

# McIDAS-V Tutorial

## Using HYDRA to Interrogate Hyperspectral Data updated November 2023 (software version 1.9)

McIDAS-V is a free, open source, visualization and data analysis software package that is the next generation in SSEC's 50-year history of sophisticated McIDAS software packages. McIDAS-V displays weather satellite (including hyperspectral) and other geophysical data in 2- and 3-dimensions. McIDAS-V can also analyze and manipulate the data with its powerful mathematical functions. McIDAS-V is built on SSEC's VisAD and Unidata's IDV libraries. The functionality of SSEC's HYDRA software package is also being integrated into McIDAS-V for viewing and analyzing hyperspectral satellite data.

More training materials are available on the McIDAS-V webpage and in the Getting Started chapter of the McIDAS-V User's Guide, which is available from the Help menu within McIDAS-V. You will be notified at the startup of McIDAS-V when new versions are available on the McIDAS-V webpage - <https://www.ssec.wisc.edu/mcidas/software/v/>.

If you encounter an error or would like to request an enhancement, please post it to the McIDAS-V Support Forums - <https://mcidas.ssec.wisc.edu/forums/>. The forums also provide the opportunity to share information with other users.

This tutorial assumes that you have McIDAS-V installed on your machine, and that you know how to start McIDAS-V. If you cannot start McIDAS-V on your machine, you should follow the instructions in the document entitled *McIDAS-V Tutorial – Installation and Introduction*.

## Terminology

There are two windows displayed when McIDAS-V first starts, the **McIDAS-V Main Display** (hereafter **Main Display**) and the **McIDAS-V Data Explorer** (hereafter **Data Explorer**).

The **Data Explorer** contains three tabs that appear in bold italics throughout this document: ***Data Sources***, ***Field Selector***, and ***Layer Controls***. Data is selected in the ***Data Sources*** tab, loaded into the ***Field Selector***, displayed in the **Main Display**, and output is formatted in the ***Layer Controls***.

Menu trees will be listed as a series (e.g. ***Edit -> Remove -> All Layers and Data Sources***).

Mouse clicks will be listed as combinations (e.g. ***Shift+Left Click+Drag***).

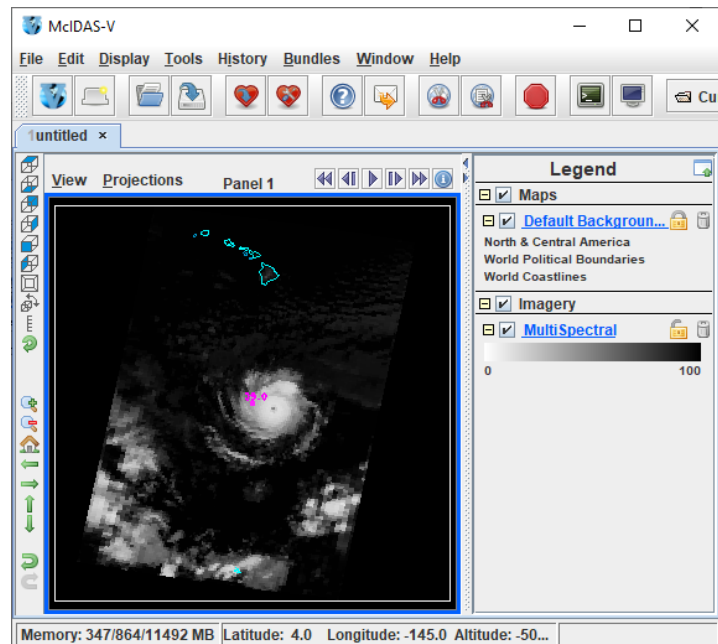
## Introduction

HYDRA (HYperspectral-viewer for Development of Research Applications) is a software package developed at SSEC, and some of its functionality has been incorporated into McIDAS-V through the ***Satellite -> HYDRA*** chooser. The HYDRA chooser is designed to work with multi/hyperspectral data and is capable of performing analysis of the data, including statistical information from scatter analysis displays of different bands of data and overlaying spectra of various bands.

## Create a Multispectral Display (AIRS Hyperspectral Data)

1. In the **Main Display** remove all layers and data sources via the *Edit -> Remove -> All Layers and Data Sources* menu item.
2. Display the data from the AIRS file dated August 08, 2023 at 12:23:21 UTC.
  - a. In the **Data Sources** tab of the **Data Explorer**, open the *Satellite -> HYDRA* chooser.
  - b. Navigate to *<local path>/Data/Hydra/AIRS.2023.08.08.124.L1B.AIRS\_Rad.v5.0.25.0.G23221105157.hdf*, and click **Add Source**.
  - c. The file loads into the **Field Selector** with the name of Hydra. To make the name more descriptive, edit the properties of the data source.
    - Under **Data Sources**, *Right Click* on *Hydra*.
    - Select **Properties**.
    - Change **Name** from *Hydra* to *AIRS 2023/08/08 12:23:21 UTC*.
    - Click **OK**.
  - d. In the **Field Selector**, under **Fields**, select *MultiSpectral -> Radiance*.
  - e. In the **Field Selector**, under **Displays**, select *MultiSpectral Display*. Click **Create Display**.
3. The MultiSpectral image displays in the **Main Display**. There are four aspects to the **MultiSpectral** display:

- The image in the **Main Display**.
- The main spectrum probe in the **Main Display** is the magenta square.
- The reference spectrum probe in the **Main Display** is the light blue square. (NOTE: The two spectrum probes may overlap, with only the magenta square visible. *Left Click+Drag* either box to view spectra measured in various pixels of image.)
- The spectra of the *MultiSpectral* layer in the **Layer Controls**. The default wavenumber is  $919.50\text{ cm}^{-1}$  ( $10.8\text{ }\mu\text{m}$ ). From the **Main Display**, click *Multi Spectral* in the **Legend** to view spectra for the AIRS file in the **Layer Controls** tab of the **Data Explorer**.



