

# SENTINEL-1 Toolbox

## SAR Basics Tutorial

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# SAR Basics Tutorial

The goal of this tutorial is to provide novice and experienced remote sensing users with step-by-step instructions on working with SAR data with the Sentinel-1 Toolbox.

For further details on operator parameters and algorithmic descriptions, please refer to the online help available within the software.

In this tutorial you will calibrate, multilook, speckle filter, and terrain correct SAR data products.

## Sample Data

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

- [ftp://rsat2:yvr578MM@ftp.mda.ca/Vancouver\\_Dataset](ftp://rsat2:yvr578MM@ftp.mda.ca/Vancouver_Dataset)

For this tutorial, we will use the Vancouver Fine Quad2 SLC 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 and unzip the **Vancouver\_R2\_FineQuad2\_HH\_VV\_HV\_VH\_SLC** product.

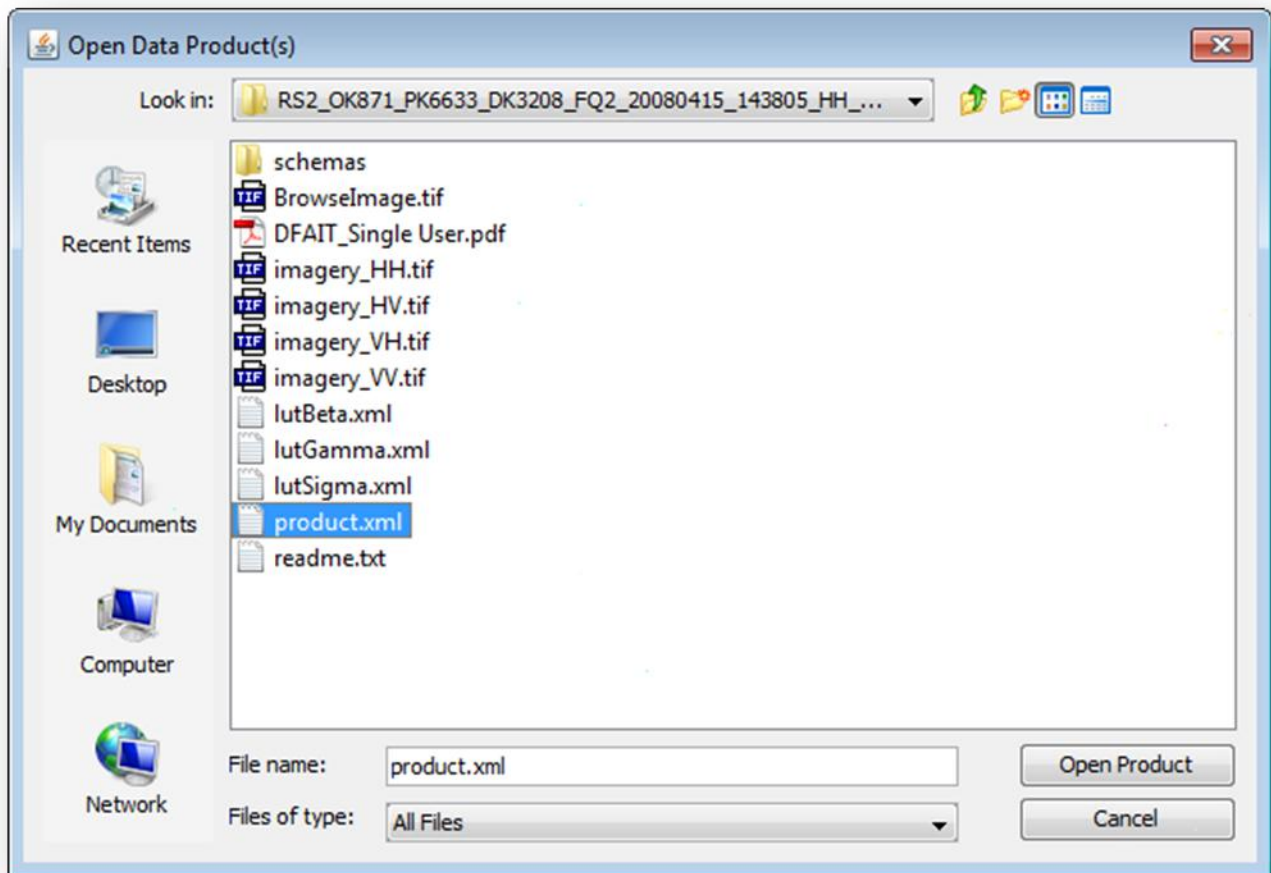
RADARSAT-2 data and products are copyright MacDonald, Dettwiler and Associates.

## Open a Product

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

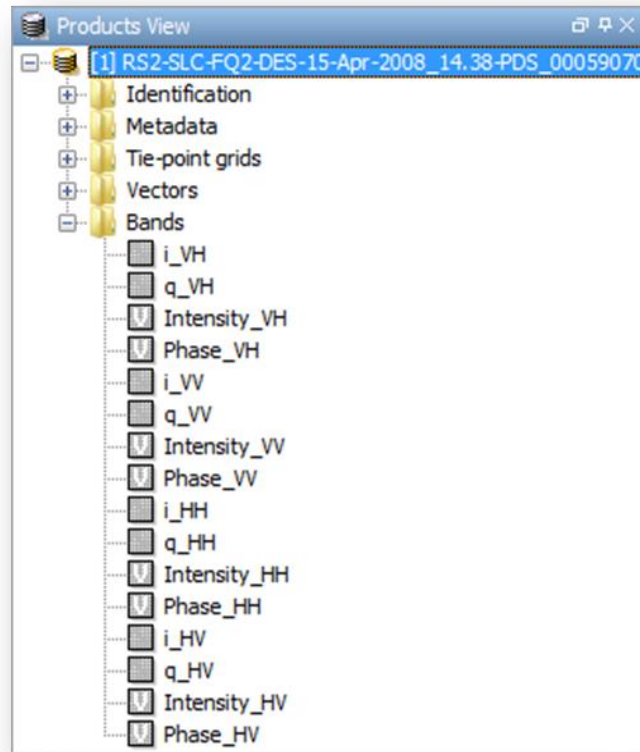
Select the **product.xml** file and press **Open Product**.

