Image Processing Lab Exercise #1 (an exercise in two parts):

Bagher Bayat, RS/GIS Group, Faculty of Earth Sciences, SBU

Part I: Introduction to the Computing Environment, Software, and Image Interpretation

Objectives:

- To introduce the basics of the computing environment
- To introduce fundamental image interpretation techniques
- To introduce basic ENVI functions
- To analyze and understand basic characteristics of various remote sensing multispectral systems

Background

Satellite imagery data have a **raster data structure**, where each pixel represents a recorded radiation intensity (radiance) in a narrow band of the electromagnetic spectrum as measured by the instrument. Each pixel contains N dimensions of data where N is the number of sensors designed to sense energy at particular wavelengths (e.g., visible blue, visible green, near infrared, etc.). These dimensions are called **spectral bands**, or just **bands** or **channels**. For the Landsat Thematic Mapper (TM) instrument, there are 7 bands, so each pixel contains 7 different radiance values. At the sensor, these data are stored as Digital Numbers (DN), the range of which varies depending on the sensor. Here are some examples:

Landsat MSS (Landsat 1-3; and 4 and 5) data come in 6-bit unsigned integers, $2^6 = 64$ levels, so DN values range 0-63 for each of four bands.
Landsat TM and ETM+ (Landsat 4 – 7) data come in 8-bit unsigned integers, $2^8 = 256$ levels, so DN values range 0-255 for each of eight bands (including thermal and panchromatic).
Landsat OLI (Landsat 8) data are provided as 16-bit integers, $2^{16} = > 65{,}536$ levels, but are rescaled to 55,000 levels. DN values range 0 – 54,999 in nine bands of reflected energy and two bands of emitted energy (thermal bands).
AVHRR data come in 10-bit unsigned integers, $2^{10} = 1024$, so DN values range 0-1023 for each band.
MODIS data come in several formats – refer to https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/ for the particular data that interest you.

To display images in ENVI, you need to assign each of the bands into one of the 3 possible color guns of the display monitor. Three primary colors (red(R), green (G), and blue (B)) can be combined to make all the other colors. Everything you see on your computer screen is some combination of these 3 colors. Each of the color guns can display up to 256 shade levels (it is also 8-bit). If only one band of the satellite image is assigned to each of the 3 RGB color guns, then it is displayed as a grayscale image. If 2 or more bands are assigned to RGB, the images are displayed as **color composites**.

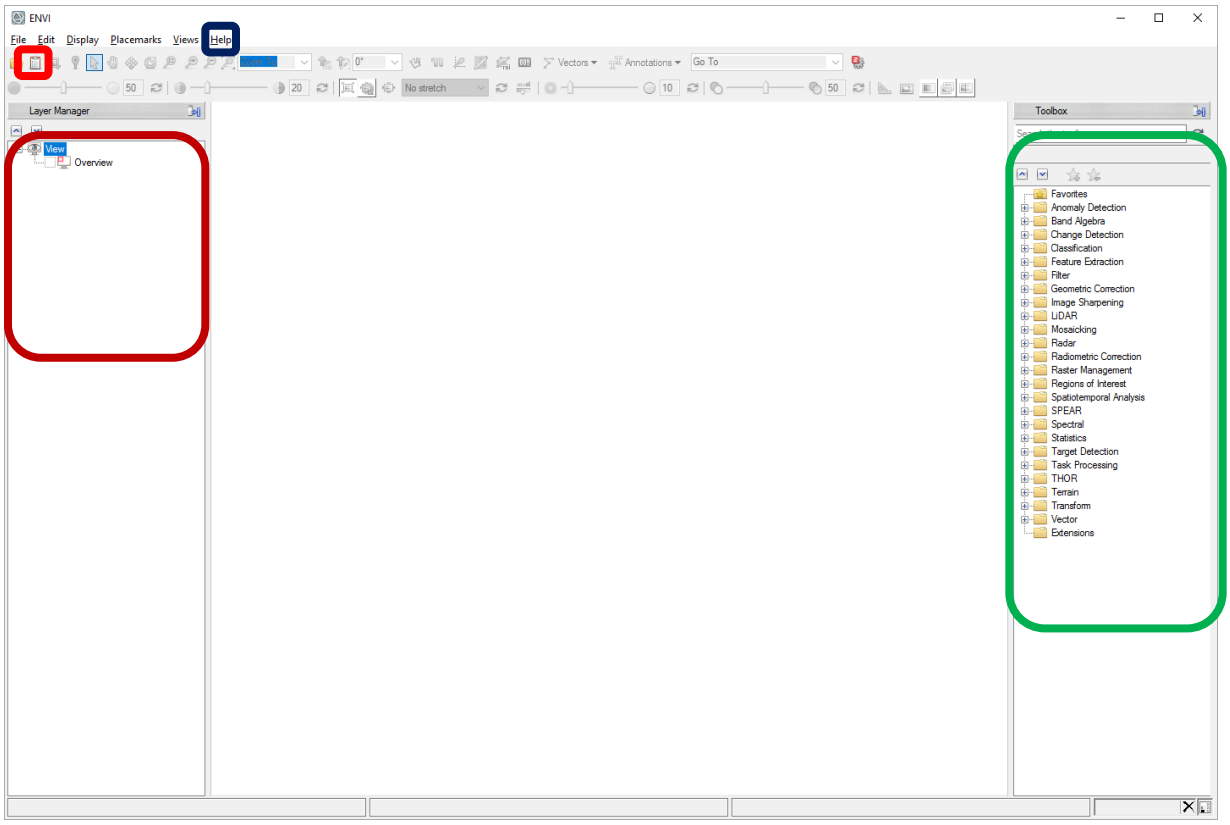
"True color composites" are created when the visible red, green, and blue bands (wavelengths) of the image are assigned to the Red, Green, and Blue color guns, respectively. Other combinations make "false color composites." Typically, the wavelength (or band) of greatest interest is placed in the R color gun to accentuate information content. In vegetation remote sensing, for example,

