

HAWAII VIIRS/MODIS WORKSHOP: LABORATORY ONE

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The goal of this laboratory session is to become familiar with the properties of the reflected solar and thermal emissive bands of the MODIS and VIIRS sensors. You will explore the properties of daytime VIIRS and MODIS data over the Hawaiian Islands and surrounding ocean and clouds using the HYDRA software developed at UW/SSEC. Your instructor will tell you where to find the data needed for this exercise on your workstation.

1.1 Examining MODIS Data

Load the Aqua MODIS data over the Hawaiian Islands on 31 July 2013 at 23:37 UTC using HYDRA 2.8.8 (see the attached instruction sheet explaining how to run HYDRA). After starting HYDRA, the Data Window will appear (Figure 1).

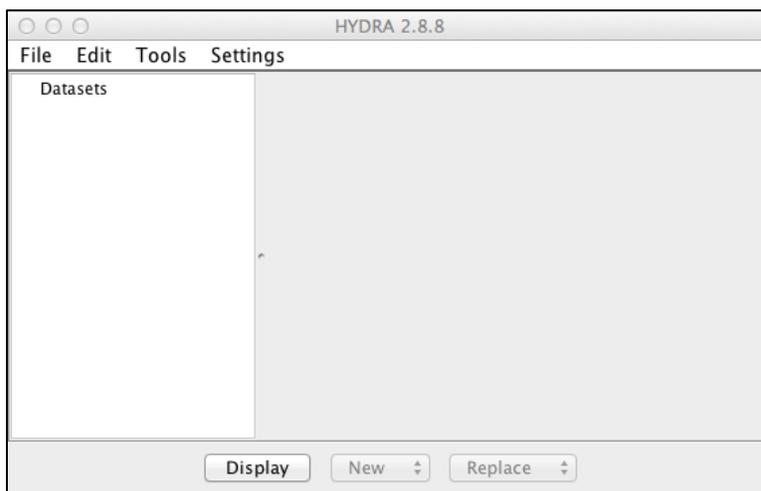


Figure 1: HYDRA Data Window at startup.

To load a MODIS Level-1B 1KM file from disk, click on “File” and select “Files” and find the file to be loaded (a1.13212.2337.1000m.hdf). When the file is loaded, an image of sub-sampled MODIS Band 31 (11 μm) brightness temperature appears on the right hand side of the Data Window (Figure 2).

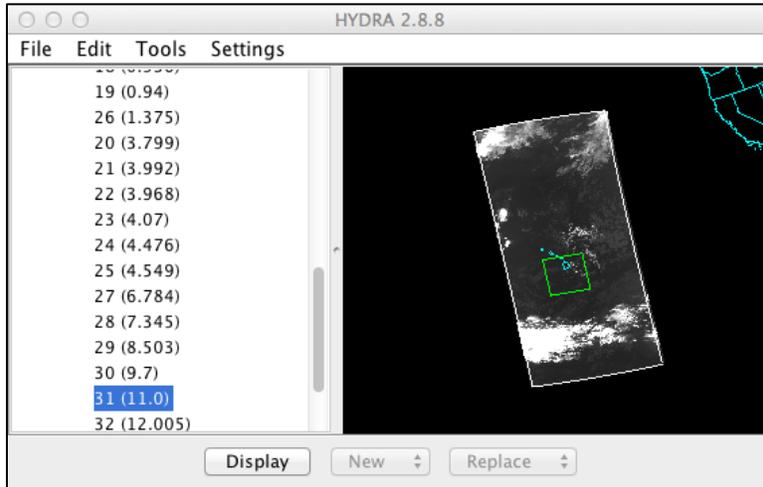


Figure 2: HYDRA Data Window after a MODIS Level-1B 1KM file has been loaded.

To display the MODIS data at full resolution (every line and pixel), click the Display button, and the region enclosed in the green box will be displayed in a new Display Window (Figure 3).