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.



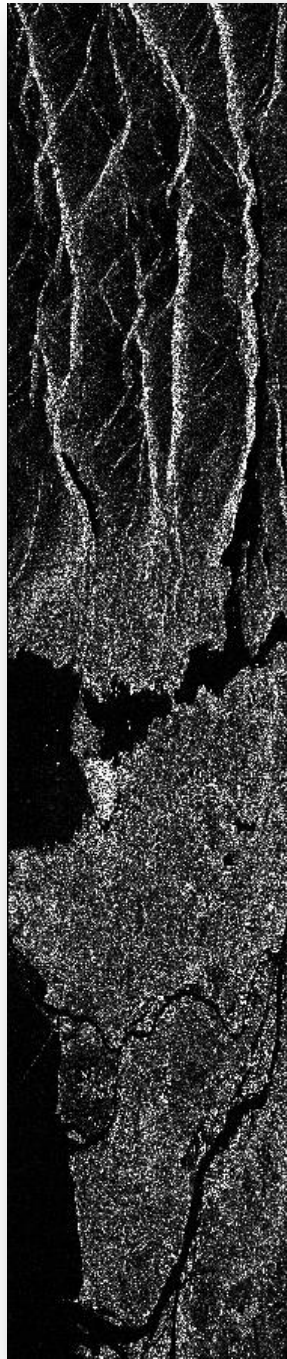
### Open the product.xml

In the **Products View** you will see the opened products. Each product consists of metadata and raster bands and may contain support information such as tie point grids or vector data.



### Products View

Double-click on the **Intensity\_VH** band to view the raster data.



### **Intensity\_VH Band**

The product is a RADARSAT-2 Single Look Complex (SLC) data product. It is a slant range image containing complex data that has not been multilooked.

The image can appear stretched in the azimuth direction (y axis) and contains a lot of noise.

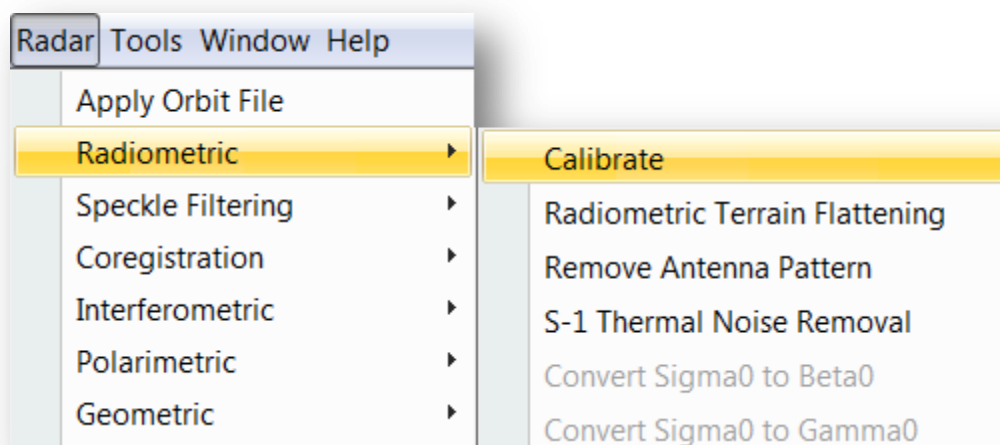
## Calibrating the Data

To properly work with the SAR data, the data should first be calibrated. This is especially true when preparing data for mosaicking where you could have several data products at different incidence angles and relative levels of brightness.

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

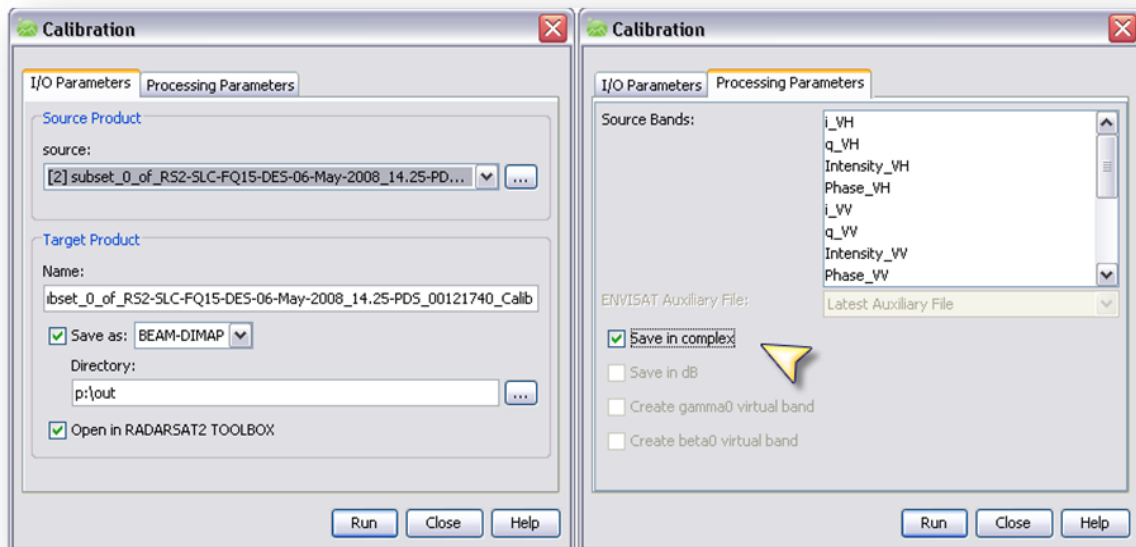
The corrections that get applied during calibration are mission-specific, therefore the software will automatically determine what kind of input product you have and what corrections need to be applied based on the product's metadata. Calibration is essential for quantitative use of SAR data.

**Step 2 - Calibrate the product:** From the **Radar** menu, go to **Radiometric** 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. Uncheck 'Save in complex' so that the calibration operator will produce a single Sigma0 band per real and imaginary pair. You would want to calibrate and keep the data as complex values when performing polarimetric processing.

### Multilooking

Multilook processing can be used to produce a product with nominal image pixel size.

