

# Java CRISM Analysis Tool (JCAT) Tutorial

Version 1.0.2

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# Introduction to JCAT

- JCAT serves as an analysis tool for data collected by the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) aboard the Mars Reconnaissance Orbiter.
- JCAT works with:
  - Targeted Empirical Records (TERs) - image cubes derived from CRISM hyperspectral targeted observations, post-processed to standardize the illumination and observation geometry and remove atmospheric gas absorptions and instrument artifacts
  - Targeted Reduced Data Records (TRDRs) – image cubes containing data calibrated to radiance or I/F
  - Map-projected Targeted Reduced Data Records (MTRDRs) – TRDR image cubes containing map-projected TER data map-projected using terrain models of the Martian surface.

# Introduction to JCAT

- JCAT allows users to view and stretch image cubes, perform I/F comparisons, alter wavelengths set for image RGB, save data and images, perform atmospheric and photometric I/F corrections, and much more.
- To read more about CRISM, JCAT, and data processing visit <https://pds-geosciences.wustl.edu/missions/mro/crism.htm>

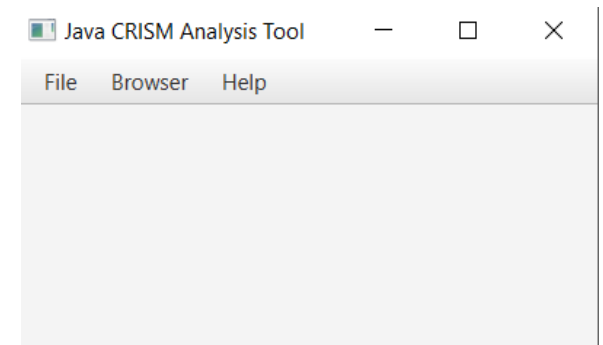
# Getting Started

- JCAT requires Java 8 or later to run, along with Java FX. The Java SE Runtime Environment 8 (JRE) from Oracle includes both.
- Any desired image file, along with its accompanying files, will need to be downloaded from the Planetary Data System (PDS) archive at Washington University in St. Louis. CRISM files may be upwards of 1 GB, so ensure there is sufficient space. These files should be placed in a folder called “JCAT” in the user’s home directory.



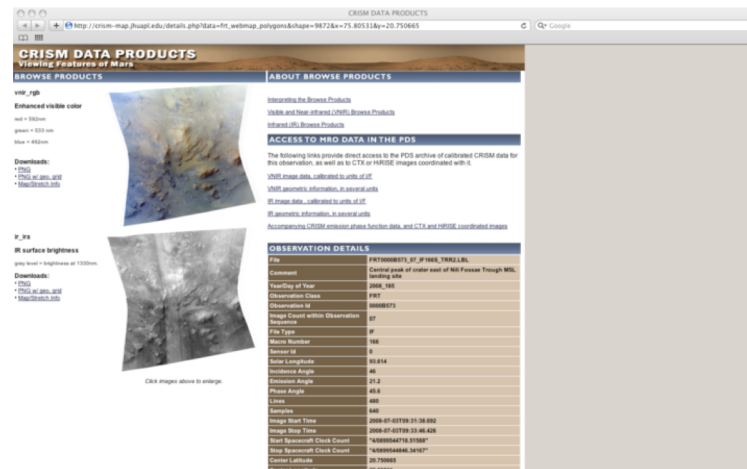
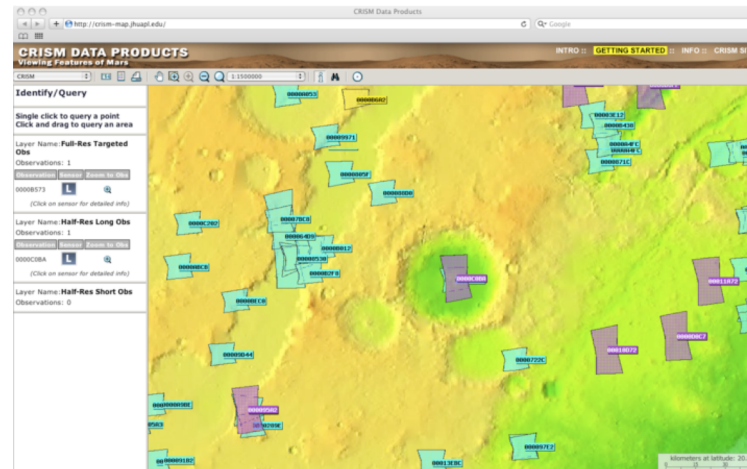
# JCAT Window – main window

- File
  - New – choose a downloaded file from home directory
  - Recent – select from a list of recently used files
  - Quit – close JCAT
- Browser
  - CRISM Map – interactive CRISM web map
  - PDS Data Product Repository – only use if you know exact location of your file
  - PDS Data Product Search – search for images that meet your criteria
- Help
  - Show Log – records actions taken by user, info and warnings
  - Documentation – show this .ppt
  - About – version, release date, authors



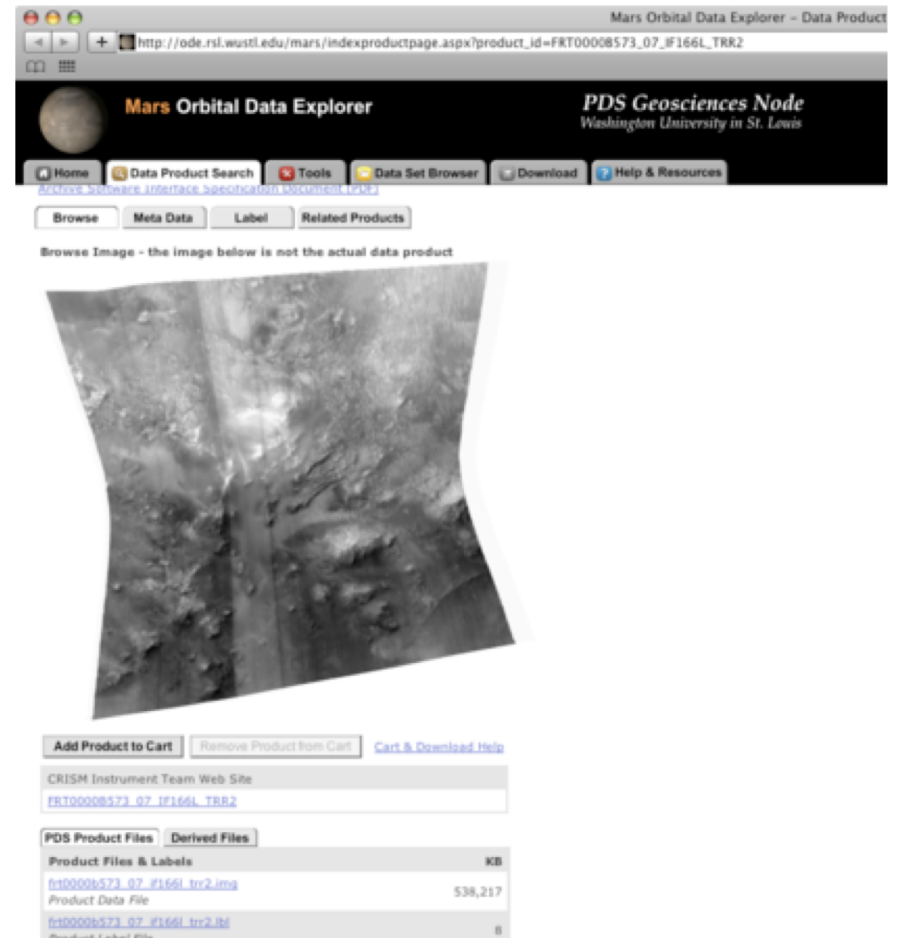
# Getting New Files – CRISM Map

- Browser -> CRISM Map, when you find an observation to download, choose the “i” icon in the toolbar and click the observation
- You can click the binoculars to enter an ID directly
- Click on the sensor to get detailed information on the observation



# Getting New Files Cont'd

- In “Access to MRO data in the PDS”, select either VNIR or IR image data depending on which sensor data you would like to view. This redirects to the Mars Orbital Data Explorer site at Washington University. See slides 9-10 for which files to download.



The screenshot shows the Mars Orbital Data Explorer website. The browser address bar displays the URL: [http://ode.rsl.wustl.edu/mars/indexproductpage.aspx?product\\_id=FRT00008573\\_07\\_IF166L\\_TRR2](http://ode.rsl.wustl.edu/mars/indexproductpage.aspx?product_id=FRT00008573_07_IF166L_TRR2). The page header includes the title "Mars Orbital Data Explorer" and "PDS Geosciences Node Washington University in St. Louis". A navigation menu contains links for Home, Data Product Search, Tools, Data Set Browser, Download, and Help & Resources. Below the menu are tabs for Browse, Meta Data, Label, and Related Products. A central image shows a grayscale view of the Martian surface with a prominent crater. Below the image are buttons for "Add Product to Cart", "Remove Product from Cart", and "Cart & Download Help". A section titled "CRISM Instrument Team Web Site" contains the product ID: [FRT00008573\\_07\\_IF166L\\_TRR2](#). At the bottom, there is a table with tabs for "PDS Product Files" and "Derived Files".

PDS Product Files	
Product Files & Labels	KB
<a href="#">fr100008573_07_if166l_trr2.img</a>	538,217
Product Data File	
<a href="#">fr100008573_07_if166l_trr2.lbl</a>	8
Product Label File	

# Using the Mars Orbital Data Explorer

- You can also find CRISM data at <https://ode.rsl.wustl.edu/mars/index.aspx>
- Select “Data Product Search”. You’ll find CRISM under Step 1: “Select One or More Desired Data Sets (Released PDS Archives) and then “Mars Reconnaissance Orbiter”
- TRDR and TER files can be downloaded using “Calibrated Data”
- MTRDR and MRDR files can be downloaded using “Derived Data”
- Select a product ID or explore CRISM data in a geographic or temporal range using the options in Step 2.
- Select your products and enter your email address. You will be sent a download link when your products are ready.

# Necessary Files: MTRDRs

Download to home directory/or JCAT folder. These will all be located in the same subdirectory on the PDS archive page. Below is an example of the necessary files for an MTRDR observation.

MTRDR - MTRx

(if) .img, .lbl

frt0001ecba\_07\_if166j\_mtr3.img

frt0001ecba\_07\_if166j\_mtr3.lbl

(wv) .tab

frt0001ecba\_07\_wv166j\_mtr3.tab

(su) .img, .lbl – OPTIONAL

frt00020c77\_07\_su166j\_mtr3.img

frt00020c77\_07\_su166j\_mtr3.lbl

x = version number

'if' files store the intensities (I/F values)

'wv' files store the wavelengths

'su' files for MTRDRs are optional – they show summary parameters and browse products (slides 25-26 and 29-30)

# Necessary Files: TRDRs and TERs

For TRDR and TER files, there are two steps. First, you will need to download the 'if' files (and 'wv' for TER) located under PDS Product Files. Then, you will need the accompanying DDR files. To find these, go to related products and scroll down – they will take the form of [frr00021da6\\_07\\_de166l\\_ddr1.img](#). Below are examples of the necessary files for a TRDR observation and a TER observation.

