

# Practical Session:

## Combining Backscatter and coherence information from Sentinel-1

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ESA Summer School 2016  
ESA-Esrin, Frascati, Rome

# Objective

To show how processing a pair (12 days apart) of Sentinel-1 TOPS SLC DV images to derive and combine backscatter and coherence information.

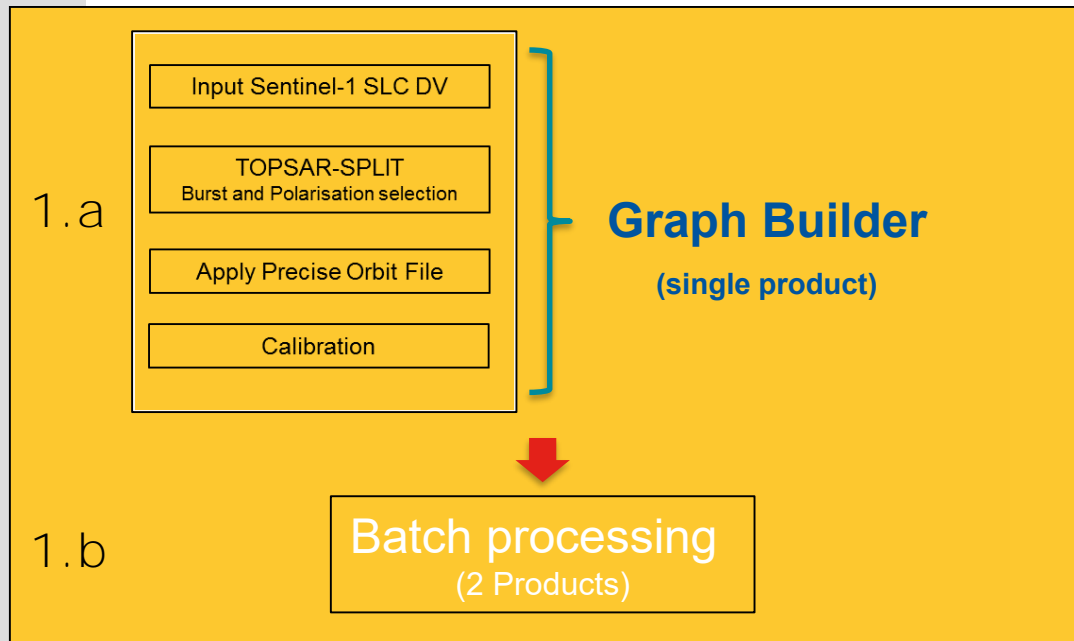
In particular:

- 4 bursts with VV polarisation only will be exploited
- Exercise will use Graph Builder, Batch Processing, GUI
- SNAP version 4 used

# Processing Steps

0. Open a Sentinel-1 SLC product

GUI



# Processing Steps

2.

TOPSAR Coregistration

**Graph Builder**

3.

Coherence and backscatter  
stack generation

**Graph Builder**

4.

Multilooking

Subset

Terrain Correction

**GUI**

5.

Linear to db

Ratio 2May/12 May

RGB Backscatters and ratio

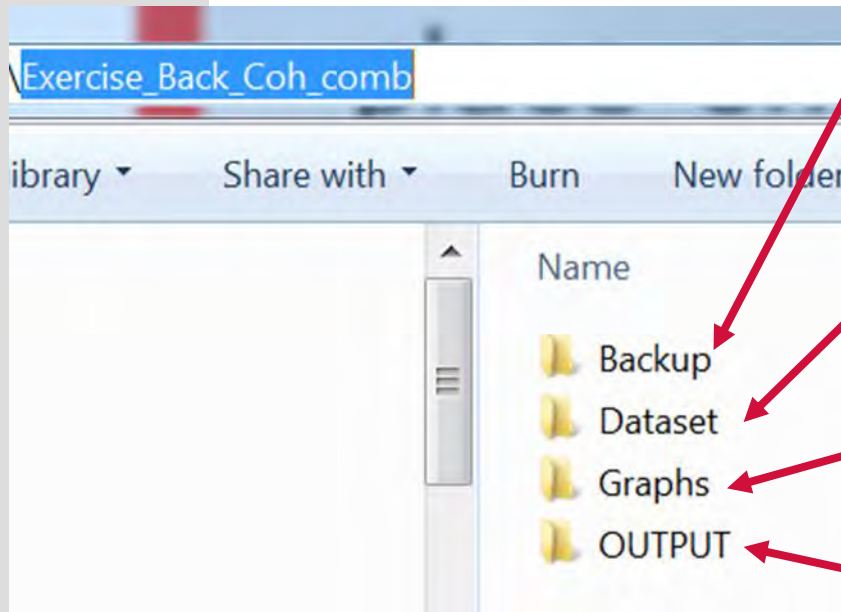
RGB Coherence and Backscatters

Export to Google Earth

**GUI**

} Analysis

# Exercise folders



*BACKUP folder with results and graphs*

*Dataset folder containing the input for the exercise*

*Folder where save the graphs*

*The OUTPUT of the exercise will be stored here*

# Dataset

ESA_SS2016 ▶ Dataset ▶		
Folder		
Name		Size
S1A_IW_SLC_1SDV_20160502T173116_20160502T173143_011083_010B11_C303.zip		4,616,242 KB
S1A_IW_SLC_1SDV_20160514T173120_20160514T173147_011258_0110A2_24ED.zip		4,598,009 KB

Product type: IW\_SLC\_1SDV

Acquisition mode: Interferometric wide swath

Product type: SLC

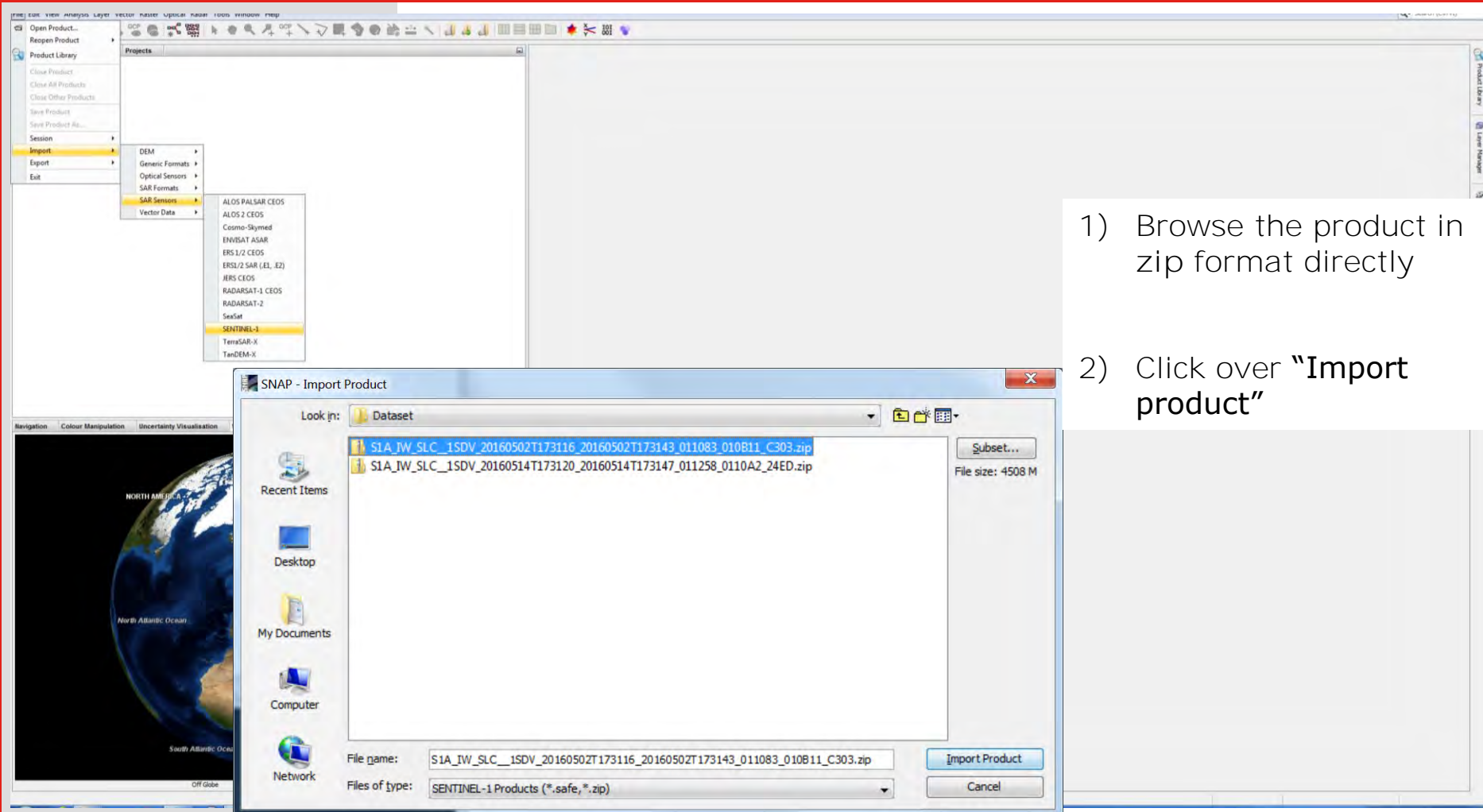
Polarisation: VV and VH

Orbit: Ascending

Location: Switzerland/France



# Step 0: Open product (02/05/2016)





# Inspecting the abstracted metadata

The screenshot displays the CATAPULT software interface, which is used for inspecting satellite metadata. The interface is divided into several panels:

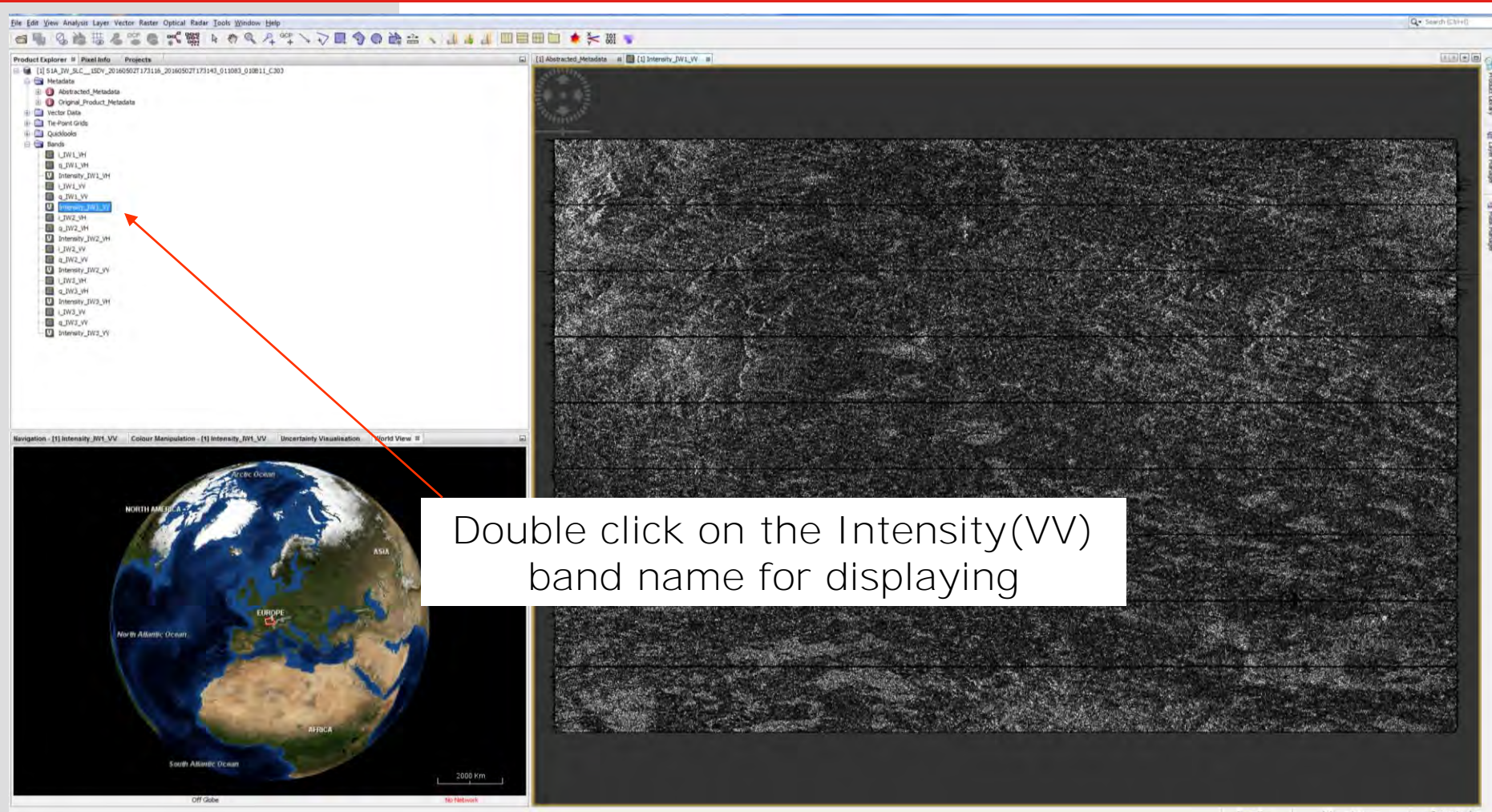
- Product Explorer (Left):** Shows a hierarchical tree of metadata categories. The 'Abstracted\_Metadata' category is selected, showing a list of metadata items including 'S1A\_IW\_SLC\_\_ISDV\_20160507T173118\_20160507T173143\_010811\_C03' and various intensity and vector data.
- Main Metadata Table (Center):** A table titled '[1] Abstracted\_Metadata' displaying a list of metadata items with their corresponding values, types, units, and descriptions. The table includes columns for Name, Value, Type, Unit, and Description.
- Globe Visualization (Bottom Left):** A 3D globe showing the Earth's surface, with labels for 'North America', 'Europe', 'Asia', 'Africa', 'North Atlantic Ocean', and 'South Atlantic Ocean'. A scale bar indicates 2000 Km.

The main metadata table contains the following data:

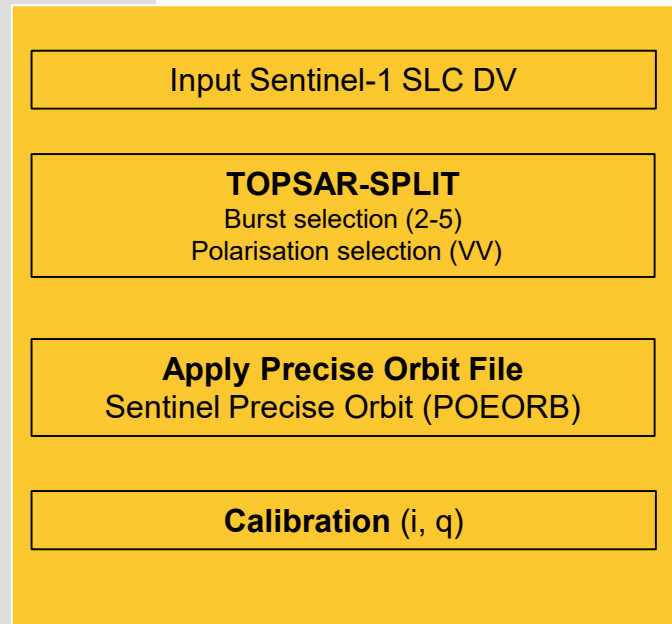
Name	Value	Type	Unit	Description
Orbit_State_Vectors				
Orbit_State_Coefficients				
Doppler_Coefficients				
Band_IW1_VH				
Band_IW1_VV				
Band_IW2_VH				
Band_IW2_VV				
Band_IW3_VH				
Band_IW3_VV				
PRODUCT	S1A_IW_SLC__ISDV_20160507T173118_20160507T173143_010811_C03	ascii		Product name
PRODUCT_TYPE	SLC	ascii		Product type
SPH_DESCRIPTOR	Sentinel-1 IW Level-1 SLC Product	ascii		Description
MISSION	SENTINEL-1A	ascii		Satellite mission
ACQUISITION_MODE	IW	ascii		Acquisition mode
antenna_pointing	right	ascii		Right or left facing
BEAMS	-	ascii		Beams used
SWATH	-	ascii		Swath name
PROC_TIME	02-MAY-2016 23:33:02.601744	uint32	utc	Processed time
Processing_system_identifier	ESA Sentinel-1 DP 002.70	ascii		Processing system identifier
orbit_cycle	77	int32		Cycle
REL_ORBIT	161	int32		Track
ABS_ORBIT	11083	int32		Orbit
STATE_VECTOR_TIME	02-MAY-2016 17:30:11.049288	uint32	utc	Time of orbit state vector
VECTOR_SOURCE	-	ascii		State vector source
incidence_near	99.999	float64	deg	
incidence_far	99.999	float64	deg	
slice_num	6	int32		Slice number
data_take_id	68369	int32		Data take identifier
first_line_time	02-MAY-2016 17:31:16.604948	uint32	utc	First zero doppler azimuth time
last_line_time	02-MAY-2016 17:31:43.565625	uint32	utc	Last zero doppler azimuth time
first_near_lat	45.45	float64	deg	
first_near_long	3.763	float64	deg	
first_far_lat	45.79	float64	deg	
first_far_long	6.98	float64	deg	
last_near_lat	46.954	float64	deg	
last_near_long	3.31	float64	deg	
last_far_lat	47.278	float64	deg	
last_far_long	6.647	float64	deg	
PASS	ASCENDING	ascii		ASCENDING or DESCENDING
SAMPLE_TYPE	COMPLEX	ascii		DETECTED or COMPLEX
mds1_tx_rx_polar	VH	ascii		Polarization
mds2_tx_rx_polar	VV	ascii		Polarization
mds3_tx_rx_polar	-	ascii		Polarization
mds4_tx_rx_polar	-	ascii		Polarization
polar_data	0	uint8	flag	Polarimetric Matrix
algorithm	-	ascii		Processing algorithm
azimuth_looks	1	float64		
range_looks	1	float64		
range_spacing	2.33	float64	m	Range sample spacing
azimuth_spacing	13.908	float64	m	Azimuth sample spacing
pulse_repetition_frequency	1,717.129	float64	Hz	PRF
radar_frequency	5,405	float64	MHz	Radar frequency
line_time_interval	0.002	float64	s	
total_size	7411	uint32	MB	Total product size
num_output_lines	13635	uint32	lines	Raster height
num_samples_per_line	71917	uint32	samples	Raster width
subset_offset_x	0	uint32	samples	X coordinate of UA corner of subset in original image



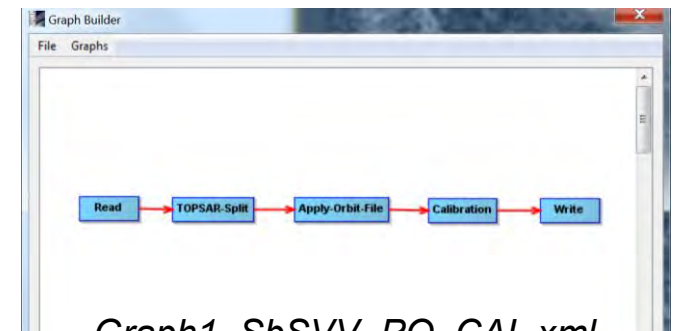
# Display a band (Intensity VV)



## Step 1.a

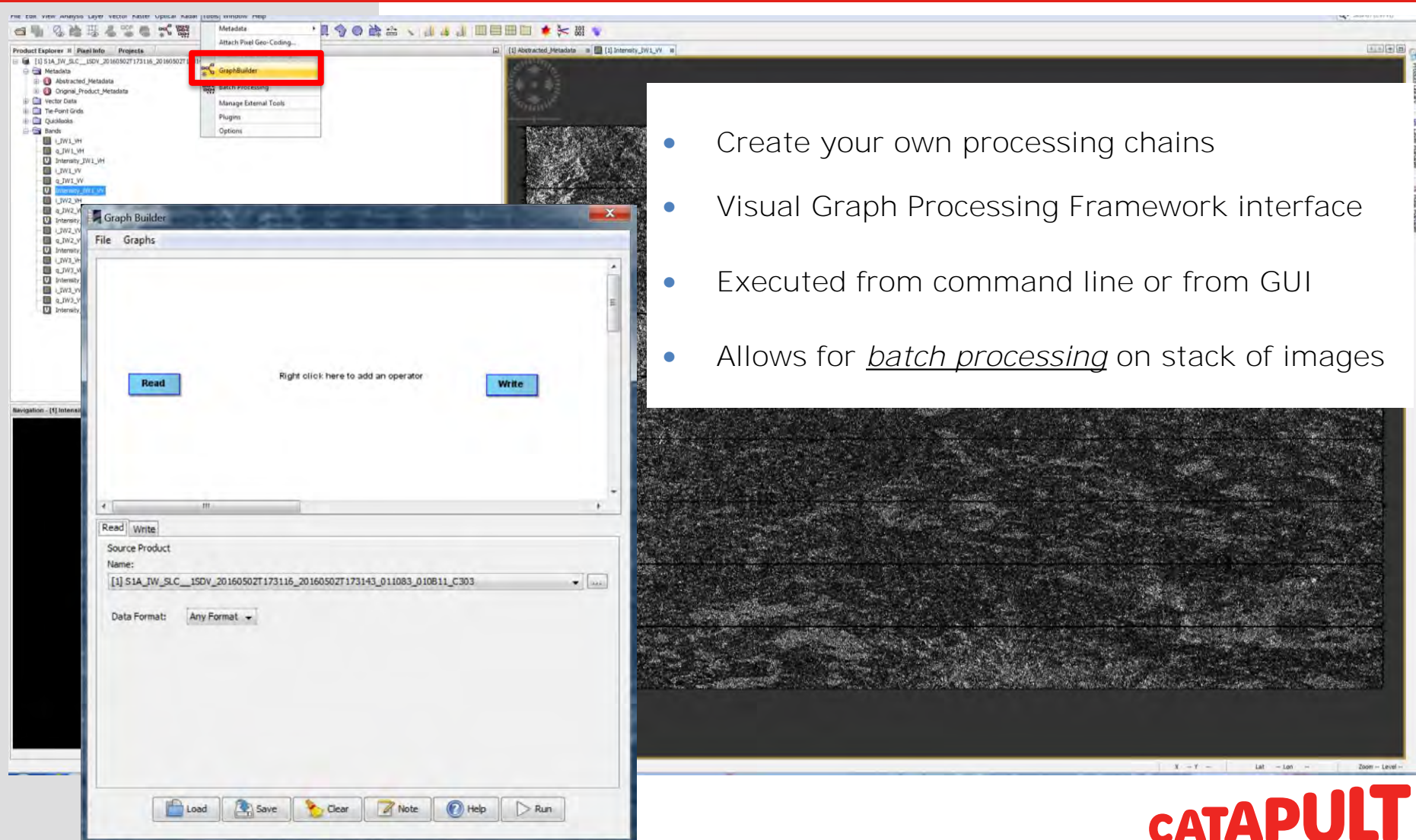


### Graph Builder (single product)



*Graph1\_SbSVV\_PO\_CAL.xml*

# The GRAPH BUILDER



- Create your own processing chains
- Visual Graph Processing Framework interface
- Executed from command line or from GUI
- Allows for batch processing on stack of images



# 1.a - Building the chain → “TOPSAR-Split” operator

The screenshot displays the CATAPULT software interface. On the left, the 'Product Explorer' pane shows a tree structure of data products, including 'Metadata', 'Abstracted\_Metadata', 'Original\_Product\_Metadata', 'Vector Data', 'Tie Point Grids', 'Quicklooks', and 'Bands'. The 'Bands' section is expanded, showing various intensity bands like 'Intensity\_IW1\_VH', 'Intensity\_IW1\_VV', etc. The main workspace shows a satellite image of the North Atlantic Ocean. Overlaid on this is the 'Graph Builder' window, which contains a workflow graph. The graph starts with a 'Read' operator, followed by a 'TOPSAR-Split' operator, and ends with a 'Write' operator. A right-click context menu is open over the 'TOPSAR-Split' operator, showing a list of available operators. The 'TOPSAR-Split' operator is highlighted in the menu. Below the menu, the 'Data Format' is set to 'Any Format'. The 'Graph Builder' window also has a 'File' menu and a 'Graphs' tab. The 'Graphs' tab is active, showing the workflow graph. The 'Graph Builder' window has a status bar at the bottom that says 'Graph is incomplete'.

Having the mouse on the white space, click on mouse right button to access the MENU of operators

# 1.a - Building the chain → “Apply Orbit File” operator

The screenshot displays the CATAPULT software interface. On the left, the 'Product Explorer' shows a tree of products including 'Abstracted\_Metadata', 'Original\_Product\_Metadata', 'Vector Data', 'Tie Point Grids', 'Quicklooks', and 'Bands'. The 'Bands' folder is expanded, showing various intensity bands like 'Intensity\_IW1\_VV'. In the center, the 'Graph Builder' window is open, showing a graph with four operators: 'Read', 'TOPSAR-Split', 'Apply-Orbit-File', and 'Write'. The 'Apply-Orbit-File' operator is highlighted with a yellow selection box. A red arrow points from the text below to the 'Apply-Orbit-File' operator. The 'Apply-Orbit-File' operator's configuration panel is visible, showing 'Name: target', 'Save as: BEAM-DIMAP', 'Directory: D:\ESA\_SS2016\OUTPUT', and 'Open in SNAP' checked. The background shows a satellite image of the Earth with labels for 'NORTH AMERICA', 'EUROPE', 'AFRICA', 'North Atlantic Ocean', and 'South Atlantic Ocean'. A scale bar indicates '2000 Km'.

Having the mouse on the white space, click on mouse right button to access the MENU of operators

# 1.a - Building the chain → “Calibration” operator

The screenshot displays the CATAPULT software interface. On the left, the 'Product Explorer' pane shows a tree structure of data products, including 'Abstracted\_Metadata', 'Original\_Product\_Metadata', 'Vector Data', 'Tie Point Grids', 'Quicklooks', and 'Bands'. The 'Bands' section is expanded, showing various intensity bands like 'Intensity\_IW1\_VV'. The main workspace shows a satellite image of the North Atlantic Ocean. Overlaid on this is the 'Graph Builder' window, which contains a 'File' menu and a 'Graphs' tab. The 'Graphs' tab shows a sequence of operators: 'Read', 'TOPSAR-Split', 'Apply-Orbit-File', 'Calibration', and 'Write'. A right-click context menu is open over the 'Calibration' operator, listing various processing options such as 'Coregistration', 'Feature Extraction', 'Geometric', 'Toolbox', 'Vector', 'Resample', 'Smoothing/Export', 'Radiometric', 'Calibration', 'RemoveAntennaPattern', 'Terrain-Flattening', and 'ThermalNoiseRemoval'. The 'Calibration' option is highlighted. Below the 'Graph Builder' window, a 'Target Product' section is visible, showing fields for 'Name', 'target', 'Save as: BEAM-DIMAP', 'Directory: D:\ESA\_SS2016\OUTPUT', and 'Open in SNAP'. A red status bar at the bottom of the 'Graph Builder' window indicates 'Graph is incomplete'.

