

### Lab 3 Image Processing 1

Utilizes Textbook's Remote Sensing Digital Database: *Chapters 3 and 4 data*.

The objectives of this lab are to learn the processing tools that are used for Preprocessing and Image Enhancement (see Chapter 9 Digital Image Processing for discussion). The tools used in this lab are in the **ENVI Toolbox**:

- Statistics (complete, including correlation matrix)
- Resize Data
- Rotate/Flip Data
- Layer stacking
- Edge enhancement

Some files are in the **Lab\_3\_Data** folder. Five questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout. Three digital files are to be uploaded to the instructor.

**IMPORTANT NOTE:** ENVI 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 display enhancements and original scale (choose Zoom Factor 1.0000).

#### 1) Statistics

We will use a Landsat 8 data set located in the "Remote Sensing Digital Database \ Ch\_3\_Landsat" folder. *Open* the subfolder named "Plate\_6\_1979-2016\_Saudi\_Change".  
Open the subfolder "Landsat-8\_2016\_OLI-TIRS".

Open ENVI. *File > Open*

"Saudi\_Landsat8\_2016\_Bnds1-7\_10-11\_Stack\_Clip\_ENVI\_"

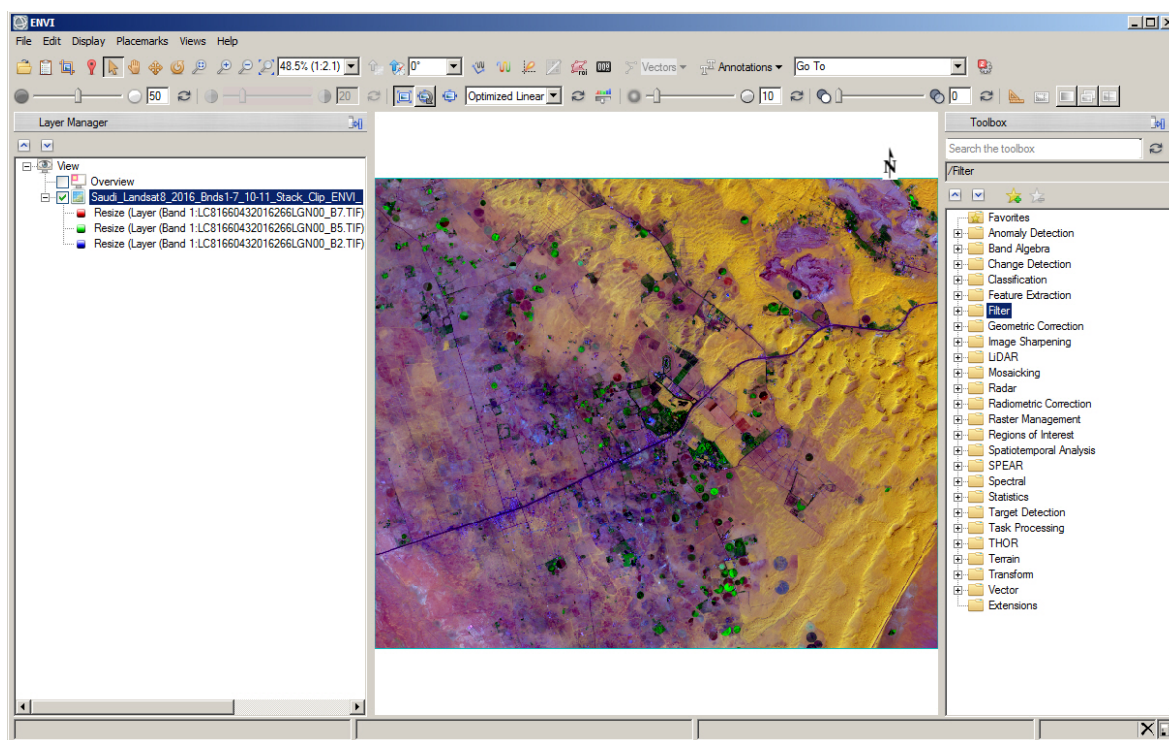
This Landsat data has 7 VNIR-SWIR bands and two TIR bands. We will evaluate the statistics for OLI bands 2-7.

*Zoom to Full Extent, File > Data Manager* So you can see all the bands.

*Right-click* on file in Layer Manager > *Change RGB Bands..*

*Load 7-5-2 as R-G-B.* (these are SWIR2 – NIR – Green bands)

Your display should appear as below – note the Toolbox on the right.



