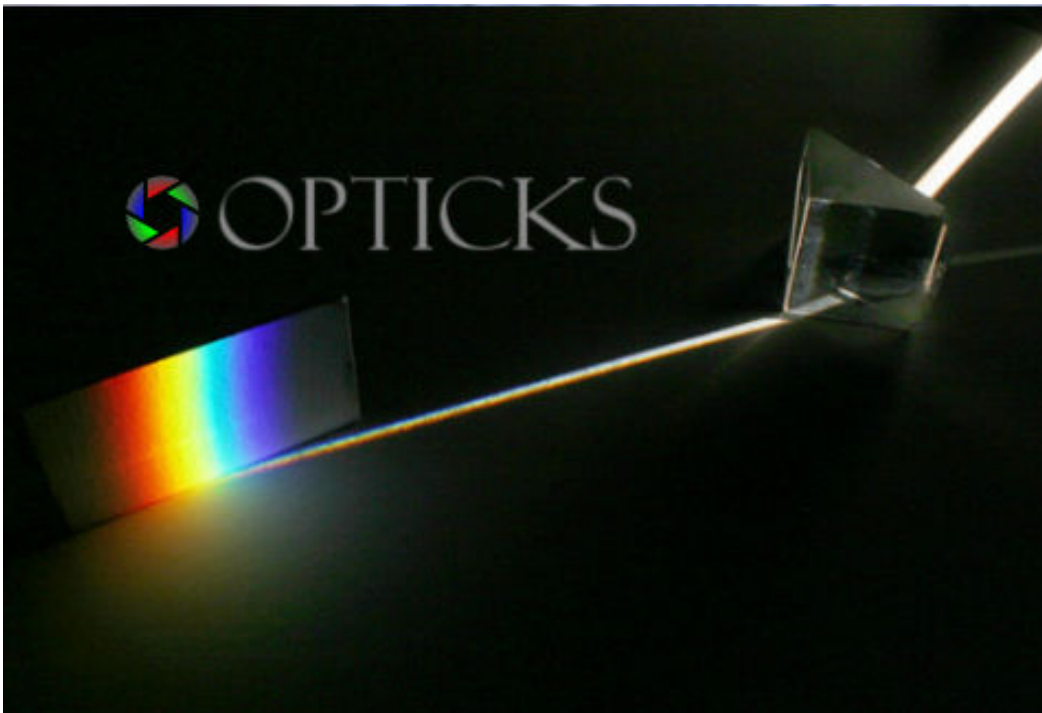


Opticks User's Guide

Open Source Image Processing Software

(DRAFT)



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Created on: 08.21.2010
Updated on: 11.14.2010

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Preface

NOTE: This document is in **DRAFT** form and is expected to have errors. **During this time, please direct all comments to the author.**

This documentation supplements and in some cases expands on the Opticks documentation found on the Help menu and online at the Opticks site. The intent of this documentation is to provide the user with a logical overview of the application as well as some additional commentary on the tools, their use, and how they are used in for a particular purpose (e.g. identifying a particular cover type or material in an image requires a series of steps and a number of tools to complete the task).

The *Opticks User Guide* begins with a general overview of the application, getting it set up and being able to load an image and becoming familiar with some of the tools and how to interact with the application interface. The Opticks site provides a much more detailed explanation of the tools. This document will explain the use of many of the tools as an analyst works through common and realistic image processing tasks as they relate to remotely sensed imagery.

Users are encouraged to refer to both this document as well as the Opticks Help as needed to complete tasks. Please submit comments, questions, errors, and issues to one of the following:

nate@jenningsplanet.com

jenninn@arc.losrios.edu

users@opticks.ballforge.net (free registration is required to post comments to the Opticks forum)

The user forum email can be found on the Opticks page under the Community section of the home page.

<http://opticks.org>

Acknowledgements

The author would like to acknowledge all of the great staff at Ball Aerospace. This small community of full time application developers has put together fairly comprehensive open source image processing software tailored for remotely sensed imagery. They all do great jobs of putting out regular software updates (several per year) with some significant improvements in each release. Being a user, unpaid developer, educator, and promoter of Opticks, I commend them on their expert abilities, guidance, and attentiveness and responsiveness to the both the user and developer communities. I want to especially acknowledge Kip Streithorst and Trevor Clarke for their patience and knowledge to help me through my first deployment of the RADAR extension as well as their successful leadership and mentorship of the first Google Summer of Code Opticks Projects. Two great extensions came out of this endeavor. I am glad to have been a part of this project. I also want to thank Michael Constatine and Dustin Atkins with their additional input and support on my questions regarding some of the Opticks functionality.

I also want to thank Kevin Rock from SpecTIR who graciously provided some of their hyperspectral data that I used to help develop the Hyperspectral content in this user guide. User's can obtain free sample data at www.spectir.com.

This user's guide is one of my contributions back to the Opticks user community with the hope that others will gain a broader appreciation for remote sensing, digital image processing, and the fact that there is a strong, user-friendly open source application that focuses on the world of remote sensing.

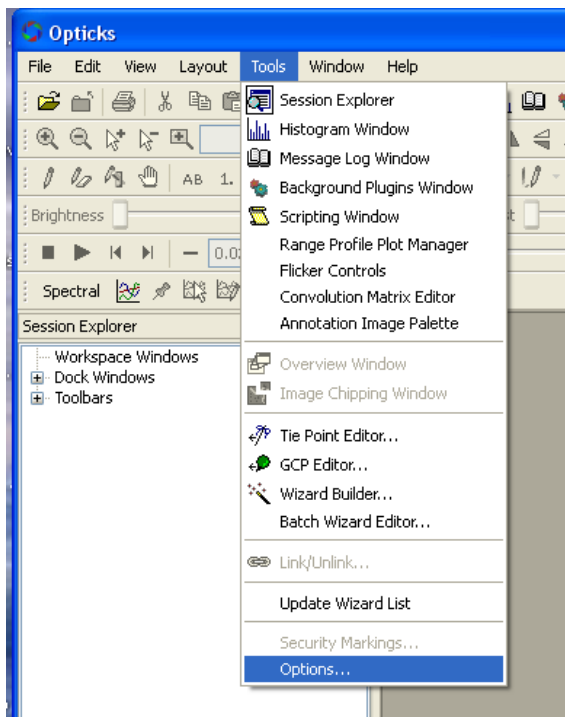
Opticks – Getting Started

See Help menu for a comprehensive explanation of the Opticks, toolbars, function descriptions and basic tutorial guides. Most of these can orient the user with Opticks functionality. Make sure to download the sample data sets or use images provided by the instructor.

Setting up the Opticks Environment

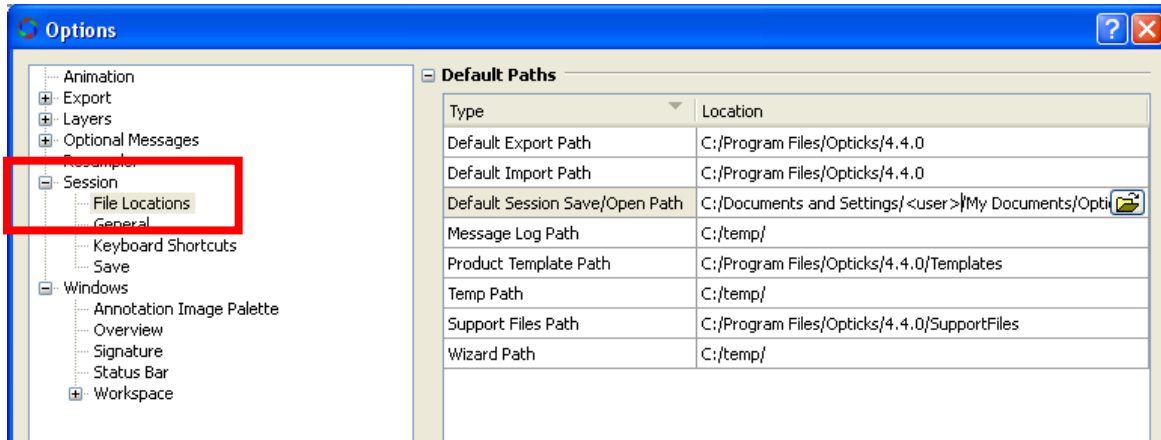
If Opticks is installed on a personal or standalone system, the default settings will likely be sufficient to perform the Opticks functions. If Opticks is used in a lab where the user does not have write access to all of the default Opticks file paths, the following settings will need to be changed. If the same user uses different computers, the settings may need to be set for each new user/machine.

Using Opticks in a multi-user lab environment, the default options for Opticks may need to be changed. The Options are found under Tools—Options. Some folders may need changing if users do not have write access to the default locations. Users should check with a technology administrator to make sure the proper access to system folders is available.



The following paths can be changed and set by the user to provide locations where users have read/write access. Normally, the paths only need to be changed once; however, in some lab configurations, specific users may need to make the same changes if different machines are used.

For the **Session—File Locations** change the paths below as needed. Write permission may be required for some locations.



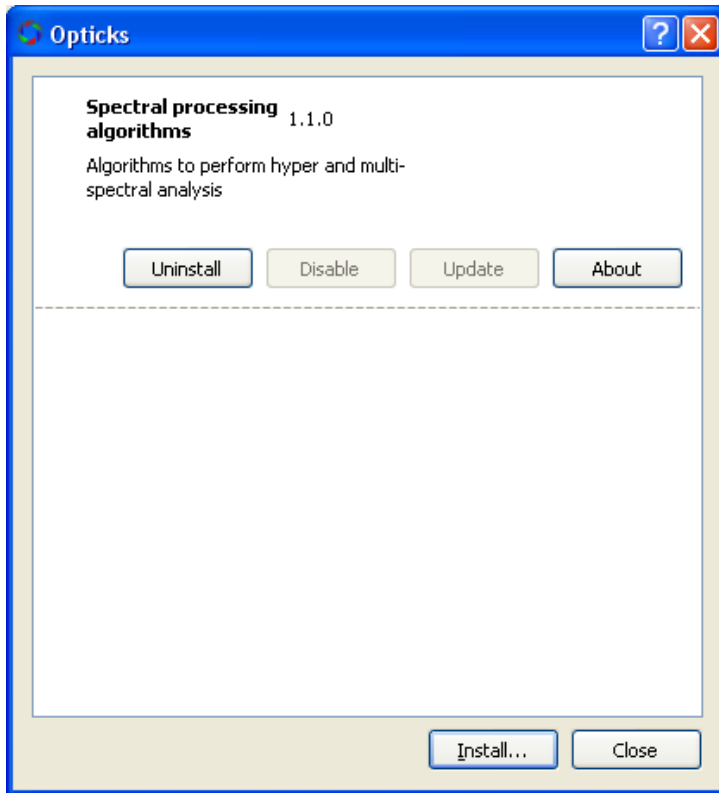
Loading Custom Plug-ins (Opticks Extensions)

Plug-ins are additional code packages that extend the core functionality of Opticks. These are custom built applications developed in C++ by the Opticks open source community and delivered as either compiled dynamic link libraries (DLLs) or from compressed files (AEB – similar to the zip format). A few plug-ins exist for Opticks (Spectral Processing, Python, RADAR, and SAR (Synthetic Aperture RADAR) that are not part of the core functionality of Opticks. Before downloading and installing plug-ins make note of the installed Opticks version and the Plug-ins version number. Plug-ins support specific versions of Opticks. Some plug-in versions are not forward or backward compatible. The Opticks Extension site will indicate which Opticks version is supported.

Three methods exist to load extensions.

1. Install Extensions for the Help menu. Once the AEB files are downloaded, users can install the extensions by going to the help menu and choosing install. The installed extensions will show up under the help menu.

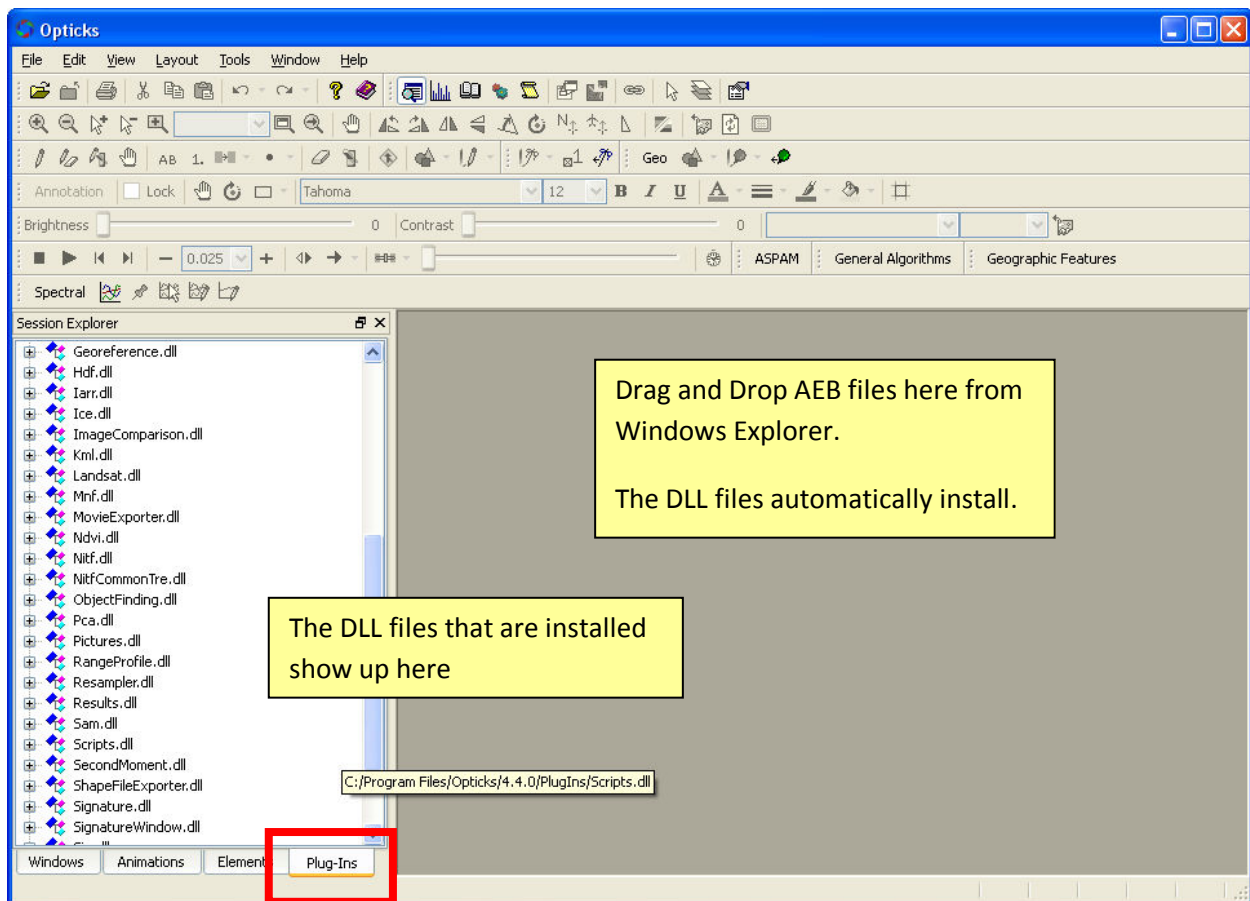




2. Drag/Drop AEB onto Opticks. Users can download the extensions from the Opticks site and simply drag and drop the AEB extension into any location on Opticks when the application is open. The AEB will extract and load in the proper location for Opticks to recognize it.

When AEB files are installed, users will see the installed extensions under the Help menu.

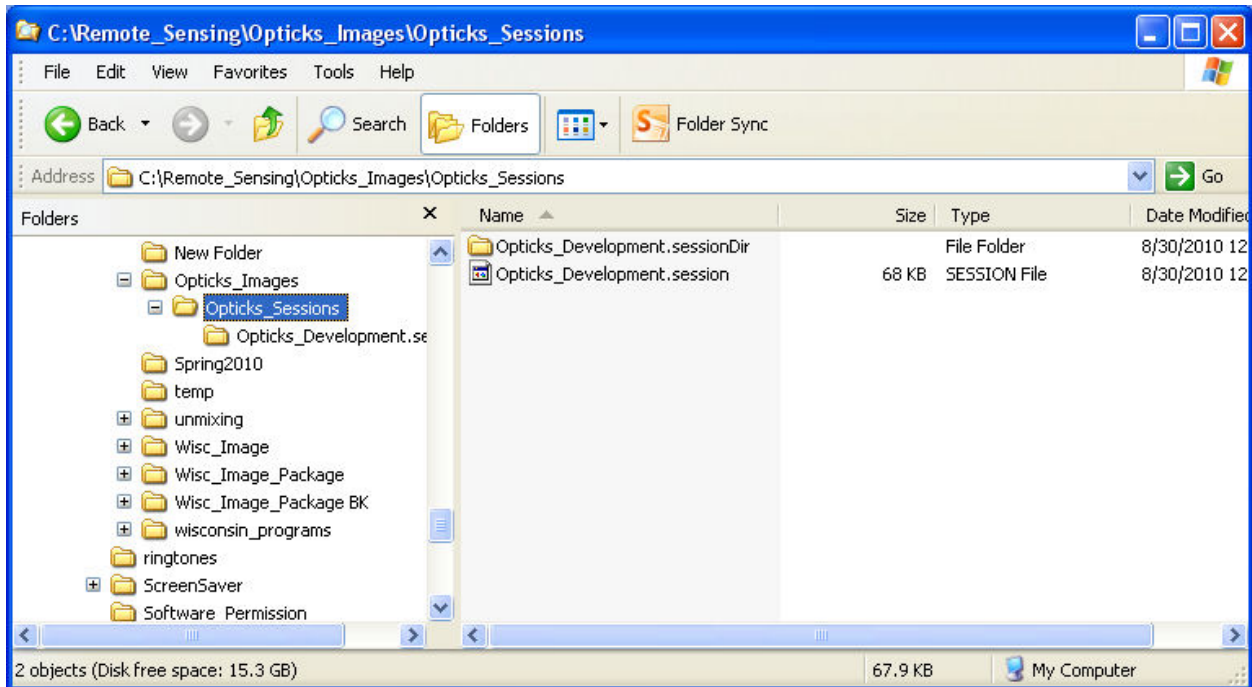
3. Copy DLL file to Opticks Plug-in directory. Download and open the zip file containing the DLL file from the Opticks extension site. Copy the DLL file to the **C:\Program Files\Opticks\<Opticks version>\Plug-ins** folder. When Opticks is open, typically a new toolbar will appear in the Session Explorer. Also, the user will see the DLL file show up in the Plug-ins Tab.



In either case, the user can check the respective Toolbar from the Session Explorer to load the toolbar if one exists for the plugin. Make sure to read any documentation that accompanies the plug in.

Saving an Opticks Session

To save an Opticks Session (similar to a project file), the user can choose File—Save Session As (or Save Session if an Opticks Session already exists) and assign a session name. The Opticks Sessions will have an extension of .Session and an Opticks Session folder (**.SessionDir**) will be created in Windows Explorer. The SessionDir contains a number of files that keep track of imagery and settings used in the respective session. Image files do not have to be stored in the same directory as the Opticks Session.