a typical false color composite image would be created by assigning the near infrared (NIR), red, and green bands into RGB, respectively. Since chlorophyll reflects strongly in the NIR part of the EMS, leafy healthy green vegetation appears bright red or sometimes fuchsia. When you download the data be sure to take all the files in the whole folder, taking just pieces or individual files can corrupt the data.

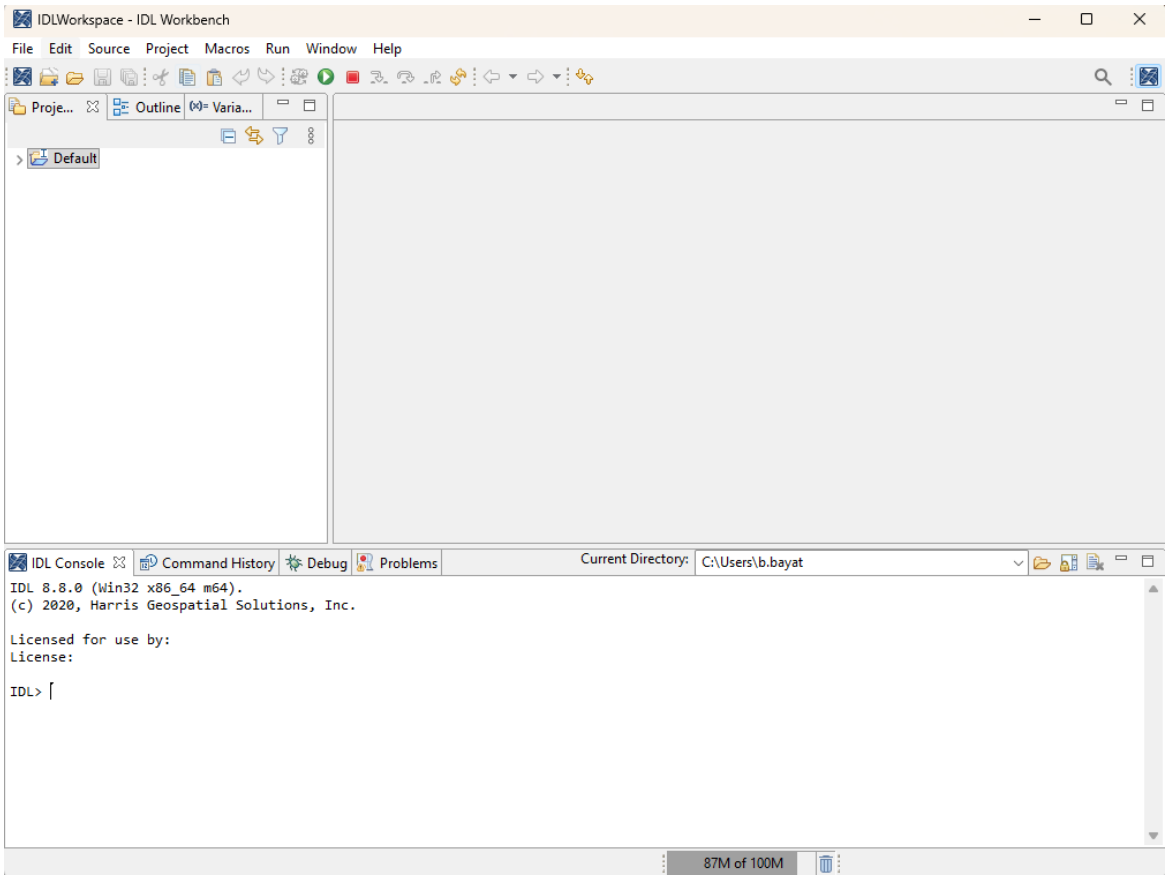
Part I: Starting ENVI

ENVI (Environment for Visualizing Images) is an image processing software that is written in IDL (Interactive Data Language). It is both menu and command line driven. Using IDL, you can develop your own processing tools and automate tasks. You can also extend the functions of ENVI by writing your own programs in IDL. In this general introduction to ENVI you will learn the basics of the ENVI layout, setting everyday ENVI properties, displaying an image, and analyzing histograms.