### *Toolbox > Statistics > Compute Statistics*

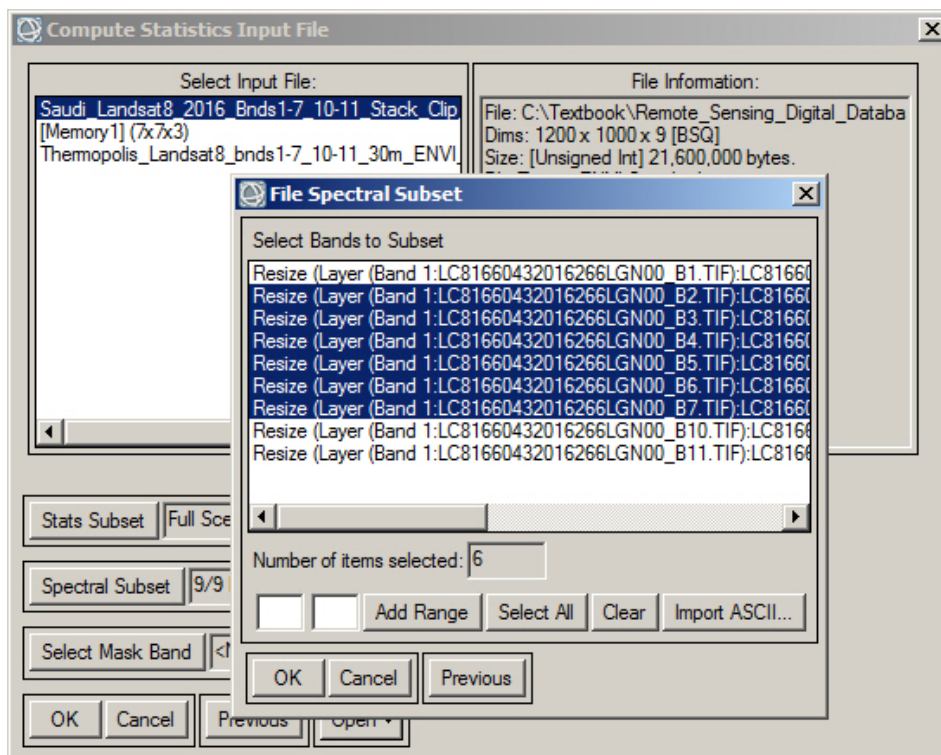
A “Compute Statistics Input File” menu pops up. Highlight the Saudi Landsat 8 input file. We want to show statistics on the **six** VNIR-SWIR bands that record reflected blue, green, red, NIR, SWIR1 and SWIR2 light (Landsat OLI bands 2 – 7). To do this, *click* on the “Spectral Subset” button that has “9/9 bands” displayed.

A smaller menu “File Spectral Subset” pops up. We will select bands 2 – 7 with the Shift or Ctrl key, and then press *Add Range > OK*

Note the “Spectral Subset” number changes to “6/9 Bands” on the “Compute Statistics Input File” menu.

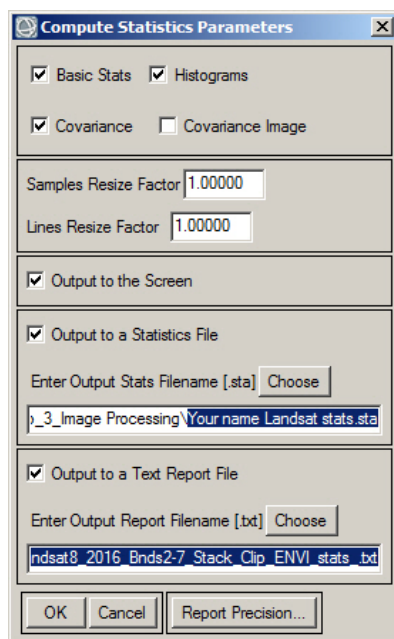
> *OK* on the “Compute Statistics Input File” window (lower left)

See menu below for selecting 6 of the 9 bands.



A “Compute Statistics Parameters” menu pops up. (see below) Check all the boxes.

Accept the default names for the ENVI statistics .sta file and the .txt Report FileName. If the default name is blank, use “VNIR-SWIR\_stats...”



Click OK when done.

A Statistics View window pops open because the “Output to the Screen” option was checked. This Toolbox report is more complete than the Quick Stats report.

