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IMAPP Remote Sensing Workshop

28 Feb. 2006

Andøya Rocket Range, Andenes, Norway

LAB 1

Lab on staging, visualizing, understanding MODIS Data

This Lab was prepared to provide an overview of the main characteristic of MODIS data. It is divided into three parts each dedicated to different areas: general overview of a MODIS scene (Ex. 1), images and instrument artifacts (Ex 2 and 3) , and examples of land and ocean applications with MODIS data (Ex. 4). It is our recommendation that you keep a log of the Lab in electronic form with your results (images and comments related to the exercises). You can either edit the doc form of this lab, or make your own log document. At the end of the Lab session we will ask you to submit a copy of your log file to the instructors. This will allow us to verify how well the information was conveyed to you. You are welcome, but not requested, to include your names in the document.

Exercise 1: Exploring a MODIS scene

1. Start Hydra, and load the Aqua MODIS scene of Norway collected on Sep. 27, 2005 at 11:50 UTC. The file name is:

MYD021KM.A2005290.1150.005.2005291202720.hdf

2. Once the image is loaded in the *Hydra* windows select from the main menu the *Start->Multi-Channel viewer*. A new window will open. Browse through the scene in several different bands (wavelengths) in this new Multi-Channel Viewer window. To enhance the image, select *Settings | Set Color Range* in the *Multi-Channel viewer*. A new window named *VisAD Histogram* will appear, as shown in Figure 1(b). Left click on the small green square at lower right, and drag it to the left of the histogram (*LeftButton+Drag*). The image should appear enhanced. You can also right click on the small green square at lower left, and drag it to the right. Close the *VisAD Histogram* window when you are finished enhancing this band. Open it again to enhance the following bands (2,3,4,28,31).

Look at the scene both in Brightness Temperatures/Reflectances (BT) and Radiances (use BT-> radiance under the Settings tool), make sure that for each band you indicate the units used to display the image:

(a) verify that for IR window channels (e.g, bands 20, 31, 32) the surface features are visible, while for absorption channels (e.g., bands 27, 34, 35, 36) they are not; explain why this happens

(b) At 11 μm (band 31) the BT ranges between 220 K and 292K . Can you locate where the minimum and maximum of BT for band 31 occur?

3. Load the full-resolution image shown in Figure 1a. To load the high-resolution image highlight the Hydra window, then click on the rightmost button in the lower part of the window (*subset image*). Click and drag the mouse to select

a small sub-region on the scene. The selected region, at 1 km resolution, will appear in the Multi-Channel Viewer window.

(a) Make an rgb image of the selected sub-region by selecting *Tools->rgb* in the Multi-Channel window menu. A new window, *RGB Combine Tool* will pop up. Enter, in this window, the correct band combination for the R G B channels, and click on the *compute* button: the rgb image will be shown in a new *RGB* window.

