Lab 4 Image Processing 2
Utilizes Textbook's Remote Sensing Digital Database: *Chapters 3, 5, and 8 data.*

The objectives of this lab are to use image enhancement tools (see Chapter 9 Digital Image Processing for discussion of enhancements) to process thermal IR, UAS (drone), and multispectral data and to introduce band math. The tasks we will complete with this lab are done with tools in the **ENVI Toolbox**:

Band Math
Density slice
Mosaicking
Masking

Four digital files are to be uploaded to the instructor and four questions are to be answered on the last page of this handout.

IMPORTANT NOTE: The "new" ENVI with the GIS-look does *not* retain display enhancements for images when you use ***Save As***. These include rotating, zooming, contrast, brightness, sharpening, stretching, Portals, or viewing multiple layers. Use the ***Export View To > Image File*** to retain displayed enhancements. Unfortunately, it appears that when exporting an enhanced 1-band grayscale image, ENVI generates a grayscale file that contains 3 identical grayscale bands. This is bad. Can you find a fix?

1) Band Math
In this exercise we will convert raw DNs displayed on an ASTER thermal IR surface temperature image of the Ghanzi area, Afghanistan to degrees Celsius (°C). See textbook Chapter 5 and Figure 5-6 for more background information.

Open the ENVI software. *File* > *Open*

Locate the nighttime, Level 2 ASTER TIR surface temperature image (AST- 08 product) from the Remote Sensing Digital Database following this path:

\ Ch_5_Thermal_IR \ Fig_5-6 Afghanistan_ASTER_Surface_Temp \ Nightime

Choose the TIF image in the "Nightime" subfolder: "Ghazni_AST_08_TIR_Surface_Kinetic_Temp_Nighttime_31aug2013_integer"

Zoom to Extent *Click-on the Cursor Value icon*

Use the Select Arrow to move the crosshairs around the ASTER TIR image.

Move from bright pixels to dark pixels.

View Metadata

Quick Stats

Select Plot (drop-down menu in upper left) > *Histogram Band 1*

NOTE: The Terra platform that hosts the ASTER system is moving from south to north during the nighttime orbit. The rotation of the earth is demonstrated by the wedge-shaped black margins of NO DATA on the East and West margins. The system records a null DN of 2000 in this NO DATA area. Ignore the wedge-shaped margins.

Question 1: A. What is the range in DN values (min – max)?

B. What is the DN range for the bin with the highest Count (located at the peak of the histogram)?

1a) Brilliant people at the Jet Propulsion Lab (JPL) and NASA deliver calibrated ASTER thermal IR products for a variety of applications at no cost. The original DNs of the pixels in a Level 2, AST-08 product (calibrated surface temperature) can be converted to degrees Celsius (°C) using the following formula (Gillespie and Rokugawa, 2001):

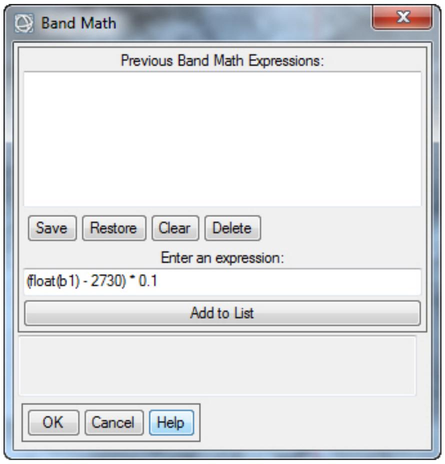
XXXX = DN of pixel on calibrated AST-08 Level 2 image
2730 = constant
YYY = Value when 2730 subtracted from DN on image (XXXX)

XXXX – 2730 = YYY * 0.1 = ZZ.Z°C

You can do this calculation on paper or with a calculator for each pixel you measured with the Cursor Value tool earlier. That is very inefficient. Fortunately, many image processing and GIS software packages include tools for you to write your own mathematical operations that can be applied to the entire image.

ENVI supplies the Band Math tool. Band Math is a powerful tool for remote sensing. Let's use it!

Toolbox > Band Algebra > Band Math



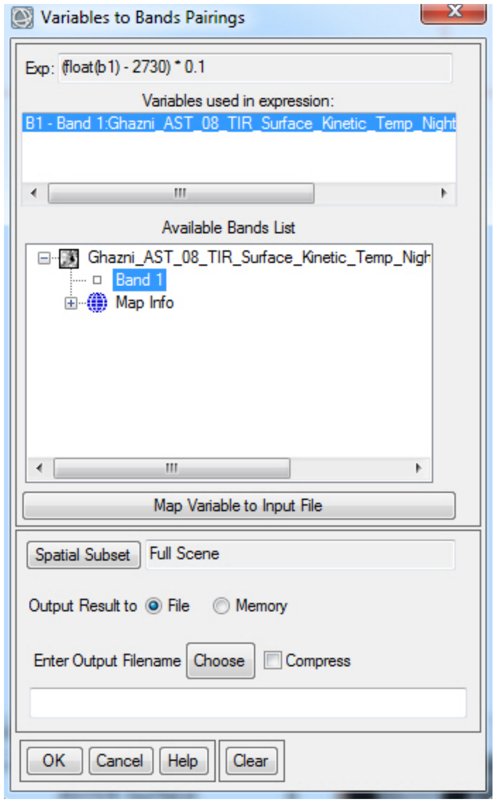
Push **Help** to see examples and better understand how band math works!!

