

University of Puerto Rico at Mayagüez Direct Broadcast Remote Sensing Workshop

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28 April 2016 Lab 3 Part 1: Investigating Atmospheric Dust using VIIRS and MODIS

1.1. Use HYDRA to open the Terra MODIS 5 minute data segment from 18 June 2015, 14:55 UTC (MOD021KM.A2015169.1455.006.2015170014457.hdf). Select the sub-region shown in Figure 1, and display Band 1 (.65 μm) reflectances at full spatial resolution.

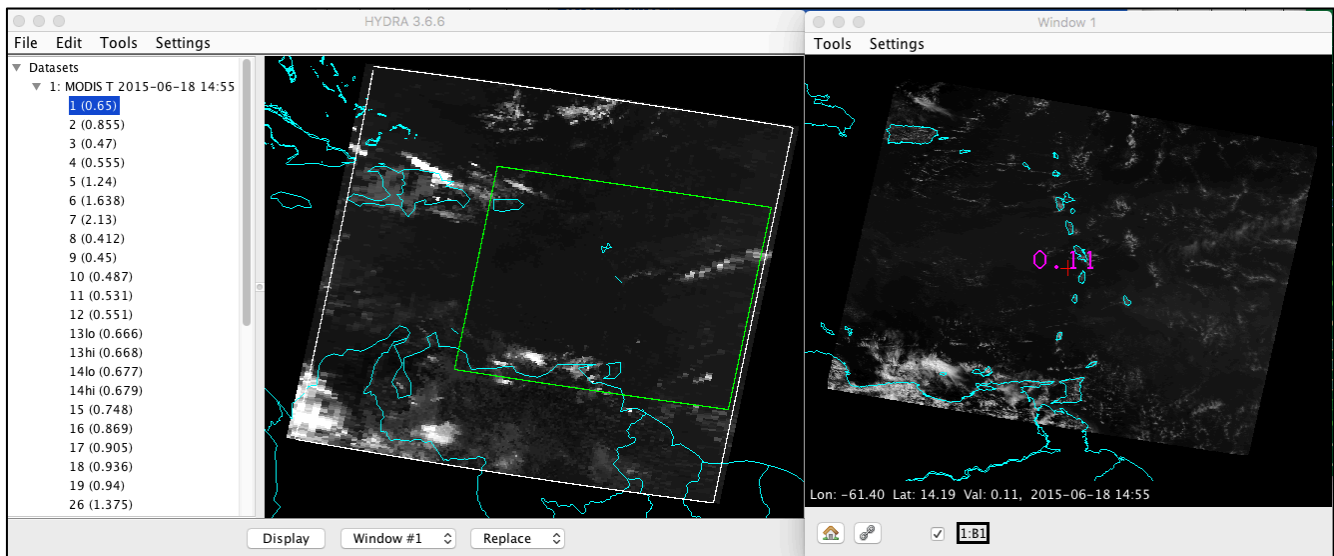


Figure 1: Terra MODIS 5 minute granule observations from 18 June 2015, 14:55 UTC.

2. Now Overlay the Band 3 (.47 micron) and Band 7 (2.13) images into Window #1, and enhance all three bands to bring out the features in each image. What features are similar, and what are different?
3. Daytime dust detection techniques take advantage of the increase in the reflectance of dust (sand and soil) with the increase in wavelength between .4 and 2.5 microns, as shown in Figure 2 from:

J. J. Qu, X. Hao, M. Kafatos and L. Wang, "Asian Dust Storm Monitoring Combining Terra and Aqua MODIS SRB Measurements," in IEEE Geoscience and Remote Sensing Letters, vol. 3, no. 4, pp. 484-486, Oct. 2006.

