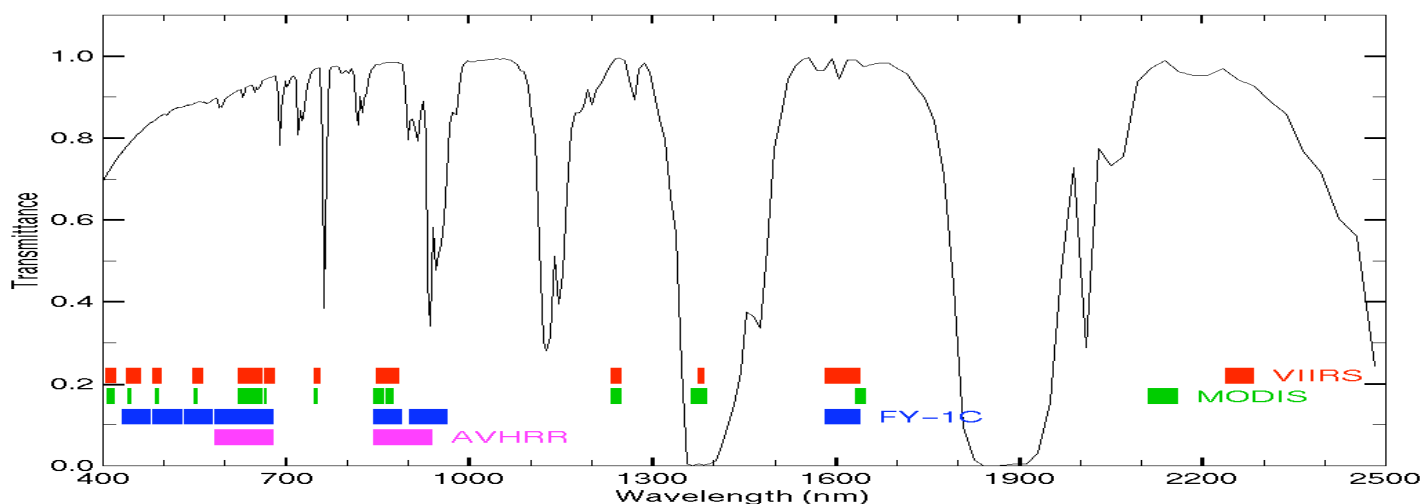


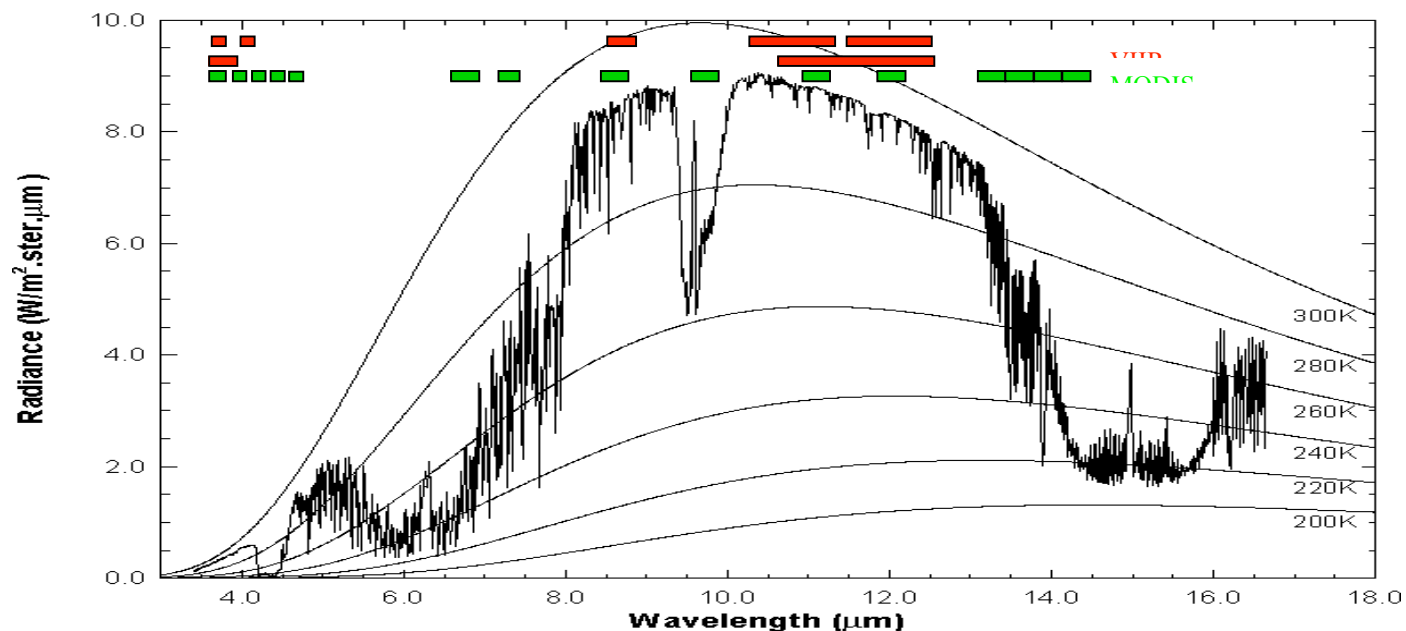
Lab 2 – Example of future HYDRA capabilities in McV as a tool to view multispectral data