Push the triangle in the white strip on the right vertical bar next to the chart to reveal details and edit colors and data values.

At the bottom of the window are tables. *Scroll* down to the “Correlation” table.

1.000 is perfect correlation. The more highly correlated the bands, the higher the correlation value. Band have perfect 1.00 correlation to themselves in this table (also called a Correlation Matrix). Negative correlation values (-) indicate that when pixels are light in one band they are dark in the other band.

Question 1: (Provide correlation values to the nearest two decimal places).

- A. What is the correlation between OLI bands 3 (green) and 2 (blue)?
- B. What is the correlation between OLI bands 4 (red) and 2 (blue)?
- C. What two bands have the least correlation (most difference spectrally)?
- D. What two bands have the highest correlation (most similar spectrally)?

Open the text document that lists the statistics.

2) Let’s look at the image in two ENVI views that are linked. The Saudi Landsat scene has active sand dunes, some pivot irrigation plots, and stabilized barren ground without vegetation.

*File > View > Two Horizontal Views*

*Right-click* on file in Layer Manager > *Change RGB Bands..*

View 1: *Load 4-3-2 as R-G-B.* (these are the visible bands).

*Drag and drop the color image from View 1 to View 2*  
(you can also load View 2 using the Data Manager)

View 2: *Right-click* on file in Layer Manager > *Change RGB Bands..*

*Load 5-4-3 as R-G-B* (this is a color IR image).

*File > View > Link Views > Link All*

Use the Pan to roam around both images. Zoom in and out. Interpret what is displayed in the scene

*Right-click* on the Landsat dataset in one of the Views in the Layer Manager

> *Band Animation*. Slow down flicker. You can pan around while flickering.

Question 2: Compare the visual gray tone of the sand dunes in the northeast and east of the band 2 (blue) and the three reflected infrared bands (5-7). Does this match the values in the correlation table? Explain.

3) Let's look at a Scatter plot of the 9-band Saudi Landsat data. *Return to one view.*

*Views > One View*

Only the 9-band Landsat file should be checked in the Layer Manager.

*Display > 2D Scatter Plot*

Compare different combinations of bands.

Save an image of the band 2 versus band 5 scatter plot.

*File > Save Plot As > Image...* "Your name\_bands\_2-5\_Scatterplot"  
save as a jpg or png.

*Upload* your image of the Scatterplot to the instructor.

Question 3: How does the scatter plot of bands 2 and 3 and the plot of bands 2 and 5 compare to the correlation table values?

4) Resize Data We will clip out a subscene of Band 5 (NIR) from the 9-band Saudi dataset.

*ENVI Toolbox > Raster Management > Resize Data*

"Resize Data Input File" window pops up. *Highlight* the Saudi Landsat 9-band dataset if needed.

*Click* on ""Spectral Subset" button. "9/9 Bands" is shown next to this button. A "File Spectral Subset" window pops up. Highlight Band 5 > Add Range and "1/9" shows up in the text next to the Spectral Subset button on the Resize menu. > *OK*

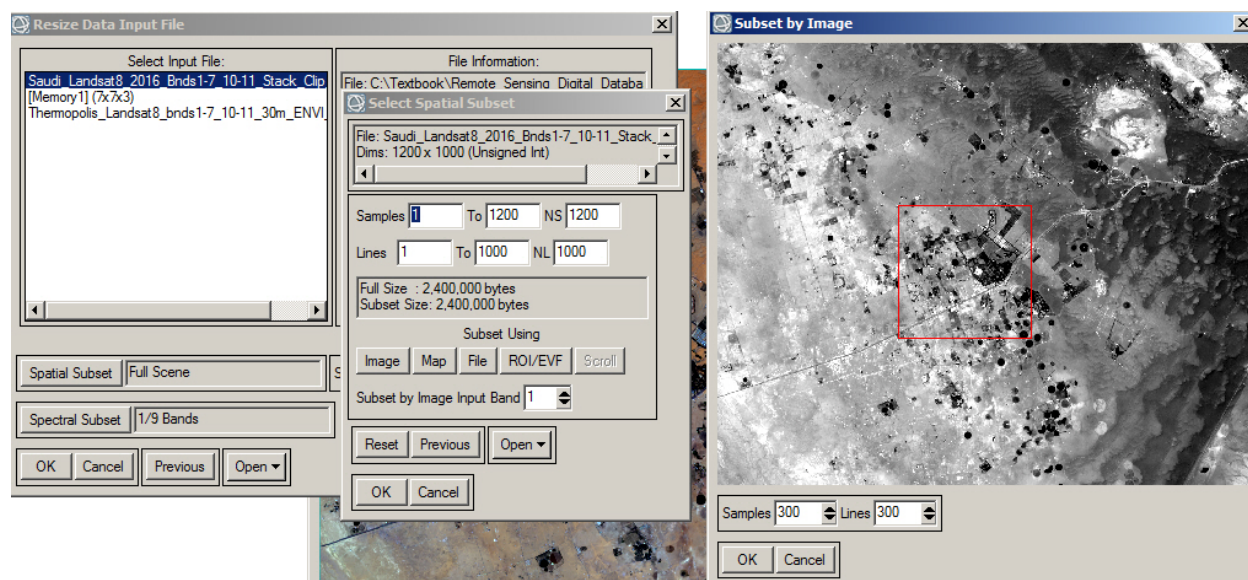
*Click* on "Spatial Subset" button > "Select Spatial Subset" window pops up. (see screen capture below)