Run ENVI 5.6 (64 bit)
First off, familiarize yourself with the layout of the ENVI screen. If you are familiar with ArcGIS software you will notice that they have a similar feel. Before moving to the next part locate the layer manager (maroon box in the figure), the toolbox (green box, but be especially aware of the Raster Management folder in the toolbox), the data manager button (red box), and the ENVI help menu (dark blue box). These will be used commonly throughout the semester.



When you open the ENVI + IDL software two different program interfaces open at the same time, the main ENVI program that you just explored and the IDL workbench window. This window (see figure below) is used only for advanced techniques involved with customizing and extending ENVI but must be opened to run ENVI +IDL. If time permits, we will utilize the IDL window later in the semester; a bit of programming knowledge will be required at that point. For now, ignore it and enjoy it as is appears and disappears.



Part II: Setting Basic ENVI Properties and Displaying an Image

Opening files and displaying images is perhaps the most basic, yet fundamentally important task for image processing software. By default when you open a file, ENVI attempts to display a true color or gray scale image automatically, based on your file type (single band vs. multi-band images). However, before even opening an image, there are several basic ENVI properties that must be set, the most important of which is the working directory.

Setting the Working Directory

Much of the ENVI interface and system-wide defaults are configurable. You can customize the ENVI configuration and save the changes. The following steps will walk you through setting the working directory and other defaults. It is important to note that after downloading the data, and opening ENVI, the next step is **always** to set your working directory and other defaults.

1. From the ENVI menu bar, select **File – Preferences.** The ENVI preferences dialog appears

2. On the left side of the dialog, select **Data Manager.**

3. On the right side of the dialog, click the **Auto Display Method for Multispectral Files** field and select **CIR** (Color Infrared) from the pull-down menu. This will cause image files to be displayed as color infrared by defaults.

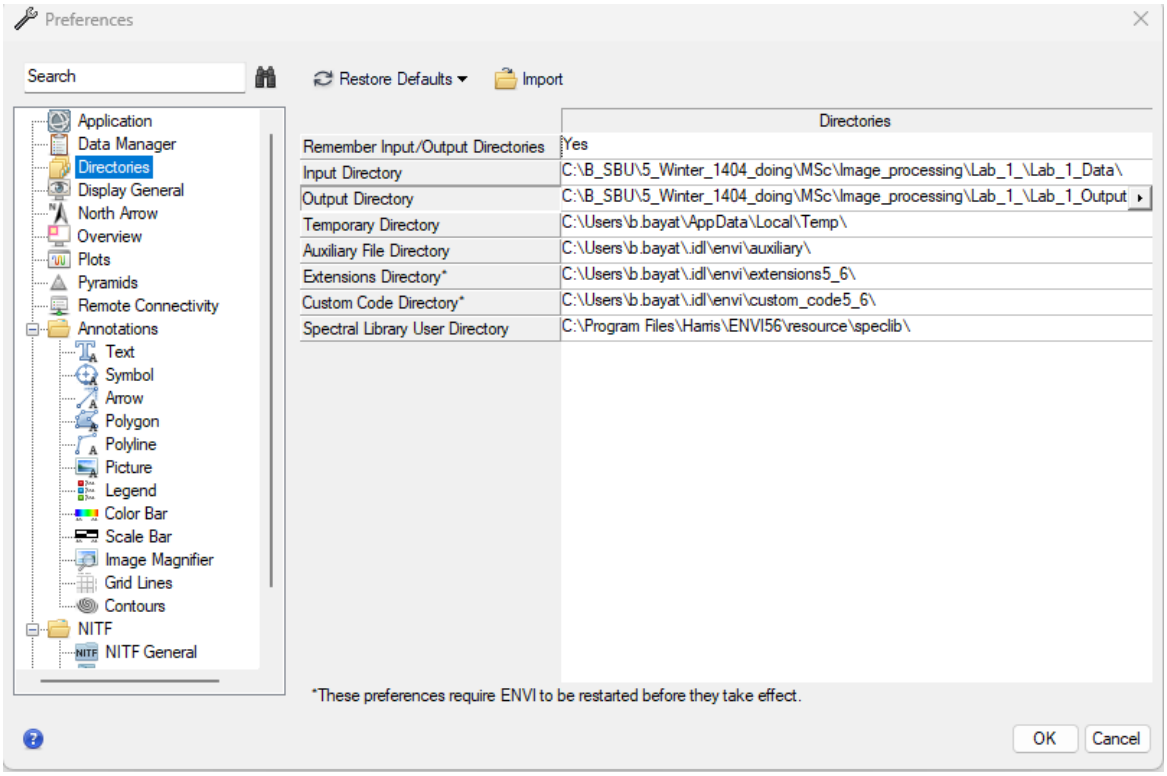
4. Look at all the options for the Data Manager and ensure the following settings are selected:

