LAB – Investigate a tropical depression with AIRS, and compare the AIRS instrument characteristics to IASI

AIRS – Atmospheric Infrared Sounder
IASI – Infrared Atmospheric Sounding Interferometer

Case: Gulf of Mexico on September 1, 2011. Tropical Depression 13 (which would become Tropical Storm Lee) is causing widespread convection. There are also a wide variety of cloud types present over the southern and eastern United States.

1. Goals of this lab:
    a. Create and interpret multi-spectral displays in McIDAS-V
    b. Understand relationship between atmospheric absorption, cloudiness, and weighting functions in the infrared
    c. Understand limb effects
    d. Learn additional quantitative tools in McIDAS-V such as data transects and scatter plots
2. Some interesting links for this case (the details aren't important):
    a. Relevant report from National Hurricane Center: http://www.nhc.noaa.gov/archive/2011/al13/al132011.public.001.shtml?
    b. Quicklook from MODIS today: http://ge.ssec.wisc.edu/modis-today/index.php?satellite=a1&product=true_color&date=2011_09_01_244&overlay_sector=false&overlay_state=true&overlay_coastline=true&sector=USA7&resolution=2000m

Here are step-by-step instructions for today's lab (key questions are in yellow):

1. In McIDAS-V, add the AIRS granule as a HYDRA data source
    a. Click the **Data Sources** tab in the **Data Explorer** window
    b. Click the arrow next to **Satellite,** then click **HYDRA**
    c. Browse to **Data → AIRS** folder and select the file '**AIRS.2011.09.01.191.L1B.AIRS_Rad.v5.0.0.0.G11245122309.hdf**'
    d. Click **Add Source**
2. Create a multi-spectral display of the of the AIRS granule
    a. Click the **Field Selector** tab of the **Data Explorer** window
    b. Select **Hydra** in the **Data Sources** panel
    c. Select **MultiSpectral Display** under **Displays → Imagery**
    d. Click **Create Display**
3. It is possible to do several things with the **MultiSpectral Display** you just created. Try the following:
    a. On the map, locate the two **Data Probes** that were created automatically, and drag them both onto the Gulf of Mexico where AIRS is plotted. They are probably on top of each other… try dragging one to see the other.
    b. Now in the **Data Explorer** window, click the **Layer Controls** tab, then click the **Display** tab. You should see spectra corresponding to each of the data probes you just dragged onto the Gulf of Mexico.
    c. Try moving one of the data probes and watch the spectra change accordingly. Note: you can zoom and pan around the spectra plot exactly the same way you can with the map.
    d. On the spectra plot, you should also see a vertical green line. You can drag this line to whichever wavenumber you want to see, and the AIRS plot will change automatically on the map.
    e. Since the software only displays wavenumbers, you might find a converter like this one to be useful: http://www.cactus2000.de/uk/unit/masswav.shtml