> *Click* on "Image" > "Subset by Image" window pops up.

> *change* Samples and Lines to 300 x 300

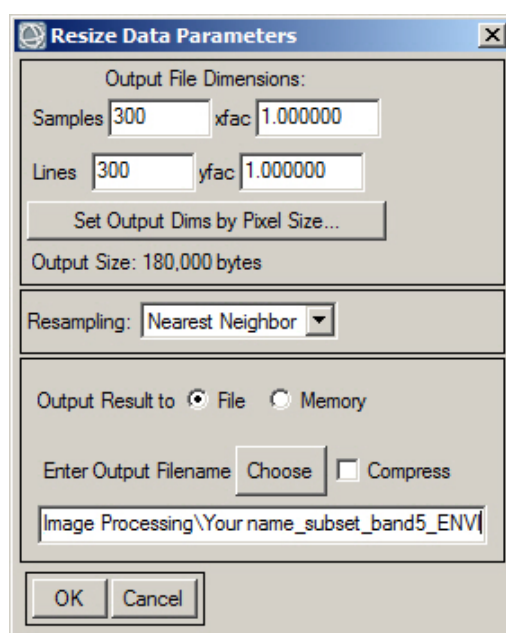
> *move* subset box to center of image > *OK* > *OK* > *OK*.

The menus are displayed below with the 3 OK buttons.



A “Resize Data Parameters” window pops up showing the 300 x 300 dimensions of the subset area. (see below).

Name the subset image “Your name\_subset\_band5\_ENVI”. The image will be in ENVI format (.img with .hdr file) > OK



Resize menu

The resized ENVI image will display in the center of the larger image in the ENVI view and will be listed in the Layer Manager.

We want to make the clipped band 5 NIR grayscale image more useful for GIS, so we will next convert the ENVI image to the universal **geotiff** format.

*Highlight the resized file in the Layer Manager*

*File > Export Selected Layer to TIFF*

**NOTE:** The same export tool is available with *Right-click* on the resized file in the Layer Manager > *Export Layer to TIFF*

*Rename the file “Your name\_subset\_band5\_geotiff”*

Check the “Display result” box > *OK*

Upload your geotiff of the resized image to the instructor.

5) Rotate/Flip Data We will use an image that does not have any coordinates. This tool is useful when georeferencing scanned images and maps to place them in a position where N is approximately up.

*Right-click View > Remove All Layers*

In the Lab\_3\_Data folder is a grayscale image without coordinates from Lab 1 named “E 8-bit.tif”

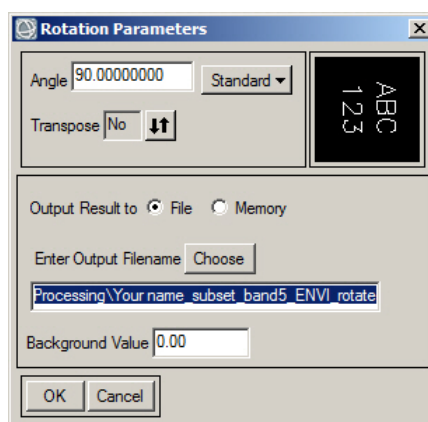
*File > Open > “E 8bit.tif” > Zoom to Full Extent*

*Right-click “E 8bit.tif” in the Layer Manager > View Metadata.* Does this image have any coordinate information?