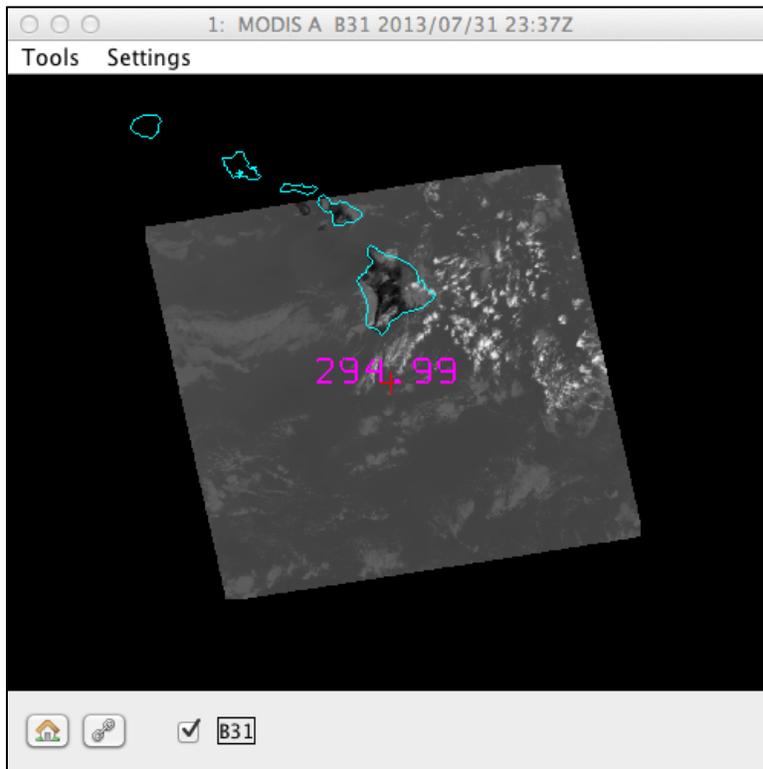


Figure 3. HYDRA Display Window showing MODIS Band 31 brightness temperature

To display a different region, go back to the Data Window and shift/left-click/drag on the image, then click Display. Select a region covering all of the Hawaiian Islands and some of the clouds at the southern end of the satellite overpass, and display it in the Data Window (Figure 4).

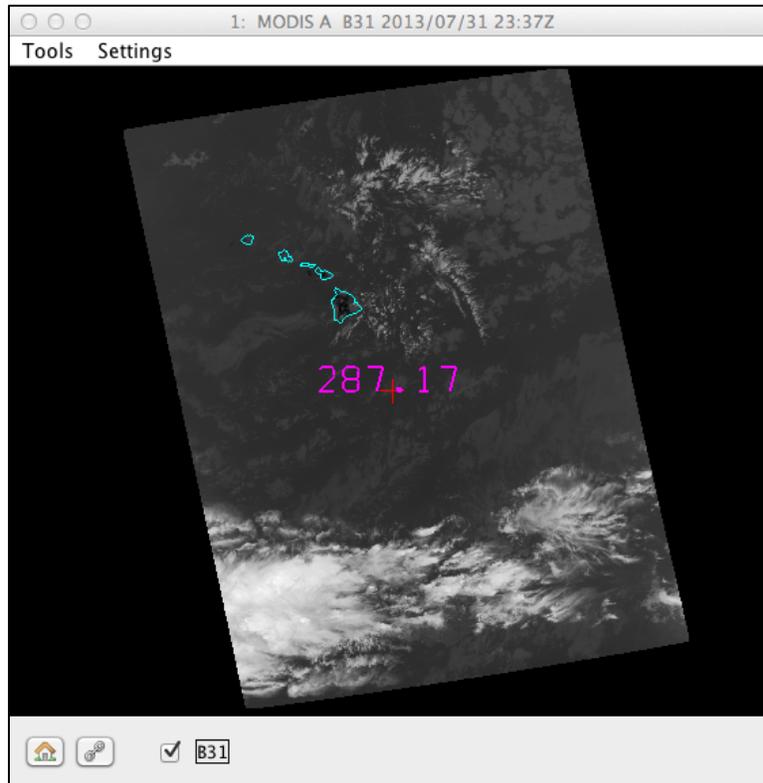


Figure 4: Ocean, Land, and Clouds data from MODIS Band 31

Now try different color table enhancements by left-clicking on the band number 'B31' in the Display Window to bring up the image enhancement tool. Adjust the min/max on the histogram by right-clicking on a green box and dragging. You can also type a value in the range or gamma boxes and then hit Enter to apply it. Switch from invGray to Rainbow. Try different color enhancements, then close the Image Enhancement Tool. You can zoom the image using shift/left-click/drag or via the scroll wheel, and you can pan the image by using control/right-click/drag. You can display the data value under the cursor (the red cross) by using left-click/drag. For infrared bands, the data value is Brightness Temperature in Kelvin. For visible bands, the data value is Reflectance (no units).