    a. **Auto Display Files On Open = Yes**
    b. **Clear View When Loading New Image = No**
    c. **Close Data Manager After Loading New Data = No**

    Think about what each of these above setting means. For example, **Clear View When Loading New Image = False**, means that image overlays can be performed automatically similarly to ArcGIS functions.

5. Select **Directories** from the left side of the dialog and then click the **Output Directory** field. Click on the pull-down menu and navigate to your working folder in your M: drive folder (the place you want all you results to be saved).

6. Repeat step 5 but this time set the **Input Directory**. When you do this navigate to where you stored your data on your M: drive. You can set up a local drive but it may disappear when your session ends. See the image below for assistance in this task.



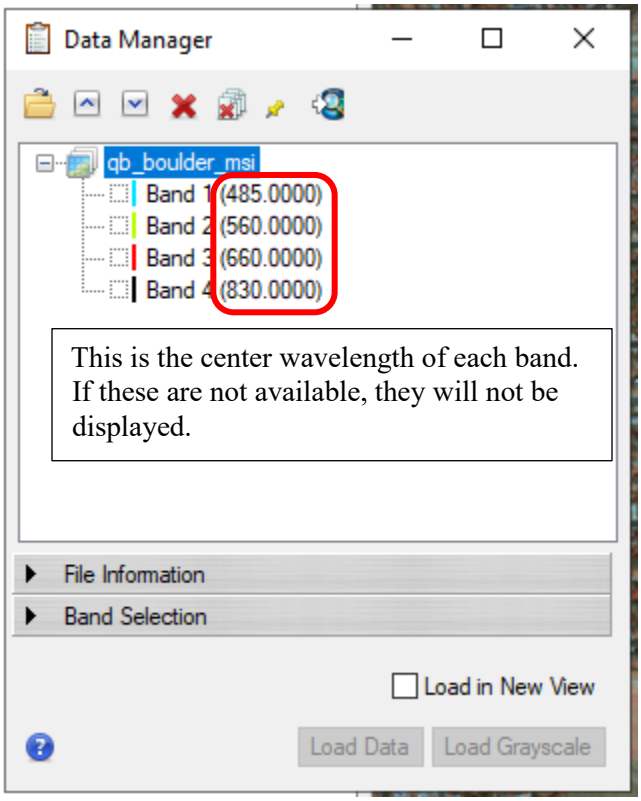
7. Click **OK** to close the Preferences dialog

Opening an Image

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

2. Since you have set the input directory with the Preferences functions, when you click **Open** your working directory on your M: drive folder should open. If it does not you need to go do the previous steps again. Select the **qb_boulder_msi.enp** image from the folder and click **Open**. Note that the .enp file has all sorts of information about the image that will be displayed when it is opened. You do not need to know about the extra information in the .enp file for now but will learn later. You will notice that there are several files associated with the boulder image, one of which is a header file. ENVI requires a header file associated with each image in order for the software to recognize and read the format of the data. The header file is not shown in the Layer Manager, but can be found in the directory with the original data with the filename extension .hdr. The image is automatically displayed as color-infrared (CIR) because you told it to do so in the Preferences Manager.

3. Click on the **Data Manager** icon (second button from the left on the toolbar). The Data Manager lists the files that you have opened and allows you to select the bands to display (see image below). When you open a file in ENVI, it is added to the top of the Data Manager List.



4. When you click on band names in the Data Manager, color assignments will automatically be assigned based on the order of red, green, and blue (in that order). Click the band name you want to assign red (this is just a trial right now click any band). A little red box appears next to the band name. Select two other bands for the green and blue. Tick Load in New View and Click **Load Data** to see the new band combination you just created.

5. Right-click on the qb_boulder_msi in the Data Manager and select **Load True Color**. ENVI looks for wavelength information in the header file to select which bands will

make a true-color. The option to load a True Color or CIR image using the right-click requires that the bands in the file have wavelength information associated with them. Note that there are real numbers with four digits after the decimal point to the right of the Band N name. These are the central wavelengths of the bands, which were included in the data. This also means that the header file was read correctly by ENVI or that the user has defined the header. Later in the semester, we will work with the header file.