Having the mouse on the white space, click on mouse right button to access the MENU of operators

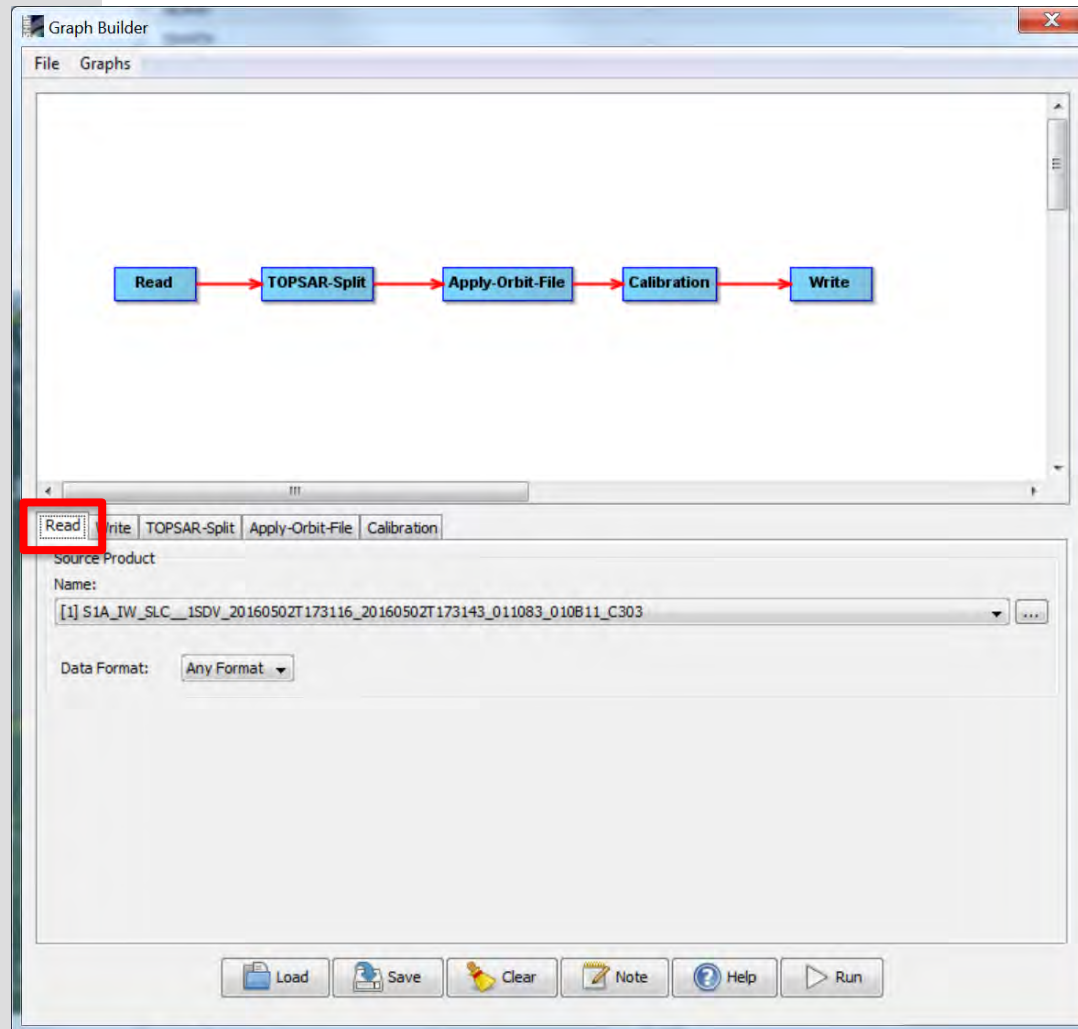


# 1.a - GB: Connecting the blocks

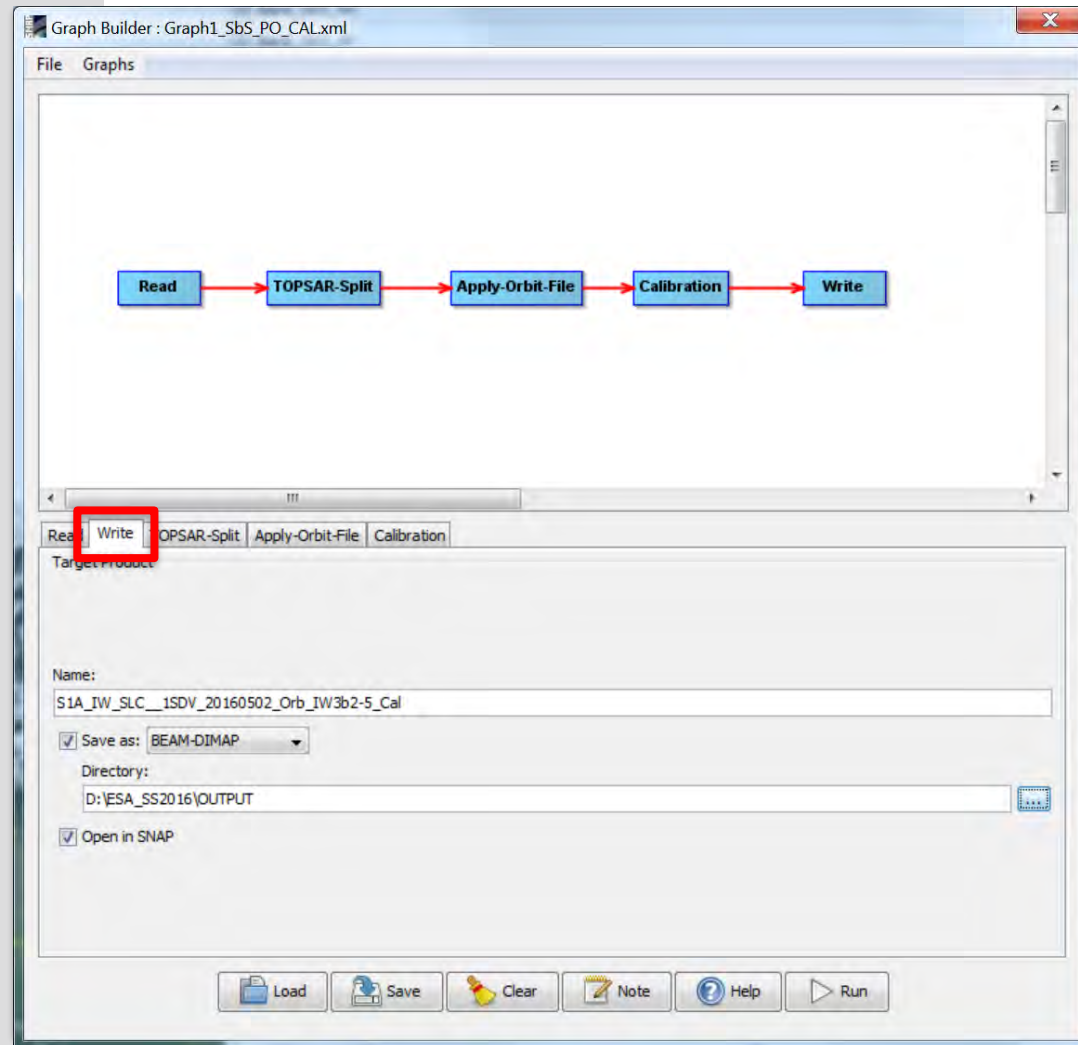
Having the mouse on the white space, click on mouse right button to access the MENU of operators → CLICK on "CONNECT GRAPH"



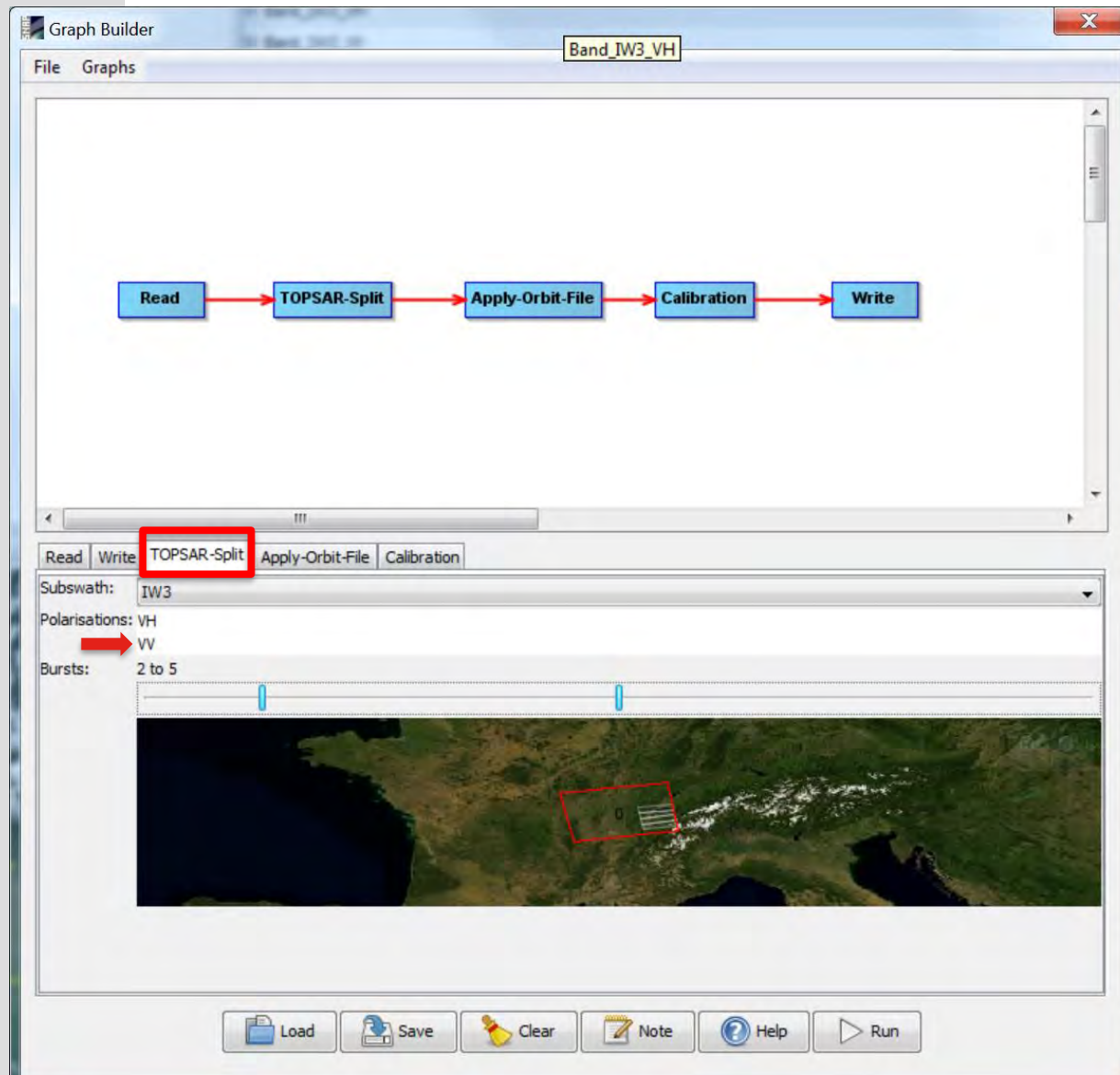
## 1.a - GB: Inserting the parameters



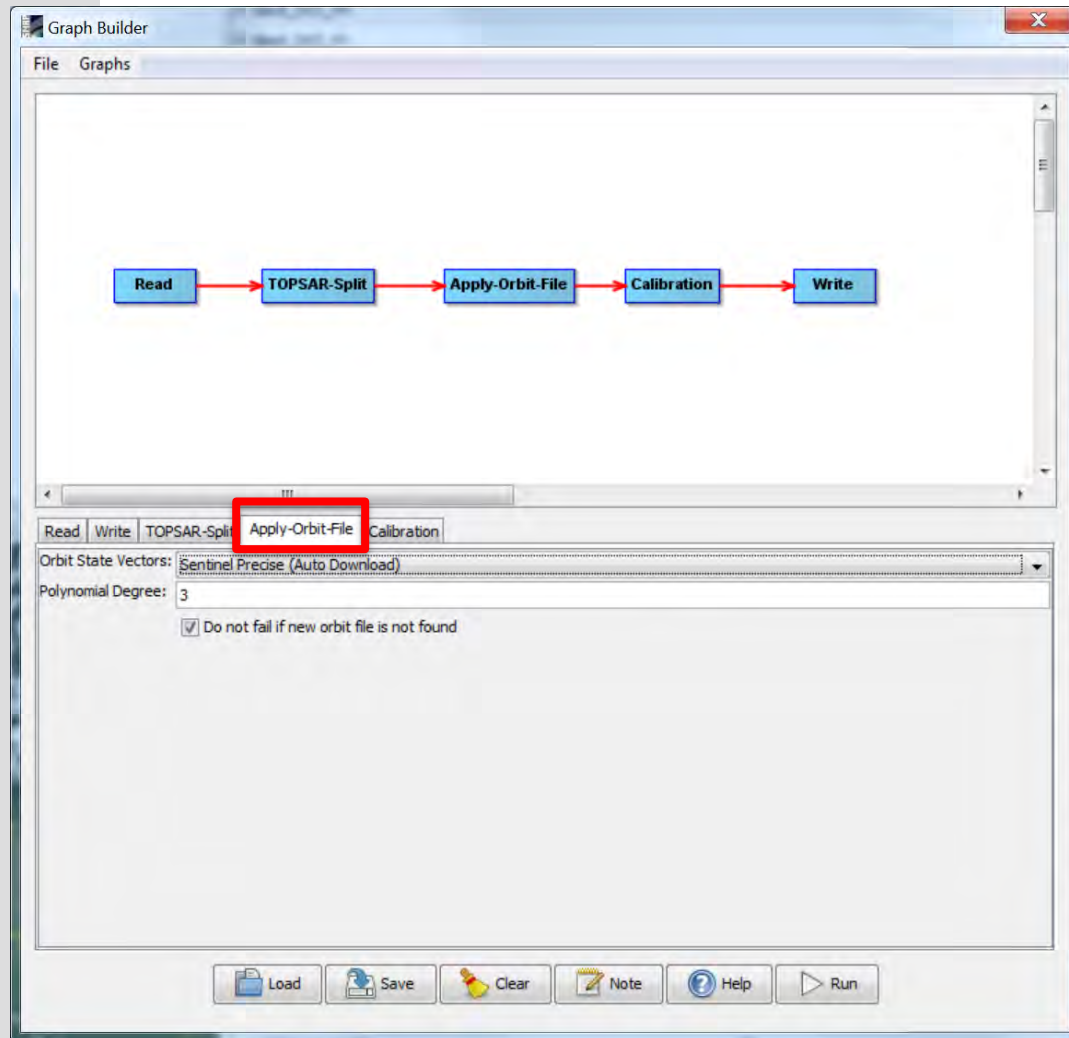
## 1.a - GB: Inserting the parameters



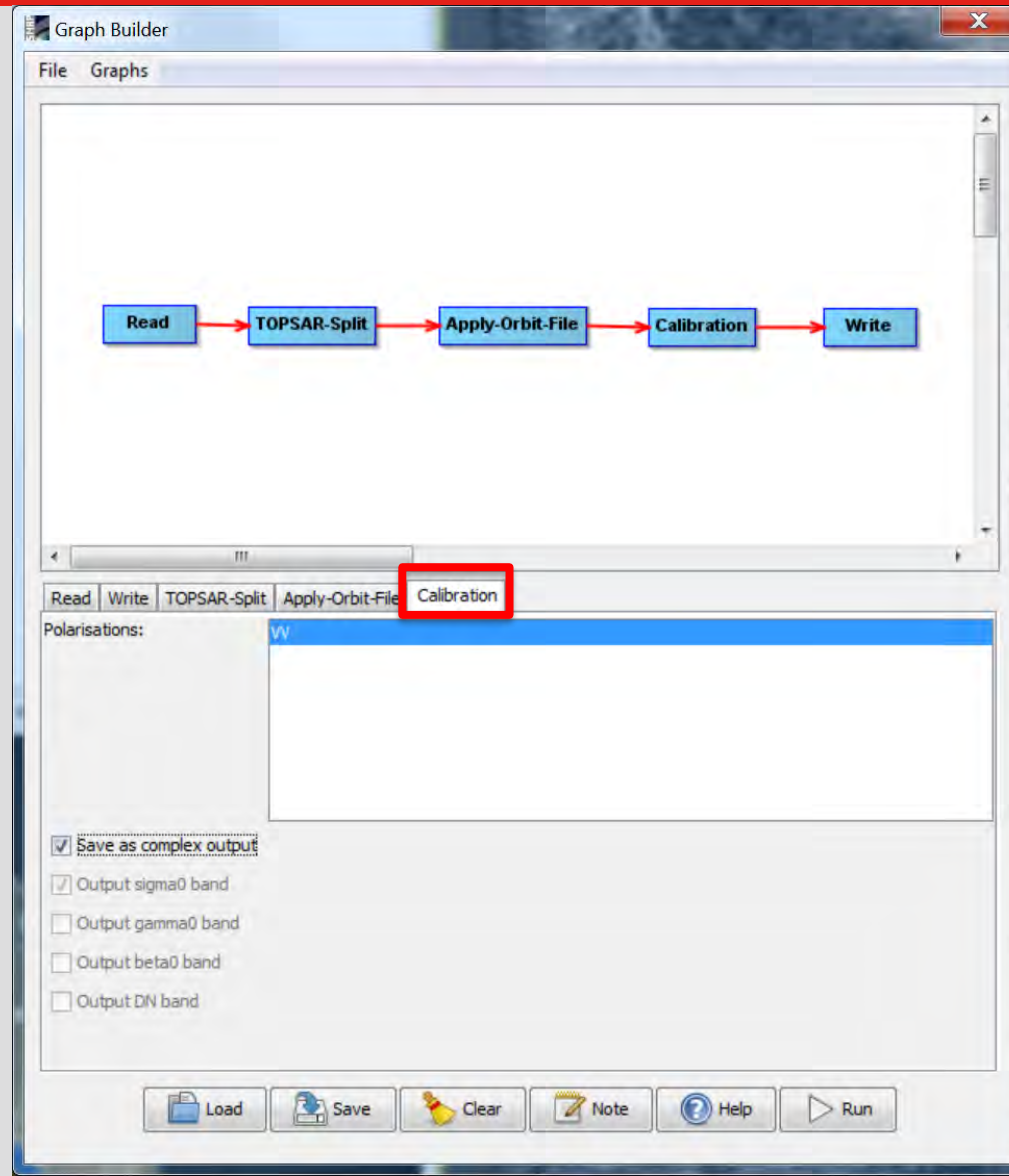
## 1.a - GB: Inserting the parameters



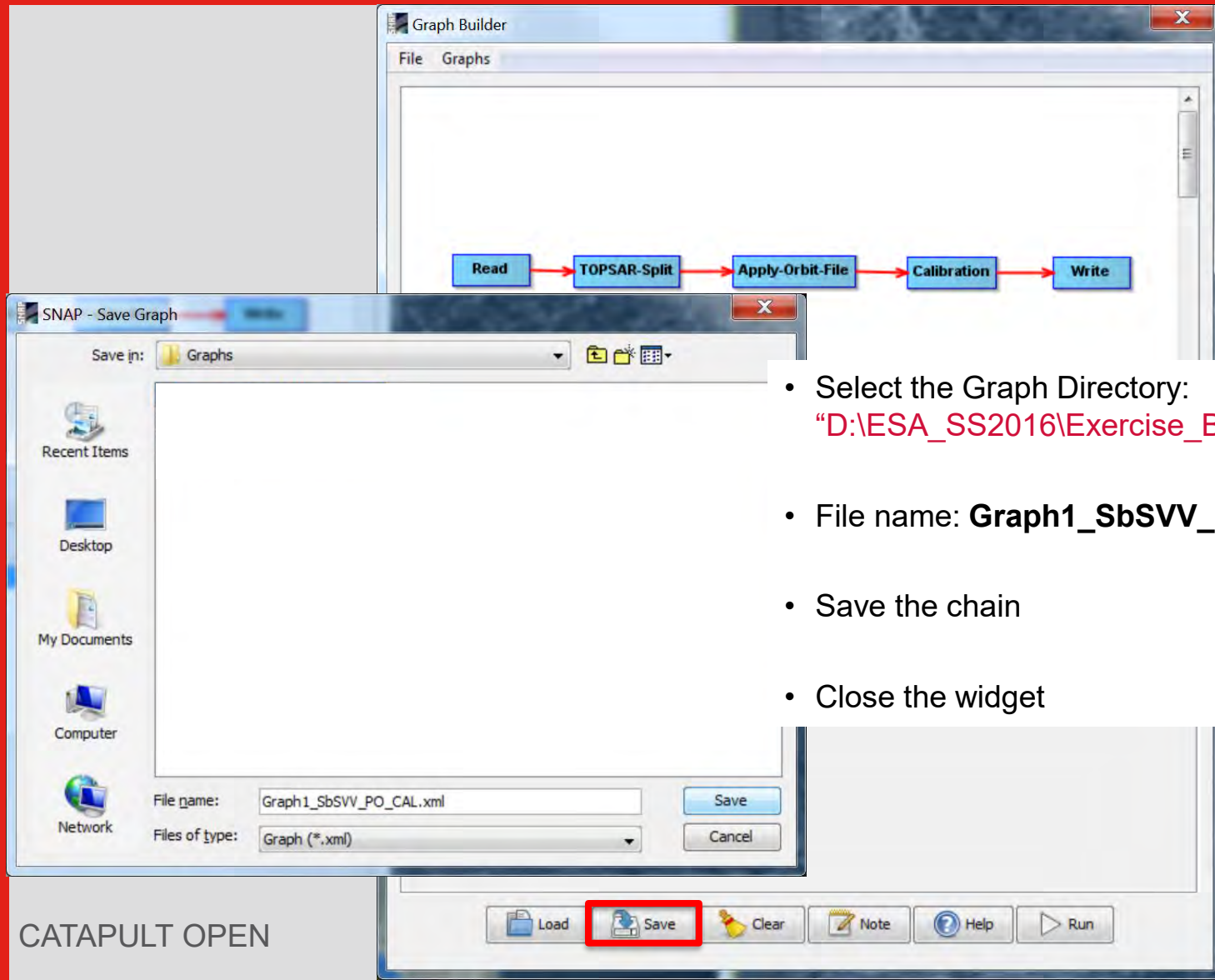
## 1.a - GB: Inserting the parameters



## 1.a - GB: Inserting the parameters



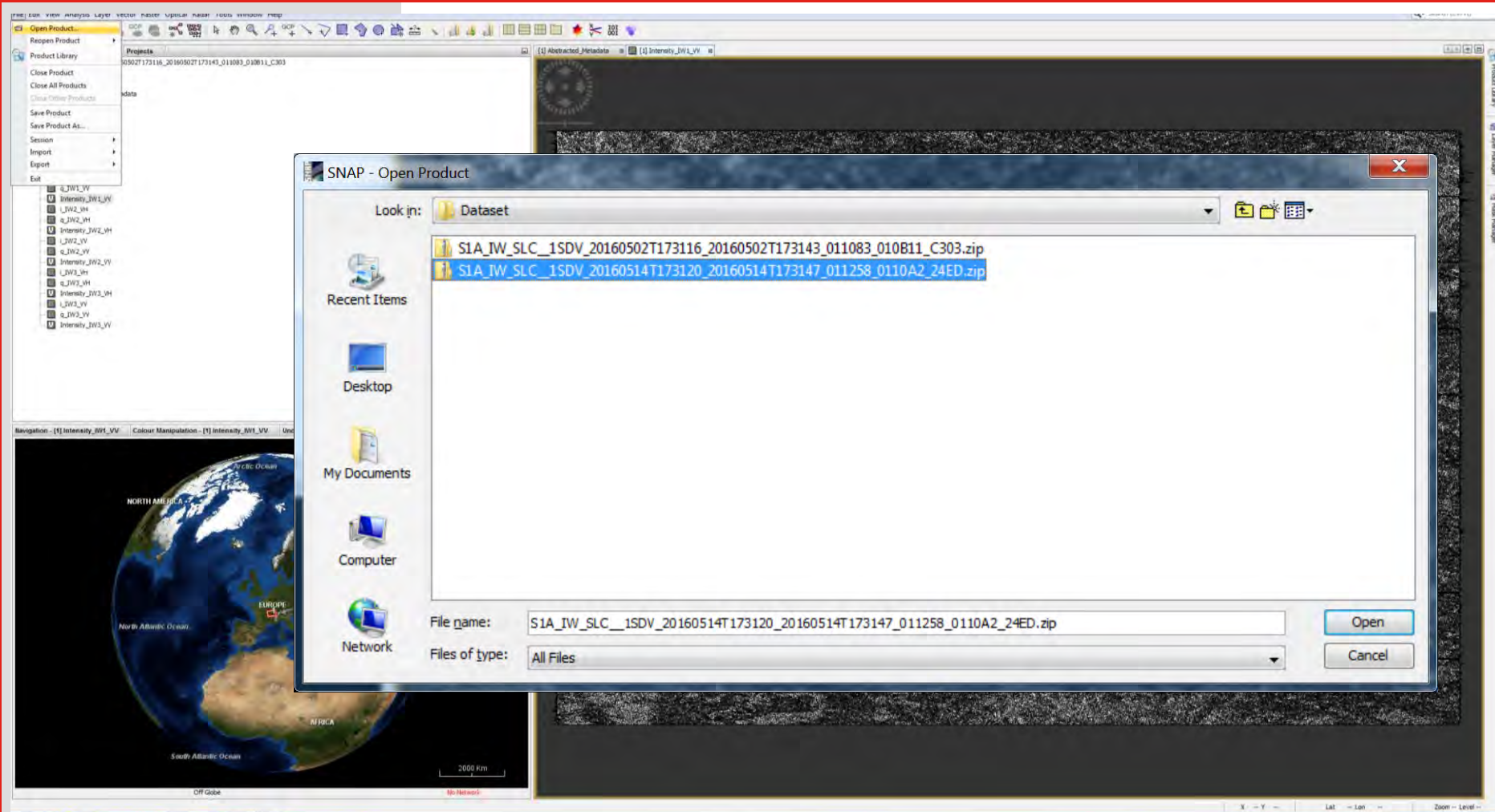
## 1.a - GB: Saving the chain



- Select the Graph Directory:  
“D:\ESA\_SS2016\Exercise\_Back\_Coh\_comb\Graphs”
- File name: **Graph1\_SbSVV\_PO\_CAL.xml**
- Save the chain
- Close the widget



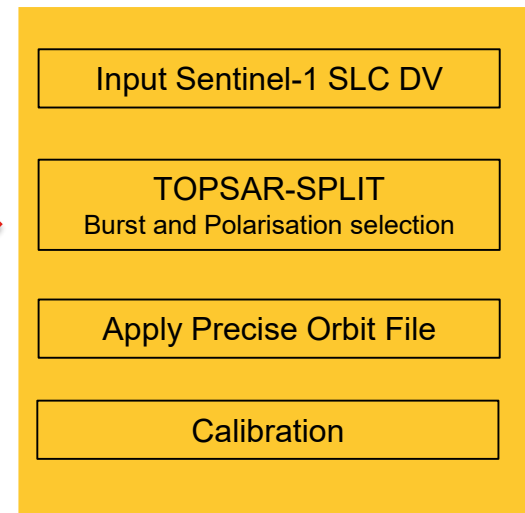
# Open product 14/05/2016





## Step 1.b: Batch processing Tool

The Chain "**Graph1\_SbSVV\_PO\_CAL.xml**" has been defined for one product.