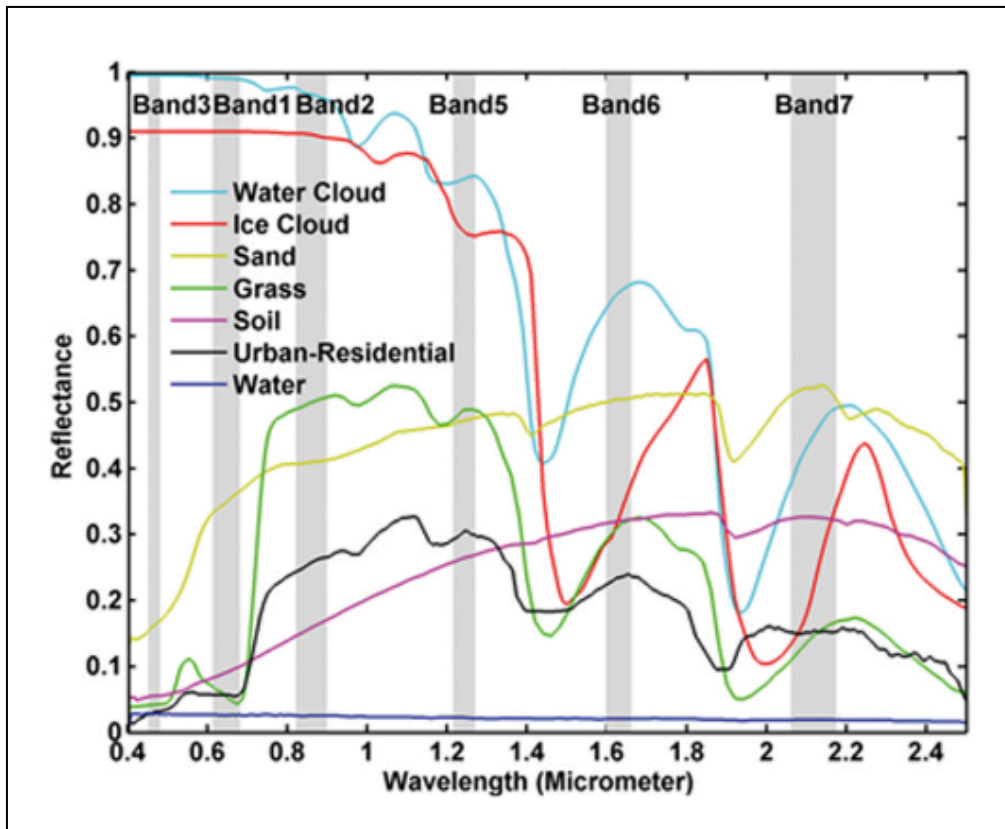


Figure 2: Reflectance of water and ice cloud, sand, grass, soil, urban residential, and water in the .4-2.5 micron spectrum from Qu, et al., 2006.

Now create a reflectance ratio band combination image using this equation:

$$\text{Band 3 (.47 micron)} / \text{Band 1 (.65 micron)}$$

and overlay the image into Window #1. Enhance the image by setting the upper limit to the natural histogram breakpoint that occurs around 1.4 as shown in Figure 3. What values do the clouds have in this image? Why? How do the patterns match up with the “hazy” regions in the Band 7 (2.1 micron) reflectance image? Why are the reflectance ratio values the highest over regions that are less hazy in the Band 7 (2.1 micron) reflectance region? Determine reflectance thresholds for detecting dust in the Band 3 (.47 micron) / Band 1 (.65 micron) image. What advantages and disadvantages are there in detecting dust using polar orbiter visible MODIS and VIIRS reflectance data?