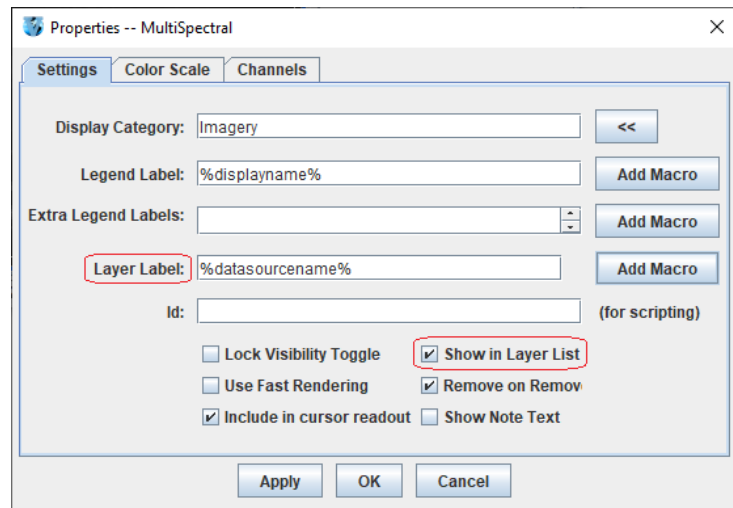
4. Add an image description to the **Main Display**.

a. In the **Layer Controls**, select **Edit -> Properties**.

b. In **Layer Label** field, remove %displayname%. Type %datasourcename%. The macro %datasourcename% is linked to the description entered in step 2c.

c. If the **Show in Layer List** box is not checked, click to activate this option.

d. Click **OK**. The customized label appears at the bottom of the **Main Display**.



5. Compare clear vs. cloudy spectra by moving the spectrum probes.

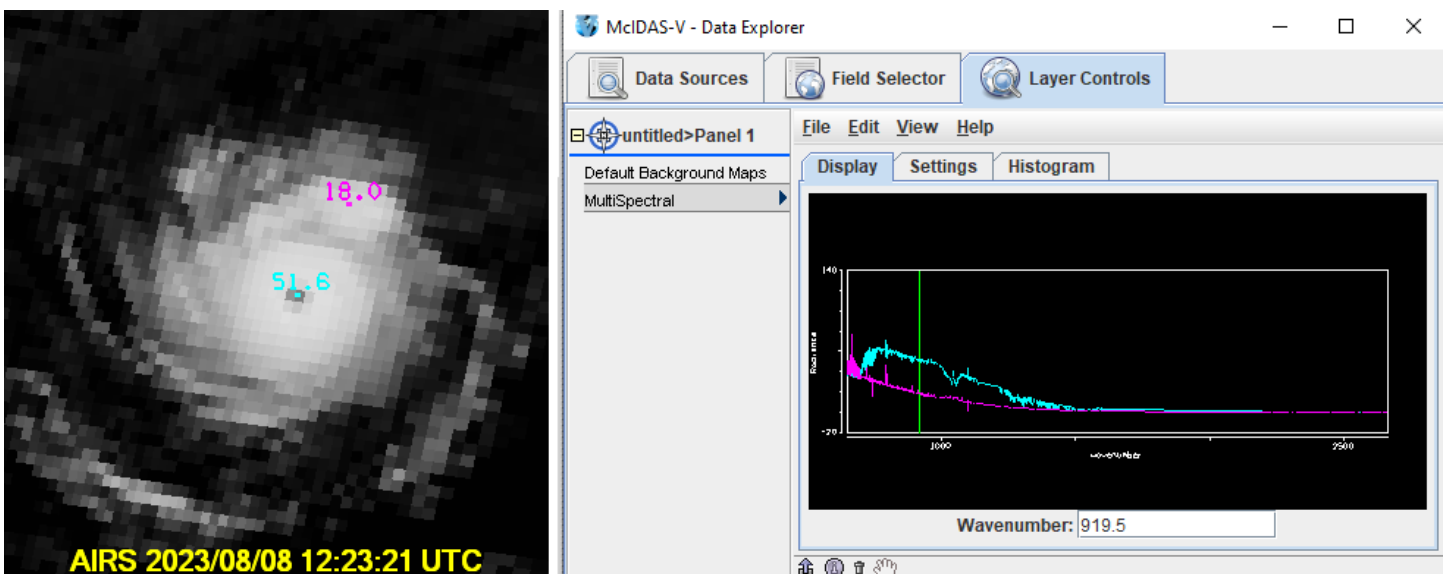
a. In the **Main Display**, **Shift+Left Click+Drag** to zoom the satellite image.

b. Place one probe over a cold cloud top and one over a dark, cloud-free pixel (such as the eye of Hurricane Florence).

c. View spectra in the **Layer Controls**. (When in the **Main Display**, click on **MultiSpectral** in the **Legend** to bring **Layer Controls** to the front.)

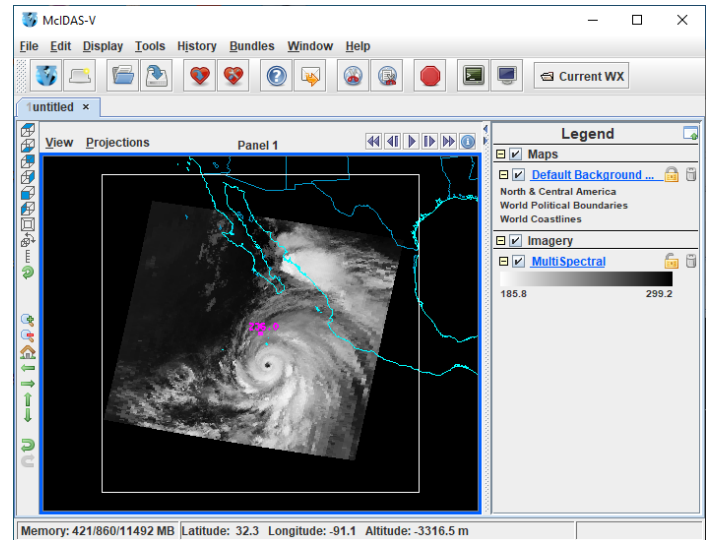
d. Zoom into interesting spectral regions **Shift+Left Click+Drag**. **Control+Left Click** returns the full spectra.

e. Choose different wave numbers by **Left Click+Dragging** the green selector bar or by entering a Wavenumber below the spectra.