Our formula XXXX – 2730 = YYY * 0.1 becomes (float(b1) - 2730) * 0.1

“float” is used before each pixel’s original DN value to ensure our degree Celsius result supports a decimal point.

Enter the Band Math formula into the “Enter an expression” box
> Add to List

Save the Band Math formula as “ASTER TIR DN to Celsius” so you can use it again in the future.
> OK The “Variables to Bands Pairings” window pops up.



Click-on the "Band 1" in the "Available Bands List"

The thermal IR band will automatically fill in the "Variables used in expression:" Name the output file "ASTER TIR Celsius_ENVI". This new image will be in ENVI format (.img with .hdr).

The ASTER TIR °C image automatically loads into the View. The new image will be very dark if "No stretch" is set. Contrast stretch with" Linear 1%"

Roam around the image with your "Cursor Value" tool. Very dark blobs of pixels along the East margin have negative °C values. These may be clouds or errors. Best to ignore.

If you are more comfortable with Fahrenheit degrees (°F), use this formula for converting °C to °F

(32**°C** × 9/5) + 32 = 89.6**°F**

Question 2: A. What is the highest temperature in °C recorded by the ASTER TIR system? (Hint: Refer to the *Quick Stats* Histogram table)

B. Do you think you should use this highest temperature if only one pixel recorded it? YES or NO

1b) Our “ASTER TIR Celsius_ENVI” grayscale image is not useful for GIS. Let’s quickly convert it to a geoTIFF format.

Right-click on “ASTER TIR Celsius_ENVI” in the Layer Manager
> Export Layer to TIFF

Name your geotiff output file “Your Name_ASTER Temp GIS.tif”

Upload to the instructor.
If you have access to a GIS, open your geoTIFF image in the GIS.

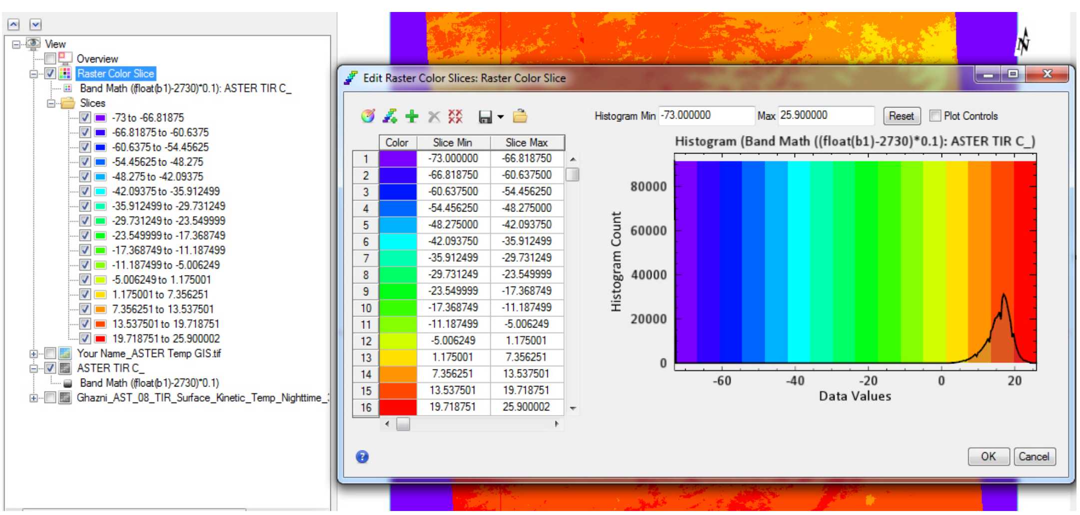
<u>2) Density Slice.</u> Use the “Raster Color Slices” tool in the ENVI Toolbox. Temperature patterns on our ASTER TIR °C grayscale image can be understood more easily if we perform a density slice on the image.

Highlight the “ASTER TIR Celsius_ENVI” image in the Layer Manager.

ENVI Toolbox > Classification > Raster Color Slices
A “Data Selection” window pops up – ensure the “Band Math (…)” entry under our “ASTER TIR Celsius_ENVI” image is highlighted. > *OK*

Automatically ENVI generates a “Raster Color Slice” image with 16 slices!