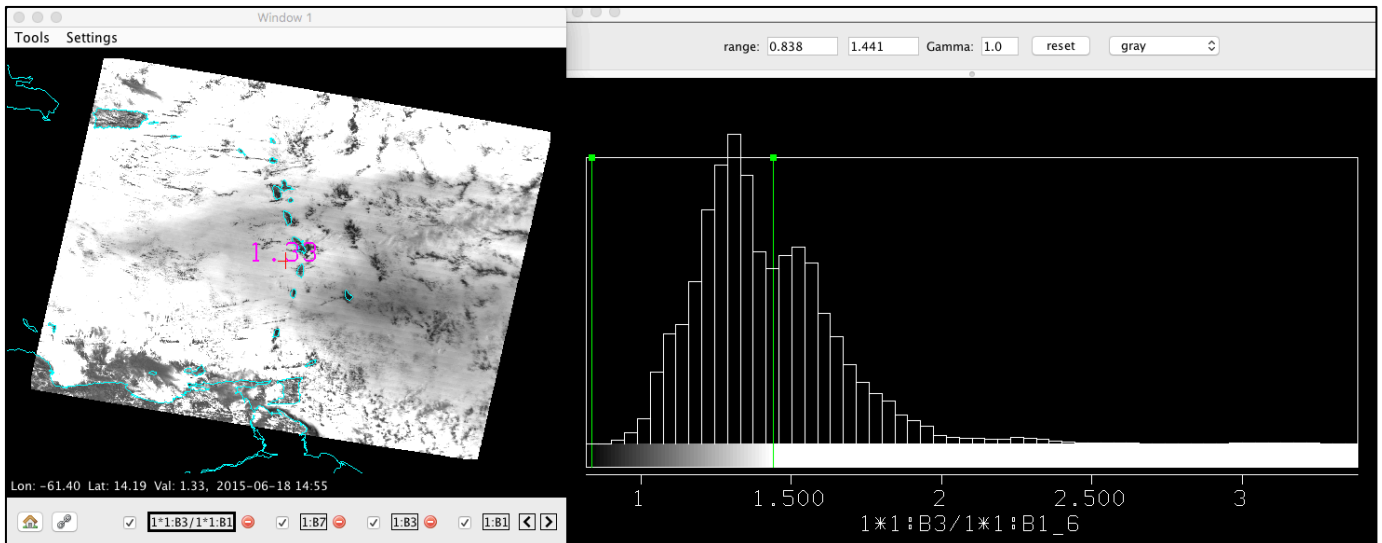


Figure 3: Reflectance ratio image (Band 3 (.47 micron) / Band 1 (.65 micron)) - left panel, and the histogram of data points in the image – right panel.

4. Now we will create an RGB image utilizing the infrared dust detection technique created by EUMETSAT and described in the dust interpretation document found at http://oiswww.eumetsat.int/~idds/html/doc/dust_interpretation.pdf.

Start by using Tools->Band Math to create MODIS brightness temperature difference combinations:

Band 32 (12.0 micron) – Band 31 (11.0 micron)
and
Band 31 (11.0 micron) - Band 29 (8.5 micron) .

Once the combinations have been created, they appear in the menu under “Combinations”. Now use the combinations to create an RGB Composite image using Red: Band 32-Band 31, Green: Band 31-Band 29, and Blue: Band 31. Once you have created this Composite, it will appear in Datasets list under “Combinations”. Now overlay the RGB into Window #1 and set the ranges and gamma as follows to enhance the image (make sure to hit the return key after typing in a value):

Band 32 (12.0 micron) - Band 31 (11.0 micron)	Red: -4 to +2 K.	Gamma: 1.0
Band 31 (11.0 micron) - Band 29 (8.5 micron)	Green: 0 to +15 K.	Gamma: 2.5
Band 31 (11.0 micron)	Blue: 261 to 289 K	Gamma: 1.0

Once you have set these values, your RGB image should look like that displayed in Figure 4. Dust will be identified over ocean as the “magenta” color.