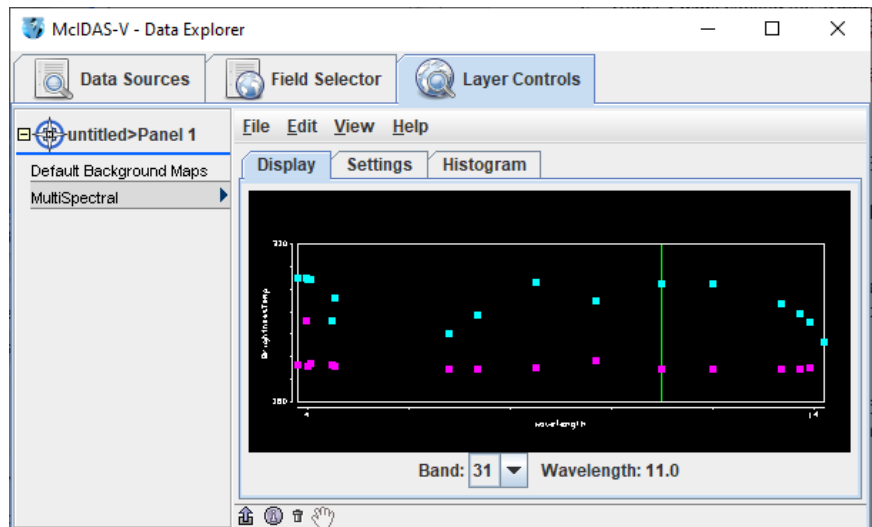
## Create a MultiSpectral Display (MODIS data)

1. Remove all layers and data sources from the previous displays.
2. Display the data from the <local path>/Data/Hydra/MYD021KM.A2023230.0930.061.2023230112307.NRT.hdf file.
  - a. In the left panel of the **Data Sources** tab of the **Data Explorer**, choose **Satellite -> HYDRA**, navigate to the MODIS file and click **Add Source**.
  - b. Change data source name. In the **Field Selector**, **Right Click** on **Hydra** under **Data Sources** and select **Properties**. Change **Name** from **Hydra** to **MODIS 2023/08/18 at 09:30:00 UTC** and click **OK**.
  - c. Under **Fields** expand the **MultiSpectral** drop down list and select **Emissive\_Bands**.
  - d. Under **Displays** select **MultiSpectral Display**.
  - e. Click **Create Display**.



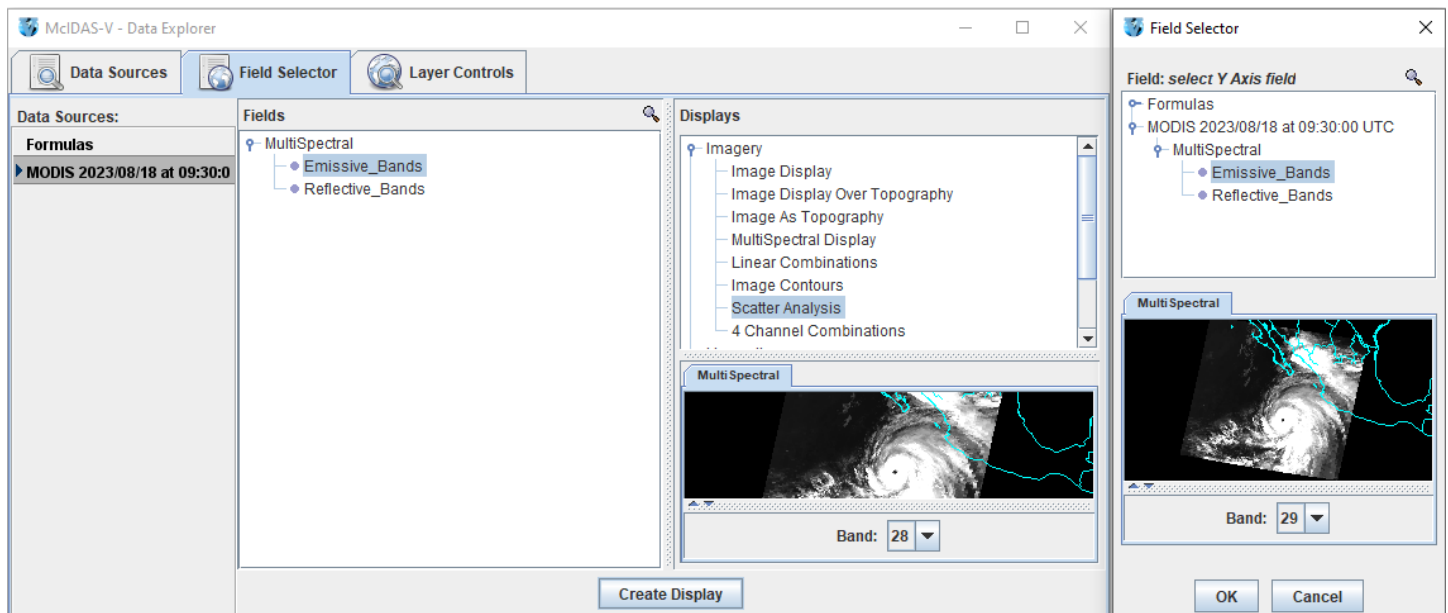
An 11.0  $\mu\text{m}$  image over Hurricane Hillary from 09:30:00 UTC on August 18, 2023 is displayed.