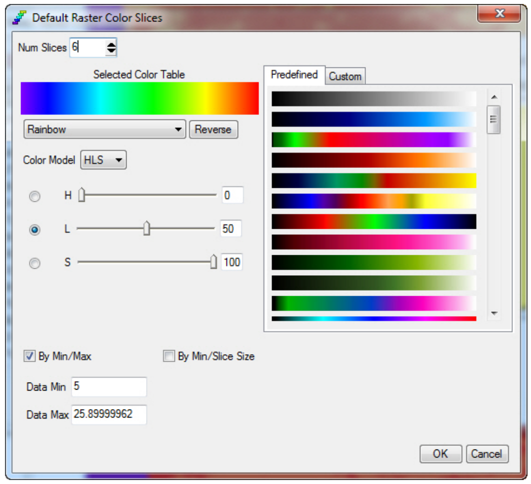
NOTE Problem*!* ENVI created 12 density slices where there is <u>no data</u> because our ASTER TIR DN histogram is not “normal” – it is skewed to the right. Image processing algorithms often <u>assume</u> a “normal” distribution of data. But often the data DNs are skewed!! Always <u>look</u> at your results to see if they are reasonable. *See below*



We MUST correct this very bad and misleading density slice image!!

Click-on the 2nd to the upper left icon *"New Default Color Slices…"*

The "Default Raster Color Slices" window pops up. (see below)



Change the *Num Slices* to "'6" and the *Data Min* to "5" > *OK*

You now see the color density slices more accurately reflect the distribution of surface temperatures on the ASTER TIR image.

In the "Edit Raster Color Slices: Raster Color Slice" window now on your screen, *save* the color density slices as a shapefile. *Drop-down* menu on diskette (6th icon from left) > Export as Shapefile…

Name your shapefile "YourName_ASTER_Temp_Density_Slice"
If you have access to a GIS, *load* this shapefile and color-code.

Upload your shapefile to the instructor.

NOTE: Converting a raster color density slice image to a vector polygon shapefile enables you to improve the symbology and legend, and fuse with other layers in your GIS. The nighttime surface temperature shapefile is awesome when faded and draped on the 30-meter SRTM DEM (available in the Remote Sensing Digital Database, Chapter 5 Thermal IR folder)

3) <u>Mosaicking.</u>
This exercise is quick and simple with ENVI. We will load two overlapping color images acquired by a USGS drone and digitally mosaic them into one image.

Remove all files from the Data Manager and Layer Manager.

The two georeferenced images are in the Remote Sensing Digital Database.

File > Open   Open the folder "Ch_8_sUAS_Manned-Aircraft" and its subfolder "UAS_USGS_West Fork Mine". The two images to load are

"dji__0260_georef_GIS.tif" and "dji__0770_georef_GIS.tif"

Zoom to Extents

With the Cursor Value, roam over the black edges around the images.

Question 3: What is the DN at the black edges of the two images?

ENVI Toolbox > Mosaicking > Seamless Mosaic > green **+** *sign (Add Scenes)*

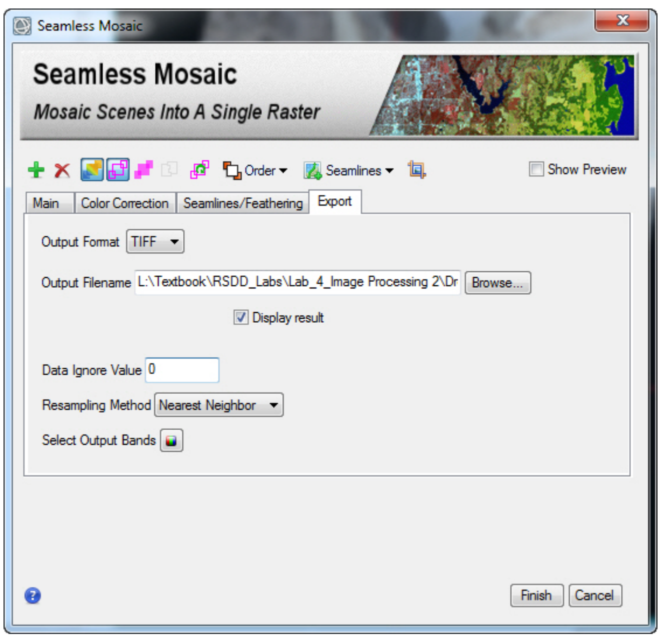
In the "Data Selection" menu, *select* both images *(ctrl key)* or *Select All > OK*

Click-on the *"*Color Correction" *tab > do not check* Histogram matching
(the mosaicked image is overly bright if you check this function)

Click-on the *"*Seamlines/Feathering" *tab > check* None

Click-on the *"*Export" *tab > "*Output Format" *dropdown menu* TIFF
"Output Filename" > "Drone mosaic"
"Data Ignore Value" . "0"   (zero – so the black margins that overlap are transparent)

Click "Show Preview"   (see tool and tabs below)



Check the preview. If OK, *Click* Finish

The processing could take a minute or two. The mosaic is over 160 MB.

