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SENTINEL-1 Toolbox

Polarimetric Tutorial

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Polarimetric Tutorial

The goal of this tutorial is to provide novice and experienced remote sensing users with step-by-step instructions on working with RADARSAT-2 data with the Sentinel-1 Toolbox. The tools have to be developed with the goal of making polarimetric processing easy to use and intuitive.

In this tutorial you will process a Quad Pol RADARSAT-2 product and produce polarimetric classifications of the data.

For an introduction to polarimetric concepts, please see the "Radar Polarimetry" chapter of the "Fundamentals of Remote Sensing" tutorial from the Canadian Centre for Remote Sensing (CCRS).

Sample Data

Sample data for RADARSAT-2 Fine Quad-Pol products supplied by MDA can be found at:

- https://mdacorporation.com/geospatial/international/satellites/RADARSAT-2/sample-data

For this tutorial, we will use the Vancouver Fine Quad Frame 1 dataset. Vancouver in British Columbia is the third largest metropolitan area in Canada located on the Pacific coast.

Vancouver Fine Quad Frame 1 Location in World Map

Download the **Vancouver_R2_FineQuad15_HH_HV_VH_VV_SLC**products.

Supported Products

The toolbox can support Quad Pol SLC products from:

- RADARSAT-2
- TerraSAR-X
- ALOS PALSAR 1 & 2

The toolbox can support Dual Pol SLC products from:

- SENTINEL-1
- ENVISAT ASAR
- RADARSAT-2
- TerraSAR-X

- ALOS PALSAR 1 & 2

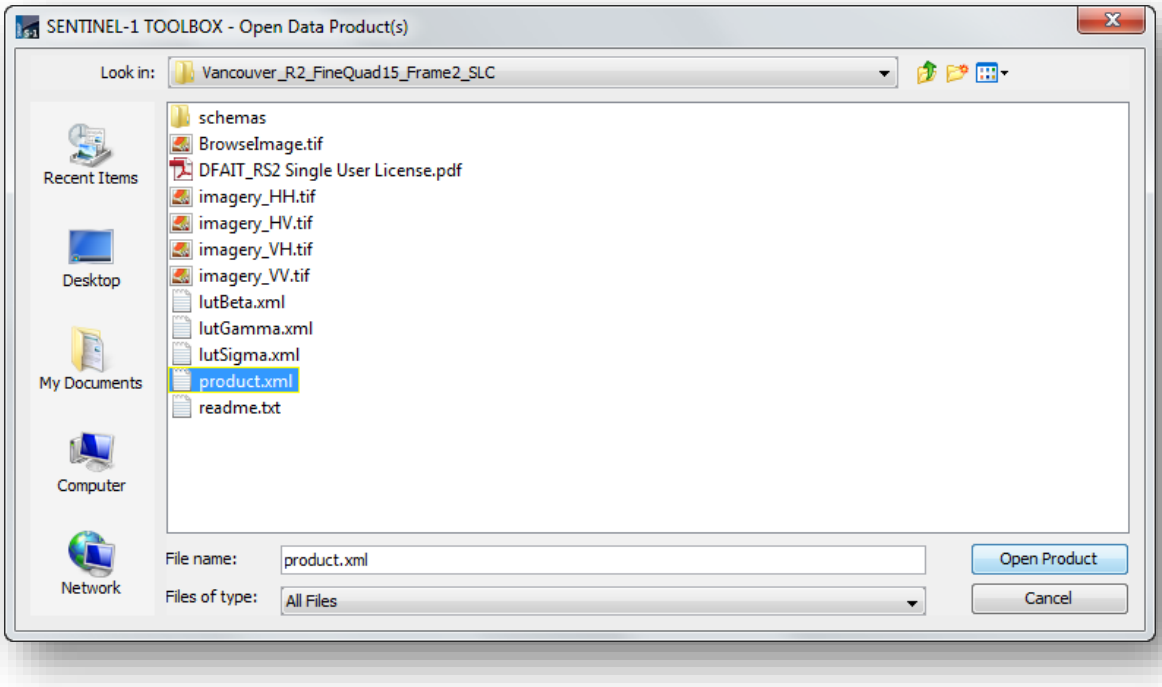
Opening a Quad Pol Product

In order to process fully polarimetric data, the input products should be Quad Pol (HH, VV, HV, VH) products and should also be Single Look Complex (SLC).

Step 1 - Open a product: Use the **Open Product** button in the top toolbar and browse for the location of the **Vancouver Fine Quad Frame 1 RADARSAT-2** product.

Select the **product.xml** file and press **Open Product**.

If your product is contained within a zip file, the Toolbox will also be able to open the product simply by selecting the zip file.

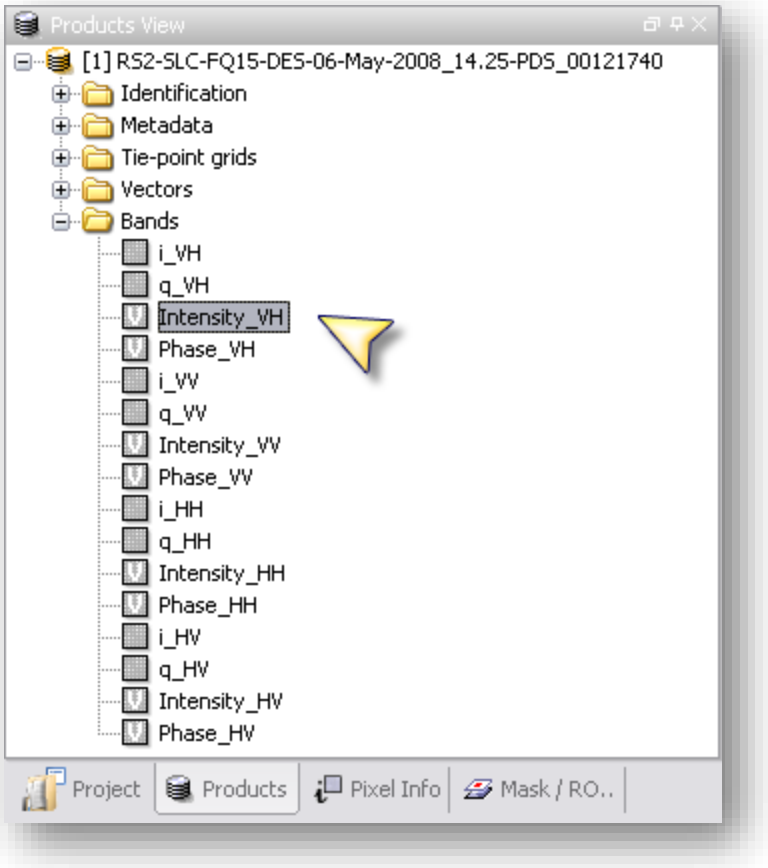


Opening a Product

Step 2 - View the product: In the **Products View** you will see the opened product. Within the product bands you will see four polarizations:

- VH
- VV
- HH
- HV

For each polarization, there will be the complex data i and q bands and two virtual bands for intensity and phase.



Products View

Step 3 - View a band: To view the VH band, double-click on the **Intensity_VH** band. Zoom in using the mouse wheel and pan by clicking and dragging the left mouse button.

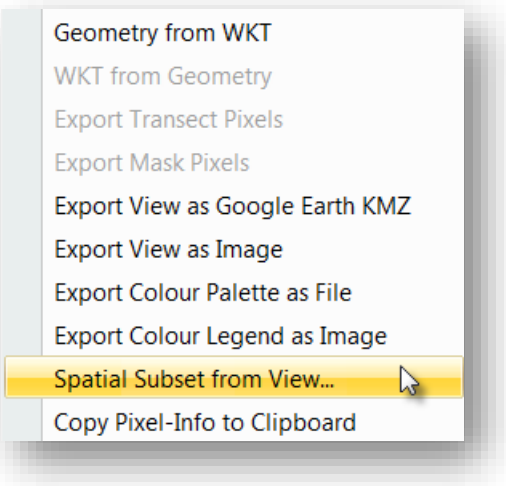
Intensity_VH Band

Pan and zoom to the Vancouver airport area.