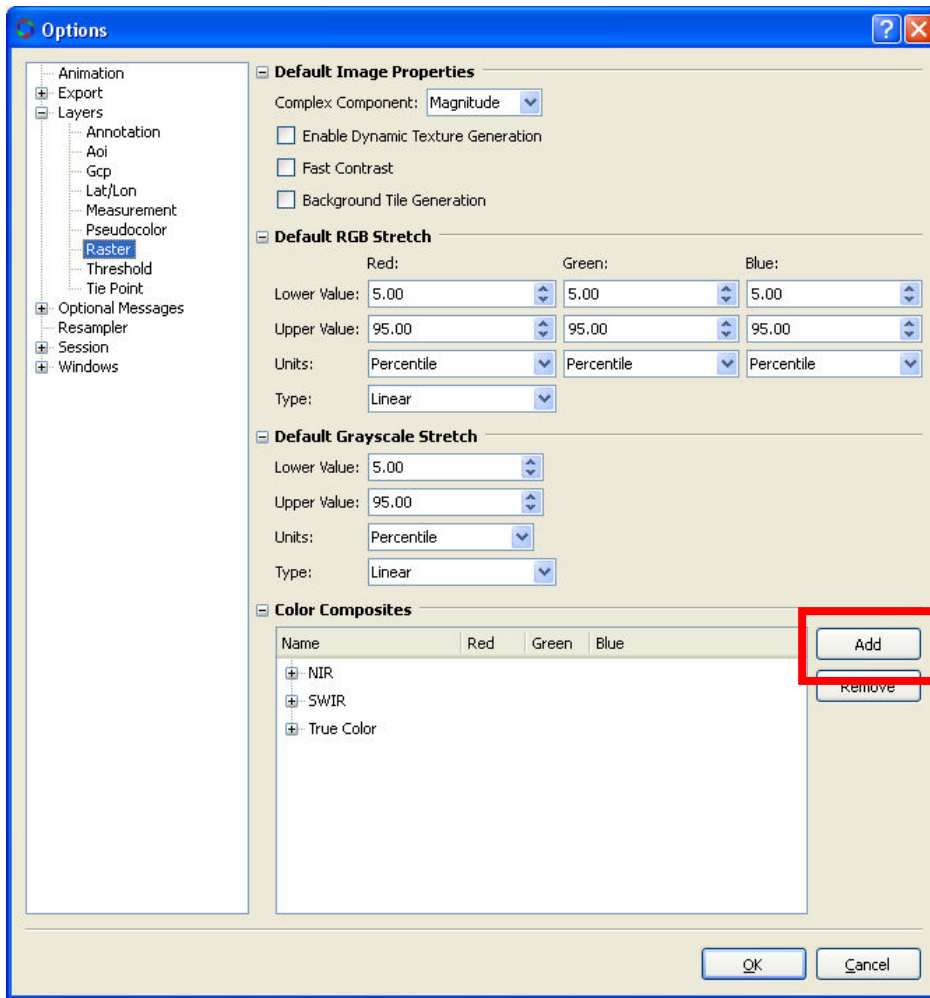


Customizing Opticks Options

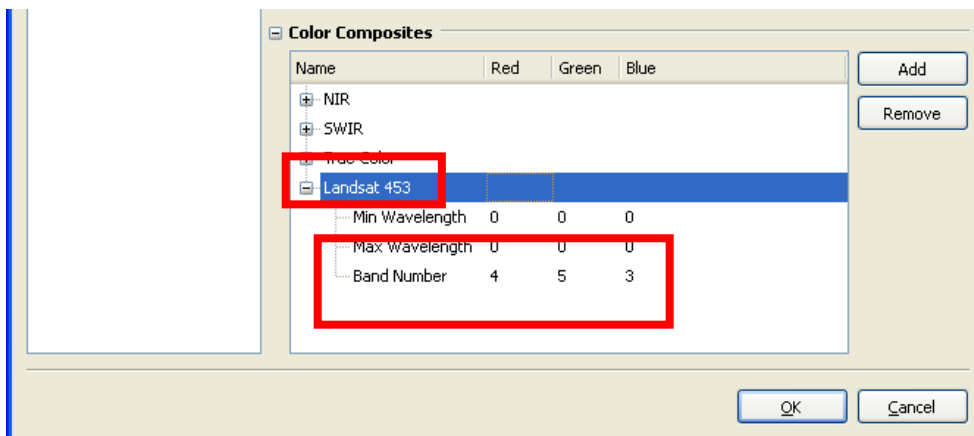
The user can also make modifications to some of the Options within Opticks such as units, colors, and custom band combinations.

Creating a Custom Band Combination

1. Under the Tools—Options menu, select Raster under the Layers Options.



2. Click on the Add button on the Color Composites portion of the Options window.
3. Make the following changes by highlighting on each element to rename the New Composite and assign band combinations. If wavelengths are known, these can also be added if necessary.



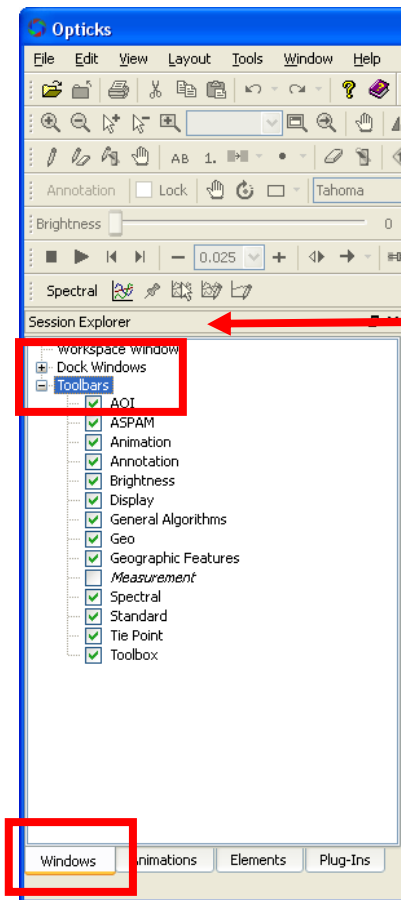
Using the New Band Combination

When users import or display imagery, this new color composite will be available.

Displaying Toolbars

Tool bars for Opticks are usually displayed at the top of the application. Additional Toolbars can be added by doing the following:

1. Click on the Toolbars menu in the Session Explorer

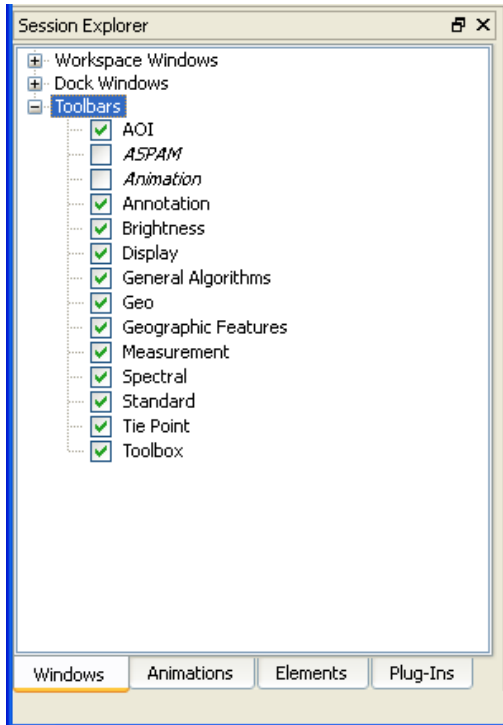


2. Check the respective box to display the toolbar

Toolbar Overview

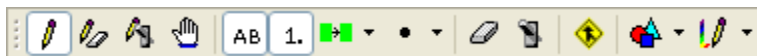
This section provides a brief overview of each Opticks Toolbar (checked below). Unchecked toolbars are not covered in this document. See the Help menu for more details on the tool. Other sections in this guide will have additional details on respective tools as they are discussed. Some toolbars are not activated until an image or other feature is loaded into Opticks. Hover the mouse over a specific tool to

see the name of the tool. Also, look at the lower left corner of the Opticks Application window to see a short description of the tool.



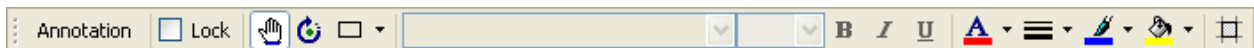
AOI

The AOI (Area of Interest) tool allows the user to create small areas on the image to perform additional operations such as create subsets, limit processing areas, and work with spectral signatures. An AOI layer must be created or exist to activate the toolbar. Some of the AOI tools are used with the Spectral Processing Toolbar as well as with processing multispectral and Hyperspectral imagery.



Annotation

The Annotation Toolbar used to add text, and other information to the image display for a simple map to be produced. An annotation layer must be created or exist to activate the toolbar.



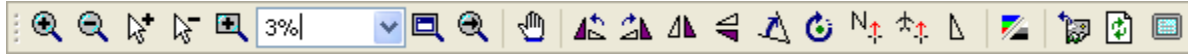
Brightness

The Brightness toolbar allows the brightness and contrast of the current image window to change. An image must be loaded into the image viewer to activate this toolbar.



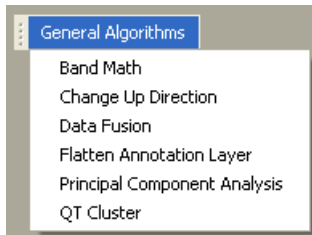
Display

The display toolbar provides the primary navigation functions for zoom in/out/full extent, pan, and various image rotation options.



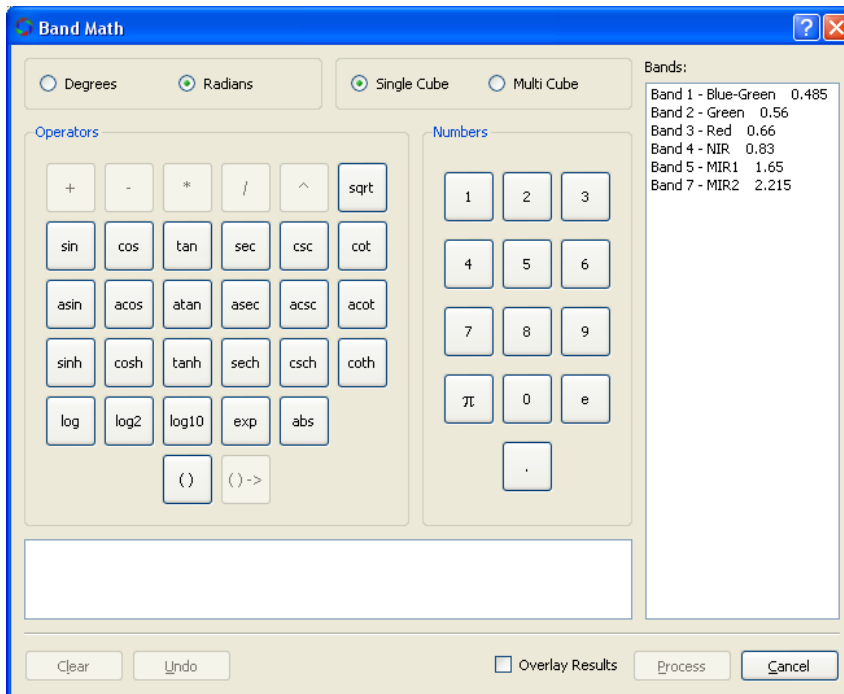
General Algorithms

The General Algorithms provide some basic image manipulation options. An image must be loaded to operate many of the functions within this toolbar.



Band Math

Provides options to perform basic math functions between different image bands (e.g. addition, subtractions, divide (band ratios), multiply, etc).



Change Up Direction

This function allows the user to change the up direction to always be at the top of the image. For example, if a satellite has a southern orbital path, the southern part of an image may be at the top and appear “upside down.” Users can change this direction if required.

Data Fusion

This function allows for two different images to be combined into a single image space or to integrate higher resolution imagery with lower resolution imagery.

Flatten Annotation Layer

This option is not yet documented.

Principle Component Analysis

This function runs a principle component analysis routine. Principle Components often is used to reduce the number of bands required for image processing as well as performing some change detection operations. Consult a Remote Sensing textbook for more details.

QT Cluster

This option is not yet documented.

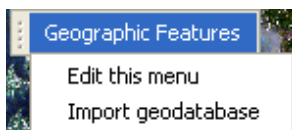
Geo

The Geo Toolbar provides the ability to assign a georeference (coordinate system) to the image. Georeferencing is discussed in more details below. Images must have a related set of ground control (GCPs) for the georeference to be assigned. The toolbar provides some basic ability to add GCPs. Latitude/Longitude, UTM, and MGRS (Military Grid Reference System) coordinate systems are supported.



Geographic Features

The Geographic Features toolbar provides the ability to load GIS shapefiles or geodatabases (including ArcSDE enterprise grade geodatabases).



Measurement

The Measurement Toolbar allows measurements to be made and displayed on the image. An image must be loaded and georeferenced to use this toolbar. Also the Measurement Mode button must be clicked.



Spectral Processing

The Spectral Processing Toolbar provides several tools and algorithms for processing hyperspectral data and creating spectral signatures for identifying different materials from hyperspectral (or other imagery). The Spectral Signature capability is provided by the Spectral Processing Extension. An image must be loaded into the viewer and some functions require the spectral values to be represented as radiance or percent reflectance as well as know the specific wavelengths for each band. Often hyperspectral data is provided with radiance or percent reflectance whereas other non-hyperspectral imagery is represented with a brightness value relative to the materials reflectance. Specific functions on the spectral toolbar are discussed in the Hyperspectral section. See Appendix B for a full description of the Spectral Processing Extension.



Standard

The Standard Toolbar provides the ability to open or import a variety of image and vector data types. A link is also provided to access the Opticks Help.



Tie Point

The Tie Point Toolbar provides some ability to collect additional points in image data so that some basic image rectification can be performed.



Toolbox

The Toolbox Toolbar is another primary toolbar that is used often in Opticks. It provides the capability to view histograms of image bands, loads the Session Explorer, load a scripting window to run custom scripts, create image subsets (image chips), link image viewers, and activate the layer edit mode that activates the AOI tools



Working with Imagery in Opticks

To use Opticks, image data must be loaded into the application. This can be achieved by going to **File—Import Data** and then search for image data or the Import Tool (Open Folder button) on the Standard Toolbar. Since a variety of imagery can be loaded (panchromatic [i.e. single band black and white], true color, multi-spectral, or hyperspectral), it can be loaded and viewed either as a single band image or 3 of the multi-spectral or hyperspectral data can be assigned to the RGB colors of the color display. By default, multi-spectral data not already saved into an Opticks session will display as black and white. The user will need to change the display to assign specific bands or wavelengths to the RGB color display.

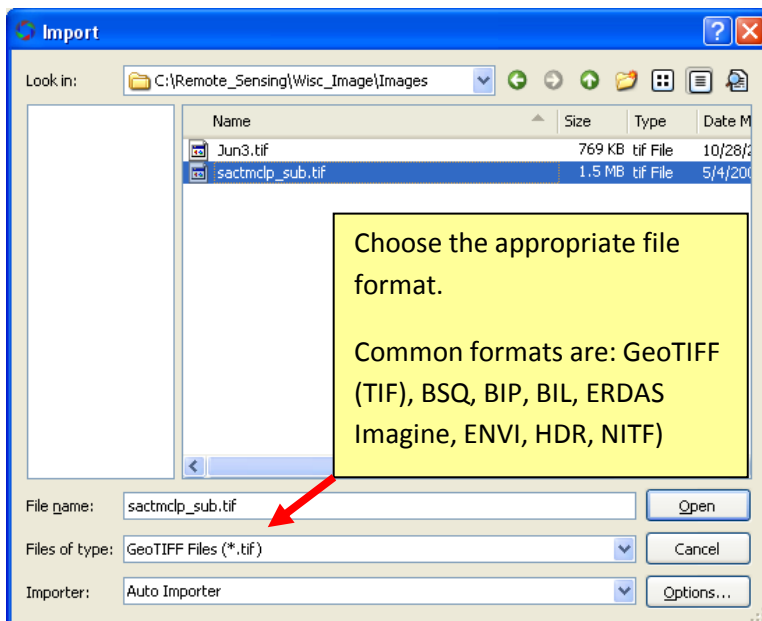
Opticks supports a number of raw and common file remote sensing image formats. Some are sensor specific, while others are in common delivered format (TIF, ERDAS Imagine, ENVI, NITF, HDR). Opticks has its own image format called ICE (Image Cube). Data can be saved and exported to this format. Other image processing software may not be able to read this format. It is recommended to save data to a more common format (e.g. TIF).

Display an Image

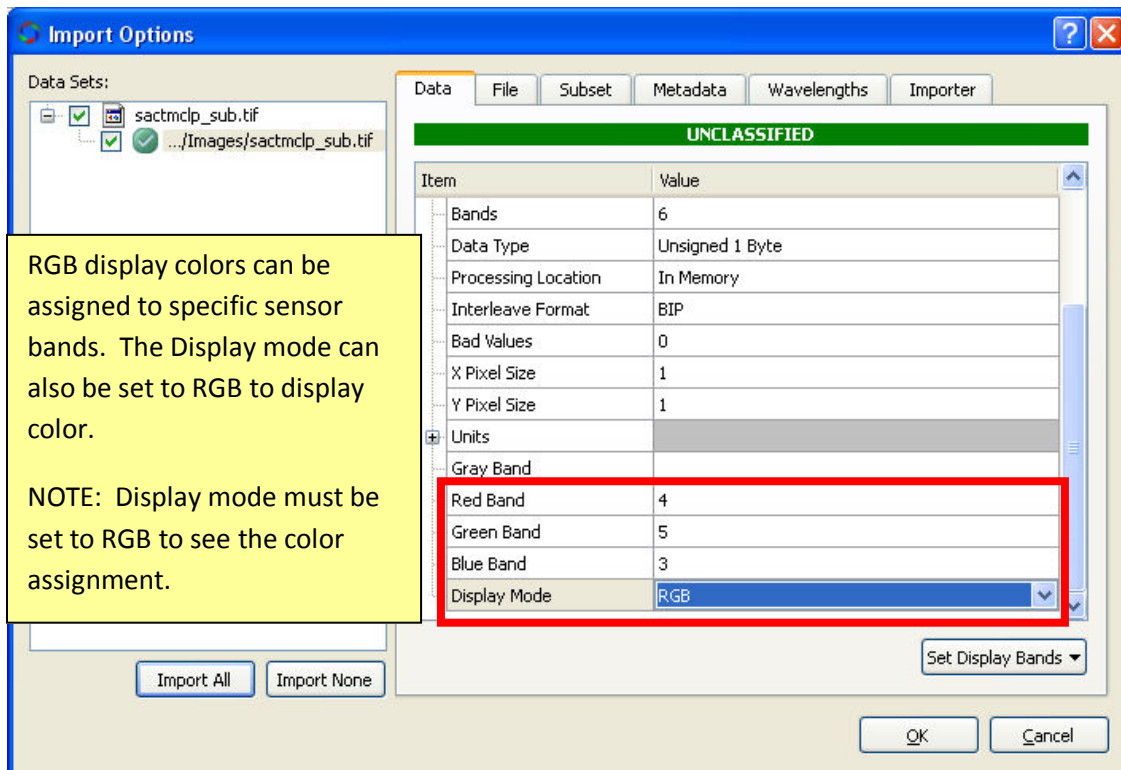
Click on the Import Data Tool



Select the specific file format and location of the file.

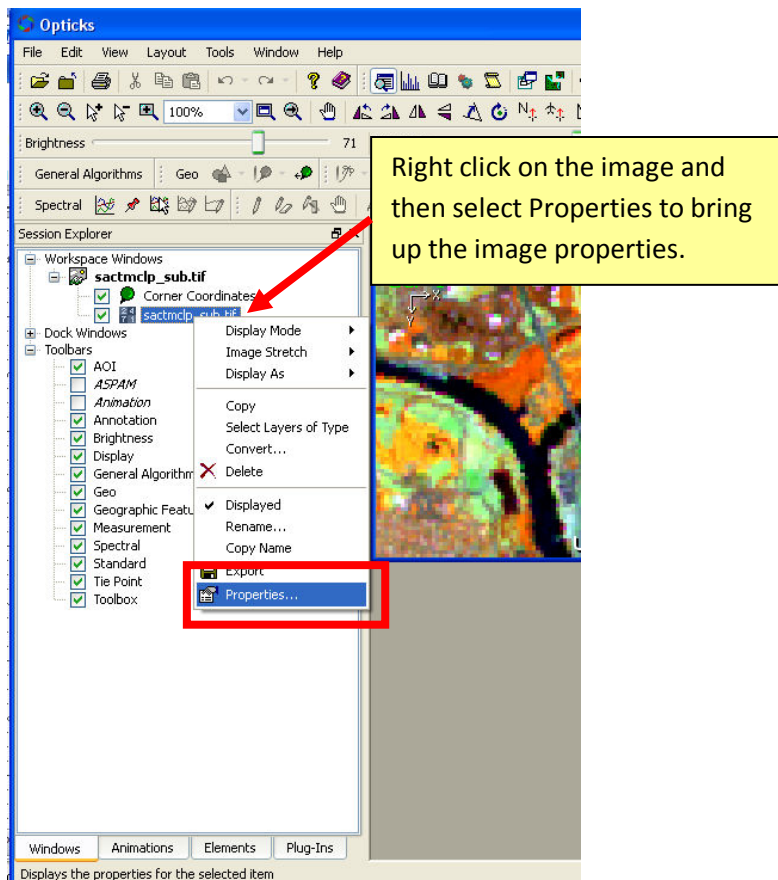


The Options button brings up an additional dialog box that allows the user to select specific bands of the image and assign them to RGB display colors, otherwise, the image will display as a grayscale image (the default).