4. Now use the functionality you learned in the previous step to explore the scene. Here are several questions you may want to consider:
    a. What are the differences in the spectra for deep convective clouds, cloud-free areas, and other interesting cloud features (for example, the topography-induced cloudiness over the Appalachian Mountains in the eastern U.S.) and why? Are there differences between cloud-free land and cloud-free ocean?
    b. For the different cloud types, how cold do you think the cloud tops are? In what spectral region would you look to get a good estimate?
    c. Why can't you estimate the surface temperature in the same way with the same accuracy?
    d. Plot various wavenumbers, located both in and out of absorption bands, and try to explain the differences you see.
    e. Try changing the plot to a CO_2 absorbing channel. For example, try about 706 cm^{-1} (about 14 microns).
    f. How do the brightness temperatures look toward the edge of the scan versus the center? Why?
    g. Now try finding a channel where you see the 'opposite' effect. Hint: if you chose 706 cm^{-1} before, a good choice is about 661 cm^{-1}.
    h. Note: when selecting a wavenumber, try zooming in on the spectra plot with the middle mouse wheel. Note how closely spaced the individual absorption lines are! So the plots you make here will be very sensitive to the exact wavenumber you choose.
    i. Why do brightness temperatures decrease toward the edge for some channels, and increase toward the edge for others? Hint: consider at what height in the atmosphere the weighting function for each channel will peak.
    j. You can explore this more quantitatively using the **Data Transect** feature of Mcidas-V:
        i. Go to the **Field Selector** tab of the **Data Explorer** window, select **Hydra** in the **Data Sources** panel, select **General → Data Transect** in the **Displays** panel, and click **Create Display**.
        ii. An Error message will appear at this point – this is a known issue that will hopefully be fixed in a future version of Mcidas-V. Just click **OK**.
        iii. A new colored point should have appeared on your map. Drag this to create a line with handles on either side, which can both moved to get a "transect" through whatever area of the data that you want.
        iv. Now, in the **Layer Controls** tab of the **Data Explorer** window, click **Hydra – Data Transect** on the left hand side. Then go to **Edit → Properties**.
        v. Click the **Channels** tab and move the vertical green line to about 706 cm^{-1}. Note, the wavenumber you choose for your data transect won't necessarily match the wavenumber you chose for your image display, this is OK.
        vi. Now you have a plot of brightness temperature values along the transect you just created.
        vii. Note: there is an "auto-scale" checkbox in the **Settings** tab that you may find useful as you change the location of your transect.
        viii. Now reconsider the behavior of brightness temperatures at the edge of the scan vs. the center quantitatively.
        ix. How large is the effect? At what distance from the edge does it become important?

<u>If you have time…</u>

5. Create a scatter plot:
    a. Go to the **Field Selector** tab and select **Hydra** in the **Data Sources** panel
    b. Select **Imagery → Scatter Analysis** in the **Displays** panel
    c. In the **Channels** tab, move the green line to select a channel in a transparent window (perhaps 900 cm^{-1}). The brightness temperature values at this wavenumber will be the x-axis values of your scatter plot.

d. Click **Create Display**
e. In the pop-up window, move the green line to select a channel in CO_2 absorption window (perhaps 706 cm^{-1}) and click **OK**
f. Scatter plot functionality:
    i. **Shift + left-click + drag** on the map to see the corresponding points on the scatter plot. You can do the same on the scatter plot to see the corresponding points on the map.
    ii. Click inside the pink, green, and blue squares to use different colors. Double-click inside these squares to clear that color.
g. To further explore the limb darkening effect, try this:
    i. Select a cloudy region on the map in a pink color
    ii. Select a cloud-free region on the map that is unaffected by limb darkening in a green color
    iii. Select a cloud-free region on the map that **is** affected by limb darkening in a blue color
    iv. Note the different regions on the scatter plot that correspond to each feature
    v. Now, clear out all the coloring (double click in the colored squares) and attempt (by dragging on the scatter plot), to color all cloudy regions pink, all regions unaffected by limb darkening in a green color, and all regions unaffected by limb darkening in a blue color

6. Load in observations from IASI and compare them to the AIRS instrument. You will load the IASI data and explore it in the same way as AIRS. Here are the instructions again:
    a. In McIDAS-V, add the IASI granule as a HYDRA data source
        i. Click the **Data Sources** tab in the **Data Explorer** window
        ii. Click the arrow next to **Satellite**, then click **HYDRA**
        iii. Browse to file '**IASI_xxx_1C_M02_20110901153057Z_20110901154057Z_N_O_20130610192053Z.h5**' under **Data → IASI**
        iv. Click **Add Source**
    b. Create a multi-spectral display of the of the IASI granule
        i. Click the **Field Selector** tab of the **Data Explorer** window
        ii. Click **Hydra** in the **Data Sources** panel
        iii. Select **Imagery → MultiSpectral Display** in the **Displays** panel
        iv. Click **Create Display**
    c. You can use the same tools as AIRS to explore the IASI scene.
    d. What differences do you note between the IASI and AIRS instruments?