Zoom in along the seam between the two images. (Scale 1:250).

Let's save a thumbnail jpg and upload it to the instructor.

File > Chip View To > File   *Choose* "Output Format" as JPEG.

Name the file "YourName_drone_mosaic_thumbnail"

No need to display. Look at it when it is saved to your folder for this lab.
My thumbnail was tiny – 60 KB and it looked OK!

Upload thumbnail jpg to the instructor.

4) Masking.

Exit the GIS-look ENVI that we have been using, and open ENVI Classic.
I find that older ENVI Classic is much more efficient at generating a Mask from a multispectral data set compared with the new ENVI front end.
I have included the Masking exercise with the new ENVI front end as an alternative supplement at the end of the Lab Manual.

We are going to use a Landsat TM SWIR1 band (TM band 5) to **mask** water around islands in the Bahamas so we only process the features on the islands without interference or noise from the water.

The textbook Chapter 3 discusses how Landsat was used for generating a bathymetry map of the seafloor in this area. Plate 9 and Figure 3-16 show the enhanced satellite image with masks that you will be using in this exercise.

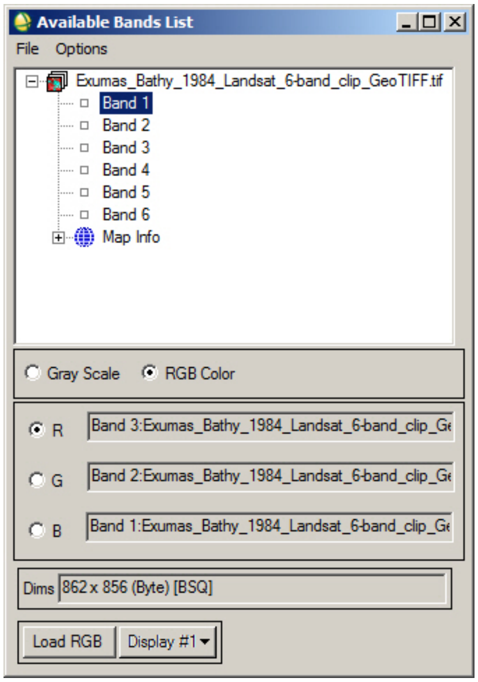
The Landsat data is in the Remote Sensing Digital Database \ Ch_3_Landsat folder.

In ENVI Classic   *File > Open Image File*

Follow this path: \ Plate_9_Bathymetry \ Original_Landsat_Data

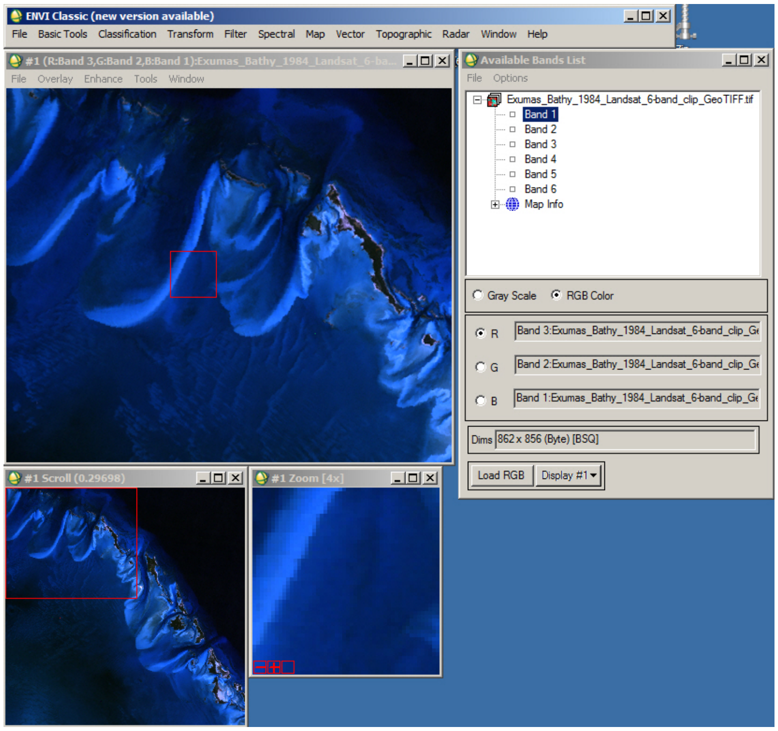
to the "Exumas_Bathy_1984_Landsat_6-band_clip_GeoTIFF" data > *Open*

An "Available Band List" window pops up with the six bands. (see below).