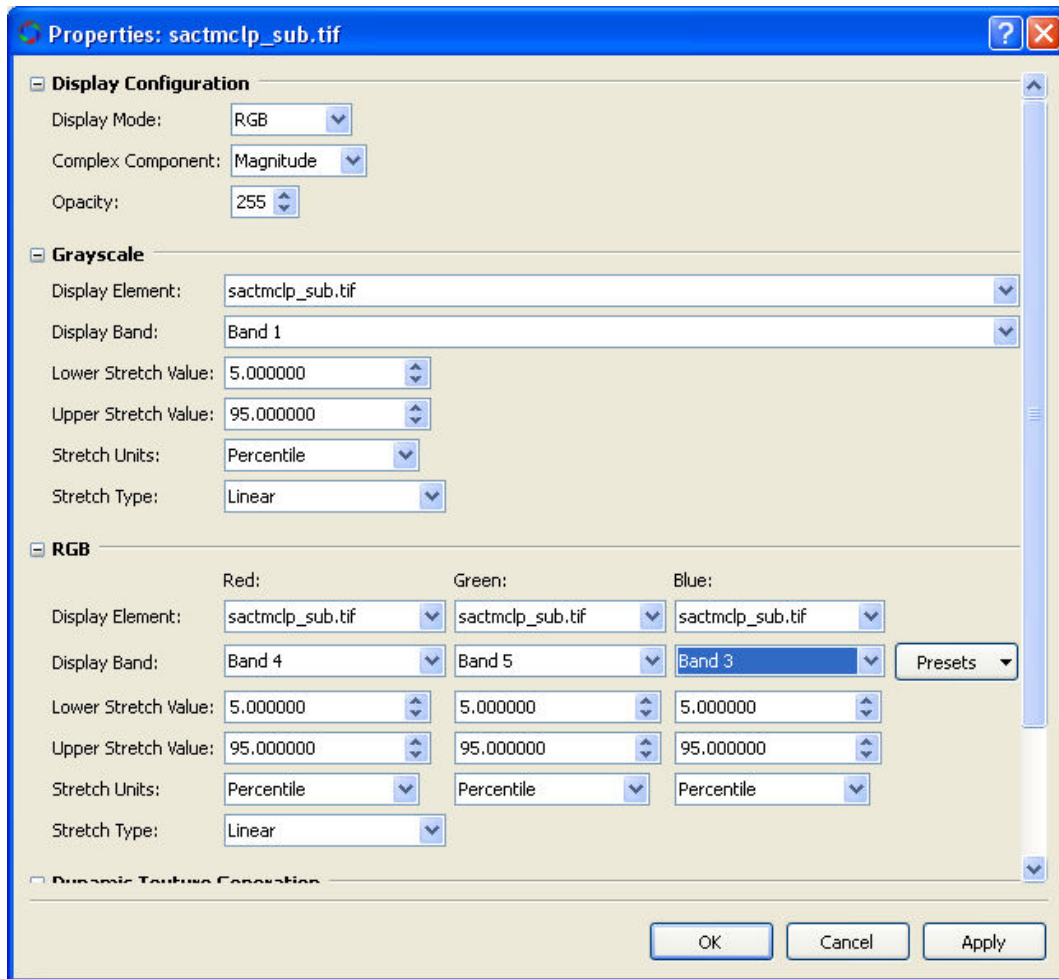


The user can change the band combination at any time by bringing up the image properties from the Session Window and then right click on the image file.

Image Properties



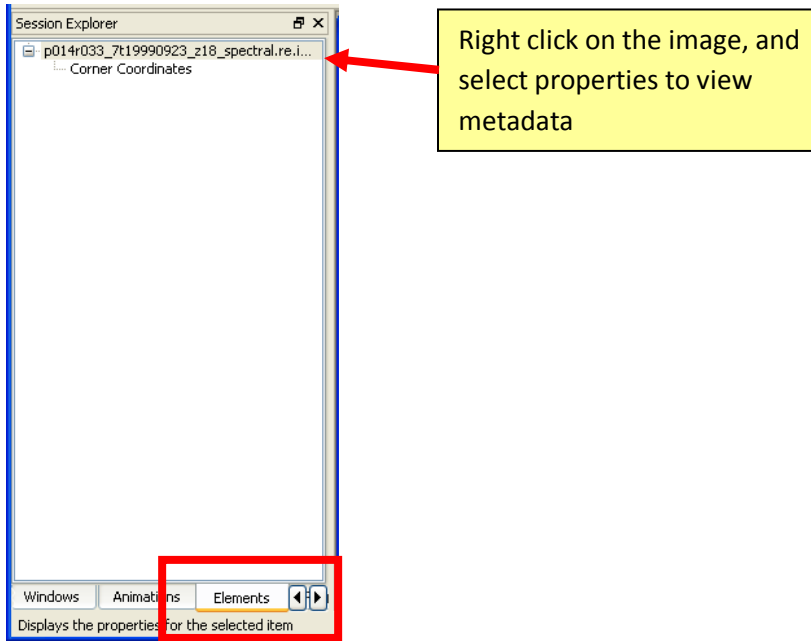
Band assignments, display mode, and image stretch can be changed in the image properties dialog box.



If the all of the display bands indicate the same band number, then the image will display in grayscale (black and white), even if the image is multi-band.

Reviewing Metadata about the Image

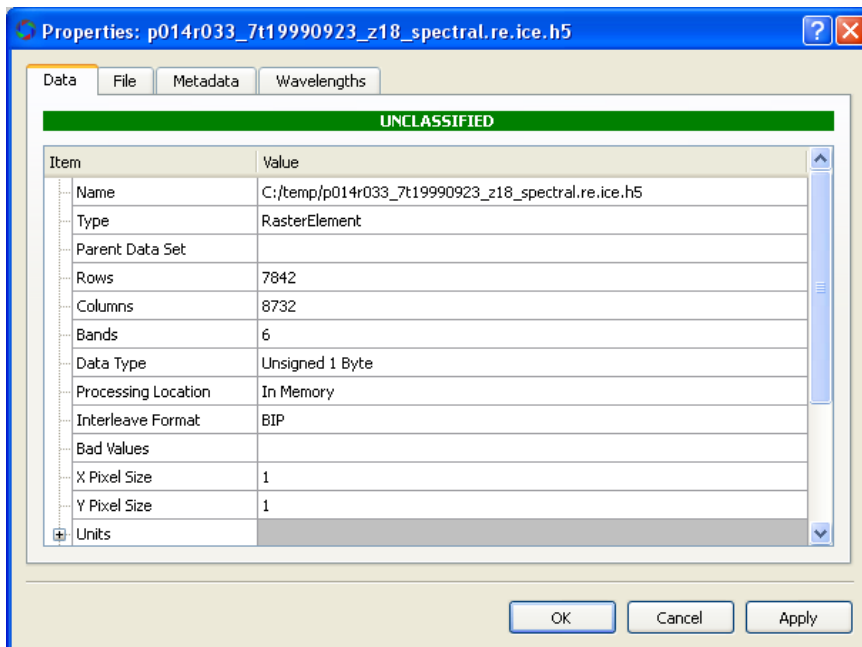
Information about an image can be viewed at the time of import or loading into Opticks or through the Elements Tab in the Session Window.



Refer to the Data Elements Properties in the Opticks Help for additional information.

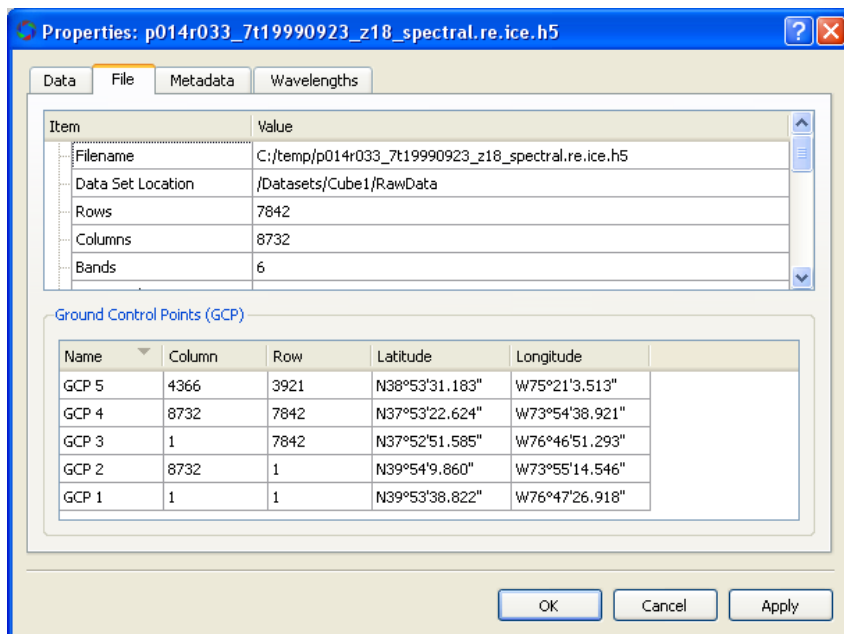
Data Tab

This tab shows the basic information about the image (bands, rows, columns, data type, pixel size, etc.).



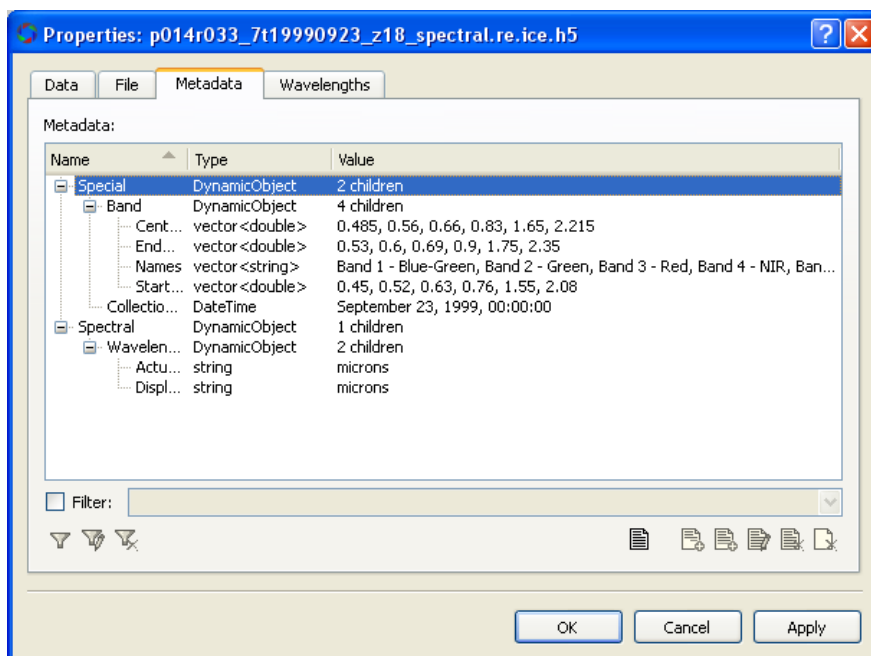
File Tab

This tab also contains much of the same information found in the Data Tab and also contains any ground control points (GCPs) that is used to place the imagery in geographic space.



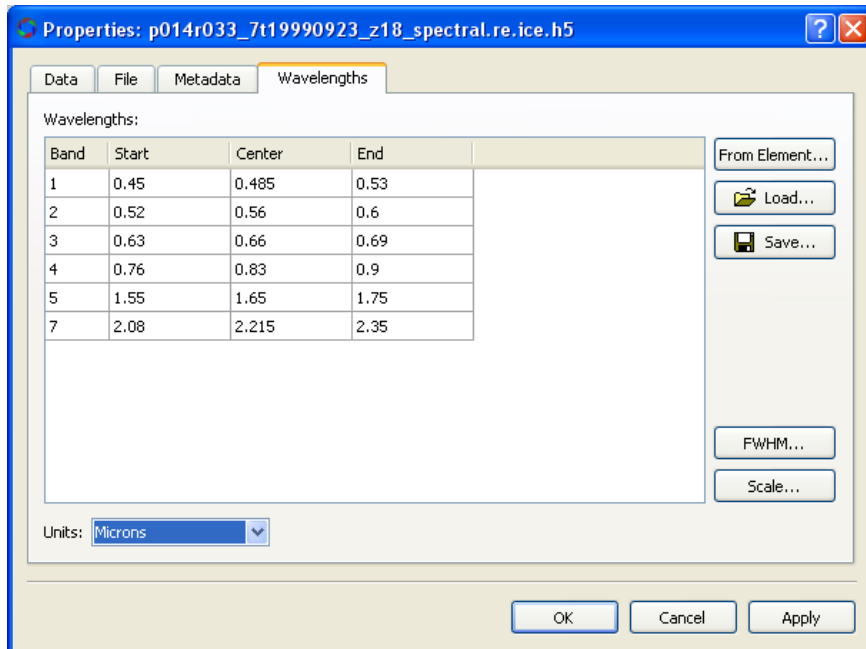
Metadata Tab

The metadata tab provides information about the wavelengths that are used in the current display.



Wavelengths Tab

The wavelengths tab provides information about the specific wavelengths for each band in the full image file. The wavelengths can be displayed in micrson, nanometers, or inverse centimeters.

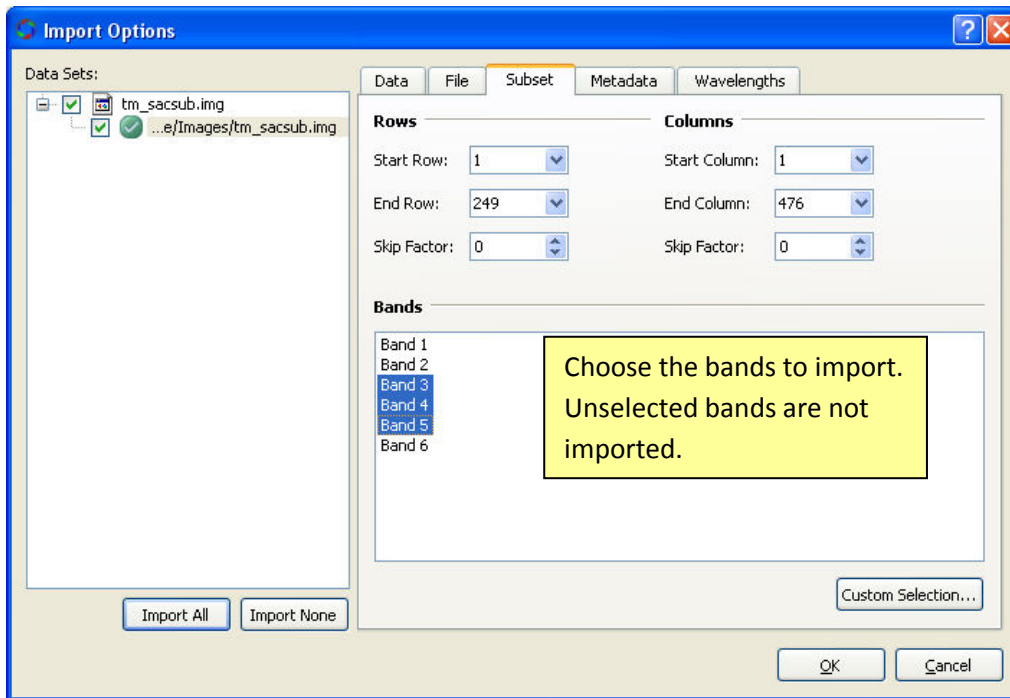
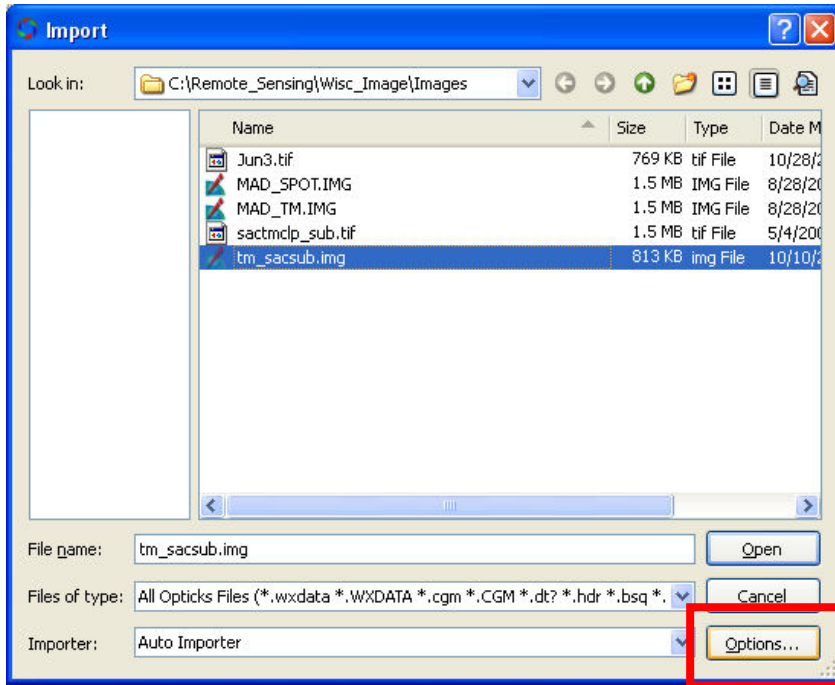


Subset an Image

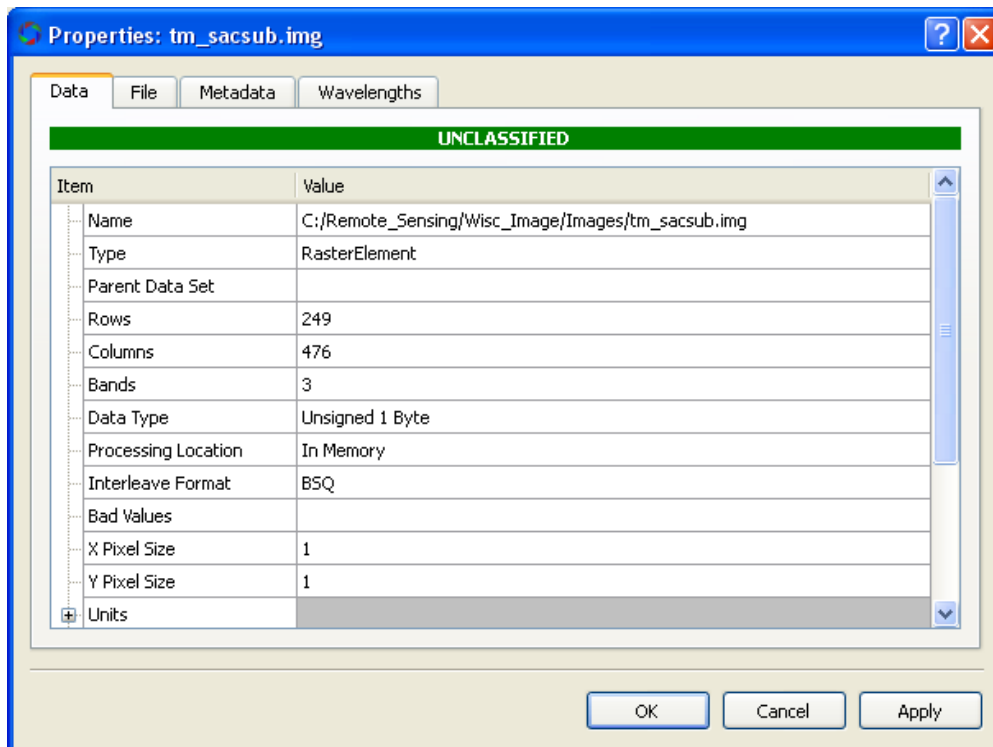
Users may not want to import an entire image into Opticks, especially if the image is very large (> 1 Gb) or if there are a large number of bands and some are known to not contain very useful information (such as hyperspectral data with the water vapor absorption bands removed). Two options are available to limit the number of bands and spatial extent of the image during import. See the Opticks Tutorial on Spectral and Spatial Subset for additional details.

Band Subset

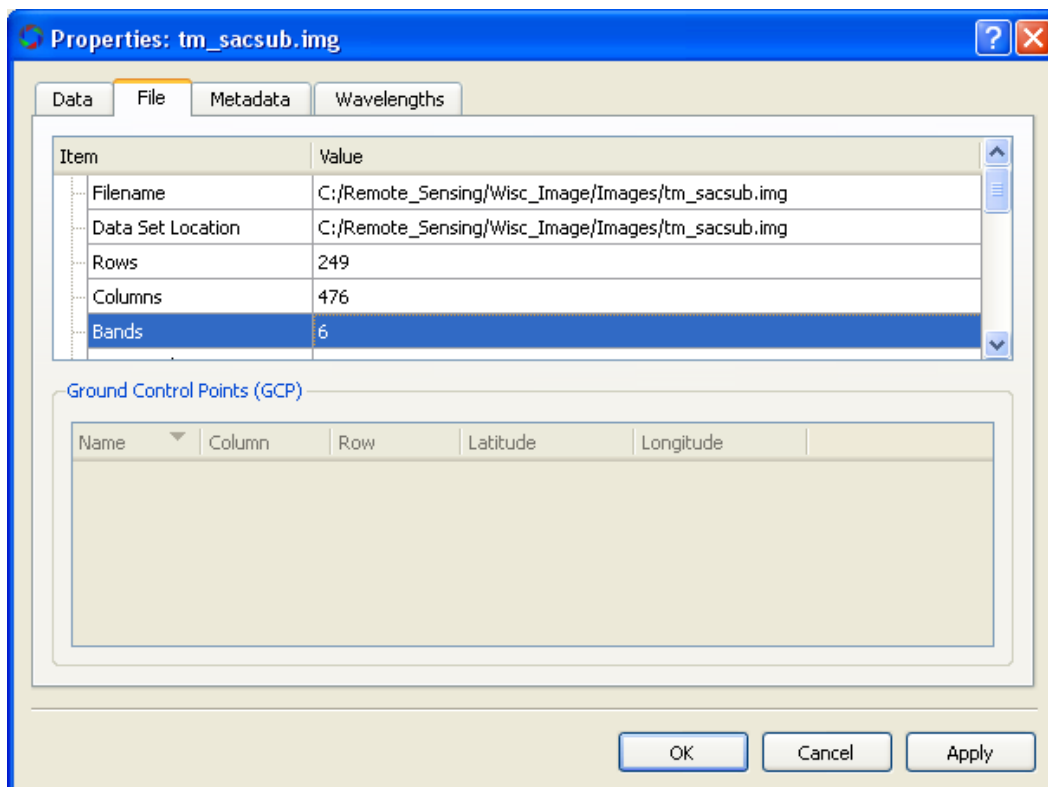
An easy way to subset an image containing a smaller number of bands than the original is to select (or ignore) bands from the input image using the Options button on the Import dialog box.