Multiple looks may be generated by averaging over range and/or azimuth resolution cells improving radiometric resolution but degrading spatial resolution.

As a result, the image will have less noise and approximate square pixel spacing after being converted from slant range to ground range.

Multilooking can be an optional step since it is not necessary when terrain correcting an image.

**Single Look Complex**

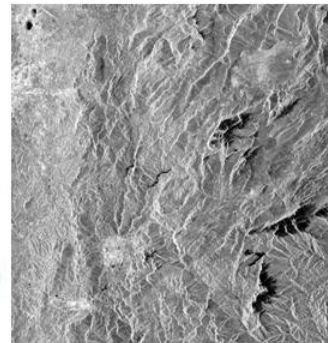
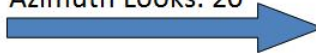
Range Looks: 1  
Azimuth Looks: 1

Range Spacing: 7.8 m  
Azimuth Spacing: 4.0 m

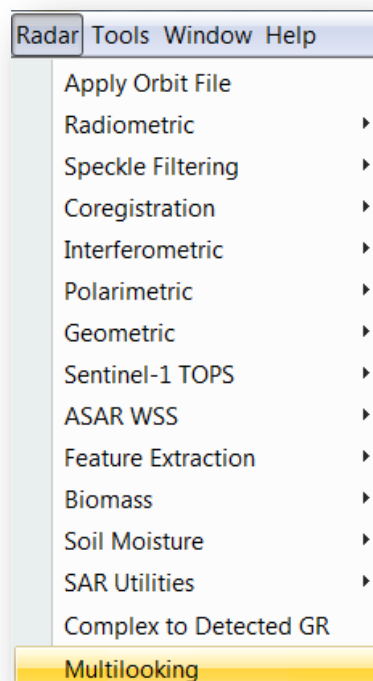
**Multilooked**

Range Looks: 4  
Azimuth Looks: 20

Range Spacing: 31.2 m  
Azimuth Spacing: 80.0 m

**Multilooking an SLC Product**

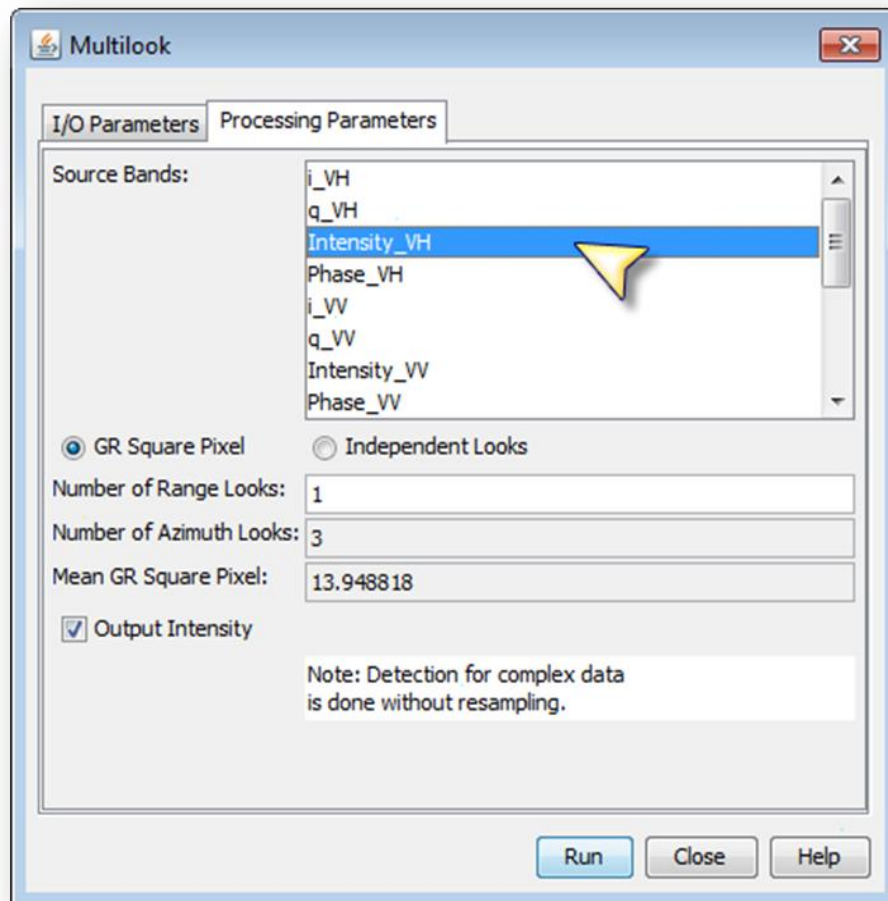
**Step 3 - Multilook the Intensity\_VH band:** From the **Radar** menu, select **Multilooking**.

**Select Multilooking**

In the **Multilook** dialog, select the **Intensity\_VH** band to only produce an output for this band.



Specify the number of range looks while the number of azimuth looks is computed based on the ground range spacing and the azimuth spacing.