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.



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 “**Load | Local Data**” 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 radiances appears, as shown in Figure 2.

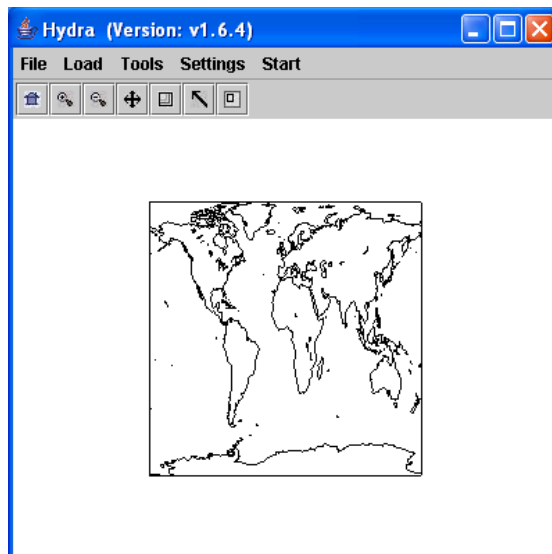


Figure 1: The HYDRA window.

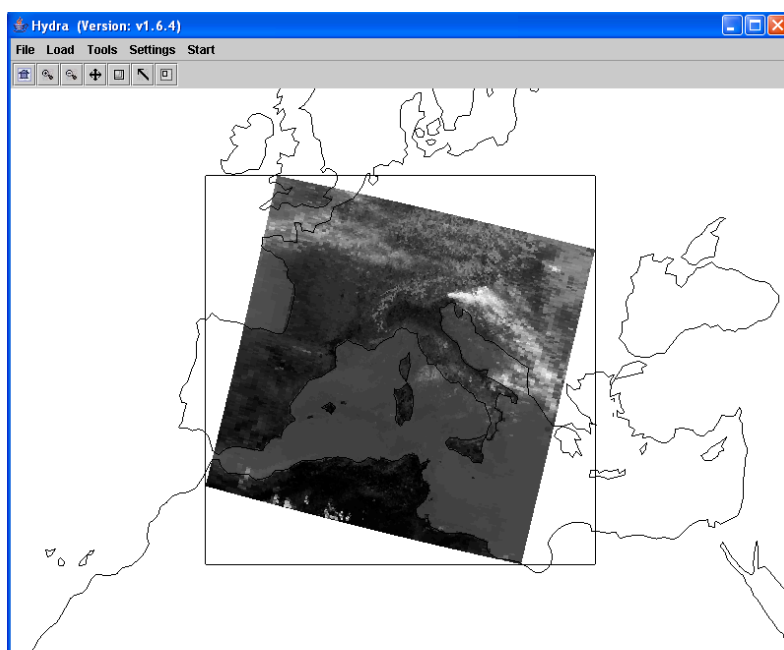


Figure 2: HYDRA window with a MODIS L1B 1KM file loaded.

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 the 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.