Notice that the imported image shows 3 bands



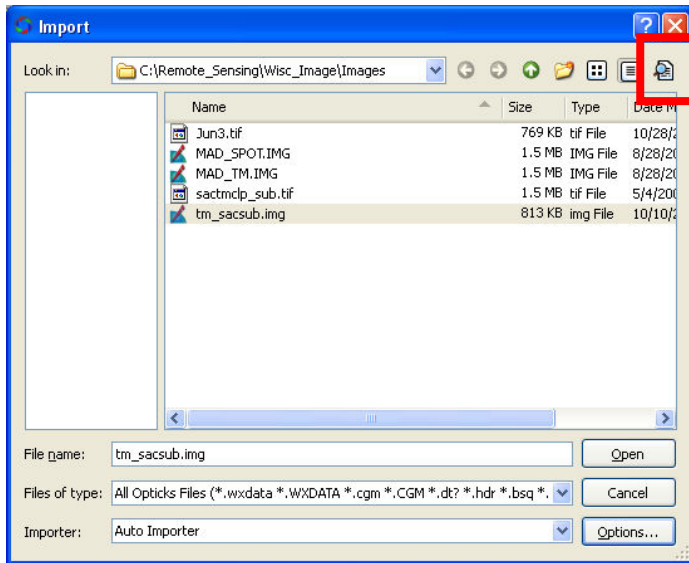
The imported file still indicates 6 bands in the original image file.



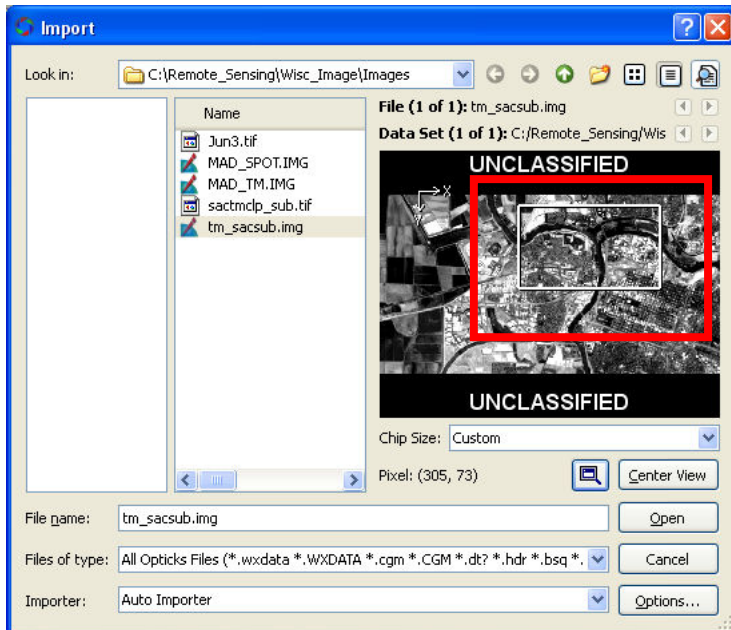
If the remaining defaults are chosen, then the image will display as gray scale. The user can use methods described above to change the band combination and to display the image as RGB (i.e. as a color display).

Spatially Subset Image

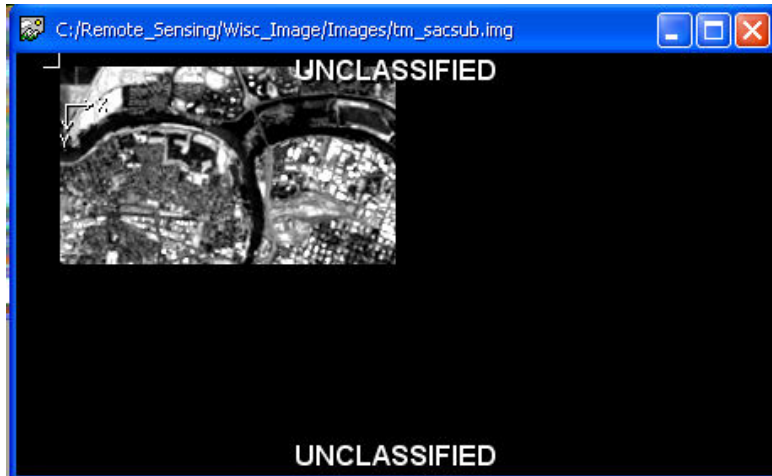
In addition to the above, the user can also limit the spatial extent of the image by using the Preview button in the Import window.



Use the tool provided to select a rectangular area to subset the image by the extent of the rectangle. Using this method in addition to the Band Subset can limit both the number of bands and the spatial extent of the imported image at the same time.



After the image is imported, the following viewer appears with the both the number of bands and the spatial extents reduced.



If the user changes the band combination, the new imported file may look like this.

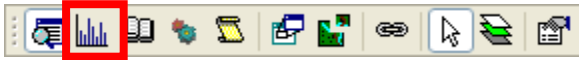


Working with Histograms

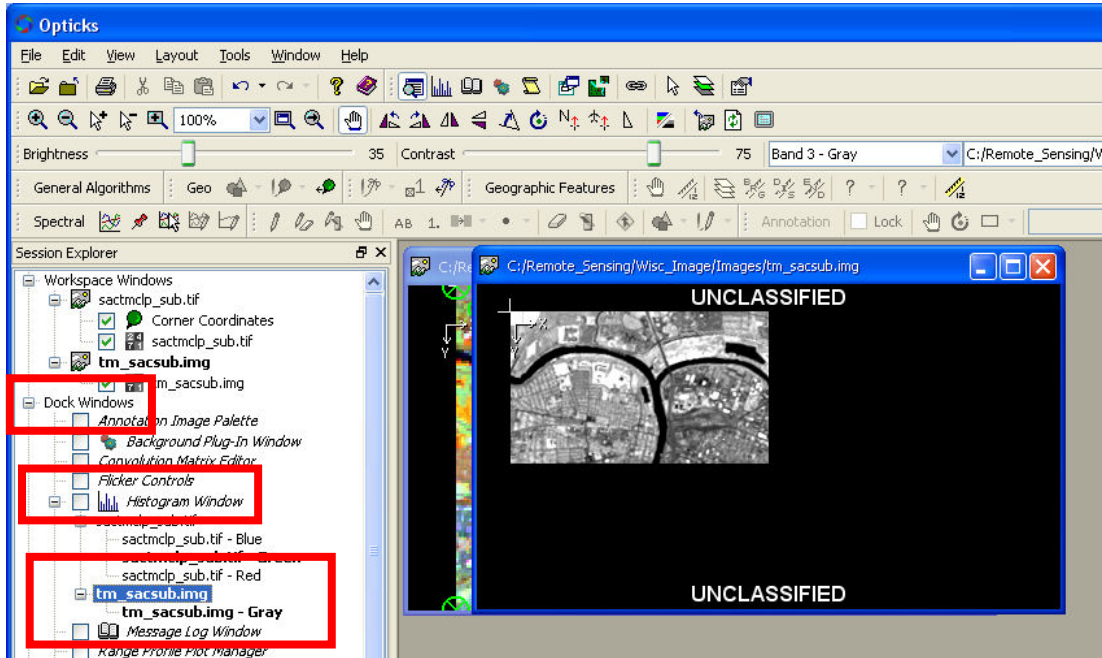
Histograms are graphical representations of data. In the case of remotely sensed imagery histograms represent the distribution of pixel values for a given spectral band. Opticks can display histograms for spectral bands. The values along the X axis may represent the brightness range (intensity levels) of an image and the Y axis represents the total count for a given brightness value. For more information see the **Opticks Help under Opticks Studio—Working with Opticks Windows—Histogram Window**.

Viewing a Histogram

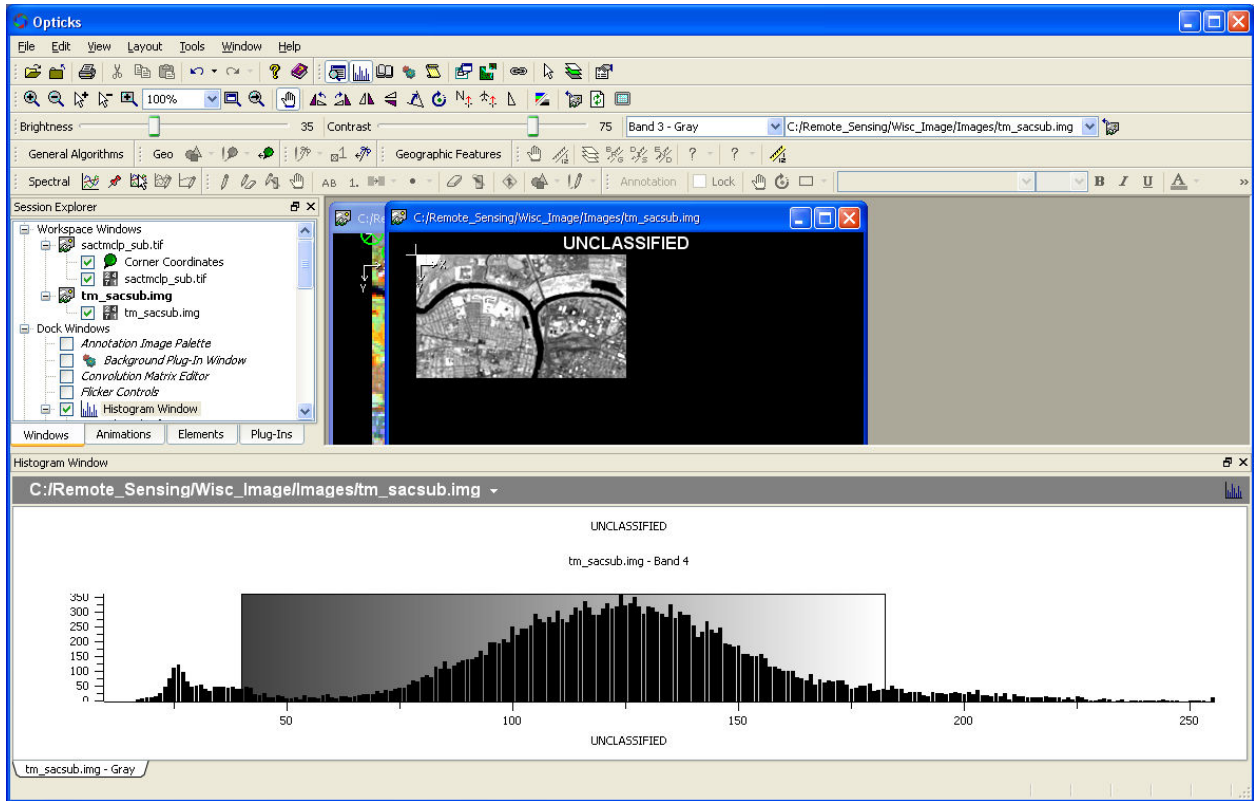
To view the histogram for a band of the active image viewer, click on the Histogram tool on the Toolbox toolbar.



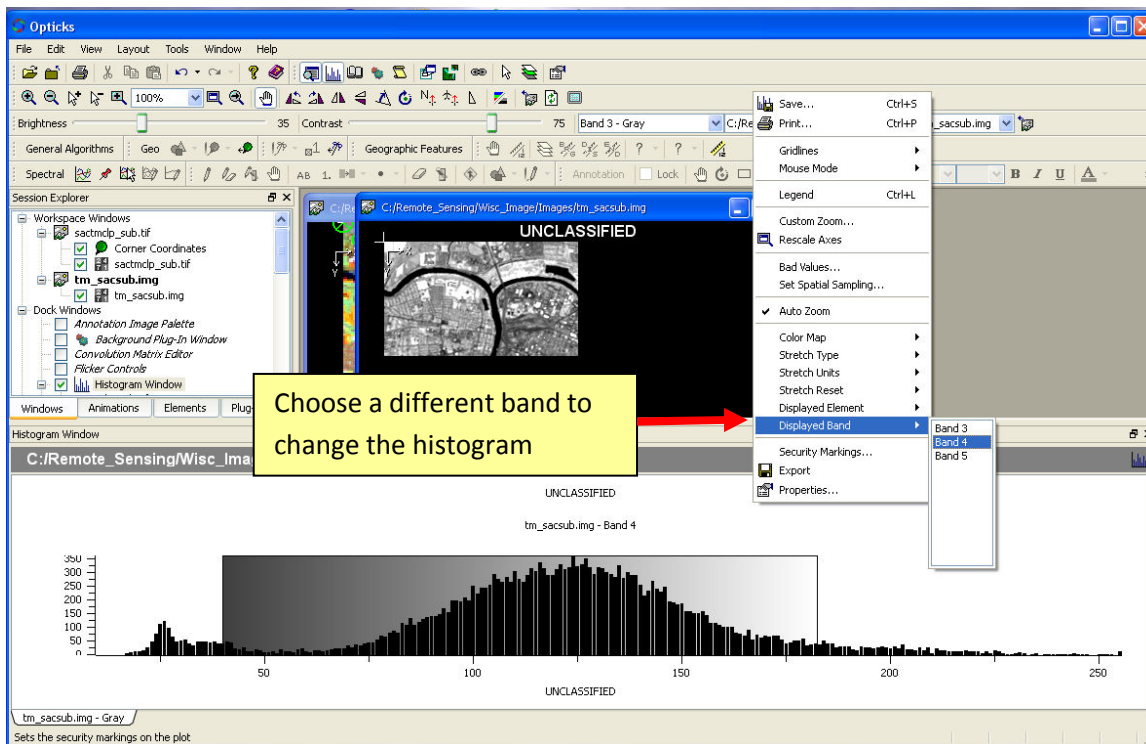
Alternatively, the user can expand the Dock Windows element under the Session Explorer, and then expand the respective image. Check the box for the Histogram Window to display the histogram for the active image.



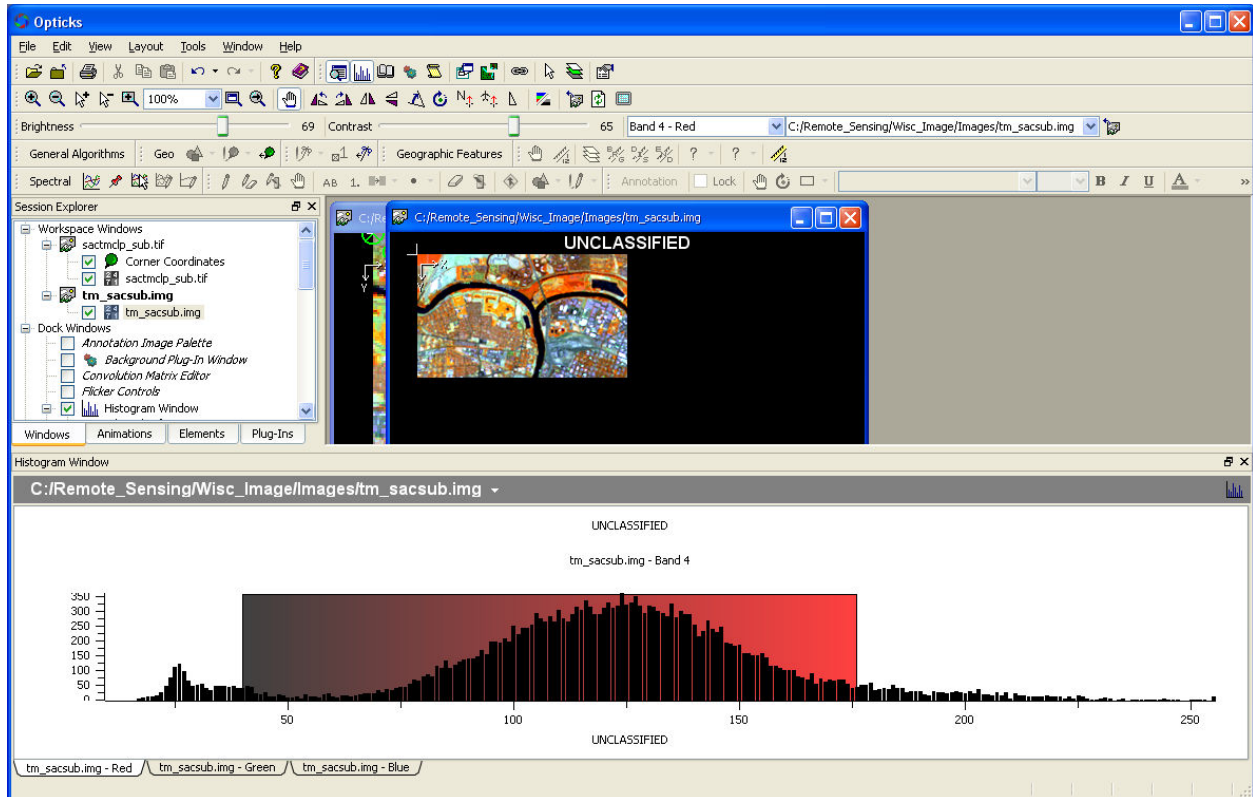
The Histogram tools loads a graphic display for one or more of the bands in the active image. If the user has only a gray scale image displayed a single histogram shows up like this.



If the image is a multiband image the user can right click in the Histogram Window and choose the Displayed Band. Select a different band to change the histogram.



If a multiband image is displayed as color a histogram is displayed like this.



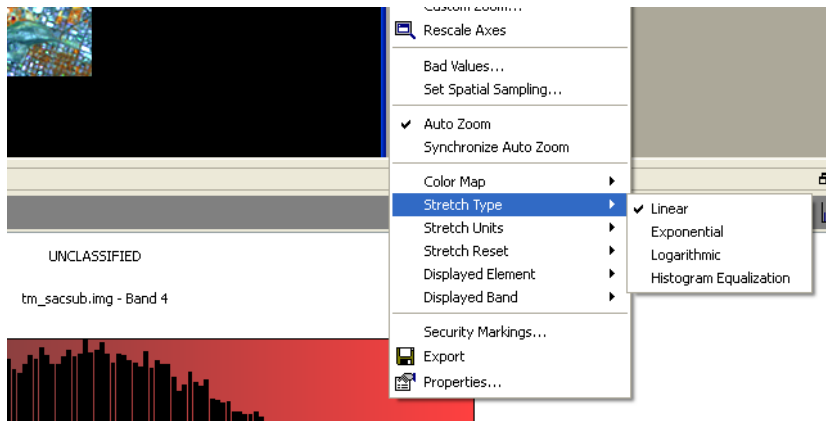
Notice the three tabs at the bottom of the histogram indicating the Red, Green, and Blue bands. When each color tab is clicked, the respective histogram is displayed. Notice the Band number at the top of the Histogram Window. Users can change the band assignment for a given color by right clicking in the Histogram Window and change the Displayed Band as described above. The displayed window will also change.

Changing the Contrast

Users can also change the stretch of the active image by left-clicking (or left-click hold and drag) on the left or right side of the colored area in the Histogram Window. The image will change in contrast.

Changing the Image Stretch

Different kinds of image stretches can also be applied to the image by using the Histogram Window. Applying an image stretch to an image can enhance different areas within an image. A typical image stretch for remotely sensed image is a two standard deviation stretch following a linear function. Different types of image stretches and units can be used per band while using the Histogram Window. Right-click in the Histogram window to access these options.