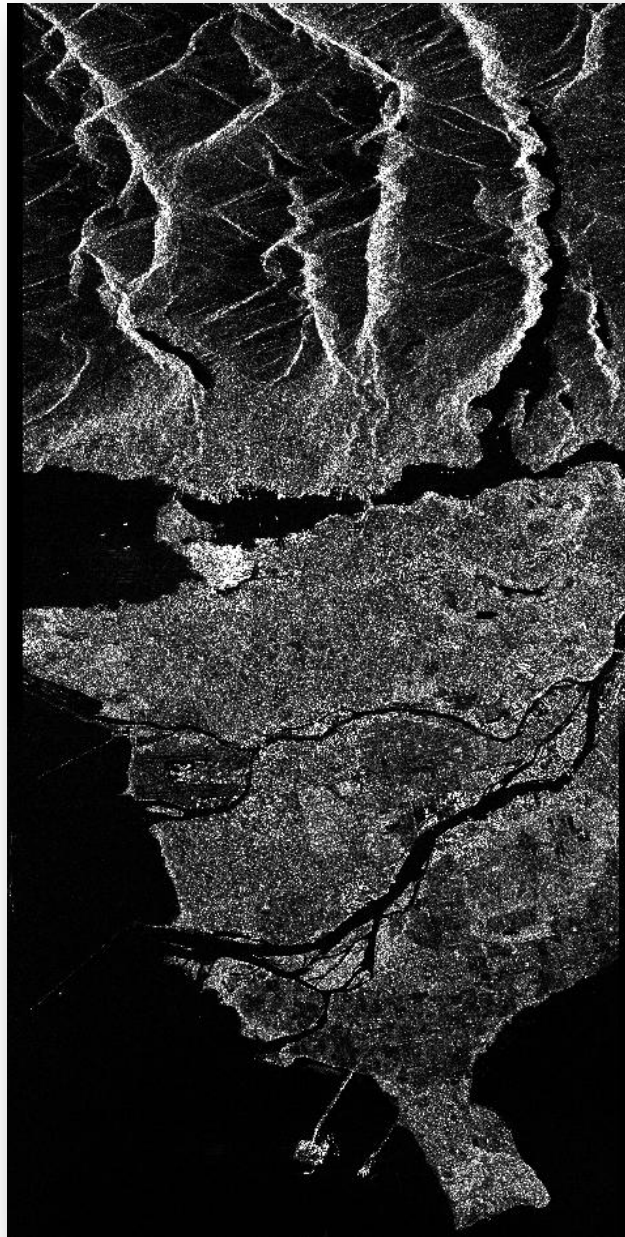
### Select Intensity\_VH band

Multilooking will produce a ground range square pixel using 1 look in range and 3 looks in azimuth. The resulting mean ground range pixel size will be 13.95 m.

Press **Run** to begin processing.

When complete, a new product will be created and will be available in the **Products View**.

In the new product, open the **Intensity\_VH** band.



**Multilooked Intensity\_VH Band**

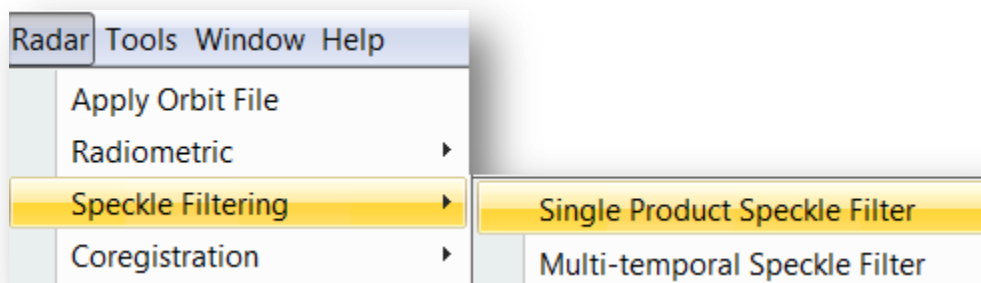
The image now looks more proportional; however, it remains with a lot of noise.

### ***Speckle Reduction***

Speckle is caused by random constructive and destructive interference resulting in salt and pepper noise throughout the image.

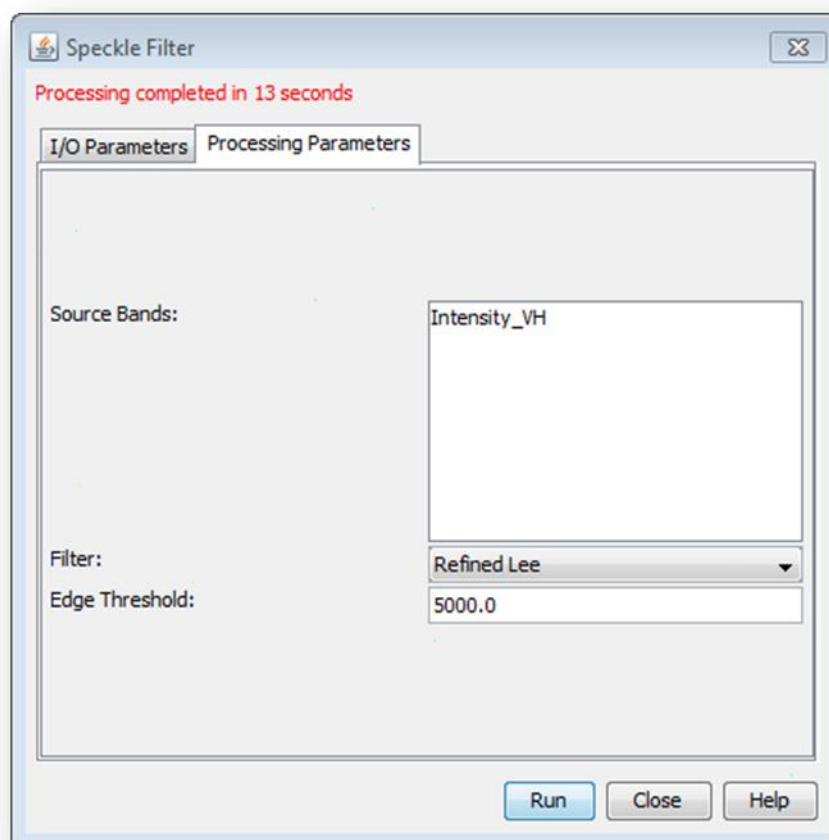
Speckle filters can be applied to the data to reduce the amount of speckle at the cost of blurred features or reduced resolution.

**Step 3 - Speckle Filtering:** Select the multilooked product and then select **Speckle Filtering/Single Product Speckle Filter** from the **Radar** menu.



### Select Single Product Speckle Filtering

From the **Speckle Filtering** dialog, select the **Refined Lee** speckle filter. The Refined Lee filter averages the image while preserving edges.



### Select Refined Lee

Press **Run** to process.

Open the newly created speckle filtered product.



### **Speckle Filtered Result**

The final processing which we will perform on this product will be to terrain correct.

## Terrain Correction

Terrain Correction will geocode the image by correcting SAR geometric distortions using a digital elevation model (DEM) and producing a map projected product.

Geocoding converts an image from Slant Range or Ground Range Geometry into a Map Coordinate System. Terrain Geocoding involves using a Digital Elevation Model (DEM) to correct for inherent SAR geometry effects such as **foreshortening**, **layover** and **shadow**.