- TRDR – TRRx/DDRx
  - (if) .img, .lbl
    - hr0002422e\_07\_if182l\_trr3.img
    - hr0002422e\_07\_if182l\_trr3.lbl
  - (de) .img, .lbl
    - hr0002422e\_07\_de182l\_ddr1.img
    - hr0002422e\_07\_de182l\_ddr1.lbl
- TER – TERx
  - (if) .img, .lbl
    - frr00021da6\_07\_if166j\_ter3.img
    - frr00021da6\_07\_if166j\_ter3.lbl
  - (wv) .tab
    - frr00021da6\_07\_wv166j\_ter3.tab
  - (de) .img, .lbl
    - frr00021da6\_07\_de166l\_ddr1.img
    - frr00021da6\_07\_de166l\_ddr1.lbl

x = version number

'if' files store the intensities (I/F values)

'wv' files store the wavelengths

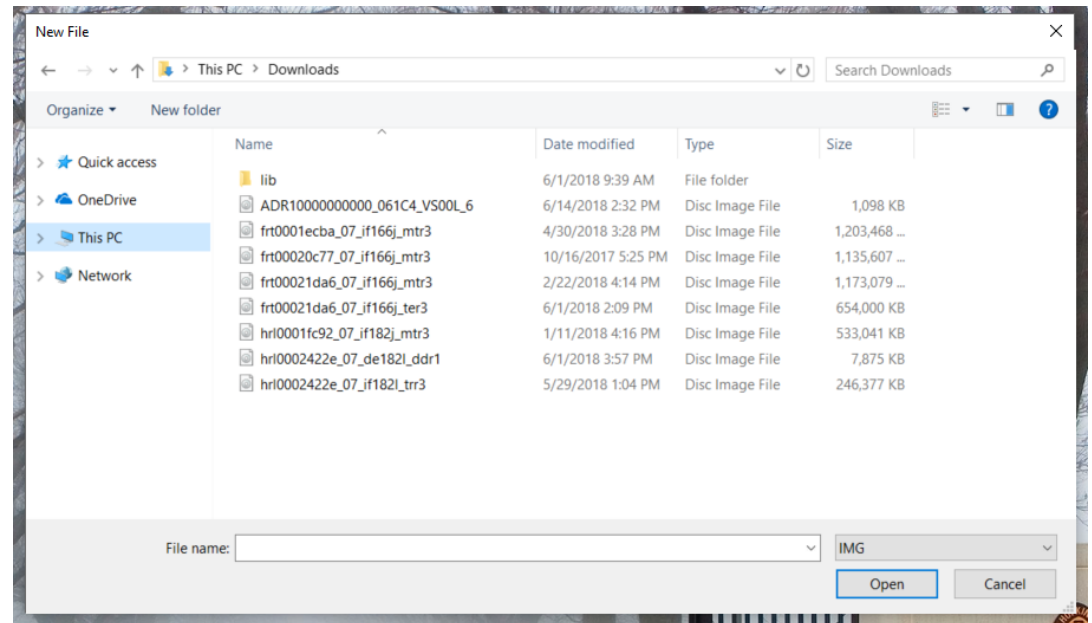
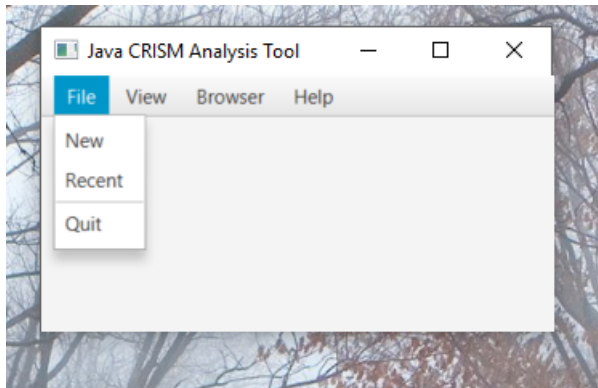
'de' files are the DDRs, they are necessary for lat/lon conversions

## New Files: Mac Only

- Filename extensions on Mac are different than windows. Go to Finder -> Preferences -> Advanced -> Show all filename extensions
- This allows you to change label and tab files to .lbl/.tab instead of .txt.
- You will be asked to either keep .txt or use .lbl/.tab. Be sure to use .lbl/.tab.
- Example:
  - “**hrl00018570\_07\_if182l\_trr3.lbl.txt**” will appear after downloading, but needs to be changed to “**hrl00018570\_07\_if182l\_trr3.lbl**”

# Opening New Files

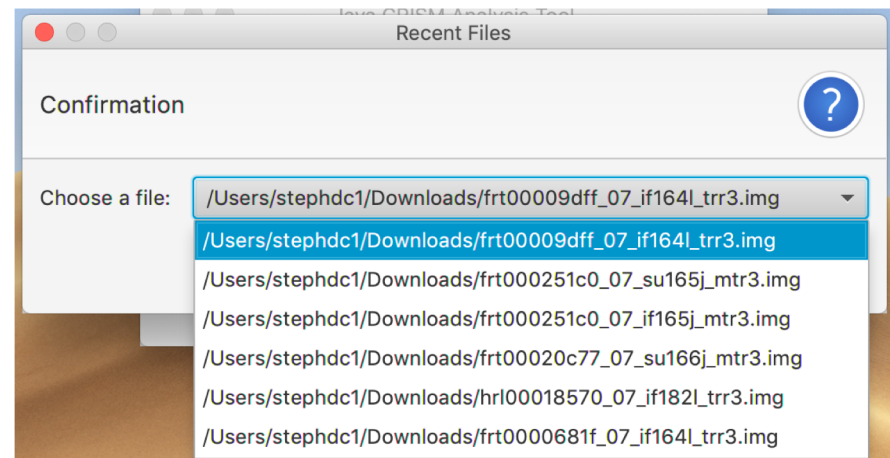
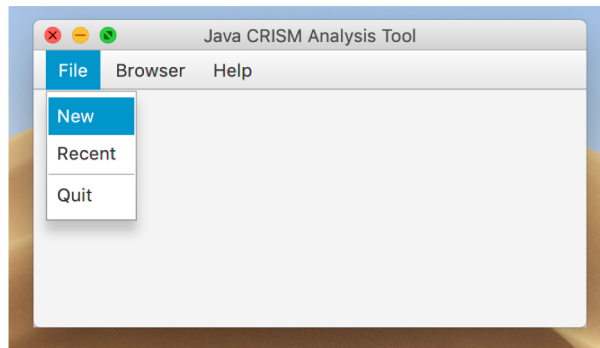
- File-> New, choose the image file you would like to view from your home directory





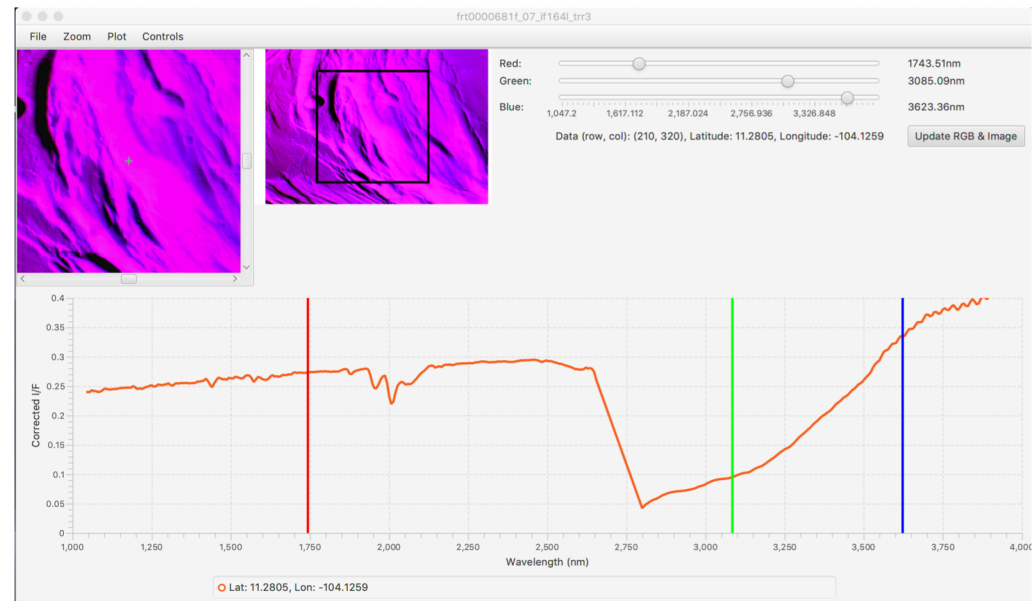
# Choosing a Recent File

- File -> Recent, a list of recently loaded files will be shown. If the location of a file has changed since you last used it. You will need to read it in like a new file.



# JCAT Image Frame

- File
  - Expand Image
    - Upon loading, a zoomed-in image(left) and reference image(right) are shown.
    - To view full-size image window, File -> Expand Image.
  - Save Image – saves current image as .png file
  - Save Spectral Data – saves single or all spectral values to a .csv file
  - Save Chart – saves screenshot of line chart as .png file
- Zoom – zoom in/out on image
- Plot
  - Reset scale – scales X, Y or both axes to default
  - Set X/Y Scale – user-set range of values within view on spectrum

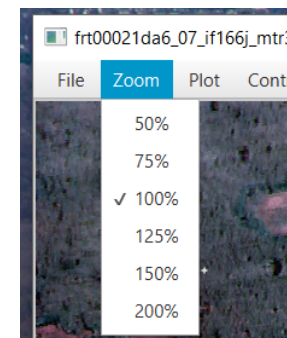
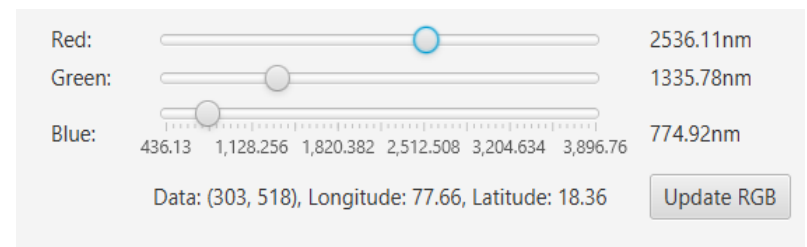
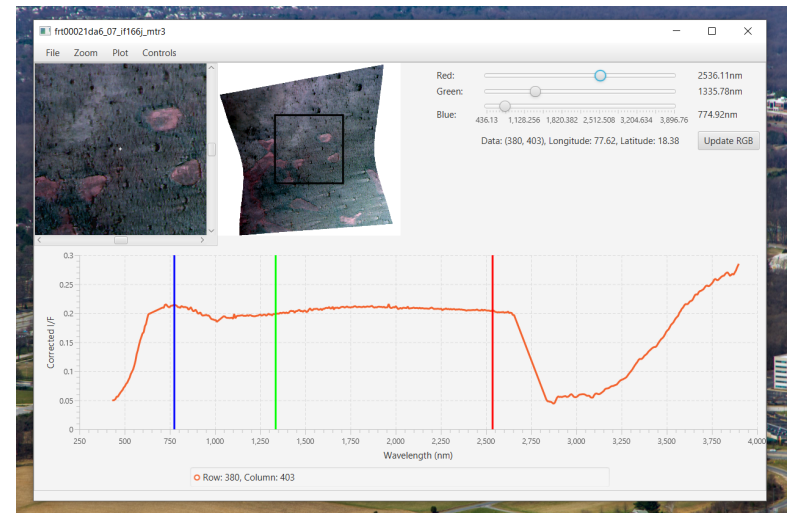


