## Lab 8 RGB-IHS-RGB Transform and Image Sharpening

Utilizes Textbook's Remote Sensing Digital Database: Chapter 4 data.

The objectives of this lab include learning about RGB and IHS (or HSV) color systems, the RGB to IHS to RGB transform, and different techniques for image sharpening. The transform exercise is long & tedious, but it will teach you about different image file types and shortcomings/complicated work-arounds with ENVI software. The tasks are done with tools in the **ENVI Toolbox**.

Six questions are to be answered on the last page of this handout and one digital file is to be uploaded to the instructor.

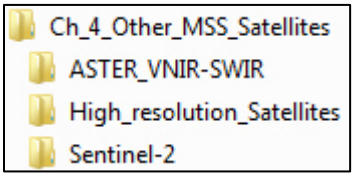
1) RGB-IHS-RGB transform

Chapter 2 discusses the additive and subtractive systems of primary colors Red, Green, and Blue. Chapter 9 discusses an alternative approach to color - the Intensity (Value), Hue, and Saturation system. Figure 9-19 shows the scaling used for the IHS system. IHS is equivalent to HSV (ENVI uses HSV)

Color images often have a pastel appearance because the images are undersaturated. RGB images have their saturation (purity of color) increased by transforming the RGB colors into IHS color space, and contrast-stretching the Saturation grayscale image. After the Saturation image is contrast-stretched, the IHS images are transformed back to RGB colors. See Figure 9-20 and Digital Image 9-1. Edge enhancement and the replacement of the intensity image with the panchromatic band can also be done prior to transforming the IHS images back to a RGB color composite.

We will create an ASTER color IR image from a 9-band ASTER multispectral dataset and contrast-stretch the color IR with a "Linear 1%" stretch.

1a) The 9-band ASTER data set is in the "Remote Sensing Digital Database \ Ch_4_Other MSS_Satellites" folder within the "ASTER_VNIR-SWIR" subfolder.




Start-up ENVI > *File* > *Open* > *drive* to the "ASTER_Geo" subfolder > *select* > "ASTER_2002_Reflectance_30m_9-band_ENVI_.img" > *Open*

*Zoom to Full Extent* > *Choose* "Linear 1%" stretch. You should see a color IR image displayed in the View. *Click-on* the 9-band file in the Layer Manager to ensure that the Bands 3N-2-1 are loaded into R-G-B. ASTER does not collect a blue band, so Band 3N = NIR, 2 = Red, and 1 = Green.

Highlight the 9-band file in the Layer Manager. We will export this enhanced color IR image using *File > Export Selected Layer to TIFF…* > Name the color IR image "ASTER_CIR_Original" and check "Display result" > *OK*

The exported color IR image should look exactly like the 3N-2-1 as R-G-B color composite made from the 9-band data set.

The Chugwater Redbeds in the Red Rose Anticline appear as yellow rocks in a Color IR image (see Figure 3-11H for location if you forgot)

*Uncheck* the 9-band dataset in the Layer Manager.

Let's open 4 Views. *Views > 2 x 2 Views*
The 3-band color IR image is in View 1. *Zoom to Full Extent*

*Highlight* View 2 (empty View in the upper right). This will ensure the IHS (HSV) color composite is displayed in View 2.

1b) First we'll use ENVI's programmed "Saturation Stretch" Tool.
ENVI Toolbox > Transform > *Saturation Stretch*
The "Saturation Stretch Input Bands" window pops up.
*Select* the 3-bands in our CIR original image as R-G-B > *OK*
Name the output "ENVI_Sat_Str_" > *Open* > *OK*
The ENVI saturation stretched CIR image appears in View 2

*Views > Link Views > Link All > OK* (empty Views don't link)

Pan and zoom around, comparing the original CIR image to the ENVI saturated stretch image.

Question 1: Discuss the differences in the colors between the original ASTER CIR image and the ENVI saturated stretched CIR image. Do you prefer the "instant" ENVI saturation stretch or your 2% saturation stretch that you created at the end of this exercise? (see page 7 below) WHY?

How was the Saturation enhancement done??? What steps are involved? Next we'll do our own saturation stretch. First we transform our RGB image to IHS (or HSV) color space.

In the Layer Manager, *drag & drop* the "ENVI_Sat_Str" CIR image into View 1 (so we don't get confused later). You can *uncheck* this image in View 1.
*Right-click* "ENVI_Sat_Str" image in View 2 in the Layer Manager > *Remove*

*Highlight* the empty View 2 so our IHS image is loaded here.