Now we want to run the chain over the 2 SLC dataset via

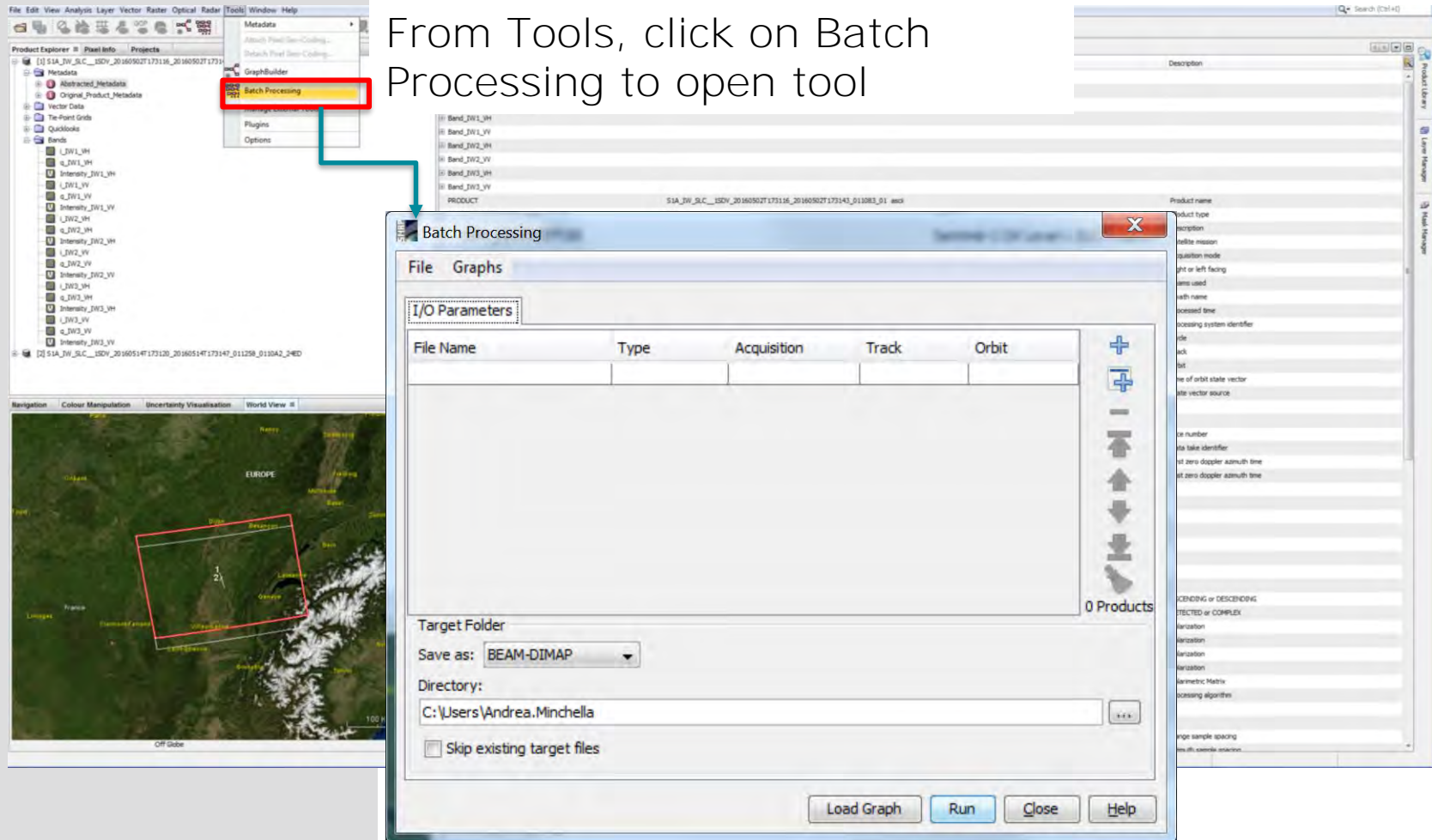
*batch processing tool*

Remember we will select 4 bursts and VV polarisation only

Batch processing  
(2 Products)

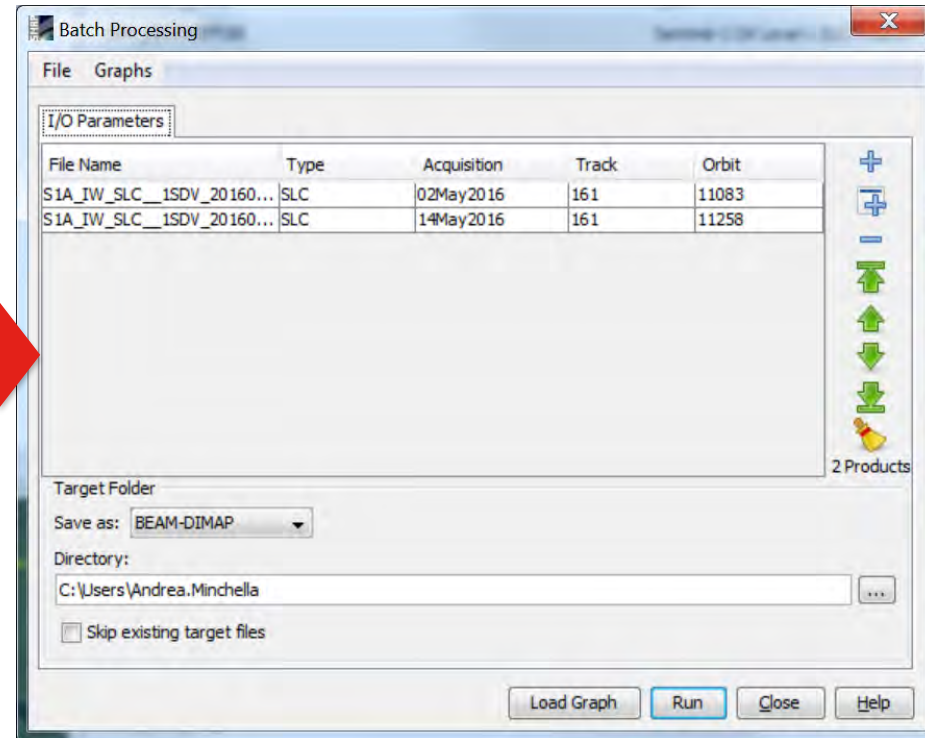
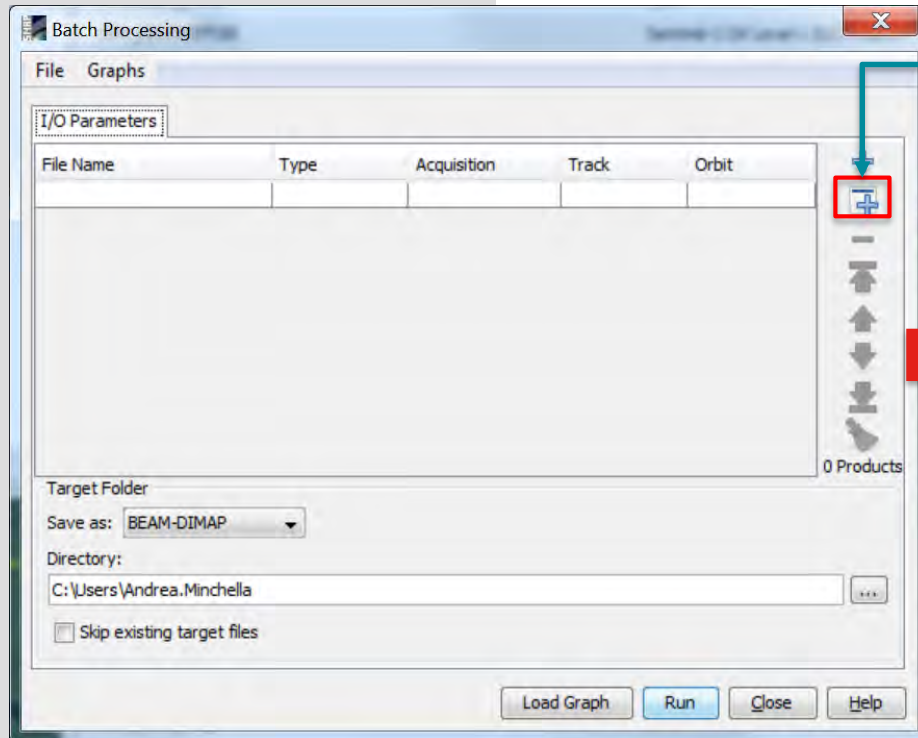
## 1.b - Batch Processing Tool

From Tools, click on Batch Processing to open tool



## 1.b - Batch processing

Click on: “Add Opened”: all products listed in the **Products View** will be added

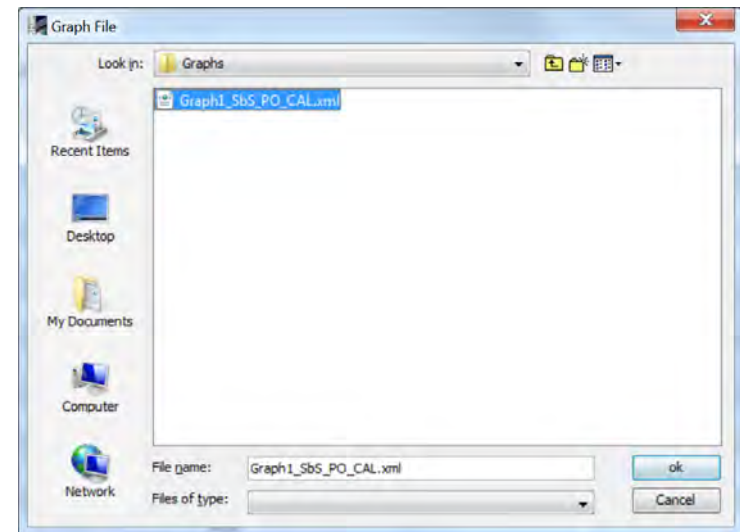
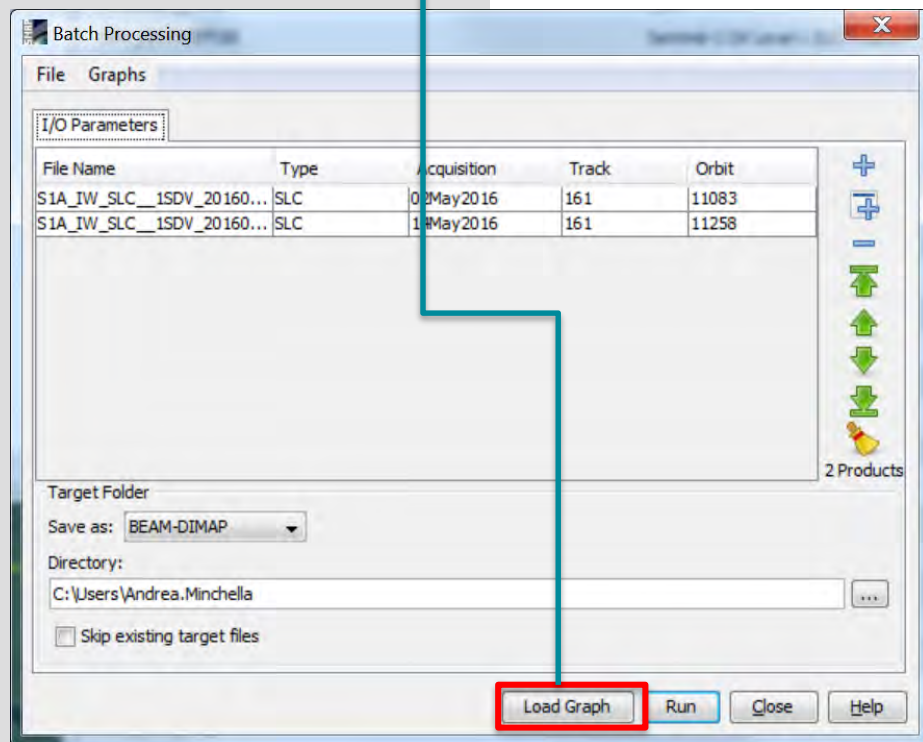


## 1.b - BP: Loading the graph (.xml)

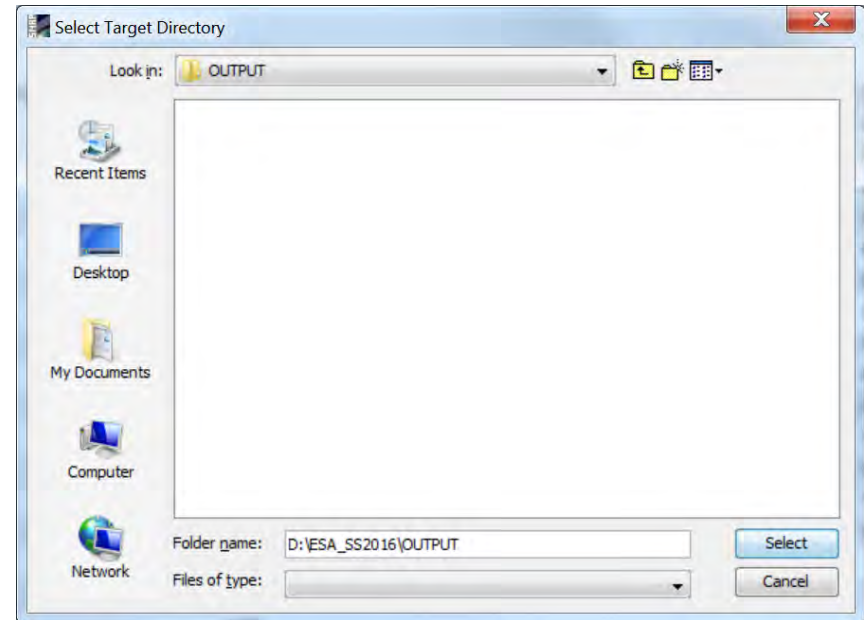
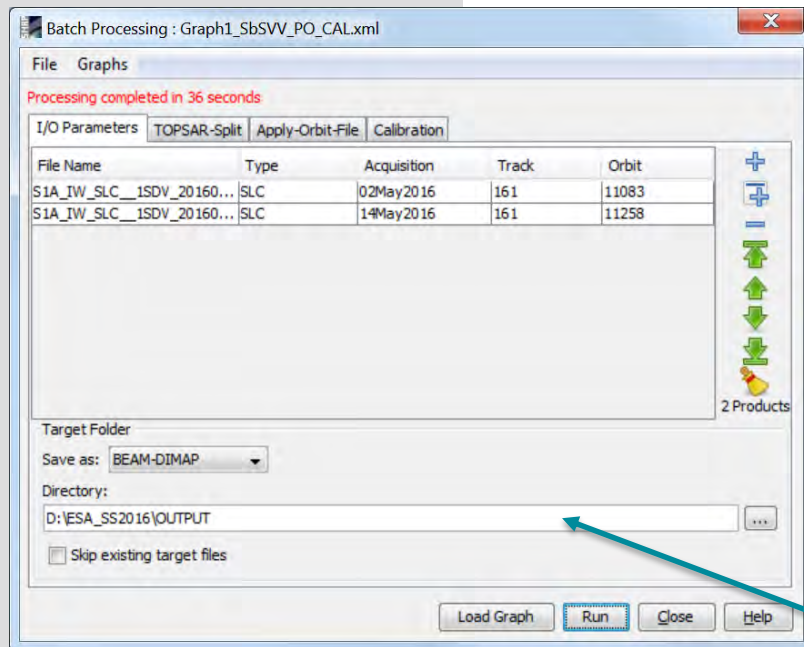
1. By using “**LOAD GRAPH**”, select the created chain

*Graph1\_SbSVV\_PO\_CAL.xml*

from “D:\ESA\_SS2016\Exercise\_Back\_Coh\_comb\Graphs”



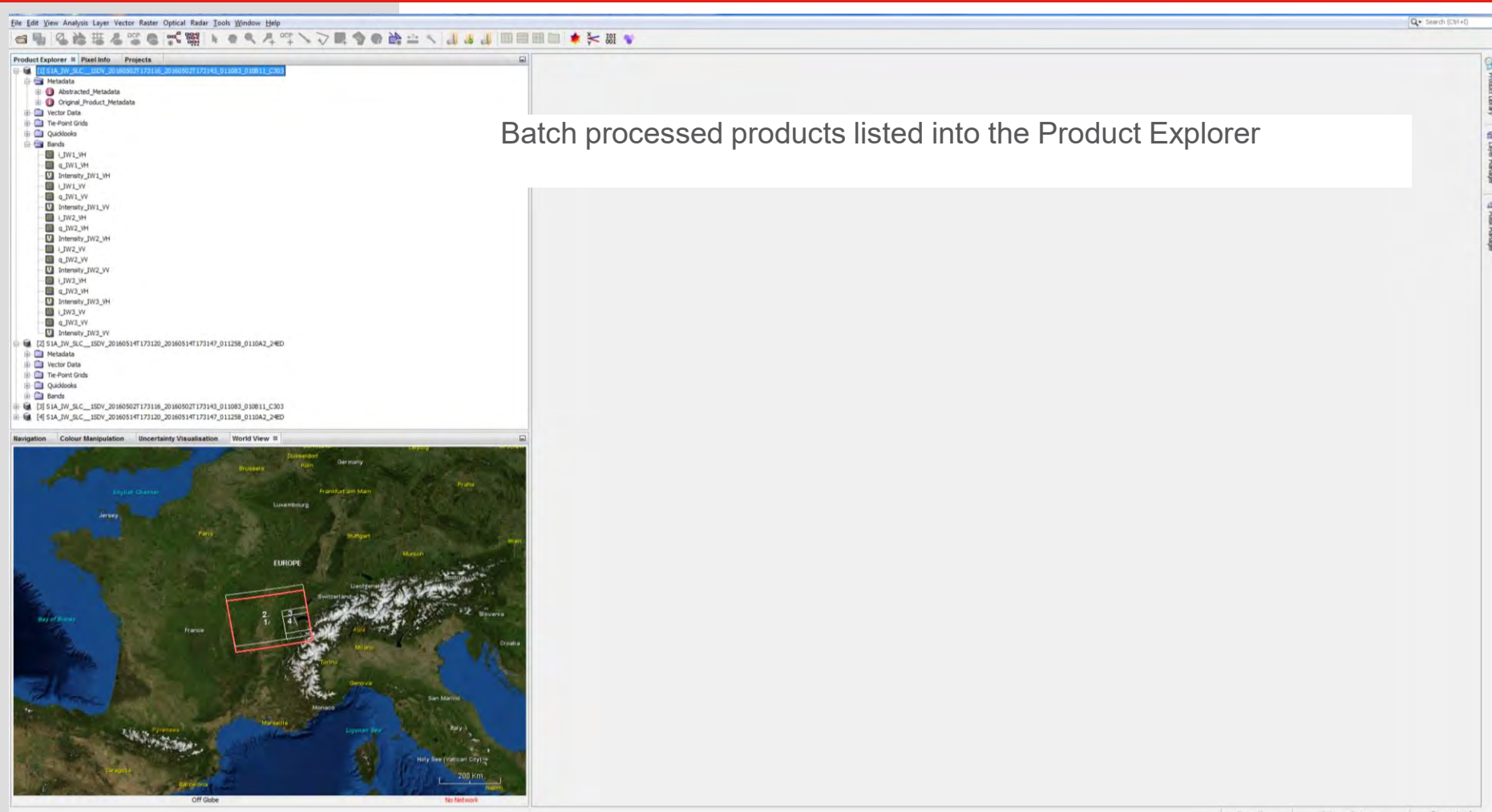
## 1.b - BP: executing the graph (.xml)



2. Select the OUTPUT directory
3. Cross Check parameters (recommended)
4. Click Run

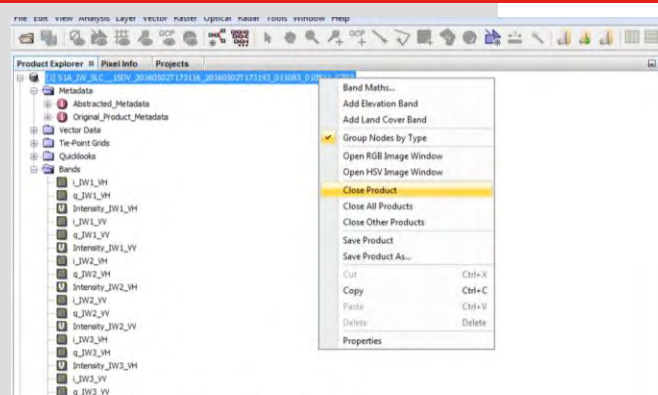
*N.B.: In the Batch Processing Tool we can't specify the name of the output product but the input name will be kept*

## 1.b - Batch processing: results





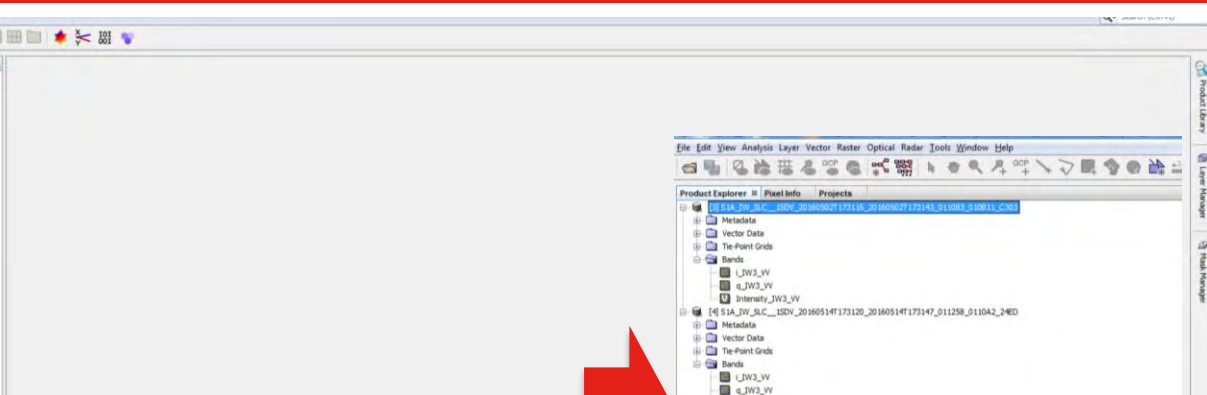
## 1.b - Batch processing: results




The screenshot shows the CATAPULT software interface. On the left, the 'Product Explorer' panel lists various products. A right-click context menu is open over the product 'S1A\_IW\_SLC\_\_1SDV\_20160507173116\_20160507173143\_011083\_0110A2\_240'. The menu options include 'Band Maths...', 'Add Elevation Band', 'Add Land Cover Band', 'Group Nodes by Type' (checked), 'Open RGB Image Window', 'Open HSV Image Window', 'Close Product' (highlighted), 'Close All Products', 'Close Other Products', 'Save Product', 'Save Product As...', 'Cut' (Ctrl+X), 'Copy' (Ctrl+C), 'Paste' (Ctrl+V), 'Delete' (Delete), and 'Properties'.

Close the 2 Sentinel-1 original products

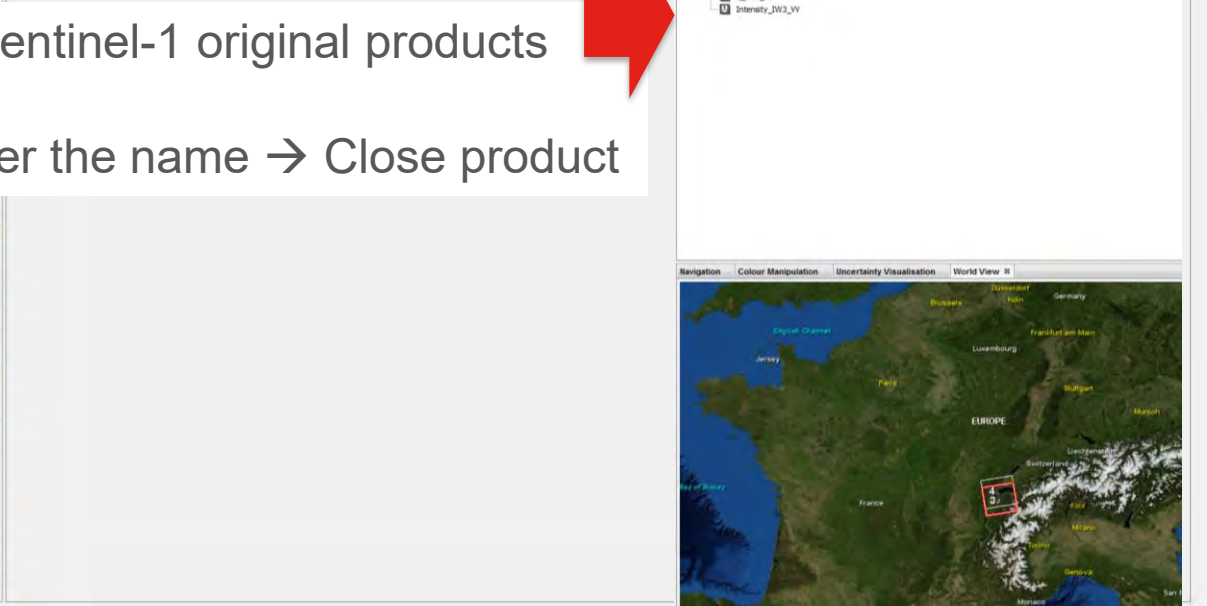
Right click over the name → Close product



This screenshot is identical to the one on the left, showing the same context menu options for the same product in the CATAPULT software.



The screenshot shows a map of Europe in the 'World View' panel. A red rectangular box highlights a region in central Europe, specifically over Germany and Poland. The map includes labels for various countries and cities, and a scale bar indicating 200 km.



This screenshot is identical to the one on the left, showing the same map of Europe with the red box highlighting the same region.