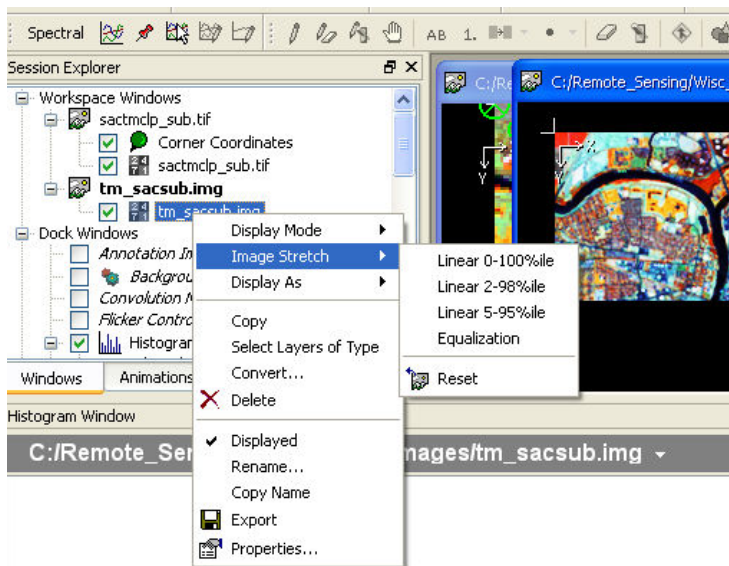
Linear – typically the default stretch and follows a linear function. The data is stretched in a linear fashion from low values to high values and tends to apply a stretch evenly across the image.

Exponential – follows an exponential curve. This stretch tends to suppress darker areas and enhance brighter areas.

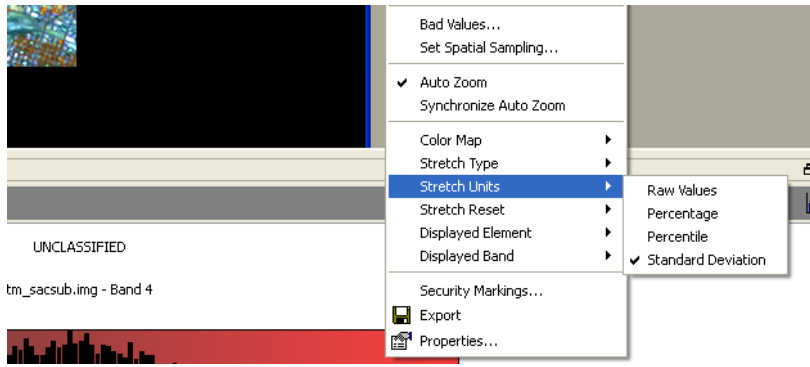
Logarithmic – follows a logarithmic curve. This stretch tends to suppress brighter values and enhance darker values.

Histogram Equalization – this stretch attempts to place an equal number of pixels to a specific number of spectral categories across the brightness range. The effect of this stretch tends to make the brighter areas just a little brighter and the darker areas just a little darker. The brighter areas can look a little more washed out.

An image stretch can also be changed by right-clicking on the image file in the Session Explorer.



The stretch units can also be changed.



Hyperspectral Processing with Opticks

Overview

Processing hyperspectral imagery is usually an involved process and often requires a number of preprocessing steps before any image analysis (usually material identification) can take place. Opticks uses the Spectral Processing Tools to accomplish these tasks. See Appendix XX for specific details of this tool set. The hyperspectral processing section describes some of the basic tasks an analyst usually implements to conduct material identification.

Hyperspectral imagery is becoming more available and affordable for organizations. Since hyperspectral usually requires special skills in image acquisition, identifying physical, chemical, and geographic properties of materials, and strong skills in image interpretation and analysis, image analysts usually need additional education and training. Opticks provides a strong overview of the tasks and is continuing to develop functionality for spectral signature analysis and processing.

Opticks offers the following hyperspectral image processing capability which primarily uses the Spectral Processing tools and algorithms, including the Signature Window and the AOI tools (to assist with some of the signature and preprocessing tasks).

1. Preprocessing
 - a. Bad Band Identification – Minimum Noise Fraction
 - b. Atmospheric Correction – Empirical Line Method and Internal Average Relative Reflectance
2. Material Identification - Constrained Energy Minimization and Spectral Angle Mapper

Future releases of Opticks expect to have some additional Signature Library comparison capability.

Sample Imagery

The sample image used in this tutorial is from NASA's AVIRIS airborne sensor (<http://aviris.jpl.nasa.gov>) and SpecTIR, an airborne hyperspectral sensor operated by the SpecTIR company, www.spectir.com. The Spectral sample imagery is from the Suwannee National Wildlife Refuge collected just before oil from the Deep Water Horizon came ashore. See the website above to download the imagery. The sensor collects 360 specific wavelengths between 400 and 2500 nm with a single "band" representing ~ 5 nm width/band. The SpecTIR image can only be used for training and evaluation. Contact SpecTIR for additional limitations and additional sample data. The AVIRIS imagery can be obtained through NASA or Opticks at <http://opticks.org>.

NOTE: It is recommended to use subsets of data to work through the development of the image processing steps and parameters (such as threshold values, etc).

Pre-requisite

Make sure to load the Spectral Processing Extension. See Appendix A for more information and a discussion of the tools and algorithms.

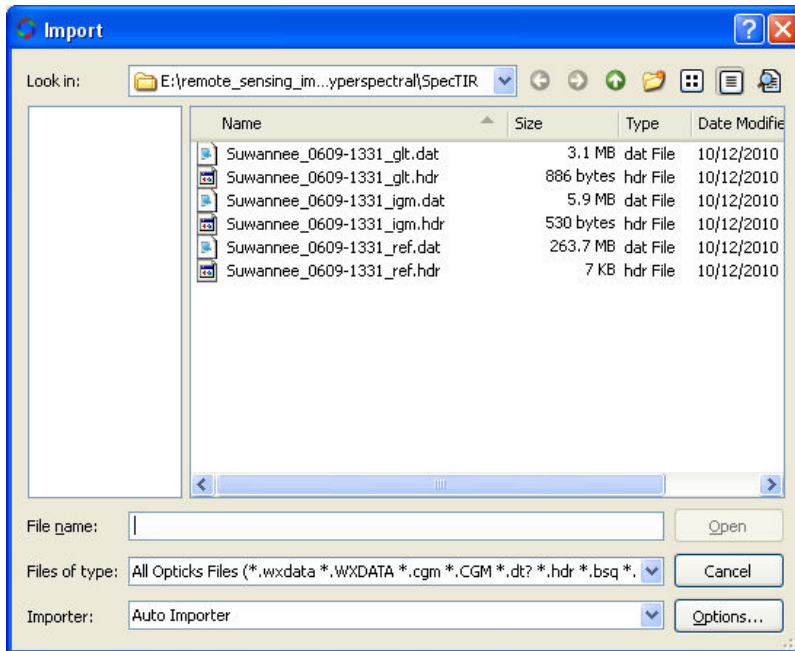
Load the Hyperspectral Image

Several options can be chosen as part of loading an image into Opticks. In the case of an ENVI or Opticks (ICE) format image, wavelength data can be directly associated with the imagery. Since so many bands exist with hyperspectral data, a couple of options exist for providing some default band display (NIR, SWIR, RGB, etc). In addition, to reduce the quantity of data loaded into memory, the analyst can choose to subset the image (virtually) by drawing a box around a portion of the full image (Spatial Subset). Also, since some hyperspectral data may have “bad bands” represented by a “salt and pepper” effect, the user can choose to ignore these bands, provided they are known before loading the image. In some cases, some general image review is needed to determine how the hyperspectral data can best be loaded. Once an Opticks Session is saved, these settings are loaded when the analyst opens the saved session.

The Suwannee-0609-1331.hdr (and .DAT file) is used in this tutorial. The imagery can be downloaded from www.spectir.com or from a local network. For the American River College Ethan Way Lab, this image can be found here:

N:\geog 342\imagery\hyperspectral\spectir

Use the Import data (folder or tool from the File menu). Change the path to the location of the image data.

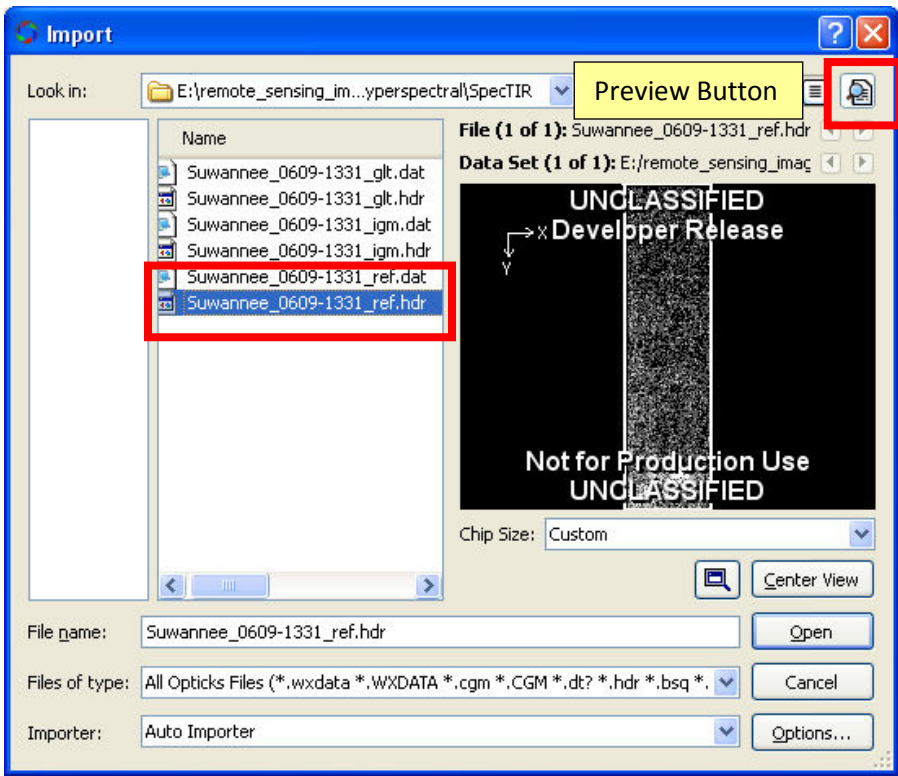



A number of files exist for the Suwannee image. Choose the **Suwannee_0609-1331_ref.hdr** file. The **.hdr** file is a header file that contains the bands, rows, and columns information for the image. The actual image has the **.dat** extension (notice the file size is much larger).

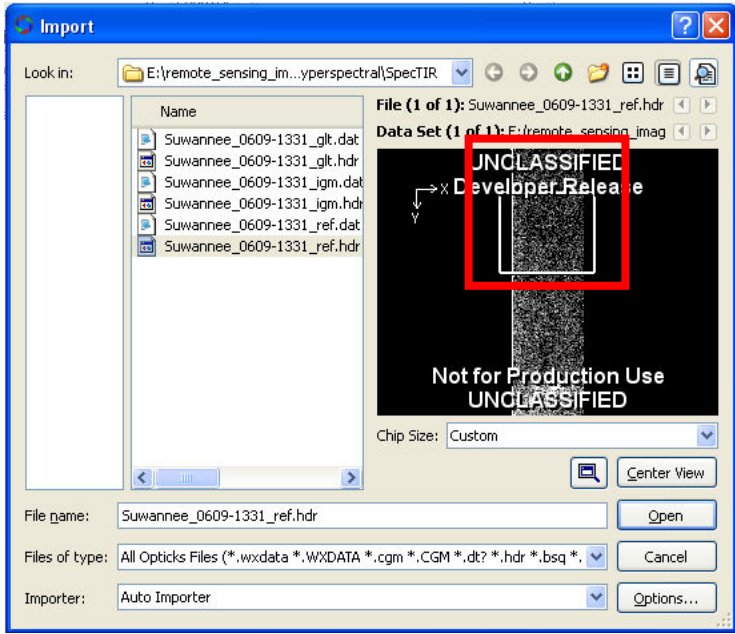
Spatial Subset (Optional)

Since hyperspectral imagery is typically quite large, the user can “subset” the imagery to a smaller geographic extent. For this tutorial, the user will subset the imagery for extra practice.

The user can use the “preview” tool to bring up a preview image of the scene. The Zoom by Extent tool can be used to select a subset of the larger image to view in Opticks. The spatial subset only loads the selected area of the image into Opticks. If the user wants to save this subset, follow the procedure below.



Zoom to an area of interest. When the cursor is placed in the preview area, the cursor will look like the zoom to extent tool .



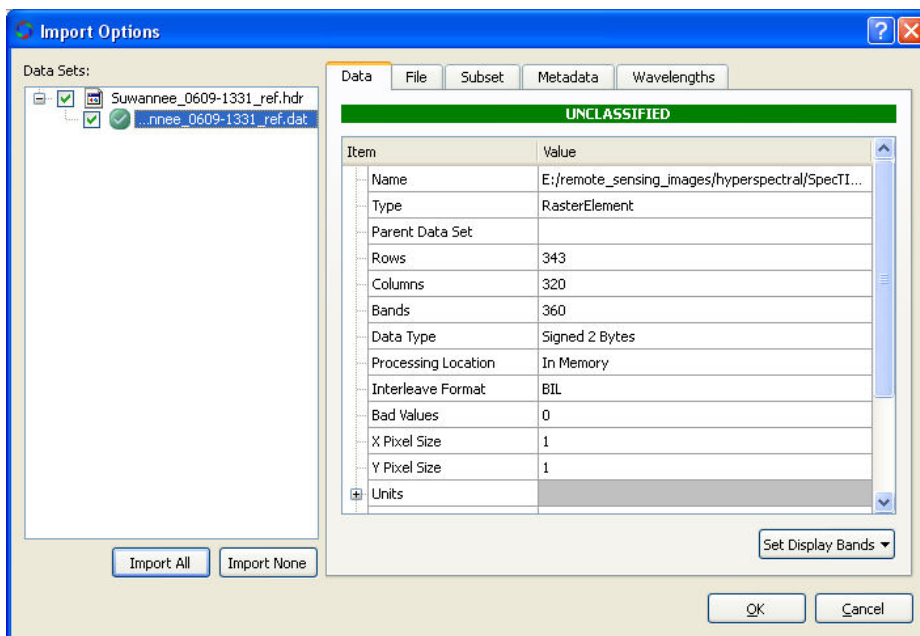
The image will zoom to this extent.

Review the Image Information

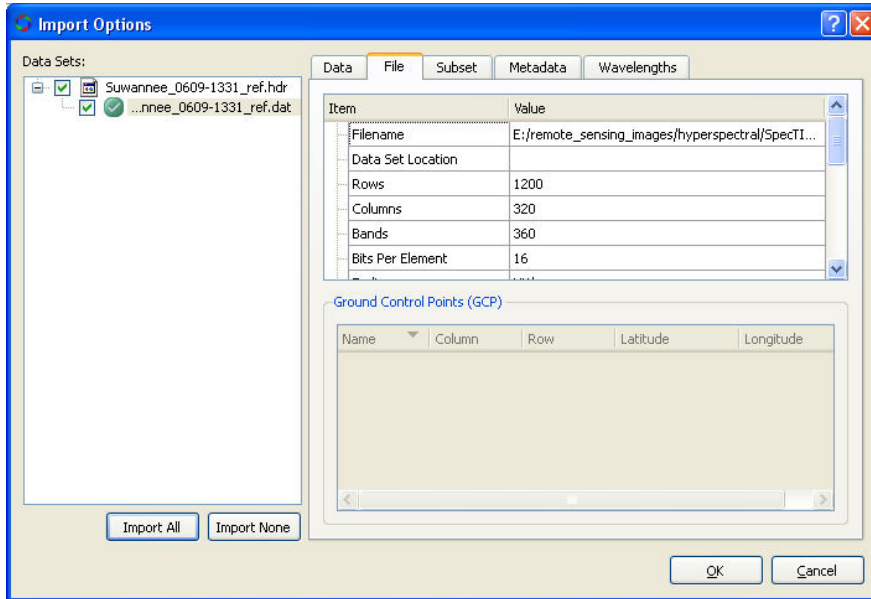
Image analysts should review the image data before using it. Opticks provides a number of tabs that provide an overview of image characteristics such as rows, columns, bands, wavelengths, etc. Use the following options to review the imagery before opening in Opticks.

1. Click Options
2. Click on each of the tabs to review the information about the image.

Data Tab

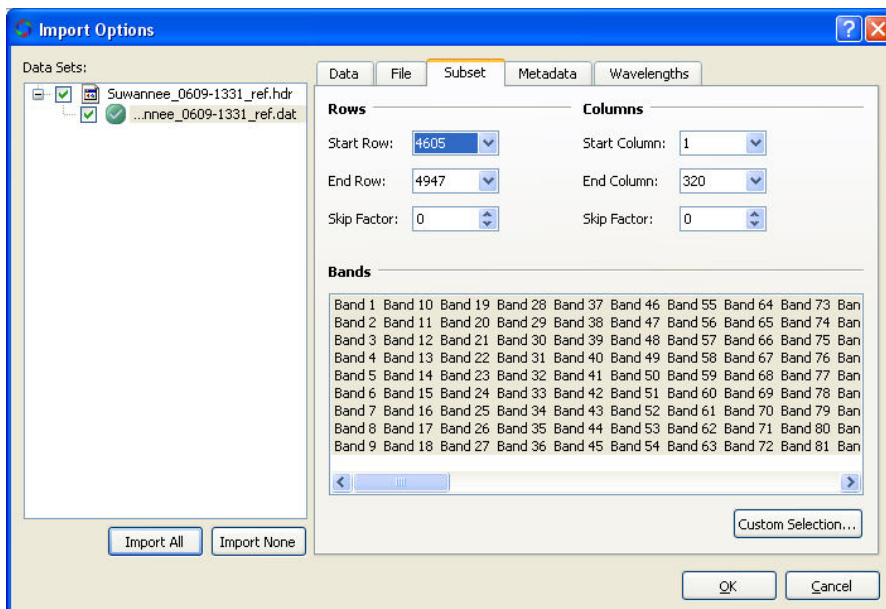


File Tab

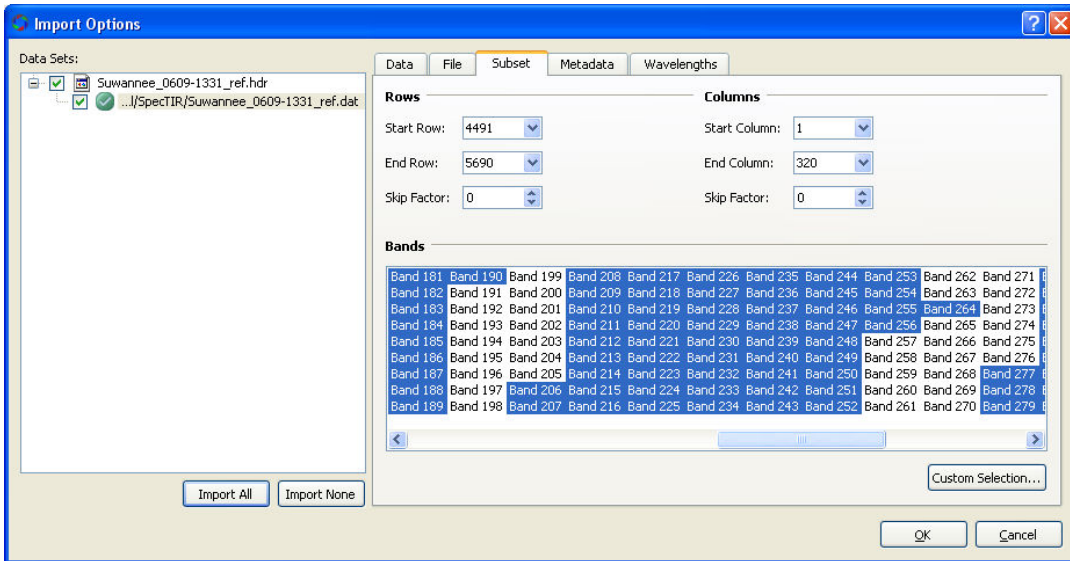


Subset Tab

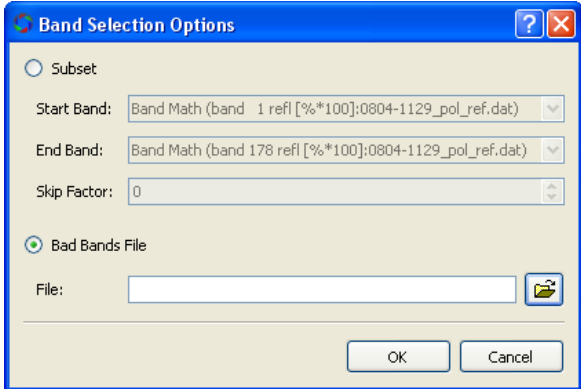
This tab provides information about the area chosen in the Spatial Subset if an area was chosen. In addition, if bands were “ignored” they will show up as “not highlighted” in the subset tab.