Creating a Subset

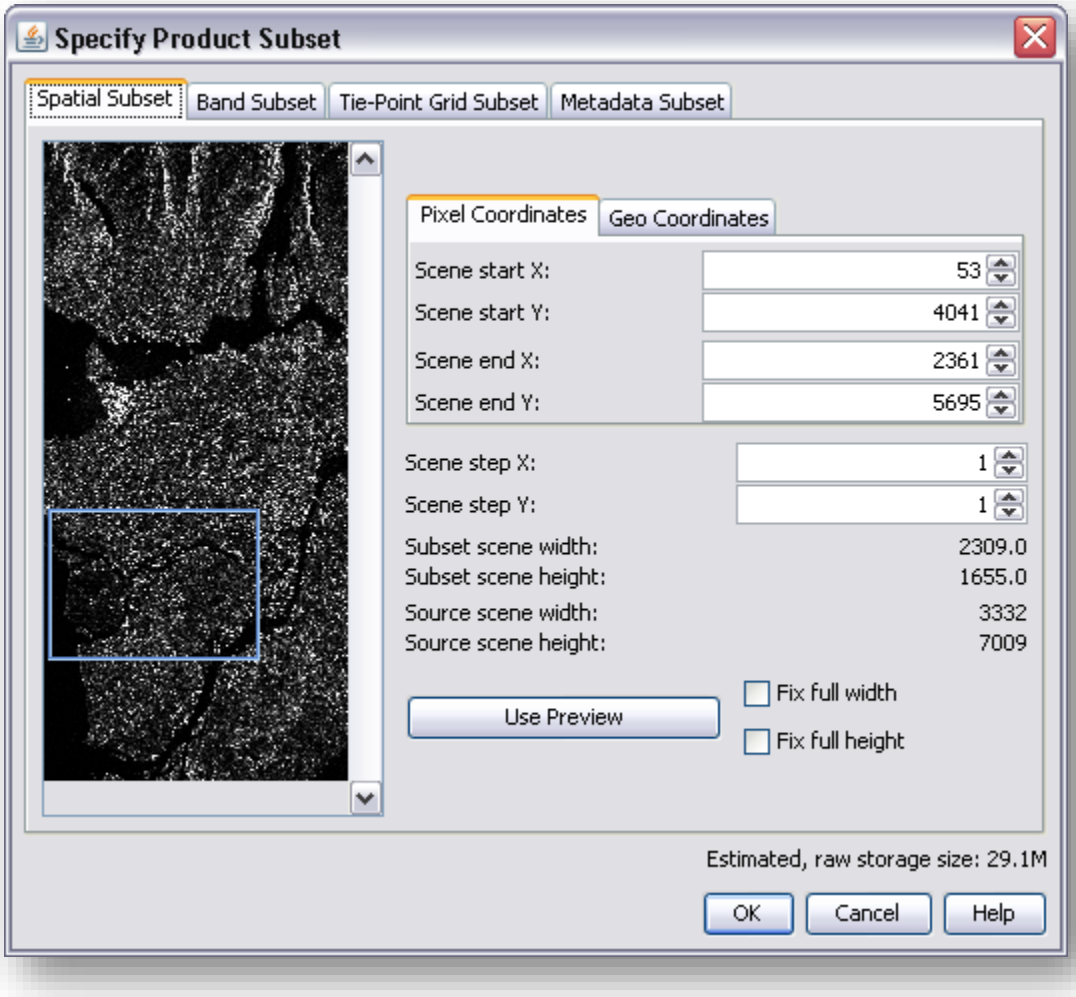
To reduce the amount of processing needed, you may create a subset around the particular area in which you are interested.

Step 4 - Create a subset from the view: Once you have zoomed and panned to your area of interest, **right click** on the image view and select **Spatial Subset from View** in the **Context** menu.



Context Menu

The subset dialog will automatically select the area you were viewing.



Specifying Product Subset

By default, all bands will be included in the subset. You will need all the bands to do the polarimetric processing. Press **OK** to create the subset.

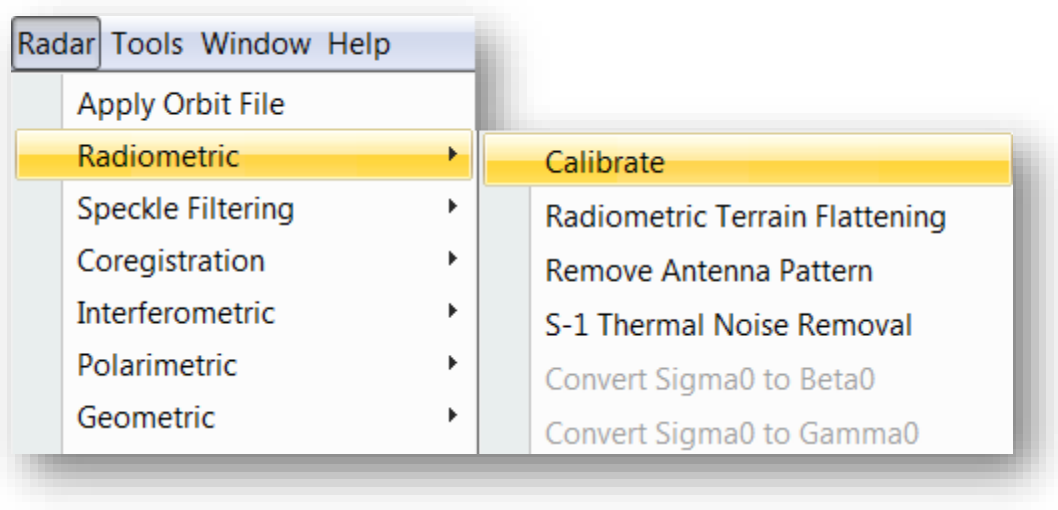
Calibrating the Data

To properly work with the SAR data, the data should first be calibrated.

Calibration radiometrically corrects a SAR image so that the pixel values truly represent the radar backscatter of the reflecting surface.

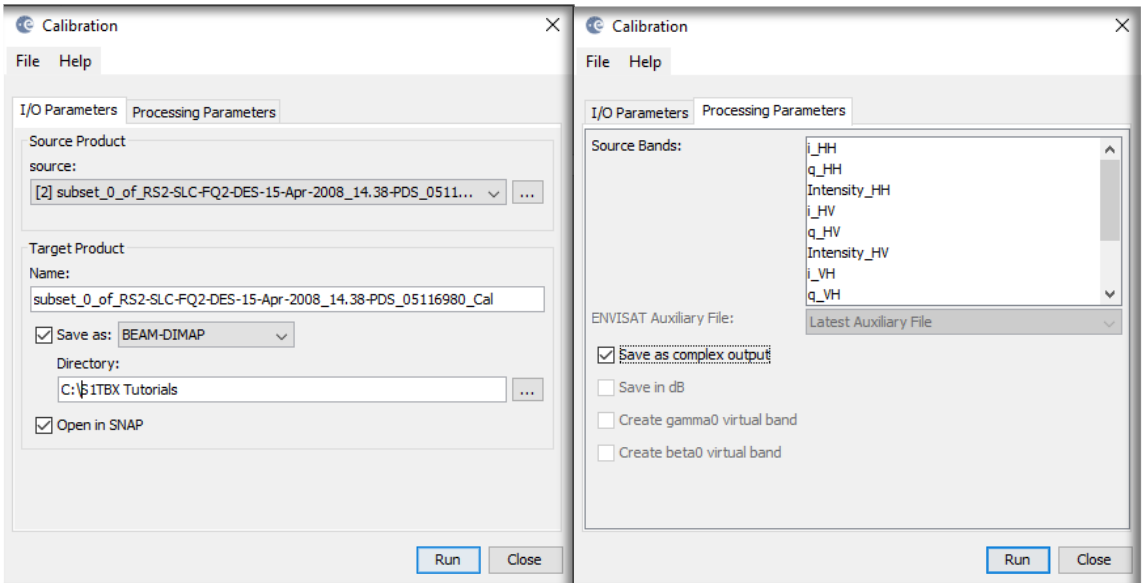
The corrections that get applied during calibration are mission-specific, therefore the software will automatically determine what kind of input product you have and what corrections need to be applied based on the product's metadata. Calibration is essential for quantitative use of SAR data.

Step 5 - Calibrate the product: From the **Radar** menu, go to the **Radiometric** menu and select **Calibrate**.



Radiometric Menu

The source product should be your newly created subset. The target product will be the new file you will create. Also select the directory in which the target product will be saved to.



Calibration Dialog

If you don't select any source bands, then the calibration operator will automatically select all real and imaginary (i, q) bands.

> **NOTE**
> For polarimetric processing the data must be complex. By default, the calibration operator will produce real sigma0 bands. To produce complex output, check mark the **Save in complex** parameter.

What Polarimetric Tools are Available?

In order to properly exploit the information within polarimetric data, you will need processing tools that convert that data into more useable forms for analysis.

The Toolbox includes polarimetric tools for:

- Polarimetric Matrix Generation
- Polarimetric Speckle Filtering
- Polarimetric Decompositions
- Polarimetric Classification

Polarimetric Matrix Generation

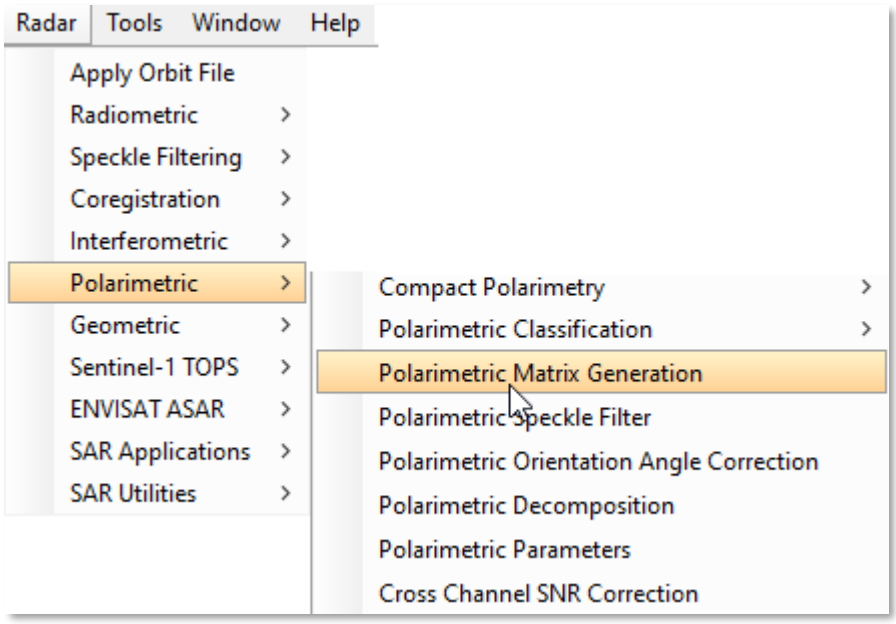
All the polarimetric tools work with either Coherency or Covariance matrices as input. Starting from a Quad Pol SLC product, you may use the **Matrix Generation** operator to convert the product into one of the following matrices:

- Covariance matrix C2
- Covariance matrix C3
- Covariance matrix C4
- Coherency matrix T3
- Coherency matrix T4

The Coherency matrix T3 is sometimes preferred because its elements have a physical interpretation (odd-bounce, even-bounce, diffuse, etc.).