6. Click on the **File Information** arrowhead in the Data Manager. Useful information is found here including file size and dimensions, data type, and map projection.

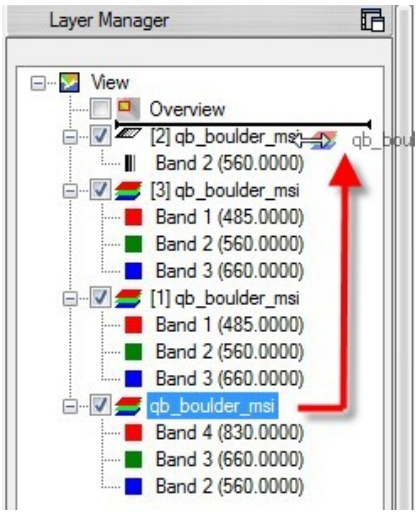
7. Click on **Band Selection** in the Data Manger. This is another tool you can use to select bands to display. The red button is currently the active one, so any band you click on will be placed here. Then the green button will be active.

8. Close the Data Manager by clicking the X on the top right of the dialog window.

Working with Layers and Multiple Viewers

You can load multiple layers into ENVI at one time and manage those layers using the Layer Manager. By default, all layers in the Layer Manager are displayed in the Image window. You can temporarily hide the display of a layer so that you can work with other layers in the Image window. You can control the order of layers in the Image by dragging and dropping layers in the Layer Manager list or by using menu options.

1. Using the Data Manger create a CIR composite (Right-click and select **Load CIR)**. Click and drag the CIR (bands 4,3,2) qb_boulder_msi to the bottom of the Layer Manager



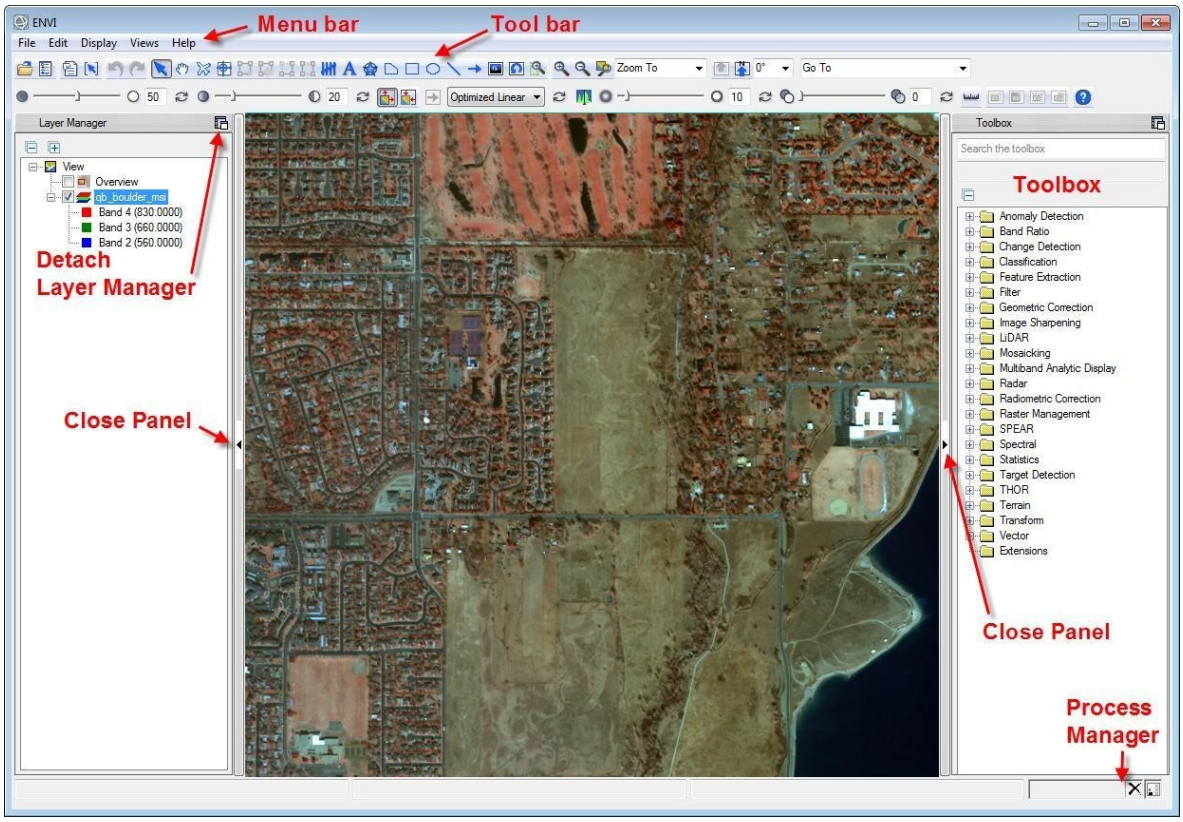
2. Click the check box for the top layer to deselect it. This hides the image from view. Click the check box again to display that layer again.