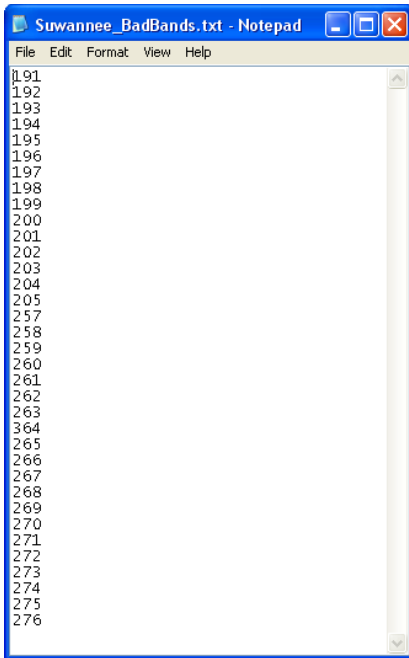
Bands not loaded are not highlighted. This is optional.



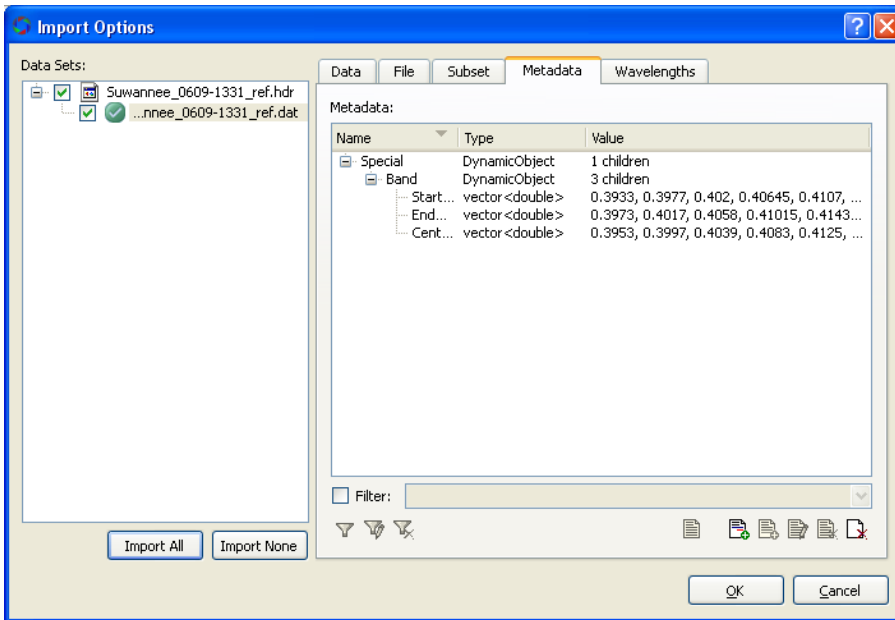
Click on Custom Selection to load a text file that contains a list of “bad bands.” This might be helpful to create if a number of images required these bands to be removed. In some cases, the “bad bands” may correlate to specific wavelengths of the spectrum such as water or carbon dioxide absorption. In the case of SpecTIR imagery, the company has developed methods to maintain as much of the original data as possible while keeping the quality of the image data high. In most cases, end users do not need to remove “bad bands.”



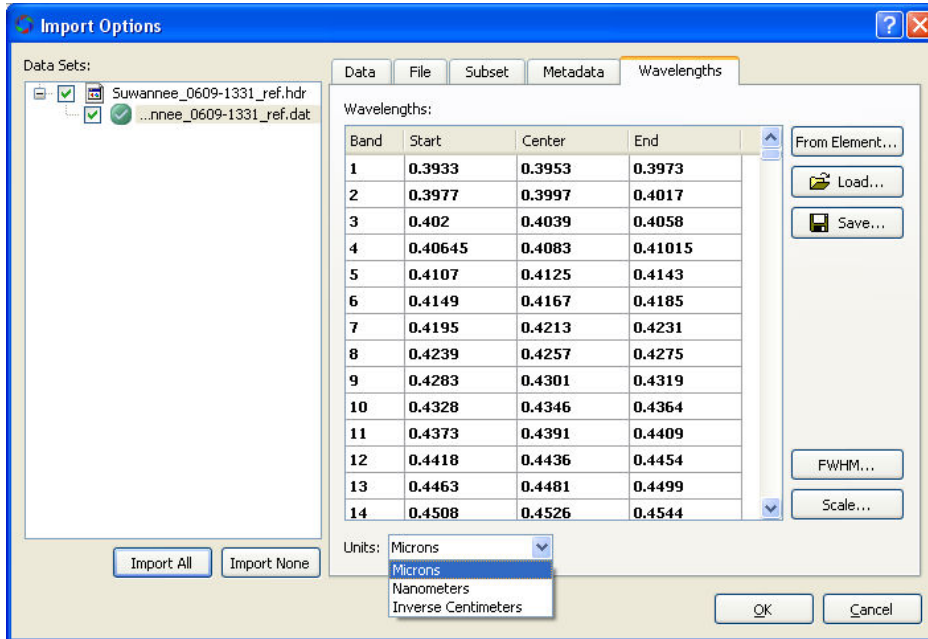
Load the text file.



Metadata Tab



Wavelengths



Notice that by changing the units of Microns, Nanometers, or Inverse Centimeters. Most of the time units will be microns or nanometers.

Load Wavelengths from File (Optional)

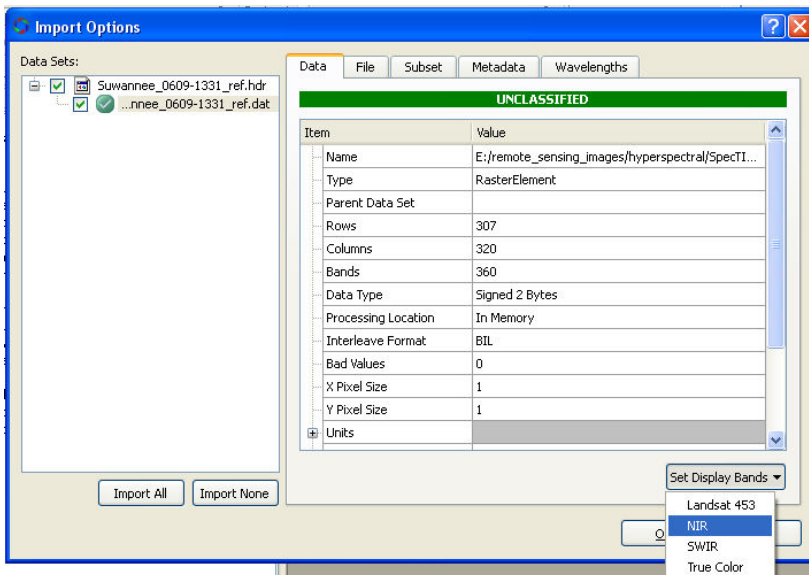
Optionally, if an image does not have wavelength values by default, a text file can be created that contains the information above. Two formats are possible: 1) WMD – wave metadata file (ENVI format) and 2) .wave (.wav or .wave) which is a plain ascii format. As an example for the .wav format, the following was created for an AVIRIS image which has 224 bands.

A text file was created with the following information obtained from http://www.csr.utexas.edu/rs/sensors/spectral_94_all.ascii. Some minor modifications were performed in Excel and then exported out to a generic comma delimited text file. The following format is required to properly load into Opticks. NOTE: These are approximate values for an AVIRIS image file. Ideally, validated wavelengths values from the image source will be obtained.

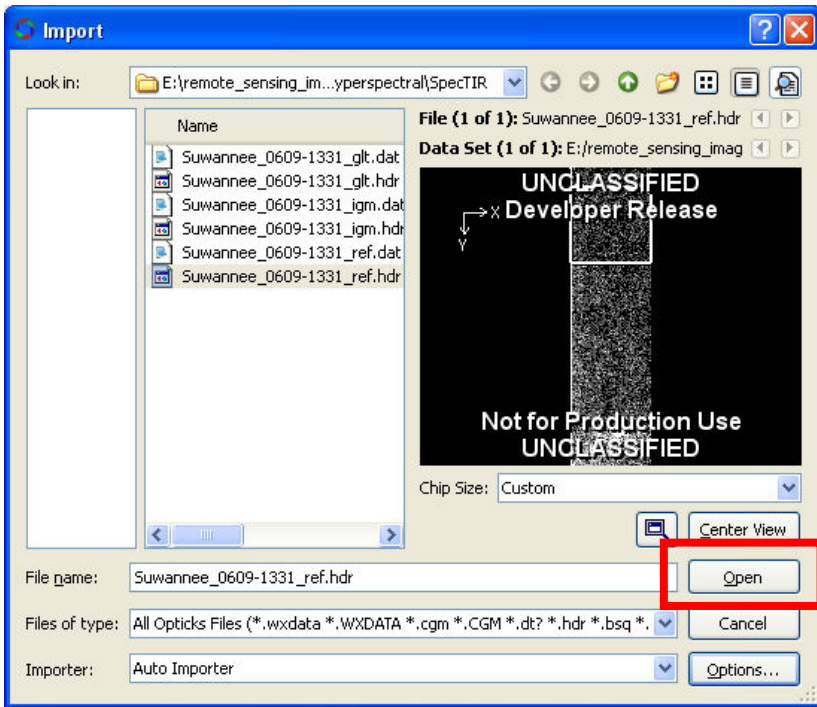
Line	Band 1	Band 2	Band 3	Band 4
1	378.304993	383.149994	387.994995	
2	387.989895	392.839996	397.690025	
3	397.6850135	402.540009	407.3950045	
4	407.3849945	412.25	417.1150055	
5	417.115021	421.980011	426.845001	
6	426.834991	431.709991	436.584991	
7	436.579986	441.459991	446.339996	
8	446.3350065	451.220001	456.1049955	
9	456.10498	460.98999	465.875	
10	465.865021	470.76001	475.654999	
11	475.654984	480.549988	485.444992	
12	485.4399865	490.339996	495.2400055	
13	495.2350165	500.140015	505.0450135	
14	505.045013	509.950012	514.855011	
15	514.8500065	519.76001	524.6700135	
16	524.6700135	529.580017	534.4900205	
17	534.485046	539.400024	544.315002	
18	544.3099665	549.22998	554.1499935	
19	554.1549985	559.070007	563.9850155	
20	563.980041	568.900024	573.820007	
21	573.8199765	578.73999	583.6600035	
22	583.655029	588.580017	593.505005	

This text file can be loaded into the Wavelength tab by choosing Load from above and finding the specific wavelength file.

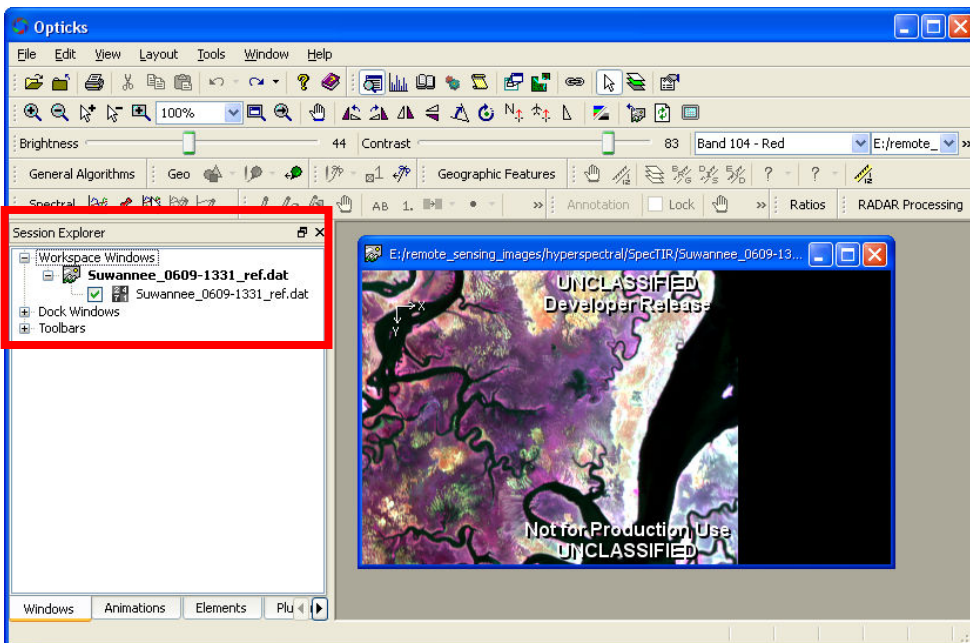
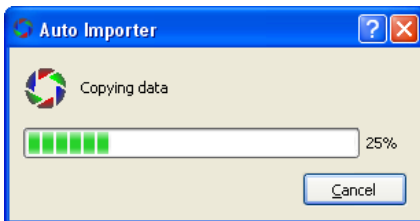
3. Click back on the Data Tab.
4. Click the Set Display Bands. The user can choose a default band combination. NIR (Near Infrared) is provided by Opticks. Although SWIR (short wave infrared) is provided by Opticks, it may not work for all image data sets. The Landsat 453 is a custom band combination created and stored by the user. See the Customizing Opticks Options for more information.
5. Choose NIR. Click OK.



6. Click Open from the Import dialog box.



The image begins to load.



7. Click on the Workspace Windows from the Session Explorer to see that the **.DAT** file is loaded.

Remove Bad Data (Minimum Noise Fraction)

Under Development. Future Updates will have this section documented. Check [www.jenningsplanet](http://www.jenningsplanet.com) (Training and Tutorials) for future updates.

Atmospheric Correction

Two algorithms exist in Opticks for performing atmospheric correction. Since objects reflect energy back to the sensor, some of it interacts with water vapor and other gases, thus preventing the sensor of capturing the “actual” surface reflectance of the object. Atmospheric correction can accommodate for some of these effects. Opticks provides two methods for performing atmospheric correction.

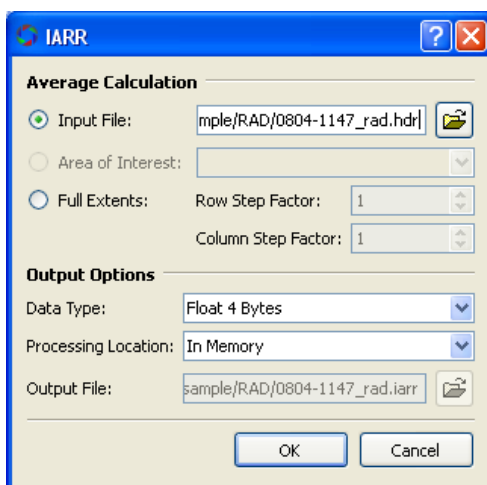
Empirical Line Method (ELM)

Under Development. Future Updates will have this section documented. Check [www.jenningsplanet](http://www.jenningsplanet.com) (Training and Tutorials) for future updates.

Internal Average Relative Reflectance (IARR)

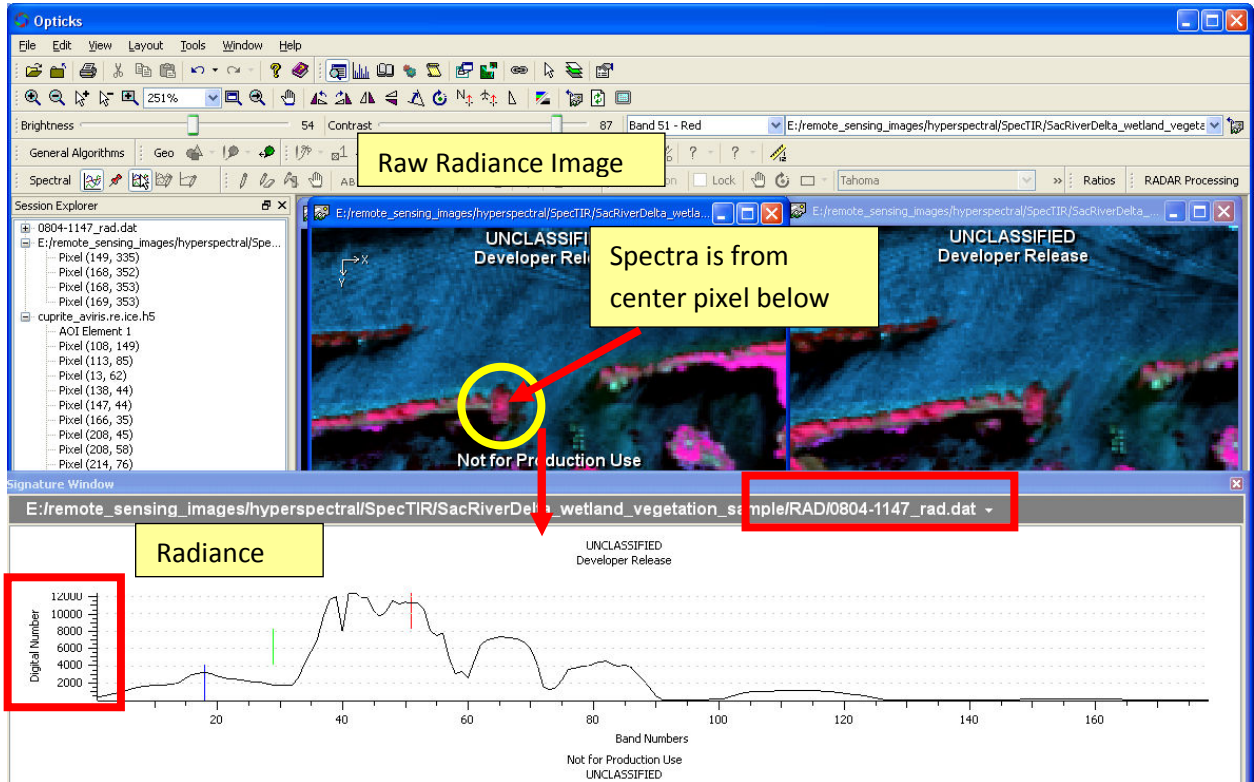
The IARR method uses an overall average of radiance values that can be applied to all of the image bands. This method does not require any field measurements or bright and dark pixel assignments. This method is not considered very robust and is mostly useful for areas that have little or no vegetation.

Use a radiance file for the input image. Typically the defaults can be accepted. An output **.IARR** file will be generated that stores the output reflectance file. This file can then be used for subsequent material identification.

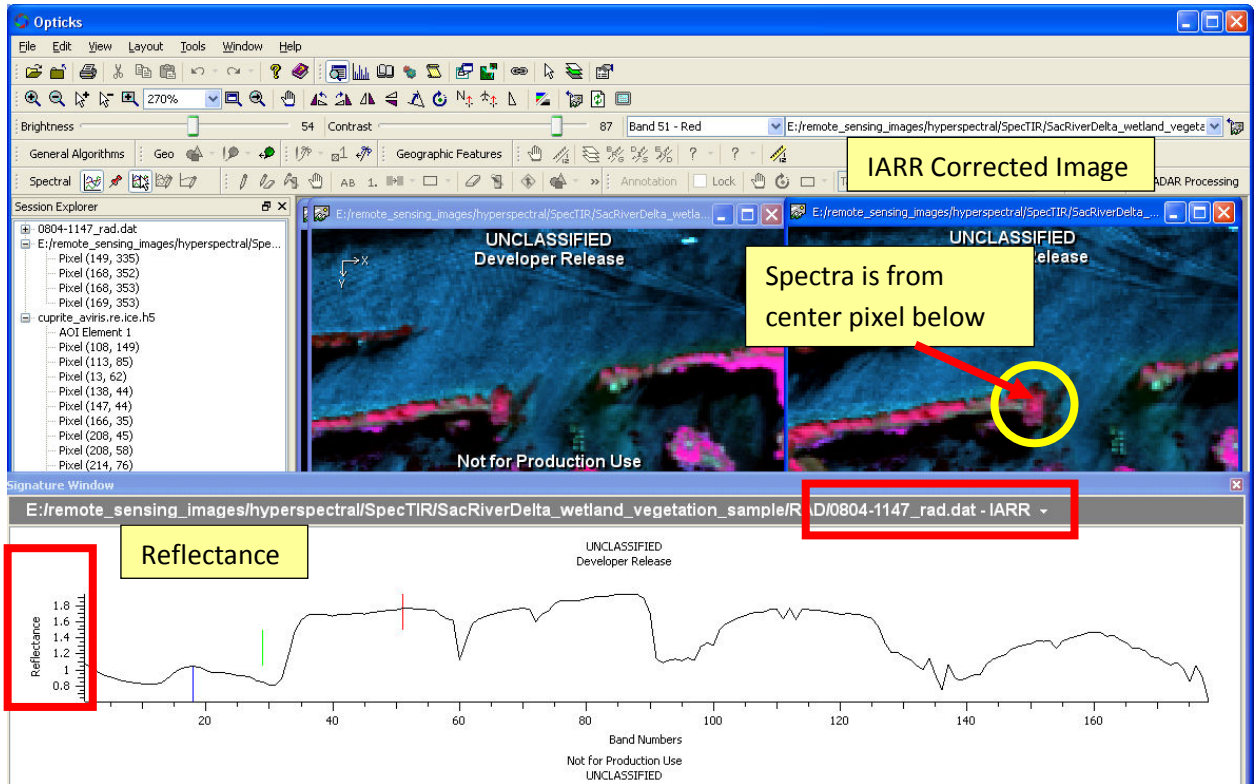


Once the IARR file is generated, the analyst can compare radiance and reflectance values from the two different images. The Display Pixel Signature Tool can be used from the Spectral Toolbar to evaluate image spectra from different locations throughout the radiance and reflectance image.