*Toolbox > Raster Management > Rotate/Flip Data*

*Select “E 8-bit.tif” in the Rotation Input File menu. > OK*

In the “Rotation Parameters” menu, *Choose the “Standard 90”*





*Rename* the rotated ENVI file “Your name\_rotate 90\_ENVI”

The rotated file automatically displays in ENVI.

*Upload* the rotated image and the same-name .hdr file to the instructor

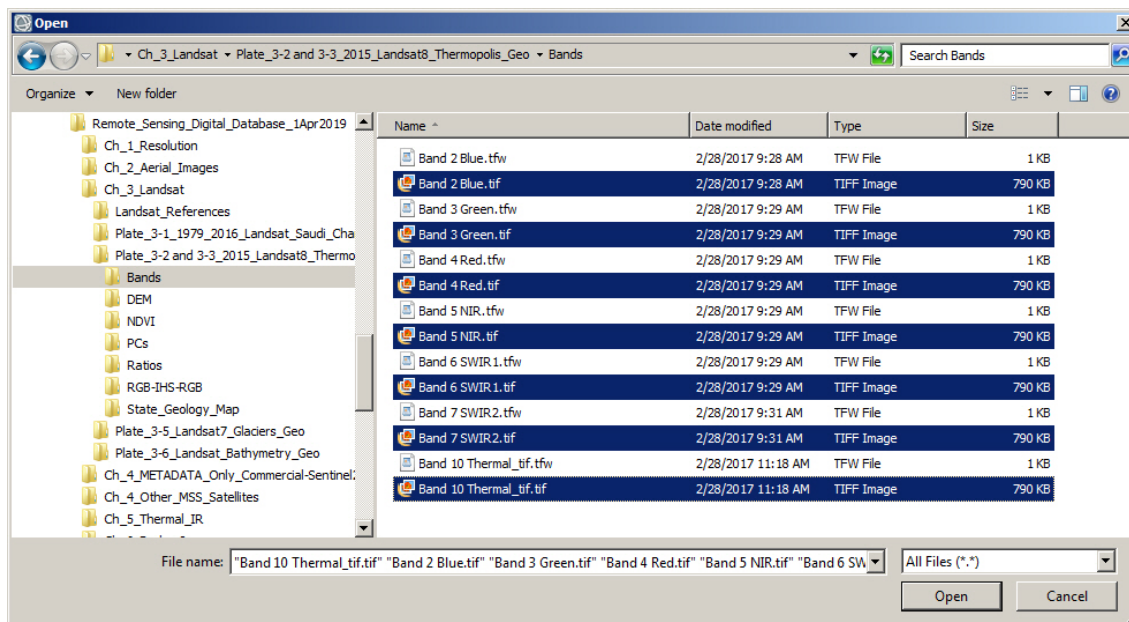
6) Layer stacking Landsat and other multispectral data are delivered as individual bands. In order to generate spectral profiles, complete spectral classification, and do other image enhancement tasks, the bands have to be stacked into one database.

We will use the Landsat 8 bands of Thermopolis that are located in the “Remote Sensing Digital Database \ Ch\_3\_Landsat” folder. Open the subfolder “Plates\_7and27\_Thermopolis”. Open the subfolder “Bands”.

You will see bands OLI bands 2 – 7 and TIR band 10 as .tifs with .tfw files (the .tfw contains georeferencing information).

In ENVI, *Right-click View > Remove All Layers*

*File > Open* highlight the seven .TIFF files > *Open* (see below)