3. Change the band displayed in the **Main Display**.
  - a. **Left Click** **MultiSpectral** in **Legend** to bring **Layer Controls** to front.
  - b. Change band with either **Left Click+Drag** option to move the green selector bar or select the **Band** from the drop-down list at the bottom of the **Display** tab of the **Layer Controls**.

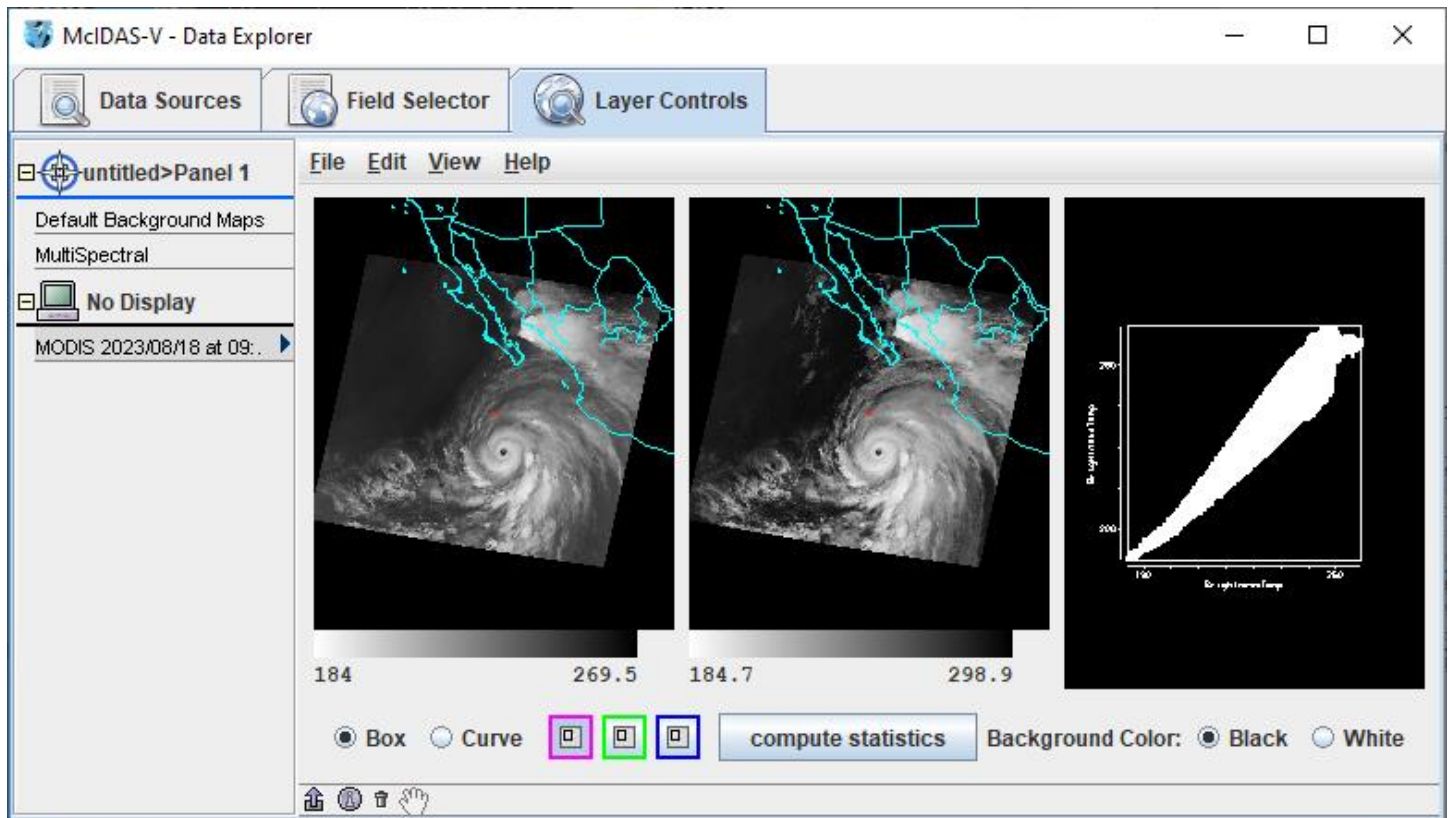


## Create a Scatter Analysis of two bands

4. Make a scatter analysis (plot) of two bands.
  - a. In **Data Explorer**, navigate to the **Field Selector** tab. If the **Data Explorer** is not visible, select **Window -> Show Data Explorer** from the **Main Display**.
  - b. Select the **Emissive\_Bands** field. This will be the x-axis in this scatter analysis. Under **Displays**, select **Imagery -> Scatter Analysis**.
  - c. Use the **Band** dropdown in the **MultiSpectral** tab in lower right panel to select **Band 28 (7.345  $\mu\text{m}$ )**. Click **Create Display**.
  - d. A **Field Selector** window will appear for selection of the y-axis data field. In this new **Field Selector**, select **Emissive\_Bands**, and then **Band 29 (8.503  $\mu\text{m}$ )** in the **MultiSpectral** tab. Click **OK**.
5. The scatter analysis will display in the **Layer Controls**.
  - The left image is the first selected field (**Emissive\_Bands band 28**).
  - The middle image is the second selected field (**Emissive\_Bands band 29**).
  - The right plot is the two-field scatter analysis. The x-axis (abscissa values) corresponds to the first field selected and the y-axis (ordinate values) corresponds to the second field selected. (In this example, band 28 (7.345  $\mu\text{m}$ ) versus band 29 (8.503  $\mu\text{m}$ )).



