Lab 5 GOES/MODIS Fire Detection   Kathleen Strabala kathy.strabala@ssec.wisc.edu
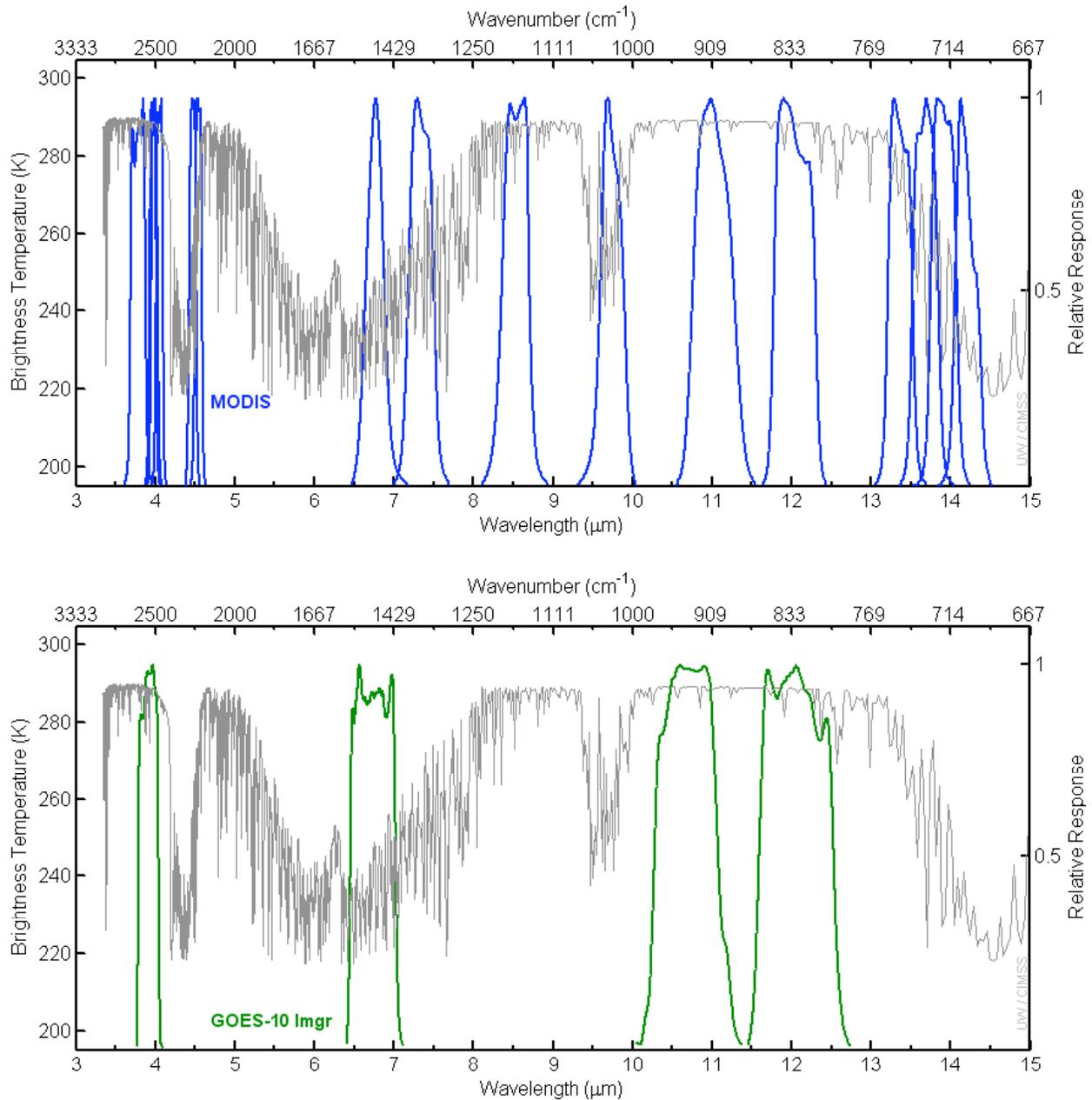
F**igure 1:** Spectral response functions for MODIS (Top) and GOES-10 Imager (Bottom) infrared bands.