CATAPULT OPEN



## Step 2: TOPSAR Coregistration

MASTER

TOPSAR-SPLIT  
Burst and Polarisation selection

Apply Precise Orbit File

Calibration

SLAVE

TOPSAR-SPLIT  
Burst and Polarisation selection

Apply Precise Orbit File

Calibration

BACK  
GEOCODING

Enhanced Spectral  
Diversity

Coregistered  
Images

Read

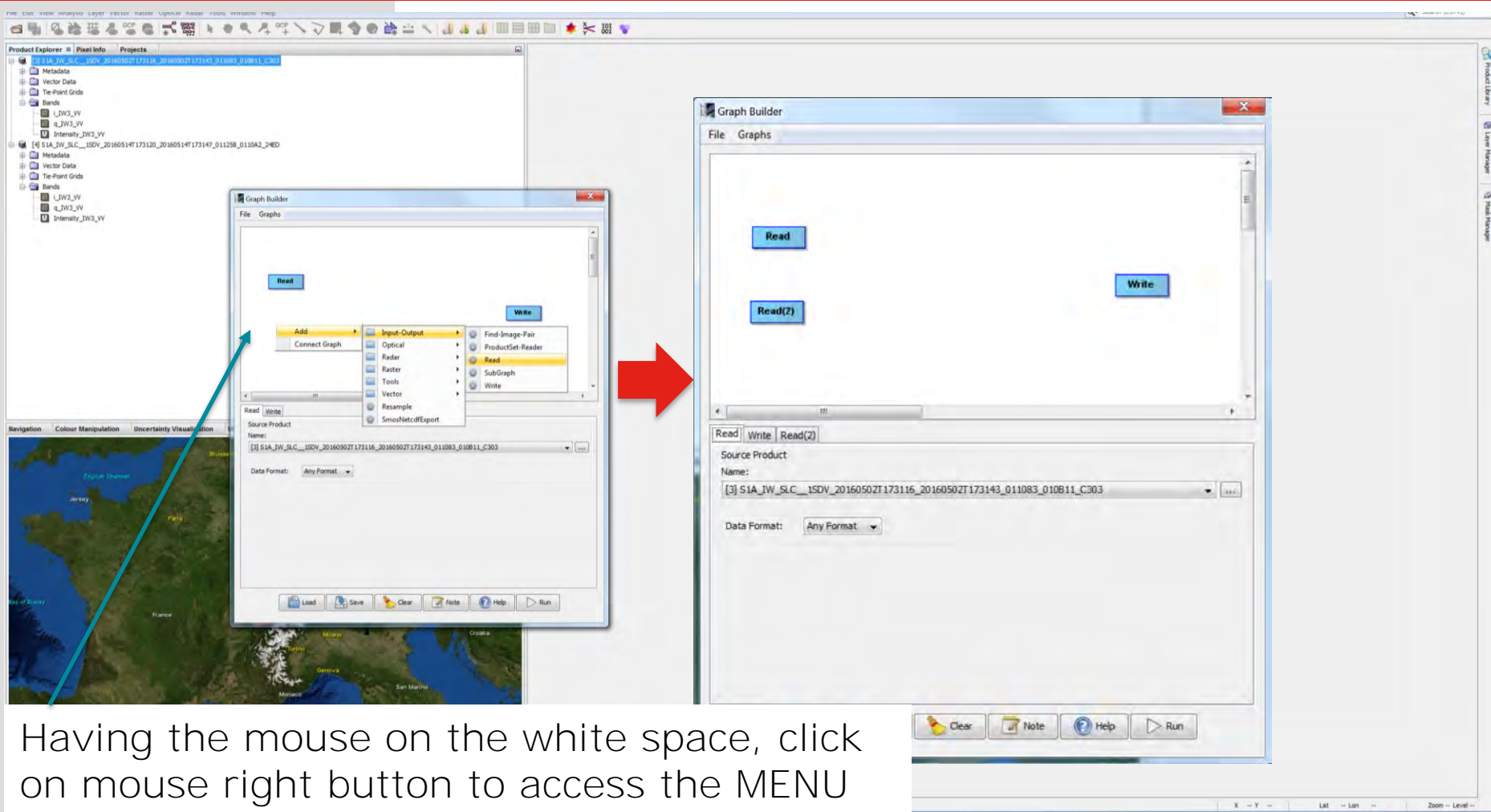
Back-Geocoding

Enhanced-Spectral-Diversity

Write

Read(2)

# TOPSAR Coregistration via GB



# TOPSAR Coregistration via GB

The screenshot displays the CATAPULT software interface for TOPSAR Coregistration via Graph Builder (GB). The main window shows a graph with nodes: Read, Read(2), Back-Geocoding, and Write. The 'Back-Geocoding' node is highlighted. The 'Product Explorer' on the left lists the source product: S1A\_IW\_SLC\_\_ISDV\_20160502T173116\_20160502T173143\_011083\_010811\_C303. The 'Graph Builder' window on the right shows the configuration for the 'Back-Geocoding' node, including the source product name and data format. A red arrow points from the 'S-1 TOPS Coregistration' menu item to the 'Back-Geocoding' node. A blue arrow points from the 'Graph is incomplete' message to the 'Run' button.

Having the mouse on the white space, click on mouse right button to access the MENU of operators

# TOPSAR Coregistration via GB

The screenshot displays the CATAPULT software interface. On the left, the 'Product Explorer' shows a tree structure of data products, including 'S1A\_IW\_SLC\_\_1SDV\_20160502T173116\_20160502T173143\_011083\_010811\_C303'. The main workspace shows a 'Graph Builder' window with a menu open, highlighting the 'S-1 TOPS Coregistration' option. A red arrow points from this menu to a larger 'Graph Builder' window on the right, which shows a workflow graph with nodes: 'Read', 'Back-Geocoding', 'Enhanced-Spectral-Diversity', and 'Write'. The 'Source Product' field is set to '[3] S1A\_IW\_SLC\_\_1SDV\_20160502T173116\_20160502T173143\_011083\_010811\_C303'. Below the graph, a map of the region around the English Channel is visible.

Having the mouse on the white space, click on mouse right button to access the MENU of operators

# GB: Connecting the blocks

The screenshot shows the Graph Builder window with a workflow diagram and a source product configuration panel. The workflow diagram consists of five blocks: 'Read', 'Read(2)', 'Back-Geocoding', 'Enhanced-Spectral-Diversity', and 'Write'. Red arrows connect 'Read' and 'Read(2)' to 'Back-Geocoding', 'Back-Geocoding' to 'Enhanced-Spectral-Diversity', and 'Enhanced-Spectral-Diversity' to 'Write'. The source product configuration panel shows the 'Source Product' name as '[3] S1A\_IW\_SLC\_\_1SDV\_20160502T173116\_20160502T173143\_011083\_010B11\_C303' and the 'Data Format' as 'Any Format'. An error message at the bottom of the window reads: 'Error in graph: [NodeId: Enhanced-Spectral-Diversity] Cannot find derampDemodPhase band in source product. Please run B...'. Below the error message are buttons for 'Load', 'Save', 'Clear', 'Note', 'Help', and 'Run'.

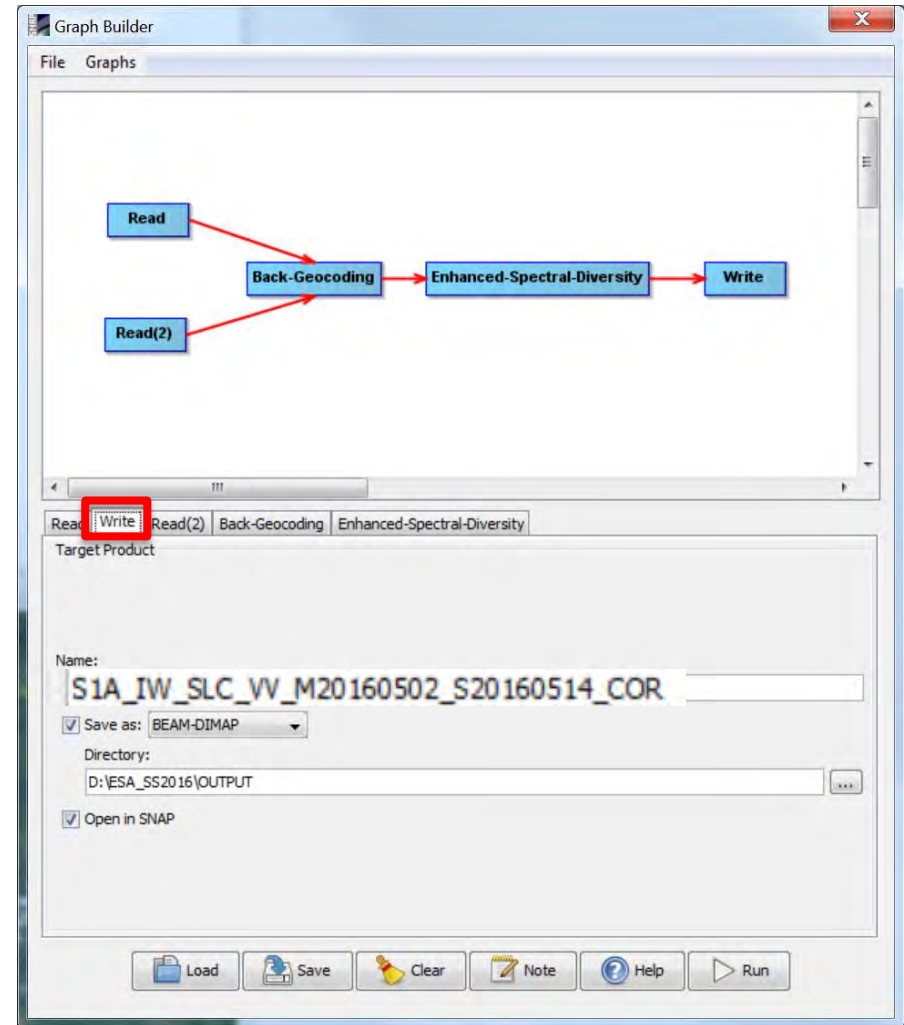
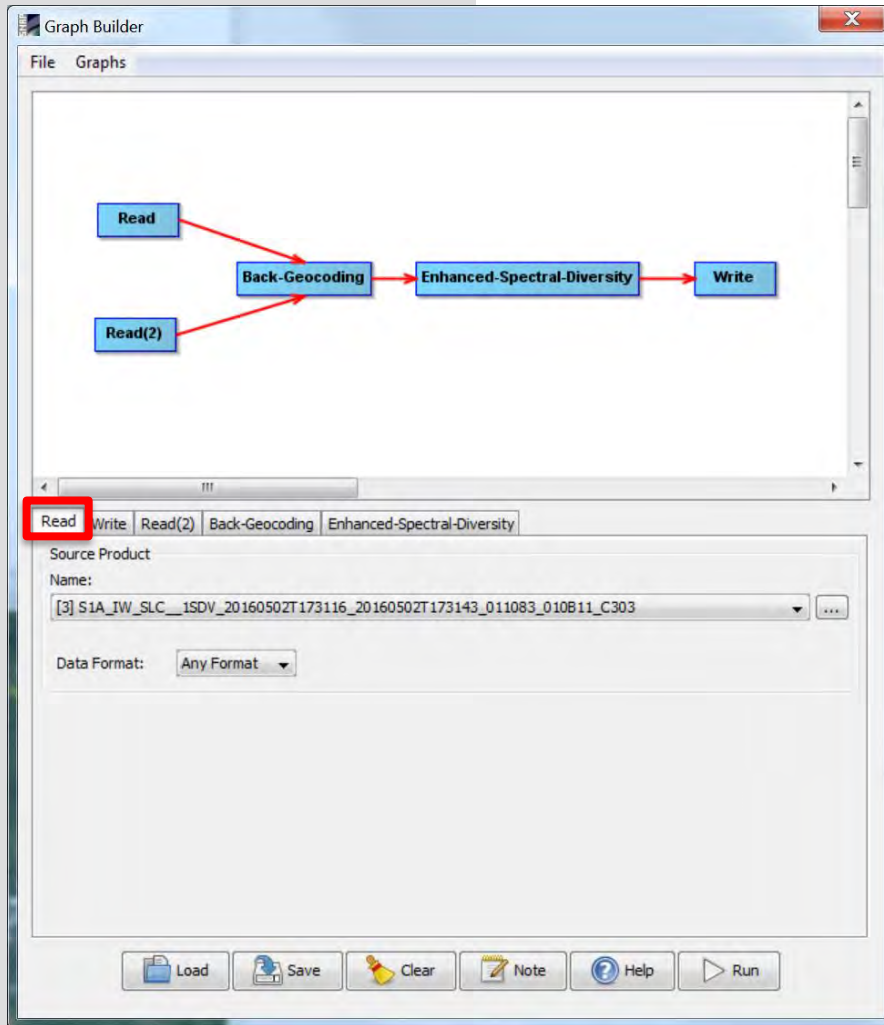
Connect the blocks manually

CATAPULT OF

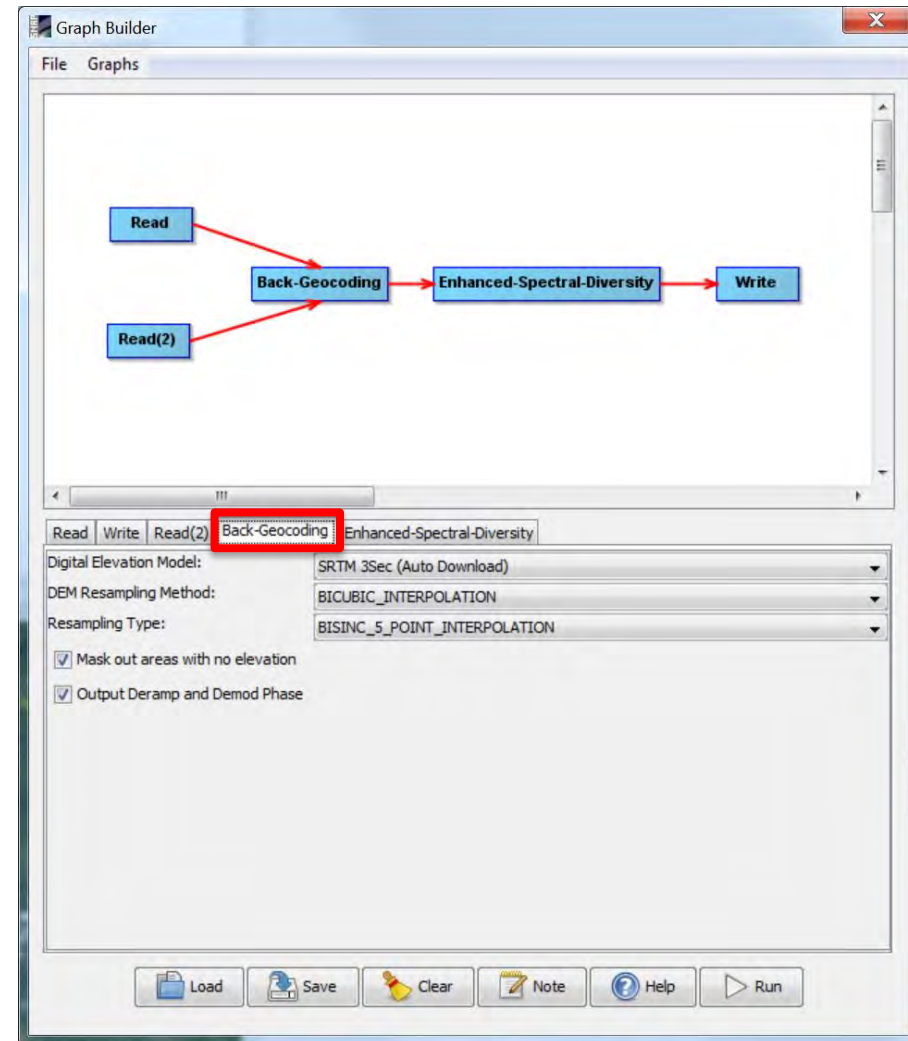
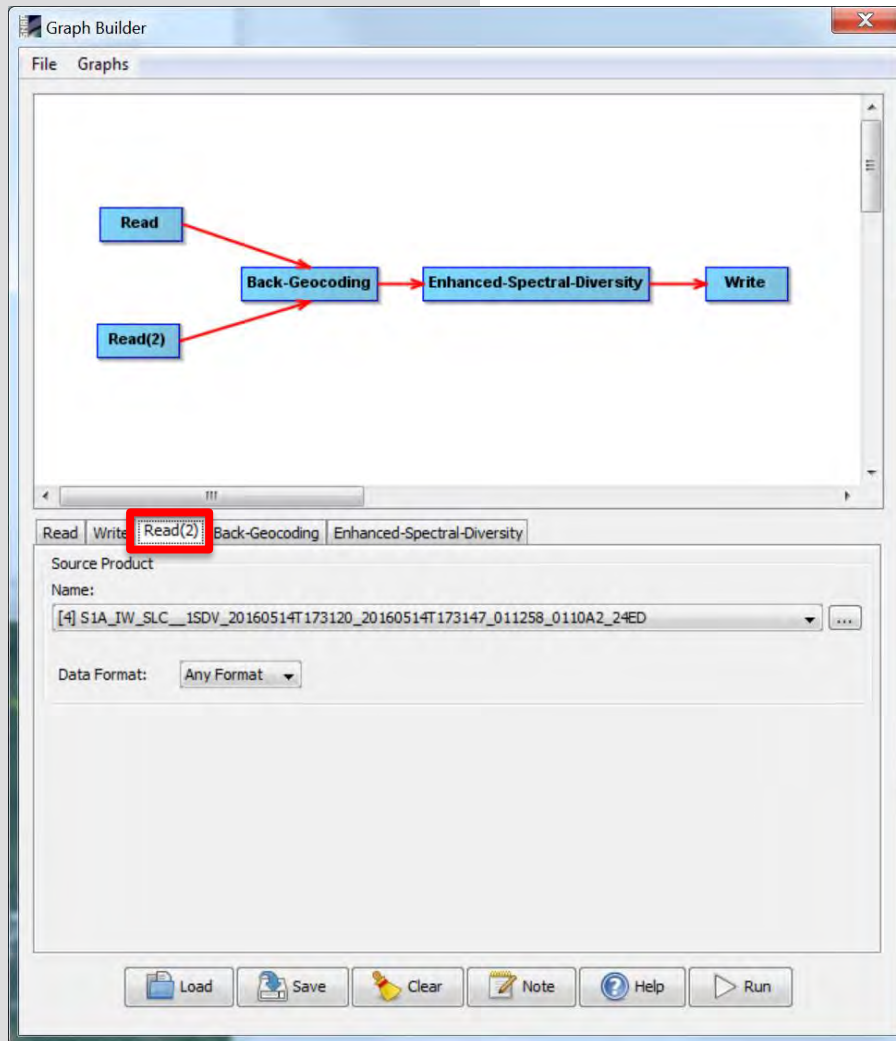
**CATAPULT**  
Satellite Applications



# Inserting the parameters

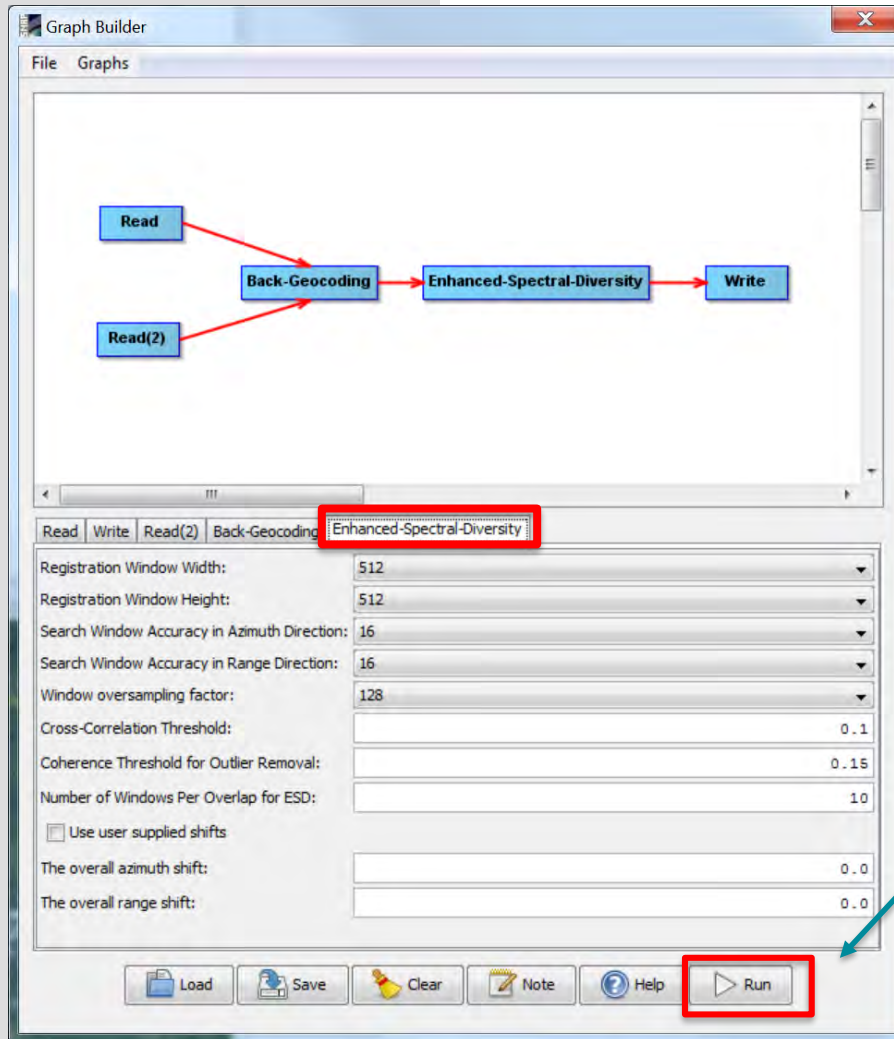


# Inserting the parameters





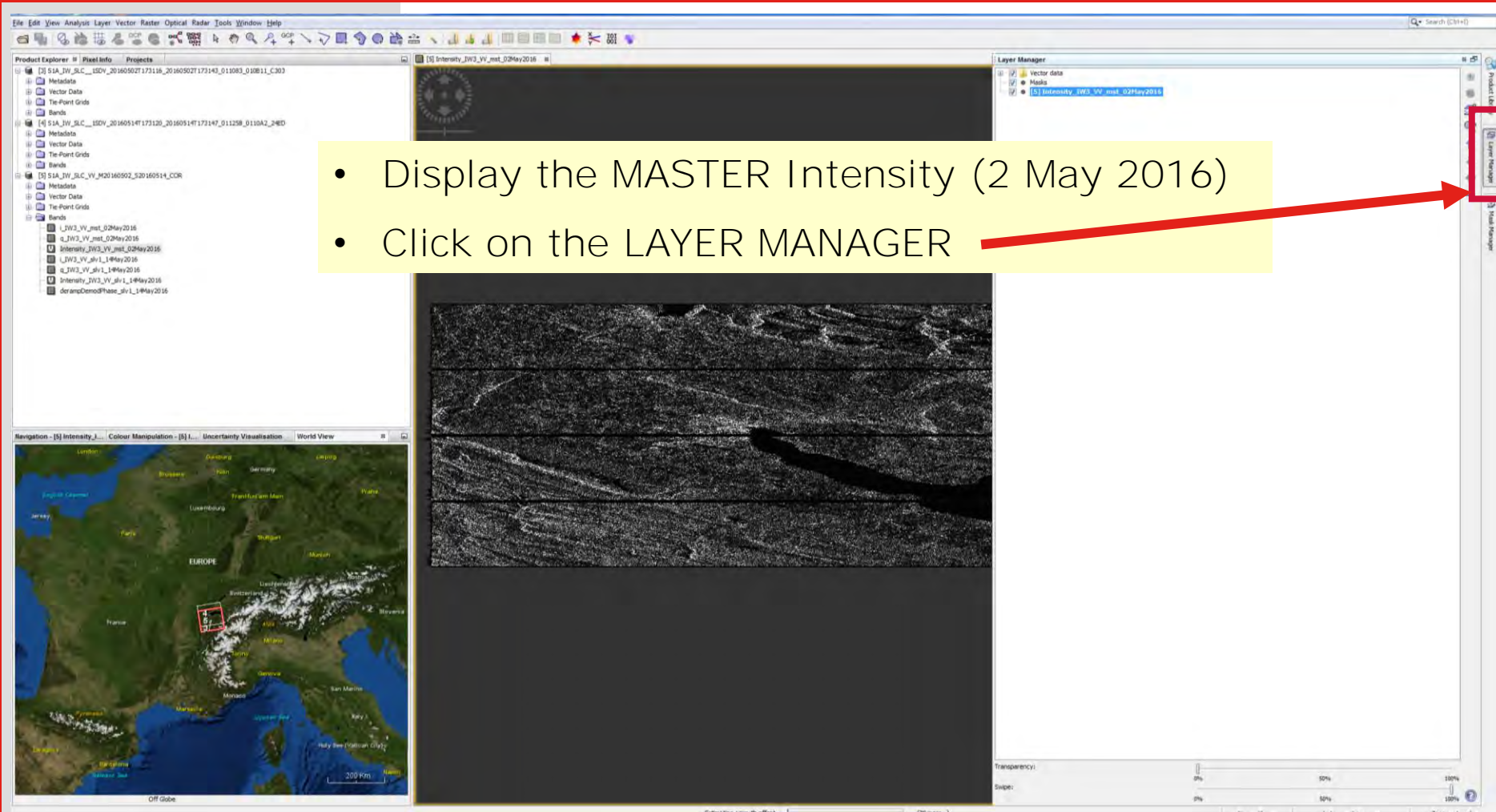
# Inserting the parameters



After inserting the parameters in the operators, execute the chain

N.B.: in the backup folder  
Graph2\_TOPSAR\_COR.xml

# Overlay Master and Slave: the Layer Manager



The screenshot displays the CATAPULT OPEN software interface. The main window is divided into several panels. On the left is the 'Product Explorer' showing a tree of data products. The top center is the 'Map View' showing a grayscale satellite image of a coastal area. The bottom left is a 'World View' showing a map of Europe with a red box indicating the current view area. The bottom right is the 'Layer Manager' panel, which lists the layers currently displayed in the map view. A red arrow points from the text 'Click on the LAYER MANAGER' to the 'Layer Manager' panel.

- Display the MASTER Intensity (2 May 2016)
- Click on the LAYER MANAGER

# Overlay Master and Slave: the Layer Manager

The screenshot displays the CATAPULT software interface. The main window shows a map with various layers. The Layer Manager on the right lists the layers: Vector data, Metadata, and Intensity\_IW3\_VV\_mst\_02May2016. A red arrow points from the Layer Manager to the Add Layer dialog box. The Add Layer dialog box has a 'Select Layer Source' tab with options: ESRI Shapefile, Image of Band / Tie-Point Grid (selected), Layer Group, Mapping Tools, and RGB Image from File. A red arrow points from the 'Image of Band / Tie-Point Grid' option to the 'Select Band / Tie-Point Grid' dialog box. The 'Select Band / Tie-Point Grid' dialog box shows a list of compatible bands and tie-point grids. The 'Intensity\_IW3\_VV\_slv1\_14May2016' layer is selected. A red circle highlights the 'Finish' button. A red arrow points from the 'Finish' button to the 'Add Layer' dialog box.