# JCAT Image Frame Cont'd

- Controls
  - Contrast – image is loaded in with a default 1 percentile stretch
    - Linear – set dimmest pixels to 0 and brightest to 255
    - 1, 2, Custom Percentile Stretch – sets the dimmest x %ile to 0 and brightest x %ile to 255
    - Spatial Subset Stretch – toggles on/off, will perform desired linear/percentile stretch based on the subset of image pixels within viewing frame (top left)
  - Spectrum Averaging Size – either see 1x1, 3x3 or 5x5 pixel box, useful to reduce noise
  - Spectrum Options – choose between single or multiple spectra layered on graph
  - Spectral Interest
    - Click – Plots the intensity of single click (1x1, 3x3, or 5x5 box)
    - Drag Avg – Averages the I/F of pixels within a rectangle dragged by user
    - Region of Interest – Averages the I/F of pixels within a region specified by user
    - Manual Input – user inputted points
    - Mouse Button Instructions – explanations of how to use spectral interest options
  - Spectrum Operations – add, subtract or ratio two different spectra
  - ATP Corrections – only available if viewing a TRDR image
    - Atmospheric – correction for absorption by CO<sub>2</sub> in atmosphere (IR detector only ~2 microns)
    - Thermal – currently no working thermal corrections
    - Photometric – correction to radiance for non-normal solar incidence:  $(I/F)/\cos(\text{incidence angle})$

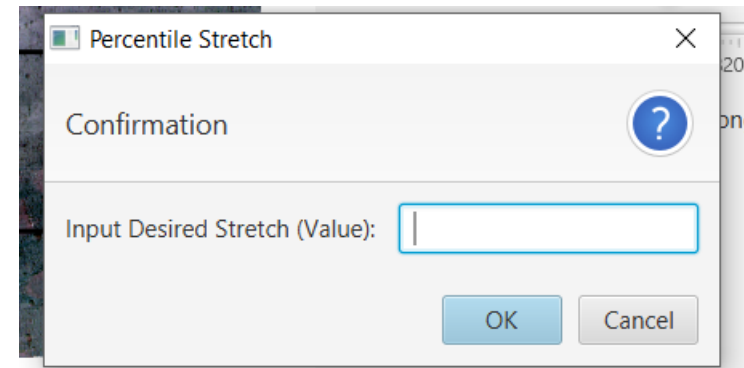
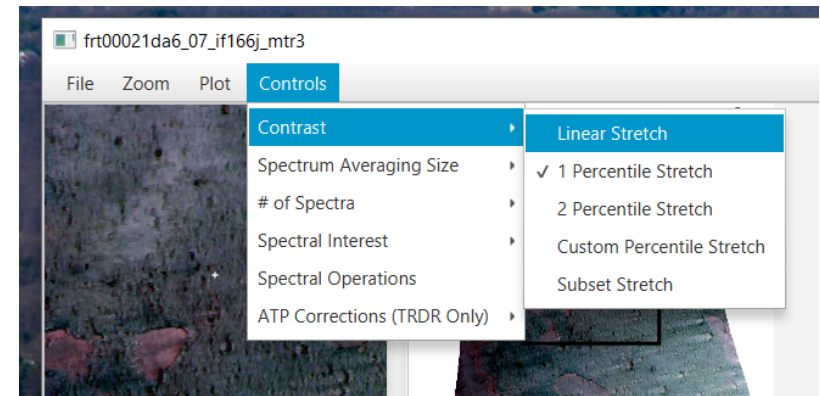
# Navigating the Image Frame

- Zoom in/ out using the zoom menu, the reference rectangle on the right image will adjust accordingly.
- The right side contains three sliders to select the wavelengths for red, green, blue. Press 'Update RGB & Image' values to apply RGB to the image and their positions on the bottom spectrum.



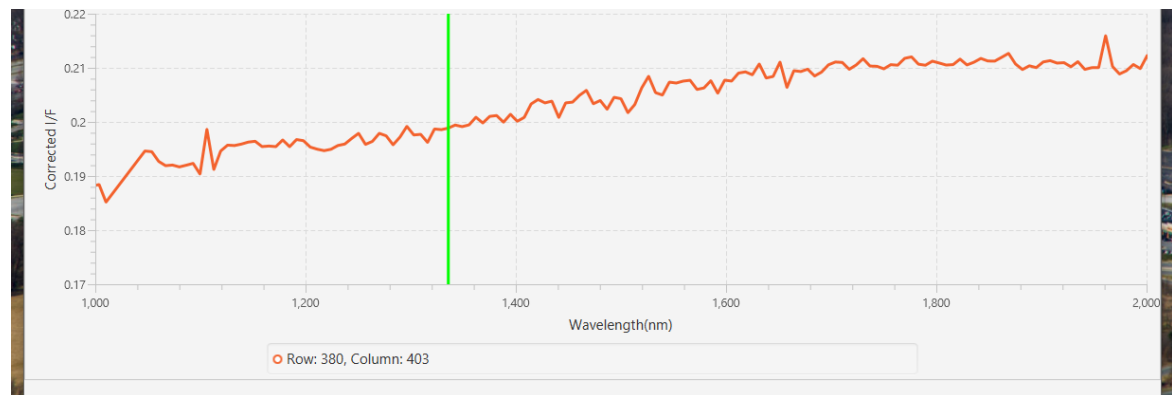
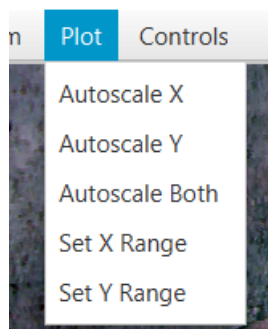
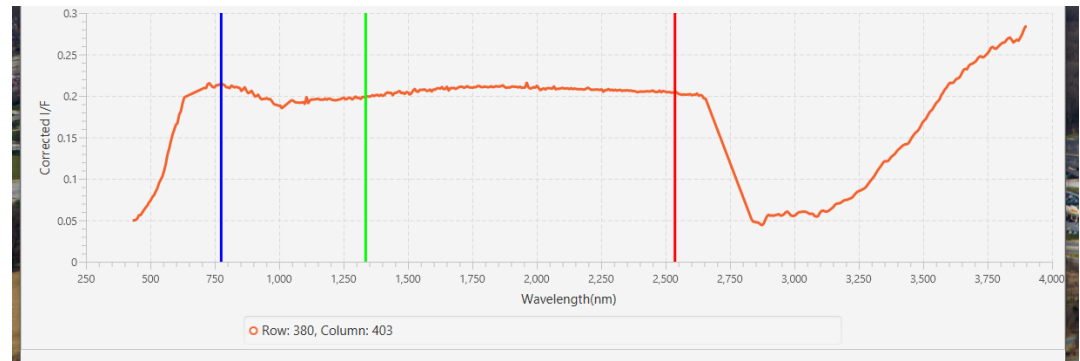
# Navigating the Image Frame Cont'd

- The images are loaded in with a default 1%ile stretch – dimmest and brightest 1%ile of pixels are set to 0, 255 respectively.
- For stretch options, Controls -> Contrast
- Linear stretch: dimmest pixel -> 0, brightest pixel-> 255
- Percentile Stretches: dimmest x%ile -> 0, brightest x%ile -> 255
- Subset Stretch – When selected, stretches are applied based on the dimmest and brightest pixels within the viewing frame(top left), rather than the entire image
- The pixels used to apply the subset stretch will be shown under the 'Update RGB & Image' button
- Click the 'Update RGB & Image' button to apply stretches and changes on RGB sliders



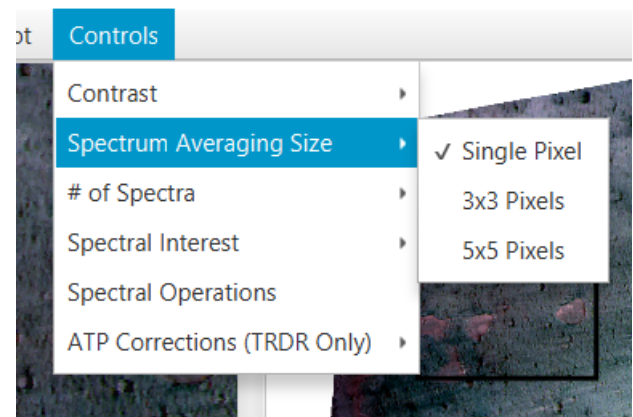
# Navigating the Image Frame Cont'd

- Spectrum on bottom displays intensity as a function of wavelength.
- Use the plot menu to change the axes.
- Auto-scale reverts axes back to original ranges.



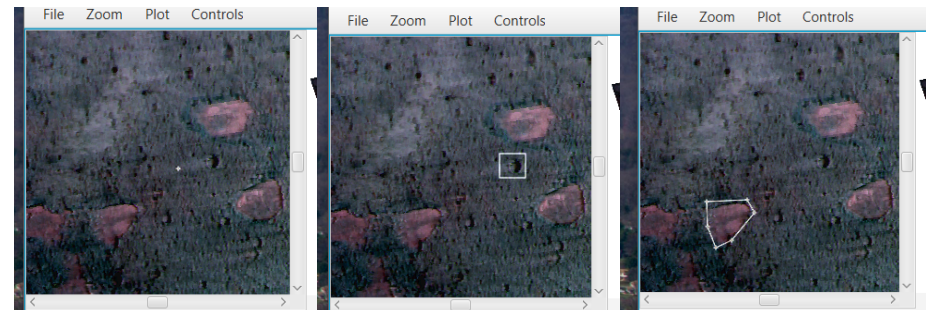
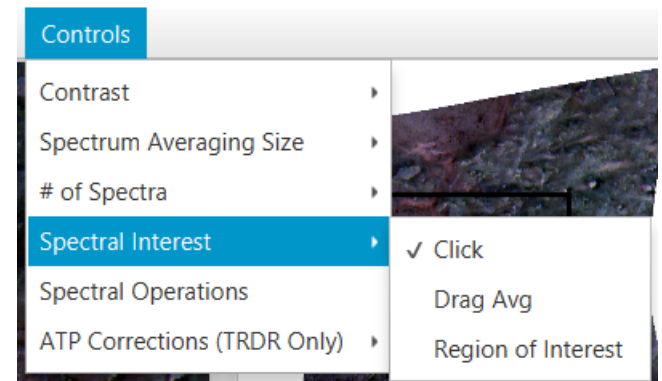
# Navigating the Image Frame Cont'd

- Click anywhere on the image to get that pixel's spectrum. The legend will show the position of the pixel.
- To reduce noise, you can change the spectrum averaging size. The 3x3 and 5x5 boxes average the surrounding 8 or 24 pixels.
- The change will be reflected by the latitude and longitude ranges in the legend.



