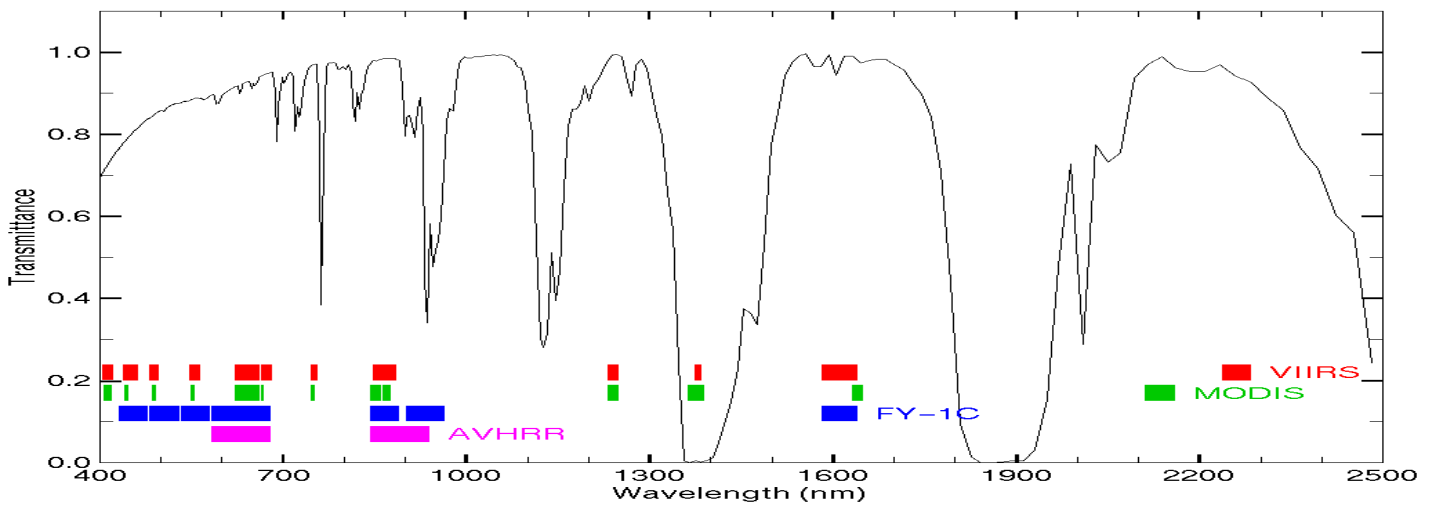
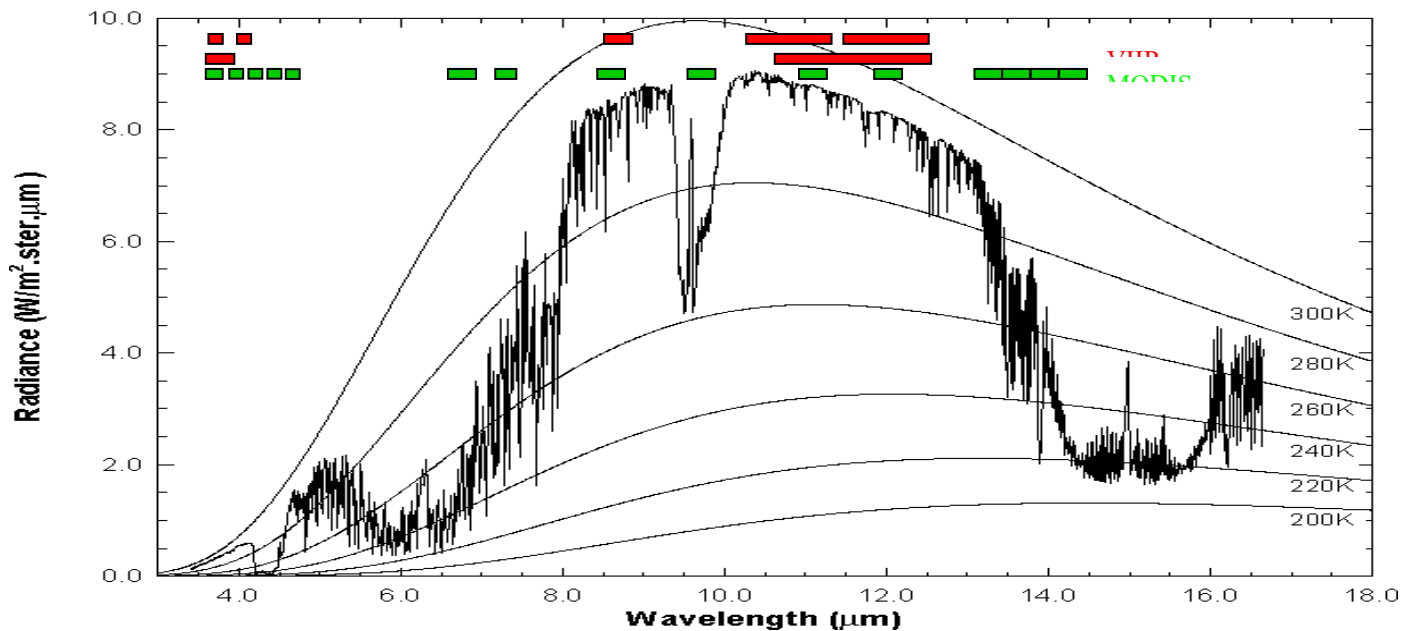