Click the “RGB Color” button > *Click* on Band 3 first, Band 2 second, and Band 1 last to create a natural color image (reflected red-green-blue light as R-G-B).

Click-on “Load RGB”. A 3-window display pops up. The color image is automatically loaded in “Display #1” with its 3 windows.The full scene is in the lower left “Scoll”, a 1:1 zoom factor image is in the large (“Image”) window (outlined in red on the “Scroll” window), and an enlargement is in the “Zoom” window (outlined in red on the “Image” window. The “Available Band List” is to the right. See below.



NOTE: Remember that Landsat TM 30 m bands are numbered 1-5 and then 7 (SWIR2). See textbook Table 3-1. TM band 6 is a 60 m thermal IR band. We did not include the thermal IR band in our layer stack, so TM band 7 is listed as "band 6" by ENVI (and other image processing software).

4a) You are looking at a natural color image of the clear water, underwater sand bars in shades of blue, and white carbonate sands around the islands.

Access one "Contrast Stretch" tool in the "Image Window" by *clicking-on*
Enhance > In the Drop-down menu *Select* " [Scoll] Linear 0-255"
this will reset the displayed image to the original DNs.

In the "Image" window *Tools > Cursor Location/Value…*

A "**+**" shows up in the "Image" window and a small "Cursor Location/Value" window pops up. If you are looking at the original data (not contrast-stretched) the "Scrn:" and "Data:" R-G-B DN values are identical.

Move the *Cursor Value* tool around the image to understand the range of DNs in the water and on land.

To brighten the color image *Enhance* > "[Scroll]" Linear 2%

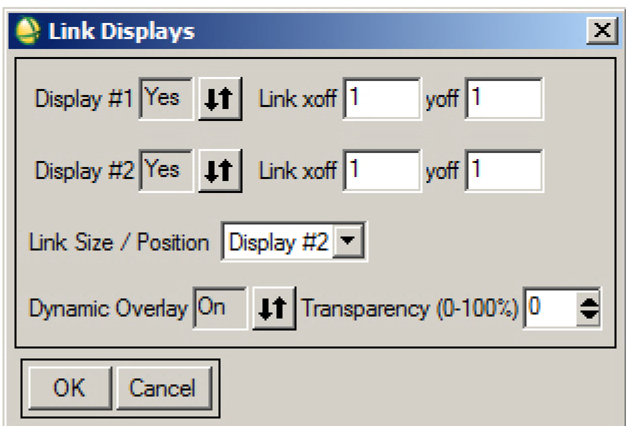
Move the *Cursor Value* tool around the image. Note how the enhanced pixels on the screen ("Scrn:") have DNs that are different compared with the original "Data:"

Now we will compare the individual grayscale bands to the natural color image by opening up a second Display ("Display #2).

In the "Available Bands List" menu, *click-on* "Band 1" >
click-on "Gray Scale" > *click-on* "Display #2" > *New Display* >
click-on "Load Band"
Band 1 pops up in Display #2 to the right of Display #1.

4b) Let's link the two views so we can compare the color image to the bands.
In Display #2 *Tools > Link > Link Displays*

The "Link Displays" window pops up. *> OK*



Choosing to start the link in Display #2 makes Display #2 the master when moving around the scene

Now you can move the Image rectangle outline in the "Scroll" window of Display #2 around to see different parts of the scene in color and as grayscale bands.

Sequentially display Bands 1 through 6 in Display #2. *Contrast-stretch* as needed with the *Enhance* tool. Press the Image or Scroll window with the cursor and the linked Display image is shown.

In the Cursor Location/Value tool, look at the original DN value for the grayscale bands as you roam around from shallow to deeper water. The original DN values are on the "Disp #2 Data:" line.

Question 4: A. What happens to the visibility of the underwater sand bars and ripples on the sea floor as you display the blue, then green, and then red bands? (Hint: read the textbook Chapter 3 and look at Plate 9)

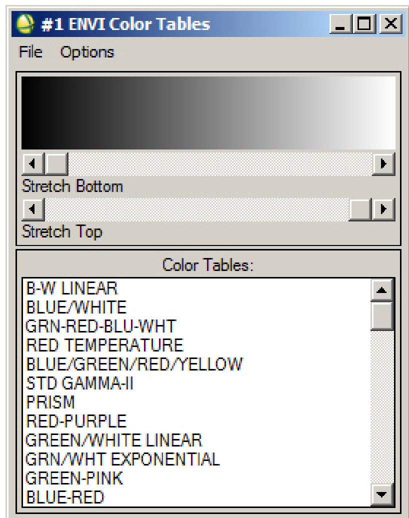
B. Why?

C. What happens to the brightness of water as you display the reflected infrared bands (Bands 4, 5, 6)? (*Contrast-stretch* each band to make the change more clear).