# Navigating the Image Frame Cont'd

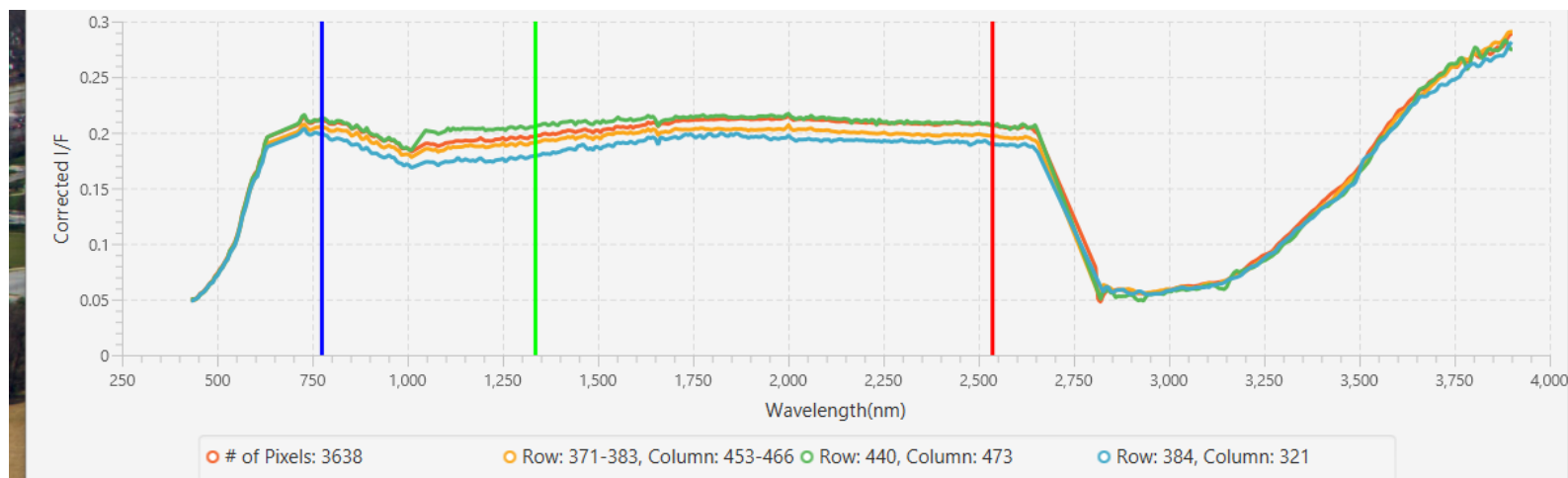
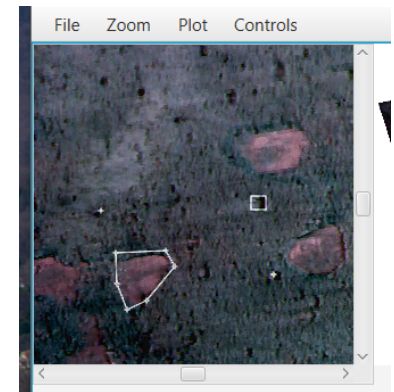
- **NOTE: A three button mouse is recommended.** Not all capabilities will be available otherwise.
- Aside from the click option, there are 'Drag Avg', 'Region of Interest', and 'Manual Input' options.
- Drag Avg (middle) allows user to drag across the image to create a rectangle. The pixels within the rectangle will be averaged.
- Region of Interest (right): Left click to add a new point to the shape. To close the shape, right click and the last point will connect to the first point. Pixels inside the shape will be averaged.
- Manual Input allows you to type in points you'd like to view. Follow the format: 'row, col'
  - If entering multiple points, put each on a separate line





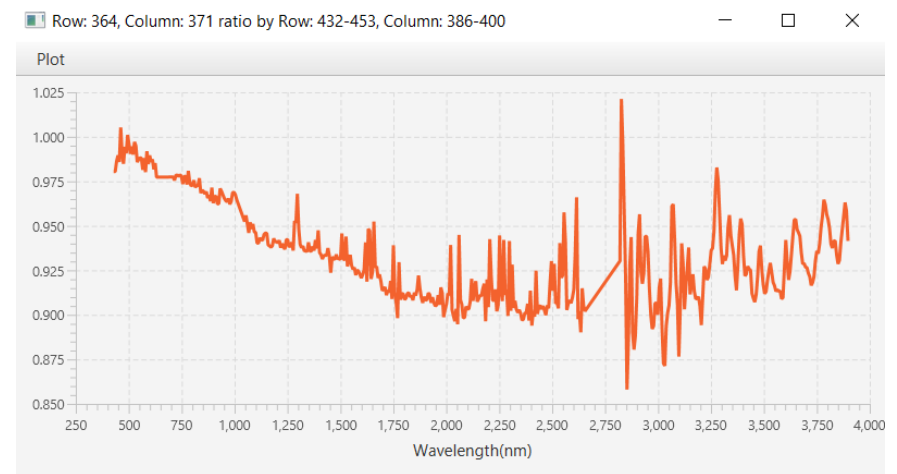
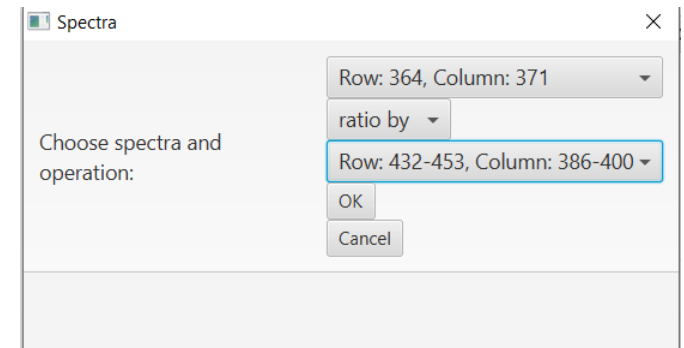
# Navigating the Image Frame Cont'd

- To layer multiple spectra on the chart, Controls -> # of Spectra -> Multiple. Only the Click and Drag Avg features are available for the additional spectra. Center click or drag to add the spectrum.
- To clear, left click on the image again. The new pixel's spectrum will appear and the previous spectra will all be removed from the chart.



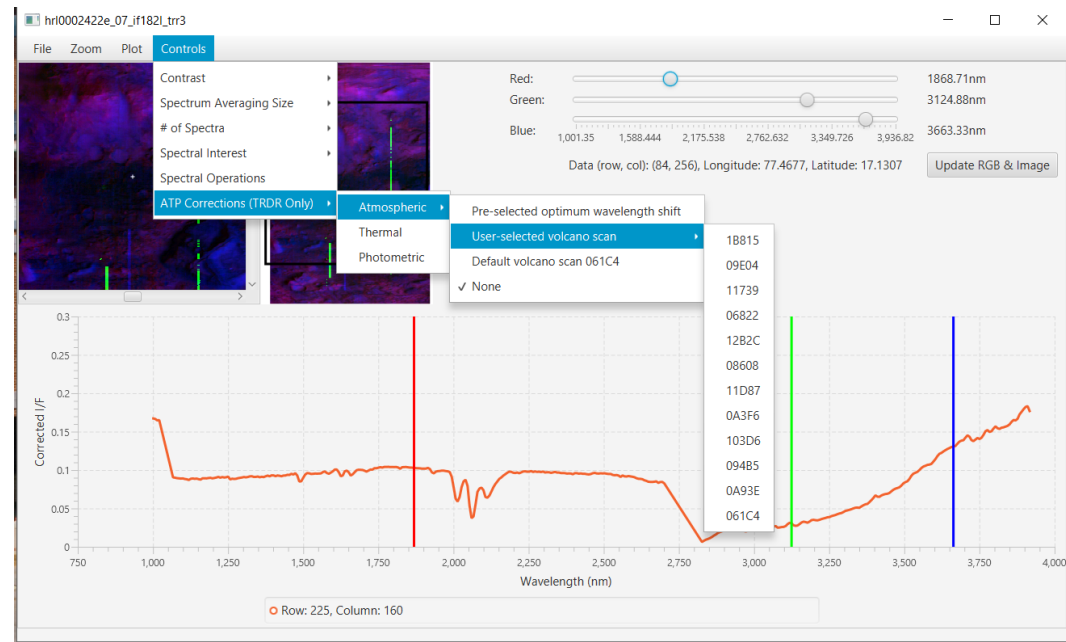
# Navigating the Image Frame Cont'd

- To add, subtract or ratio spectra, select Controls -> Spectral Operations.
- Select the spectra and operation you'd like to perform.
- Axes scaling features are available under the Plot menu.
- Use the file menu to save the data or chart to a .csv or .png file



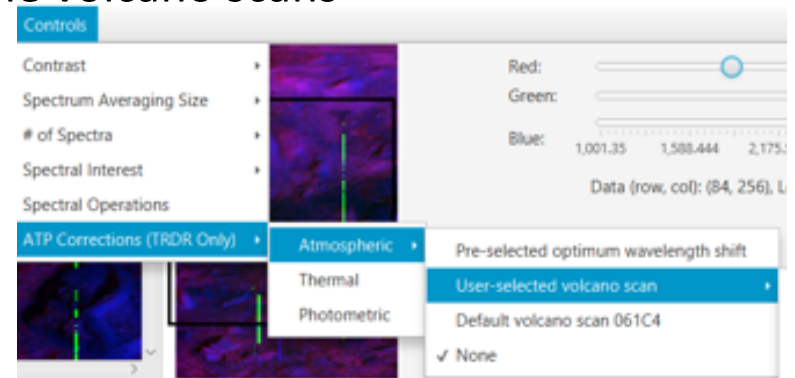
# Navigating the Image Frame Cont'd

- Under Controls, there are ATP Corrections. These are only applicable for TRDR files.
- Atmospheric corrections remove the attenuation of surface brightness by atmospheric gases, mainly carbon dioxide and water vapor. They use a scaled measured brightness ratio of the summit and base of Olympus Mons ("volcano scan correction") to represent attenuation by atmospheric gases. The effects can be seen in the dips around 2 microns. (For longwave sensor TRDR files only)
- Currently, there are no working thermal corrections.
- Photometric corrections transform the spectrum of reflected sunlight to what it would be if the Sun illuminated the surface at a normal incidence angle (if the Sun was overhead)