Table: MODIS Channel Number, Wavelength (μm), and Primary Application

Reflective Bands			Emissive Bands		
1,2	0.645, 0.865	land/cld boundaries	20-23	3.750(2), 3.959, 4.050	sfc/cld temperature
3,4	0.470, 0.555	land/cld properties	24,25	4.465, 4.515	atm temperature
5-7	1.24, 1.64, 2.13	“	27,28	6.715, 7.325	water vapor
8-10	0.415, 0.443, 0.490	ocean color/chlorophyll	29	8.55	sfc/cld temperature
11-13	0.531, 0.565, 0.653	“	30	9.73	ozone
14-16	0.681, 0.75, 0.865	“	31,32	11.03, 12.02	sfc/cld temperature
17-19	0.905, 0.936, 0.940	atm water vapor	33-34	13.335, 13.635,	cld top properties
26	1.375	cirrus clouds	35-36	13.935, 14.235	cld top properties



High resolution atmospheric absorption spectrum and comparative blackbody curves.



The goal of this exercise is to get familiar with the HYDRA visualization software and with the general characteristics of the MODIS data

Inspect the scene over Italy on 29 May 2001 detected by MODIS using HYDRA (see the attached instruction sheet explaining how to run HYDRA). After engaging HYDRA the HYDRA window appears (Figure 1). To load a MODIS Level-1B 1KM file from disk, click on “data | local” and select the file to be loaded (e.g., MOD021KM.A2001149.1030.003.2001154234131.hdf). When the file is loaded, an image of the 11 μm Brightness Temperature appears, as shown in Figure 2.

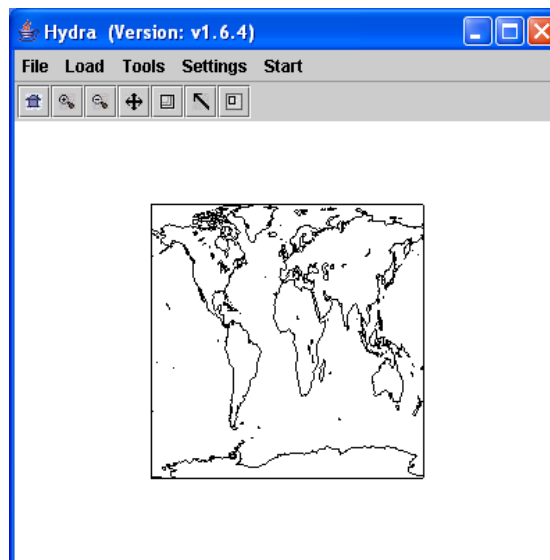


Figure 1: The HYDRA window.