*ENVI Toolbox > Transform > Color Transforms > RGB to HSV Color Transform*
The "RBG to HSV Input Bands" window pops-up.
Sequentially *click-on* Band 1 to Red, Band 2 to Green, Band 3 to Blue > *OK*

The "RGB to HSV Parameters" window pops-up.
Select the Original CIR bands 1, 2, 3 as R, G, B > *OK*
*Name* the file "ASTER_IHS" > *OK*

The HSV color composite displays in View 3. We want to see the individual Hue, Saturation, and Value (Intensity) grayscale images in Views 2, 3, and 4.

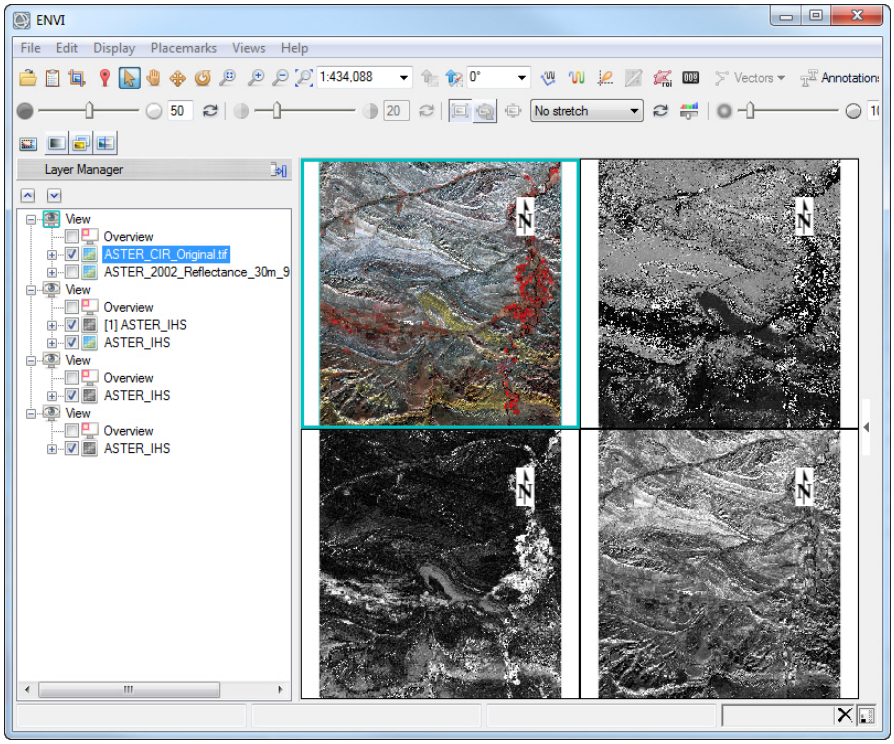
*Open* the "Data Manager"

The "ASTER_HS" I, H, S grayscale images are at the top of the list.
*Highlight* View 2
*Click-on* Hue > Load Grayscale > *Zoom to Full Extent > Linear 1%*

*Highlight* View 3
*Click-on* Saturation > Load Grayscale > *Zoom to Full Extent > Linear 1%*

*Highlight* View 4
*Click-on* Value (Intensity) > Load Grayscale > *Zoom to Full Extent > Linear 1%*

The four views should look like the screen capture below.



*Open* the Histogram Stretch icon to the right of the Contrast Stretch drop-down menu.
Click on each View and look at the histogram. Look at the horizontal scale on the histograms. The scale used on the horizontal axis (brightness) is different for the RGB image (View 1) and the Hue image (View 2). Saturation and Intensity (Value) use the same scale, which is different than the scale used by RGB images and Hue images.

Question 2: A. Which HSV grayscale image has a significant skew to the left (meaning most pixels are dark)?

B) What is the range of brightness for Hue pixels?

C) What is the range of brightness for Intensity (Value) and Saturation pixels?

D) What is the brightness value on the horizontal axis of the Saturation (View 3) histogram when you slide the vertical line to the left so that 95% of the pixels are below that brightness value (Hint: look above the vertical line for the data brightness value and percentage of pixels to the left of the vertical line).

1c) We want to pan and zoom to the same pixels in the four views.
*Views > Link Views > Link All > OK*

*Select* the Cursor Value tool and *click-on* the "Link Views" and the "Display information for all Views" icons located along the top of the tool.