Now investigate the selected scene in Band 31 (11 μm thermal). Find the approximate minimum and maximum values of brightness temperature (Kelvin and Celsius) over Land, Ocean, and Clouds, and describe the region where it occurs (e.g., “off the western shore of the Big Island”):

Land: Min _____ K _____ C (describe the region):

Land: Max _____ K _____ C (describe the region):

Ocean: Min _____ K _____ C (describe the region):

Ocean: Max _____ K _____ C (describe the region):

Cloud: Min _____ K _____ C (describe the region):

Cloud: Max _____ K _____ C (describe the region):

Now load Band 2 (0.86 μm visible) data for the same region. Find the approximate minimum and maximum values of reflectance over Land, Ocean, and Clouds, and describe the region where it occurs:

Land: Min _____ (describe the region):

Land: Max _____ (describe the region):

Ocean: Min _____ (describe the region):

Ocean: Max _____ (describe the region):

Cloud: Min _____ (describe the region):

Cloud: Max _____ (describe the region):

In areas where Band 2 reflectance is unavailable, report the maximum Band 1 reflectance below:

Cloud: Max _____ (describe the region):

1.2 MODIS True Color and RGB Composite Images

Create a true color image of the same region you examined in section 1.1 by selecting Tools / RGBComposite in the Hydra Data Window. Then click on bands in the Datasets section of the Data Window in the order you want them to be displayed as red/green/blue. To create a true color image, select bands 1, 4, 3 (0.66, 0.55, 0.45 μm), then click on the Display button in the RGBComposite tool (the RGB image will appear in a new Display Window). The true color image shows the scene as it would appear to the human eye (approximately). Another useful

RGB combination is bands 7, 2, 1 (2.1, 0.86, 0.66 μm). With both (1, 4, 3) and (7, 2, 1) RGB images on screen, comment on the appearance (e.g. color, brightness) of the following regions in each image (you may want to adjust the gamma for both images first).

Vegetation	(1, 4, 3)_____	(7, 2, 1)_____
Soil	(1, 4, 3)_____	(7, 2, 1)_____
Water	(1, 4, 3)_____	(7, 2, 1)_____
Clouds	(1, 4, 3)_____	(7, 2, 1)_____

1.3 MODIS Atmosphere and Cloud Characteristics

Select a new region from the southern end of the satellite overpass as shown in Figure 5.

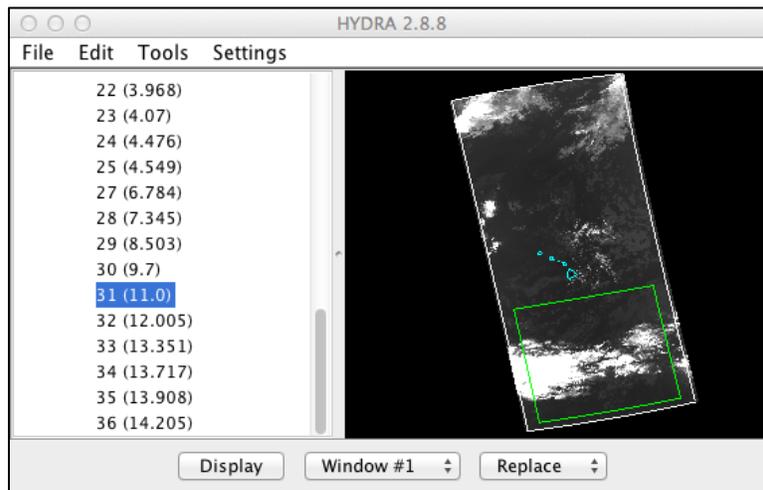


Figure 5: Atmosphere and Cloud Region

The following MODIS bands are useful for examining the properties of the atmosphere and clouds: 1-7, 26 (cloud detection and phase); 24, 25, 27, 28 (atmospheric temperature and moisture); 30 (ozone); 29, 31, 32 (cloud top temperature); 33-36 (cloud height).

Comment on the appearance of any atmospheric features you can see in the region you just selected in MODIS bands 1 and 31. In particular, note what kind of clouds appear in the region (e.g., stratus, cumulus, cirrus).