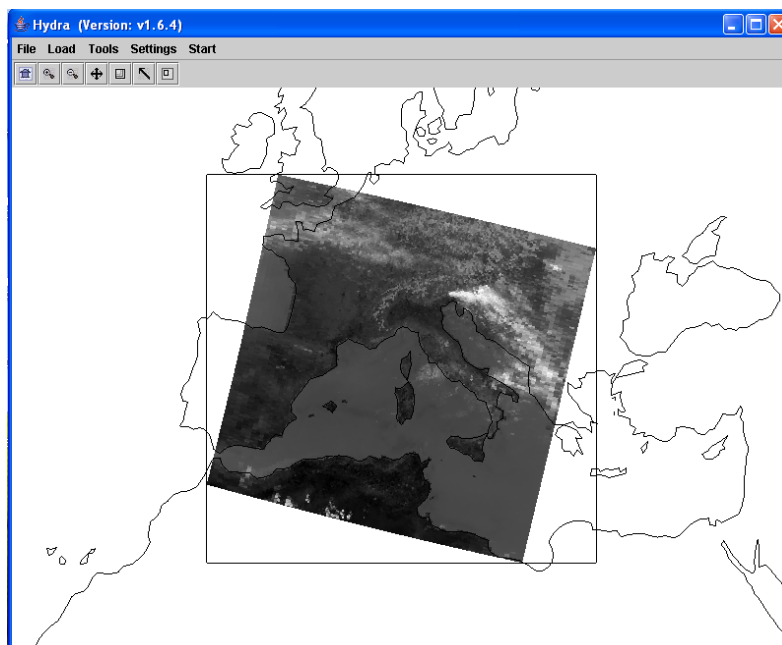


Figure 2: HYDRA window with a MODIS L1B 1KM file loaded.

1. Get familiar with the command menu **Settings**. Band 31 (11 μm) is automatically displayed at reduced resolution. Try different black and white enhancements by adjusting the color range (**Set Color Range**). Use the toolbar at the top to zoom in and zoom out and translate the image. Reset the image. Display the image in color and try different color enhancements.

2. **Start** the **Multichannel Viewer**. Display the data at full resolution by selecting a subset of the data displayed in the Hydra window (right most icon in toolbar in the Hydra window). The one kilometer resolution data will appear in the Multichannel Viewer window (see Figure 3). Zoom in on island of Sardinia west of Italy in the Multi-Channel Viewer window and in the Hydra window – compare the resolution in the images. Use the arrow icon at the bottom of the Multichannel Viewer window to scroll around in the full resolution image – locate the lat & lon of the min and max brightness temperature values in the image.