### Foreshortening

- The period of time a slope is illuminated by the transmitted pulse of the radar energy determines the length of the slope on radar imagery.
- This results in shortening of a terrain slope on radar imagery in all cases except when the local angle of incidence ( $\theta$ ) is equal to  $90^\circ$ .

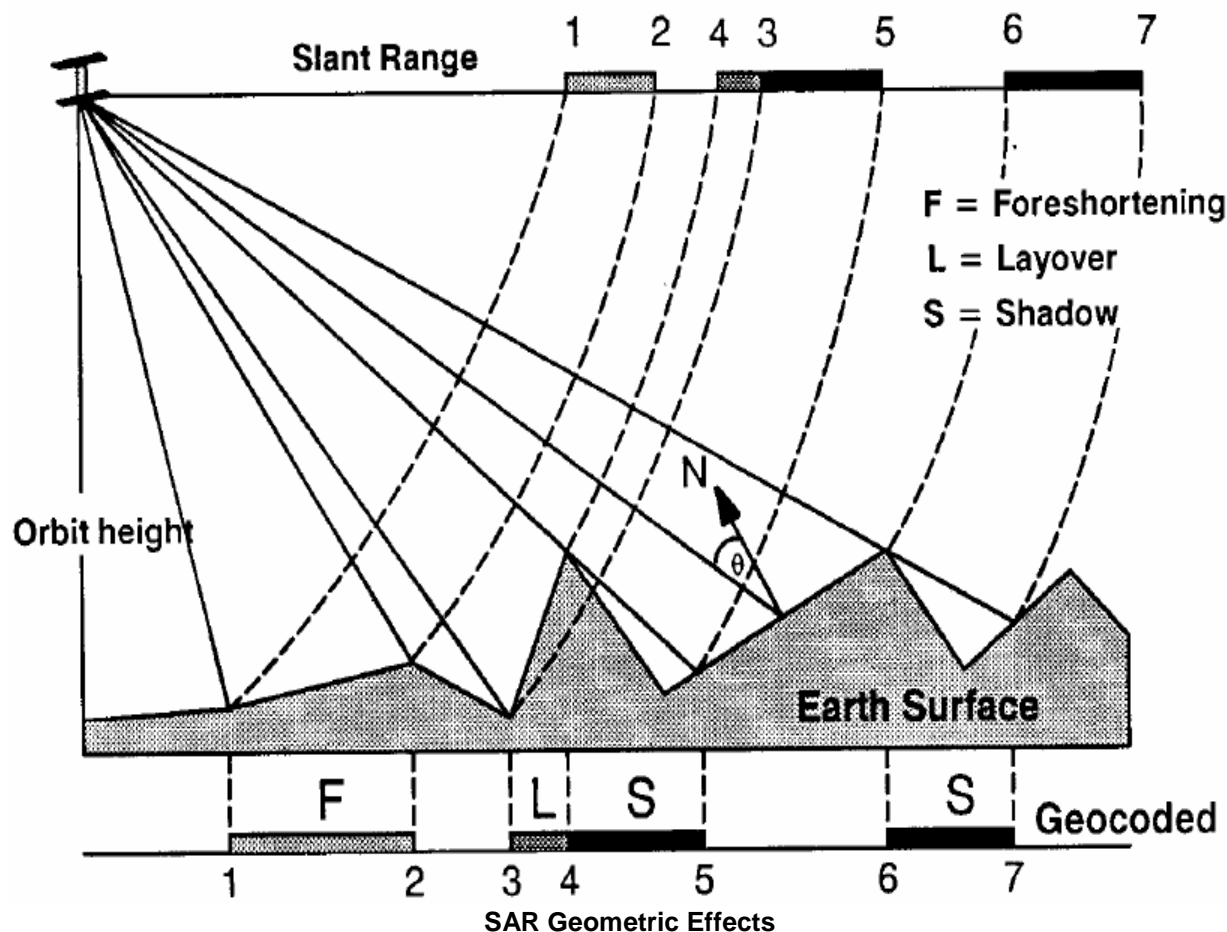
### Layover

- When the top of the terrain slope is closer to the radar platform than the bottom the former will be recorded sooner than the latter.
- The sequence at which the points along the terrain are imaged produces an image that appears inverted.
- Radar layover is dependant on the difference in slant range distance between the top and bottom of the feature.

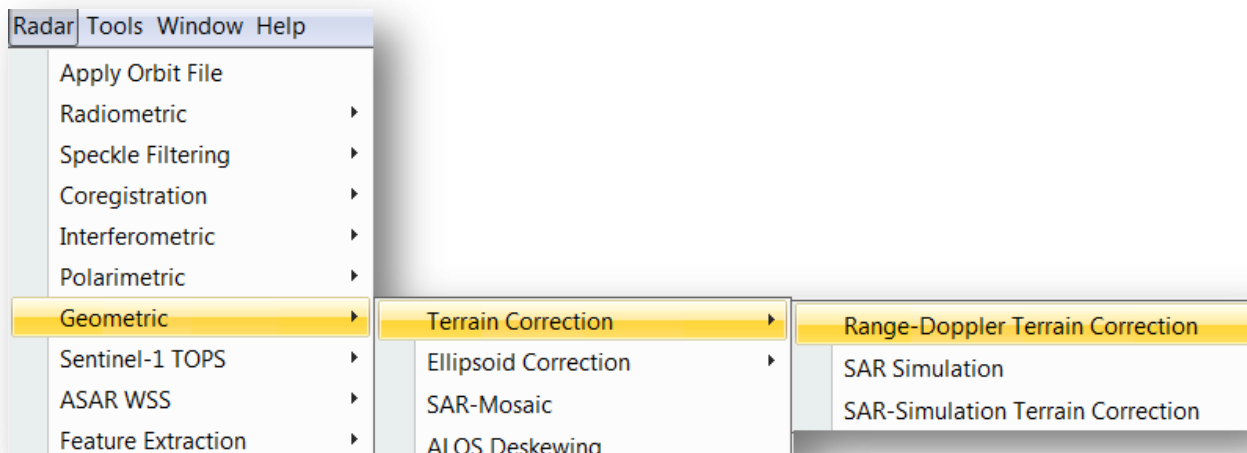
### Shadow

- The back-slope is obscured from the imaging beam causing no return area or radar shadow.