6. Analyze the scatter plot and images by highlighting a box or region in any of three panels.



- To draw a box, click the **Box** radio button and select one of the colors. Use *Shift+Left Click+Drag* option to draw box over a region of the scatter plot. The corresponding points are highlighted in the image.
  - Conversely, select a region of interest in one of the images. The corresponding points are highlighted in the scatter plot.
  - To draw a shape, click the **Curve** radio button. Use *Left Click+Drag* option to draw an enclosed shape.
  - To remove a color from the scatter plot, *Double Click* in that color's selection box.
7. Click the **compute statistics** button at the bottom of the **Layer Controls**. A window with the scatter plot statistics will appear. Also, there is an option to save the statistics as a CSV file.

## Problem Sets

The previous examples provide general instructions for loading and displaying multi and hyperspectral data. The problem sets below introduce new topics related to the data, and challenges to extend concepts covered in the lessons. Attempt completion of each problem set before checking the solutions. Solutions are provided below the problem set.

1. Use the *<local path>/Data/Hydra/ MOD021KM.A2023261.1600.061.2023262011632.hdf* file to create a Normalized Difference Vegetation Index (NDVI) where:

$$\text{NDVI} = [\text{Band 2 (0.86 } \mu\text{m)} - \text{Band 1 (0.65 } \mu\text{m)}] / [\text{Band 2 (0.86 } \mu\text{m)} + \text{Band 2 (0.65 } \mu\text{m)}].$$

This can be done by displaying the Reflectance data with the “4 Channel Combinations” formula. Display the output of this formula, set the range to -1 to 1, and the enhancement to be Satellite > GOES > NDVI.

2. Use the *<local path>/Data/Hydra/ MOD021KM.A2023261.1600.061.2023262011632.hdf* file to create a scatter analysis of Band 31 vs (Band 29 – Band 31). Make channel 31 the x-axis. Then, scatter Band 31 vs. (Band 31 – Band 32). Compare the two.
3. Make an online-offline difference of the 2023 AIRS data.



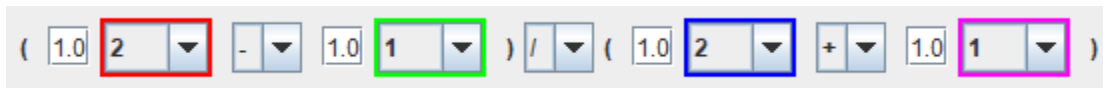
## Problem Set #1 – Solution

Use the *<local path>/Data/Hydra/ MOD021KM.A2023261.1600.061.2023262011632.hdf* file to create a Normalized Difference Vegetation Index (NDVI) where:

$$\text{NDVI} = [\text{Band 2 (0.86 } \mu\text{m)} - \text{Band 1 (0.65 } \mu\text{m)}] / [\text{Band 2 (0.86 } \mu\text{m)} + \text{Band 2 (0.65 } \mu\text{m)}].$$

This can be done by displaying the Reflectance data with the “4 Channel Combinations” formula. Display the output of this formula, set the range to -1 to 1, and the enhancement to be Satellite > GOES > NDVI.

1. In the left panel of the **Data Sources** tab of the **Data Explorer**, choose **Satellite -> HYDRA**, navigate to the MOD021KM.A2023261.1600.061.2023262011632.hdf MODIS file and click **Add Source**.
2. In the **Fields** panel of the **Field Selector**, choose the **MultiSpectral > Reflective\_Bands** field.
3. In the **Displays** panel of the **Field Selector**, choose the **Imagery > 4 Channel Combinations** display type.
4. Click **Create Display**.
5. In the **Channel Combination Tool** tab of the **Layer Controls**, use the dropdowns to define the bands and operators to use to create the NDVI.



6. Click the **Compute New Field** button at the bottom of the **Layer Controls**.
7. In the **Fields** panel of the **Field Selector**, choose the **MultiSpectral > (((1.0 \* a) - (1.0\*b)) / ((1.0\*c) + (1.0 \*d)))** field.
8. In the **Displays** panel of the **Field Selector**, choose the **Imagery > Image Display** display type.
9. Click **Create Display**.
10. **Right-Click** on the enhancement in the **Legend** of the **Main Display** and choose **Change Range**. Enter a range of -1 to 1 (the standard range for NDVI) and click OK.
11. **Right-Click** on the enhancement and select **Satellite > GOES > NDVI**.