1. Open Hydra and load the GOES10 imager area from 4 September 2007, 17:28 UTC
(GOES10_IMAGER_2007247_1728.area). Open a Multi-Channel Viewer. Now go back to the
Hydra main window and open a new Hydra main window (**File->New**) and load in the MODIS data
from 4 September 2007, 17:25 UTC (MYD021KM.A2007247.1725.005.2007275125156.hdf). Open a
Multi-Channel Viewer from this new main Hydra window and change the band to 22 (3.97 μm).
When you finish you should have two Hydra main windows and two Multi-Channel Viewers open as
shown in Figure 2.
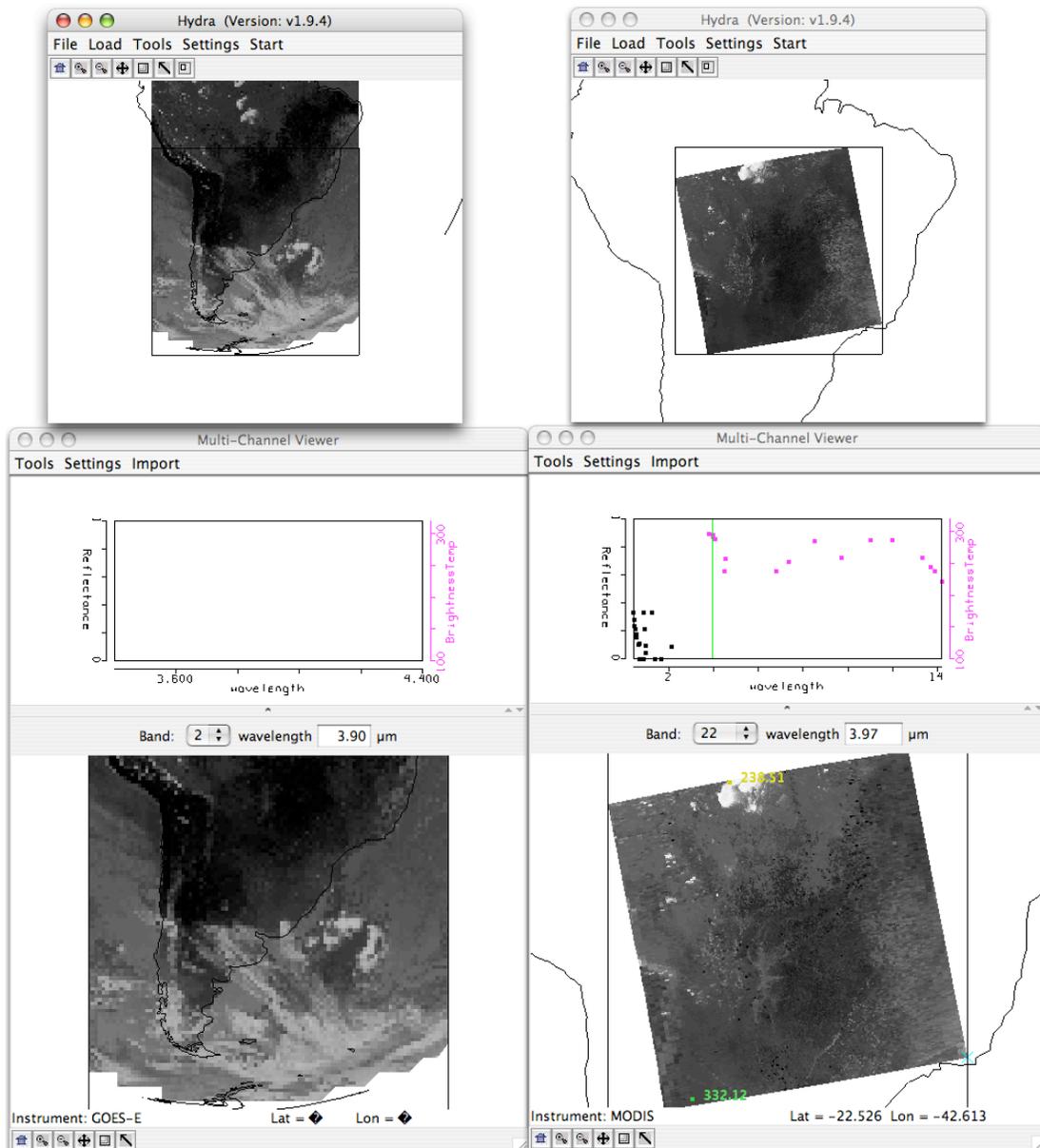
Figure 2: Hydra display of GOES-10 imager data from 17:28 UTC 4 September 2007 (Left Panel) and MODIS data from 17:25 UTC 4 September 2007 (Right Panel).