1) Click on +

2) Select Image of Band / Tie-Point Grid and click on Next

1. Select the Slave

2. Click on

CATAPULT OPEN

**CATAPULT**  
Satellite Applications

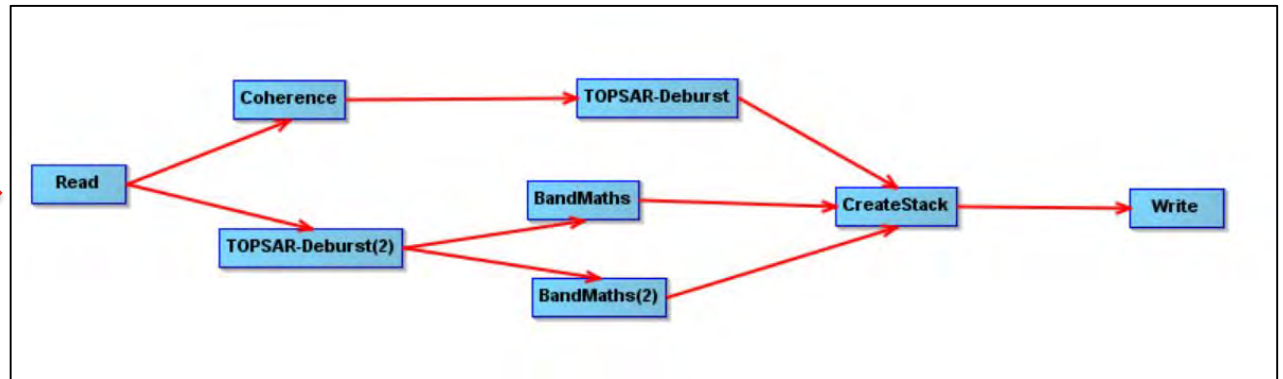
## CATAPULT OPEN



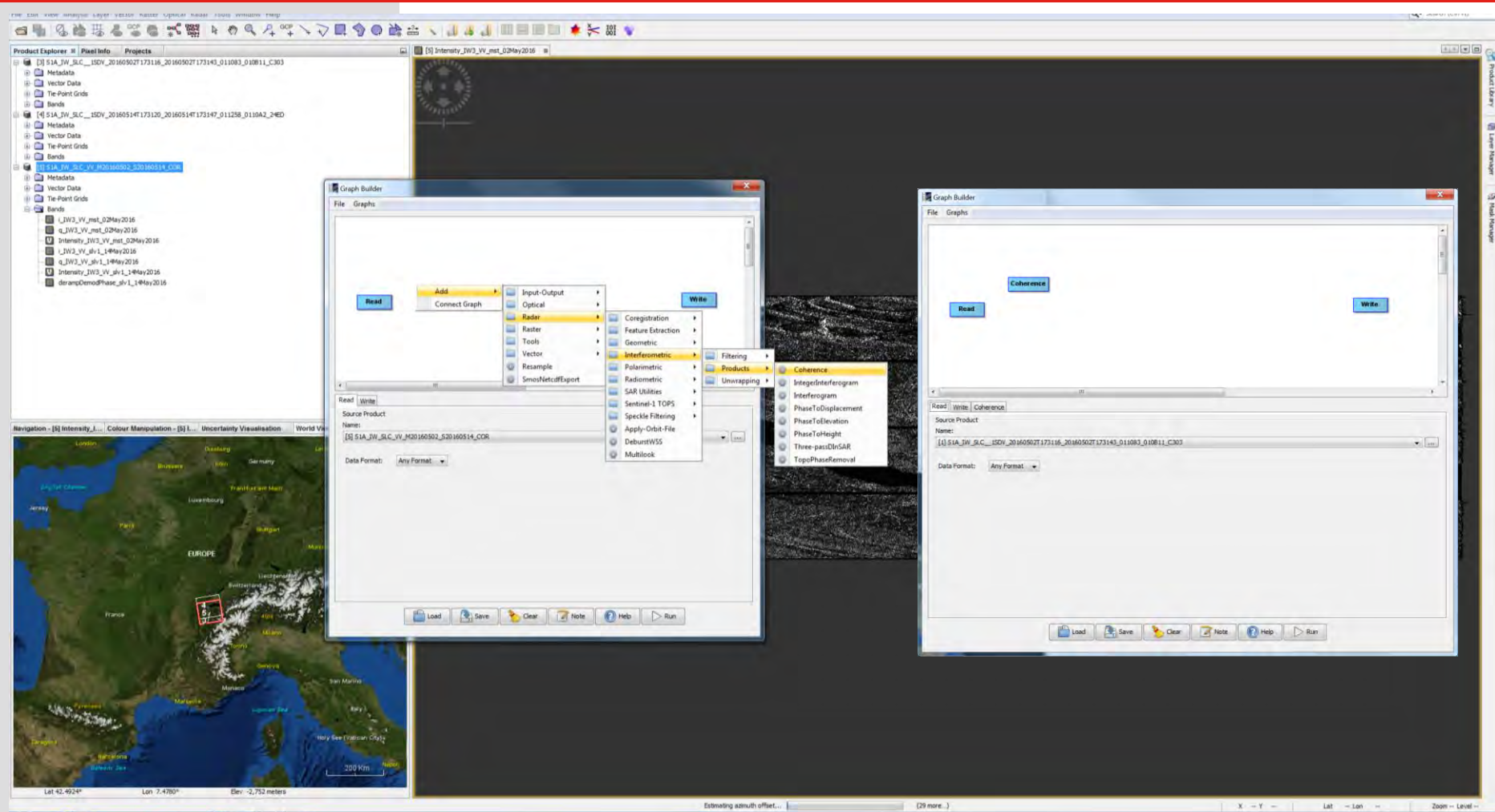


### 3 STEP: Coherence and Backscatter stack generation

Coregistered  
Images



# 3 STEP: Coherence and Backscatter stack generation

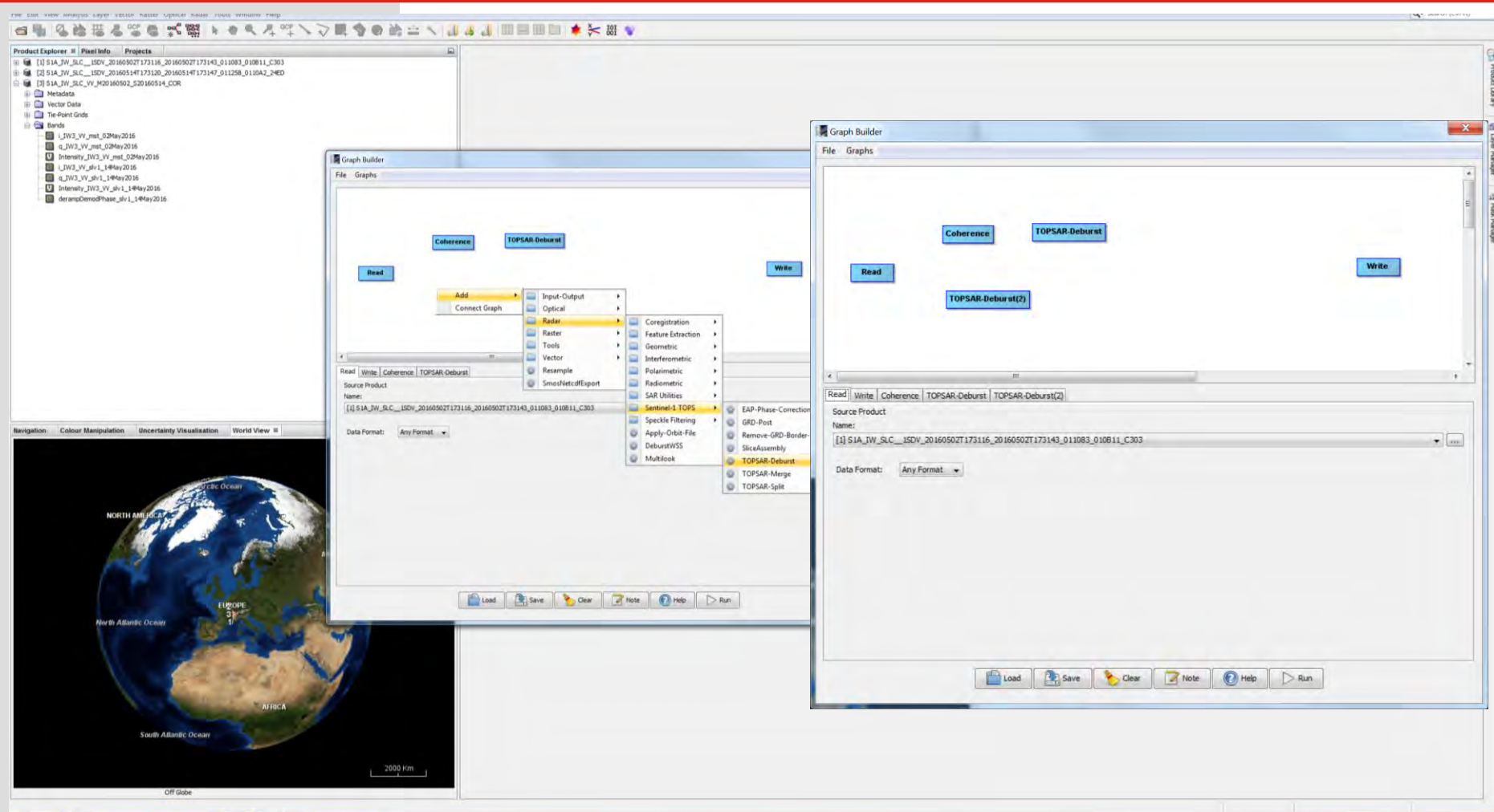




## CATAPULT OPEN



# 3 STEP: Coherence and Backscatter stack generation



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The screenshot displays the CATAPULT OPEN software interface, which is used for processing satellite data. The main window is divided into several panels:

- Product Explorer:** Located on the left, it shows a list of products and metadata. The selected product is `[1] S1A_IW_SLC__1SDV_20160502T173116_20160502T173143_011083_010811_C303`.
- Graph Builder:** Two instances of this window are shown, illustrating the workflow for generating coherence and backscatter stacks.
  - Left Graph Builder:** The workflow starts with a **Read** node, followed by a **Coherence** node, and then a **TOPSAR-Deburst** node. The **Write** node is also present.
  - Right Graph Builder:** The workflow starts with a **Read** node, followed by a **Coherence** node, then a **TOPSAR-Deburst** node, and finally a **BandMats** node. The **Write** node is also present.
- Map View:** Located at the bottom left, it shows a globe with the selected product's footprint highlighted. The map includes labels for **NORTH AMERICA**, **EUROPE**, **North Atlantic Ocean**, and **South Atlantic Ocean**. The coordinates are `Lat: -6.5683°` and `Lon: 28.4895°`.

# 3 STEP: Coherence and Backscatter stack generation

The screenshot displays the CATAPULT OPEN software interface, which is used for processing satellite data. The main window is divided into several panels:

- Product Explorer:** Located on the left, it lists various data products and metadata, including SIA\_IW\_SLC and Intensity\_IW3\_VV.
- Graph Builder:** This panel contains two workflow graphs. The left graph shows a sequence: Read → Coherence → TOPSAR-Deburst → BandMaths. The right graph shows: Read → Coherence → TOPSAR-Deburst → BandMaths(2) → BandMaths(2) → Write.
- Navigation:** At the bottom left, there is a globe view showing the geographical location of the data, with labels for North America, Europe, Africa, and the Atlantic Ocean.
- Source Product:** A dropdown menu in the bottom right of the Graph Builder window shows the selected source product: SIA\_IW\_SLC\_20160502T173116\_20160502T173143\_011083\_010811\_C303.



# 3 STEP: Coherence and Backscatter stack generation

The screenshot displays the CATAPULT OPEN software interface, which is used for processing satellite data. The main window is divided into several panels:

- Product Explorer:** Located on the left, it lists various data products and their metadata.
- Graph Builder:** The central workspace where a workflow is constructed. It features a canvas with nodes (Read, Coherence, TOPSAR-Deburst, BandMaths, CreateStack, Write) connected by arrows. A context menu is open over the 'Write' node, showing options like 'Input-Output', 'Optical', 'Radar', 'Raster', 'Tools', 'Vector', 'Resample', and 'Smoothing/Export'. The 'Write' node is selected, and the 'CreateStack' option is highlighted in the 'Stack Tools' submenu.
- Navigation:** At the bottom left, it shows a globe view of the Earth with a red box indicating the area of interest over Europe and North Africa. A scale bar indicates 2000 Km.
- Properties Panel:** On the right, it shows the properties for the selected 'Write' node, including options for 'Square Pixel', 'Coherence Range Window Size', 'Coherence Azimuth Window Size', 'Subtract flat-earth phase in coherence phase', 'Degree of "Flat Earth" polynomial', 'Number of "Flat Earth" estimation points', and 'Orbit interpolation degree'.

The workflow in the Graph Builder is as follows:

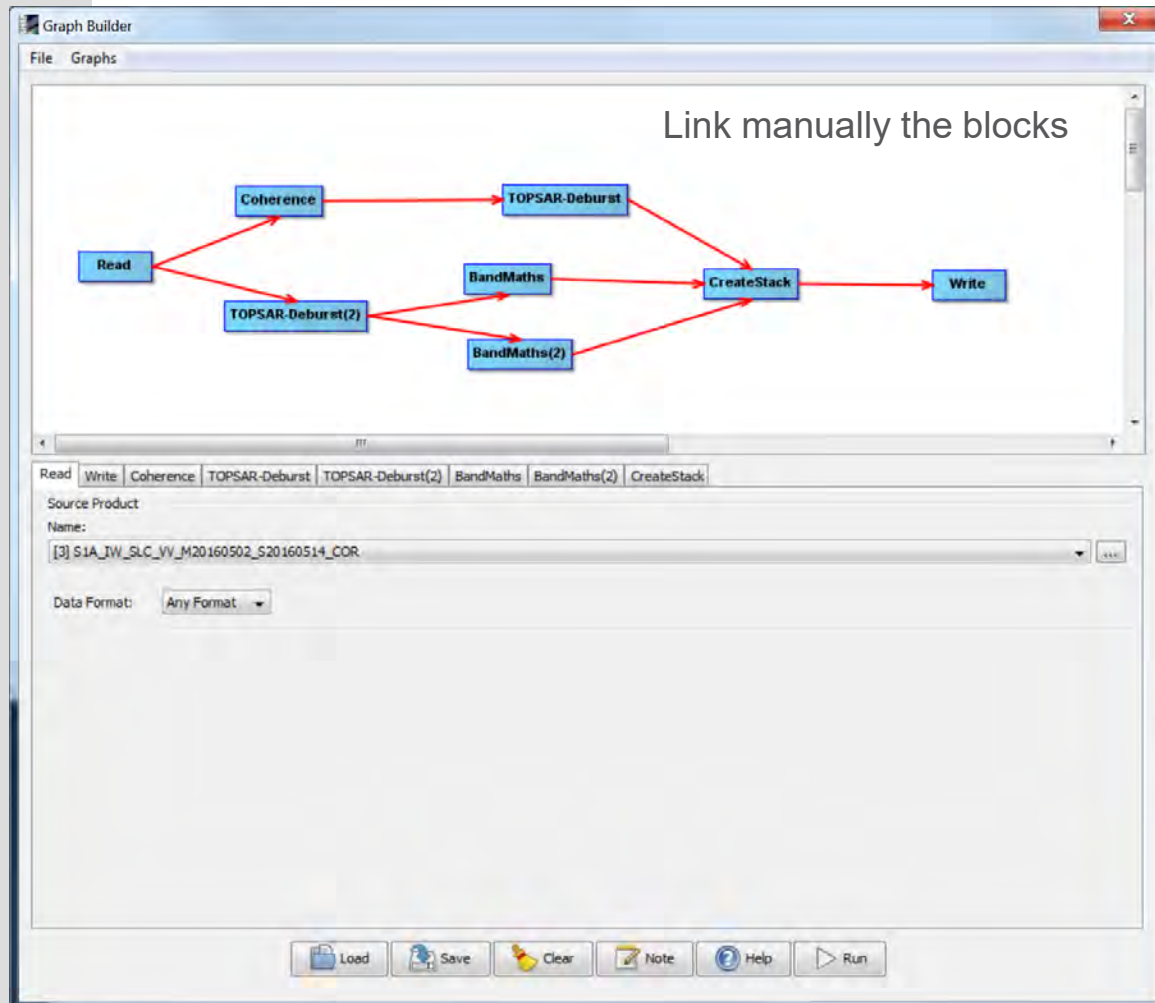
```
graph LR; Read --> Coherence; Read --> TOPSAR-Deburst2[TOPSAR-Deburst(2)]; Coherence --> TOPSAR-Deburst; TOPSAR-Deburst2 --> BandMaths; TOPSAR-Deburst2 --> BandMaths2[BandMaths(2)]; BandMaths --> CreateStack; BandMaths2 --> CreateStack; CreateStack --> Write;
```

The 'Write' node properties are:

- ☒ Square Pixel
- Coherence Range Window Size: 10
- Coherence Azimuth Window Size: 2
- ☐ Subtract flat-earth phase in coherence phase
- Degree of "Flat Earth" polynomial: 5
- Number of "Flat Earth" estimation points: 501
- Orbit interpolation degree: 2

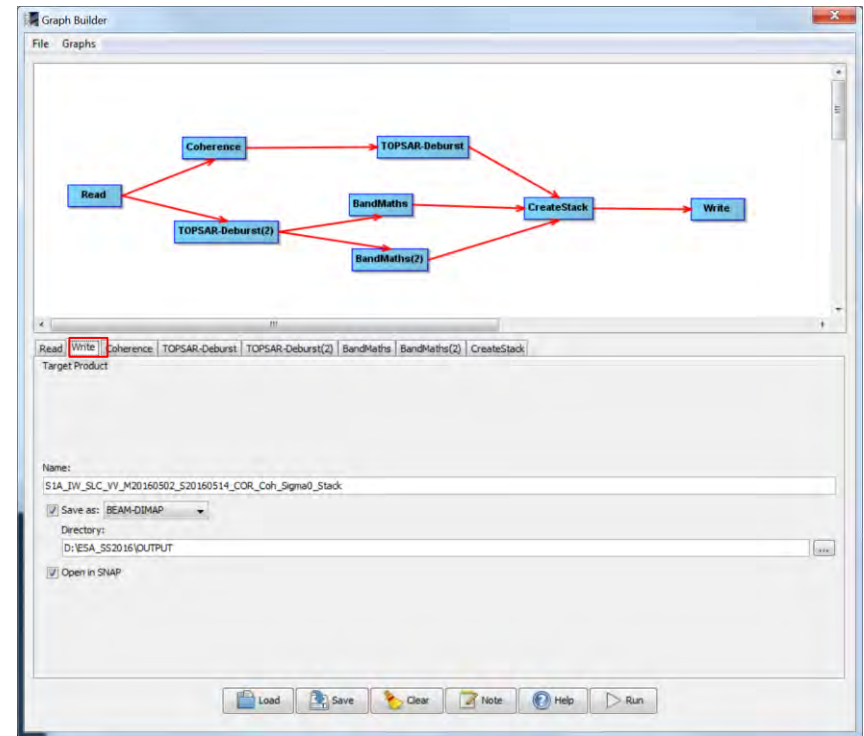
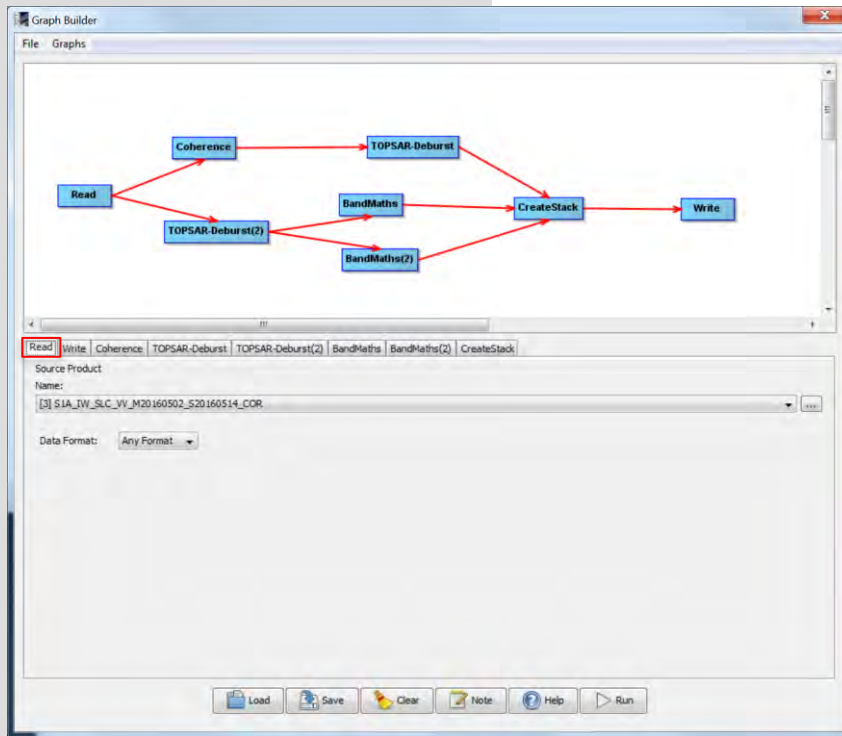
The 'Graph is incomplete' message is displayed at the bottom of the Graph Builder window.

## 3 STEP: Coherence and Backscatter stack generation

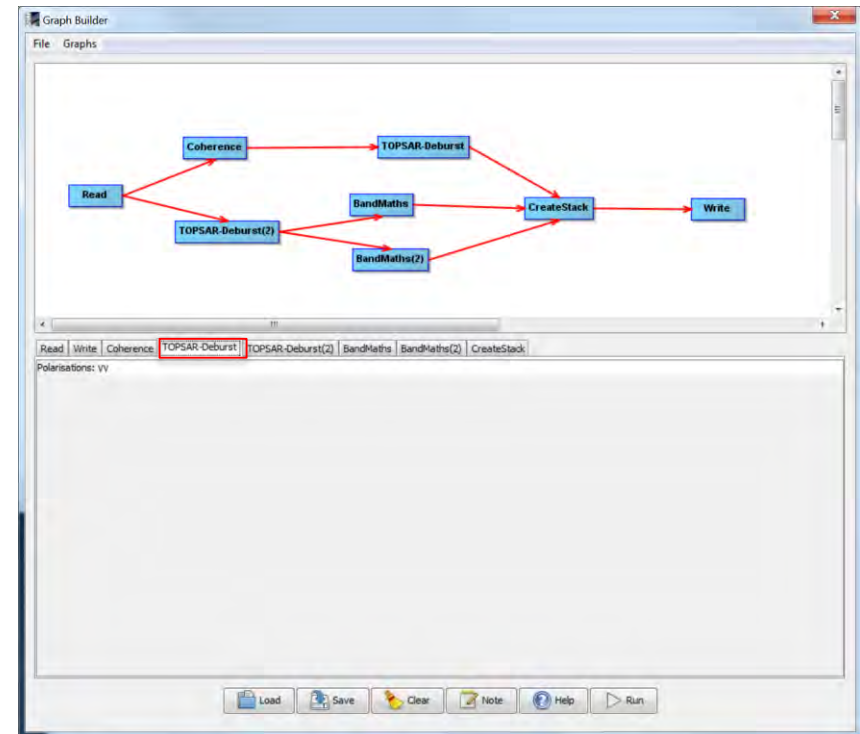
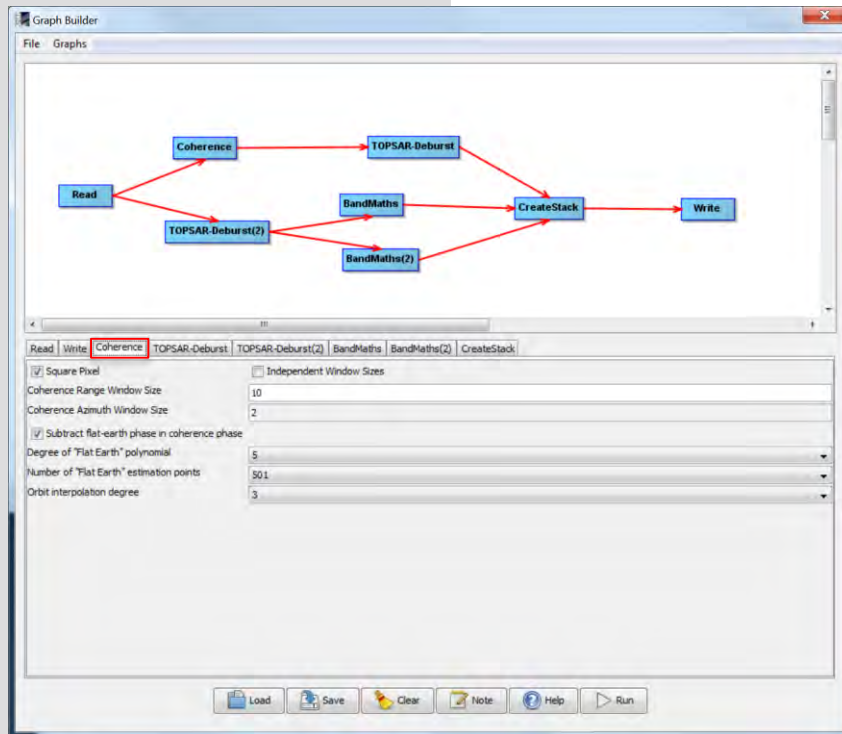




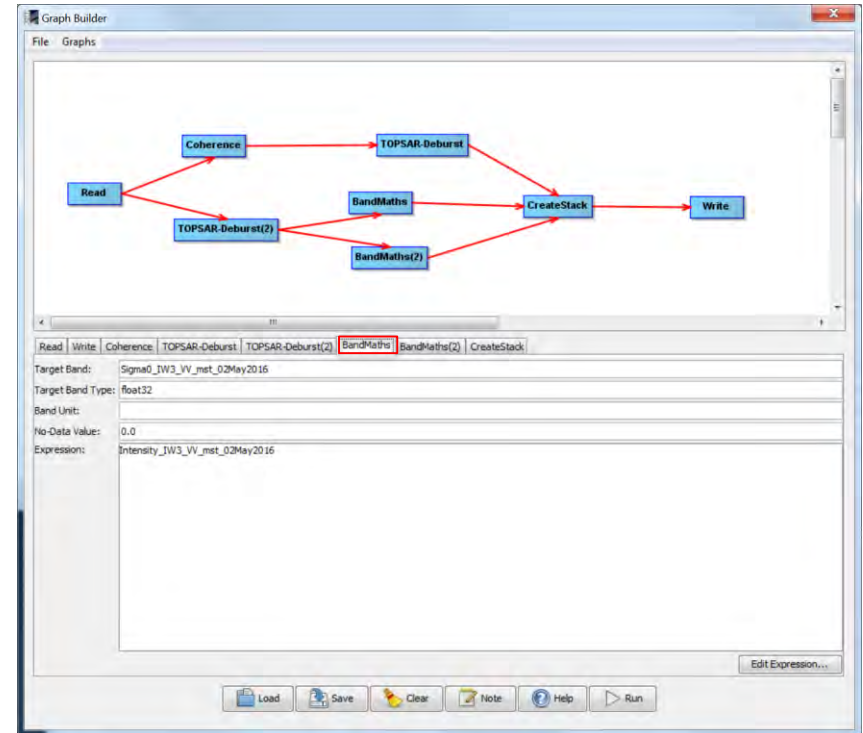
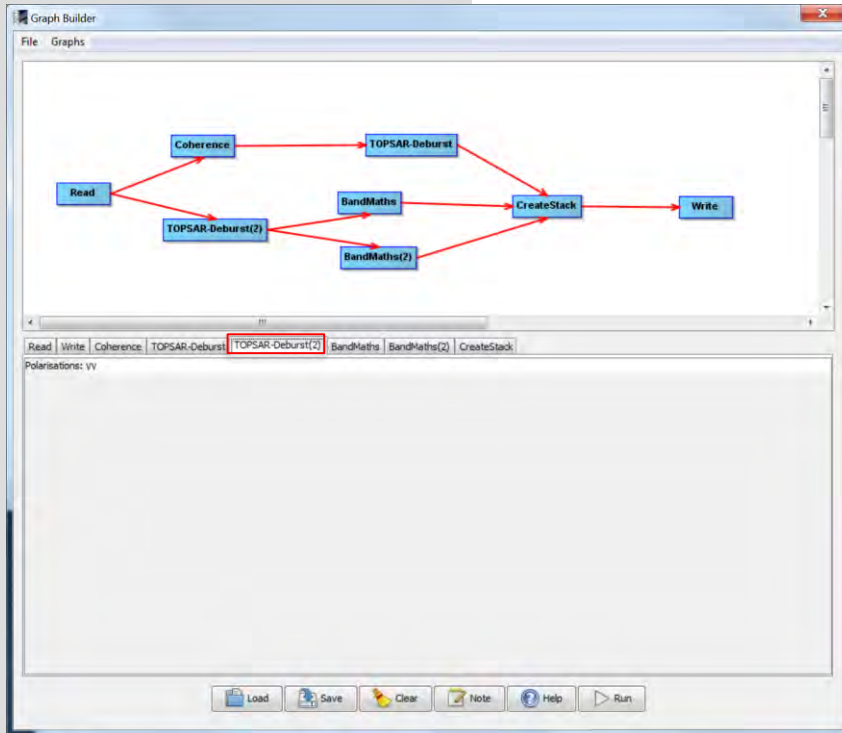
# 3 STEP: Parameters