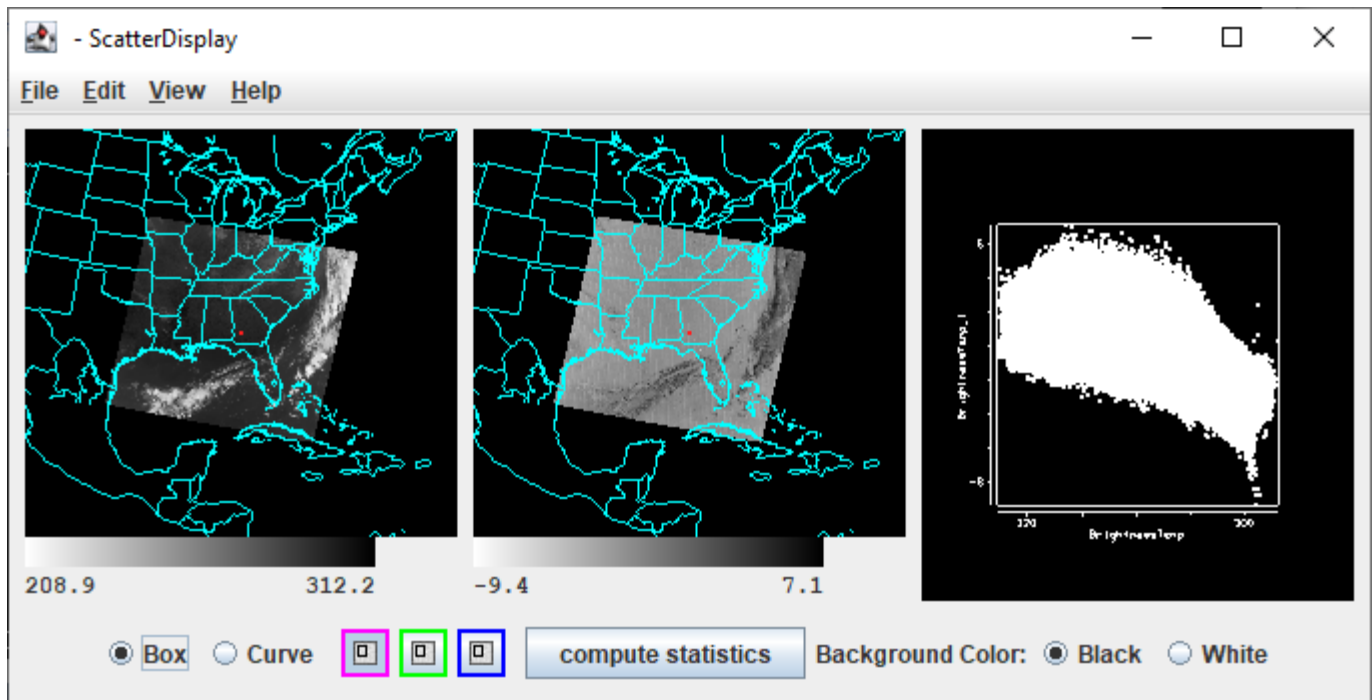


## Problem Set #2 – Solution

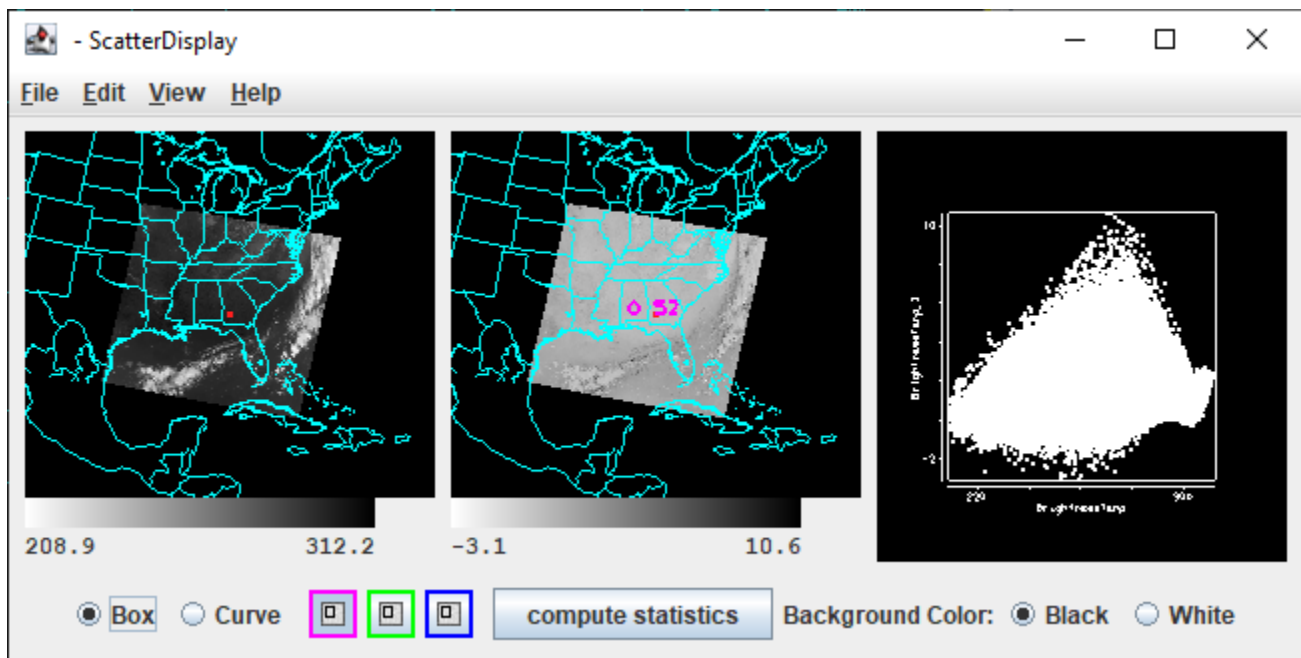
Use the *<local path>/Data/Hydra/ MOD021KM.A2023261.1600.061.2023262011632.hdf* file to create a scatter analysis of Band 31 vs (Band 29 – Band 31). Make channel 31 the x-axis. Then, scatter Band 31 vs. (Band 31 – Band 32). Compare the two.

1. Remove all layers via the **Edit -> Remove -> All Layers** menu item in the **Main Display**.
2. Create the 4 channel combination. In the **Field Selector**:
  - a. Under **Fields**, select **Emissive\_Bands** from the **MultiSpectral** list.
  - b. Under **Displays**, select **4 Channel Combinations**.
  - c. Click **Create Display**.
3. Create the “Band 29 – Band 31” difference image.
  - a. Select *Band 29* in red channel box.
  - b. To the right of the red drop-down menu, select the minus (-) operator from the drop-down list.
  - c. Select *Band 31* in the green channel box.
  - d. Click **Compute New Field**.
4. Repeat step 3 to create the “Band 31 – Band 32” difference image.
  - a. Select *Band 31* in red channel box
  - b. To the right of the red drop-down menu, select the minus (-) operator from the drop-down list.
  - c. Select *Band 32* in the green channel box.
  - d. Click **Compute New Field**.
5. Return to **Field Selector** to create the Scatter Analysis.
  - a. Under **Fields**, select **Emissive\_Bands**.
  - b. Under **Displays**, select **Scatter Analysis**.
  - c. Click **Create Display**. (The default emissive band is band 31. This will be the x-axis).
  - d. A **Field Selector** window appears for the y-axis, data selection. Select the “Band 29 – Band 31” difference image (This is the first  $((1.0*a) - (1.0*b))$  image in the **MultiSpectral** drop down list).
  - e. Click **OK**.