Please note that the entire portion of the GOES-10 data is not being displayed in the Multi-Channel Viewer. You can scroll up to see the rest of the data set.

2. Try to locate the region of the GOES-10 data set that matches the area covered by the MODIS 5 minute granules. Use the Arrow navigation tool at the bottom of the MODIS image to investigate brightness temperatures over the scene. Since the navigation in both of the Multi-Channel Viewer data set windows are linked together, you will also see the values of the same points in the GOES-10 image displayed.

(a) Compare 3.9 μm brightness temperatures between the two instruments (band 2 for GOES-10 and MODIS band 22). Look over the whole MODIS image including the clouds. How do the values compare? Give some reasons for the differences.

(b) Now compare the 11 µm brightness temperatures between both instruments (band 31 MODIS and band 4 for GOES-10). How do the values compare?

3. Now select a region to examine at full resolution as shown in Figure 3. Try to capture the same region in both Hydra windows.
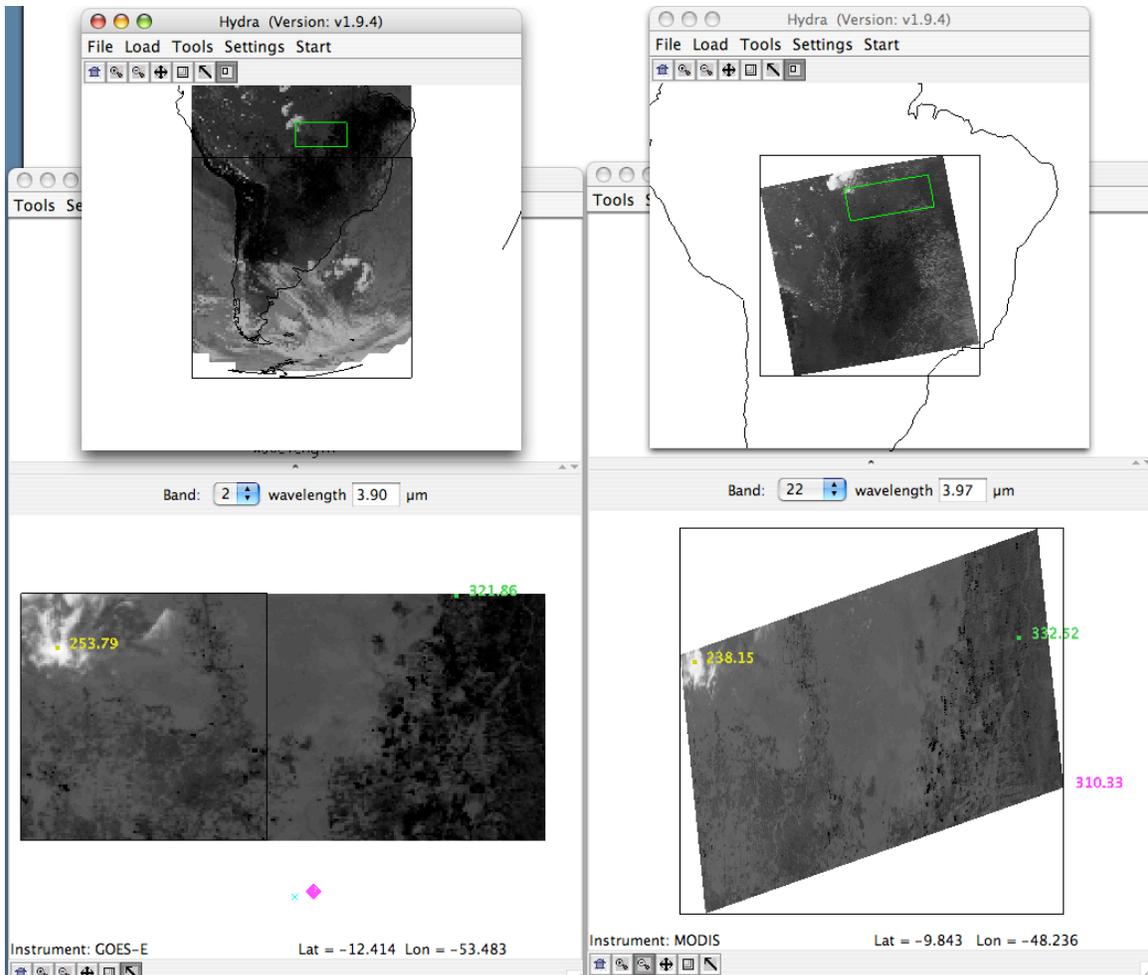
Figure 3: GOES-10 (Left Panels) and MODIS (Right Panels) main Hydra windows and Multi-Channel Viewer full resolution subsetted regions from 4 September 2007.