Uncorrected Radiance Image



IARR Image Corrected for Atmospheric Effects



Material Identification

After the various corrections are complete, the hyperspectral imagery is ready for use primarily to detect the geographic occurrence of different kinds of materials such as specific vegetation types, minerals, geologic features, contaminants, etc.

The hyperspectral imagery should have wavelength information available. If the image does not load the wavelength values by default, see the Spectral Processing Extension (see Wavelengths) below to learn how to generate a file that can be used to with the image data. The image needs to be loaded into an Opticks Viewer.

Two material identification methods are available in Opticks: 1) Constrained Energy Minimization and 2) Spectral Angle Mapper. The process below shows the process an analyst needs to perform to conduct a material identification. The image below is for demonstration purposes only.

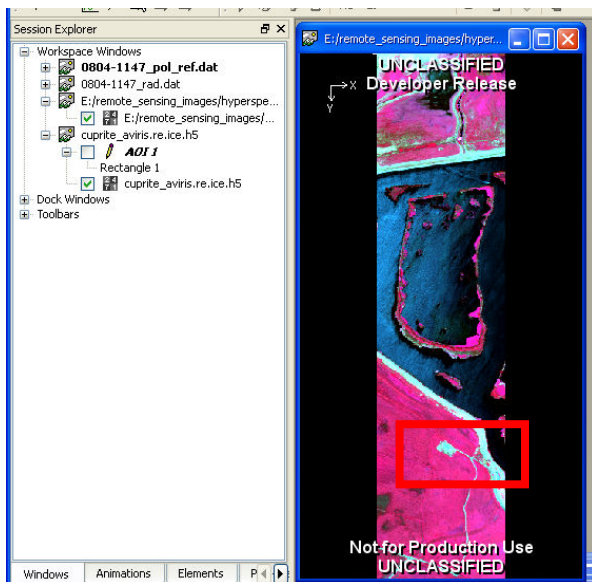
Before using either algorithm, a pixel or area of interest must be selected for evaluation.

Constrained Energy Minimization

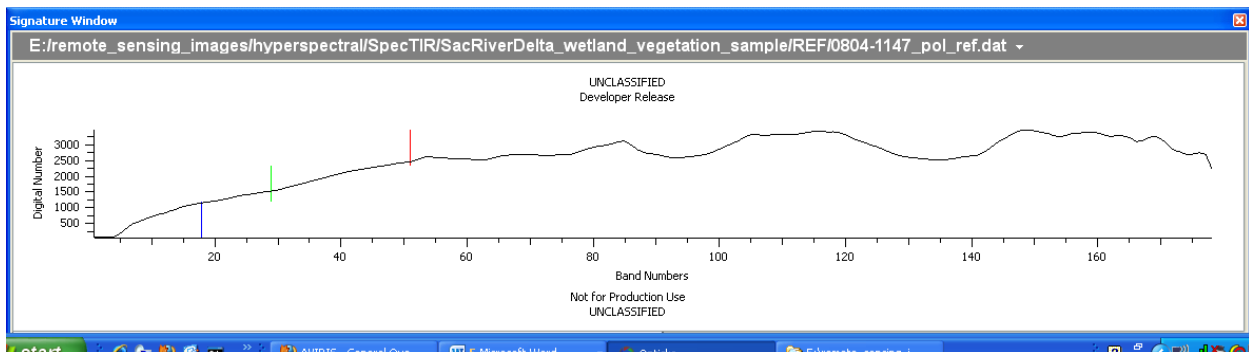
Under Development. Future Updates will have this section documented. Check www.jenningsplanet.com (Training and Tutorials) for future updates.

Spectral Angle Mapper

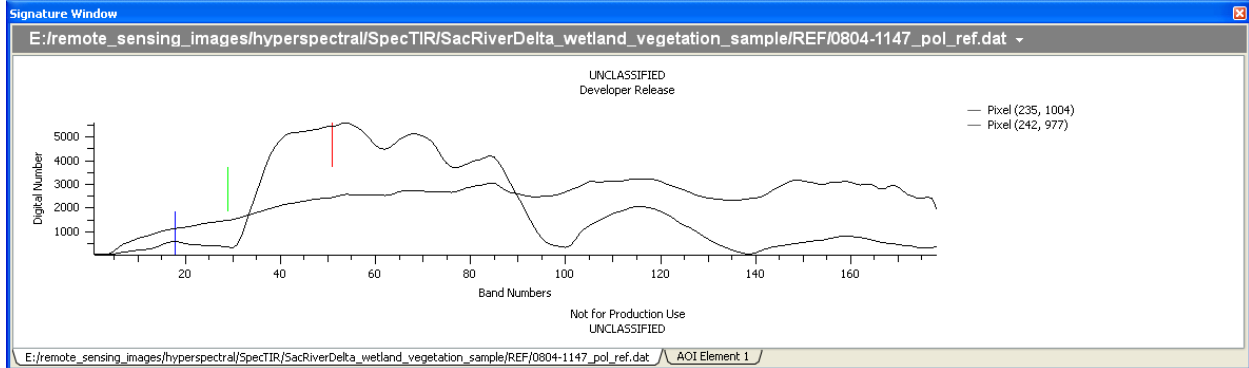
1. Zoom to an area of interest in the image.
2. Use the Display Pixel Signature tool or use the AOI tools to generate an AOI and then generate a spectral signature from it. For example, the image can be zoomed to the area shown in red, then the Display Pixel Signature tool can be used to select a pixel to generate a spectral curve shown below.



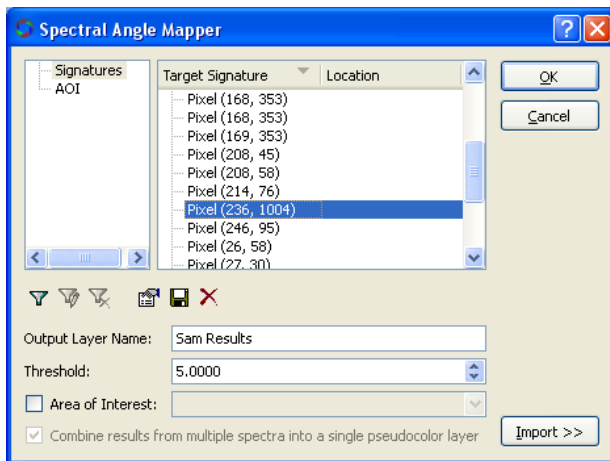
For example, click on a pixel (**236, 1004**) in the above image to bring up a spectral curve for the selected pixel. Look in the lower right to see the row and column of the cursor. Note the pixel row and column; it will be needed in the next step to run the Spectral Angle Mapper algorithm. Alternatively, the user can show the legend in the signature window (Right click in the Signature Window—Legend) to show the row and column of each spectral signature.



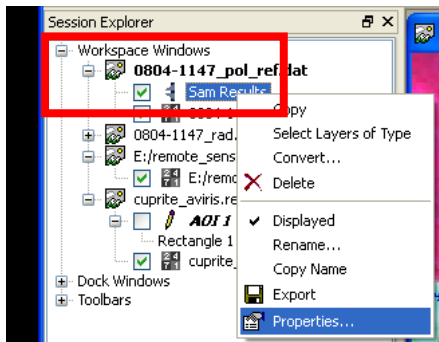
Signature Window with Legend shown.

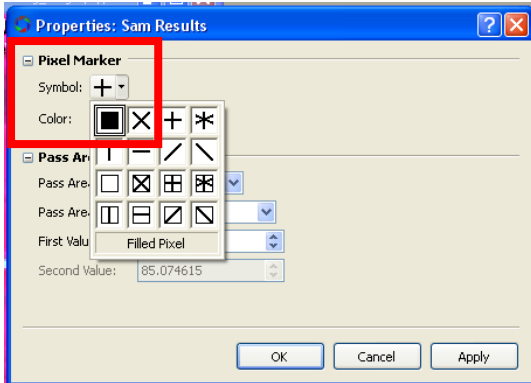


3. Click on the Spectral Toolbar—Material ID—SAM.
4. Choose the pixel above from the Signature list.

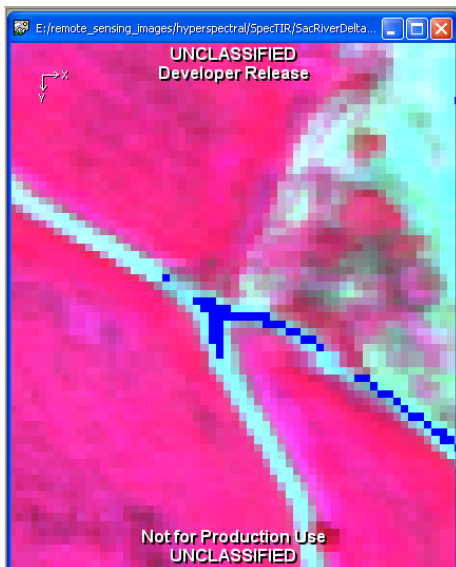


5. Click OK. If the identified pixels look like little "+", right click on the SAM Results and select properties and change the marker to a filled in square. Change the color if desired.



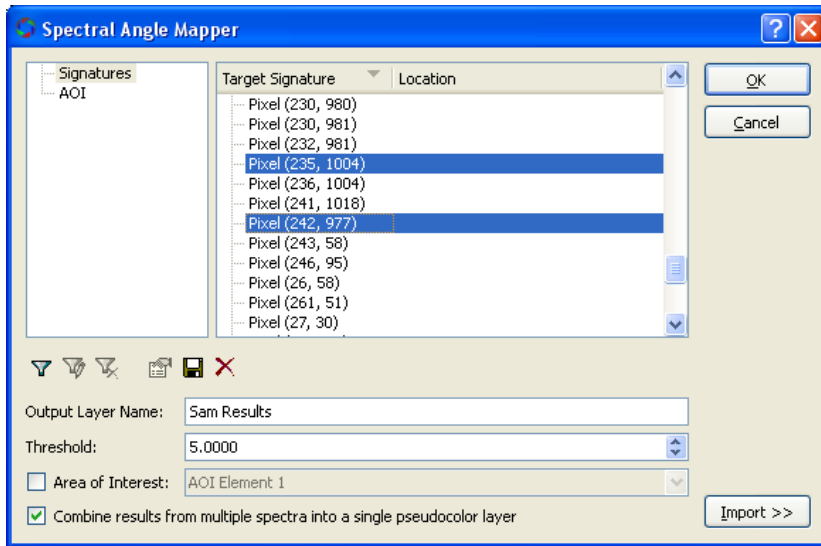


The results of the SAM algorithm are shown below for the local area where the pixel was chosen. Zoom out and pan around to see the geographic extent of the SAM results.

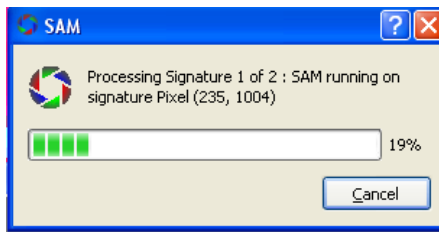


To process more than one material type at a time, select different cover types to identify in the image using the Display Signature tool. Multiple spectral curves will appear in the Signature Window. See the example Signature Window above. Click on the Spectral Tools—Material ID – SAM to identify the material.

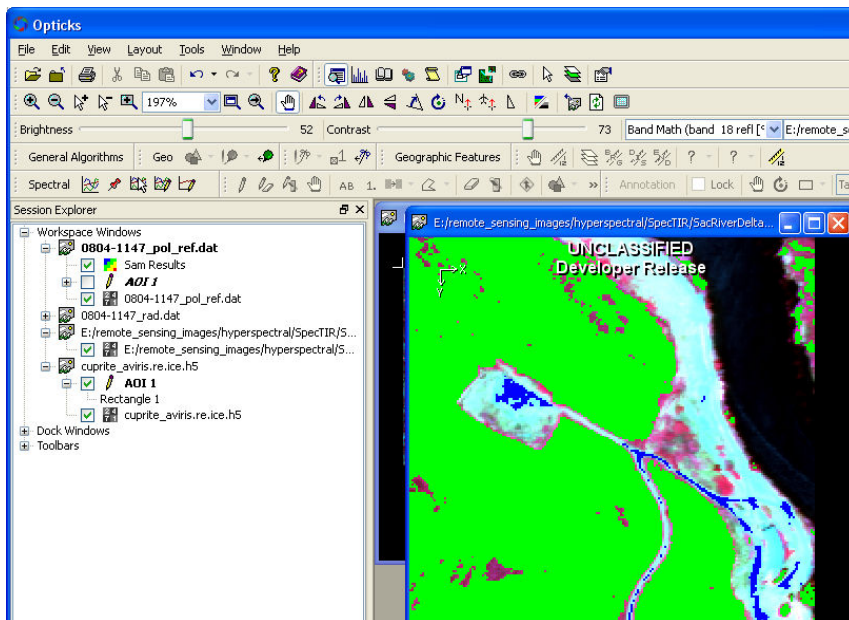
NOTE: This will likely take a little longer than a single material type. It is recommended to use smaller subsets of the image to develop and refine the processing steps and parameters (such as threshold values, etc).



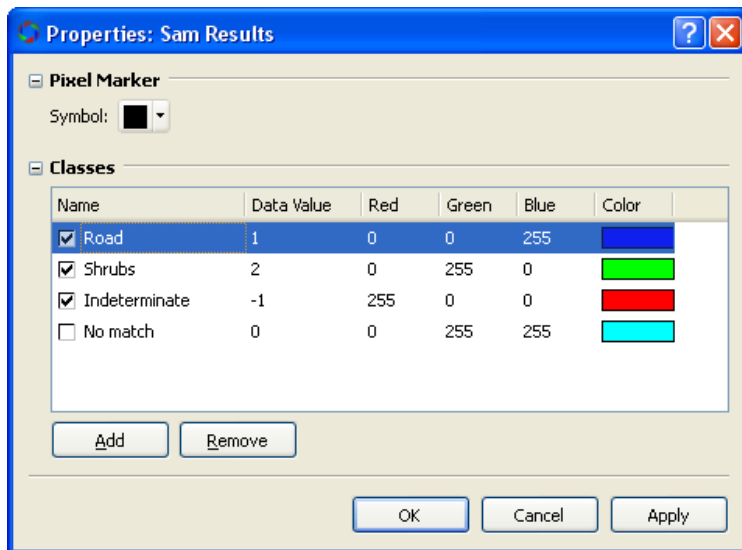
Notice the progress meter shows which signature is being processed.



The resulting SAM Layer has multiple colors shown (i.e. a pseudo color layer).



The colors and display type can be changed by right clicking on the SAM Results in the Workspace Window. The name of the class can also be changed by clicking on the name and providing an alternate name.

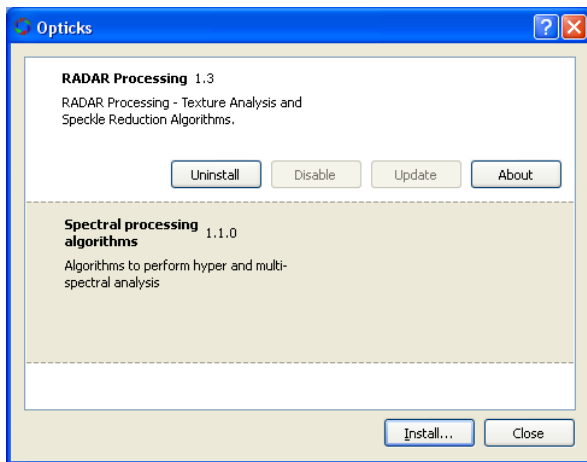


Appendix A - Spectral Processing Extension

The Spectral Processing Extension is a plug-in created by the Opticks team that provide some spectral analysis capabilities for multispectral and hyperspectral image data. Most of the functions are used with hyperspectral data for pre-processing or material identification. See the Hyperspectral section for more details to use some of the spectral tools and algorithms. The KMeans classification algorithm is currently in draft form for Opticks version 4.4.x with its primary function being a semi-automated (hybrid of unsupervised and supervised methods) classification algorithm.

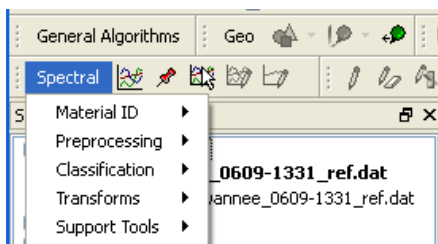
Install the Spectral Processing Extension

Drag and Drop the Spectral.AEB file into Opticks or go to the Opticks Help—Extensions—Install to install the AEB file. The spectral Toolbar will be loaded. Users will likely need to restart Opticks for the new extension to appear. After the extension is installed, the user will see the following dialog box from the Help—Extensions menu item.



Spectral Toolbar

The Spectral Toolbar contains both algorithms (image processing functions) and some tools to use with image data and spectral signatures.



The spectral tools are used to create, view, and evaluate spectral signatures created by the user. The spectral signatures will be used in algorithms to categorize other pixels in the image containing the same material. The Signature Window will often be used in conjunction with these tools.

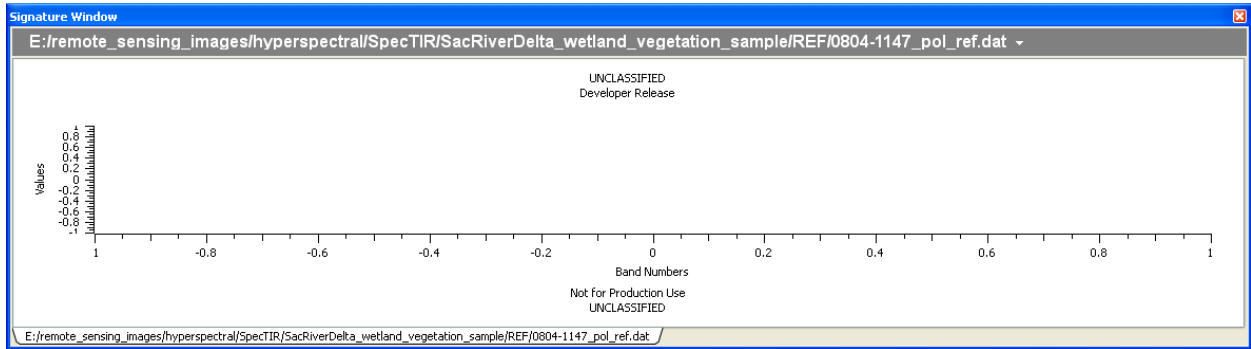
Spectral Tools



From left to right the tools are:

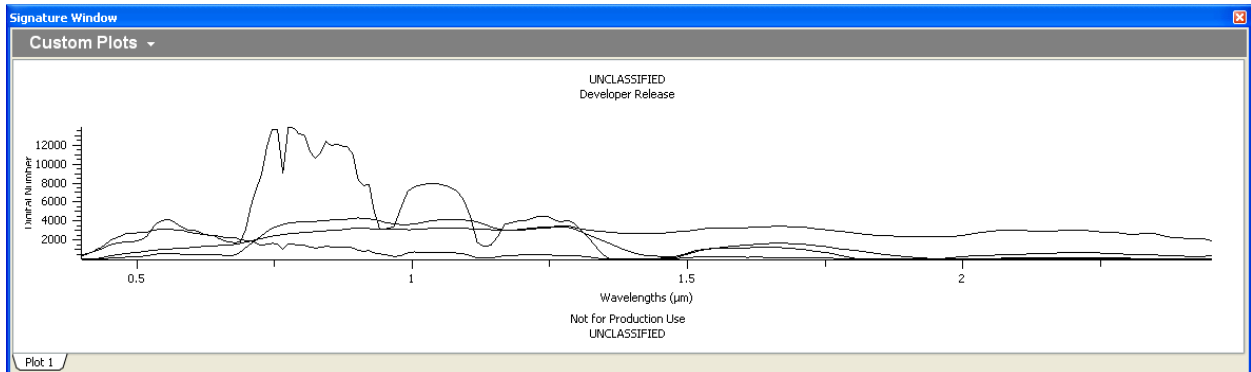
Show Signature Window

The window is typically for the active image viewer



Pin/Unpin Signature Window

Creates a custom plot area to capture spectral signatures from different image windows. Images must have the same kind of units (bands or wavelengths) to display in this plot.