For cloud detection, Bands 1, 2, 26, 27, and 31 are often used. Briefly describe the appearance of cloud features in each of these bands, particularly in comparison to regions that appear cloud-free. You may find it helpful to several bands displayed at the same time.

Which bands would be most useful in the daytime? Why?

Which bands would be most useful at nighttime? Why?

Does Band 26 show as many clouds as Band 1? Describe a situation where Band 26 might detect a cloud that is not obvious appear in Band 1.

MODIS Band 31 is sometimes called an infrared window. This is because at a wavelength of 11 microns the atmosphere acts like a transparent window from the surface (or cloud top) to the top of the atmosphere. However, not all the infrared bands on MODIS are windows. Examine the following MODIS infrared bands and classify them as transparent, partially opaque, or opaque (an opaque band is one where surface features are completely invisible). Also note the brightness temperature (Kelvin) over a clear ocean location and over a cloud feature.

	Classification	Clear Ocean BT	Cloud Feature BT
24	_____	_____	_____
25	_____	_____	_____
27	_____	_____	_____
28	_____	_____	_____
29	_____	_____	_____
30	_____	_____	_____
31	_____	_____	_____
34	_____	_____	_____
36	_____	_____	_____

1.4 Examining VIIRS Data

Now load the VIIRS data from the same date (2013/07/31) at 23:14 UTC. In the HYDRA Data Window, select File / VIIRS directory, and navigate to the name of the directory containing the

VIIRS data (don't go into the directory). Click once on the name of the VIIRS data directory, then click Choose. This will open all the VIIRS SDR files found in the directory and display the M15 (11 μm) brightness temperatures in the Data Window (Figure 6). Then select and display a region covering the southern half of the satellite overpass (Figure 7).