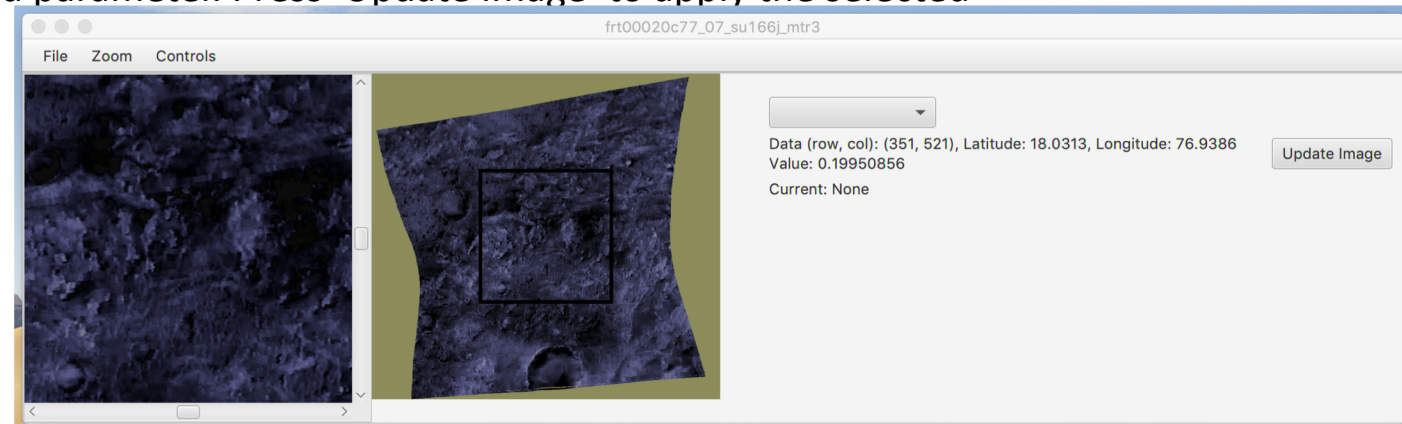
# Navigating the Image Frame Cont'd

- Atmospheric Corrections:
  - Pre-selected optimum wavelength shift – runs a routine to find the volcano scan with the minimum shift artifact due to tiny changes in the instrument over time. This is the recommended choice.
    - NOTE: if not previously paired with a volcano scan, routine may take time
    - Will save paired files so routine is only performed once
  - User-selected – select from a list of available volcano scans
  - Default – this is the 061C4 volcano scan



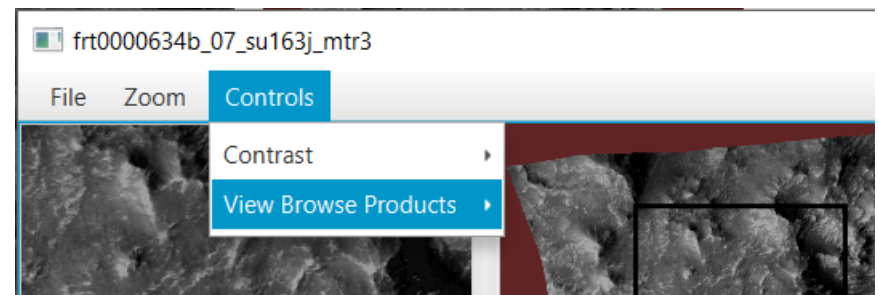
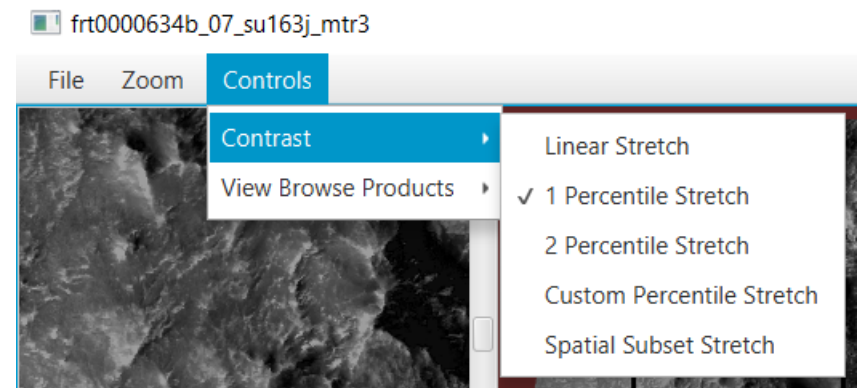
# Summary Parameter Image Frame(MTRDR)

- A summary parameter image shows strength of a mineral absorption or other spectral feature. Read more about summary parameters at: <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014JE004627>
- For MTRDR images, su types will open a new window (e.g. frt00020c77\_07\_su166j\_mtr3.img)
- Upon loading, a zoomed-in image(left) and reference image(right) are shown. To view full image, File -> Expand Image.
- The right side contains a drop-down menu to select a summary parameter. To the right of the slider is the selected parameter. Press 'Update Image' to apply the selected parameter to the image.



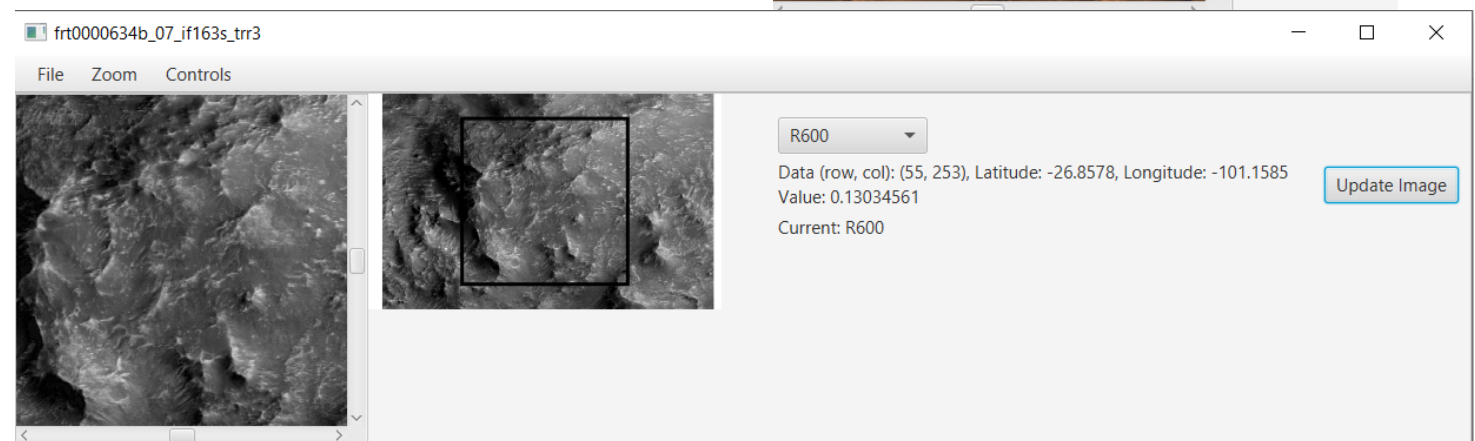
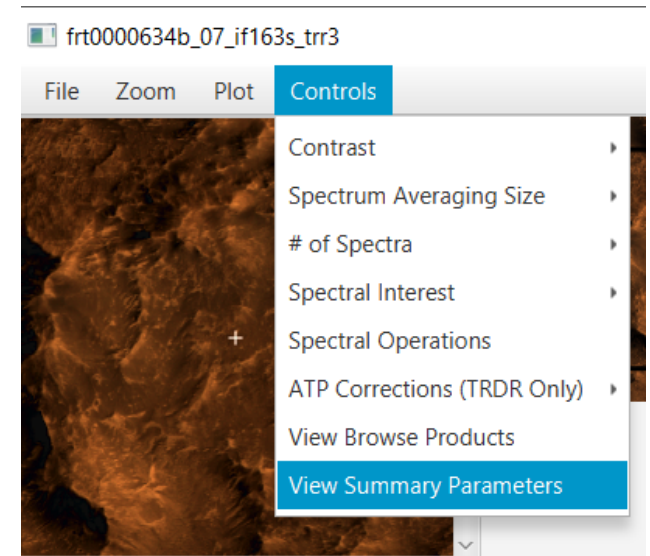
# Summary Parameters Frame(MTRDR) Cont'd

- Zoom in/ out using the zoom menu, the reference rectangle on the right image will adjust accordingly.
- The images are loaded in with a default 1%ile stretch , same as main 'if' image
- Same stretch options are available here
- Click the 'Update Image' button to apply selected stretches and summary parameters.
- To view the browse products select "View Browse Products"



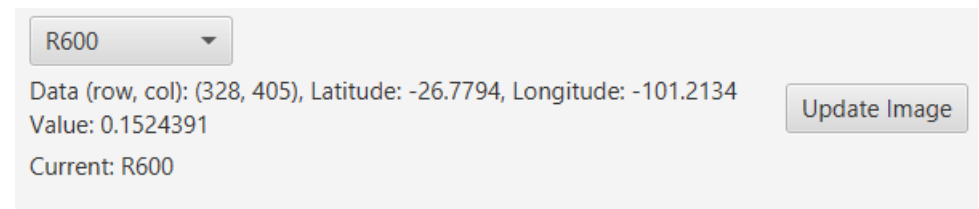
# Summary Parameters (TRDR)

- To view summary parameters for TRDR files select “View Summary Parameters” in the controls menu of the main ‘if’ image window
- Sum param values are located under the lat/lon information



## Summary Parameters Cont'd

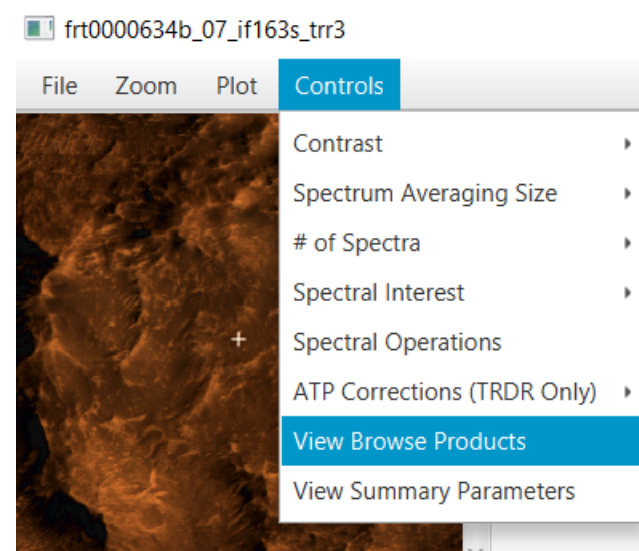
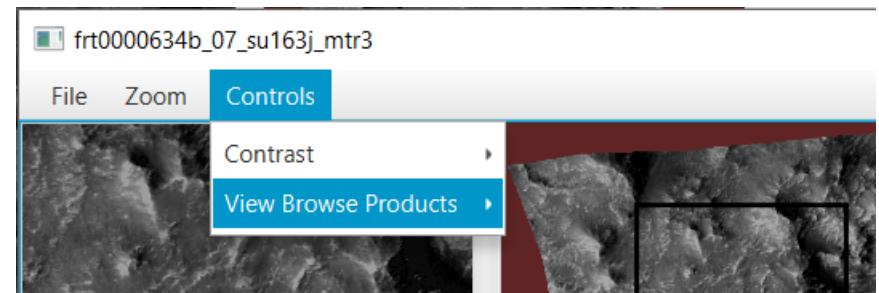
- Select a summary parameter from the list and click the “Update Image” button to continue.
- Contrasts can still be selected from the controls menu
- Sum param values are located under the lat/lon information
- NOTE: RPEAK1, BDI1000VIS, BDI1000IR, VAR and BDI2000 are currently not available for TRDR products