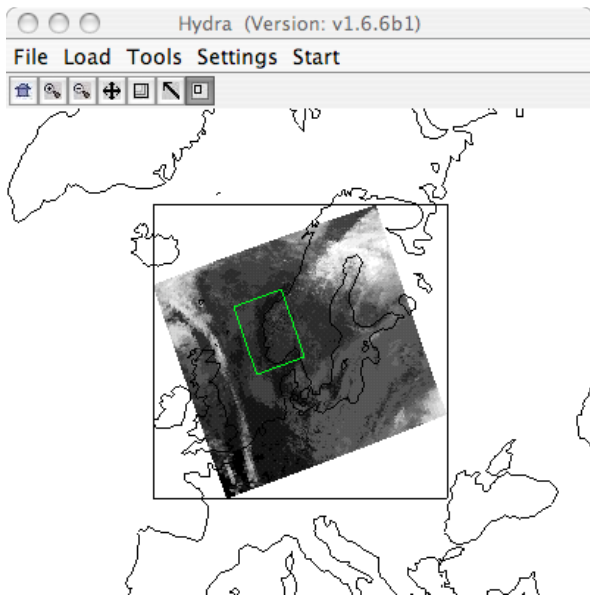


Figure 1(a): Norway region selection

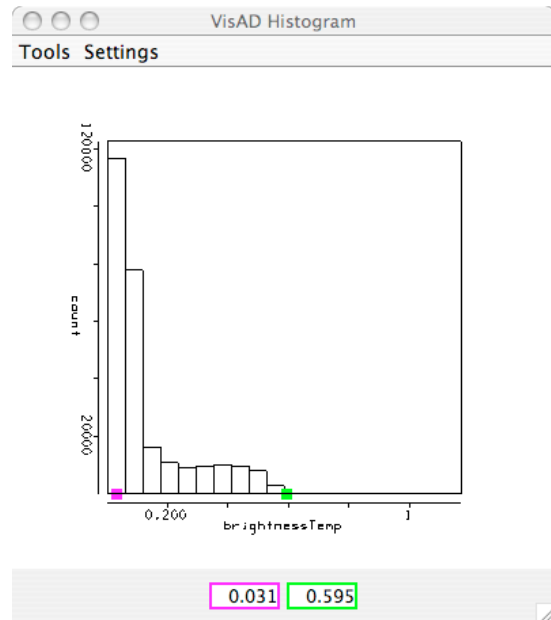


Figure 1(b): Image enhancement histogram

4. Always working with full resolution data sub-select different regions (over clouds, mountains and ocean). In the Multi-Channel Viewer Window, click on the rightmost button from the left (*pick image*), and click on any pixel of your scene. The spectrum on the top panel of the Multi-Channel Viewer window will show the observed BT or reflectance for that channel:

(a) describe for each scene the relative changes for the emissive bands at 11 μm (band 31) and at 12 μm (band 32);

(b) What are typical reflectance values in band 1 over ocean, land, and cloud features?

(c) Are there non-physical values? If yes, can you guess why?

(d) What are typical brightness temperature values in band 31 over ocean, land, and cloud features?

(e) What are the lowest and highest values in band 31 over the entire scene, and where do they occur?

(f) Now select band 20 (3.8 μm) and display the image. Note how much warmer the 3.8 μm brightness temperatures are than those for 11 μm (band 31). Where is this difference more evident?

(g) What could be responsible for this?

(h) Could this happen at night-time?

5. Switch from BT to Radiances. The observations for a single pixel assume a well defined shape both in the visible and in the infrared bands. In the spectrum windows (upper plot of the Multi-Channel viewer) draw two Planck's function curves which would fit both the VIS and the IR bands (save the image in the spectrum windows in jpeg format and hand-draw the Planck's function with any available graphics software).

(a) Are there specific channels where the observations depart from the curves? If yes, why?

(b) Where do the curves seem to intercept each other?

(c) Do they really intercept? Explain why.

6. Now load band 27 BTs, which is used for cloud detection and to derive upper troposphere humidity.

(a) What are the lowest and highest brightness temperature values you observe in band 27?

(b) Briefly describe features in the scene which appear to be due to atmospheric conditions.