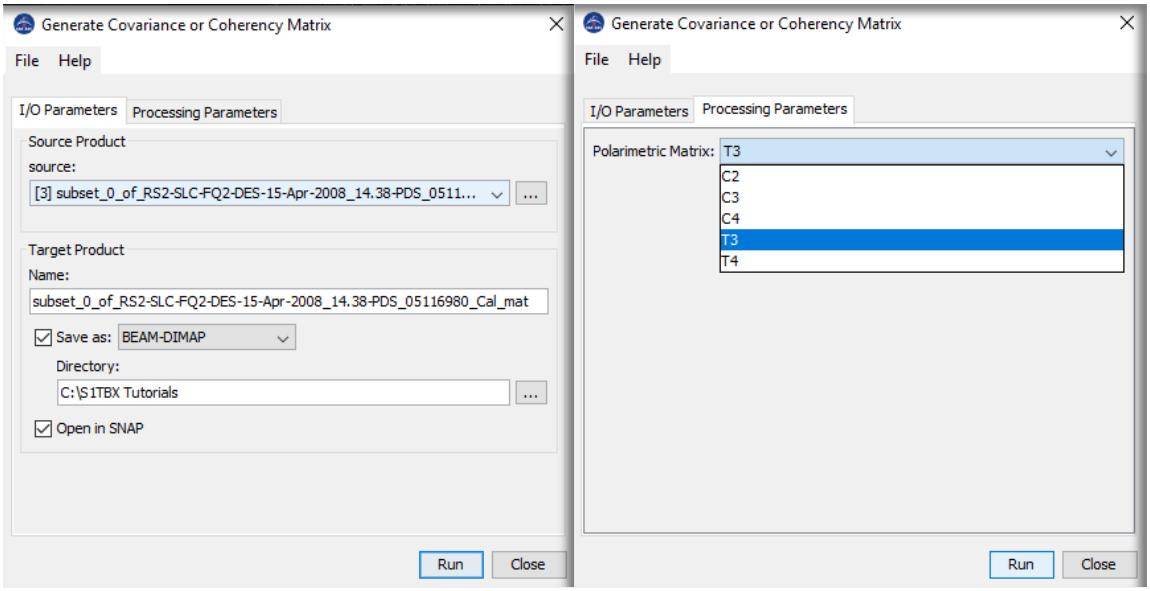
Use the **Matrix Generation** operator when you would like to explicitly select which matrix to use. For simplicity, a Quad Pol SLC product can be used directly by any polarimetric operator. In such a case, the input Quad Pol will automatically be converted to a T3 matrix.

Step 6 - Generate a T3 matrix: Select **Polarimetric Matrix Generation** from the **Polarimetric** menu.



Polarimetric Menu

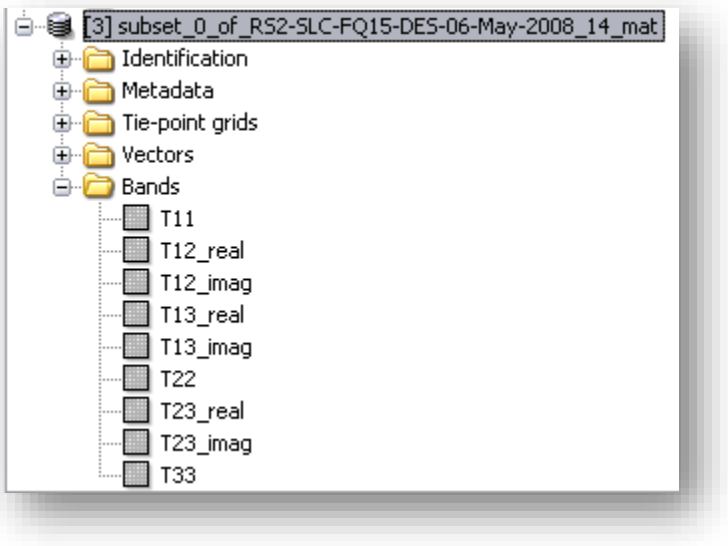
The source product should be your newly created calibrated subset. The target product will be the new file you will create. Also select the directory in which the target product will be saved to.



Generate Covariance or Coherency Matrix Dialog

In the **Processing Parameters** tab, select a **T3** matrix to convert the Quad Pol product into a Coherency matrix T3. Press **Run** to begin processing.

When the processing completes, a new product will be added to the **Products View**. You will notice the new bands produced correspond to the elements of the **T3** matrix.



Products View Showing New Bands Produced

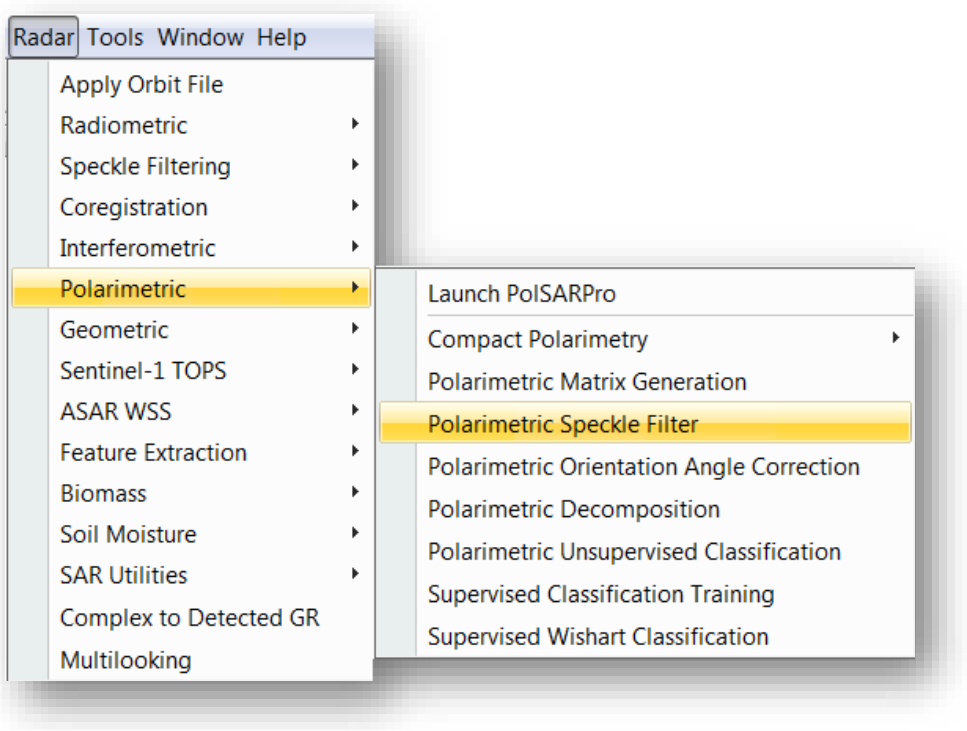
Polarimetric Speckle Filtering

To clean up some of the speckle inherent in SAR images, you can apply a speckle filter. When working with a single polarized detected or SLC image, you may use the conventional Speckle Filters found in the **SAR Processing** menu. However, for full polarimetric data, there are polarimetric speckle filters available that take advantage of all bands and preserve the complex information.

For polarimetric speckle filtering, the following filters are available:

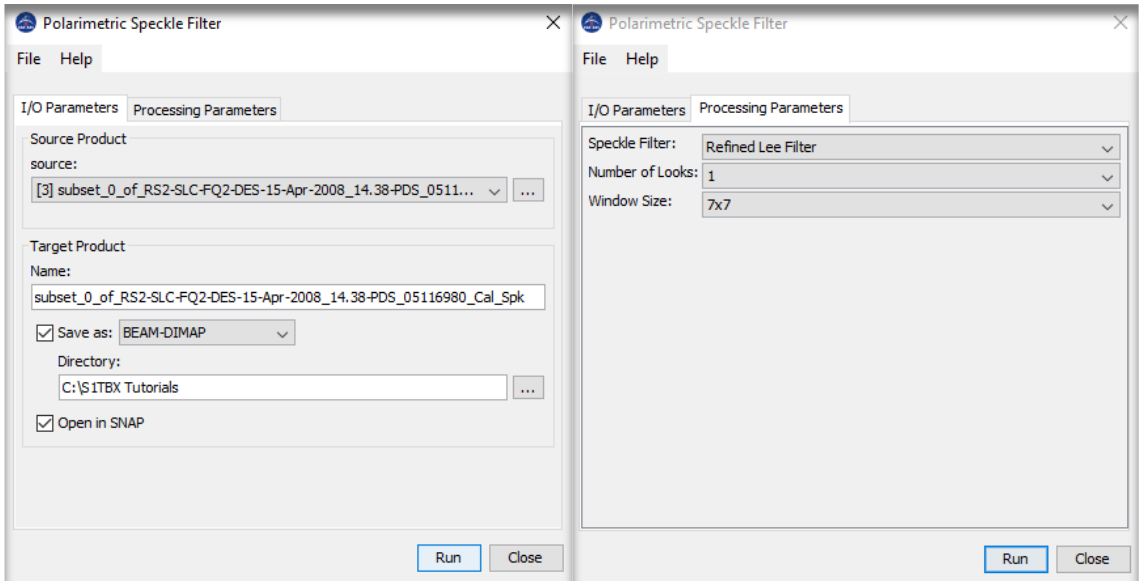
- Boxcar
- Improved Lee Sigma
- Refined Lee
- Intensity Driven Adaptive Neighbourhood (IDAN)

Step 7 - Apply a Speckle Filter: Select **Polarimetric Speckle Filter** from the **Polarimetric** menu.