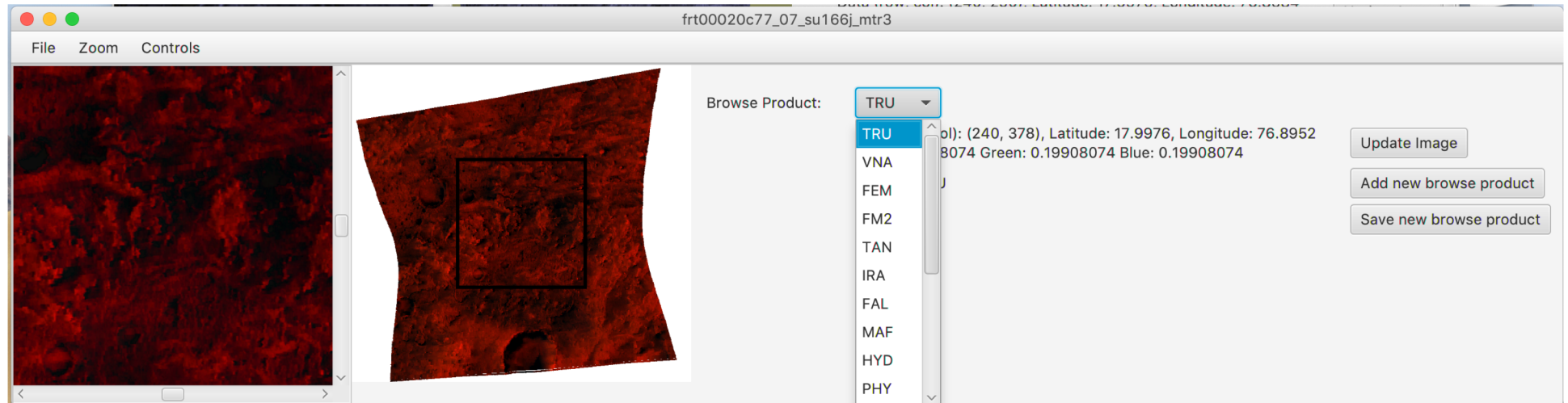
# Browse Products

- Browse products are standard, thematic combinations of summary products that show variations in the presence of a related class of minerals. See more at <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014JE004627>
- For MTRDR files, select “View Browse Products” once you’ve opened the summary parameters window
- For TRDR files, select “View Browse Products” to launch the browse products window



# Browse Products Cont'd

- Select from the list of browse products and click the update image button to display the image
- RGB values are shown to the right
- By selecting new browse product, choose which summary parameters will be the RGB values. "Update image" will display new browse product
- Option to save and label new browse product



# Example Workflow – Retrieving Files

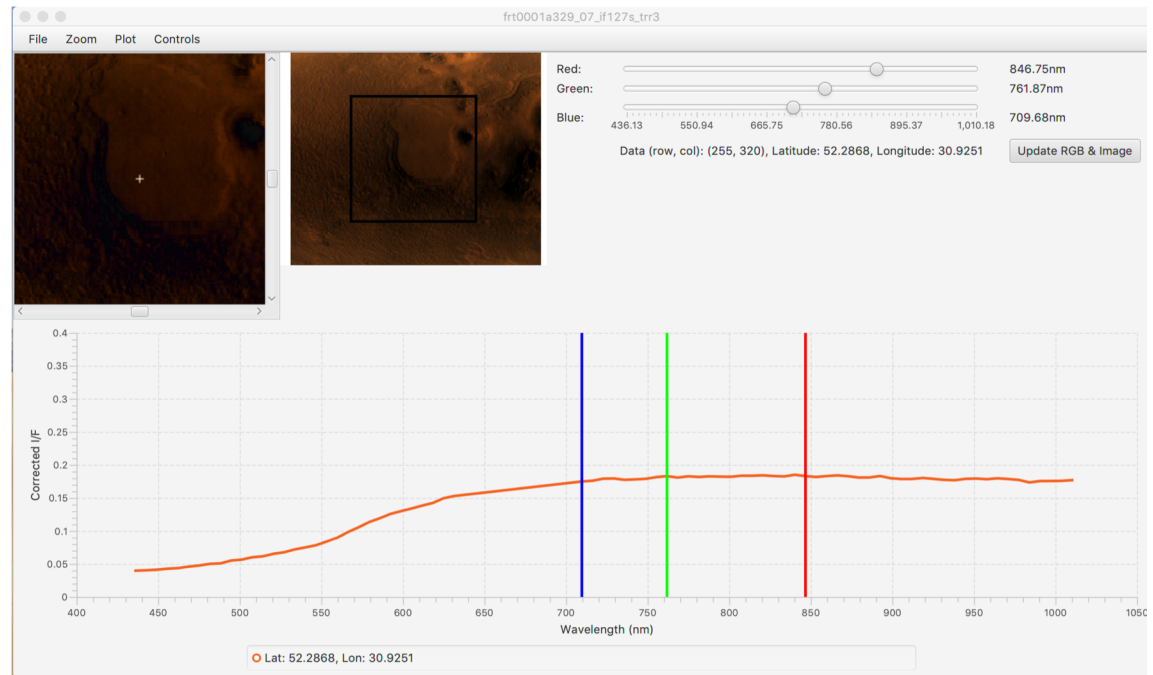
- Let's take a look at the interactive CRISM map (Browser -> CRISM Map)
- If we zoom in to around 52.3, 31.0 (lat, lon), we can download observation **0001A329** in the top right, click on the sensor, then choose the VNIR image data
- Refer back to slides 5-11 for how to download the necessary files for a CRISM images
- Select this as a new file in JCAT when downloaded

The screenshot shows the CRISM Data Products website interface. The top section displays a map of Mars with various observation points marked by colored labels. The left sidebar contains 'Map Information' and 'Keymap'. The main content area shows a detailed view of a specific observation, 0001A329, with a 'Browse Products' section listing different data types like 'vnr\_rgb' and 'ir\_ira'. A 'Downloads' section provides links for downloading the data in different formats. The bottom right section contains 'OBSERVATION DETAILS' with a table of metadata.

OBSERVATION DETAILS	
File	FRT0001A329_07_IF127S_TRR3.LBL
Comment	COORD Target - 34842 Depositional fan emanating from young fluvial valleys in Lyot Crater Climate Change PUB - urgent for stereo completion
Year/Day of Year	2010_218
Observation Class	FRT
Observation Id	0001A329
Image Count within Observation Sequence	07
File Type	IF
Macro Number	127
Sensor Id	S

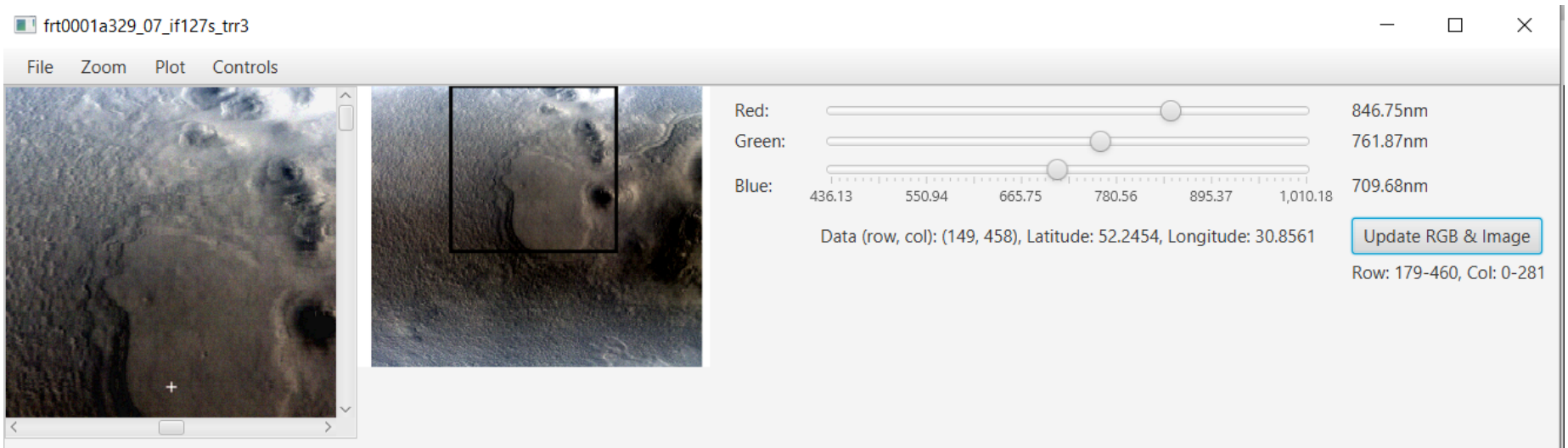
# Example Workflow

- The image will load in the upper left corner. Clicking on a point will show the spectrum on the bottom and be reflected on the image with a crosshair.
- You may zoom in/out using the zoom menu or expand the image to its full size under the file menu.
- Images are loaded in with a default 1%ile stretch meaning the dimmest pixels are assigned minimum brightness (0) and brightest assigned maximum brightness (255).
- The sliders in the upper right allow you to manipulate the wavelengths set for red, green and blue. Slide them around and update the image to see their effect.



# Example Workflow

- Try some of the different stretching options under Controls->Contrast. The spatial subset stretch uses only the pixels within the viewing range to assign minimum and maximum brightness instead of the entire image. These tools are helpful to see different spots that may be more present at one band than another.



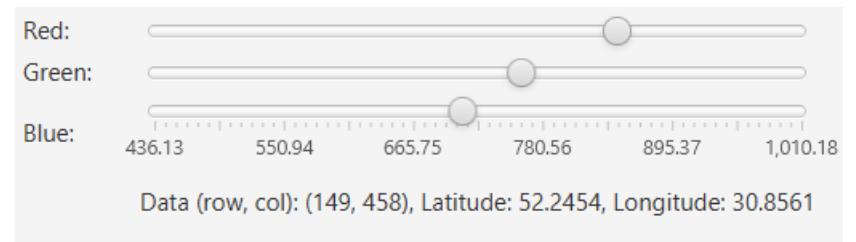
The screenshot shows a software window titled "frit0001a329\_07\_if127s\_trr3" with a menu bar containing "File", "Zoom", "Plot", and "Controls". The main area displays a satellite image of a planetary surface. A zoomed-in view of a specific region is shown to the right. Below the images are three sliders for "Red", "Green", and "Blue" channels. The "Red" slider is set to 846.75nm, the "Green" slider to 761.87nm, and the "Blue" slider to 709.68nm. The x-axis for the sliders ranges from 436.13 to 1,010.18. Below the sliders, the text "Data (row, col): (149, 458), Latitude: 52.2454, Longitude: 30.8561" is displayed. A blue button labeled "Update RGB & Image" is located to the right of the sliders. Below the button, the text "Row: 179-460, Col: 0-281" is shown.