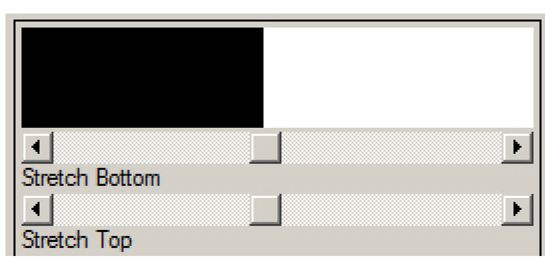
D. Why?

4c) Landsat TM band 5 (SWIR1) does a good job of differentiating water from land. Using the "Available Band List" *Load Band* > Band 5 as a "Gray Scale" into Display #2.. Now we will make a binary (black and white) image of Band 5 in Display #2.

Tools > *Color Mapping* > *ENVI Color Tables* (see below)



The B-W Linear grayscale from black to White should be displayed. (See above). Move the stretch buttons toward the center of the sliders. You are doing a linear stretch, with the top slider moving pixels toward the left side to pure black (DN = 0) and the bottom slider moving pixels toward the right side to pure white (DN = 255). Align the slider buttons so the black-white pattern has a sharp boundary (see below). This could be termed a "Linear 50%" contrast stretch.

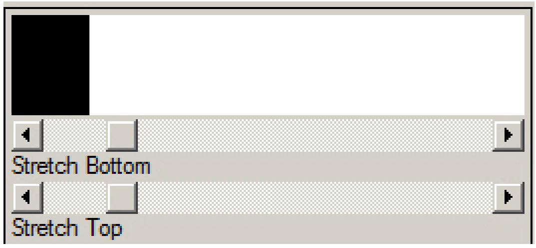


Look at the Band 5 image in Display #2. The pixels are only black or white. (See “Cursor Location / Value” “Disp #2…Scrn:” DN values).

Our goal is to display islands as white and water as black. The Linear 50% stretch is excessive - a significant portion of the land on the islands is black which should represent water.

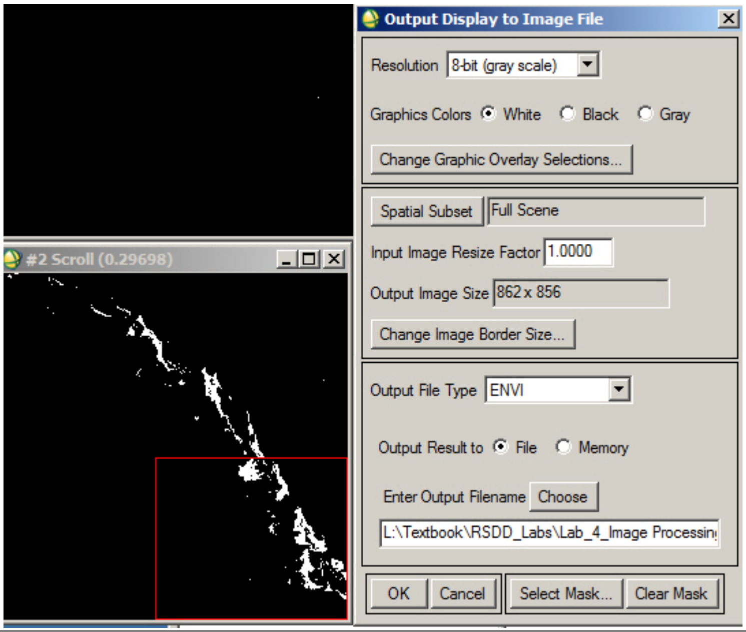
Redo the sliders on the “#2 ENVI Color Tables” window. Move the vertical Black-white boundary left so that the land on the islands is displayed as white.

Press the Image or Scroll window with the cursor and the linked Display image is shown. This will help you determine when you have an appropriate land – water boundary. I decided on the following black – white boundary.



Note that there are lakes on the islands and the white sands may be saturated – so the SWIR TM band 5 records these as dark pixels. These pixels are in the black water class.

To save our TM Band 5 Black-White image we use Display #2 Image drop-down menus *File > Save Image As > Image File* The Output Display to Image File window pops up.



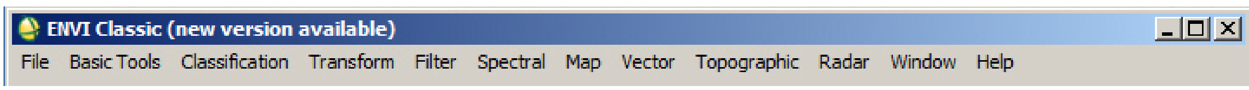
Choose the defaults. The "Resolution " is "8-bit (gray scale)" Save the image as "TM_Band5_BW_8-bit_ENVI"

The saved image automatically shows up in the "Available Band List" and is highlighted so it easily displays next.