(a) Again, the entire subset is not being displayed in the GOES-10 imager Multi-Channel Viewer. Display the entire subset and compare the projections. Now change the MODIS projection to instrument (**Settings->Projections->Instrument**). Now compare the projections. The bow tie effect of the MODIS instrument is now more evident on the right side of the image.

4. Change to band 2 for GOES-10 and MODIS band 22 (the 3.9 µm bands). Set the lower bounds of the temperature range to 280 K for each instrument (this will help find the darkest pixels). Create a transect across some of the darkest pixels in the MODIS band 22 scene as shown in Figure 4. Once the transect window is open, de-select *Transect->update all* which will turn off the mapping between the two windows. What range of values do you observe in the transect? Do you notice anything that looks strange to you? Grab the transect point locater by right clicking and holding down the mouse button on the green point located at the bottom of the transect window X-axis. Move the position to the location along the transect where there seems to be missing data. Why do you think the values are missing?

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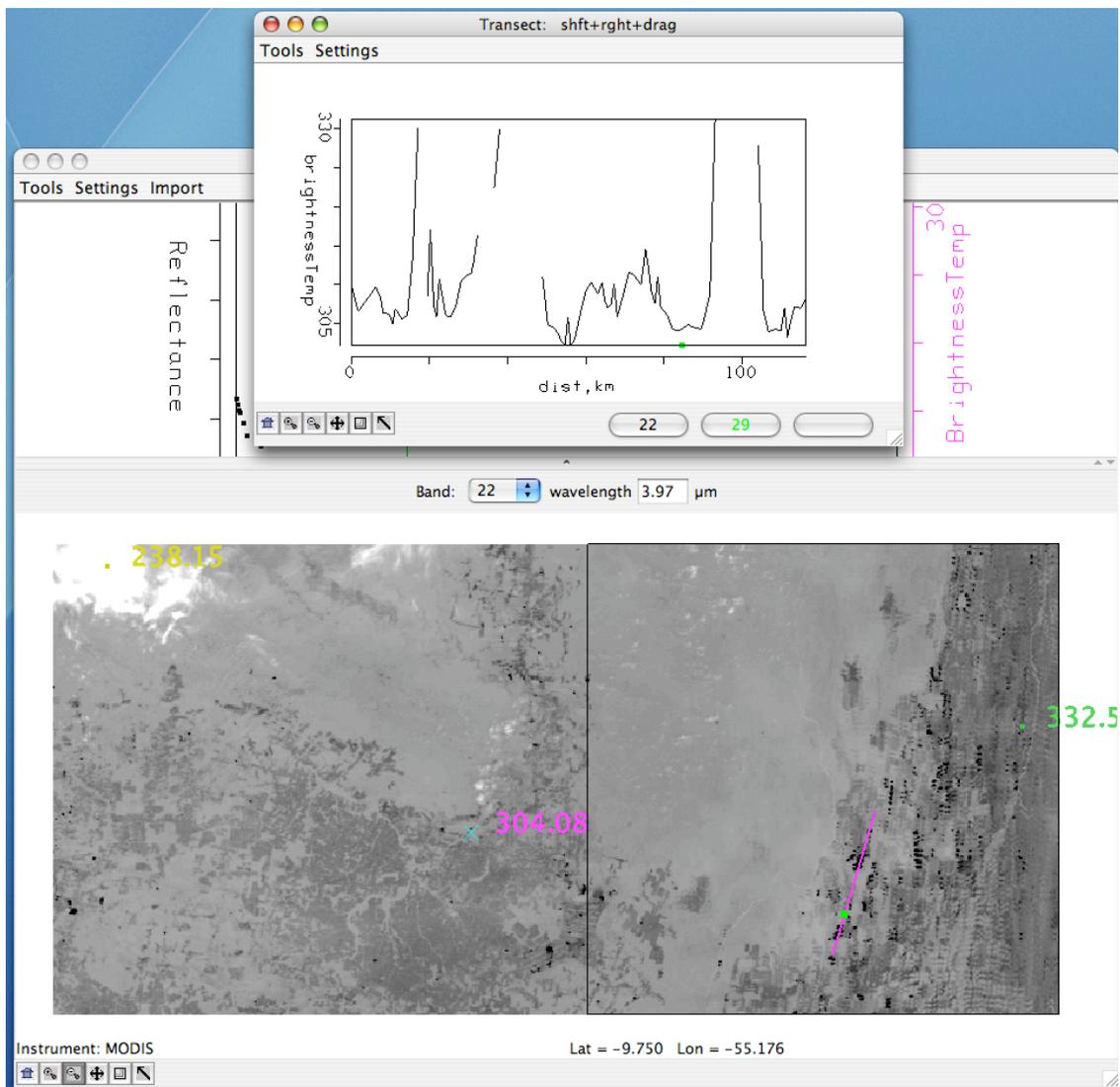
Figure 4: Transect of MODIS Band 22 (3.9 µm) brightness temperatures from 4 September 2007.

(a) Now look at the values in the GOES-10 image by selecting Tools->Transect in the GOES-10 Multi-Channel Viewer. A transect will appear in blue on the image in the wrong location, so very carefully try to draw a new transect in the GOES-10 image to match the transect in the MODIS image. If you are successful, the transect will appear in the same window with the MODIS values. Compare the values. Are there missing values in the GOES-10 data? Change the bands to 11 µm for each instrument. How do these brightness temperatures compare? What are the reasons for the temperature differences observed between the instrument bands?