Channel	Value (nm)
Red	846.75
Green	761.87
Blue	709.68

Data (row, col): (149, 458), Latitude: 52.2454, Longitude: 30.8561  
Row: 179-460, Col: 0-281

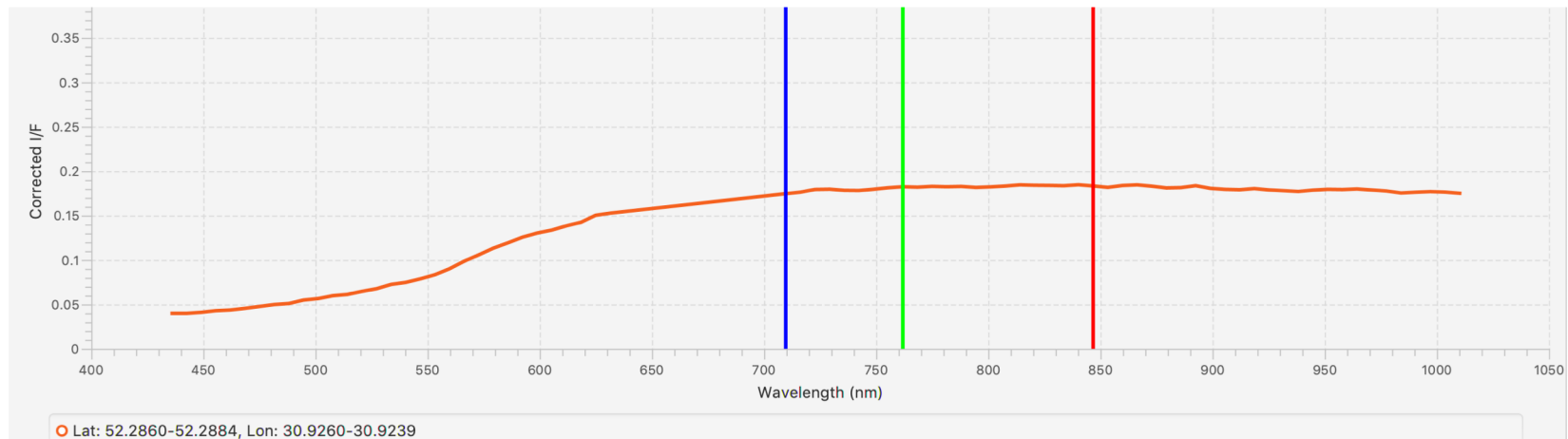
# Example Workflow

- Let's take a look at the values underneath the RGB sliders.
- The Data points refer to the image scene. The origin (0, 0) is in the upper left of the image.
- The latitude and longitude coordinates are also displayed. Be careful- up, down, right, left don't always correspond to North, South, East and West.



# Example Workflow

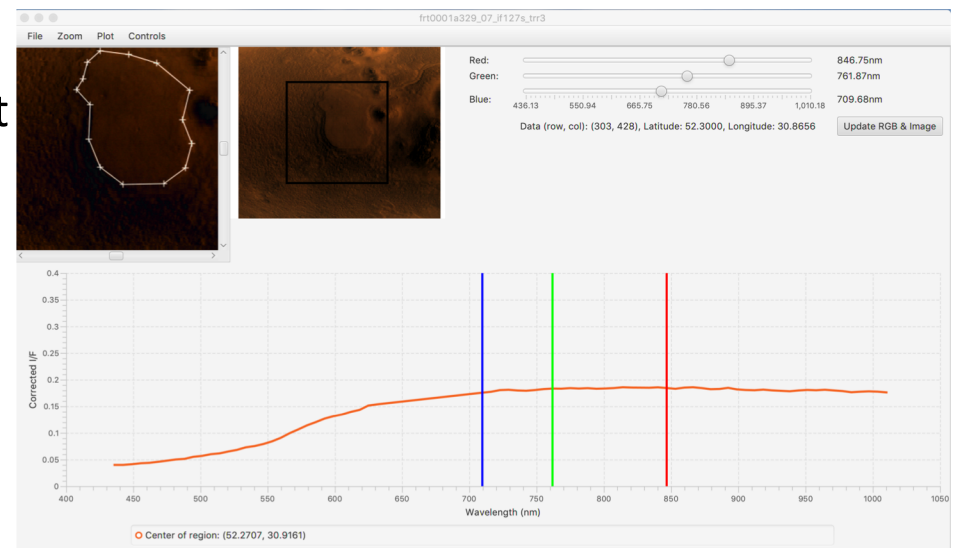
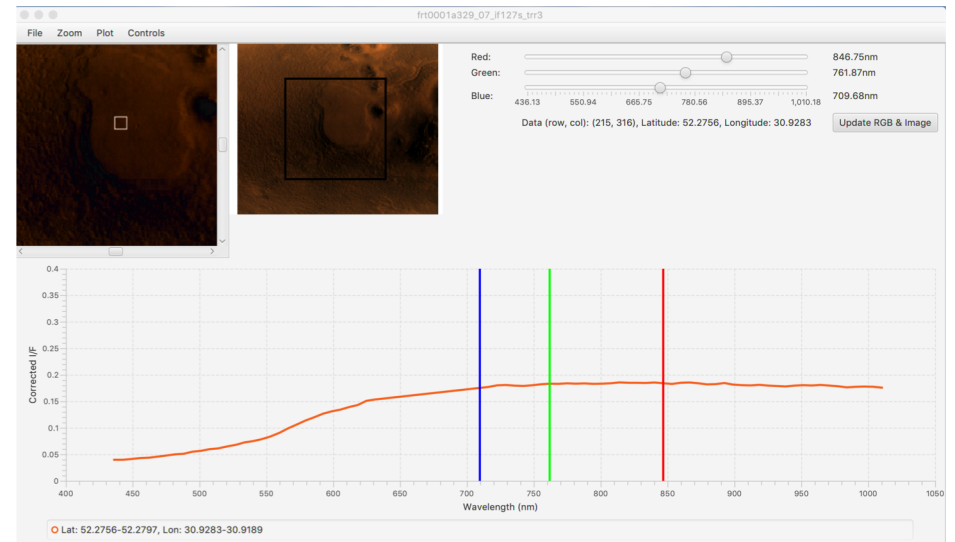
- Go to Controls -> Spectrum Averaging Width. It is currently set to Single Pixel. This means just the pixel clicked will have its spectrum shown.
- Choose 5x5 Pixels. This will average the selected pixel with its surrounding 24 pixels, creating a 5x5 box. This is very useful to reduce noise in the image that may not carry any information. The new averaged area will be reflected in the legend of the chart.





# Example Workflow

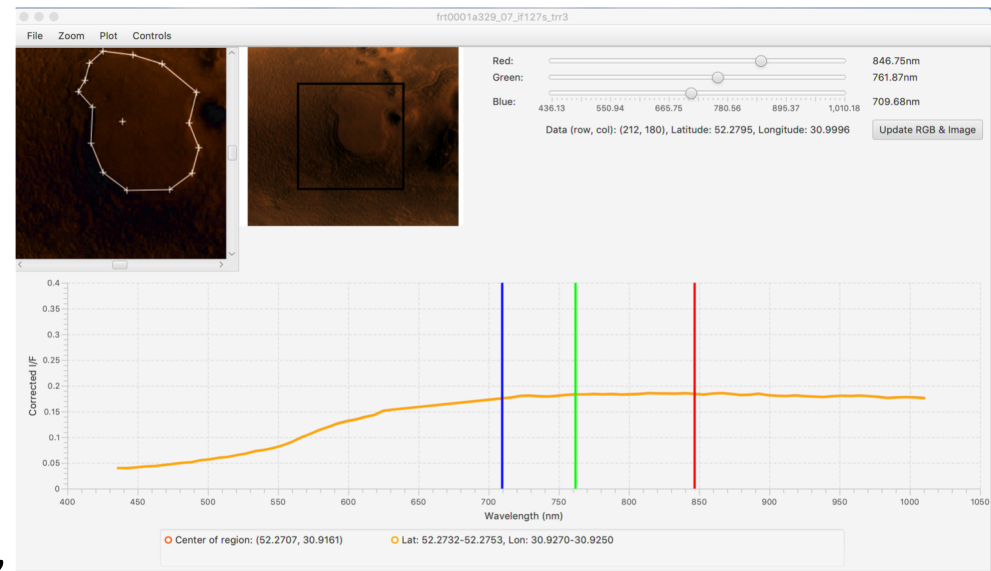
- Let's use average a larger area. Choose Controls -> Spectral Interest -> Drag Avg. Now, instead of clicking, press drag and release on the image to average the pixels within the rectangle you just created.
- In order to use the Region of Interest tool, left click to add points to the shape. To close the shape, right click and the last point will connect to the first, averaging the pixels inside. Try clicking around the large mound in the center of the image.
- Know that these may take longer since they are averaging many more pixels than before.





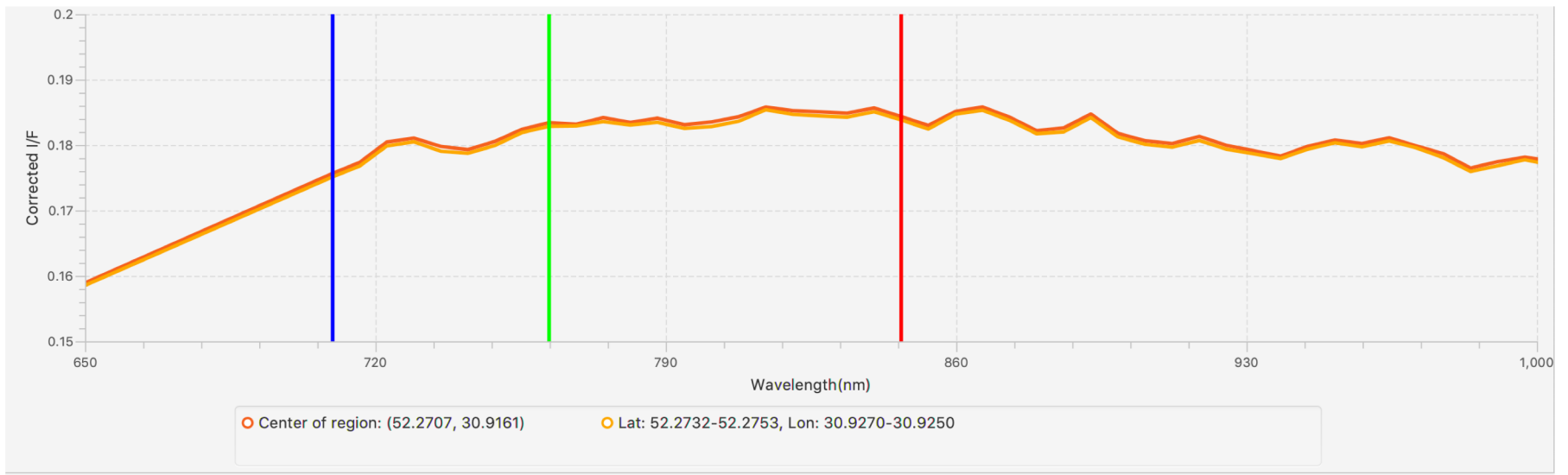
# Example Workflow

- Let's compare a point on that mound with the average of its entirety. Go to Controls -> # of Spectra -> Two+. Now, select Click instead of Region of Interest under Spectral Interest.
- When adding new spectra onto the chart, use the center click function of the mouse. Since we are clicking, simply center click somewhere on the mound and the spectra will both appear on the chart.