Select Polarimetric Speckle Filter

In the **Processing Parameters** tab, select the **Refined Lee** speckle filter. Press the **Help** button to call up the online help for further information.



Polarimetric Speckle Filter Dialog

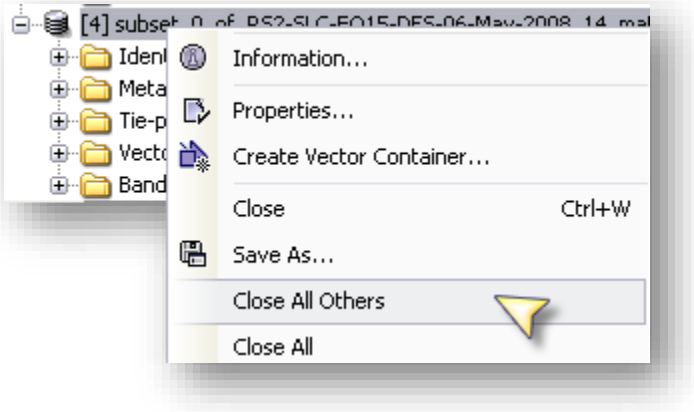
Press **Run** to begin processing.

When the processing completes, your new speckle filtered product should have the same bands as your T3 product, however the data will have been filtered.

Open the **T11** band in both the **T3** product and in **new speckle filtered T3** product to compare before and after images. The resulting image will have less speckle but also appear more blurred.

Before **After**

To clean up your **Products View**, you may now right-click on the **speckle filtered T3** product and from the popup menu select **Close All Others** to close all other products and leave only the **speckle filtered T3** opened.



Closing All Other Products in Products View

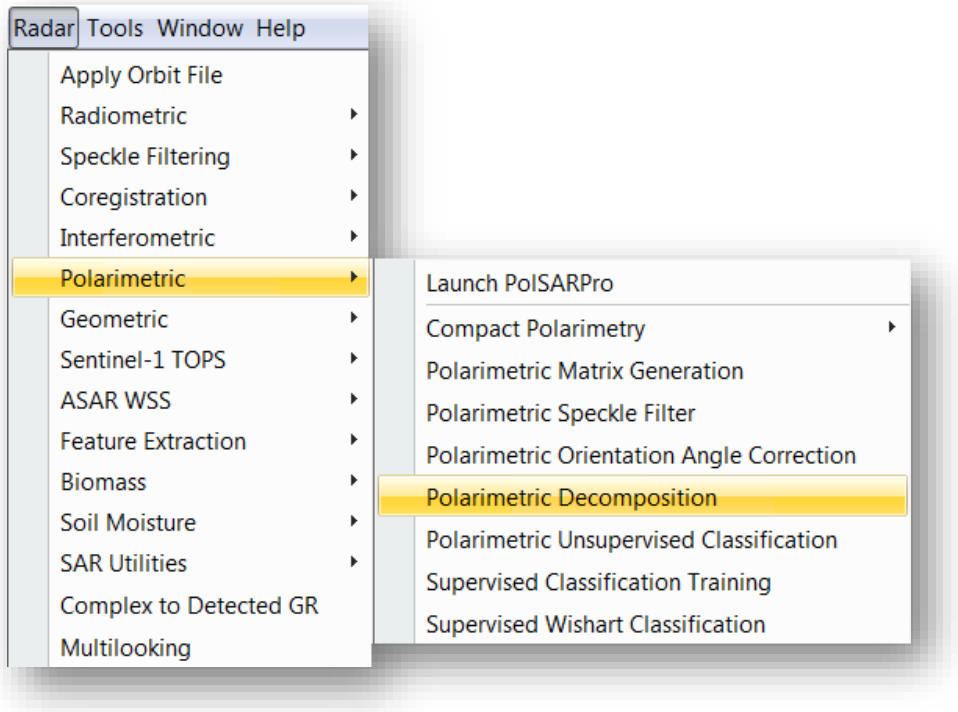
Polarimetric Decompositions

Polarimetric decompositions allow the separation of different scattering contributions and can be used to extract information about the scattering process.

The following polarimetric decompositions are available:

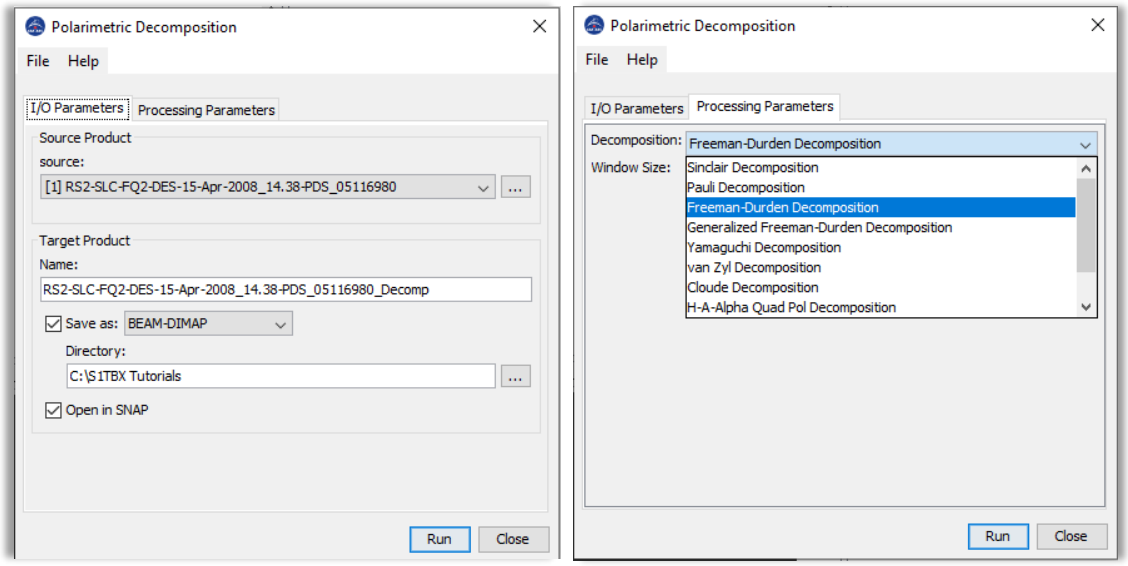
- Sinclair
- Pauli
- Freeman-Durden
- Yamaguchi
- Van Zyl
- Cloude
- H-a Alpha
- Touzi

Step 8 - Produce a decomposition: Select **Polarimetric Decomposition** from the **Polarimetric** menu.



Select Polarimetric Decomposition

Select the **Freeman-Durden** decomposition.

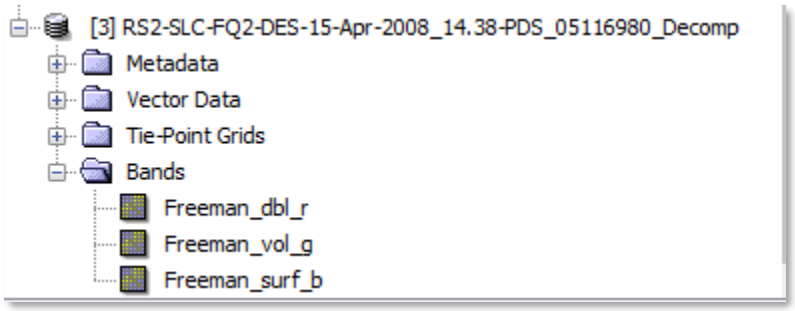


Freeman-Durden Decomposition Dialog

The window size parameter corresponds to the amount of averaging applied to each pixel.

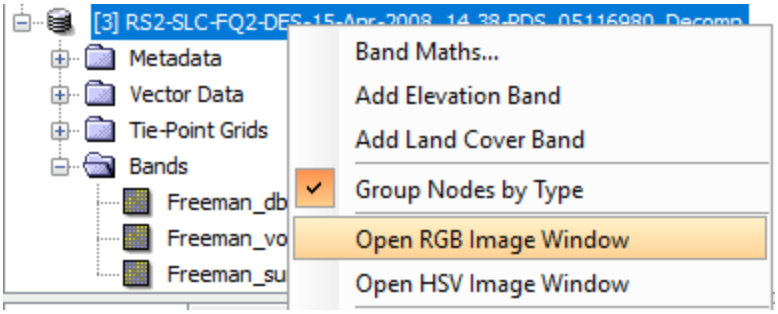
Press **Run** to begin processing.

When the processing completes, your new Freeman-Durden decomposition product will have three bands corresponding to double bounce, volume scattering and surface scattering.