(b) Change the MODIS window to band 21 (3.99 µm). Look at the range of values in the transect. Are there missing values? MODIS band 21 is the MODIS fire channel. It is sensitive to a broader range of temperatures and less sensitive to fine scale temperatures changes. It has a saturation value of 500 K compared to band 22, that saturates at 331 K. Look at the brightness temperatures of all the emissive bands in the top panel of the MODIS Multi-Channel Viewer for pixels in and around the hot spots. Now change the units back to radiances and repeat this step. Comment on how the 4 µm channels behave relative to the 11 µm window region values in both brightness temperatures and radiances. When you are through change back to Brightness Temperatures.
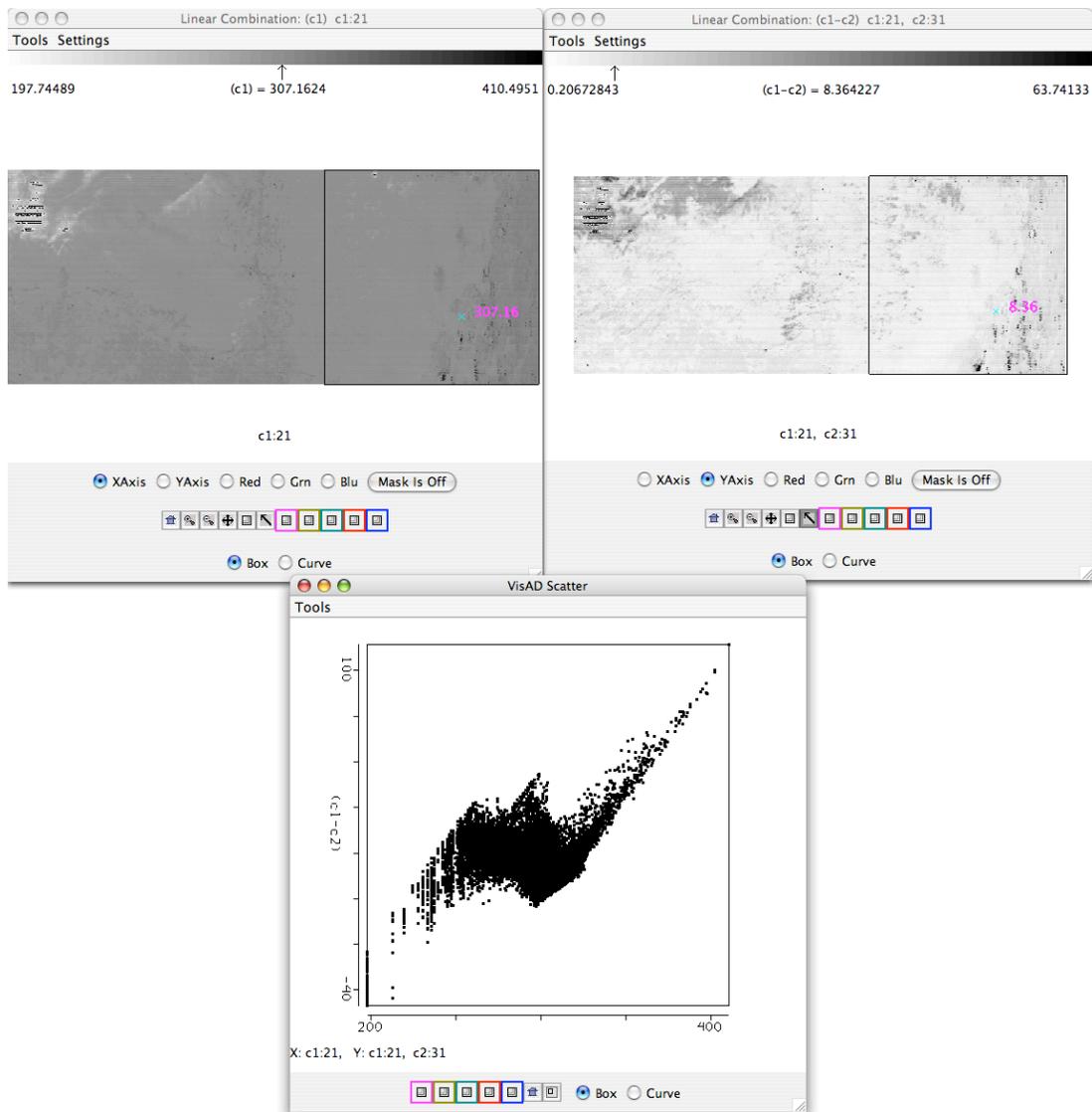
Figure 5: Scatter diagram (Bottom Panel) of the MODIS 4 μm band on the X-Axis (Top Left Panel) and 4-11 μm brightness temperatures differences (Top Right Panel) on the Y-Axis.