3. Right-click on one of the file names in the Layer Manager, and note the various options, including Display in Portal, and change Order. Select **Remove**.

4. From the ENVI menu select **Views -- Create New View**. The display is divided into two with one of the Views being empty. The new View is also listed in the Layer Manager.
5. Click the Data Manager icon to open it. Then right-click on one of the band names and select **Load Grayscale**. The band will be loaded into the empty View.

6. Experiment with other views by selecting **Two Horizontal Views, 2x2 Views**, etc.

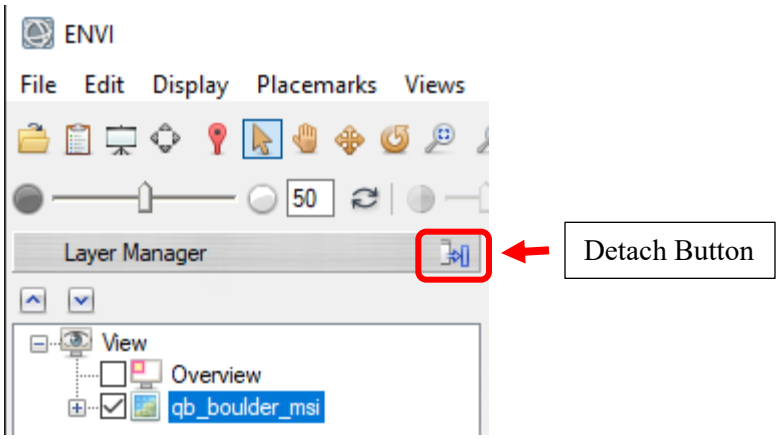
7. Return to a 2x2 View. There will be four Views listed in the Layer Manager. Right click on the View at the bottom of the list and select **Remove View**. You will now have three Views with one of them extending across the bottom of the display. Use the Data Manager to place an image in any View that is empty. To select a View for updating, either click on it in the display or click on its listing in the Layer Manager.



8. Select **Views -- One View** and close the Data Manager.

Exploring the ENVI interface

The following steps will walk you through basic buttons and sliders in the ENVI interface. These are all button / sliders that you will use consistently throughout the semester. Learn these now; as in the future when we tell you to use one of these buttons we will not explain what it does or where the button is.



1. Detach the Layer Manager panel by clicking the **Detach** button (see figure above). Note that the Toolbox also has a detach button.

2. Reattach the Layer Manager panel by clicking the **X** on the top right of the Layer Manager window.

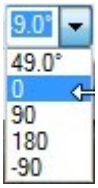
3. You can also collapse the Layer Manager by clicking the close file button on the top of the Data Manager window.

4. Click the **Cursor Value (** **):On Demand Updates (**)button. The Cursor value dialog will appear along with display crosshairs. The cursor value dialog initially shows the coordinates for the crosshair. As you move your cursor around the image, the coordinates update. Move the crosshairs around the image and note the different raster values. Close the cursor dialog box.

5. Click the **Pan** button then click and drag your cursor in the Image window to pan in the direction of the mouse. When in Select mode you can also use the middle mouse button to perform a pan.

6. Click the **Fly** button then click in the display and hold to continuously drift in the direction of the cursor. Positioning the mouse further from the center of the display causes the drift to increase in speed.

7. Click the **Rotate** button then click and drag the cursor in a clockwise or counterclockwise direction to rotate the image. The degrees drop-down list near the middle of the upper toolbar interactively reports the current degree of rotation.



8. Click the **Select** button to exit the Rotate tool.

9. Click the degrees drop-down list on the toolbar and select **0°.** Note that you can also use the North Up button  instead of the 0° rotation to get the same orientation. The grayed-out Top Up button  is used to orient the image when it contains Rational Polynomial Coefficient (RPC) information (not needed now).

10. Click the **Zoom** button  and then click and drag your cursor to draw a box around an area near the center of the image. This will zoom in to that area.

11. Click on the **Fixed Zoom In** and **Fixed Zoom Out** buttons. The current zoom factor and pixel scale are shown in the drop-down menu to the right. 

Click on the arrowhead for this menu and note the options for zoom factor (pixel scale). At the bottom of this list click on **Use Map Scale**. Now select some different map scales from the pulldown menu. Access the drop-down menu again and select **Use Pixel Scale**. This will return to the default behavior.