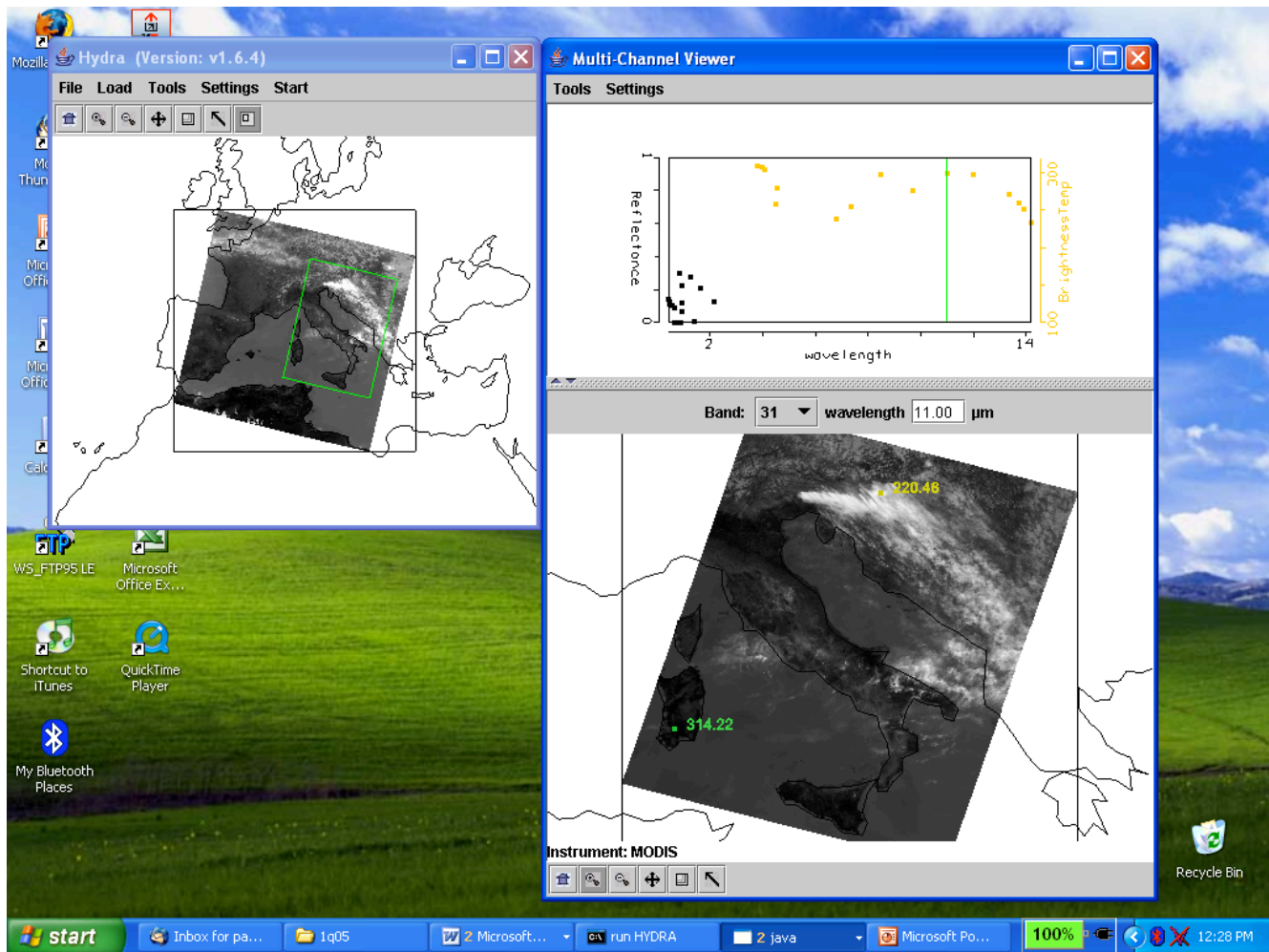


Figure 3: One kilometer resolution data displayed in the Multichannel Viewer window

- Now select **Band number 20** ($3.8 \mu\text{m}$) and display the image. Note how much warmer the $3.8 \mu\text{m}$ brightness temperatures are than those for $11 \mu\text{m}$. What can be responsible for this? Create an image of $3.8 \mu\text{m}$ brightness temperatures allowing the range of values to span 270 to 310 K (using **Set Color Range** under **Settings**). Do the same for $11 \mu\text{m}$. Look at the images side by side. Note how the clouds are much larger in the $11 \mu\text{m}$ image. Can you explain why?
- Display a **Reference Spectrum** (under **Tools**). Compare the brightness temperature spectra in some locations near the shoreline (over land and sea) in northwestern Italy (See Figure 4). Note the patches where the $3.8 \mu\text{m}$ brightness temperatures are much greater than those for $11 \mu\text{m}$. What could be causing this?