The effects of these distortions can be seen below. The distance between 1 and 2 can appear shorter than it should and the return for 4 can occur before the return for 3 due to the elevation.



**Step 4 - Terrain Correction:** Select the multilooked and speckle filtered product and then select **Range-Doppler Terrain Correction** from the **SAR Processing/Geometric** menu.

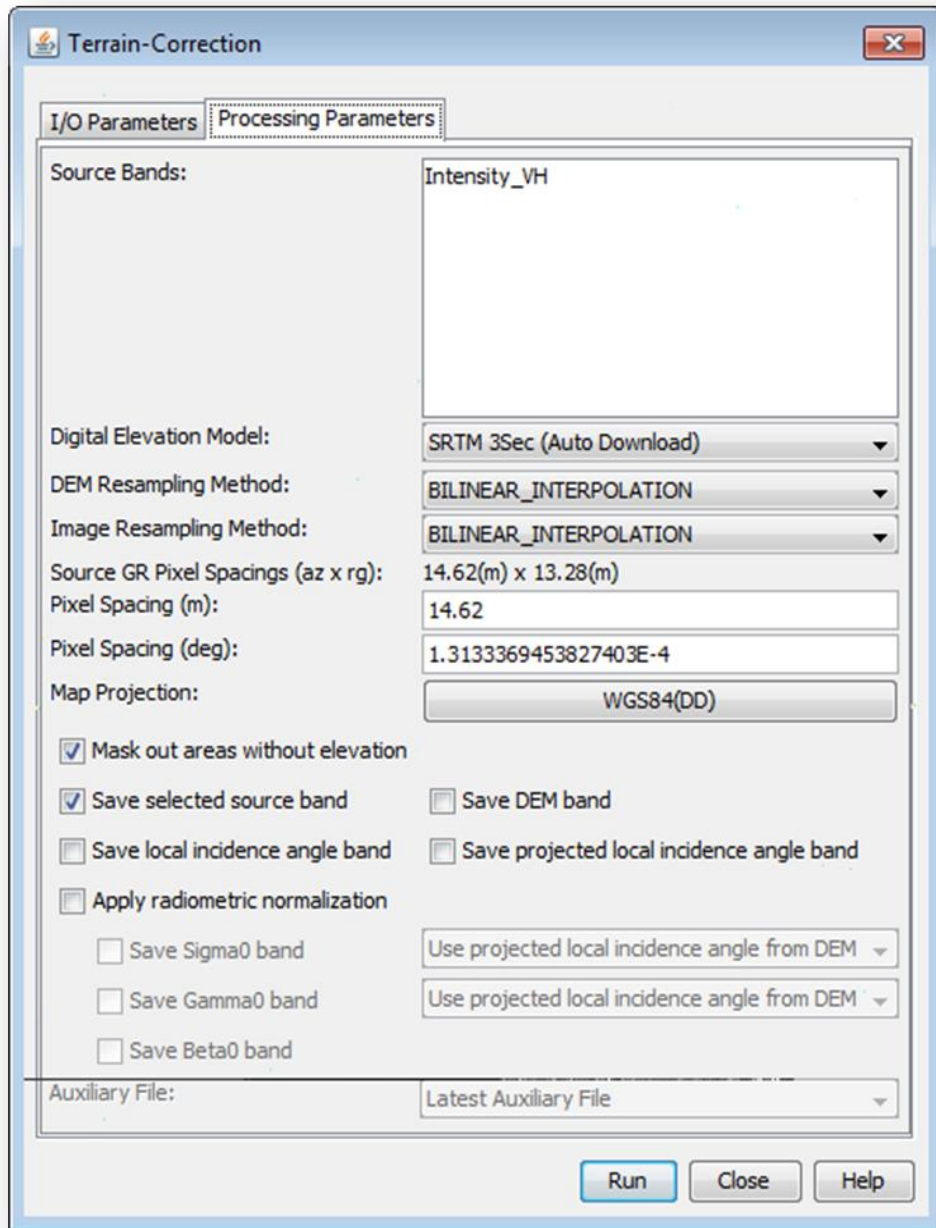


#### Select Range-Doppler Terrain Correction

By default, the terrain correction will use the SRTM 3 sec DEM. The software will automatically determine the DEM tiles needed and download them automatically from internet servers.

The default output map projection is Geographic Latitude/Longitude.





The image shows a software dialog box titled "Terrain-Correction". It has two tabs: "I/O Parameters" and "Processing Parameters". The "Processing Parameters" tab is active. The dialog contains several input fields and checkboxes. The "Source Bands" field is set to "Intensity\_VH". The "Digital Elevation Model" is set to "SRTM 3Sec (Auto Download)". The "DEM Resampling Method" and "Image Resampling Method" are both set to "BILINEAR\_INTERPOLATION". The "Source GR Pixel Spacings (az x rg)" is set to "14.62(m) x 13.28(m)". The "Pixel Spacing (m)" is set to "14.62". The "Pixel Spacing (deg)" is set to "1.3133369453827403E-4". The "Map Projection" is set to "WGS84(DD)". There are several checkboxes: "Mask out areas without elevation" (checked), "Save selected source band" (checked), "Save local incidence angle band" (unchecked), "Apply radiometric normalization" (unchecked), "Save DEM band" (unchecked), "Save projected local incidence angle band" (unchecked), "Save Sigma0 band" (unchecked), "Save Gamma0 band" (unchecked), and "Save Beta0 band" (unchecked). There are also two dropdown menus for "Use projected local incidence angle from DEM". The "Auxiliary File" is set to "Latest Auxiliary File". At the bottom, there are three buttons: "Run", "Close", and "Help".