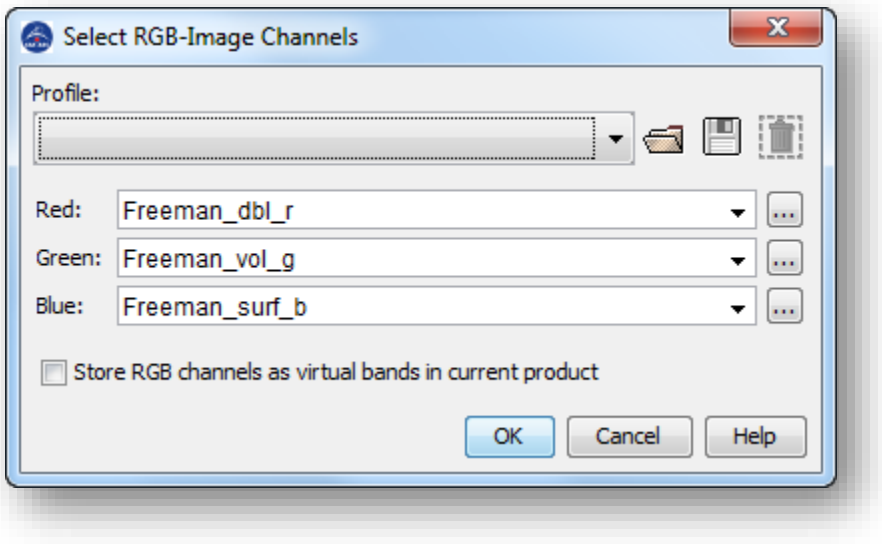
Products View Showing Freeman-Durden Bands

Step 9 - View in RGB: You can view all three bands in an RGB colour view by right-clicking on the product name and selecting **Open RGB Image Window** from the popup menu.



Viewing Products in RGB

Within the RGB channel selection dialog, select the Red, Green, Blue components for the respective bands **Freeman_dbl_r**, **Freeman_vol_g**, **Freeman_surf_b**. Press **OK** to create the RGB view.



Selecting RGB Image Channels

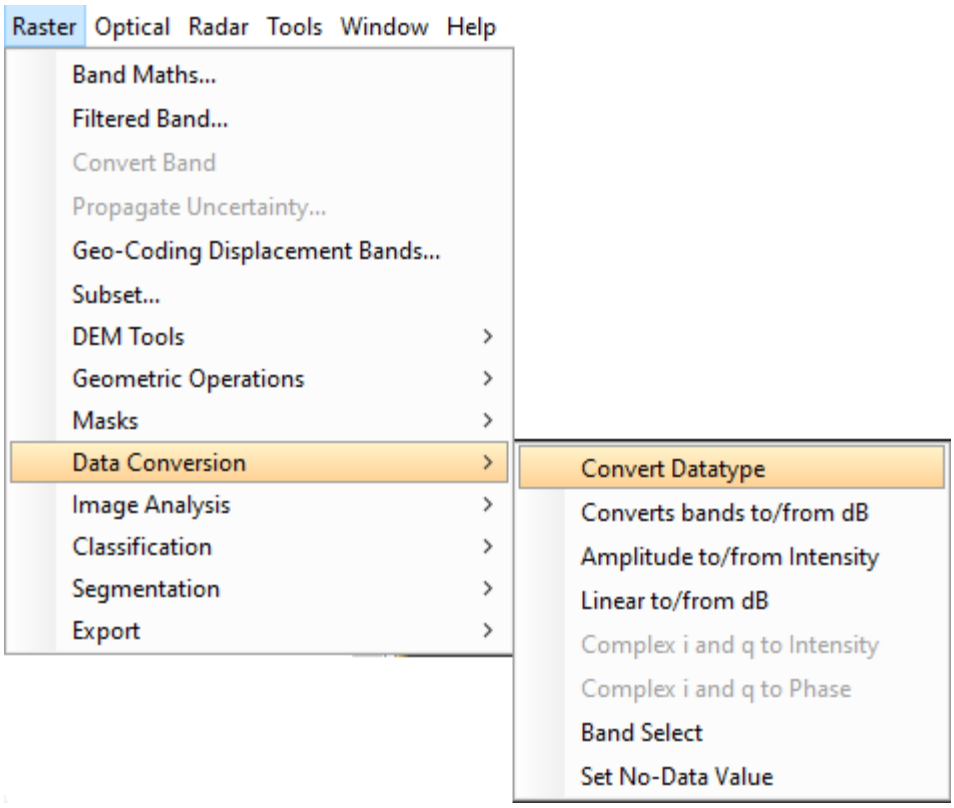
RGB Freeman-Durden Image

The resulting RGB image shows surface scattering in **blue** from the airport runways, roads and water bodies. Buildings produce double bounce and are shown in **red**. Vegetation produces volume scattering and is therefore shown in **green**.

Step 10 - Export the RGB as an image: You may now wish to export the colour image to an image file format such as JPEG or PNG to use in a report or presentation.

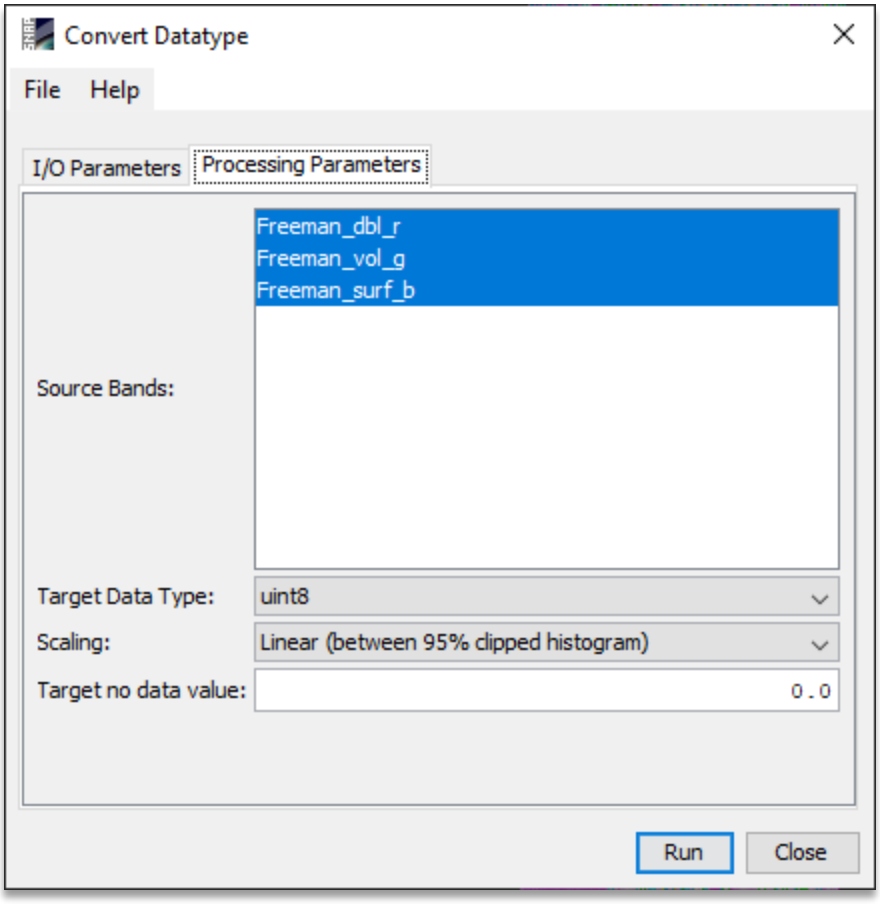
The processed data will usually be saved as Float64 data type. Although it is possible to save JPG, PNG and GeoTIFF files as Float64, the typical image viewing software may expect data to be in UINT8 or UINT16.

To convert the data type, select **Convert Data Type** from the Raster menu, under Data Conversion



Select Convert Data Type

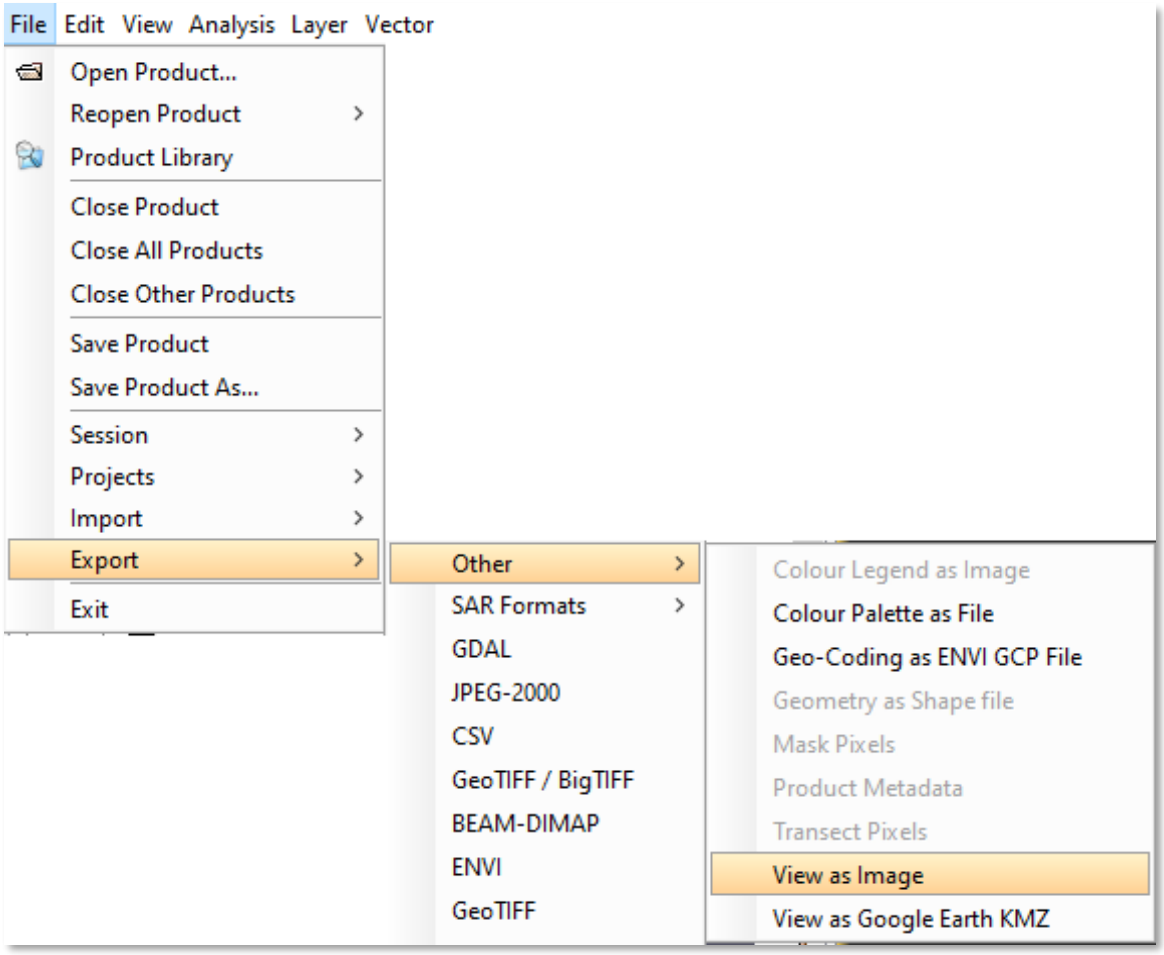
In the Convert Data Type dialog, choose to output UINT8 using linear scaling clipping to 95% of the histogram.