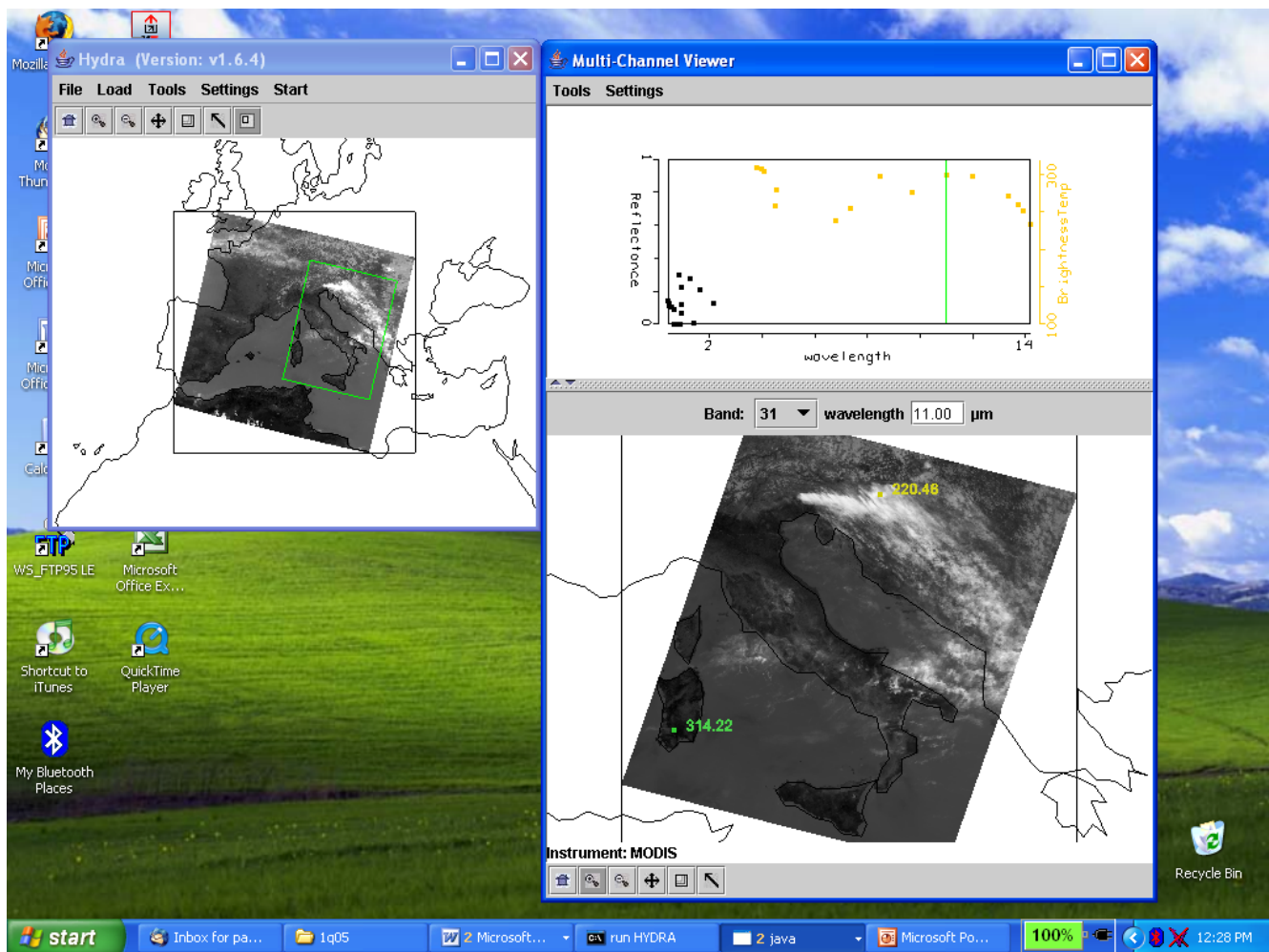


Figure 3: One kilometer resolution data displayed in the Multichannel Viewer window

3. Now select **Band number 20** (3.8 μm) and display the image. Note how much warmer the 3.8 μm brightness temperatures are than those for 11 μm . What can be responsible for this? Create an image of 3.8 μm brightness temperatures allowing the range of values to span 270 to 310 K (using **Set Color Range** under **Settings**). Do the same for 11 μm . Create a power point slide with the two images side by side. Note how the clouds are much larger in the 11 μm image.

4. Display a **Reference Spectrum** (under **Tools**). Compare the brightness temperature spectra in some locations near the shoreline (over land and sea) in northwestern Italy. Note the patches where the 3.8 μm brightness temperatures are much greater than those for 11 μm . What could be causing this?