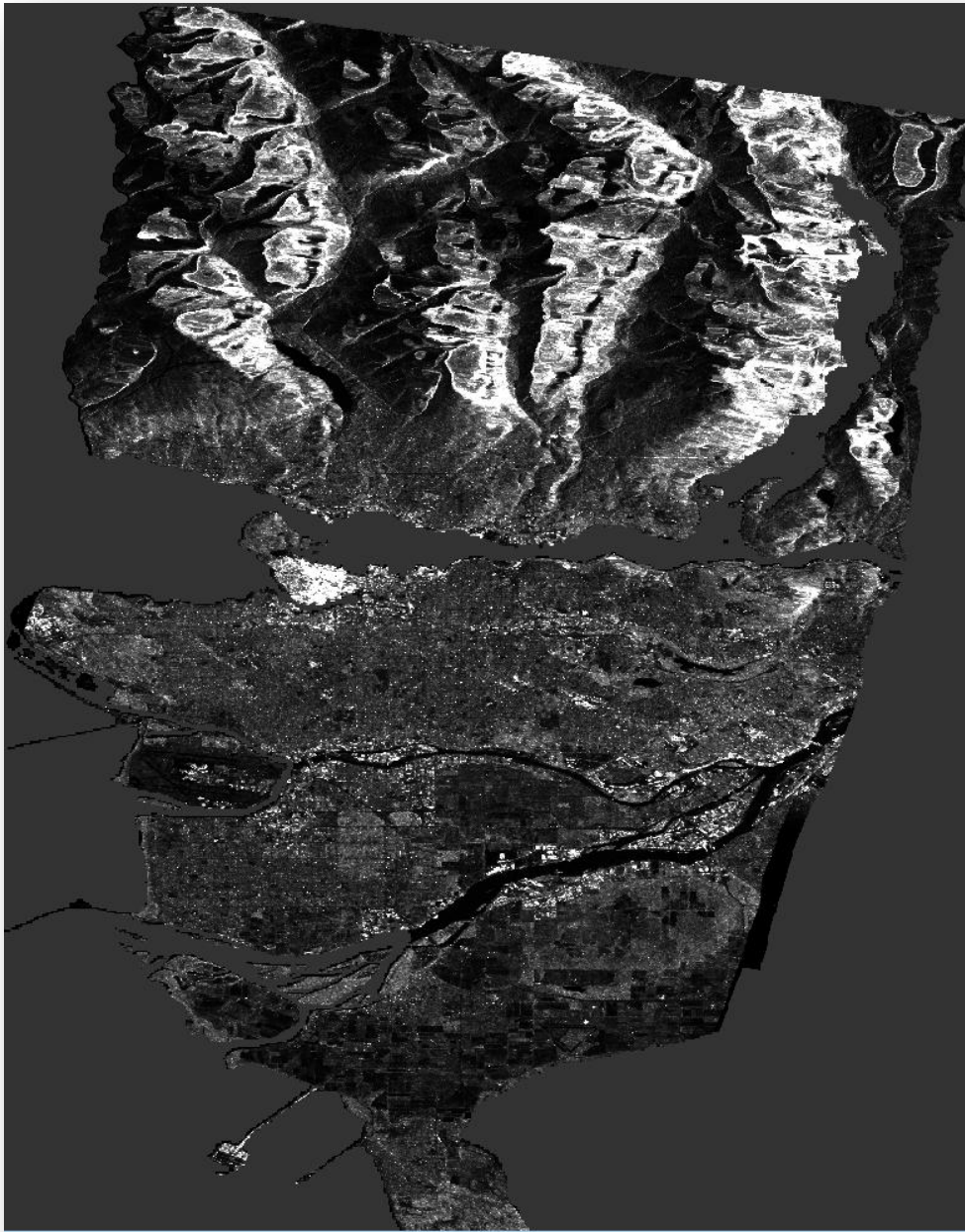
Source Bands:	Intensity_VH
Digital Elevation Model:	SRTM 3Sec (Auto Download)
DEM Resampling Method:	BILINEAR_INTERPOLATION
Image Resampling Method:	BILINEAR_INTERPOLATION
Source GR Pixel Spacings (az x rg):	14.62(m) x 13.28(m)
Pixel Spacing (m):	14.62
Pixel Spacing (deg):	1.3133369453827403E-4
Map Projection:	WGS84(DD)
<input checked="" type="checkbox"/> Mask out areas without elevation	
<input checked="" type="checkbox"/> Save selected source band	<input type="checkbox"/> Save DEM band
<input type="checkbox"/> Save local incidence angle band	<input type="checkbox"/> Save projected local incidence angle band
<input type="checkbox"/> Apply radiometric normalization	
<input type="checkbox"/> Save Sigma0 band	Use projected local incidence angle from DEM
<input type="checkbox"/> Save Gamma0 band	Use projected local incidence angle from DEM
<input type="checkbox"/> Save Beta0 band	
Auxiliary File:	Latest Auxiliary File

Run Close Help

**Terrain Correction Dialog**

Press **Run** to process.

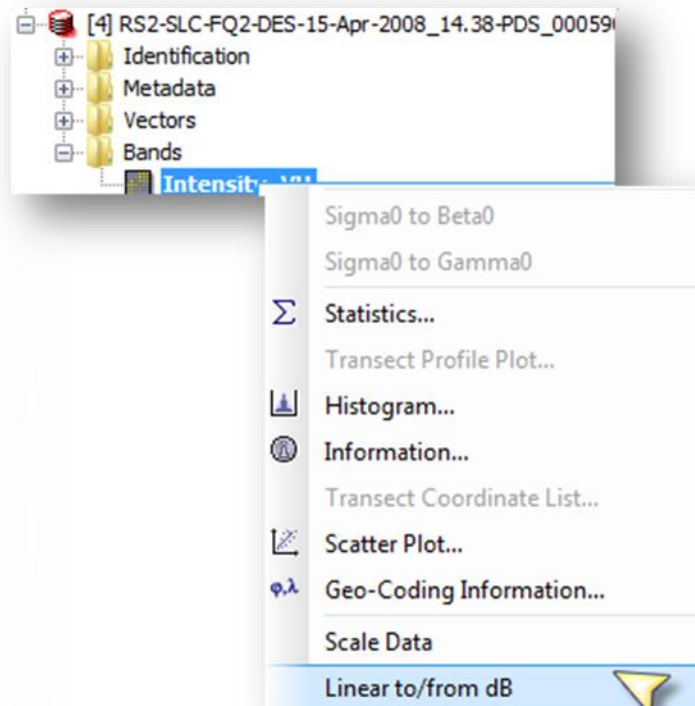
Open the terrain corrected product.