The Scatter Display will display in the *Layer Controls*.



6. Repeat step 5 to create a scatter analysis display using band 31 as the x-axis and “Band 31 – Band 32” as the y-axis. “Band 31 – Band 32” will be the second  $((1.0*a) - (1.0*b))$  image in the **MultiSpectral** drop down list. The Scatter Display will display in the *Layer Controls*.



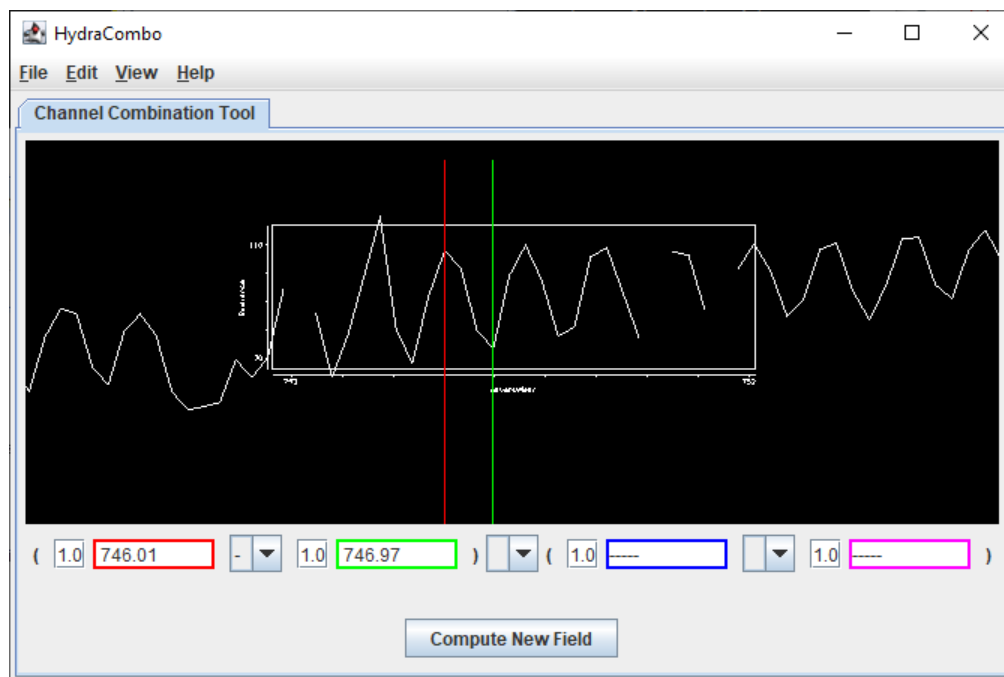
7. Compare the scatter displays.

- Undock each display: In **Layer Controls** for each Scatter Display, select **View -> Undock from Data Explorer**.
- Arrange the scatter displays so both windows are visible on your monitor.
- Use the scatter analysis tools to draw boxes and curves on the images and scatter plot.

### Problem Set #3 - Solution

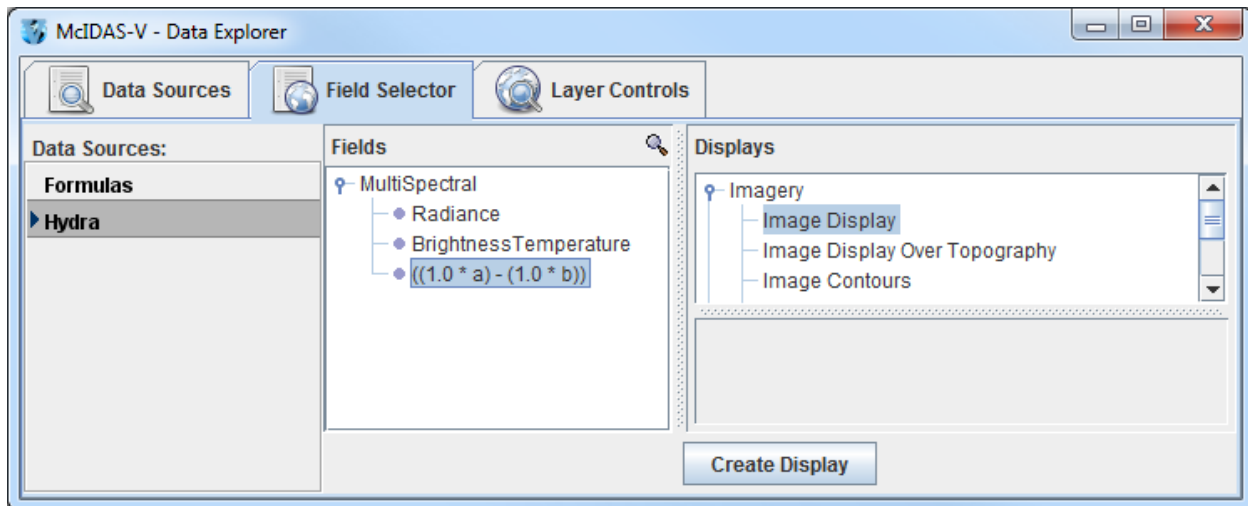
Make an online-offline difference of the 2023 AIRS data.