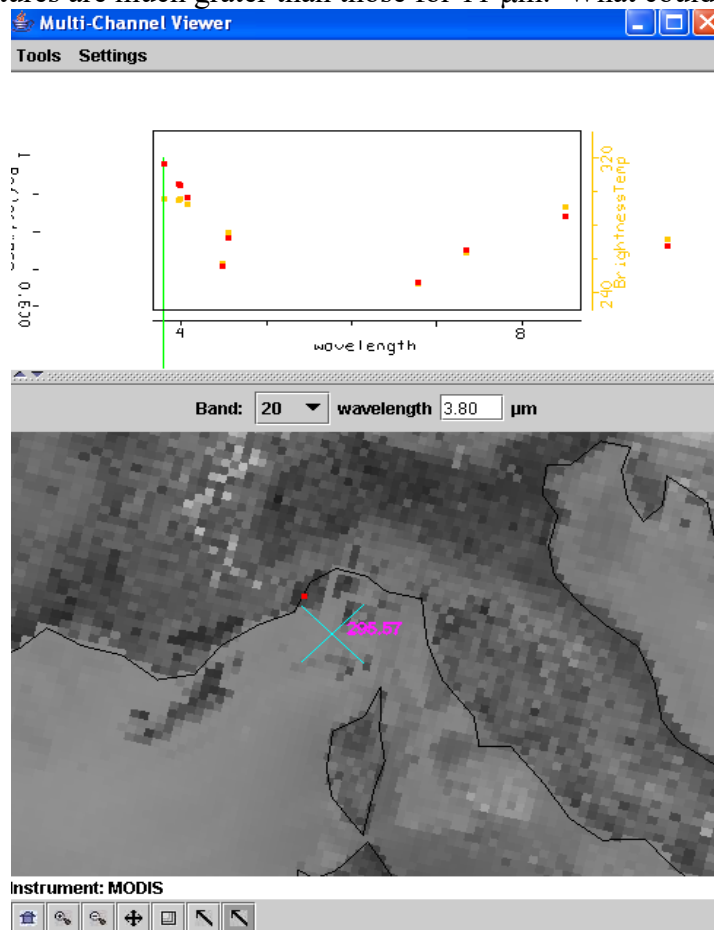


Figure 4: Multichannel Viewer window display of reference spectrum.

5. Display a **Transect** (under **Tools**) in the 3.8 μm image going through clouds, sea, and desert (see Figure 5). What are the min and max brightness temperatures encountered. Do the same for 11 μm (enable *last two* option in the transect window). Discuss the difference.

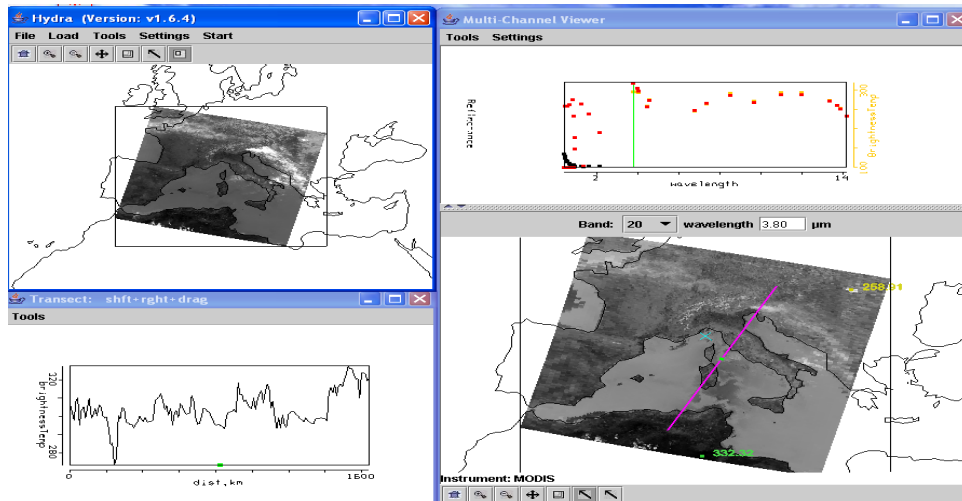


Figure 5: Brightness temperature transect of line displayed in Multichannel Viewer window

6. Open **Linear Combinations window** (under **Tools**) and display 0.55 μm reflectances on the y-axis and 11 μm brightness temperatures on the x-axis of a scatter plot (see Figure 6). Using the color areas boxes (or curves to encircle areas) to highlight pixels in the scatter plot and find where they are located in the images. Save your scatter plot and associated images on a power point slide. Explain high / low reflectances and cold / warm brightness temperature combinations in the notes section of the powerpoint slide. Construct the same scatter plot with radiances ($\text{W}/\text{ster}/\text{m}^2/\mu\text{m}$) instead of reflectances and brightness temperatures.