Question 3: With the Cursor Value tool, *Click-on* a light brown – light orange agricultural field (fallow – no vigorous crops growing) in the color IR in View 1. The data values for each type of image are listed in the "Data:" entry space of the Cursor Value window. Write the data values you find for the same feature in the table below

| View | Type of Image | Data Value (brightness) |
|---|---|---|
| View #1 | Color IR | |
| View #2 | Hue | |
| View #3 | Saturation | |
| View #4 | Intensity (Value) | |

1d) We want to brighten the Saturation grayscale image, but we cannot use the "Linear 1%" because that would take the darkest 1% of the pixels and turn them black.

*Highlight* View 3 (Saturation) > *Zoom to Full Extent* > *Change* the contrast-stretch from "Linear 1%" to "No stretch"
*Open* the "Histogram Stretch"
Move the Histogram away from View so you can see how the brightness changes in the Saturation image as you send bright pixels to pure white (1.0)

*Drag* the maximum vertical slider (right side of the histogram) to the left so that 2% of the pixels are brightened to 1.0. (98% of the pixels are to the left of the vertical slider). The brightness value should be 0.8.

NOTE: The bright red, color IR pixels in the irrigated fields may be oversaturated and blend together with this saturation stretch (a visual loss of information).

Now we want to save the brightened Saturation grayscale image.
*File > Export View > Image File* > Ensure "Full" is active >
*Accept* the other Defaults >

*Name* the file "Sat_5pct_brighter_ENVI" > *Display Results > OK*

*Press on the "+"* sign next to the brighter Saturation image (.dat format) in the Layer Manager View 3 list
Unfortunately, ENVI created a 3-band grayscale image when we only want 1 band in the grayscale image!! This is a bad software shortcoming.

"We must save our brightened grayscale Saturation image as a NEW, 1-band grayscale image!

*File > Save As > Save As (ENVI, NITF….)"*
The "Data Selection" window pops-up. Ensure our brightened Saturation image is selected.

*Click on* "Spectral subset" button > The Spectral Subset window pops-up.
Select "Band 2" *> OK > OK* (all 3 bands are identical – so pick any one)

The "Save File as Parameters" window pops-up.
Name file "Sat_2pct_brighter_1band" > Check "Display results" *> OK*

*Uncheck* the older files in View #3 so only our "Sat_2pct_brighter_1band" is checked. >

1e) Right-click on the “Sat_1pct_brighter_1band” file in the Layer Manager.
> *View Metadata* > Raster tab
Our brightened, 1-band saturation image is a Byte data type. 8-bit. DN brightness ranges from 0 to 255.

Look at the histogram brightness values with the Histogram Stretch tool.
Brightness ranges from 0 to 255. (see all the pixels at 255 on the right vertical axis – we sent 5% of the pixels to pure white)

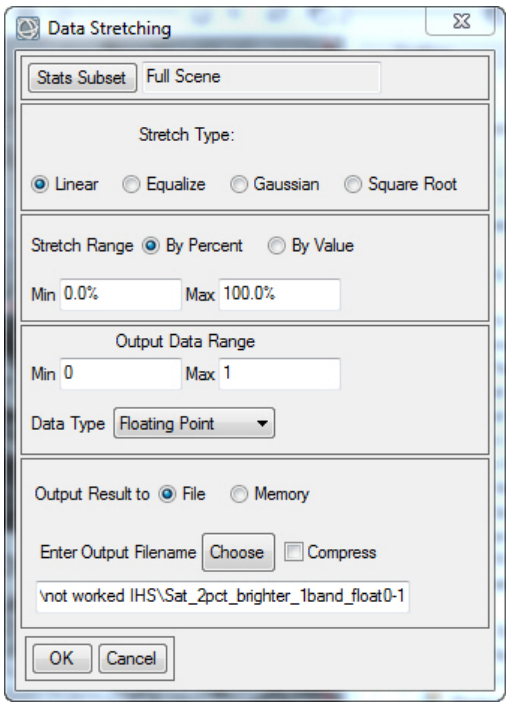
**BUT** our Saturation image in IHS color space was a float (decimal) grayscale image with brightness DNs that ranged from 0 to 1.

1f) So we have to convert our 8-bit image to a float image with DN range from 0 to 1.
*ENVI Toolbox > Raster Management > Stretch Data*
The “Data Stretch Input File” window pops-up.
Ensure our new 1-band Saturation .dat file is selected. > *OK*

The “Data Stretching” window pops up
Accept defaults.