- Remove all layers and data sources via the **Edit -> Remove -> All Layers and Data Sources** menu item in the **Main Display**.
- Load the 2018 AIRS data file through the **Satellite -> HYDRA** chooser in the **Data Sources** tab of the **Data Explorer**.
- Return to the **Field Selector**, choose the **Radiance** field, and select **4 Channel Combinations** under **Displays** and click **Create Display**.
- Enter in the equation  $746.01 \text{ (red)} - 746.97 \text{ (green)}$  and hit Enter after each number. The vertical red and green lines in the spectrum will move to  $746.01 \text{ cm}^{-1}$  and  $746.97 \text{ cm}^{-1}$ , respectively. The red band is the online value and the green band is the offline value.

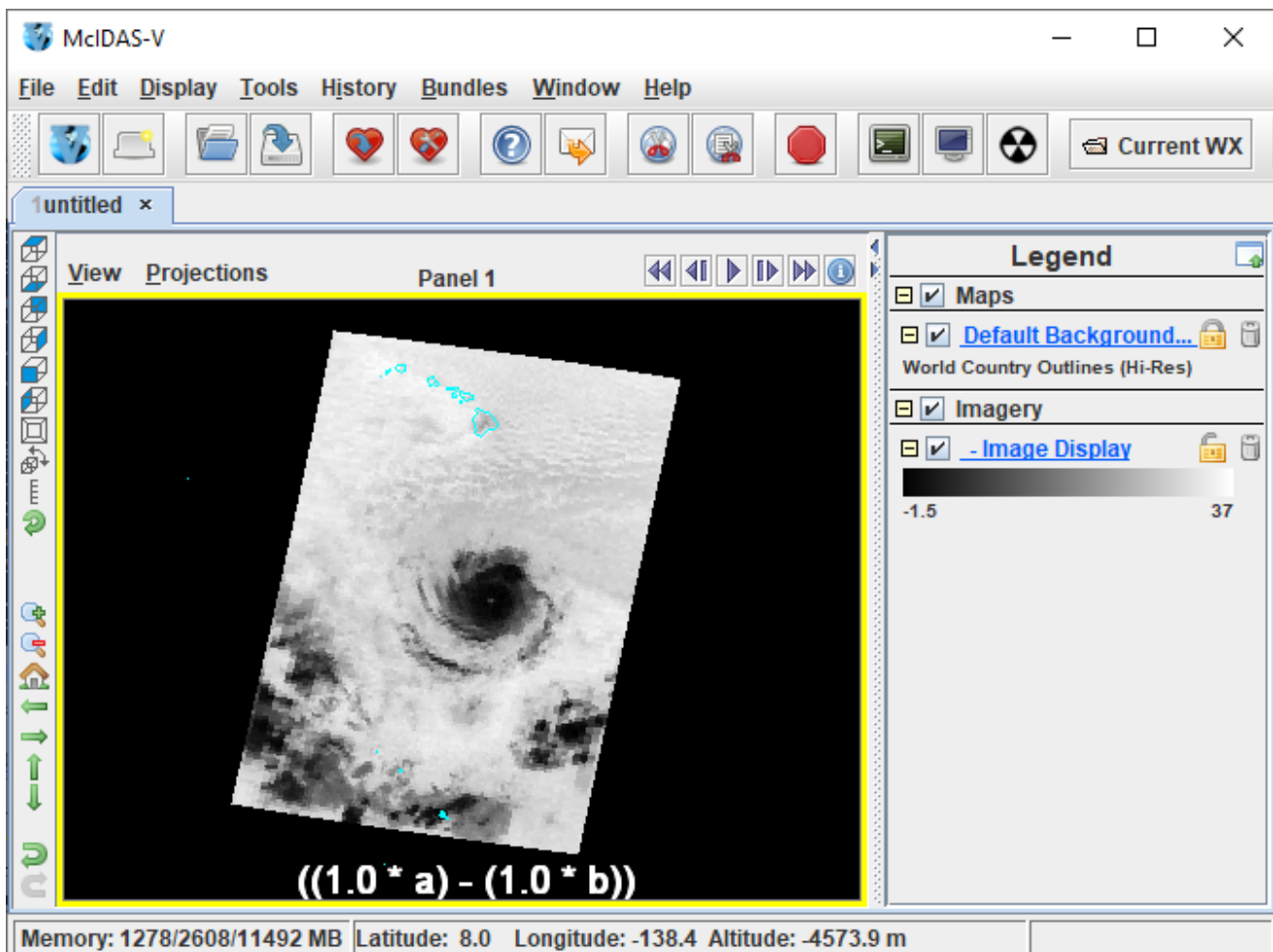


- Zoom in over the region by using the **Shift+Left Click+Drag** option. Reset the spectrum by **Control+Left Click**.
- Click **Compute New Field** to create a new field of this online - offline difference.

7. The resulting field will be  $((1.0*a) - (1.0*b))$  in the **Field Selector** under the **MultiSpectral** field in the **Fields** list. Click on this new field and select **Image Display** under **Displays** and click **Create Display**.



The resulting image from the online-offline calculation shows the vertical temperature gradient – in cloudy regions (darker), the difference is small because both the online and offline wave numbers detect clouds. In clear regions (lighter), the difference between the two wave numbers is larger because of the temperature gradient through the atmosphere.



## Spectra

**Select spectra** - write wavenumber in box, select channel from pulldown menu, or middle button click

**Shift+Left Click+Drag** – (Zoom) Select portion of spectra for magnification.

**Control+Left Click** – Return to full spectrum

**Left Click+Drag** – Move spectrum right or left

**Middle mouse button (or wheel) click** – Read Brightness Temperatures and Wavenumbers. Provides Brightness Temperature value and Wavenumber at cursor location. It will also move the green line and change the image to that wavenumber.

## Image

**Left Click on a probe and drag** – Change probe location (The spectra will display for new location)

**Change band** – use spectra window, write wavenumber in box, or middle button click

**Move image up or down** – use arrow icons in left utility bar

**Zoom** – **Shift+Right Click+Drag** over window –or- mouse scroll wheel forward or backward

**Return to Original Image View** – Click on house icon in left utility bar