The seven bands should be displayed in ENVI. *Zoom to Full Extent*

*Toolbox > raster Management > Layer Stacking*

The “Layer Stacking Parameters” window pops up > *Import File...*

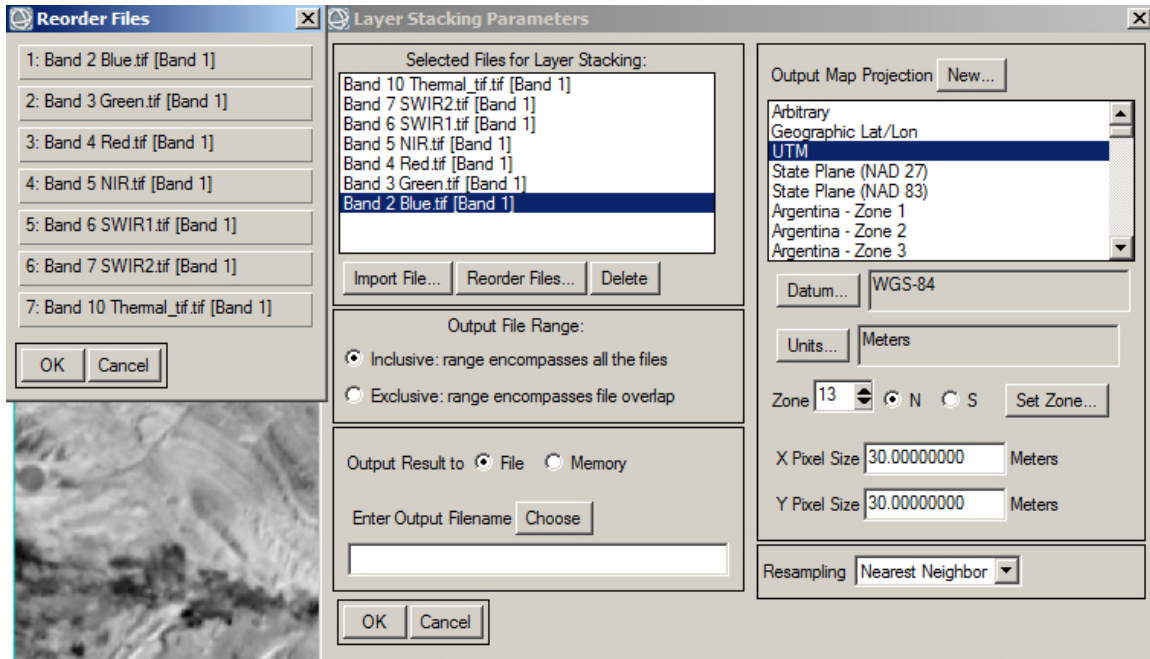
The “Layer Stacking Input File” window pops up.

*Highlight* the seven bands > *OK*



In the “Layer Stacking Parameters” window the georeferenced bands automatically fill in the map projection parameters. > *Reorder Files...*

See below. Reorder if band number are not sequential (2 to 7 and then 10) > OK



Name the output stack “Landsat8\_Thermopolis\_Stack\_7 bands\_ENVI”

The Data Manager will list the 7 bands.

Display different color combinations of your new stacked Landsat bands.

## 7) Edge Enhancement

Let’s remove all the layers in the view and load a commercial, high spatial resolution image discussed in the textbook Chapter 4 (see Figure 4-9). The data is provided by DigitalGlobe. The scene covers a portion of Tokyo with their Worldview-3 satellite (WV-3).

*Right-click on View > Remove* all the other images in the View.

*File > Open > “Remote Sensing Digital Database \*  
*Chapter\_4\_Other\_MSS\_Satellites” \ High\_resolution\_Satellites \*  
*Worldview-3\_pan-MSS\_Tokyo” folder*

*Select “Tokyo\_WV-3\_4-bnd\_30cm\_pan-sharpened\_MSS\_11-bit\_GeoTIFF”*  
*> Open*

We'll create a natural color image with 30 cm spatial resolution. DigitalGlobe delivers data with bands 1, 2, 3, 4 as reflected blue, green, red, near IR light.

*Select Band 3 – Band 2 – Band 1 as Red – Green – Blue*

*Zoom-in* to the lower left corner so the two red & white construction cranes, the street below, and the southwest corner of the baseball stadium is in your view.

*Set scale to 1:300*

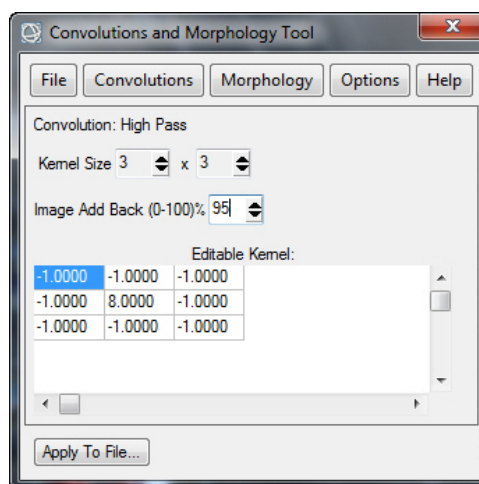
Let's use the Sharpen Slider in the 2<sup>nd</sup> from top row of icons to see what happens with high pass and low pass filters.

