlap between them.

6. In the **Enter Output Filename** field, enter `mosaic_balanced.dat` and click **OK**.

7. In the Available Bands List, click **RGB Color**. Under `mosaic_balanced.dat`, select **Band 1, Band 2**, and **Band 3**, and click **Load RGB**. The seams between the two images are nearly invisible now.