Exercise 2: Examining MODIS image artifacts

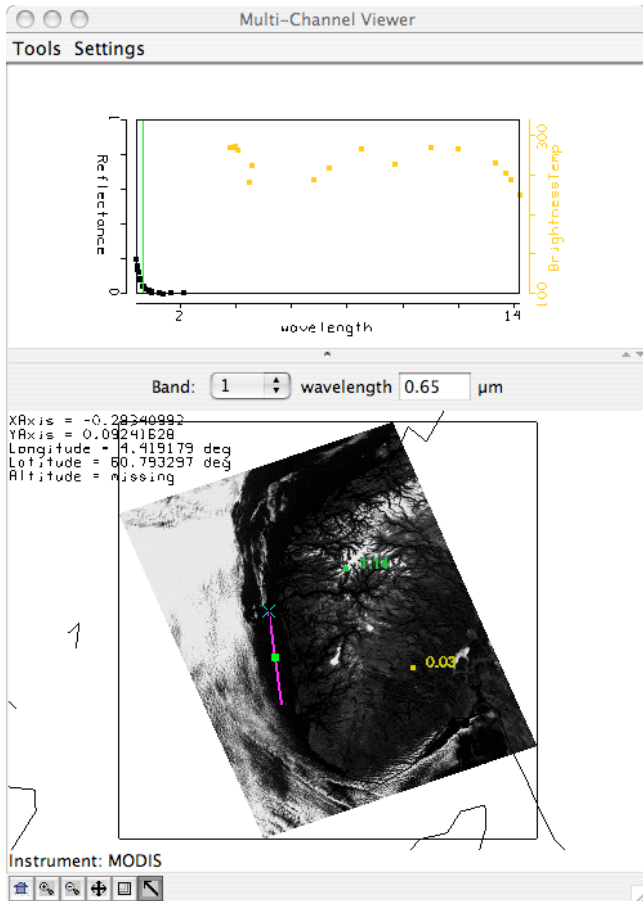
1. Using the same MODIS file, load the full resolution data for band 1 over the region shown in Figure 1(a).

(a) Try to visualize the Bow-Tie effect. In particular explain in which part of the MODIS granule this effect is evident, and what you had to do to visualize it.

(b) Can you think of any possible application of the redundancy introduced by the bow-tie effect?

2. Using the same full resolution data for the region indicate in figure 1(a)

(a) Create a transect in the Multi-Channel Viewer (*Tools -> Transect* and then *shift + right + Drag*) as shown in figure 1(c) for VIS bands 1,2,3. Describe the differences you can notice in the Transect Window for the 3 VIS bands.



(b) Now take the same transect for IR band 31 and 27. Briefly describe relevant differences between these two bands in the image and in the Transect window and classify according to:

- atmospheric conditions
- instrument artifacts such as detector imbalance, bad detectors, and mirror side differences

(c) For band 27 only:

- What is the approximate peak to peak noise (in Kelvin) and what it is due to?

- Does the observed pattern appear to be consistent (i.e., predictable) in the transect plot?

- How would you correct the image (i.e., remove the striping) if:

- the detectors are out of balance with each other?

- one detector is behaving unpredictably?

- all detectors are biased with respect to truth?

Close the *Transect* window when you are done with this question.

4. Now load band 8, which is used for ocean color retrievals. This band generally saturates over bright targets such as clouds or deserts. Working on the same region shown in Figure 1(a) which includes some clouds, determine:

(a) What is the saturation reflectance value in band 8?

(b) What is the saturation reflectance in bands 9, 12, 13, and 16?

(c) Other than clouds, what features in this region cause these bands to saturate? You may need to examine other bands (e.g., 1, 2, 31) to answer this question.

Exercise 3: Examining destriped MODIS images

1. Close your existing Hydra session, and start a new session. Load the destriped Aqua MODIS file on disk named

MYD021KM.A2005290.1150.005.2005291202720.destripe.hdf

In this file, thermal emissive bands 20, 22-25, 27-36, and reflected solar band 26 have been *destriped* by the method of matching empirical distribution functions.

(a) Examine the destriped MODIS bands in the same way as Exercise 2, part 1 (a). Briefly note how the image quality has improved in the destriped MODIS bands.

(b) In particular repeat the band 27 transect plot of Exercise 2, part 3 (a). What is your estimate for the peak to peak noise (in Kelvin) of the destriped 27 data?

Exercise 4: General Land and Ocean Applications with MODIS data

1. Using the scene over Europe and the North Atlantic observed on 18 April 2003 (day 108) by MODIS, proceed in the following steps. Close all the windows used in the previous exercises and load local image file MYD021KM.A2003108.1245.004.2004089182113.hdf.