(c) From the MODIS Multi-Channel Viewer, open the Linear Combinations Window and make a single image of Band 21 (3.99 μm) and a combination window of Band 21 (3.99 μm) – Band 31 (11 μm) as shown in Figure 5.   Choose the band 21 image as the X-axis and the brightness temperature difference image as the Y-axis, and create a scatter diagram. Save the scatter diagram by using the *Tools->Capture Display* option in the scatter diagram window. Identify the different patterns in the scatter diagrams. Where do clouds occur? Where are the fires? What are the regions with values less than zero?

(d) Fire detection algorithms often use a series of tests to determine if a pixel contains a fire.   If you were to create a fire detection technique for MODIS, what thresholds would you use for an:

   i) 3.99 μm (Band 21) micron brightness temperature test
   ii) 4-11 μm micron brightness temperature difference test (Band 21 – Band 31)

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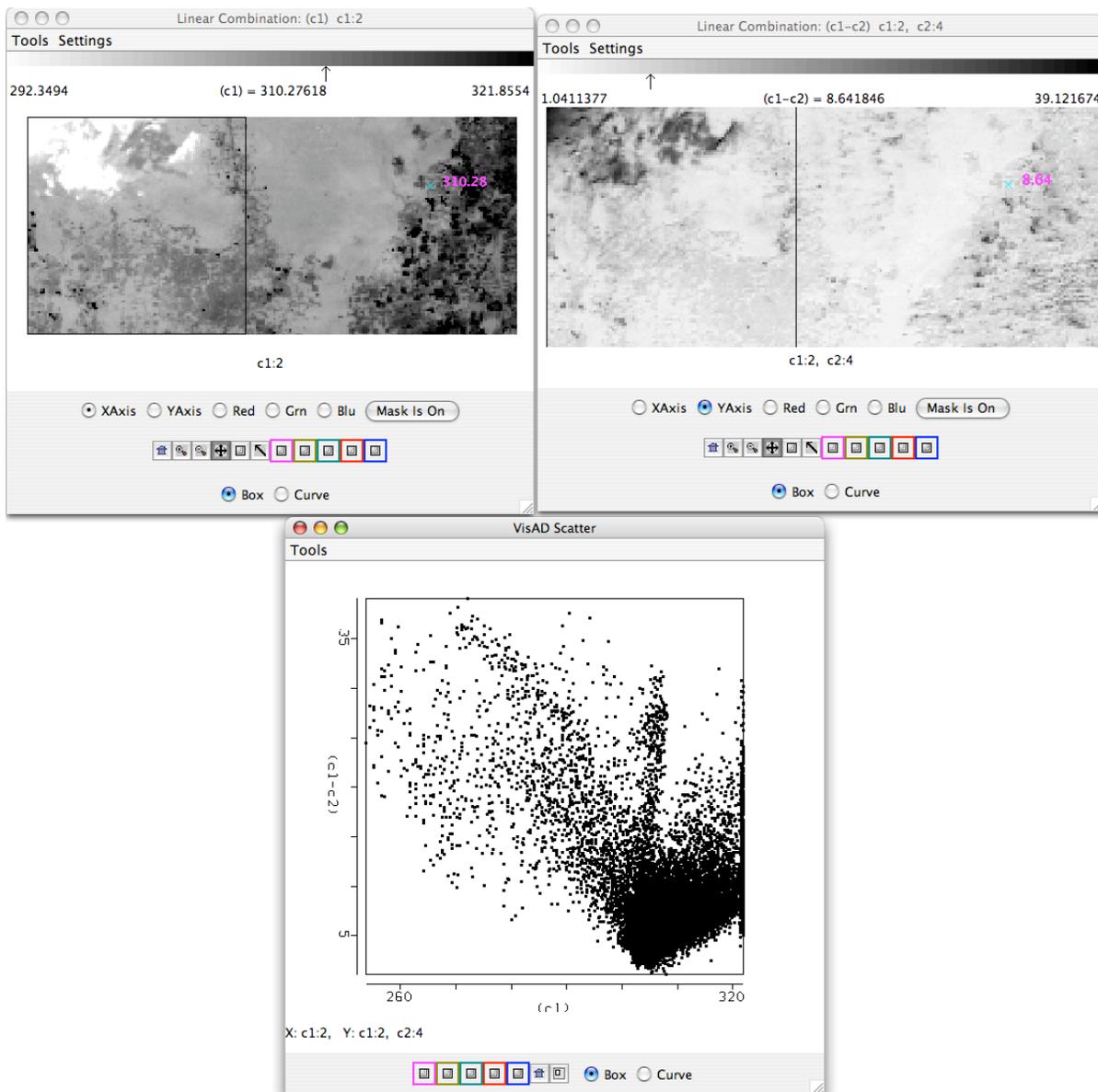
Figure 6: Scatter diagram (Bottom Panel) of the GOES-10 4 µm band on the X-Axis (Top Left Panel) and 4-11 µm brightness temperatures differences (Top Right Panel) on the Y-Axis.