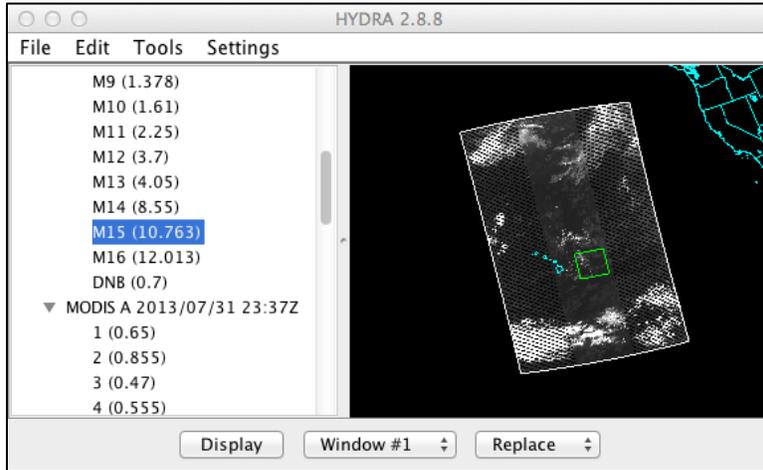


Figure 6: VIIRS M15 data over the Hawaiian Islands

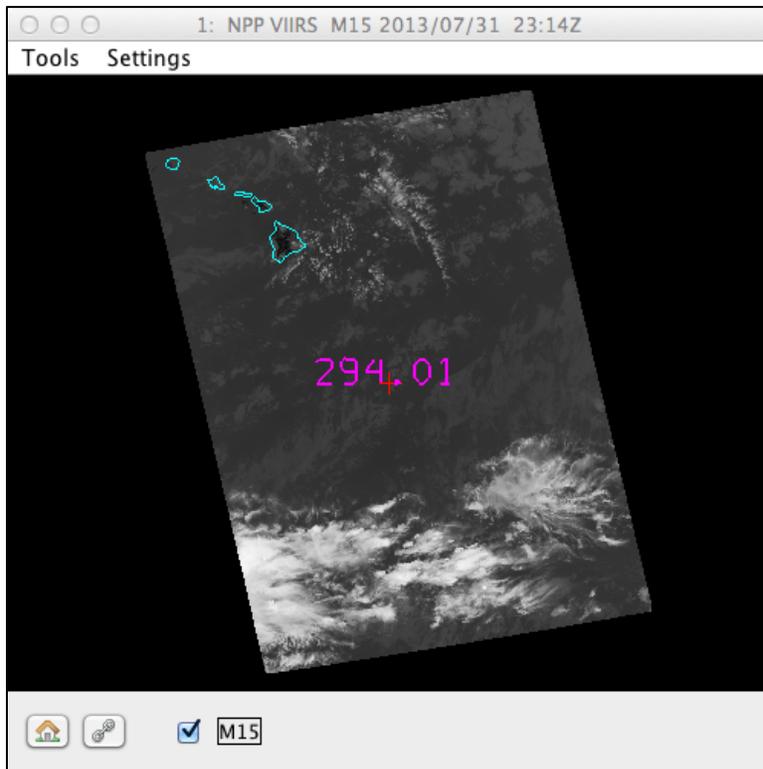


Figure 7: VIIRS M15 full resolution data

The MODIS data for this date should still be available in the HYDRA Data Window. Click on Band 31 of MODIS (11 μm), and then select the same region (Figure 8).

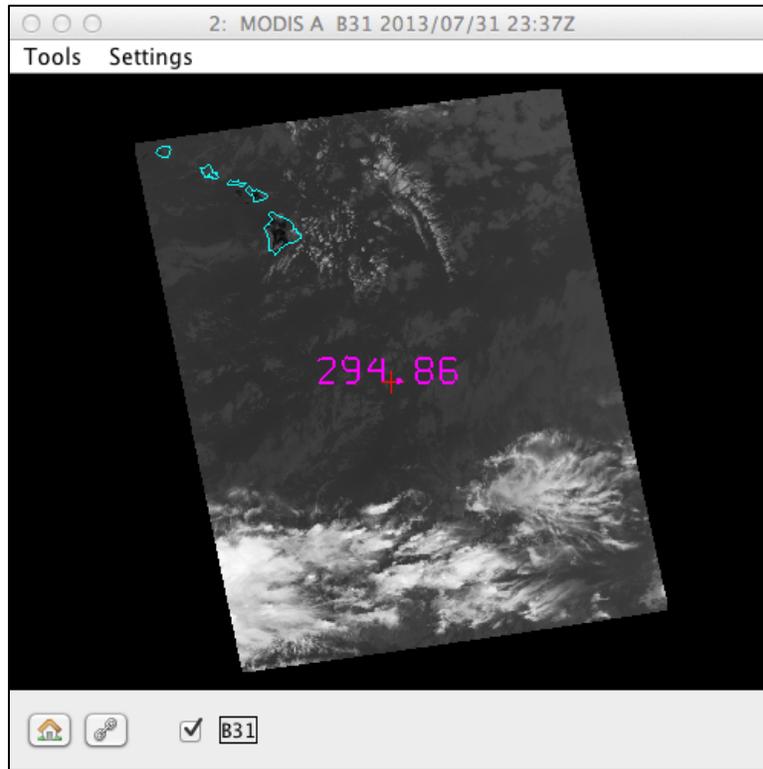


Figure 8: MODIS Band 31 full resolution data

Zoom in on the cloud features at the bottom left of the image. What are the approximate coldest cloud top temperatures you can find in (a) VIIRS, and (b) MODIS? Changing to a different color scale may help you find the coldest regions.

VIIRS BT (K) _____ MODIS BT (K) _____

Does one sensor seem to be better at showing structure over the cold cloud tops? Keep in mind that the images were obtained at 23:14Z (VIIRS) and 23:37Z (MODIS) so features may have changed slightly.

Now load the same scene for VIIRS band M7 (0.86 μm visible) in Display Window 1 and MODIS band 2 (also 0.86 μm visible) in Display Window 2. Zoom in on the cloud features at the

bottom left of the image. What are the highest reflectances you can find in (a) VIIRS, and (b) MODIS?

VIIRS Reflectance _____ MODIS Reflectance _____

Does one sensor seem to be better at showing structure over the bright cloud tops? Look at some of the smaller scale cloud features on the southwest edge of the region. Can you see any differences between the VIIRS M-band 750-meter pixels and the MODIS 1000-meter pixels?

1.5 Examining Land and Ocean Features in VIIRS and MODIS Data

Using the same region you selected in the previous section, and still displaying VIIRS M7 and MODIS Band 2 in two Display Windows, zoom in on the Hawaiian Islands. Enhance both images to show the land and ocean features (use the same enhancement for both). Note the appearance of the water surface and the land surface. At this wavelength bare soil will be dark and vegetation will be bright. At this wavelength the ocean should look dark unless there is sun glint.