**Terrain Corrected Image**

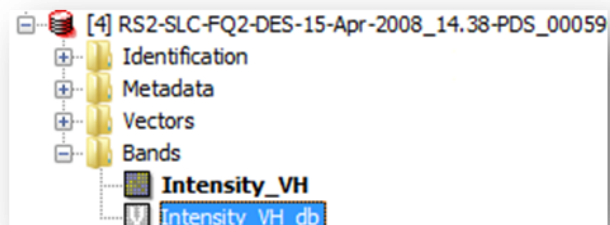
To view the image in decibel scaling, right-click on the terrain corrected **Intensity\_VH** band and select **Linear to/from dB** to convert the data using a virtual band.





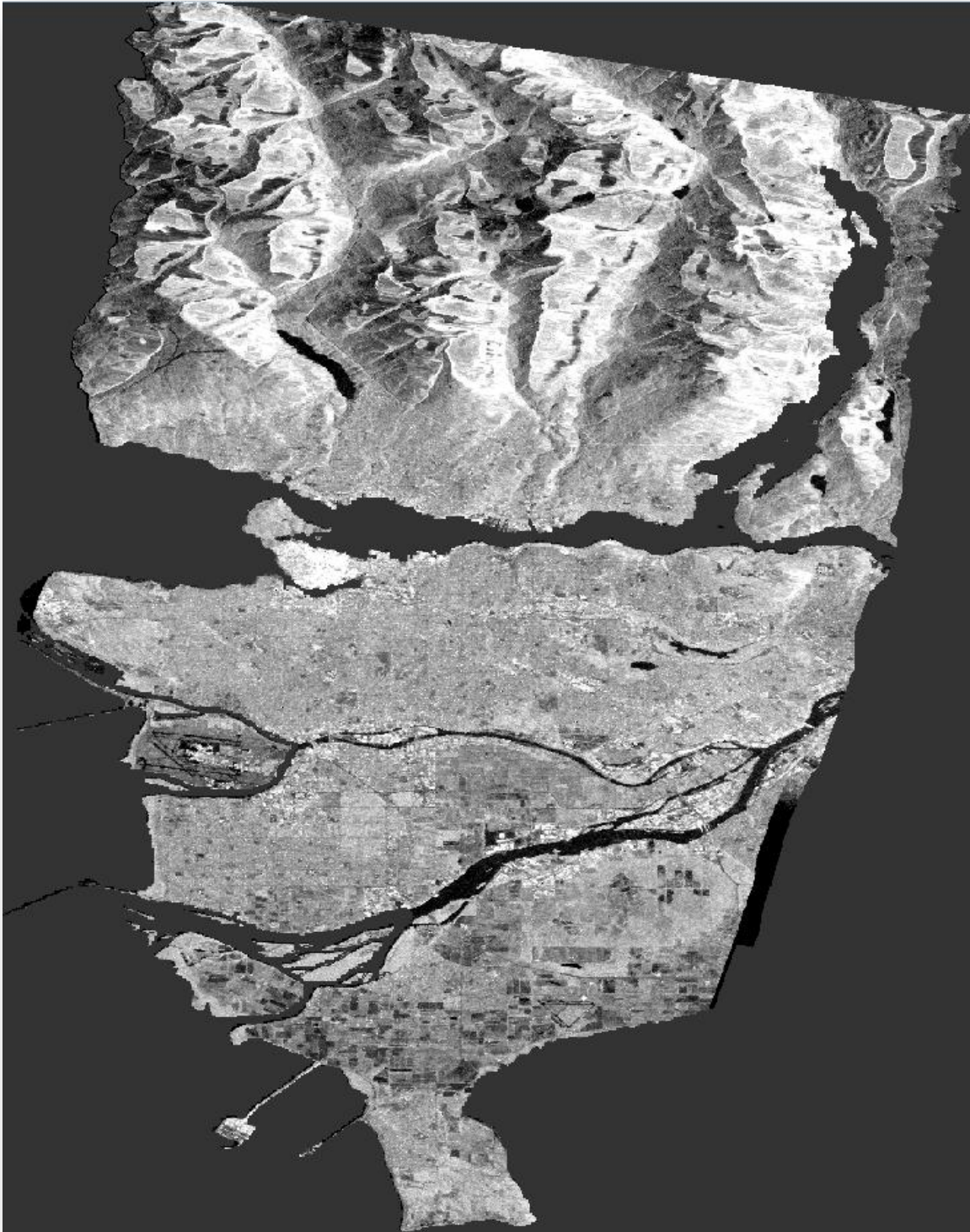
### Select Linear to/from dB

A new virtual band will be created with the expression  $10 \cdot \log_{10}(\text{Intensity\_VH})$ .

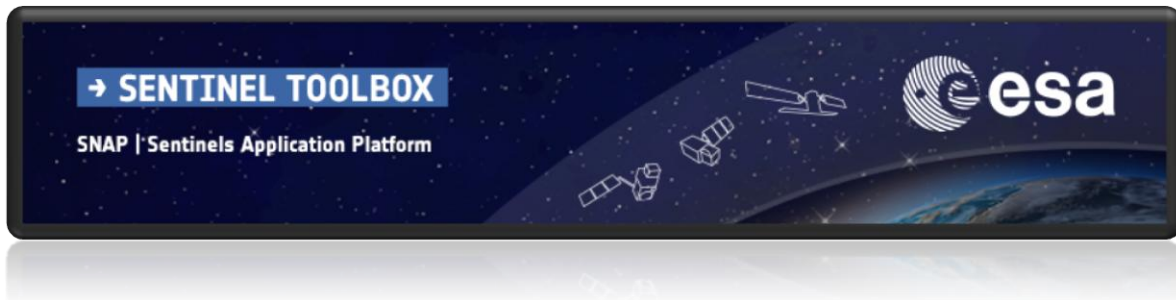


### New Intensity\_VH\_dB band

Double-click on the new **Intensity\_VH\_dB** band to open it.



**Terrain Corrected Band in dB**



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/>