Select uint8 with Linear Scaling

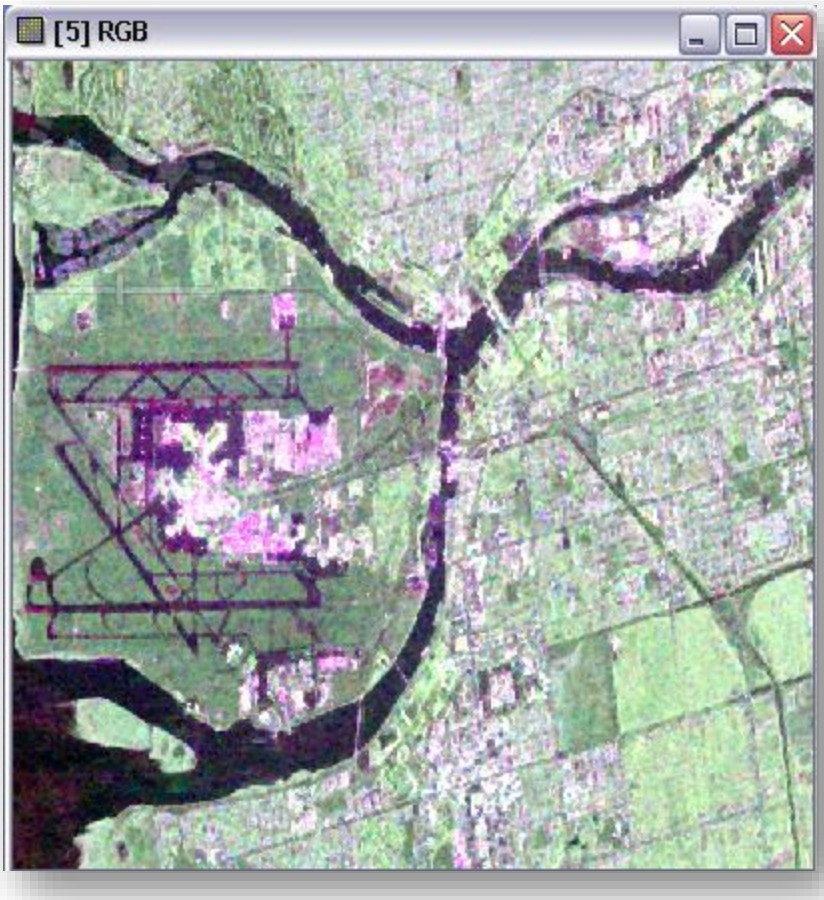
Now you may export the converted product to a common image file format.

From the **File** menu, go to the **Export** submenu, Other submenu, and select **View as Image**. In the **Save** dialog, enter the name, location and type of image to export.

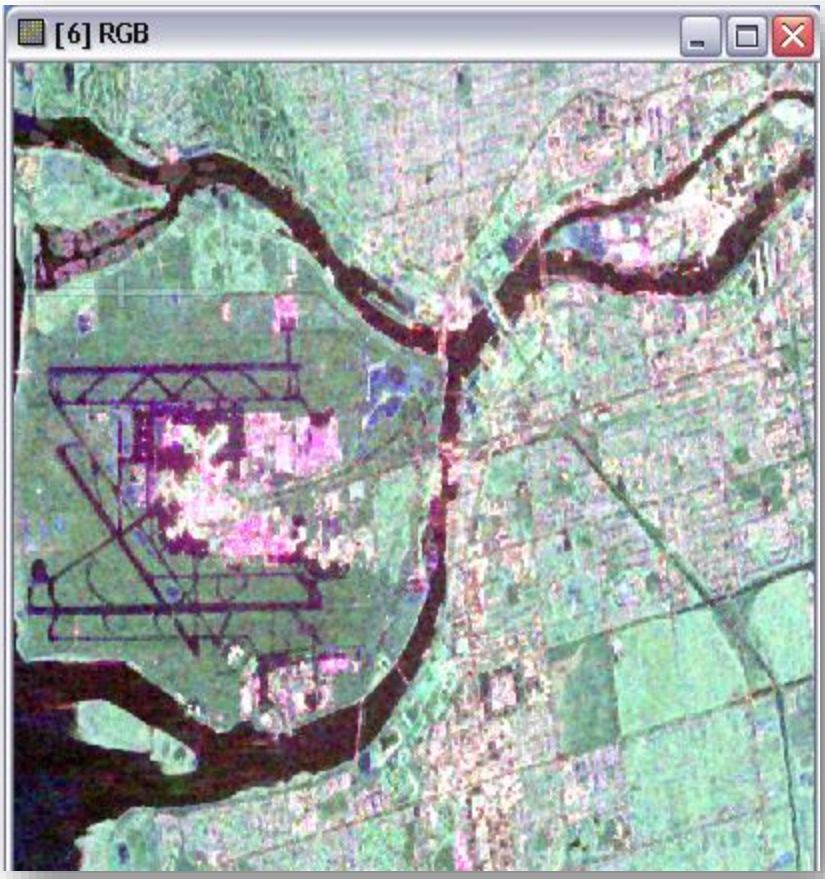


Exporting an RGB Image to bmp, jpg, png

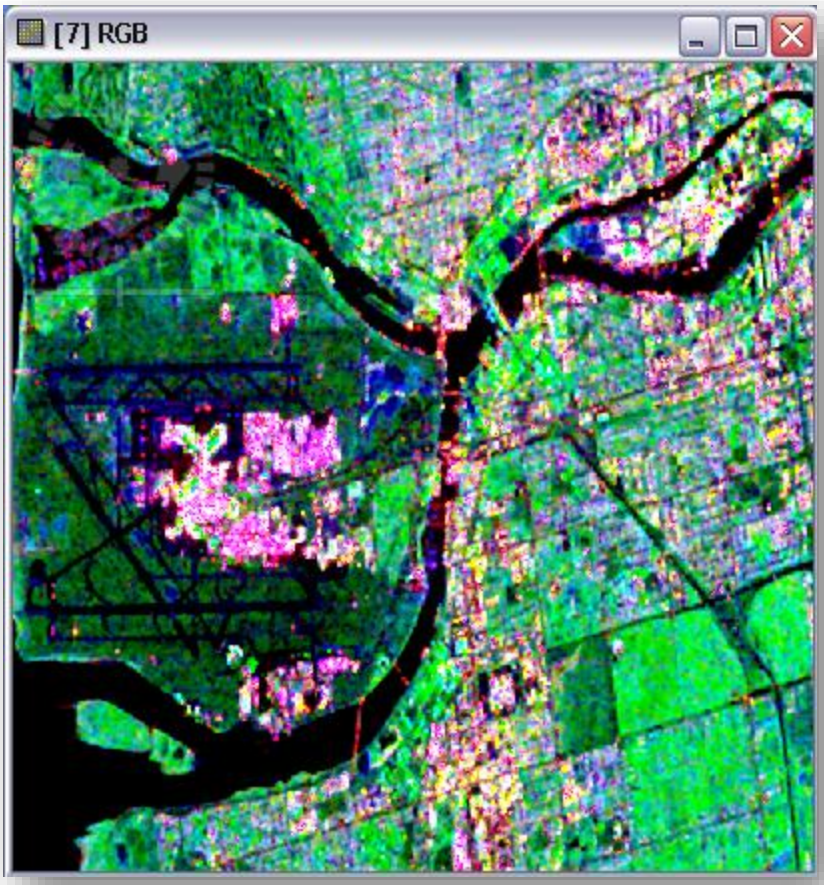
Step 11 - Produce all other Decompositions: Using the speckle filtered T3 as input, repeat the decomposition processing for all other decompositions and compare the results.