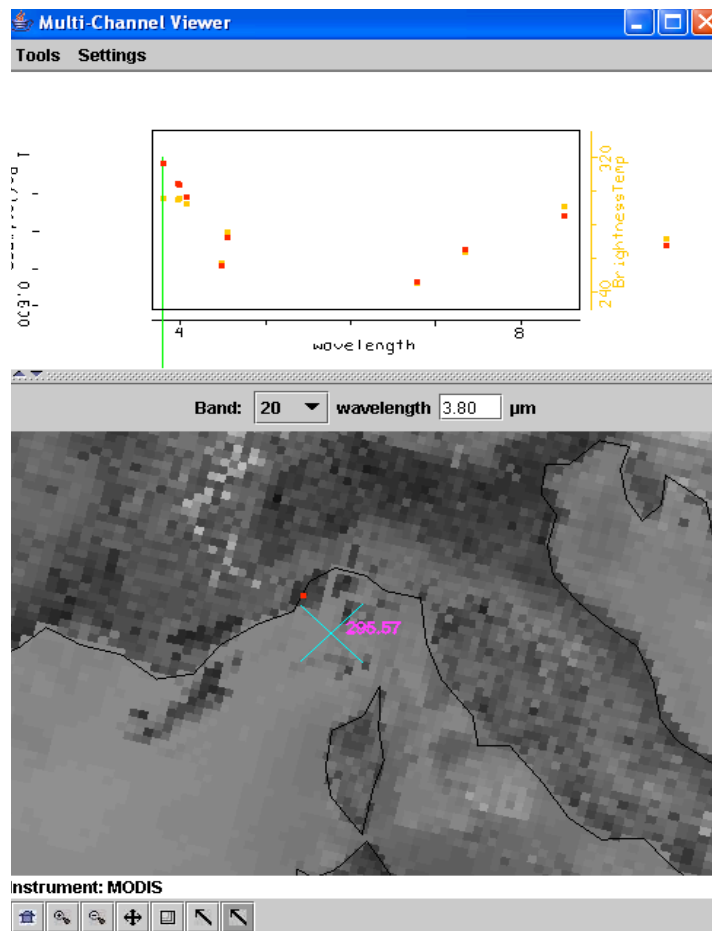


Figure 4: Multichannel Viewer window display of reference spectrum.

5. Close the Multi-Channel Viewer window and then open a new one. 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. Discuss the difference.

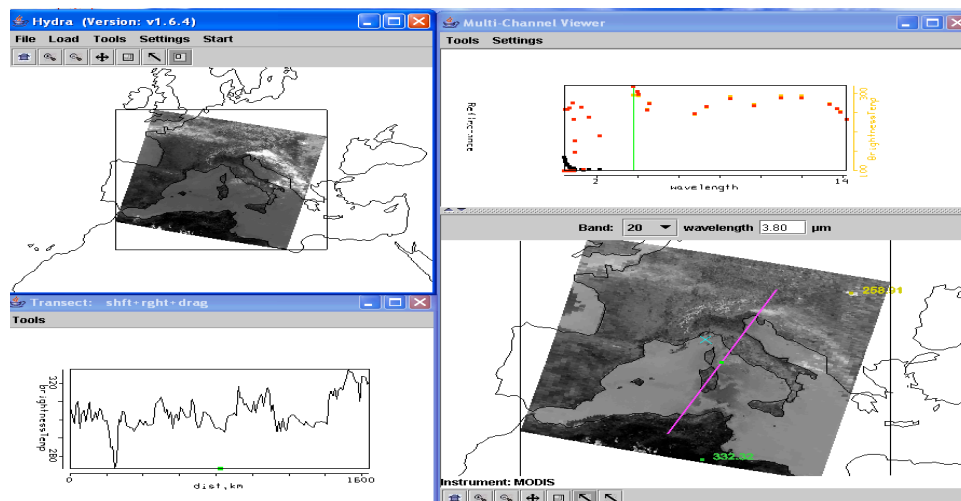


Figure 5: Brightness temperature transect of line displayed in Multichannel Viewer window

6. Open **Linear Combinations** (under **Tools**) and display $0.65\ \mu\text{m}$ reflectances on the y-axis and $11\ \mu\text{m}$ 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. Explain high / low reflectances and cold / warm brightness temperature. Identify regions of ice clouds, ocean sun glint (reflectance), coastal fog, desert and snow.