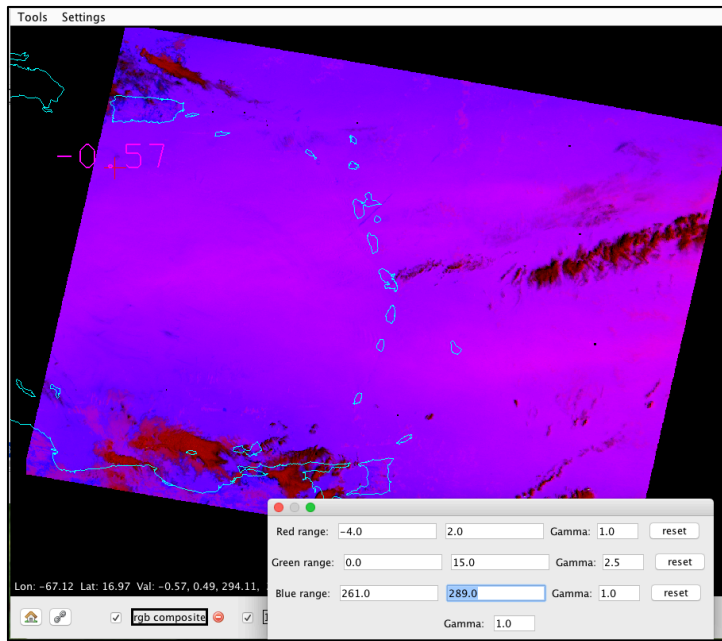


Figure 4: EUMETSAT dust RGB created from our Terra MODIS input data from 18 June 2015.

5. How well do you think this technique identifies the dust region? Compare it to using the reflectance ratio technique. Which do you think is better at detecting dust? Which of the three RGB combination of MODIS bands and band differences are contributing most to the dust detection (you can load each one in a separate window if it helps) and why? What are the advantages and disadvantages of using an infrared technique for detecting dust?

6. Overlay the Terra MODIS Aerosol optical depth parameter OD from the MOD04 product file from the same date/time (MOD04_L2.A2015169.1455.006.2015174115415.hdf) into Window #1 and change the enhancement to Rainbow. Why is there such limited optical depth retrievals over our region? How might using MODIS and VIIRS together improve the data loss region? Do the high aerosol values match with the areas we have identified using the visible and IR dust identification techniques? How does using a subjective technique to detect dust, compare with using a quantitative product? Which do you prefer and why?

7. Finally, overlay the aerosol optical depth OD_small field from the MOD04 file list into Window #1. This field attempts to provide information on the relative size of the detected aerosols by providing a ratio between the small particles (find mode) and the large particles. If the values are low, it is an indication of large particles (like dust), if the values are high, it indicates small particles (like smoke). Using this information, identify two different types of aerosols in the image and guess the source of each.

Extra Credit

8. Follow the instructions in step 4., and create a EUMETSAT RGB dust image using the VIIRS data from 18 June 2015, 16:59 UTC and compare the result with the MODIS image you created. How has the dust image changed? What instrument characteristics should we keep in mind when comparing the images? When you are finished, close HYDRA.

Lab 3 Part 2: Investigating Water Clarity using VIIRS data

2.1. Use HYDRA to open the Aqua MODIS 5 minute data segment from 29 January 2016, 18:45 UTC (MYD021KM.A2016029.1845.006.hdf). Select the sub-region shown in Figure 1, and display Band 31 (11.0 μm) brightness temperatures at full spatial resolution.