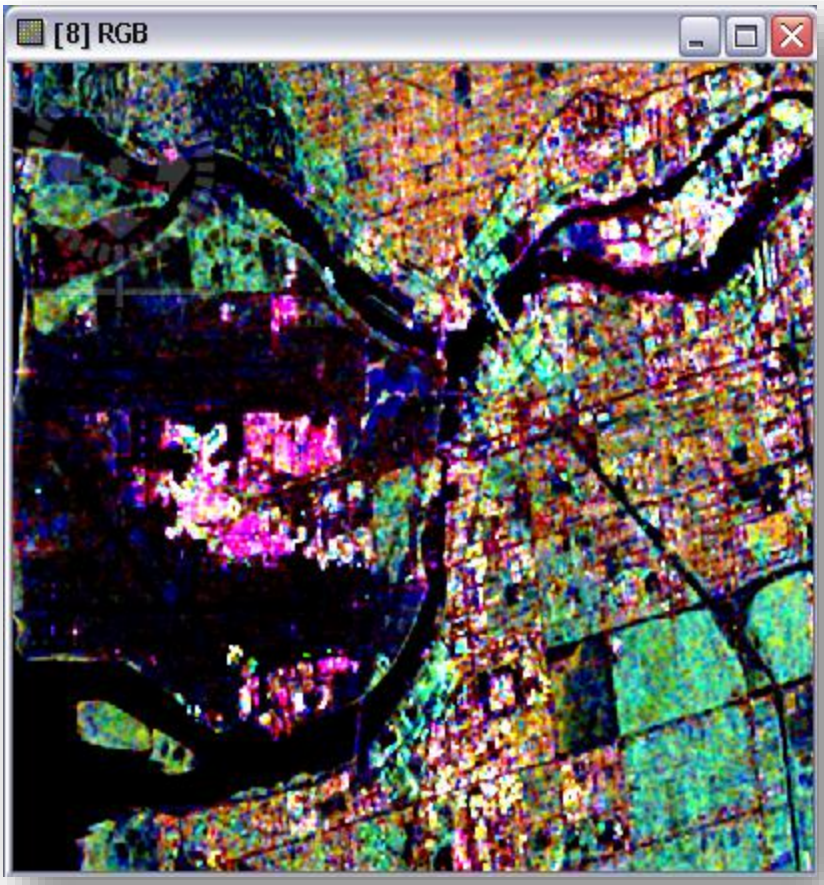
Sinclair Decomposition



Pauli Decomposition

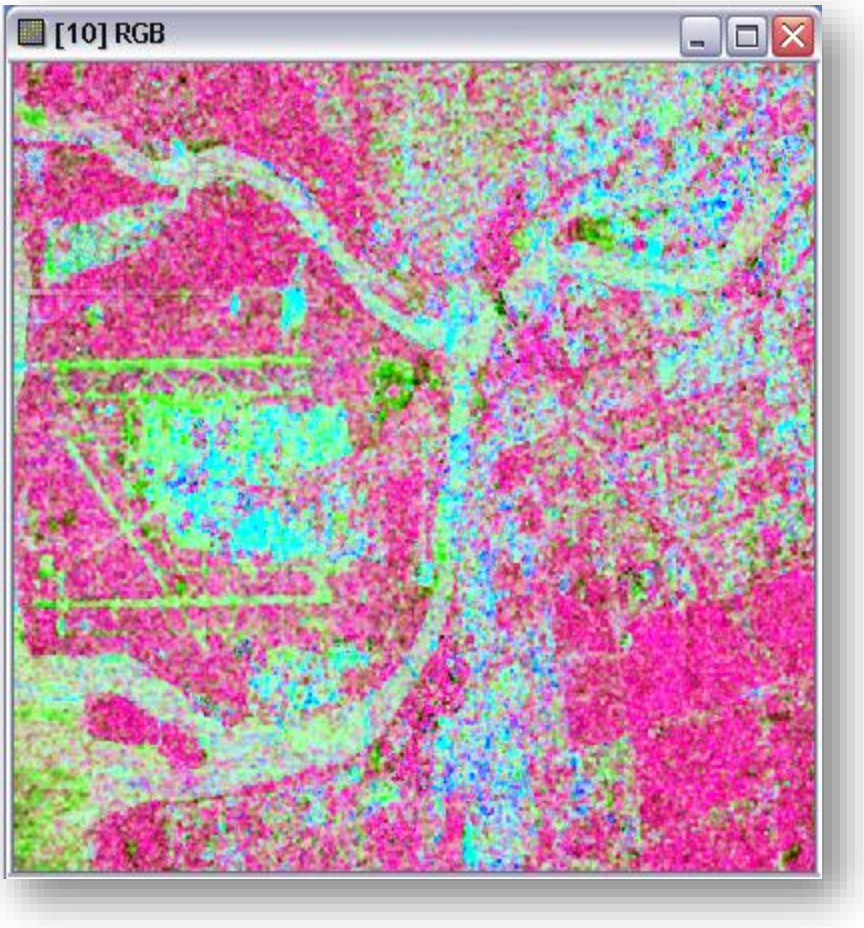


Yamaguchi Decomposition



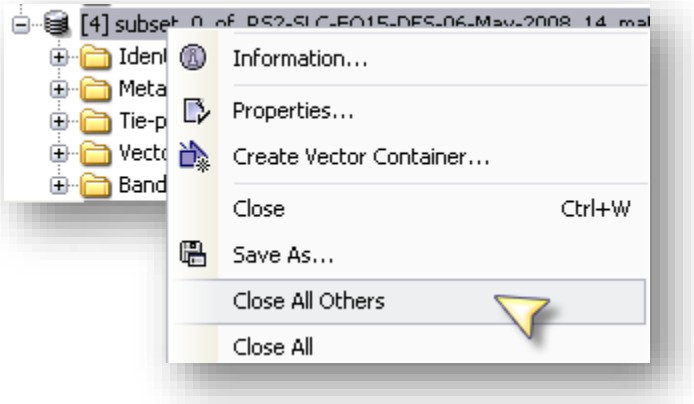
Van Zyl Decomposition

Cloude Decomposition



H-a-Alpha Decomposition

To clean up your **Products View**, you may now right-click on the **speckle filtered T3** product and from the pop-up menu select **Close All Others** to close all other products and leave only the **speckle filtered T3** opened.



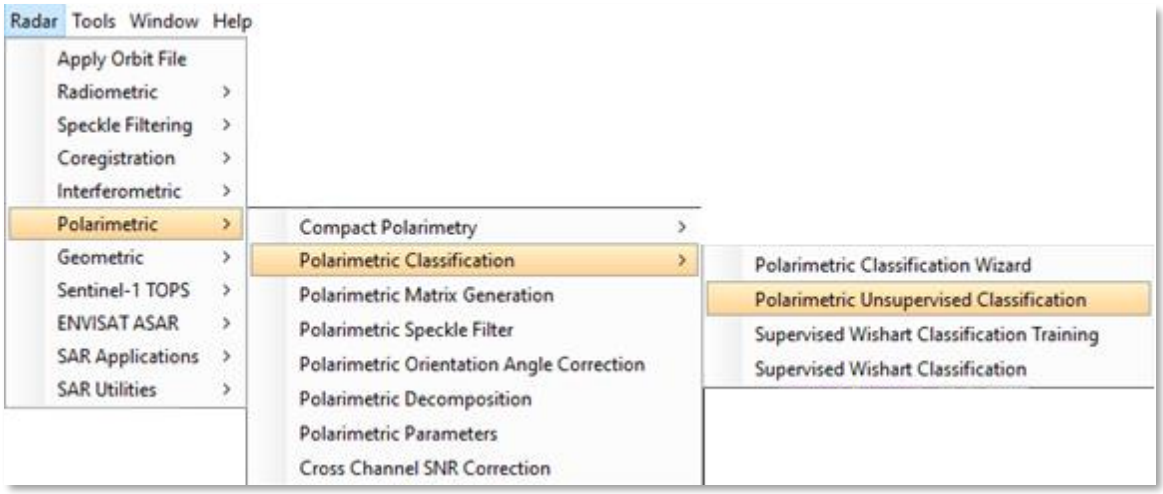
Cleaning up Products View

Unsupervised Polarimetric Classification

Using the **speckle filtered T3** product as input, you will now process the unsupervised polarimetric classification to group similar pixels into classes.

Unsupervised classification does not rely on user specified classes to be matched. Instead, it automatically determines what classes exist in the data and how best each pixel can be grouped.

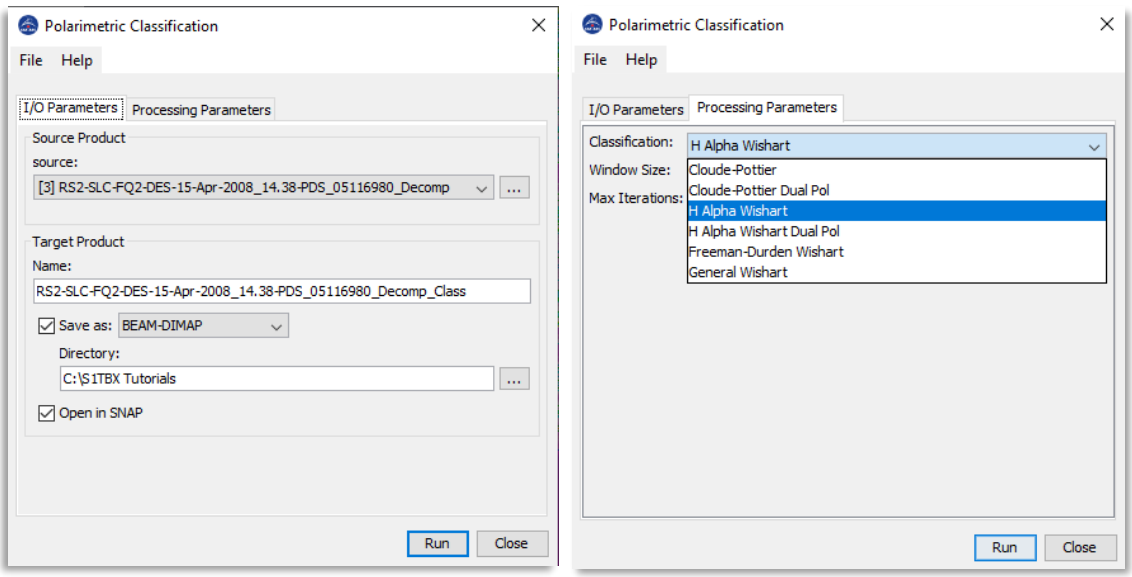
Step 12 - Apply unsupervised classification: Using the **T3 speckle filtered** product as input, select **Polarimetric Unsupervised Classification** from the **Polarimetric Classification** sub-menu.