Comment on where land regions look bright and dark:

Land is bright in this region _____ Reflectance value _____

Land is dark in this region _____ Reflectance value _____

Comment on where ocean regions look bright and dark:

Ocean is bright in this region _____ Reflectance value _____

Ocean is dark in this region _____ Reflectance value _____

In the VIIRS Display Window, select Tools / Transect to activate the Transect tool. This will display a new window showing a transect plot along the magenta line shown in the VIIRS Display Window. You can move the endpoints or center of the transect by clicking on either end or the center and dragging. Activate the Transect tool in the MODIS Display Window, and a MODIS transect at the same position will be plotted on the same axes. Use the Transect tool to find an area where the VIIRS and MODIS reflectances are obviously different in the two images, but the difference is not due to clouds. Describe the area where the two images look different, and what might be causing the difference.

Region Description: _____

Now load VIIRS band I2 (375 meter) and MODIS QKM band 2 (250 meter) in new Display Windows. Center and zoom into the Big Island. Note the difference in image resolution compared to the VIIRS M7 and MODIS 1KM band 2 images. Close the VIIRS M7 and MODIS 1KM band 2 images.

Use the Transect tool to create transect plots for VIIRS I2 and MODIS QKM band 2 from north to south across the big island, avoiding clouds as much as possible. On the transect plot, note where the highest and lowest values of 0.86 micron reflectance occur. Now load VIIRS band I1 (0.66 μm visible) in the VIIRS Display Window as an Overlay, and display MODIS QKM band 1 (0.66 μm visible) in the MODIS Display Window as an Overlay. When an overlay image is present in a Display Window, multiple band names will be listed at the bottom of the Display Window (Figure 9). When you click the tick-mark next to the band name (e.g., B1), it will turn that band on and off.

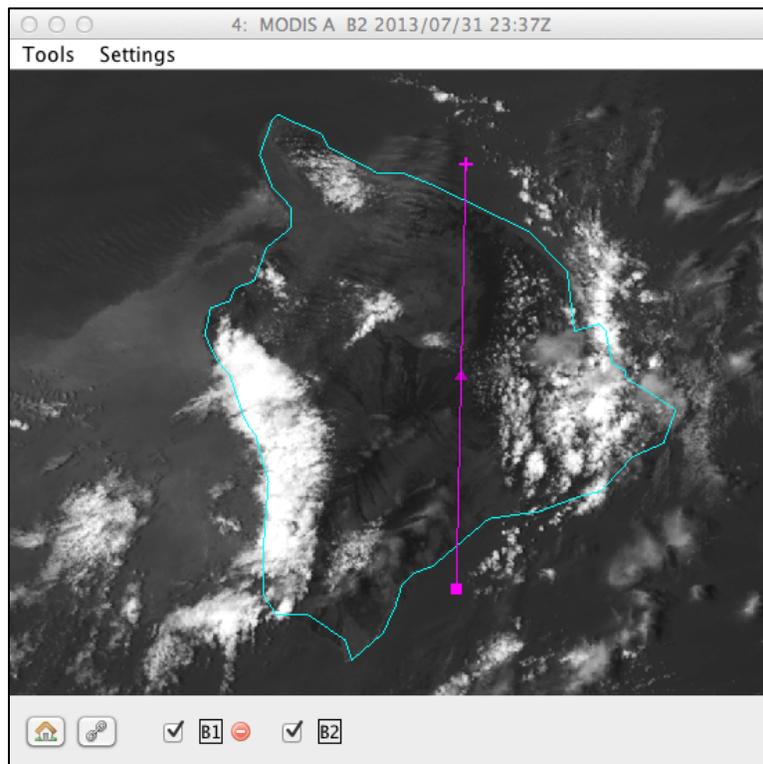


Figure 9: MODIS QKM Bands 1 and 2 in a Display Window with Transect.

In the VIIRS and MODIS windows, turn I1 and B1 on and off, and notice where the 0.66 μm reflectance is different than the 0.86 μm reflectance. It should tell you something about the vegetation cover on the Big Island. The right panel of Figure 10 shows the visible reflectance of several land surface types (soil, grass, snow) as a function of visible wavelength.