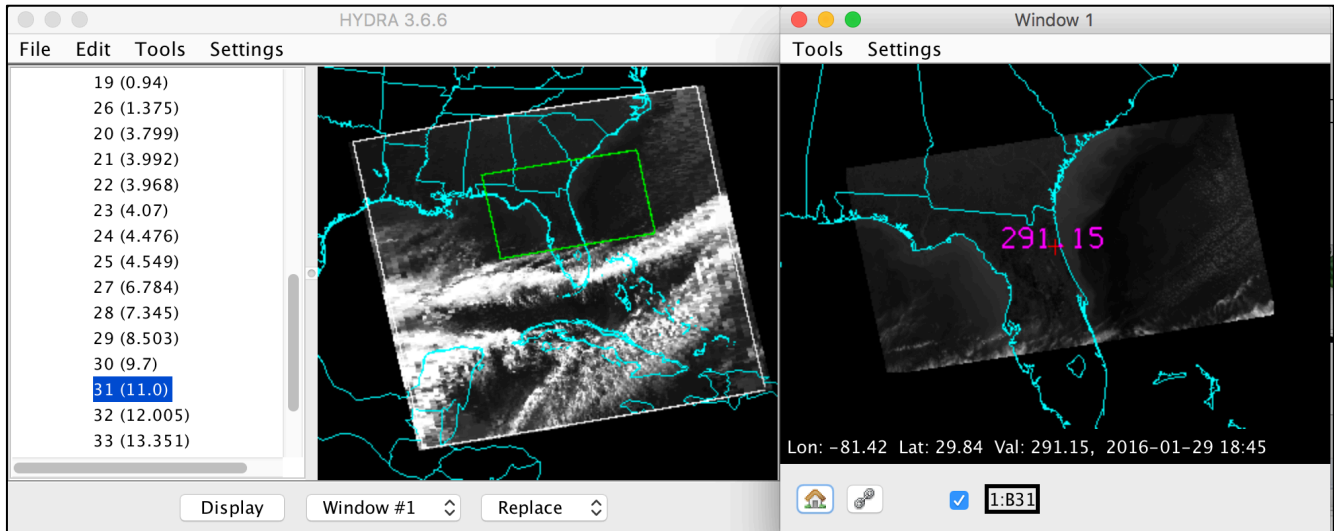


Figure 1: Aqua MODIS 5 minute granule observations from 29 January 2016, 18:45 UTC.

2. Load in the matching Aqua MODIS SeaWiFS Data Analysis System (SeaDAS) file for the 29 January 2016, 18:45 UTC time period (SEADAS_modis_d20160129_t184500_t185000.hdf), and overlay the remote sensing reflectance images from bands .443 micron (Rrs_443 - MODIS Band 11) and .531 micron (Rrs_531 - MODIS Band 9) into Window #1. The displayed reflectance values are water leaving radiances divided by the top of atmosphere incoming solar irradiance at that wavelength. Try to enhance the images to bring out features in the water. Why are the reflectance values so low? Describe the features you see in the images?

3. The SeaDAS ocean color algorithm relies on the ratio of blue (.45 micron region) and green (.55 micron region) remote sensing reflectances as the basis for determining the chlorophyll concentration for a given Field-of-View (FOV). For example, as the amount of phytoplankton increase, the “greener” the water becomes, and the ratio between .45 micron and .55 micron reflectances decreases (see Figure 2). To investigate the ratio over the MODIS scene, use the Band Math tool to create the Rrs_{443}/Rrs_{531} ratio. Once it is created, it is placed in the Datasets menu under “Combinations”.

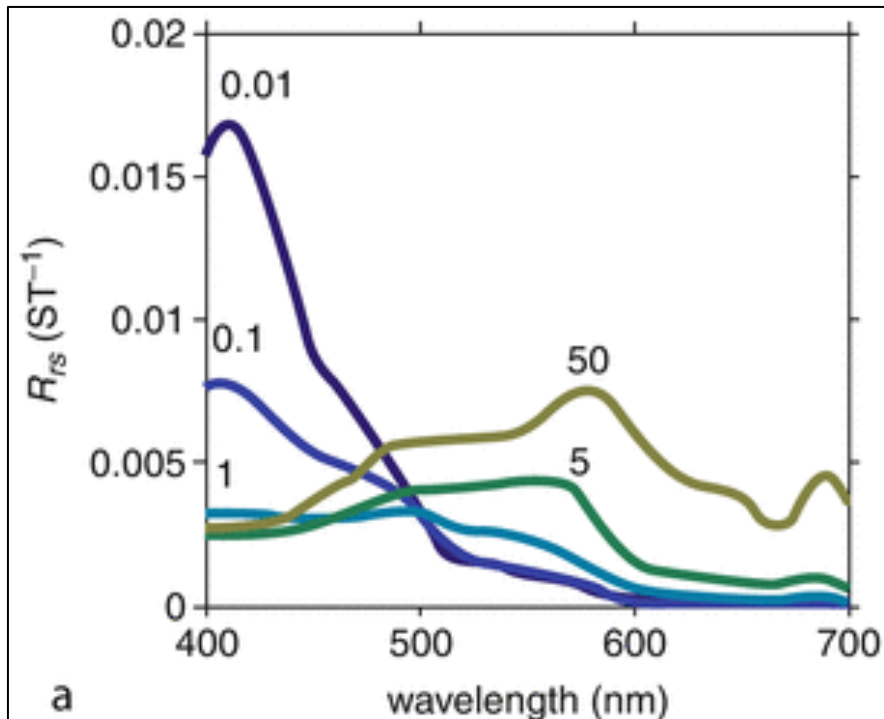


Figure 2: Measured remote sensing reflectances for a variety of different chlorophyll concentrations. Taken from Remote Sensing of Ocean Color, Dierssen and Randolph, Encyclopedia of Sustainability Science and Technology, 2012, 8952-8975.