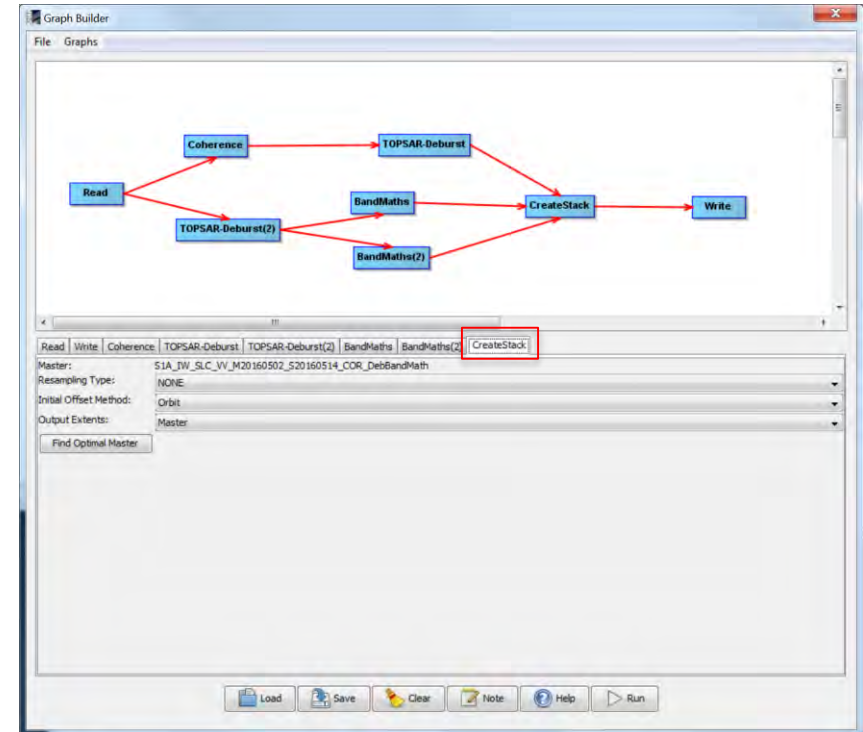
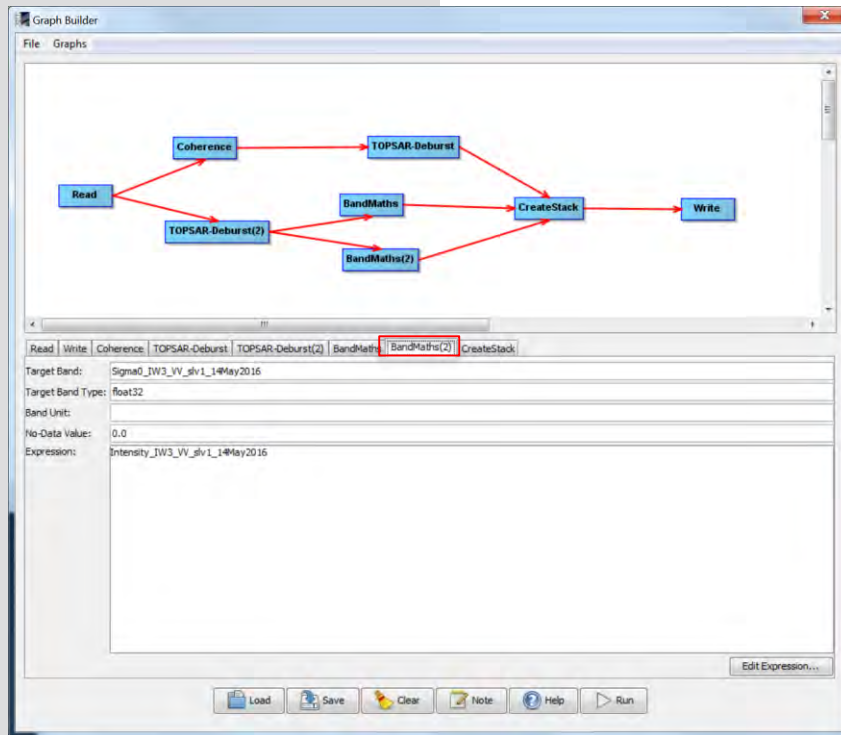
# 3 STEP: Parameters



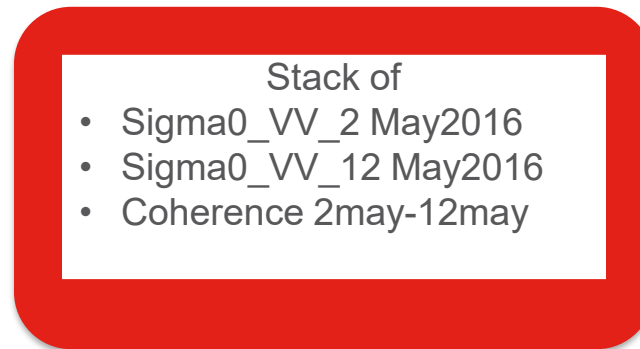
# 3 STEP: Parameters



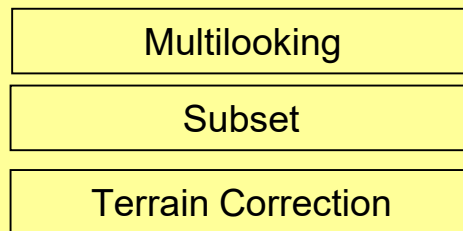
# 3 STEP: Parameters



## 4 Step: ML, Subset, Terrain Correction



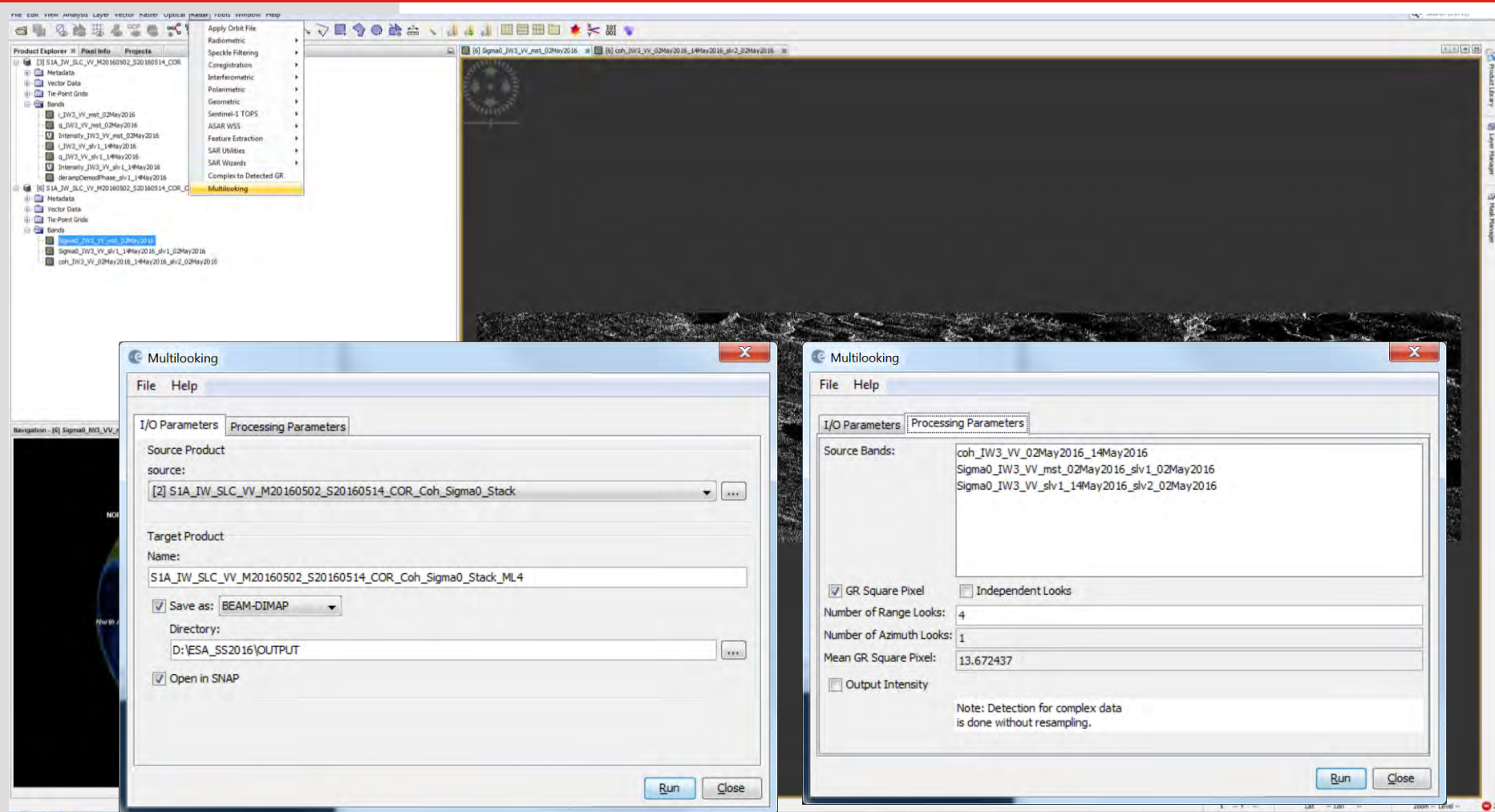
4.



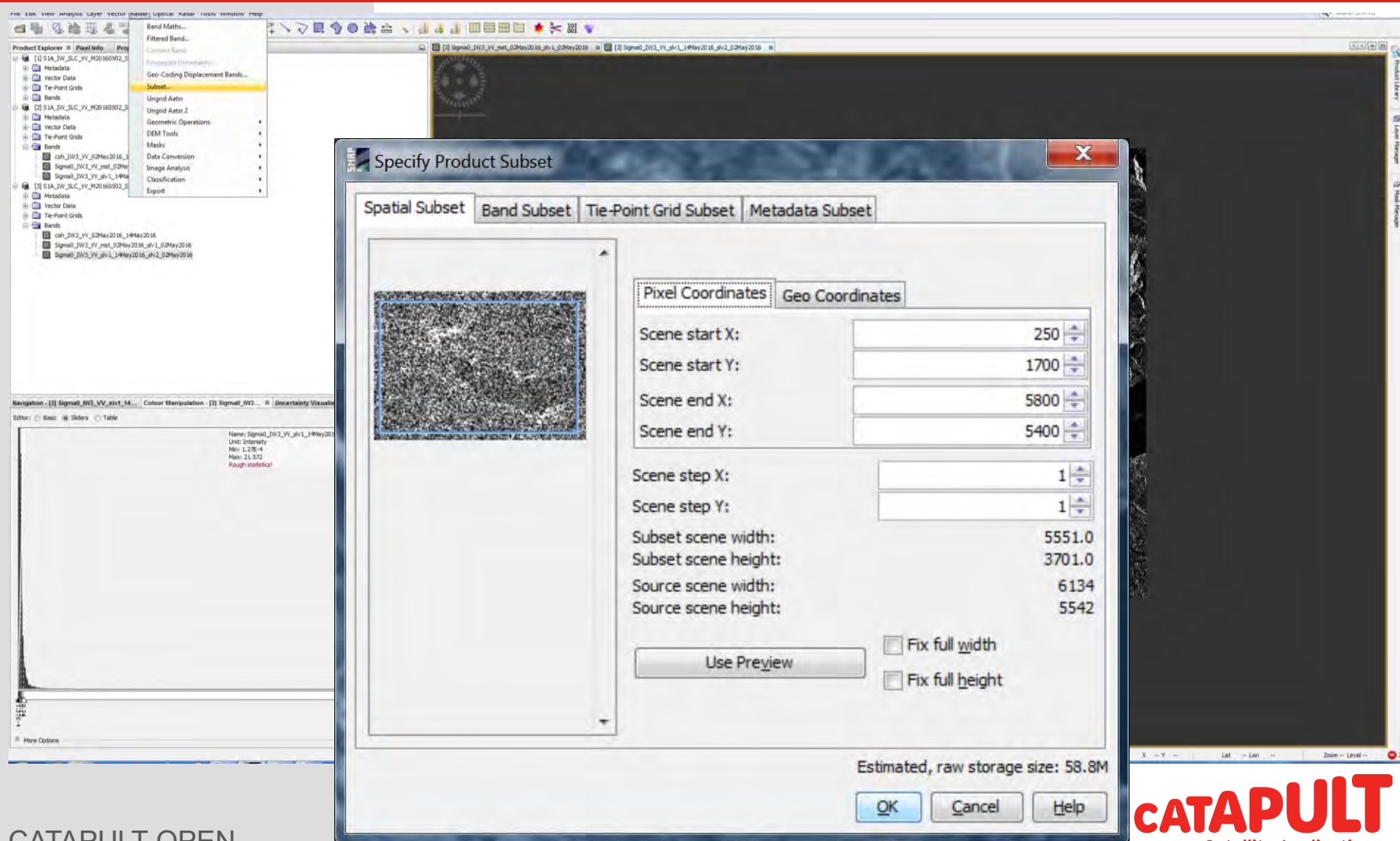
GUI



## 4 Step: ML



## 4 Step: Subset

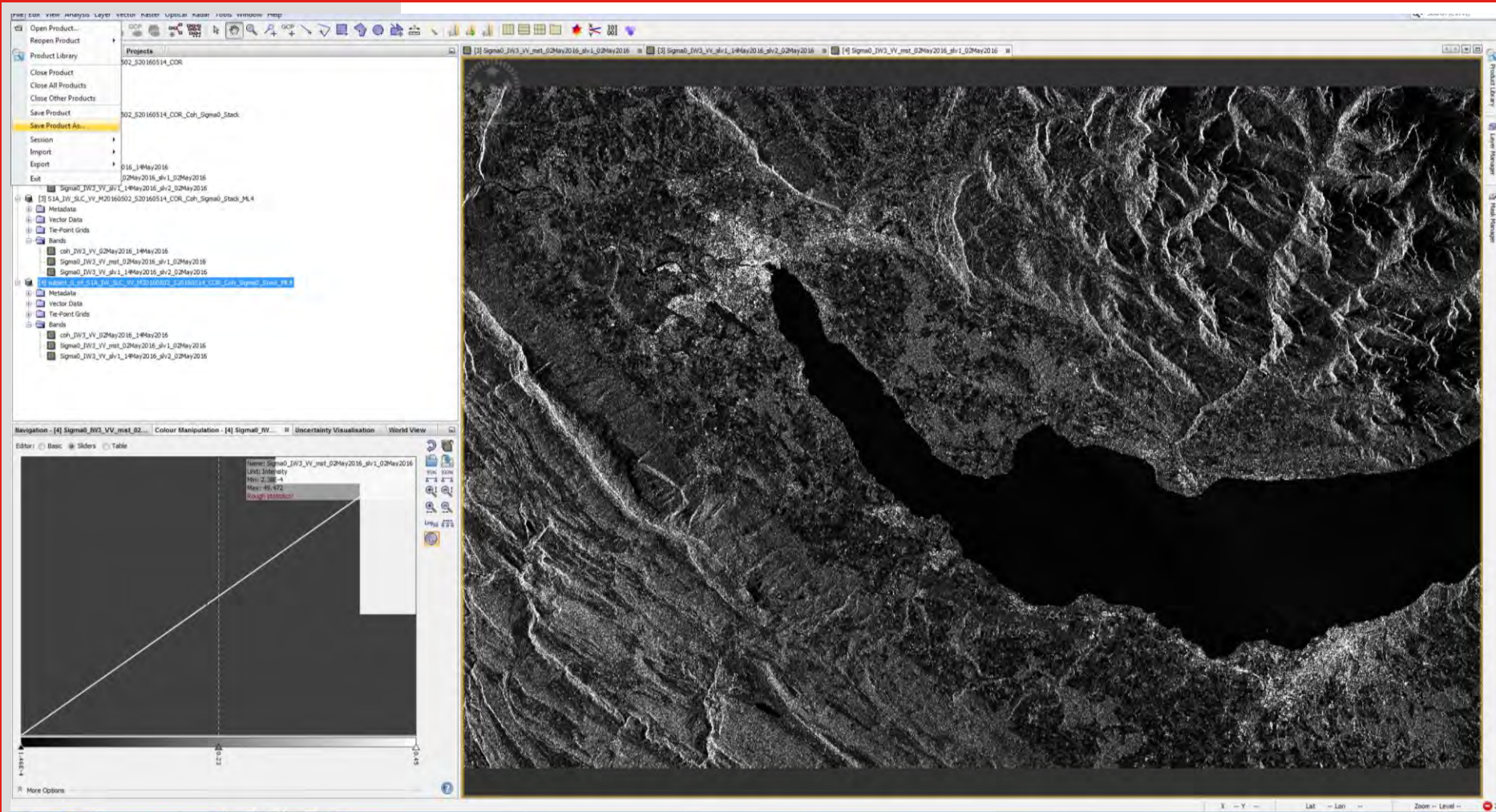


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## 4 Step: Saving the subset

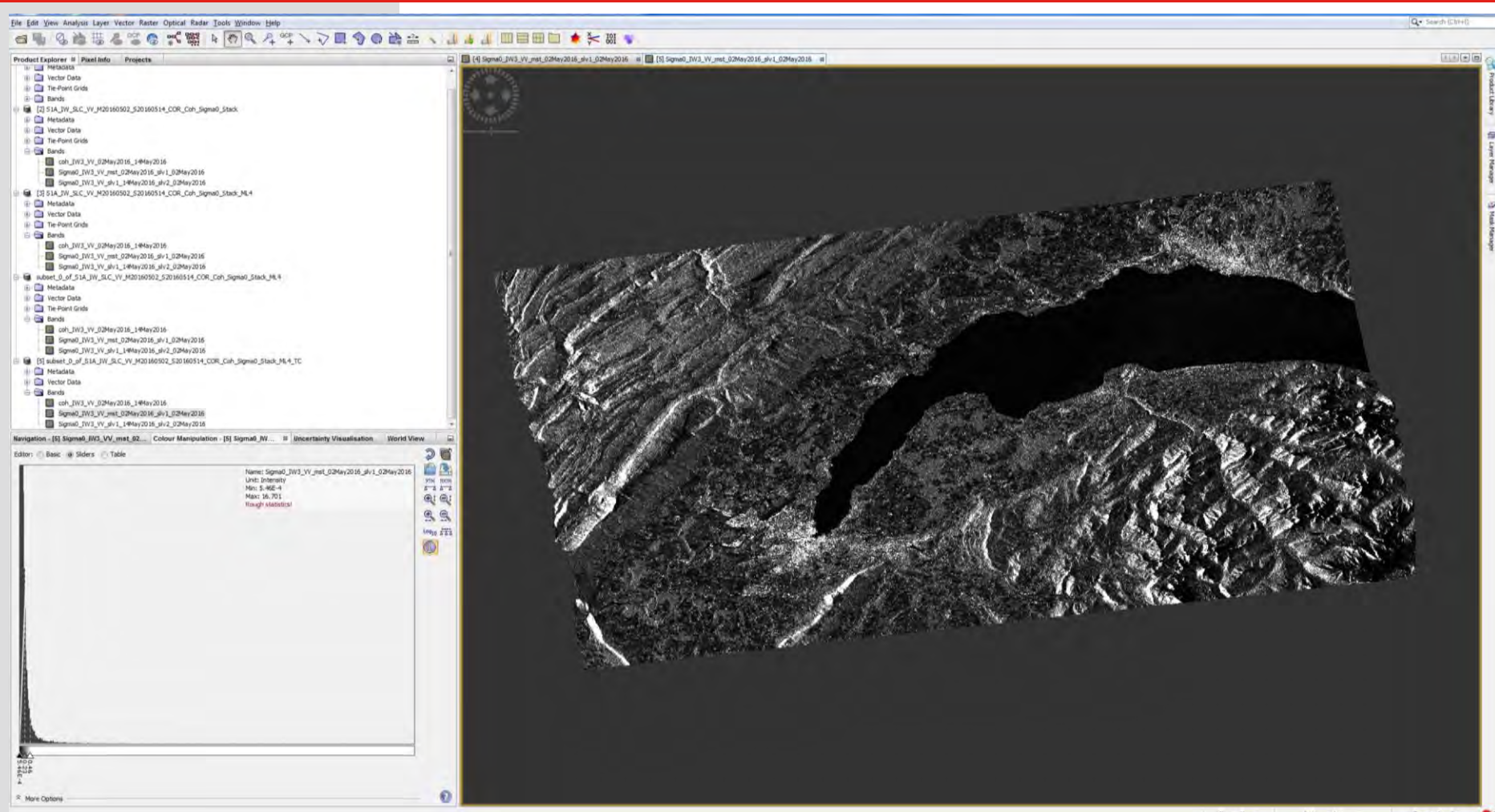


## 4 Step: Terrain Correction

The screenshot shows the SNAP (Scientific Data Processing) software interface. The main window displays a SAR image of a coastal area. The 'Range Doppler Terrain Correction' dialog is open, showing the 'I/O Parameters' tab. The 'Source Product' is 'subset\_0\_of\_S1A\_IW\_SLC\_VV\_M20160502\_S20160514\_COR\_Coh\_Sigma0\_Stack\_ML4'. The 'Target Product' is 'subset\_0\_of\_S1A\_IW\_SLC\_VV\_M20160502\_S20160514\_COR\_Coh\_Sigma0\_Stack\_ML4\_TC'. The 'Save as' is 'BEAM-DIMAP'. The 'Directory' is 'D:\ESA\_SS2016\OUTPUT'. The 'Open in SNAP' checkbox is checked. The 'Range Doppler Terrain Correction' dialog is also open, showing the 'Processing Parameters' tab. The 'Source Bands' are 'coh\_IW3\_VV\_02May2016\_14May2016', 'Sigma0\_IW3\_VV\_mst\_02May2016\_slv1\_02May2016', and 'Sigma0\_IW3\_VV\_slv1\_14May2016\_slv2\_02May2016'. The 'Digital Elevation Model' is 'SRTM 3Sec (Auto Download)'. The 'DEM Resampling Method' is 'BILINEAR\_INTERPOLATION'. The 'Image Resampling Method' is 'BILINEAR\_INTERPOLATION'. The 'Source GR Pixel Spacings (az x rg)' are '13.88(m) x 13.48(m)'. The 'Pixel Spacing (m)' is '13.88'. The 'Pixel Spacing (deg)' is '1.246861614357896E-4'. The 'Map Projection' is 'WGS84(DD)'. The 'Mask out areas without elevation' checkbox is checked. The 'Output complex data' checkbox is unchecked. The 'Output bands for' section includes 'Selected source band' (checked), 'DEM' (unchecked), 'Latitude & Longitude' (unchecked), 'Incidence angle from ellipsoid' (unchecked), 'Local incidence angle' (unchecked), and 'Projected local incidence angle' (unchecked). The 'Apply radiometric normalization' checkbox is unchecked. The 'Save Sigma0 band' checkbox is unchecked, with the value 'Use projected local incidence angle from DEM'. The 'Save Gamma0 band' checkbox is unchecked, with the value 'Use projected local incidence angle from DEM'. The 'Save Beta0 band' checkbox is unchecked. The 'Auxiliary File (ASAR only)' is 'Latest Auxiliary File'. The 'Run' and 'Close' buttons are at the bottom of the dialog.



# Step 5 - Analysis





## Step 5 - Analysis

Stack of Multilooked and terrain corrected

- Sigma0\_VV\_2 May2016
- Sigma0\_VV\_12 May2016
- Coherence 2may-12may



Linear to db

Ratio 2May/12 May

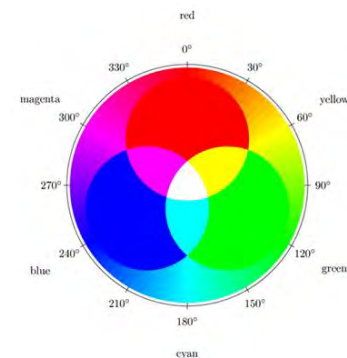
RGB Backscatters and Backscatter ratio

RGB Coherence and Backscatter

Export to Google Earth

GUI

} Analysis



5.

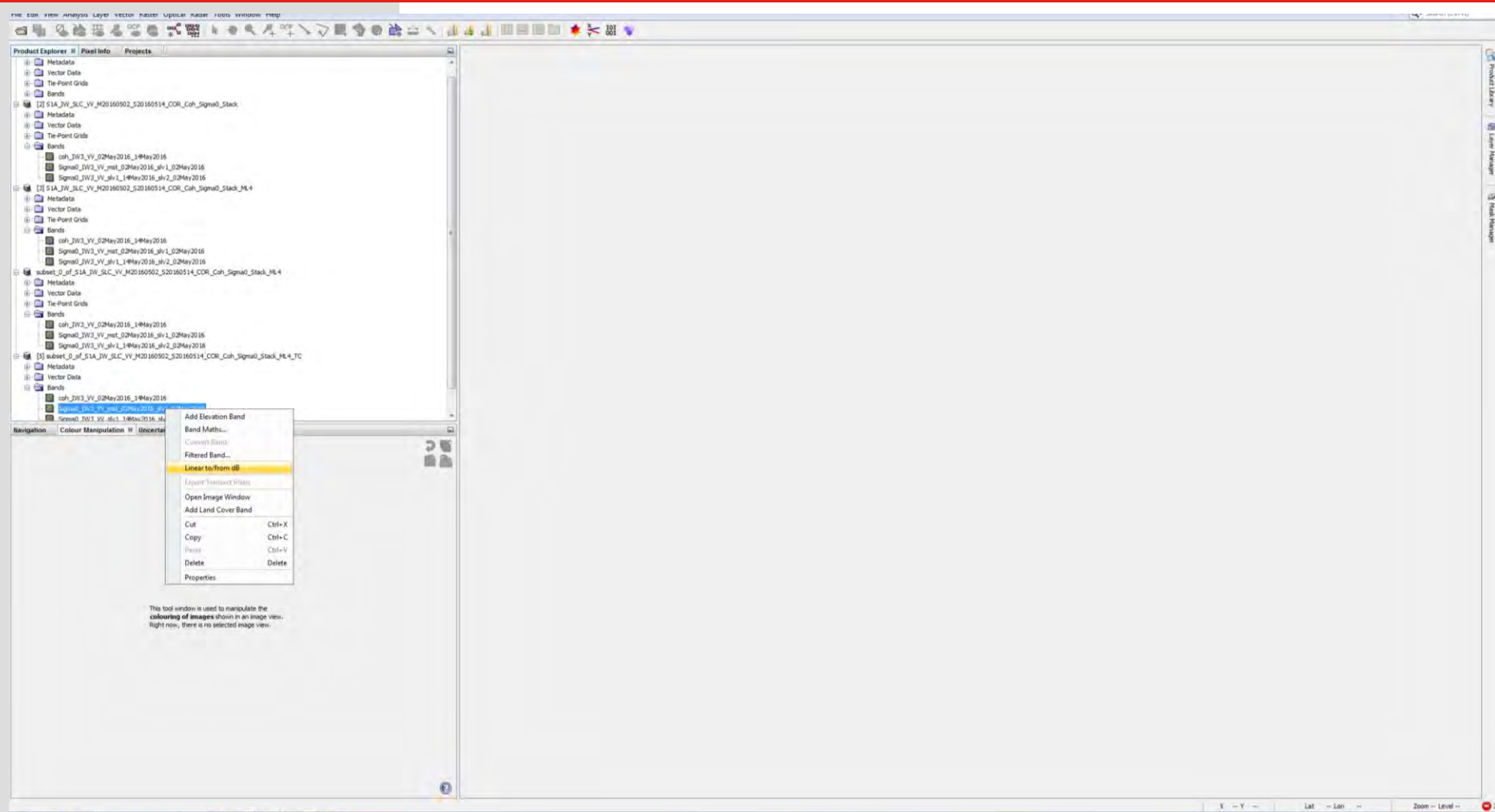
## 5 Step – Change detection

- Backscatter intensity and the interferometric correlation are relatively independent quantities containing complementary thematic information.
- The additional information contained in the interferometric correlation can be used for land-use classification and the retrieval of geophysical and biophysical parameters.