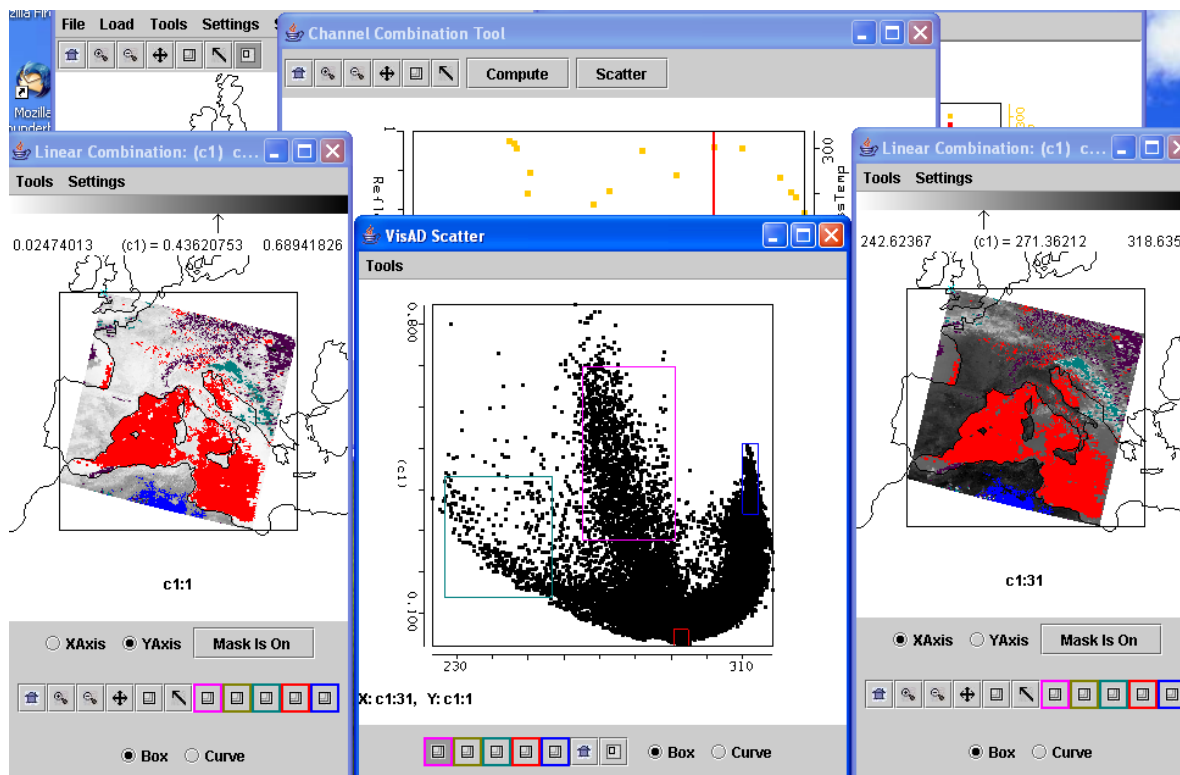


Figure 6: Scatter plot of vis on y-axis and IRW on x-axis

7. Using the *Linear Combinations* window, create an image of the difference of $3.8\ \mu\text{m}$ minus $11\ \mu\text{m}$ brightness temperatures. Display the difference image in color. Use the color range to enhance features in various regions. Save this on a power point slide. Suggest three causes for the large differences for these two window channels? Explain.
8. In the notes section of the three power point slides created for exercises 3, 6, and 7 explain the features you see. Identify regions of ice clouds, ocean sun glint, coastal fog, desert, and snow.