(e) Now close the Linear Combinations window. Make sure you have the GOES-10 window units set to brightness temperatures and open up a new Linear Combinations window from the GOES-10 Multi-Channel Viewer. Create a scatter diagram of the 4 µm band (Band 2) on the X-Axis and 4-11 µm brightness temperature differences (Band 2 - Band 4) on the Y-Axis as shown in Figure 6. Do you recognize the patterns that you saw in the MODIS scatter diagram? How do they differ? Give reasons why they differ. You may wish to display the MODIS scatter diagram that you saved to help you. Why do the maximum values of 4-11 µm brightness temperatures differences cut off so sharply. How will this affect your ability to detect fires?

(f) Now apply the fire detection threshold that you created for the MODIS instrument in exercise 4d to this GOES-10 data set. Describe your results.

(g) Consider how these things would affect your ability to detect fires:

   i). Hot surfaces
  ii). Clouds
 iii). A really large fire

(h) What are the advantages and disadvantages of GOES-10 Imager and MODIS fire detection capabilities? How do they compliment each other?

(i) See how the official MODIS fire algorithm performs on our data set. From the main Hydra MODIS window, load in the MODIS Level 2 fire product for this same time (MYD14_L2.A2007247.1725.hdf). A new window will appear labeled MODIS Fire Mask Product, and the 5 category fire mask will be overlaid on the image in the Multi-Channel Viewer. You can toggle the mask off and on from the product window. How does the mask perform? Find a region where you think it does not perform well, and give reasons why it might be failing.

Extra Credit Exercise: Fire detection using the GOES-10 Sounder

5. Load in the GOES-10 Sounder data from 4 September 2007, 17:31 UTC (GOES10_SOUNDER_2007247_1731.area). Open a new Multi-Channel Viewer, and try to select the same geographical region of data as displayed in Figure 3. Examine the region in the 4 and 11 μm regions (sounder bands 17 and 8). Note the range of values. How do they compare to the MODIS and GOES-10 imager values?

(a) Now create another scatter diagram of the 4 μm band on the X-Axis and 4-11 μm brightness temperatures differences on the Y-Axis using the GOES-10 Sounder data. Do you recognize any similar patterns to that of MODIS or the GOES-10 Imager? How do the range of values differ?

(b) Now apply the fire detection threshold tests that you created in exercise 4(d) using your MODIS thresholds. Describe your results.

(b) Describe how the fire detection capabilities of the GOES-10 Sounder compare with those of the GOES-10 Imager and MODIS instruments.