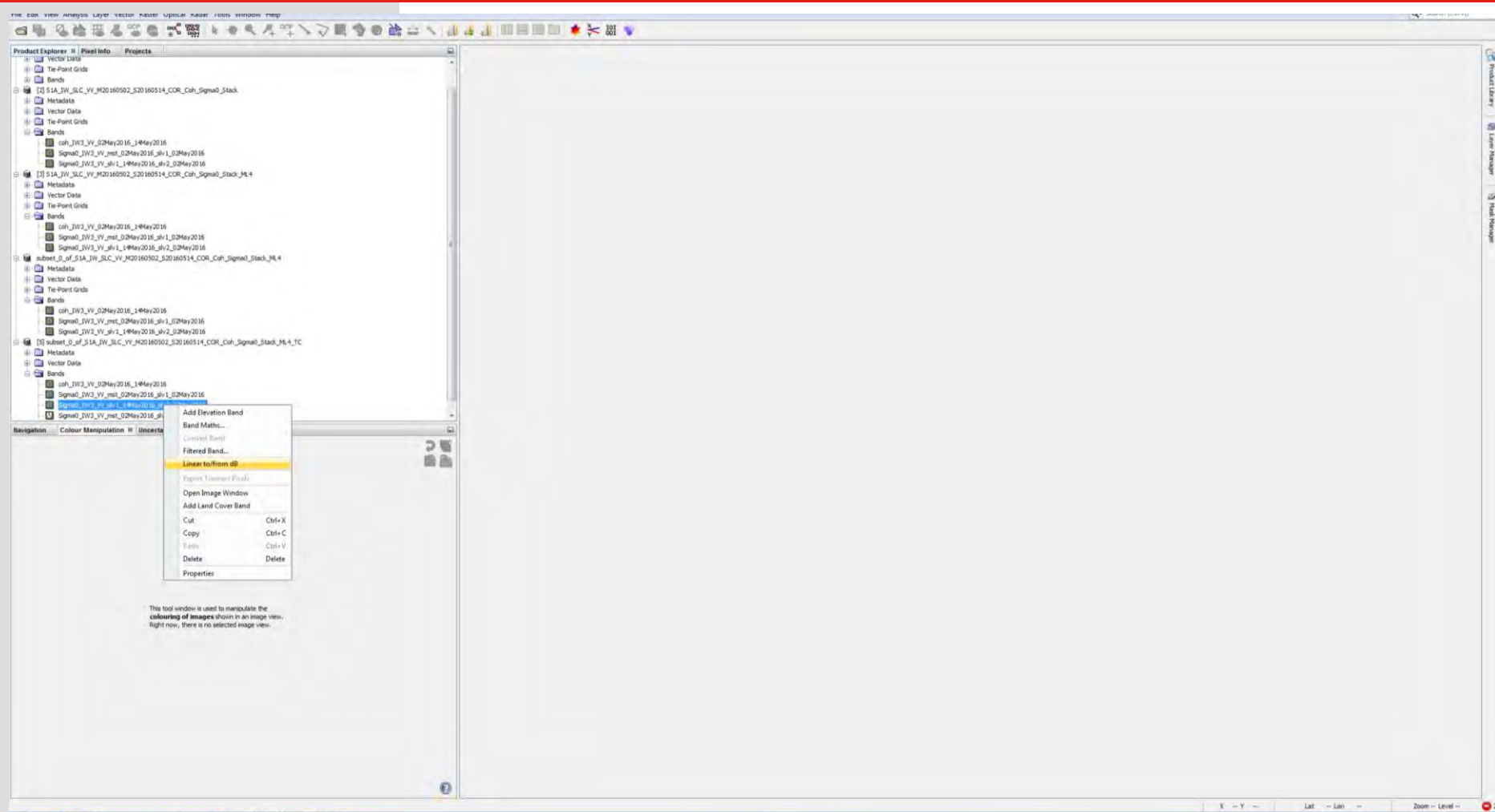
RGB composite = **R** Sigma0<sub>1date</sub>, **G** Sigma0<sub>2 date</sub>, **B** Ratio Sigma0<sub>1date</sub> / Sigma0<sub>2 date</sub>

RGB composite = **R** Coherence<sub>1date-2date</sub>, **G** Sigma0<sub>1date</sub>, **B** Ratio Sigma0<sub>1date</sub> / Sigma0<sub>2 date</sub>

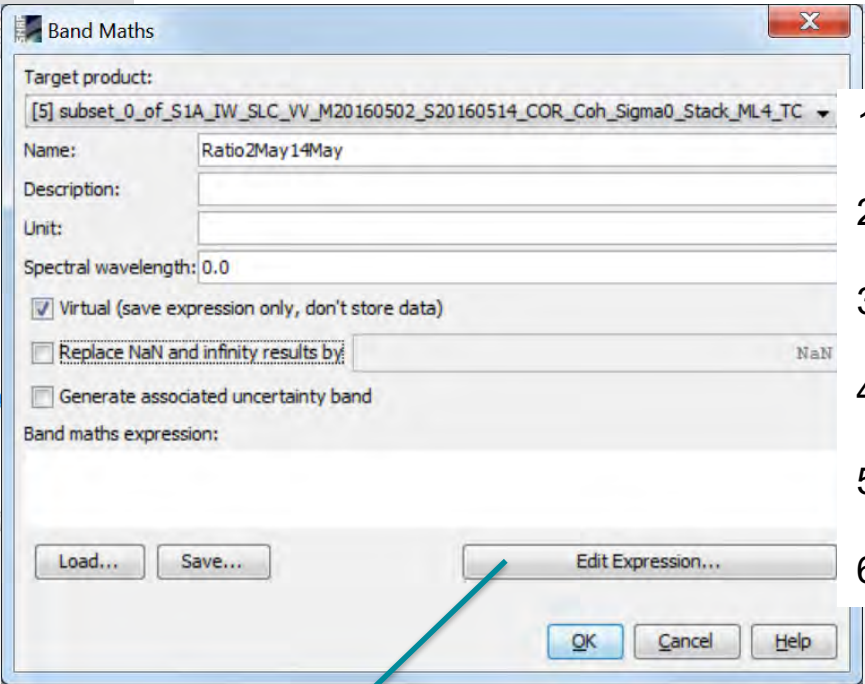
# Step 5: Linear to db



## Step 5: Linear to db



# Step 5: Ratio 2May/12 May (band maths Op)



1. Utility → Band Maths Op

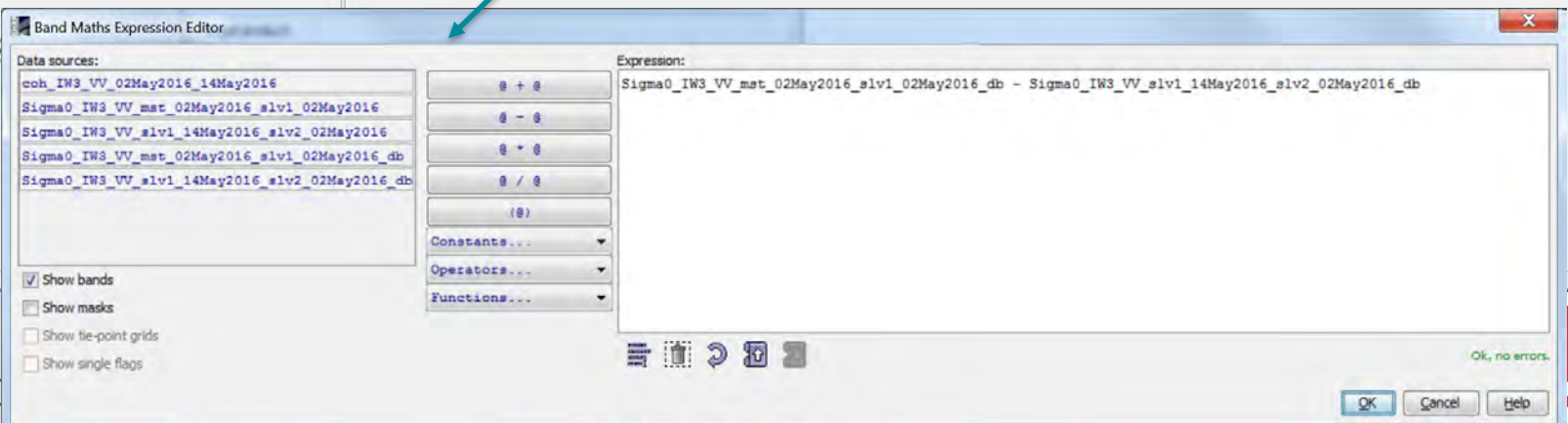
2. Select Target product

3. Name: write Ratio2May14May

4. Check Virtual option

5. Uncheck Replace NaN

6. Click to Edit Expression



Band Maths Expression Editor

Data sources:

- coh\_IW3\_VV\_02May2016\_14May2016
- Sigma0\_IW3\_VV\_mst\_02May2016\_slv1\_02May2016
- Sigma0\_IW3\_VV\_slv1\_14May2016\_slv2\_02May2016
- Sigma0\_IW3\_VV\_mst\_02May2016\_slv1\_02May2016\_db
- Sigma0\_IW3\_VV\_slv1\_14May2016\_slv2\_02May2016\_db

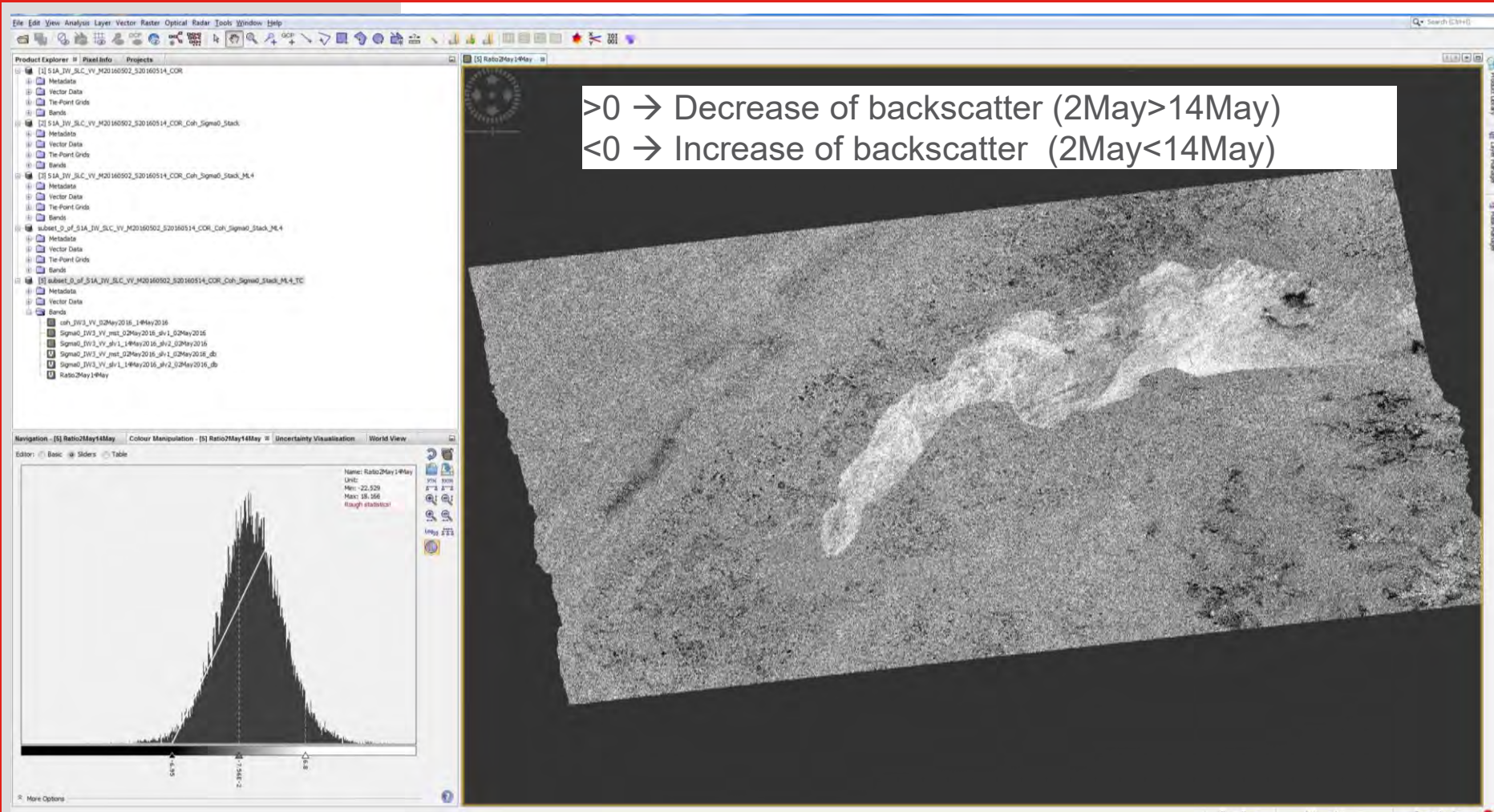
Expression:

Sigma0\_IW3\_VV\_mst\_02May2016\_slv1\_02May2016\_db - Sigma0\_IW3\_VV\_slv1\_14May2016\_slv2\_02May2016\_db

OK, no errors.



## Step 5: Ratio 2May/12 May



## Step 5: Visualisation RGB (Backscatter and ratio)

Right click over the product name

Select RGB-Image Channels

Profile:

Red: Sigma0\_IW3\_VV\_mst\_02May2016\_slv1\_02May2016\_db

Green: Sigma0\_IW3\_VV\_slv1\_14May2016\_slv2\_02May2016\_db

Blue: Ratio2May14May

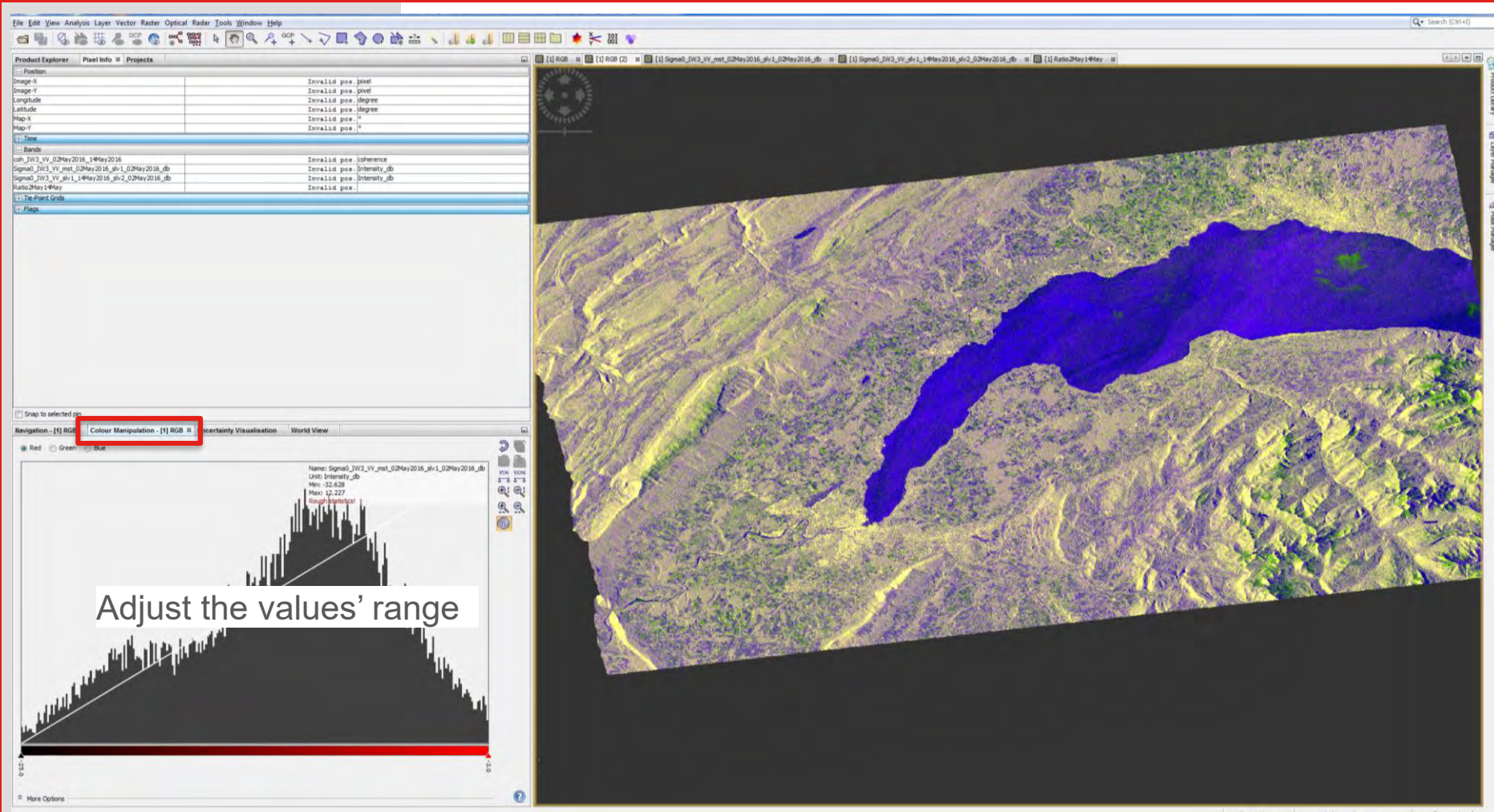
Expressions are valid

☐ Store RGB channels as virtual bands in current product

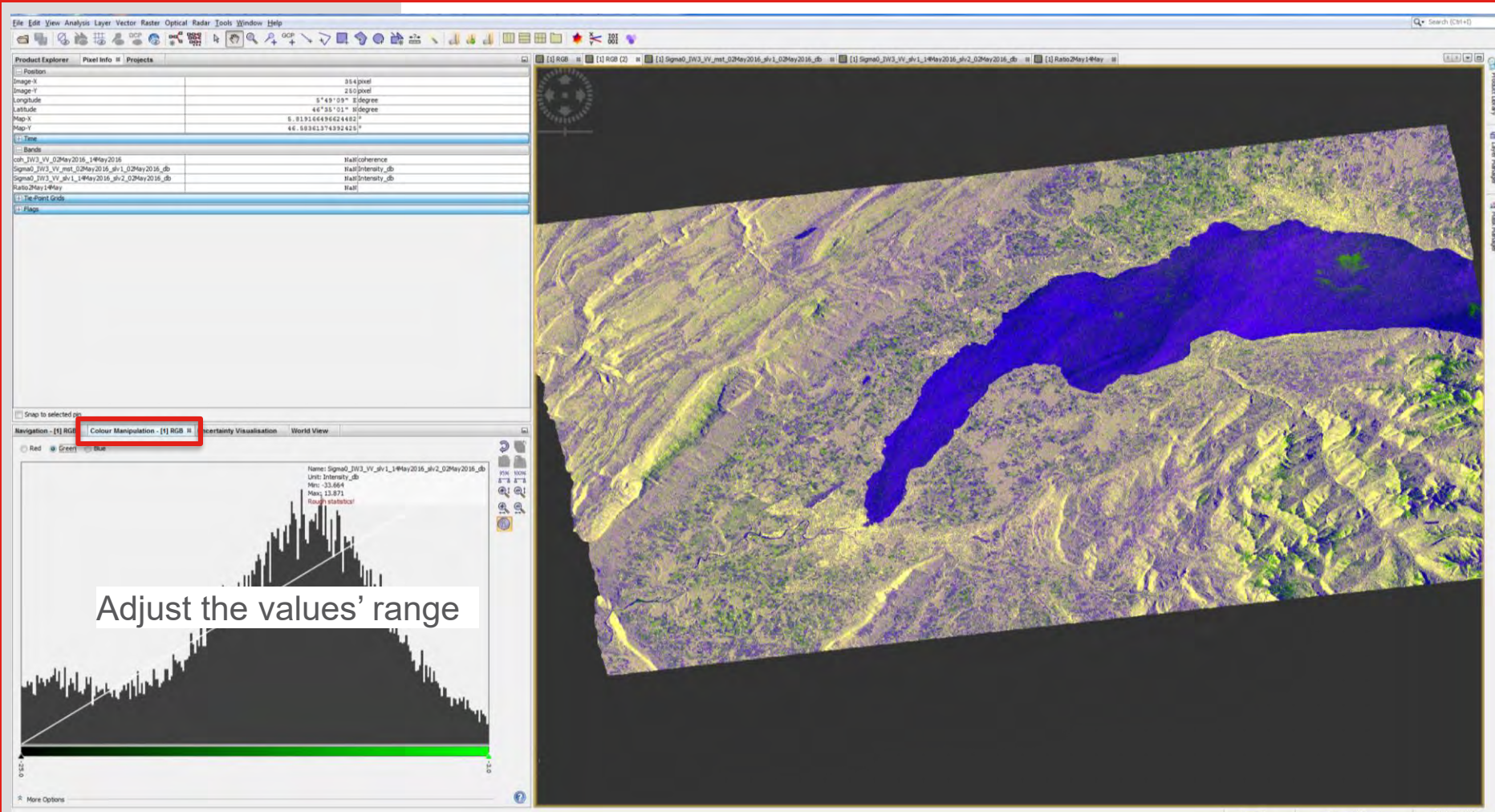
OK Cancel Help



## Step 5: Adjusting the range (Backscatter and ratio)

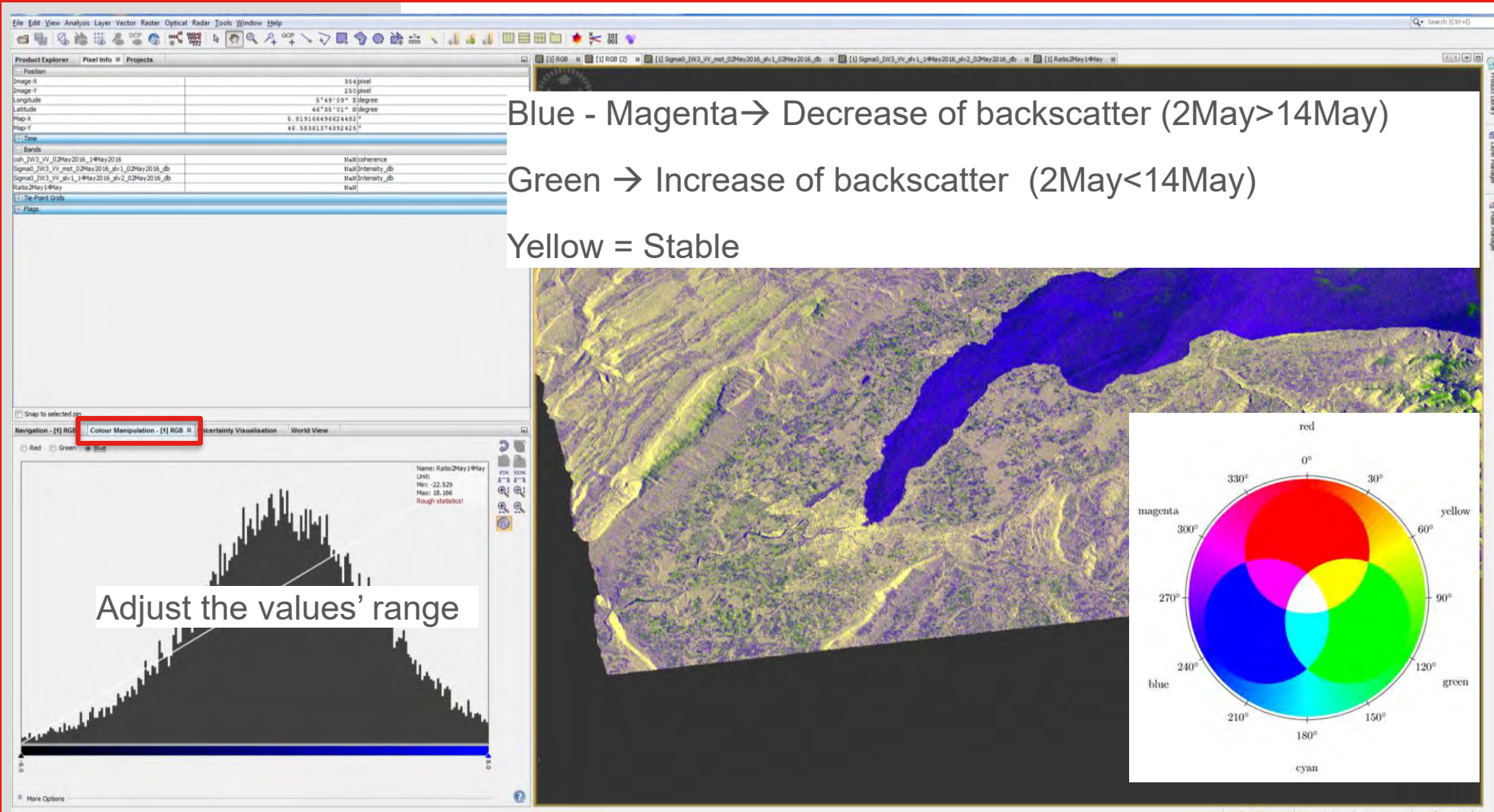


## Step 5: Adjusting the range (Backscatter and ratio)





## Step 5: Adjusting the range (Backscatter and ratio)





# Step 5: Visualisation RGB (Coherence and Backscatter)

The screenshot displays the CATAPULT OPEN software interface. The main window shows a satellite image with a color bar at the bottom. A dialog box titled 'Select RGB-Image Channels' is open, allowing the user to select channels for the Red, Green, and Blue color channels. The 'Red' channel is set to 'coh\_IW3\_VV\_02May2016\_14May2016', the 'Green' channel is set to 'Sigma0\_IW3\_VV\_mst\_02May2016\_slv1\_02May2016', and the 'Blue' channel is set to 'Ratio2May14May'. The 'Store RGB channels as virtual bands in current product' checkbox is unchecked. The 'Ratio2May14May' band is highlighted in the 'Product Explorer' on the left. A histogram of the 'Ratio2May14May' band is shown in the bottom left, with a text overlay 'Adjust the values' range' pointing to the x-axis. The histogram shows a distribution of values from 0 to 1, with a peak around 0.5. The text 'Name: Ratio2May14May', 'Units: -22.529', 'Max: 18.166', and 'Rough Statistics' are visible next to the histogram.