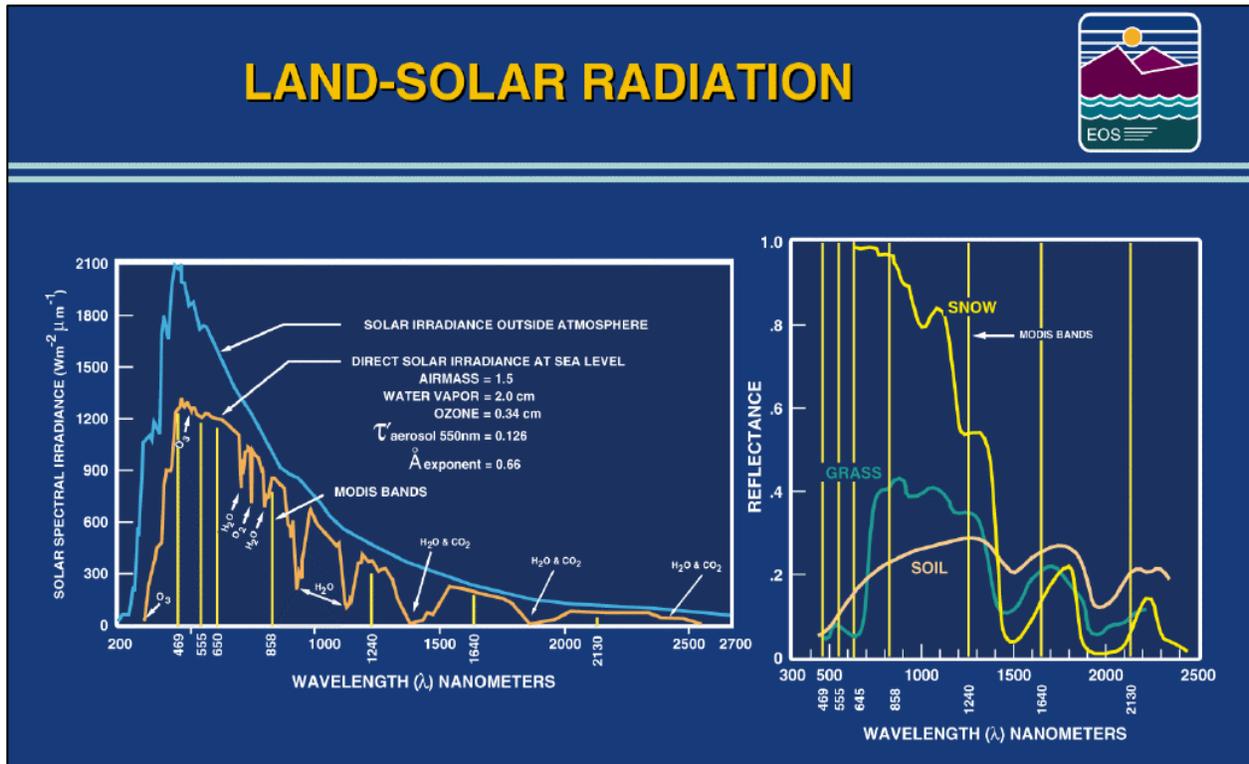


Figure 10: Land Surface Reflectance at Visible Wavelengths

From Figure 10, note the relative reflectance of soil vs. grass at 0.64 microns and 0.86 microns. Does the VIIRS and MODIS imagery follow the same trend? Close the MODIS Display Window, leaving the VIIRS Display Window open. In the HYDRA Data Window, select Tools / FourChannelCombine to construct an image of normalized vegetation index (NDVI) according to the following equation:

$$\text{NDVI} = [\text{Band I2 (0.86}\mu\text{m)} - \text{Band I1 (0.65}\mu\text{m)}] / [\text{Band I2 (0.86}\mu\text{m)} + \text{Band I1 (0.65}\mu\text{m)}].$$

Can you discriminate regions with some vegetation from those with little? What are the NDVI values in regions with significant vegetation; what are they in non-vegetated regions?

NDVI for vegetation: _____ NDVI for soil: _____

Now load VIIRS Band I5 (11.5 μm) in a new Display Window. Adjust the color scale to highlight the land surface features over the Big Island. Use the Transect Tool to create transect plots across the Big Island for the VIIRS NDVI Display Window and the Band I5 Display Window. What is the effect of vegetation on surface temperature?

Finally, create a true color image of the Big Island using Tools / RGBComposite in the HYDRA Data Window from VIIRS Bands M5, M4, M3 and adjust the image enhancement so that the colors look natural (change the gamma value). Does the true color image confirm your discrimination of the areas of the Big Island covered by vegetation vs. no vegetation?

END OF LAB ONE