12. Click on the **Zoom To Full Extent** button  . This is a useful button to view your entire image in the display.

13. In the **Go To** window, type in **660.5,390** and hit the <Enter> key. This should center the image on a track near a large reservoir. If the Crosshairs are turned on, they will be placed on the location you specify. If you type in x, y locations and both values are integers or are outside the range used for Lat/Long, ENVI assumes they are pixel coordinates. If x and y values are greater than 30,000, append a "p" to one of the values to indicate it is a pixel coordinate, not a map coordinate. If the image is a subset, offsets are taken into account. Data coordinates are specified by appending an asterisk (*) after one of the coordinates.

14. Type **39 59 51N,105 12 28.5W** in the **Go To** window and hit the <Enter> key. The display will be centered on a small beach jutting into the reservoir. Map coordinates (e.g., Easting and Northing in a UTM projection) can also be used with the Go To tool. Also, MGRS (Military Grid Reference System) coordinates can be typed as an alphanumeric string. MGRS Northing and Easting values can have up to five digits of precision. Note that you can click on the arrowhead to access a pull-down list of previously used coordinates.

15. The next row of tools in the ENVI menu includes various sliders for **Brightness, Contrast, Sharpen**, and **Transparency**. Experiment with these. Note: you should click on the image name in layer manager and select it, then these tools become activated. They can be manipulated in the following ways:

    - Click on the slider bar to the right or left of the indicator, or click the slider then use the **<Page Up>** or **<Page Down>** keys to move the slider up or down incrementally by ten percent.
    - Click on the icons at each end of the slider bar, or click the slider then use the arrow keys on the keyboard to move the slider incrementally by one unit.

- Click the slider then use the **<Home>** key on the keyboard to move the slider to 100 and the **<End>** key to move the slider to 0.

16. Click the Reset button on each slider to return them to their default values.

17. To clear the screen entirely and start new ENVI sessions go to **Views – One View**.

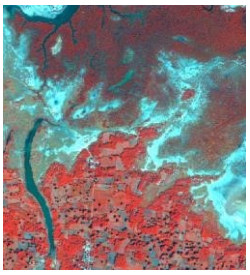
18. To remove images right-click view in the **Layer Manager** and say remove all. You can right-click and remove individual files within the layer manager as well.

Part V: Basic Image Interpretation

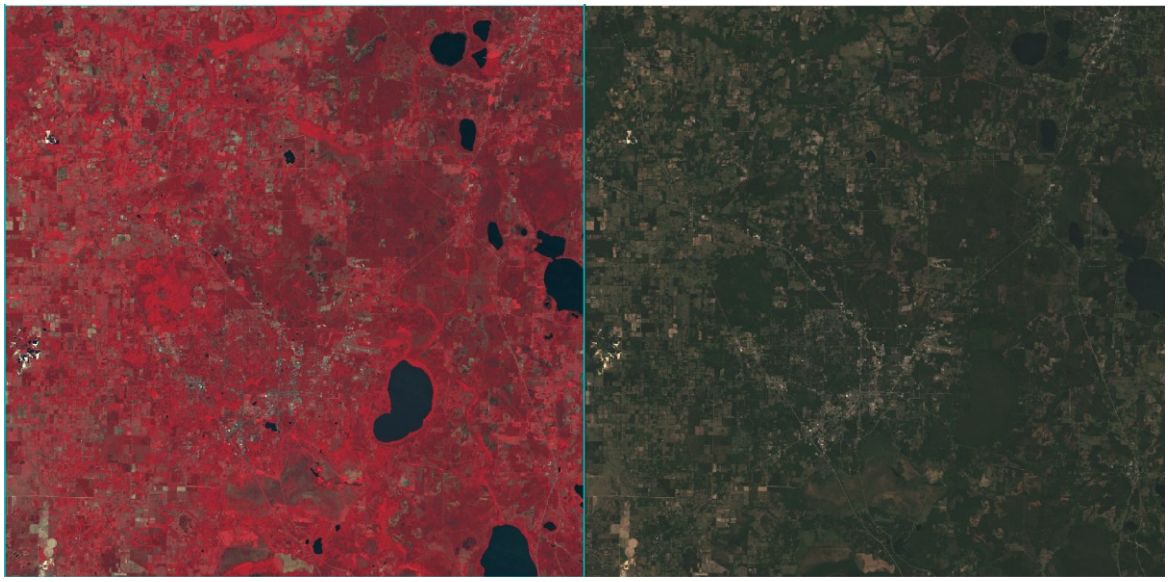
The above steps showed you how to load an image composite, now you try to display the following images from **different** sensors. Use the Data Manager to create each of the below composites. Think about what each band combination means. Is it a true color composite or a false color composite?