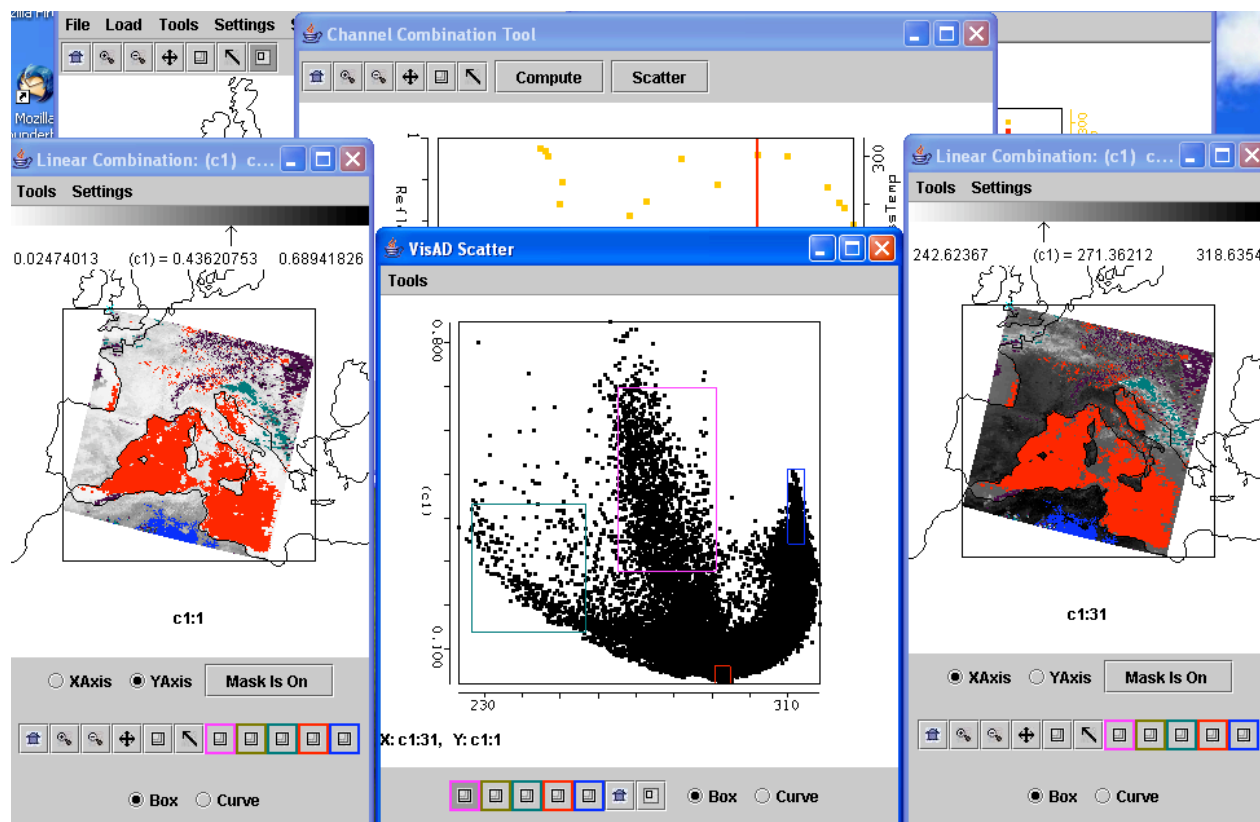


Figure 6: Scatter plot of vis on y-axis and IRW on x-axis

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. Suggest two causes for the large differences for these two window channels? Explain.

Extra Exercise: Hyperspectral data in Hydra.

1. Open **Hydra** and load the file: AIRS.2005.08.28.103.L1B.AIRS_Rad.v4.0.9.0.G05241172839.hdf. Under **Start** open the **MultiChannel Viewer** and the following should appear (see Figure 2).