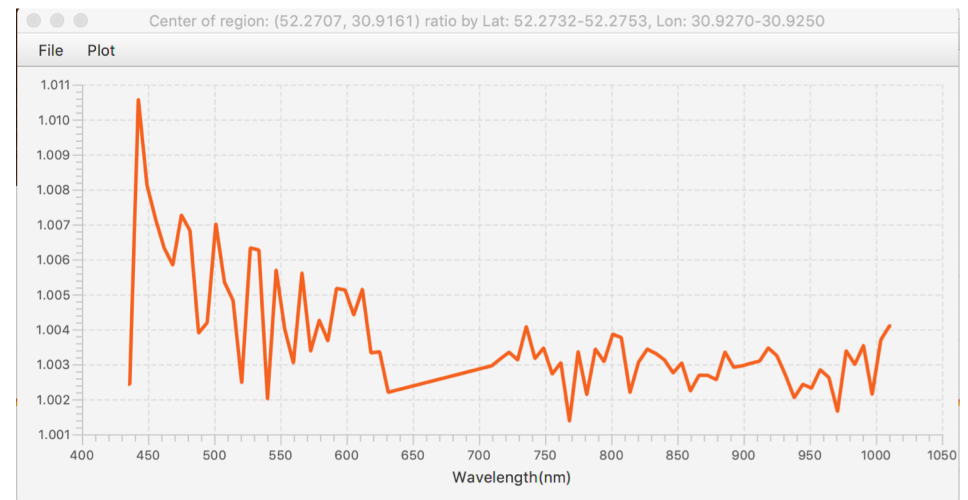
# Example Workflow

- It's hard to see any information-carrying features in the spectrum when it is so zoomed out. Go to Plot -> Set X/Y Range to adjust the values you see on screen. To get back, Autoscale Both.



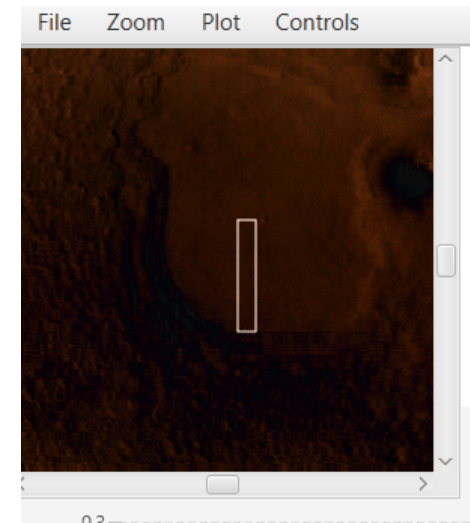
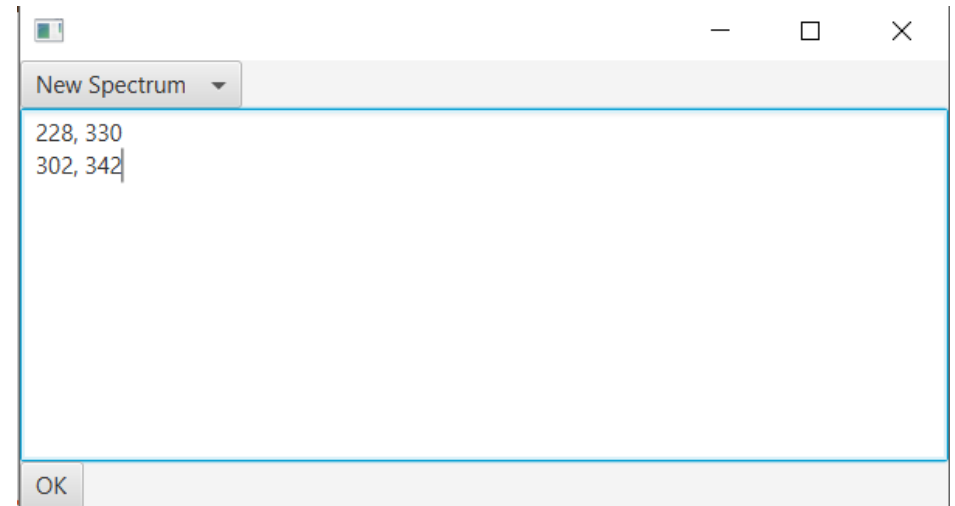
# Example Workflow

- Looking at the visualization is nice, but sometimes seeing the numbers is better. Go to Controls -> Spectral Operations. Ratio the two spectra and see the resulting plot.
- You can also adjust the axes on this chart under the Plot menu.



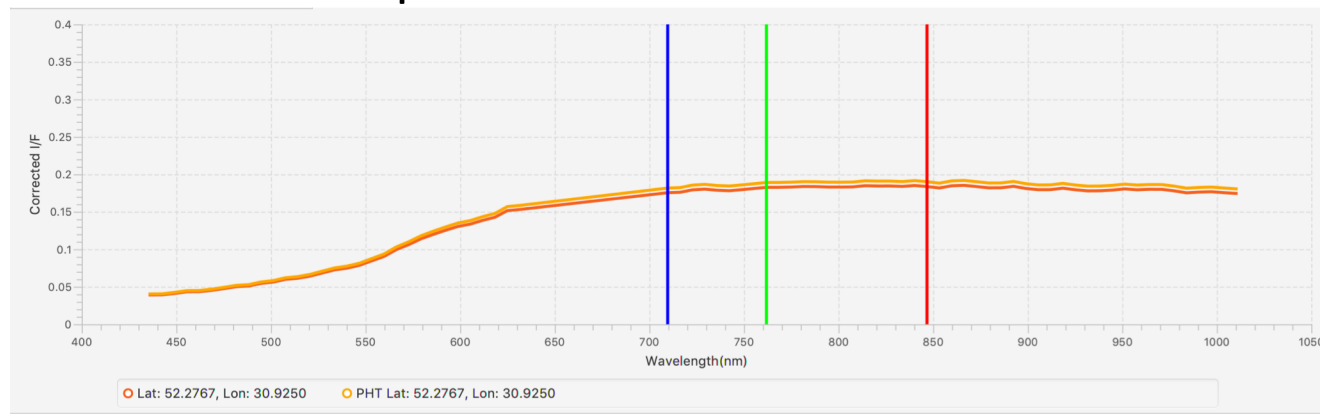
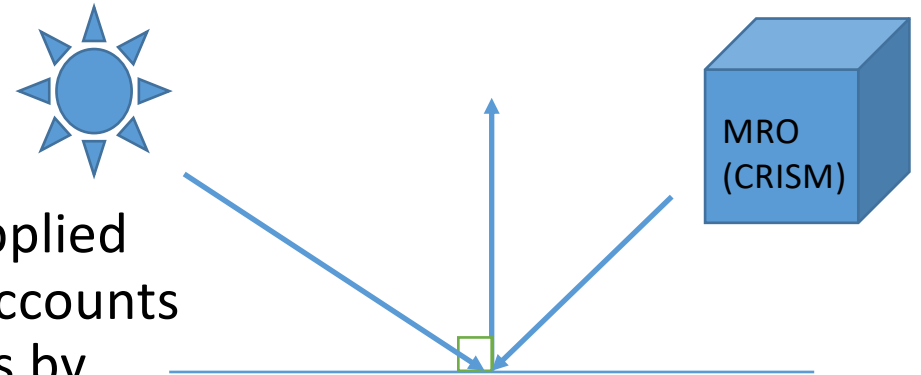
# Example Workflow

- Instead of clicking around the image, another way of entering data more precisely is by manually inputting the points you would like to see. Select Controls -> Spectral Interest -> Input Manually
- In the choice box, select if you would like to create a new chart or add another spectrum onto the existing chart.
- In the text box, type what point(s) you wish to see. One point for a single pixel, two points for a rectangular region, or three or more for a region of interest (make sure these are in the order you would like them drawn on the image).
- **IMPORTANT:** the format for these points should be 'row, col' – any additional/removed spaces can cause issues with what points end up being used.



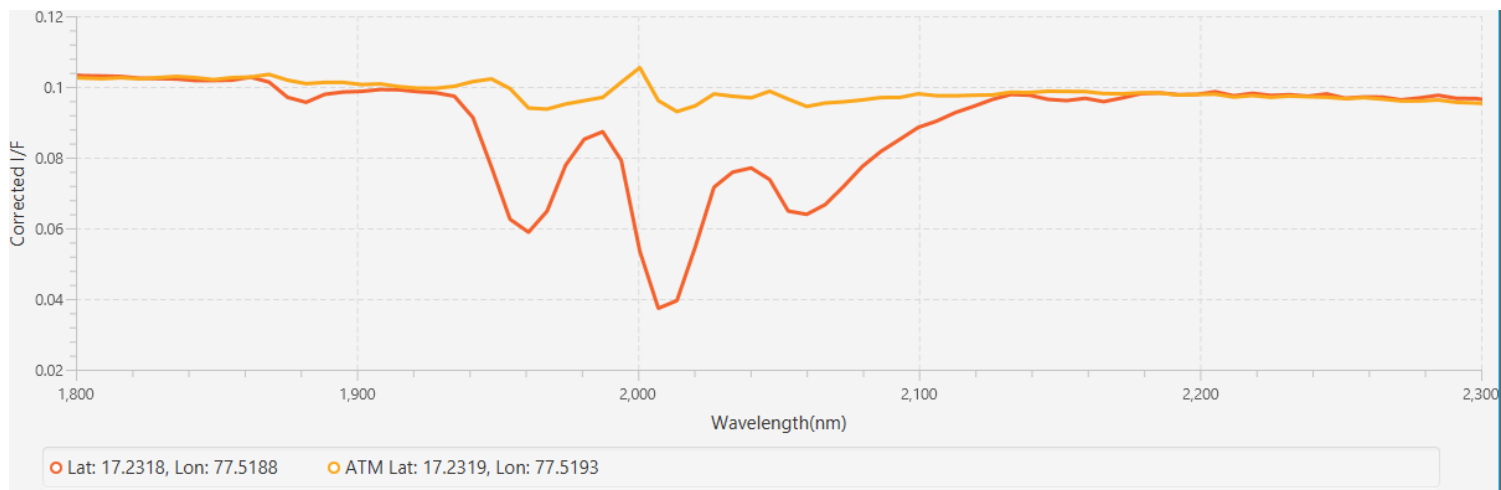
# Example Workflow

- One type of correction that can be applied to this image is a photometric. This accounts for non-normal solar incidence angles by dividing the scene's spectrum by the cosine of the incidence angle.
- Apply it and select the same point to see the difference.



# Example Workflow

- In this image, we don't have to worry. But whenever looking at a TRDR image from the "L" sensor (1000-4000 nm), there is an absorption feature around 2000 nm from CO<sub>2</sub> atmospheric interference.
- To correct that, go to Controls -> ATP Corrections -> Atmospheric. There are several options. Choose from many or run an optimization routine providing the best correction for your particular image.



# Example Workflow

- Go under the File menu to save something you like. You can save the current image (.png), chart (.png) or the actual data (.csv).