"Available Band List" > *push* "Display #1" button > *New Display* > *push "Load Band"* Our TM Band 5 8-bit image is loaded into Display #3.

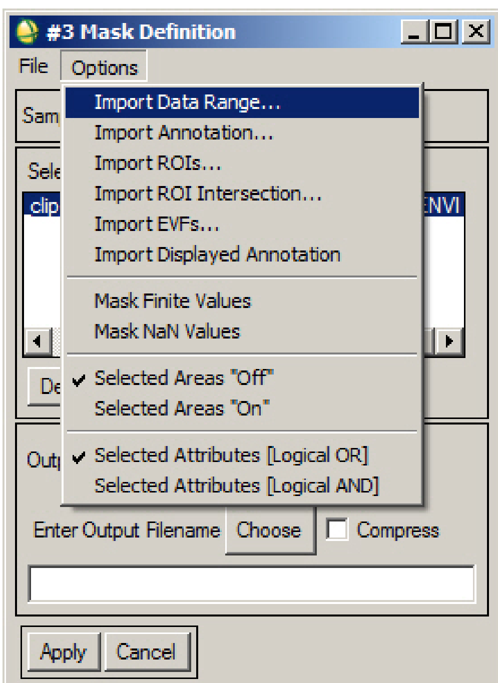
4d) Build the Mask. Now we will convert our 8-bit grayscale image (with 255 levels of gray even though only 0 and 255 are used) to a Mask with DNs of 0 and 1.

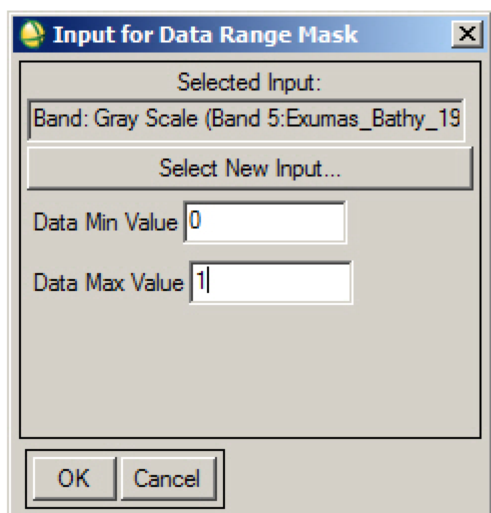
We use the drop-down menus on the ENVI Classic Toolbar (see below).



Basic Tools > *Masking* > *Build Mask* *Select* Display #3

The "#3 Mask Definition" window pops up. Our TM Band 5 8-bit image is highlighted by ENVI. *Options* > *Import Data Range* (shown below on left)





The "Import for Data Range Mask" menu pops up. Enter 0 and 1.
This sets the mask for "water" > *OK*

In the Options drop-down menu ensure "Selected Areas "Off"

Name the Mask “Water_Mask_0-1_Off” so that you remember you used 0-1 and “off” in the Mask Definition.   > *Apply*

NOTE: The combination of 0-1 and “off” in the Mask Definition ensures that the mask will be opaque over water pixels and transparent over land pixels so water will not interfere with processing analysis of the land cover on the islands.   This is always confusing and trial & error with these parameters seems to be the typical way to get the Mask you want…

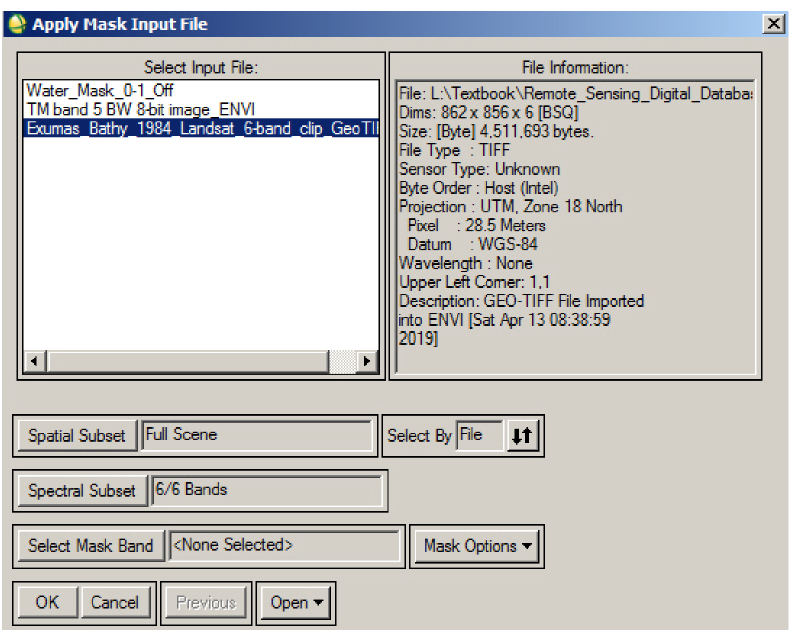
The mask automatically loads into the “Available Band List” and is highlighted.
Push “Display #...” drop-down menu and *choose* “New Display”
Push “Load Band?