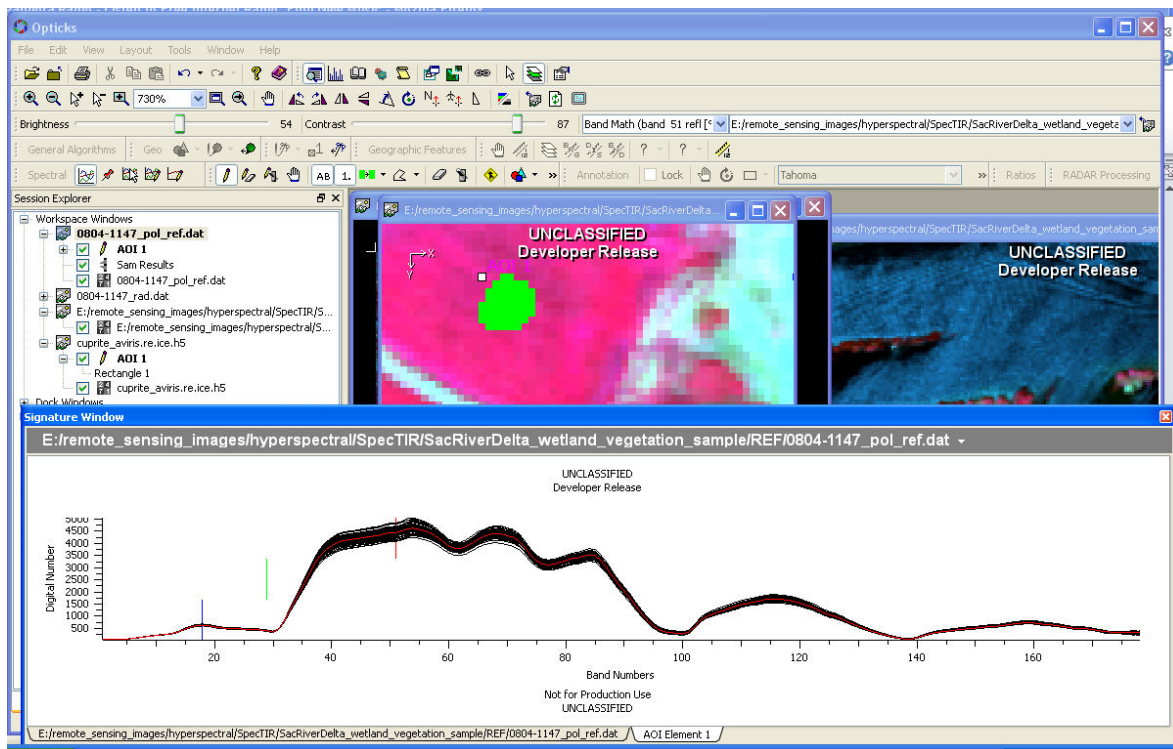


Create a spectral signature with the mouse

Click inside an image window with this tool to generate a spectral signature, similar to those shown above.

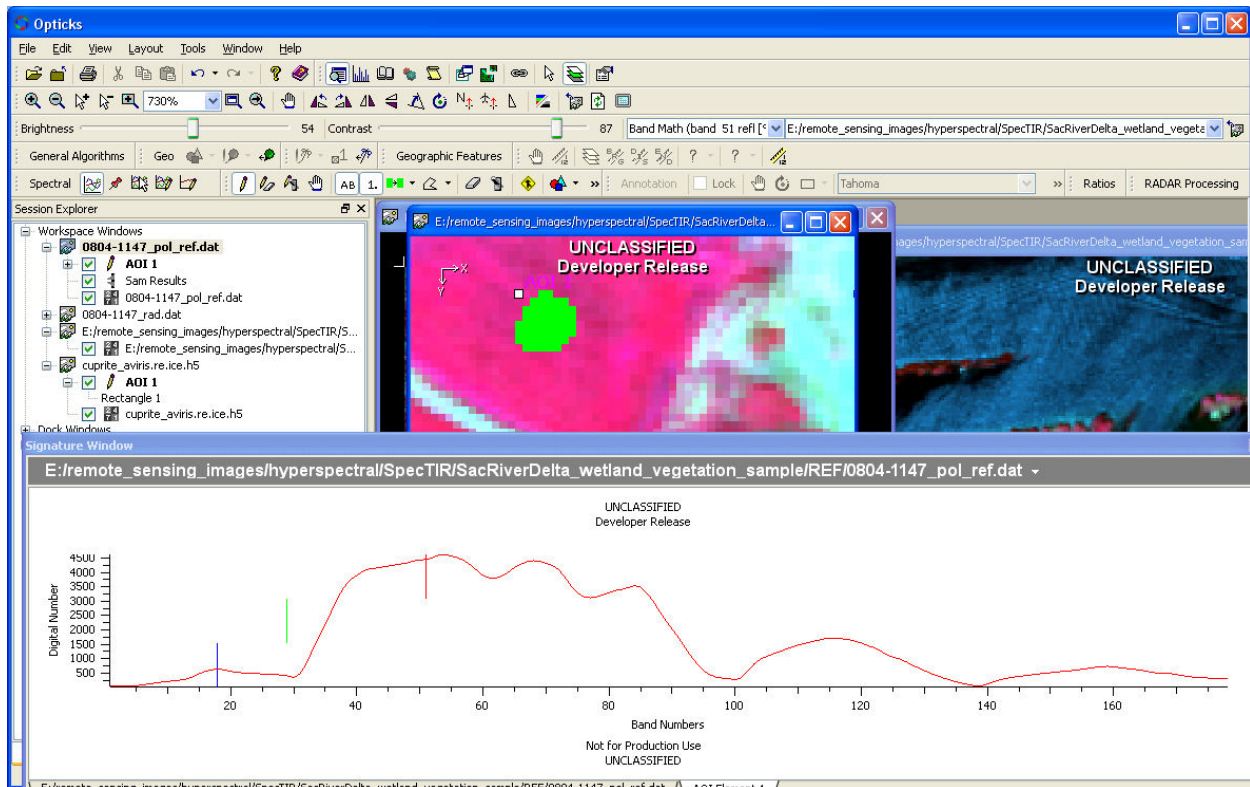
Display AOI and average signature

Displays both the individual signature of each pixel in the AOI as well as the average signature of the pixels in the current AOI. This plot requires an AOI to exist in an image viewer. The signature plot is derived from the pixels within the AOI. Each black spectral curve represents each pixel spectra. The red curve represents the average spectra of the pixels in the AOI.

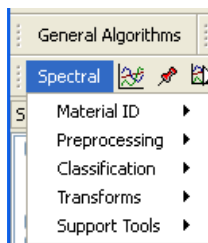


Display Average Signature of AOI

Displays the average signature of all the pixels in the current AOI. The red curve represents the average spectral for all of the pixels within the AOI.



Spectral Algorithms



Material ID

Material ID contains two different functions that can be used to identify material types within the image

- a. CEM – Constrained Energy Minimization
- b. SAM – Spectral Angle Mapper

Preprocessing

Preprocessing contains two different functions to perform some pre-processing on a raw hyperspectral image. These are two methods of converting radiance values (often captured by the sensor) to reflectivity values (often used by the end user) for image analysis. These are considered atmospheric

correction methods that correct for water and various atmospheric gases that affect the “reflectance” of objects back to the sensor.

- a. ELM – Empirical Line Method
- b. IARR – Internal Average Relative Reflectance

Classification

This is the Draft KMeans algorithm and is not officially released by Opticks.

Transforms

This option contains the Minimum Noise Fraction (MNF) for both Inverse and Reverse transforms. This function is often used as a pre-processing step for hyperspectral data to remove some noise that is inherent in the image before further processing is completed.

NOTE: NDVI is and will be a transform function that will eventually be removed from this toolset and placed on a different tool set. Refer to the Ratio Wizards in Appendix A that show a number of ratios, including NDVI.

Support Tools

Support Tools contains the Spectral Library Builder and the Spectral Signature Window. The window can also be activated from the toolset described above. The spectral library builder can be used to generate, save, and import/export spectral signatures for use in material identification.

Appendix B – Creating and Using Wizards

Wizards

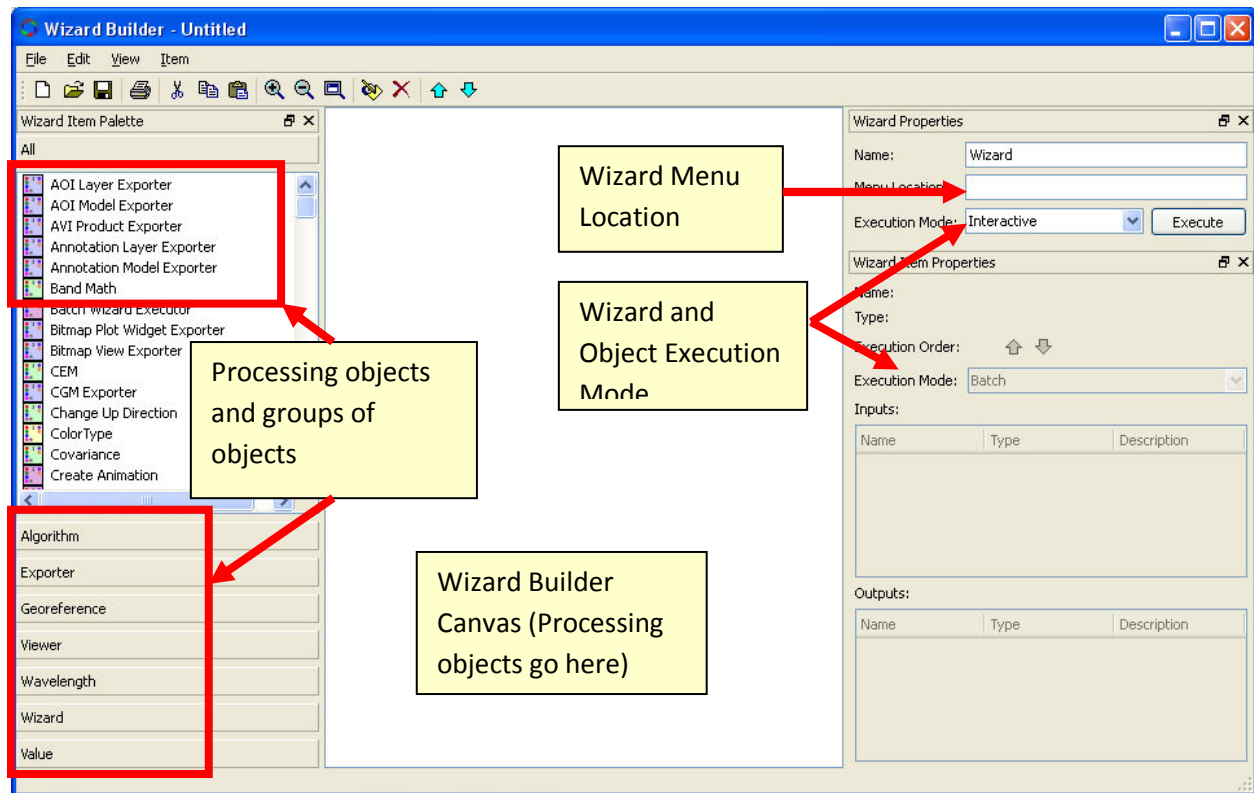
Wizards in Opticks allow the user to develop and create a process (i.e. a workflow or model) and then can reuse it for different inputs and outputs. Wizards can assist with improving productivity of repetitive tasks and can also add functionality to Opticks without requiring any special programming skills. Wizards can be executed in various ways such as within the Wizard Builder, from a custom toolbar and menu list, or externally by running a command or batch file.

Using Wizards for Common Tasks

Some Image processing tasks that are not part of the core Opticks functionality are good options for creating a wizard. One such example is the creating band ratios using the Band Math Tool. Ratios can be computed using the Band Math Tool, but this is typically a single operation and the user cannot save the math expression without copying and saving it to an external file. This can be cumbersome since the expression can be complex. One alternative to expanding the flexibility of the Band Math Tool is to incorporate it into a custom wizard where the user can develop the algorithm one time and then reuse it for different kinds of images.

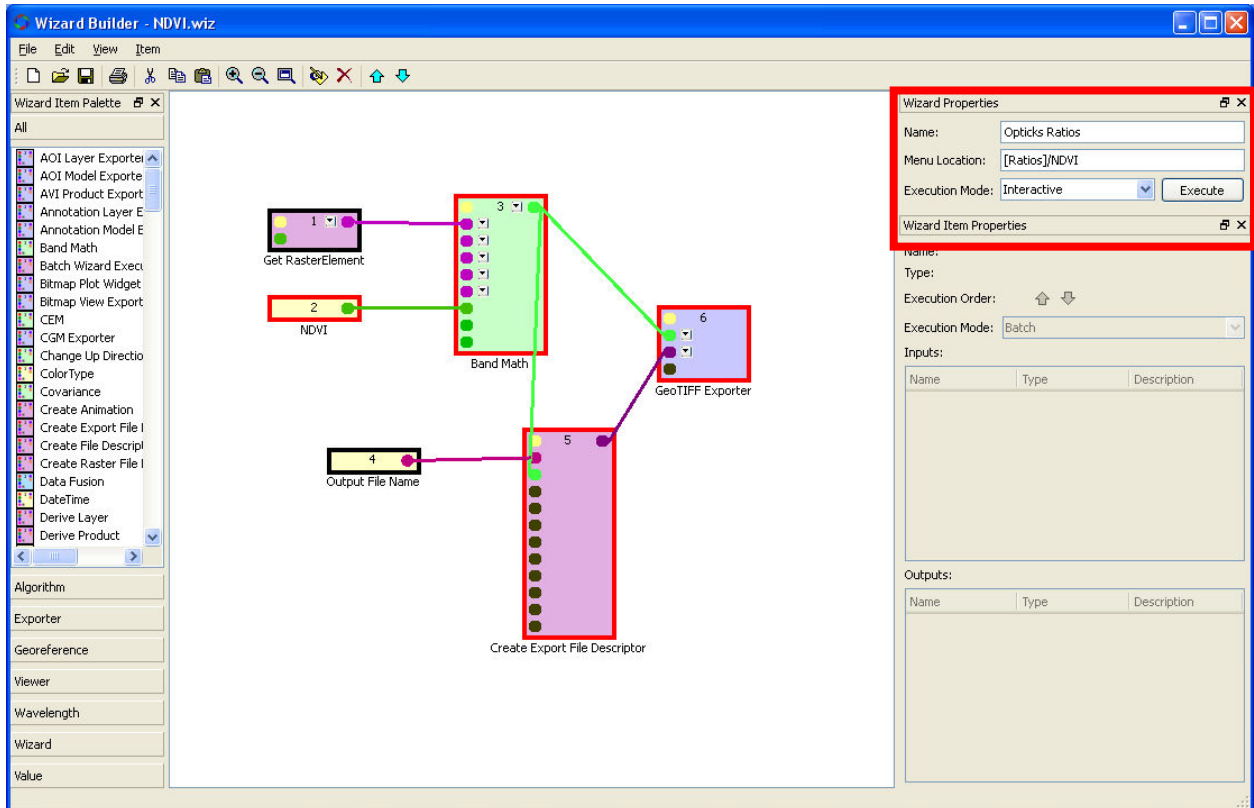
Building a Wizard

To create a custom wizard, the Wizard Builder is used. The Wizard Builder is started from **Tools—Wizard Builder**. The Wizard Builder is displayed.



A set of processing objects are displayed on the left side. These are used to build the model and show up in the middle section. The right side of the Wizard Builder is used to determine how a process will be executed (interactive through user input or batch mode for automating tasks) as well as changing the order of objects and indicating if a custom toolbar will be created with menu options to run the wizard.

An example of a simple model is shown below.



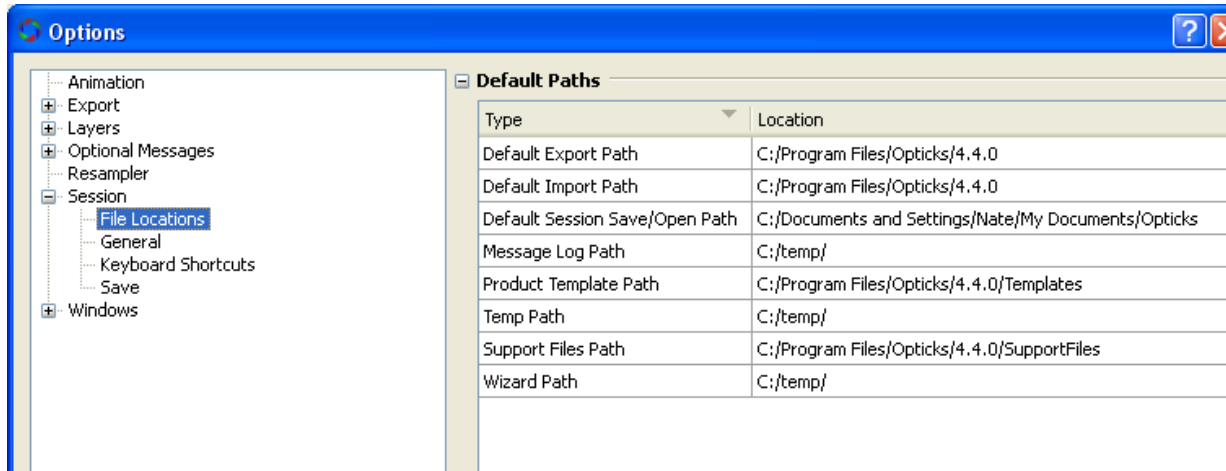
This model shows the Band Math Tool as well as a Get Raster Element object to solicit an image file that is already open in Opticks as well as the actual math expression (e.g. NDVI) that the Band Math Tool uses. The model also includes objects to solicit an output file name from the user and the file will be exported using the TIF format.

The Execution Mode (upper right) is set to Interactive indicating the tool will require some user input to run to the tool. If the execution mode was set to Batch, the user would click the menu option (or the Execute button in the Wizard) and the process would run without user interaction. Notice on the upper right that a menu location has been set to:

[Ratios]/NDVI

This structure indicates that a tool bar called “Ratios” will be used and /NDVI indicates a menu option under the Ratio tool bar.

NOTE: For Opticks to properly use the custom toolbars the Wizard Path must be set and the wizard files must reside in this folder. Below, the Wizard Path is set to C:\temp, but this can be changed by the user under **Tools—Options**.



The processing objects above are numbered indicating the order in which they are used. The first object is the Get Raster Element. The Get Raster Element allows the user to choose an existing file that has been imported into Opticks. Alternatively, Import Data Set (i.e. an input file that is not currently displayed in Opticks and solicited from the user by making the object Interactive) can be used. If the image already is open in Opticks, the user will be shown a message that the image is already loaded. The second object is the math expression. Both objects are required to run the Band Math Tool (third object), since the Band Math tool requires an image (i.e. an image cube) and an expression for the tool to operate.

Also note the different colored outlines on the objects.

1. Black indicates an interactive object (one that requires user input)
2. Red indicates batch mode (that does not require user input)

Each object in the Wizard Builder can have different modes of operation similar to that of the entire model. In the example above, two interactive objects exist:

- 1) the input file (Get Raster Element)
- 2) the Output File name (a name provided by the user and will have the TIF extension)

Four batch objects exist in the model and will not have any user interaction:

- 1) the math expression
- 2) the actual processing of the math expressions through the use of the Band Math Tool
- 3) create File Export Description (this sets up the export function to tell Opticks an output file will be generated)
- 4) the kind of exporter (in this case a GeoTIFF export type)

The inputs to the model are:

1. Input Raster (already opened within Opticks)
2. Math expression
3. Band Math Tool

The outputs to the model are:

1. Output GeoTIFF that requires:
 1. File name
 2. Export descriptor

Note that the Band Math Tool has two green lines, one going to the Export File Descriptor and one going to the GeoTIFF Exporter. Both the Export File Descriptor and GeoTIFF Exporter need to know that an image file, in this case the output raster of the Band Math Tool. The Export File Descriptor is connected to the GeoTIFF Exporter so that the GeoTIFF Exporter knows the specific kind of export file to create.

The exact same structure can be used for any Band Math function, with these changes:

1. The specific math function
2. The output filename

Alternatively, the user can modify the model to also solicit any valid input file, provided it is not already imported into Opticks.

In the model above, the user can choose to not write (save) an output file and the output from the Band Math Tool will appear in a new window in Opticks. The user can save the image at a later time.

Updating the Wizard List

Before Opticks is aware of any new changes to a Wizard or Wizard Toolbar, the Update Wizard List menu option must be checked to refresh the Wizard List (Tools—Update Wizard List).

The following ratios were added as part of the “Ratios” toolbar.



Each of the specific ratios is a separate Wizard (.wiz files) although they all show up under the Ratios toolbar because they have the same [Ratios] toolbar placement and all of the .wiz files exist in the same directory (set by the Wizard Path under Options).

The ratios are common to Landsat TM. Additional ratios can easily be added and other menu options created for different sensors.