Fill in the “Output Data Range” as Min = 0 and Max = 1
Data Type should be “Floating Point”
name the new grayscale image “Sat_2pct_brighter_1band_float0-1”

(see filled-in menu below)




> *OK*

1g) *Uncheck* other files in View #3. Only our new float grayscale Saturation image should be displayed and *checked* in the Layer Manager

View metadata for our new float image. > *Close*
Look at the histogram with the Histogram Stretch tool –
we can see 0 to 1 on brightness axis!!

We have increased the mean brightness and the standard deviation of the saturated grayscale image by our 2% clip of the brightest pixels.
The original Saturation image had a mean of 0.21 and a StdDev of 0.19

Question 4: What is the mean and StdDev of the stretched saturation grayscale image? (Hint: Quick Stats has the answer). This confirms numerically what we see visually between the original and stretched saturation image.

1h) Now we will combine our Hue, Intensity, and our brightened float 0-1 Saturation image and transform this new IHS combination into a hopefully much more vibrant color IR image!

*ENVI Toolbox > Transform > Color Transforms > HSV to RGB Color Transform*
The HSV to RGB Input Bands window pops-up

The "H" is filled with our "ASTER IHS" Hue Band 1
The "S" is filled with our new brighter, float, 0-1 Saturation image at the top of the list ("Sat_5pct_brighter_1band_float0-1")
The "V" is filled with our ASTER IHS" Val Band 3 > *OK*

*Name* the transformed RGB color IR image "ASTER_my_sat_str_ENVI"

1i) The new color IR image in View #3 is much brighter and vibrant compared with our original color IR image in View #1!! Success!!

To make a useful GIS geoTIFF of the brighter Color IR image in View #3
*File > Export Selected Layer to TIFF >*
name "ASTER_CIR_my_sat_str_GIS" *click* "Display result"

1j) After all that work, let's save a chip view of the brighter Color IR image for the instructor.

*Zoom to Full Extent > File > Chip View To… > File > Select* JPEG
Name your output "YourName_ASTER_CIR_my_sat_str"

No need to display result >*OK*

Upload the jpg to the instructor.

2) Image Sharpening

This will be a short, simple exercise using DigitalGlobe's high resolution satellite imagery over Tokyo. In almost all cases a panchromatic (grayscale) image is acquired with higher spatial resolution compared with the multispectral color bands that collect a narrower wavelength range within a larger pixel. The pan and multispectral bands are collected at the same time, so alignment/registration issues are minimized.

*Start up* a new ENVI display. The data are in "Ch_4_Other_MSS_Satellites" folder, inside the "High_resolution_Satellites" subfolder and its "Worldview-3-pan-MSS_Tokyo" folder.

Read the pdf description of the awesome Worldview-3 satellite is in the Tokyo folder.

*File > Open* drive to the Tokyo folder described above
*Select* "Tokyo_WV-3_30cm_panchromatic_GIS" and
"Tokyo_WV-3_4-bnd_120cm_11-bit_MSS_GeoTIFF"

*Views > Two Vertical Views*
*Drag* the pan image into View #2 > *Remove* the pan image in View #1.

*Views > Link Views > Link All > OK*
*Zoom to Full Extent > Contrast stretch*
*Pan around and zoom in and out –*
*Zoom in* to the baseball field in the lower portion of the image.
Do you see a difference in the level of detail between
the 120 cm color and 30 cm pan images?

**NOTE:** 30 cm is the highest spatial resolution allowed by the U.S. government for civilian applications at this time (April 2019) *Brighten both Views with "Linear 2%"*

Open the "Data Manager"
DigitalGlobe's multispectral band sequence is:
Band 1, 2, 3, 4 = Blue, Green, Red, NearIR

Click on the "**+**" sign next to the multispectral data set.
Bands 3-2-1 are loaded as R-G-B

Question 5: Is the 3-band image displayed in View #1 natural color or color IR?