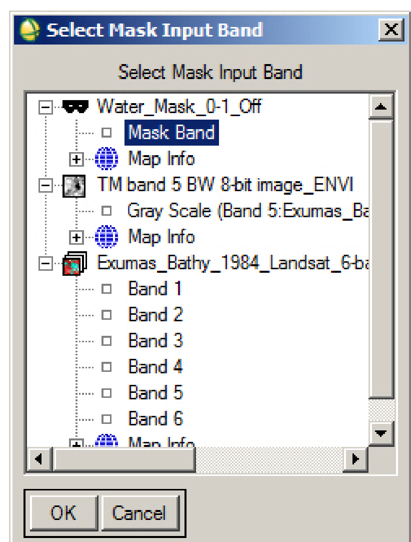
Move your Cursor Location/Value tool over the water and land. They should have DNs of 0 and 1, respectively.

4e) Apply the Mask

ENVI Toolbar > *Basic Tools* > *Masking* > *Apply Mask*
The “Apply Mask Input File” window pops up. This is the data we want to mask – the 6-band Landsat dataset.

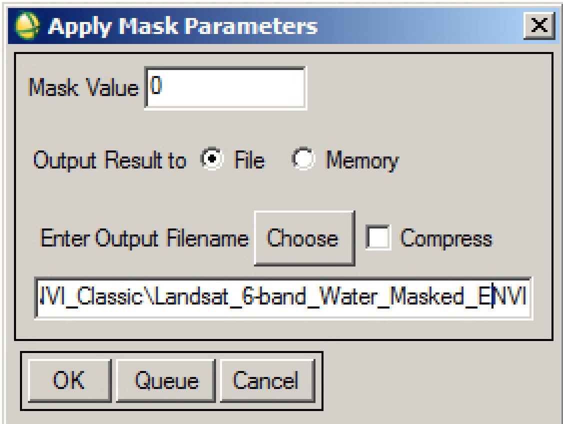
“Select Input File:”   *Select* the 6-band Landsat dataset > *OK*
Buttons pop in on the “Apply Mask Input File” window (see below)





Click-on the “Select Mask Band” button. Our water mask shows up at the top of the “Select Mask Input Band” window (see above)   > *OK*   > *OK*

An "Apply Mask Parameters" window pops up. (see below)



Name the file "Landsat_6-band_Water_Masked_ENVI" > *OK*

The masked Landsat displays in the "Available Bands List"

Display a color IR image (TM bands 4-3-2 as R-G-B)
Click the "RGB Color" > *Push* the "Load RGB" button
Your masked color image will display in your last Display.

Move the Zoom window over a large island > *Enhance* > *[Zoom] Equalization*
You are contrast-stretching using **only** the pixels in the Zoom window.
This stretch reveals <u>significant</u> differences in the vigor of vegetation on different islands and within larger islands.

4f) Our masked ENVI color IR Landsat is more useful in GIS so others can view it – and we could import our color IR image into Google Earth if it was a geoTIFF.

We want to save the 3- band color composite so we use the ENVI <u>Image</u> menus
File > Save Image As > Image File…
Choose "Resolution" drop-down menu "24-bit Color (BSQ)
Choose "Output File Type" drop-down menu "TIFF/GeoTIFF

Name the GIS-ready dataset:
"YourName_Landsat_ColorIR_Masked_Water_GIS" > *OK*

Upload the 24-bit GIS-ready color IR image to the instructor.

If you have access to a GIS, load the 6-band multispectral dataset.

Lab 4 Image Processing 2 Name:

Upload the following files to the instructor:

(1) "Your Name_ASTER Temp GIS.tif" geotiff

(2) "YourName_ASTER_Temp_Density_Slice" shapefile

(3) "YourName_drone_mosaic_thumbnail" jpg

(4D) "YourName_Landsat_ColorIR_Masked_Water_GIS" geotiff

Question 1: A. What is the range in DN values (min – max)?

B. What is the DN range for the bin with the highest Count (located at the peak of the histogram)?

Question 2: A. What is the highest temperature in °C recorded by the ASTER TIR system? (Hint: Refer to the *Quick Stats* Histogram table)

B. Do you think you should use this highest temperature if only one pixel recorded it? YES or NO

Question 3: What is the DN at the black edges of the two images?

Question 4: A. What happens to the visibility of the underwater sand bars and ripples on the sea floor as you display the blue, then green, and then red bands? (Hint: read the textbook Chapter 3 and look at Plate 9).

B. Why?

C. What happens to the brightness of water as you display the reflected infrared bands (Bands 4, 5, 6)? (*Contrast-stretch* each band to make the change more clear).

D. Why?