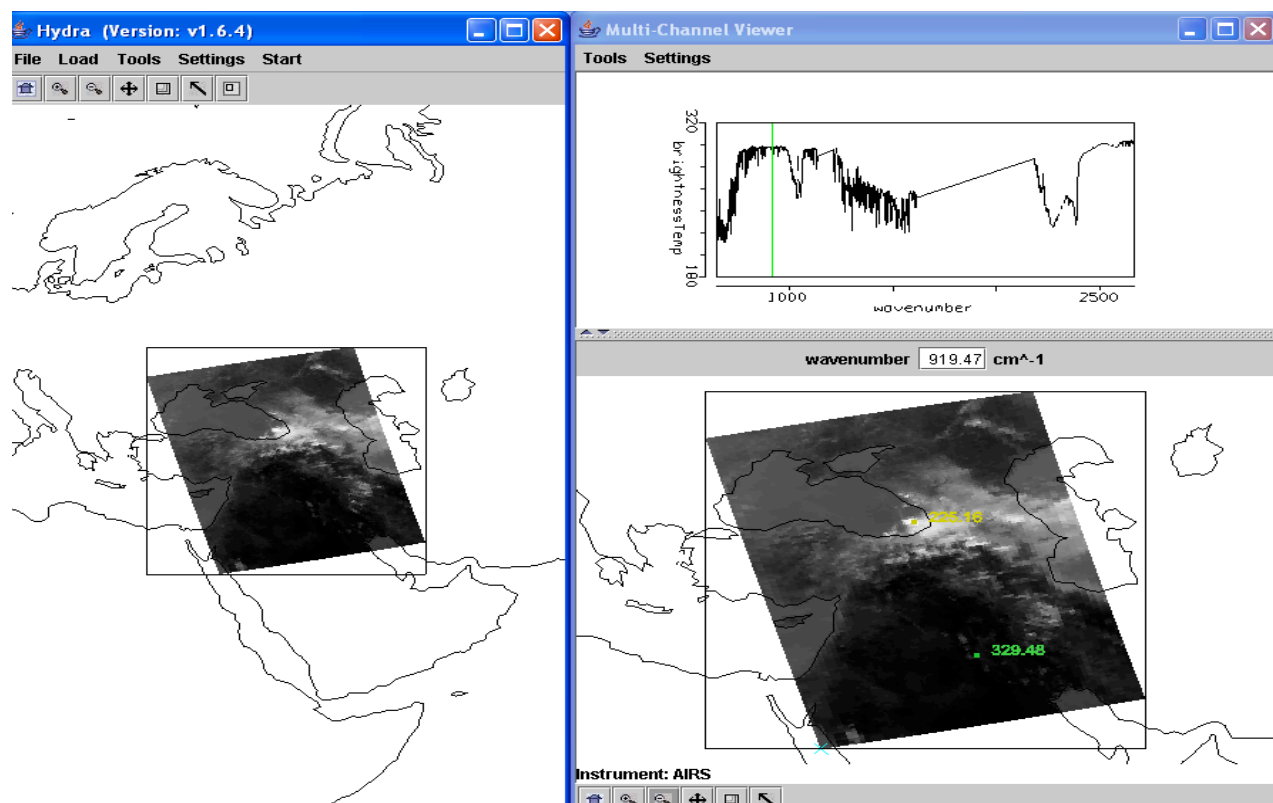


Figure 2: Hydra display of AIRS data showing BT spectra from warmest pixel and IRW image over the Black and Caspian Seas on 28 August 2005.

1a. Explore the image to view spectra measured in various pixels. Look closely at the spectra and comment on how it differs from the IASI spectra. Zoom in on the IR window again until you can see individual water vapor lines. Again, note what differences you see from the IASI data.

Appendix –Summary of HYDRA Commands

HYDRA main window

Displays a world map and shows **File**, **Load**, **Tools**, **Settings**, and **Start** at top.

File offers

Exit to closes this window

Load has the options

Local Data allows you to search local directories to find MODIS, AIRS, GOES or Meteosat data.

Remote Data allows you to get data from a remote server

(a) Terra or Aqua Direct Broadcast or (b) Goddard DAAC

GOES/MSG allows you to get geostationary satellite data from an ADDE server

Lidar allows you to get Calipso data

AREA allows you to display subsetter McIDAS SEVIRI and GOES area files

After a data granule is selected HYDRA displays the infrared window (at reduced resolution 4 km for MODIS) on a world map.