Extras

Exercise 1: True and false color band combination

The goal of this exercise is to introduce the user to RGB combinations of MODIS bands

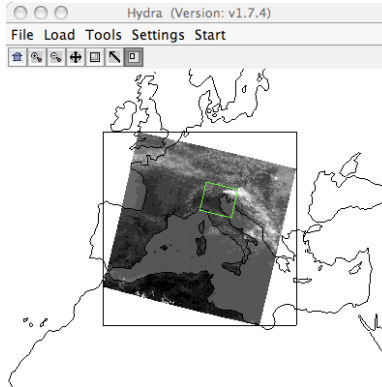


Figure 7

1.1 Create an RGB true color image of the selected sub-region (figure 7) by selecting Tools | rgb in the Multi-Channel Viewer window. A new window named "RGB Combine Tool" will be created. Select bands 1, 4, 3 (0.66, 0.55, 0.45 μm) for the true color RGB image, and click on the Compute button (the RGB image will appear in a new 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 the (1, 4, 3) and (7, 2, 1) RGB images on screen, comment on the appearance of vegetation, desert / bare soil, water, and clouds in each image.

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

1.2 Which combination of channel would you use to visually discriminate ice clouds from water clouds?

Exercise 2: Examining MODIS image artifacts

The goal of this exercise is to introduce the user to some of the artifacts characteristic of satellite observations with specific emphasis on MODIS.

Using the same Terra MODIS Level 1B file, load the full resolution data for band 1 over the region shown in Figure 8.

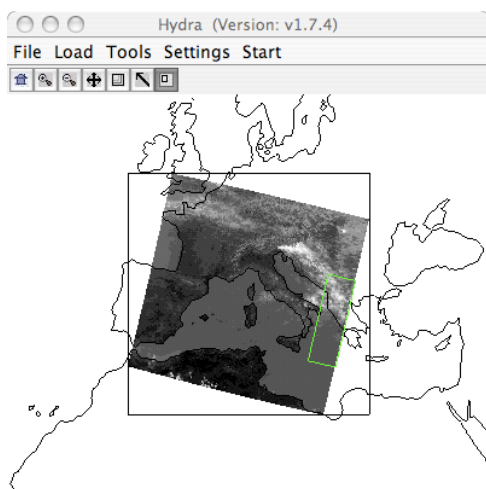


Figure 8: MODIS region selection

2.1 Using the *Setting->Projection->Instrument* option in the MultiChannel viewer window, try to visualize the so called Bow-Tie effect, and describe its appearance in the image. In particular, explain in which part of the MODIS granule this effect is evident, and what you had to do to visualize it..

2.2 Now load the full resolution subset as shown in Figure 8, and display band 31 (11 μm).

(a) Create a transect by selecting Tools | Transect in the Multi-Channel Viewer window (a new window will be created to hold the transect plot). Now hold down the shift key, then right click and drag on the image to select a transect from North to South in the area shown in Figure 9.

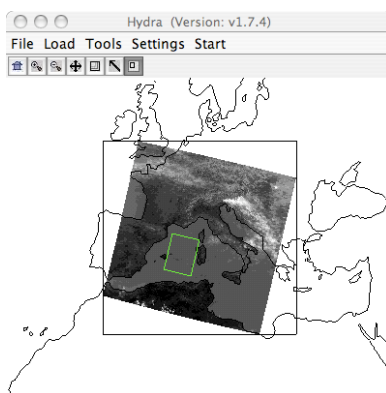


Figure 9: Transect Selection Region

(b) Now activate the *last two* option in the settings of the transect window and look at the same scene (with the transect plot active) in band 27. Is there any difference between the two bands that might be due instrument artifacts such as detector imbalance, bad detectors, and mirror side differences?

(c) In particular for band 27 only:

- What is the approximate peak-to-peak noise in the transect plot (in Kelvin), and what could be the cause?

- Does the observed pattern appear to be consistent (i.e., predictable) in the transect plot? Can you identify the period of the noise pattern?

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

2.3 Now load band 8 (0.45 μm), which is used for ocean color retrievals. This band generally saturates over bright targets such as clouds or deserts. Examine different regions of the scene to find areas where band 8 saturates.

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

(b) What is the saturation reflectance in bands 9, 12, 13, and 16 (0.443, 0.565, 0.653, 0.865 μm)?

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

(d) Are there non-physical reflectance or BT values which can not be explained by striping and/or saturation?

(e) If yes, can you explain those non-physical values?