When opening each of the following images, make sure you remove all the data associated with each of them in BOTH the layer manager and the data manager. In layer manager, click on "view" and hit "remove all layers". In data manger hit the "close all files" icon. This will make it easier for you to keep track of the image that you are currently dealing with. Also, when you open each image, hit the "zoom to layer extent" button (see above) so that you will be able to quickly find the image on display and see it in its entirety.

Quickbird *quickbird_haiti_17jan03.img* Color Infrared Composite RGB = Bands 4, 2, 1

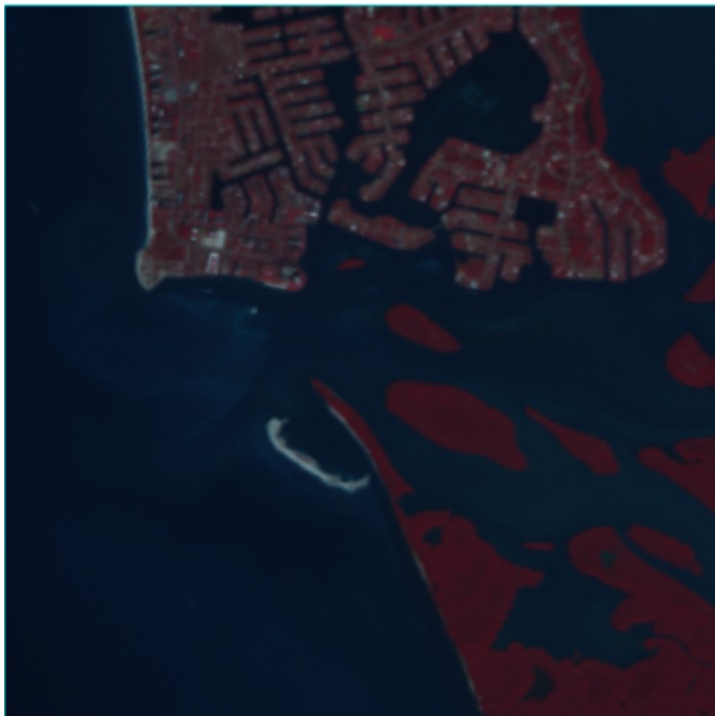


Landsat TM *tm_gville_22mar1997.img* Color Infrared Composite RGB = Bands 4, 3, 2 and Natural Color Composite RGB = Bands 3, 2, 1 (Toggle between the images and see what the different bands highlight). The image when you pull it up will look slightly different than the sample below until you Zoom to Full Extent. This is ok; it will still work the same way.



Landsat ETM *etm_stjohnsriver_11feb2003.img* Color Infrared Composite RGB = Bands 4, 3,2 Color Composite RGB = Bands 5, 4, 3. Minimize all the "classes" that pop up in your layer manager. You won't need to use them and the amount of them will be overwhelming. They are only ENVI display categories and not additional image bands!

SPOT XS HRV *spot_marcoisland_21oct1988.img* Color Infrared Composite RGB = 3, 2, 1 Again here, minimize all the classes that pop up in your layer manager. For this one, instead of going into the data manager to change the bands, right click over the name of the image in the layer manger and select "Change RGB Bands". When this box pops up, select the bands indicated above and hit "ok" to apply them.



THE CHALLENGE

Within the lab 1 data folder there is one last image we have not used, a Quickbird image of the Florida Keys. Given what you have learned during these preceding steps complete the following challenge.

Challenge: Open the Florida Keys image. Within ENVI create a **Create New View** twice (giving you a total of three views). Using the Data Manager create the following three RGB composites. Once you've made the three views, click on each of the "views" in the layer manager and load a new FL image from there as:

1. A true color composite
2. A grayscale image of the NIR band
3. A Color infrared false color composite (NIR, Red, Green)

Part II:

Objectives

- Browse various remote sensing and free imagery resources available on the web. We may not complete this section in the lab time in which case this is what you need to do later.

Browse the Sites

This part of the lab will introduce you to various free remote sensor data sources and tutorials available on the Internet. After browsing these sites, you can download an image of your choice and play with it! You are free to use any type of imagery: photography, multispectral, radar, etc. This will be a good set of locations to keep, although as with most things on the Internet these locations are constantly changing.

Imagery Sites

SOURCES:

USGS Global Visualization Viewer

USGS EROS Data Center Earth Explorer

Informative Fun Sites

USGS Landsat Missions

NSSDC Photo Gallery: Earth

Goddard DAAC FTP site

International Institute for Geo-Information Science and Earth Observation

USGS EarthNow Near Real-Time Landsat Images

NASA Visible Earth

Commercial Remote Sensing Image Providers

MAXAR (Formerly DigitalGlobe: QuickBird, GeoEye, WorldView and other high spatial resolution satellites and instruments)

The WWW Virtual Library: Remote Sensing Organizations

This is the end of this Lab!

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