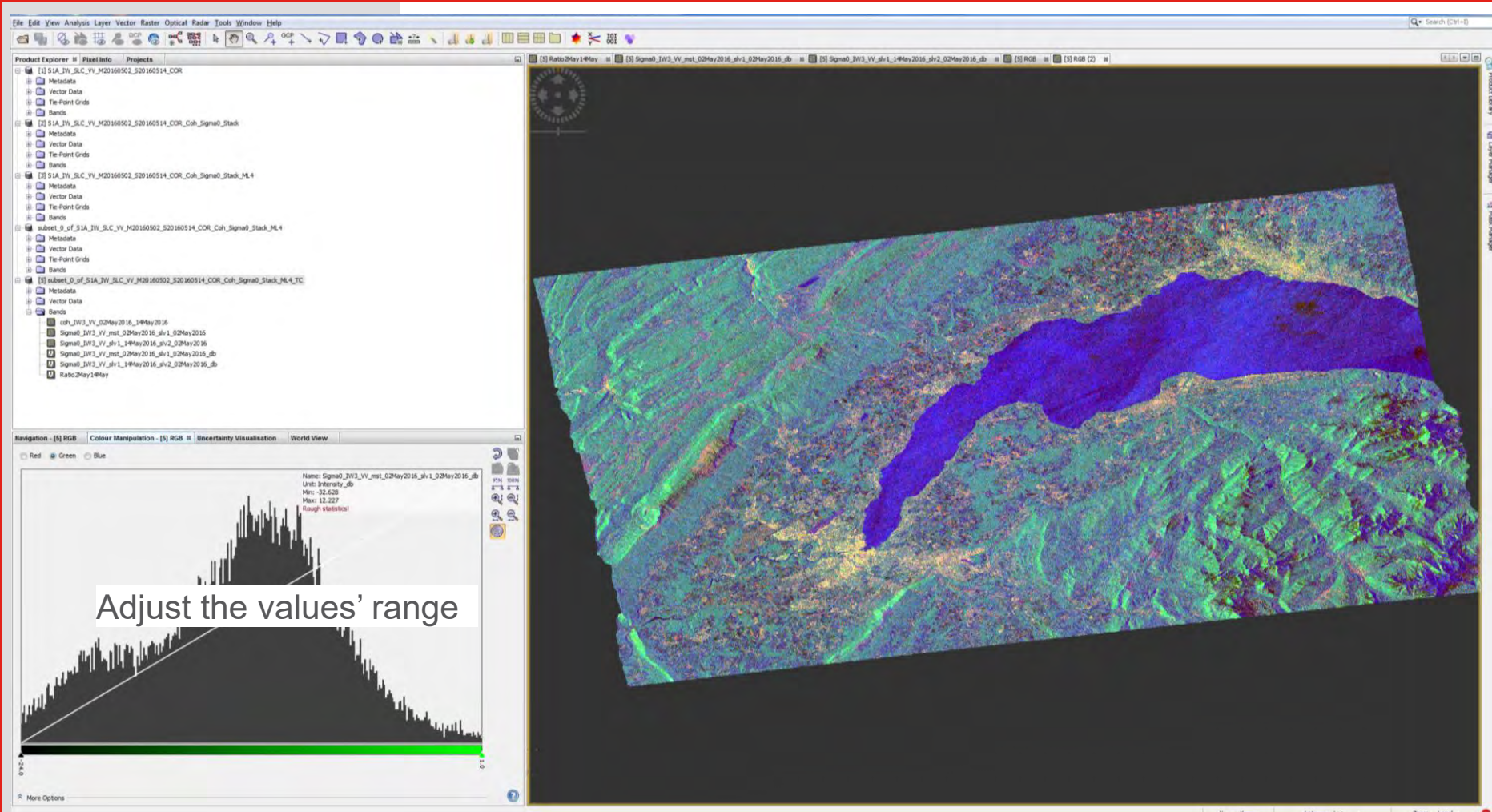
Adjust the values' range

## CATAPULT OPEN

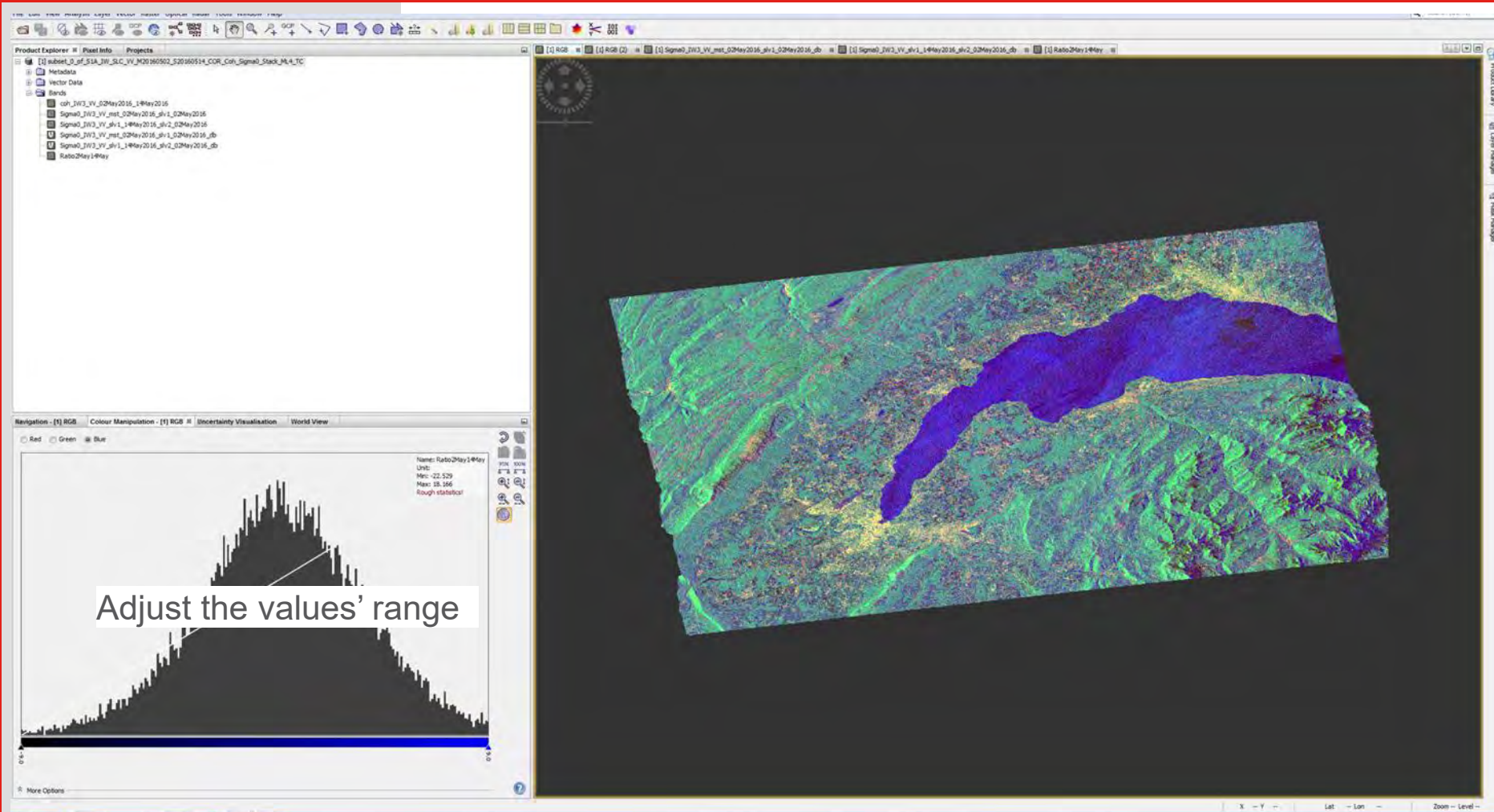




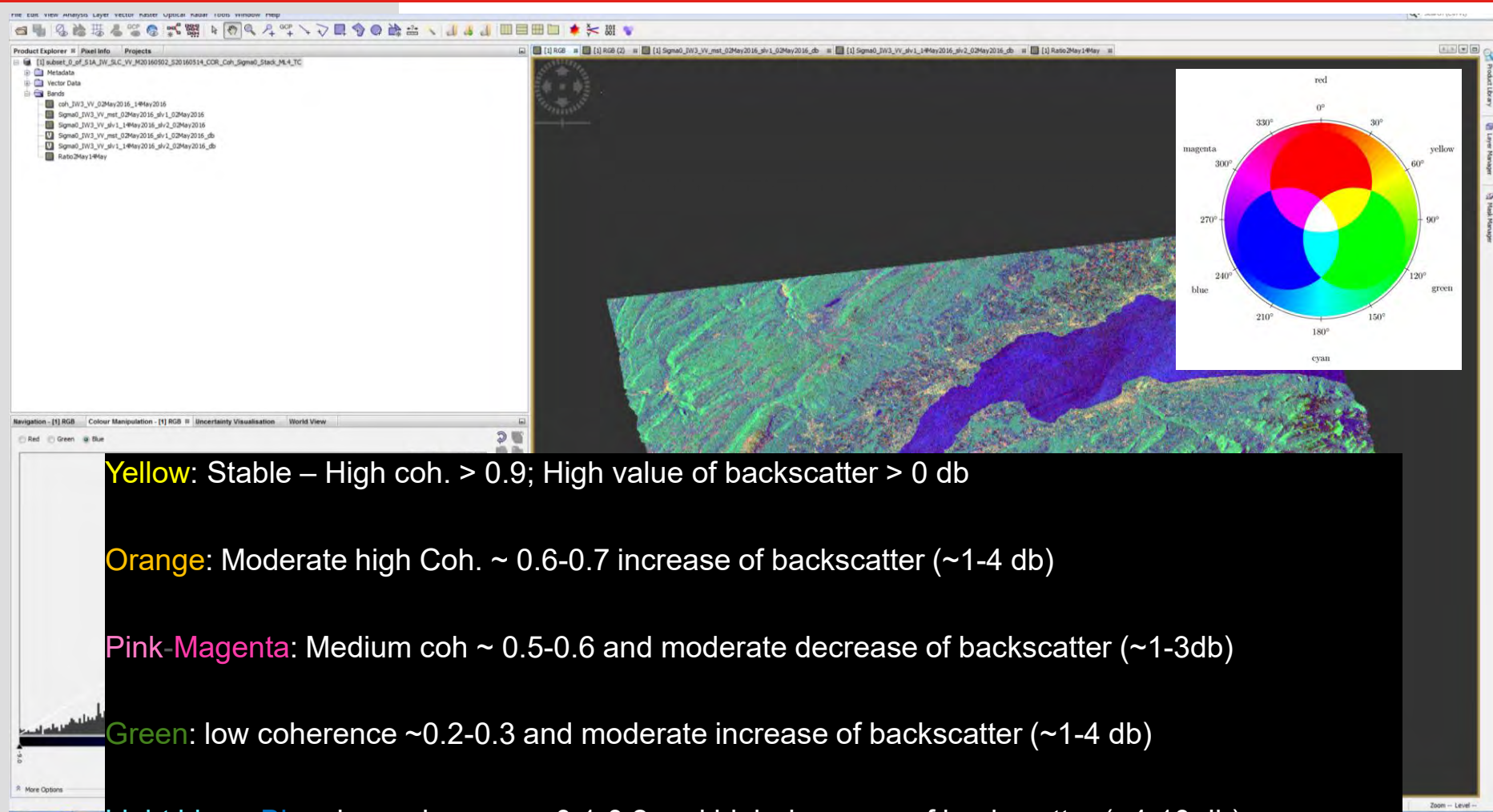
# Step 5: RGB - Coherence and Backscatter



# Step 5: RGB - Coherence and Backscatter

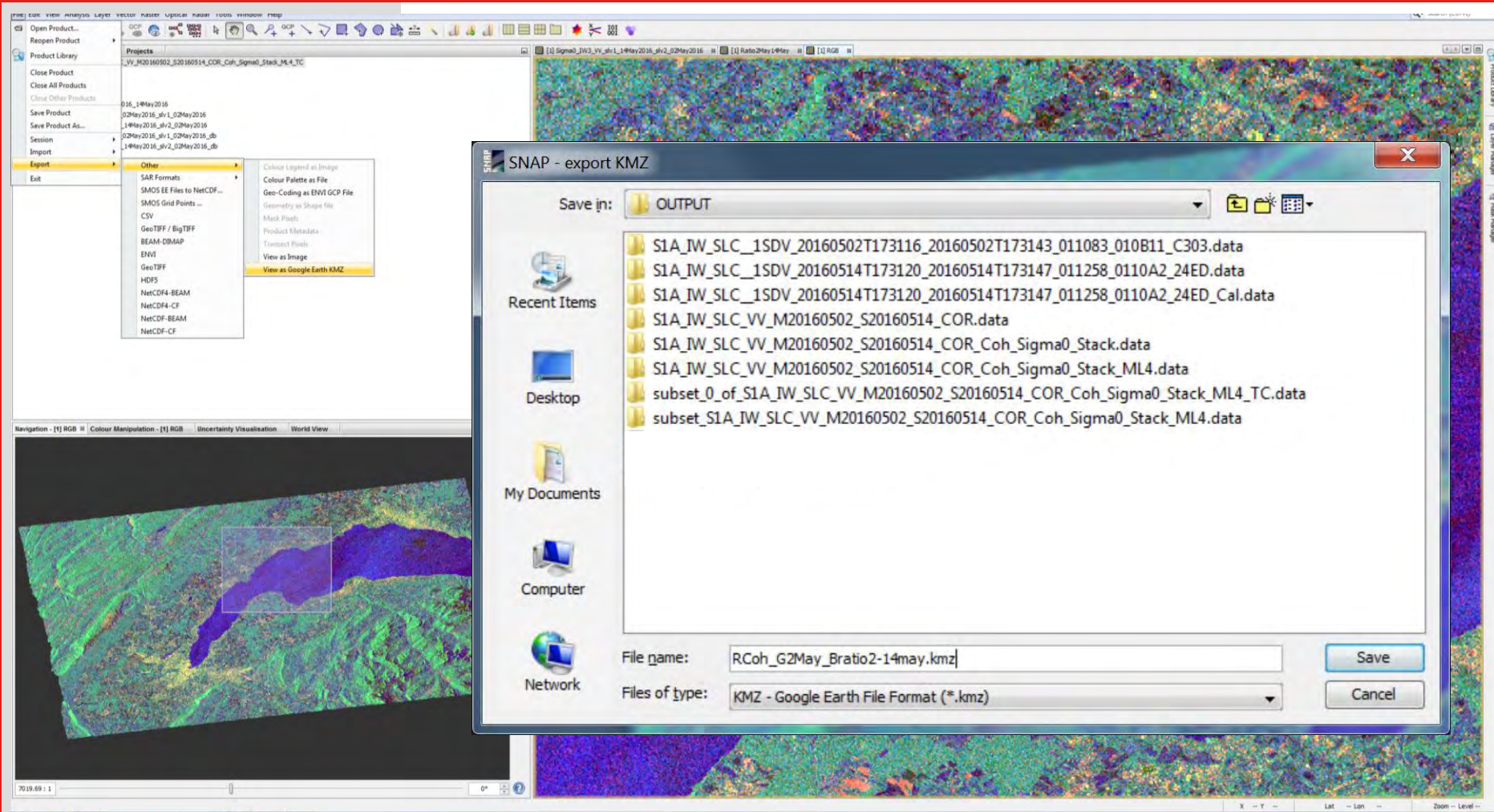


## Step 5: RGB - Coherence and Backscatter



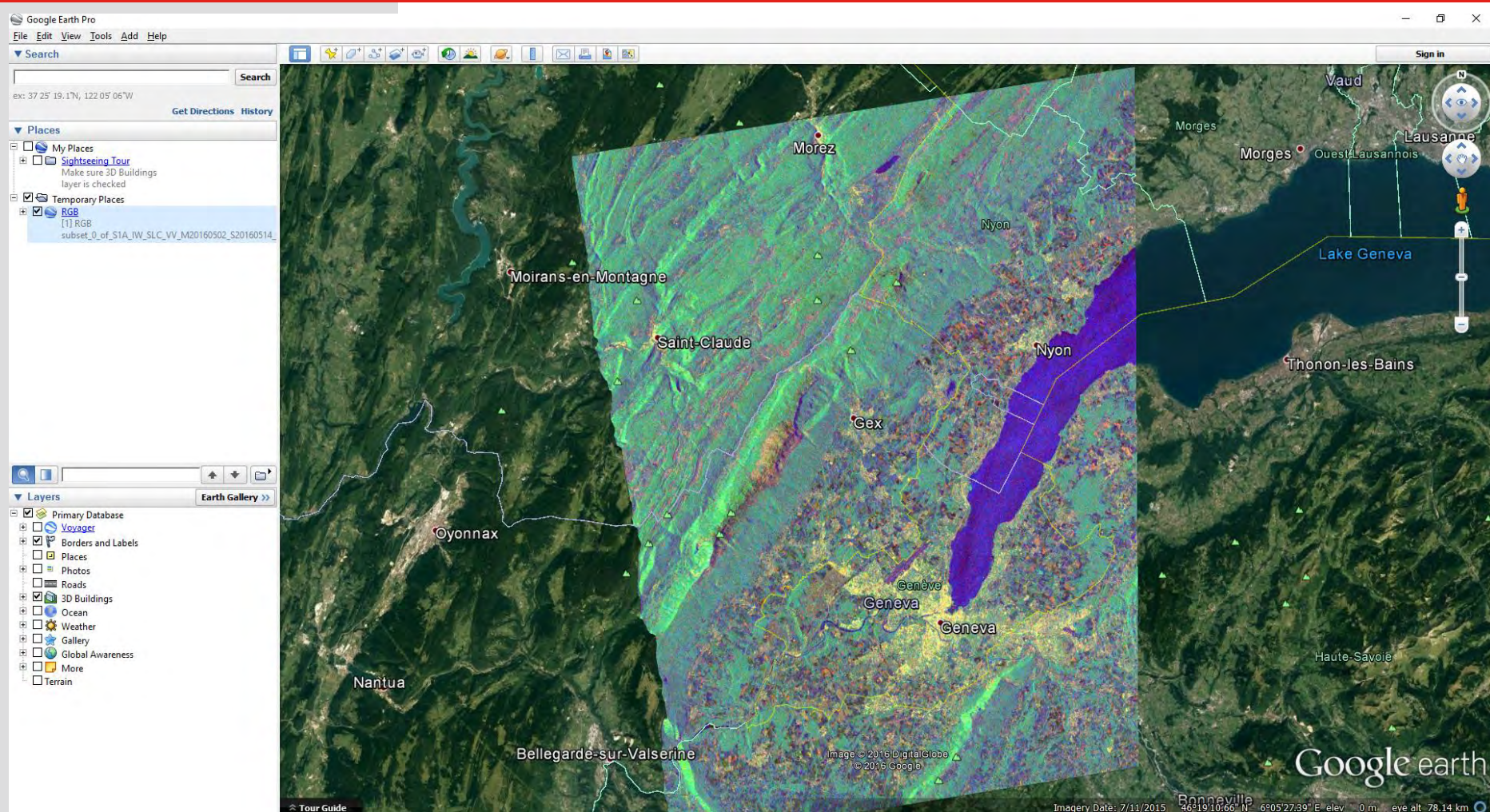


# RGB Coherence and Backscatter: Export to Google Earth



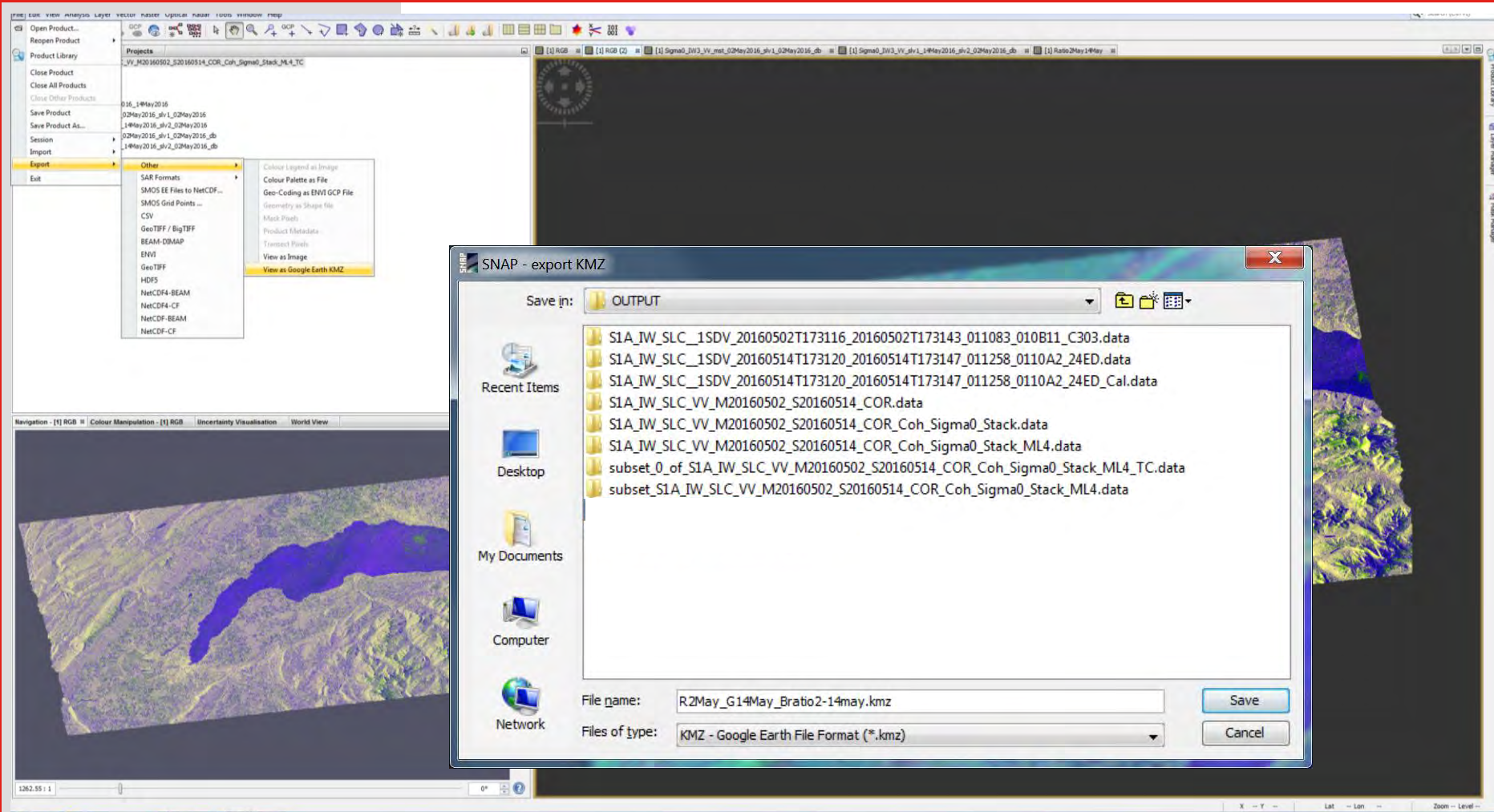


# RGB Coherence and Backscatter: Export to Google Earth



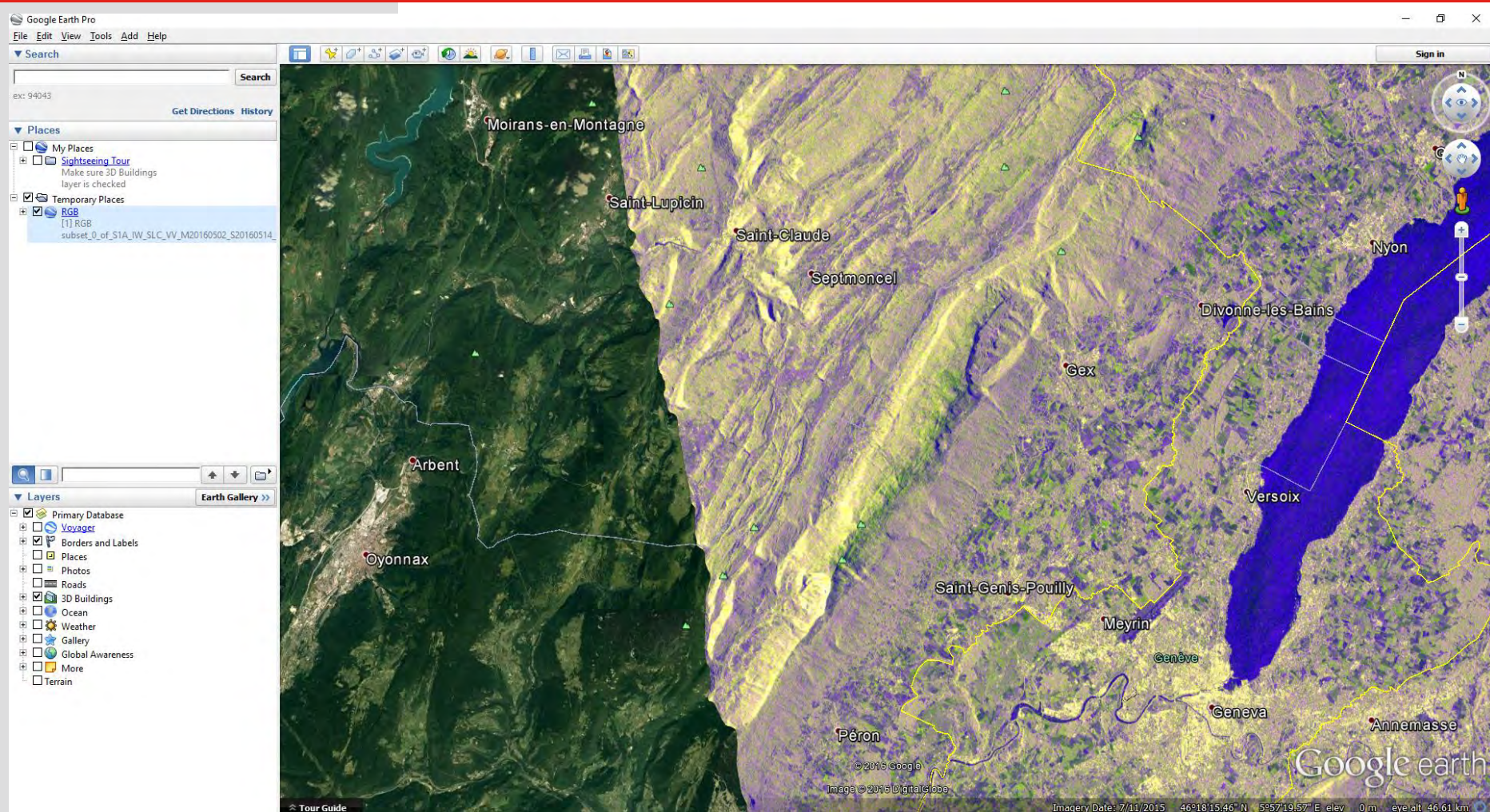


# RGB Backscatters and ratio: Export to Google Earth





# RGB Backscatters and ratio: Export to Google Earth





# Satellite Applications

Any Question?