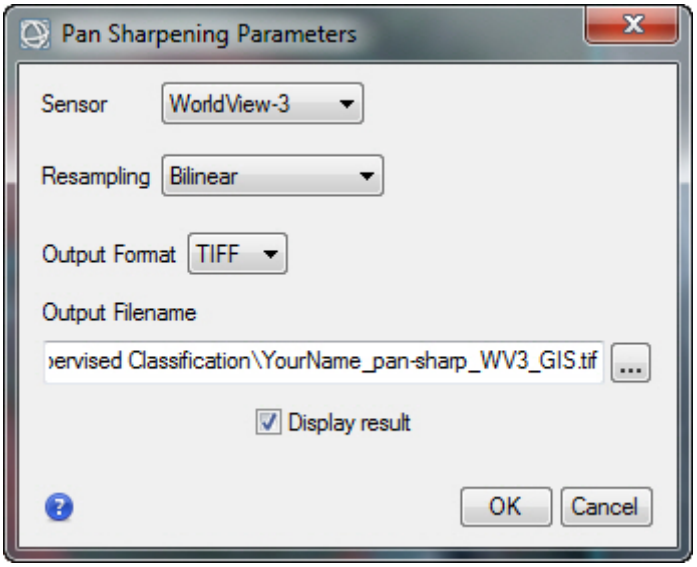
Highlight View #2 with the pan image

*ENVI Toolbox > Image Sharpening > Gram-Schmidt Pan Sharpening*
The "Data Selection" *window pops-up*

*Select* “Low Spatial Resolution Multi Band Input File:”
*Select* the 120 cm data set > *OK*

The “Data Selection” *window pops-up again*
*Select* “High Spatial Resolution Pan Band Input File:”
*Select* the 30 cm pan image > *OK*

The “Pan Sharpening Parameters” window pops-up
Sensor choose *WorldView-3*
Accept Resampling *Bilinear*
Output Format *TIFF* (we are going to load this into GIS)
Name “Your Name_pan-sharp_WV3_GIS”
*check* Display result > *OK* (The filled in menu is shown below)




The fusion or pan-sharpening process can take a long time. There is an activity indicator in the lower right of the ENVI Display window.

NOTE: Use ENVI Help and type in “sharpening” in the Index search box. Learn about the differences with the many tools ENVI offers.

2a) move the 120 cm multispectral data into one view and in the other view display our 30 cm pan-sharpened image.

Both files should default to 3-2-1 as R-G-B. The two Views should still be linked. Contrast stretch both files with “Linear 2%”

*Zoom to Full Extent* Evaluate the imagery and answer question 6A below.
*Zoom-in* to the in-field at the baseball stadium in the lower left corner of the scene and answer question 6B below.

Question 6: A. Do you see much difference in spatial detail when both the 120 cm and 30 cm images are *Zoomed to Full Extent*?

B. Describe the difference in spatial detail when zoomed-in to the baseball in-field at baseball stadium.

C. Each 120 cm pixel covers how much more area compared to each 30 cm pixel? (Can answer with cm-based measurement or a magnitude difference (for example, 5 x more area)

2b) Let's see what a color IR image looks like at the baseball field.

*Right-click* the pan-sharpened 4-band dataset in Layer Manager > *Change RGB Bands* > *select* Band 4 as R, Band 3 as G, Band 2 as *B* > *OK*

*Right-click* the 120 cm, 4-band dataset in Layer Manager > *Change RGB Bands* > *select* Band 4 as R, Band 3 as G, Band 2 as *B* > *OK*

A color IR image should be more detailed compared to a color image because the long wavelength Near IR band is not scattered as much as the short wavelength Blue band by the atmosphere.

Zoom out and then zoom in to the tennis courts in the lower right portion of the scene. The WorldView-3 imagery is discussed and the tennis court features are interpreted in the textbook's Figure 4-9.

Do you see a remarkable difference in clarity between the 30 cm Color IR image and the 120 cm color IR image?

If you have time, try out the other image-sharpening algorithms. The difference in colors and sharpness with different algorithms can be significant.

**Lab 8 RGB-IHS-RGB and Image Sharpening Name:**

Upload the following files to the instructor:

(1j) "YourName_ASTER_CIR_my_sat_str" .jpg

Question 1: A. Discuss the differences in the colors between the original ASTER CIR image and the ENVI saturated stretched CIR image.

B. Do you prefer the "instant" ENVI saturation stretch or your 2% saturation stretch that you created at the end of this exercise? (page 7) WHY?

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| View #4 | Intensity (Value) | |

Question 4: What is the mean and StdDev of the stretched saturation grayscale image? (Hint: Quick Stats has the answer).

Question 5: Is the 3-band image displayed in View #1 natural color or color IR?

Question 6: A. Do you see much difference in spatial detail when both the 120 cm and 30 cm images are *Zoomed to Full Extent*?

B. Describe the difference in spatial detail when zoomed-in to the baseball in-field at baseball stadium.

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