Tools offers

Capture Display to save the image as a jpeg

Settings has

Set Color Range where the histogram of brightness temperatures or radiances can be adjusted to maximize contrast – the color range can be altered with a right click plus drag at either end of the color scale

Set Color Scale where **Color**, **Gray** and **Inverse Gray** gives choice of color, grey, or inverse grey (which produces white clouds for infrared channels)

The toolbar at the top enables reset, zoom in, zoom out, translate, box magnify, find location, and subset at full resolution functions

Reset (left click on reset and then click on image to restore original image)

Zoom in (left click on zoom in plus click on image enables enlargement)

Zoom out (left click on zoom out plus click on image enables far view)

Translate (left click on translate plus click on image enables moving the image within the window)

Box magnify (left click on box plus click and drag to create box for enlargement)

Find location (left click on arrow plus click on image displays location of the chosen pixel)

Subset at full resolution (only after Multi-Channel Viewer is engaged, then left click on subset plus click and drag on image creates a subset of image at full resolution; this is automatically transferred from HYDRA into the Multi-Channel Viewer when both are engaged – data is displayed at reduced resolution by default unless subset function is used)

Start opens **Viewer**

wherein the measured spectra (wavenumber on x-axis and radiance or brightness

temperature on y-axis) is displayed along with a spectral band superimposed on a world map. Left click on arrow icon in the bottom toolbar allows you to see the pixel value for a given lat-lon (using left click and drag).

Tools menu (appears in **Multi-Channel Viewer** window)

Linear Combinations opens the **Channel Combination Tool** display where you can specify linear combinations of spectral bands a,b,c and d
(a $+x$ / b) $+x$ / (c $+x$ / d).

rgb allows you to select a spectral channel for each color in the RGB display

Transect allows you to create a line on the image and see the temperatures or radiances along the transect marked by shift plus right click and drag.

Capture Display allows you to save the image as a jpeg

Statistics displays the min and max values in the image

Reference Spectrum allows you to compare spectral measurements from two selected pixels (controlled by the arrows in the bottom toolbar)

Settings (on the Viewer) has

Set Color Range where the histogram of brightness temperatures or radiances can be adjusted to maximize contrast – the color range can be altered with a right click plus drag at either end of the color scale

BT->radiance allowing you to toggle from brightness temperatures to radiances in the infrared spectral channels

Projection offers **Lambert Equal Area** or **Instrument** projections of the data

Set Color Scale where **Color**, **Gray** and **Inverse Gray** gives choice of color, grey, or inverse grey (which produces white clouds)

Lat/Lon Grid can be superimposed on the image by using the toggle

Image Label labels the image with the instrument and day/time of the data

The **Channel Combination Tool** offers the usual tool bar and

Compute to create an image of the selected linear combination (you can indicate at the bottom your preference for this linear combination to be on the x- or y-axis in the scatter plot) and displays a toolbar for image manipulations (five color boxes are available in the toolbar to select regions by boxes or curves in the image that will be displayed in the scatter plot; a left click drag in the image highlights the chosen points in the scatter plot).

Scatter creates a scatter plot of the chosen x- and y-axis linear combinations. Five color area boxes (or area curves) in the bottom toolbar of the scatter plot allow you to select points in the scatter plot that will be displayed in the x-axis and y-axis images; a left click drag in the scatter plot highlights the chosen points in the scatter plot and simultaneously in the x- and y-axis images. Conversely (as indicated before) left click drag in the x- or y- axis images shows the locations of the chosen pixels in the scatter plot. Each color area box (or area curve) can be erased with a left click when the color box is engaged; after erasure another area box (or area curve) can be selected for this color. The zoom capability in the scatter plot (on the bottom right of the toolbar) allows you to enlarge special features in the scatter plot and investigated them in more detail.

Viewing Level 2 Products

When viewing level 2 products (staged in a separate file), HYDRA generates a display of that product. Current choices include the cloud mask (from MOD35), total column ozone and water vapor (from MOD07), cloud top properties (from MOD06), and AIRS profile retrievals (generated using a statistical regression retrieval algorithm trained with AIRS spectra calculated from radiosonde observations).

When viewing MOD07 or AIRS profiles, *Variables* offers the choice to display

- air temperature profiles
- total ozone
- precipitable water
- surface temperature
- water vapor profiles
- surface pressure
- ozone profiles

Levels offers 17 levels between 1100 and 50 hPa for the retrieval field display.

Settings offers a choice to *Set Color Range*, *Set Color Scale*, and *Show Color Bar*. The last choice enables superposition of a color bar label that identifies the values of the product associated with each color.

Tools offers the option of *Reference Profile* that allows you to compare level 2 products from two selected pixels (controlled by the arrows in the bottom toolbar where the red dot indicates the location of the second profile) and *Transect* that allows you to construct a transect across the level 2 product image.