Select Polarimetric Unsupervised Classification

In the **Processing Parameters** tab, select the **Wishart Classification**.

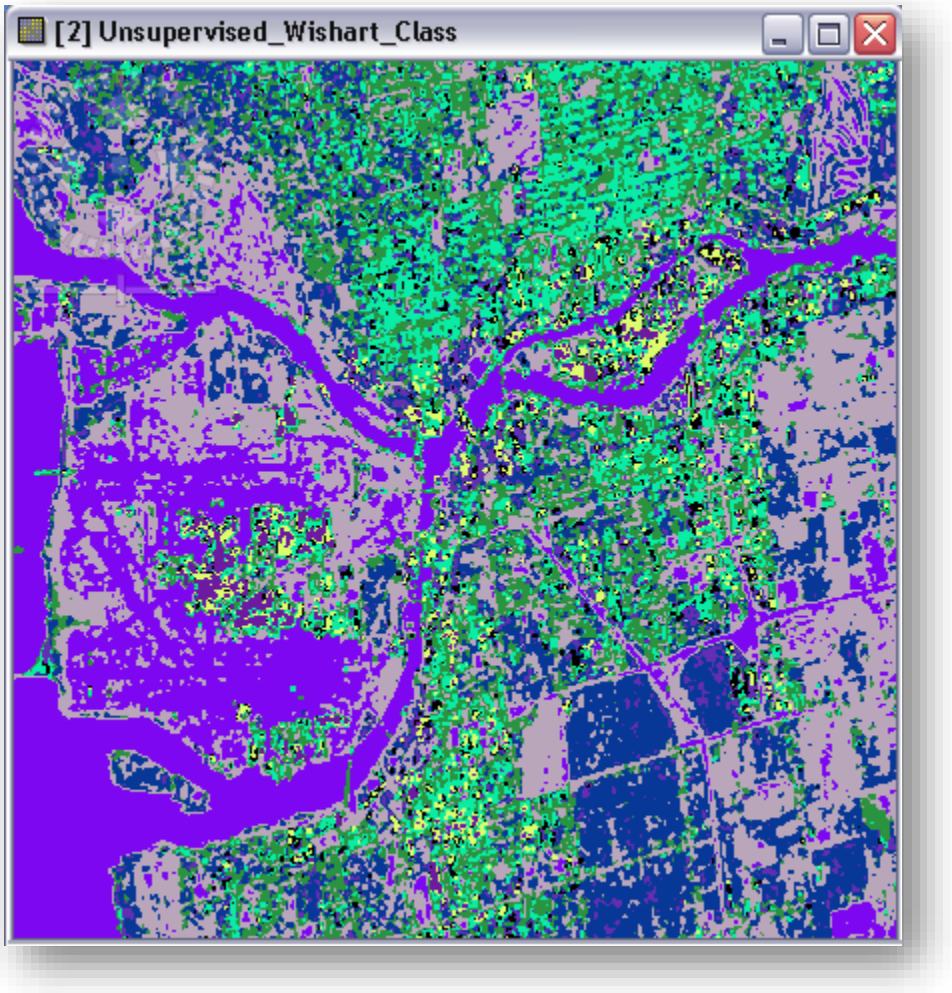
Press the **Help** button to call up the online help for further information.



Unsupervised Classification Dialog

Press **Run** to begin processing.

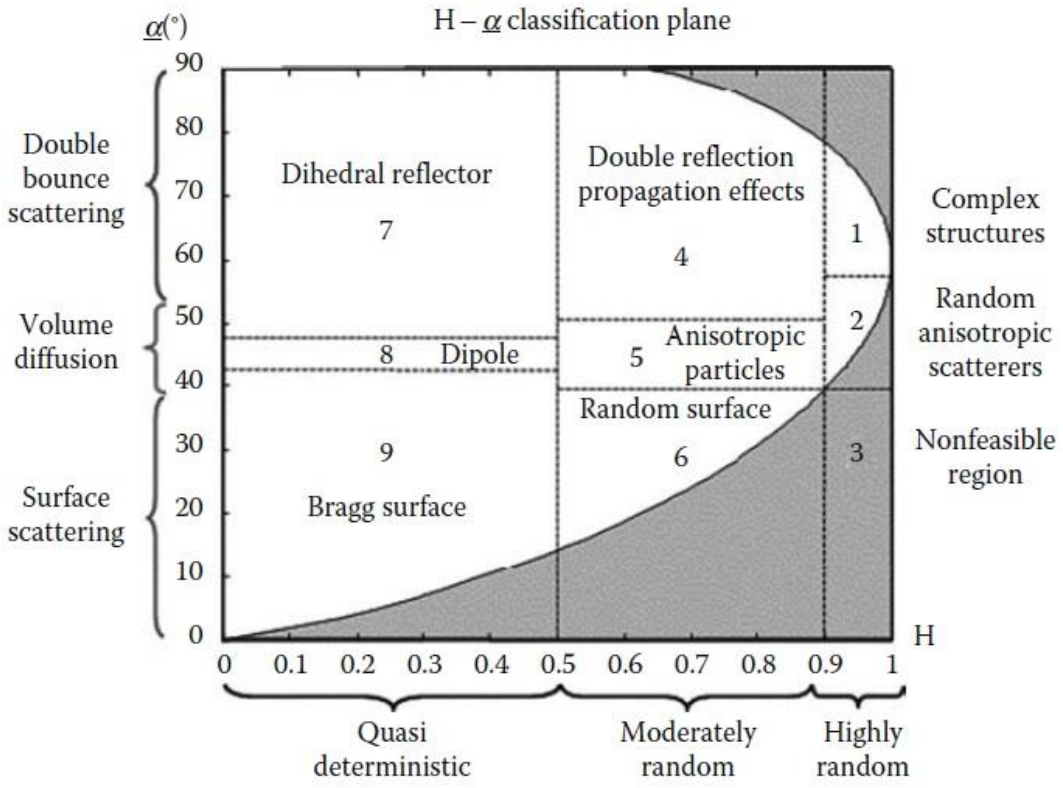
When the processing completes, your new classification results product will have a single band with several regions each belonging to one of nine classes.



Unsupervised Wishart Classification

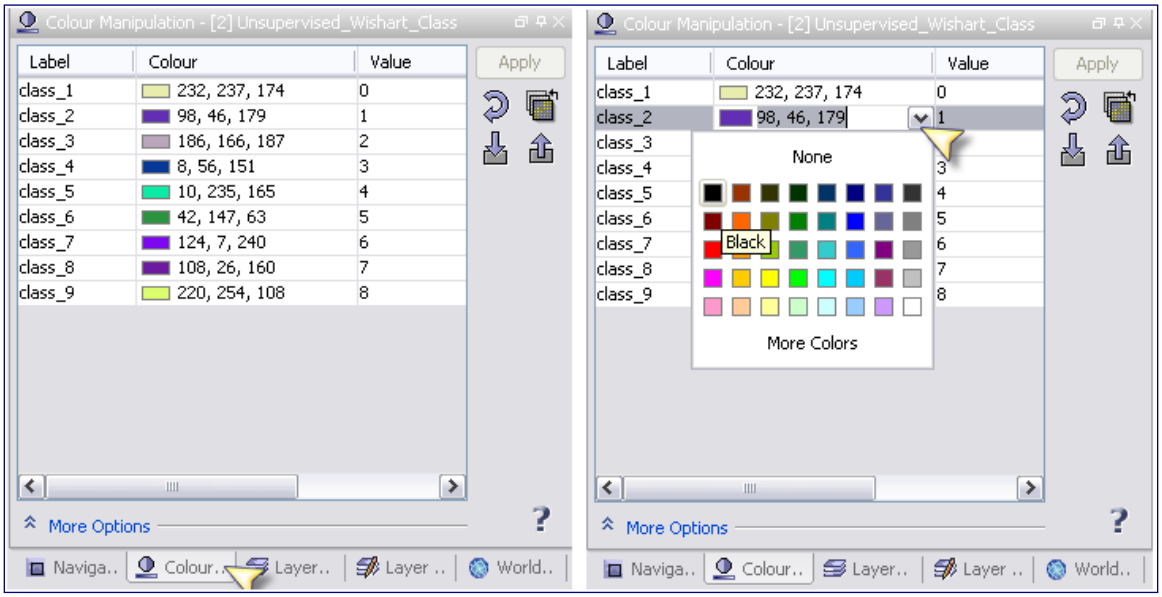
Both the Cloude-Pottier and the Wishart classifiers are based on the use of the Entropy (H) / Alpha (α) plane. The Wishart classifier will continue to compute the centres of the nine clusters, and then reclassify the pixels based on their Wishart distances to cluster centres.

The classes can be interpreted according to the H-α classification plane.



H-α Classification Plane

You may change the default colours for each class within the colour manipulation tool window. Use the pull-down control on the colour to select a new colour. Use the export and import buttons on the right-hand side to save and load colour look-up tables.



Colour Manipulation Tool Window

For more tutorials visit the Sentinel Toolboxes website

http://step.esa.int/main/doc/tutorials/

Send comments to the SNAP Forum

http://forum.step.esa.int/