4. Display the R_{rs_443}/R_{rs_531} ratio image into a new Window. Enhance the image by setting the range between -2.0 and 6.0 (Figure 3 – right panel). Where are the highest non-cloud values? Where are they the lowest? Based upon these the reflectance ratio values, where would you expect the water to be green? Where would you expect the water to look blue?

5. Create a true color image using Red: MODIS Band 1 (.65 micron), Green: MODIS Band 4 (.55 micron) and Blue: MODIS Band 3 (.47 micron) reflectances. Overlay the image into Window #2. Once the image is displayed, change the Gamma enhancement for the Red, Green and Blue layers to .4 (Figure 3 – center panel). Does the image look as you expected it to based upon your answer to question Number 4? If not, can you think of reasons why it might be different than expected from our two band ratio?

6. Now overlay the SeaDAS chlorophyll concentration product (chlor) product in units of mg/m^3 into Window #2. Enhance the image by setting the data range to be between -2.0 and 6.0, and change the enhancement to Rainbow (Figure 3 – left panel). How do the image patterns compare with the reflectance ratio image? Where are the highest chlorophyll values located? How would adding information from other combinations of remote sensing reflectance ratios in the .4 to .6 micron wavelength regions improve the simple ratio product we created?

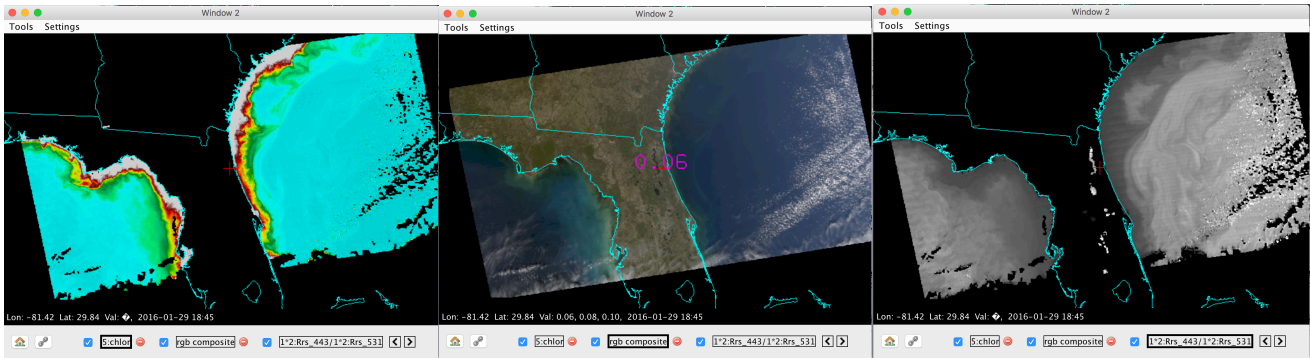


Figure 3: Aqua MODIS SeaDAS chlorophyll product (left panel), a true color RGB image (center panel) and the SeaDAS remote sensing reflectance ratio .443 micron / .531 micron image (right panel) from the 29 January 2016 data set observed at 18:45 UTC.

7. Now Overlay the SeaDAS Sea Surface Temperature product (SST) into Window #2 and enhance it. Is there a relationship between SST and chlorophyll concentration?

Extra Credit

8. Load in the VIIRS SeaDAS chlorophyll product from the VIIRS 18 June 2015, 16:16 UTC data set and compare the result with the MODIS chlorophyll product. How do the chlorophyll concentration values and patterns compare? What instrument characteristics should we keep in mind when doing these comparisons?