(a) Demonstrate some of the spectral signatures indicated in figure 4 of the *Useful Material Handout*. In each case sub-select a full resolution portion of the granule and identify which spectral signature you are demonstrating.

- Look at snow over Norway in 0.65 and 1.6 μm .
- Look at vegetation over Norway in 0.65 and 0.86 μm .
- Look at near shore waters in 0.55 and 0.45 μm .
- Look at ocean waters in 11 and 13.9 μm

(b) Identify typical reflectance values for each

- Look at snow over Norway in 0.65 and 1.6 μm .
0.65 μm [min _____;max _____]
1.6 μm [min _____;max _____]

- Look at vegetation over Norway in 0.65 and 0.86 μm .
0.65 μm [min _____;max _____]
0.86 μm [min _____;max _____]
- Look at near shore waters in 0.55 and 0.45 μm .
0.55 μm [min _____;max _____]
0.45 μm [min _____;max _____]
- Look at ocean waters in 11 and 13.9 μm .
11 μm [min _____;max _____]
13.9 μm [min _____;max _____]

2. Use the **Linear Combination** tool to combine spectral bands to explore the vegetation index that is based on the relatively low leaf and grass reflectance from spectral bands below 0.72 μm and relatively high reflectance from spectral bands above.

(a) Construct a pseudo image of normalized vegetation index $[\text{Band 2 (0.86}\mu\text{m)} - \text{Band 1 (0.65}\mu\text{m)}] / [\text{Band 2 (0.86}\mu\text{m)} + \text{Band 1 (0.65}\mu\text{m)}]$. Can you discriminate regions with some vegetation from those with little? What are the NDVI values in regions without significant vegetation; what are they in vegetated regions?

(b) Leave the pseudo band window open and create a new image of Band 31 (11.0 μm) using **Compute**. Map the NDVI values from 2a on the Y axis (by clicking the Y axis button) against Band 31 (11.0 μm) on the X axis (by clicking the X axis button). Click on the scatter button to open a scatter plot window. Select different regions in the scatter plot window and look at the corresponding points in the linear combination windows.

3. Select an ocean region within the Hydra window. Now select Band 9 (0.45 μm) in the Multi-Channel Viewer and display the reflectance image.

(a) Construct a pseudo image of $[\text{Band 12 (0.56}\mu\text{m)} / \text{Band 9 (0.45}\mu\text{m)}]$. Using Figure 4 of the *Useful Material Handout* explain why higher values of this ratio should indicate water regions with more phytoplankton from those with little? What is the likely source of the phytoplankton plumes?

(b) Create a pseudo image of $\text{SST} = \text{Band 31 (11.0 } \mu\text{m)} + [\text{Band 31 (11.0 } \mu\text{m)} - \text{Band 32 (12.0 } \mu\text{m)}]$ using **Compute**. What is the range of SST values in the selected part of the ocean? Can you explain why the SST is different near the coast, compared to the deeper waters?

(c) Map the phytoplankton values from 3a on the Y axis (by clicking the Y axis button) against the SST from 3b on the X axis (by clicking the X axis button). Click on the *Scatter* button to open a scatter plot window. Select different regions in the scatter plot window and look at the corresponding points in the linear combination windows. Are high concentrations of phytoplankton associated with warmer or colder waters? Explain.

4. MODIS bands 3 (0.45 μm), 1 (0.65 μm), and 2 (0.87 μm) microns are sensitive to the reflectance of the ocean surface. Clear ocean waters are most reflective in at shorter wavelengths, and become darker at longer wavelengths. Sediment laden waters are however more reflective at longer wavelengths, which gives them a brownish to reddish color. Construct images of bands 3, 2, and 1, and describe the patterns of sediment seen in each band.

(a) Which band is most sensitive to low amounts of sediment?

(b) Which band is most sensitive to high amounts of sediment?

(c) Try constructing an image from band 2 / band 1, and compare it to an image of SST as described previously. Do you see any correlation between sediment and SST? What might cause the sediment and SST values to be related?