Question 4: A. Describe the change in visual appearance of the red & white construction cranes when the Sharpen slider is set to 100 and to the far left of the slider (beyond the no change vertical line on the slider).

B. What level of sharpening provides an image that you find most informative (answer with the number to the right of the slider)

To improve our understanding of edge enhancement, we will now use the **Toolbox** for high pass and low pass filtering of our Tokyo 4-band dataset.

Chapter 9 Digital Image Processing has an extensive discussion on edge enhancement (see Figures 9-14 to 9-18). We will be using a High Pass filter that is similar to the Laplacian filter shown in Figure 9-14, but the center and corner pixel values are different. See ENVI Tool below that is opened via the Toolbox.



*Filter > Convolutions and Morphology*

Press the buttons across the top to see the many possible variations.

Click on the Help button to obtain a better understanding of the tools.

The high-pass filter that we will use is shown above. This filter “....Removes the low frequency components of an image while retaining the high frequency (local variations).” ENVI Help.

As a recap of what is discussed in Chapter 9, let us assume that the 3 x 3 filter cell is on a pixel with a DN value of 52. The algorithm does the calculation shown below for the center cell to every pixel in the image...except along the margin of the image! The center pixel is changed from 52 to 64 in the example below.

$$[-65 + -55 + -65 + -60 + 416 + -60 + -60 + -55 + -60] = [416 + -480] = +64$$

Original DNs				High Pass Filter				Edge Enhancement		
65	55	65		-1	-1	-1		65	55	65
60	52	60	→	-1	8	-1	→	60	64	60
60	55	60		-1	-1	-1		60	55	60

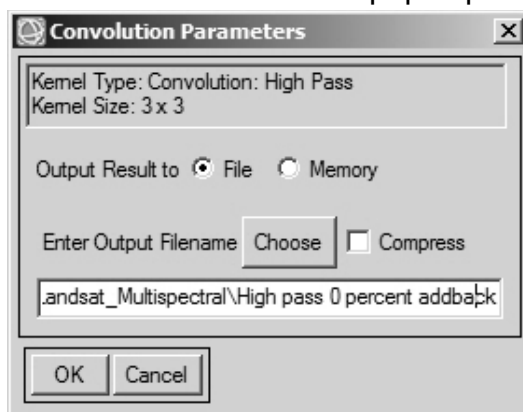
First we will do the high pass filter with 0% image add back.

*Filter > Convolutions and Morphology > 0% Add Back > Apply to File*

A “Convolution Input File” window pops up – select the Tokyo 4-bnd dataset.

Apply this high pass filter to all four bands – so just say *OK*

The Convolution Parameters window pops up – name your file



You should see something like the image below – a high pass filter applied with 0% add back on the Tokyo satellite image – edges are emphasized....maybe good for input to AI and fracture/fault/linear feature detection... but not a visually pleasing image. You usually have to do some contrast stretch to make the image appear without being oversaturated (blown out).



Repeat the Convolutions and Morphology high pass filtering, but change the Add back to 95%. Addback means the percentage of the original image added back to the edge-enhanced image. 95% Add back is often used to create a sharper image for interpretation.

In the ENVI Layer manager compare the original color image with the image that has been edge-enhanced with a high pass filter but with 95 % image add back. Is the 95% add back more informative compared to the original?

Let's do a Low-Pass Filter. Low pass filters "...Preserves the low frequency components of an image, which smoothes it." ENVI Help. Low pass filters are useful for noisy data and used extensively in geophysics.

Toolbox > *Filter* > *Convolutions and Morphology* > *Convolutions* > *Low Pass*

*Kernal size = 3     0% Image Add Back*

*Repeat but with Kernal size = 13     0% Image Add Back*

Question 5: What is the difference in image appearance when a low pass filter with a 3 x 3 kernal is applied compared with a low pass filter with a 13 x 13 kernel?

**Lab 3 Image Processing****Name:**

Upload the following files to the instructor:

(3) "Your name\_bands\_2-5\_Scatterplot"

(4) "Your name\_subset\_band5\_geotiff"

(5) "Your name\_rotate 90\_ENVI.img" with ENVI .hdr file (two files)

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Question 5: What is the difference in image appearance when a low pass filter with a 3 x 3 kernel is applied compared with a low pass filter with a 13 x 13 kernel?