

# Data processing of spaceborne SAR data

Earth Observation

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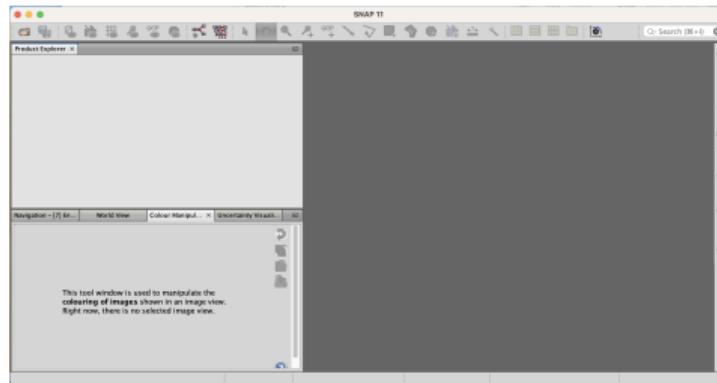
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# SNAP

## 1 Introduction

This presentation is to train on opening a S1 SLC product ad making the necessary steps to generate a usable SLC image.



- Install the Desktop version of SNAP 11.
- Open the SLC folder.



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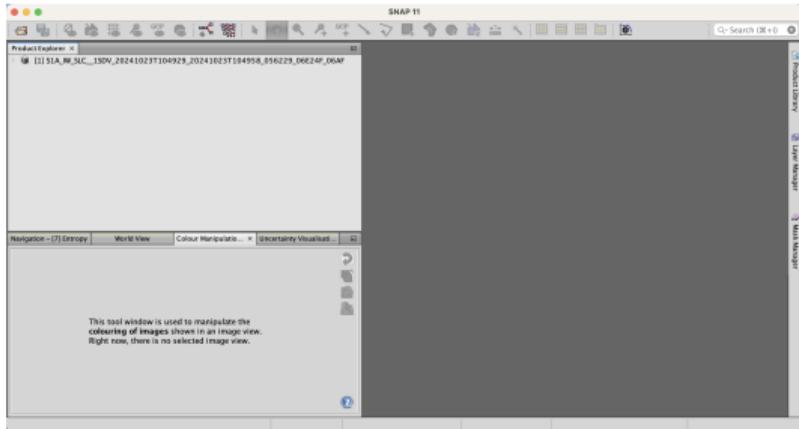
## 2 Preliminary analysis

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# The SLC S1 product

## 2 Preliminary analysis



- Just drag and drop one of the SLC \*.zip data in the **Product Explorer** window.
- Let's assume using "S1A\_IW\_SLC\_1SDV\_20241023T104929\_20241023T104958\_056229\_06E24F\_06AF" product in the "South West" folder.



# Metadata

## 2 Preliminary analysis

This screenshot shows the Sentinel-1 Metadata Editor interface. On the left, the Product Explorer tree view is open, showing a single product node under [1] Abstracted\_Metadata. The main area displays the 'Abstracted\_Metadata' table with various parameters. A tooltip at the bottom left explains the 'Image Manipulation' tool.

Name	Value	Type	Unit	Description
Orbit_State_Vectors				SIGR2_Coefficients
Orbit_RP_Coeffs				Orbital_Period_Coeffs
Raxd_R01_VH				
Raxd_R01_VV				
Raxd_R02_VH				
Raxd_R02_VV				
Raxd_R03_VH				
Raxd_R03_VV				
PRODUCT_ID	S1A_IW_SLC_15DV_20241023T104529_20241023T104958_058229_08824F_08AF	string		Product name
PRODUCT_TYPE	SLC	string		Product type
SPI_DESCRIPTOR	Sentinel-1 W Level-1 SLC Prod.	string		Description
MISSION	SENTINEL-1A	string		Satellite mission
ACQUISITION_MODE	WV	string		Acquisition mode
antenna_pointing	right	string		Right or left facing
BEAMS	-	string		Beams used
SWATH	-	string		Swath name
PROD_TIME	23-OCT-2024 13:05:07.8481	uint32	vv	Processed time
Processing_system_idem	ESA Sentinel-1 PP 093.00	string		Processing system identifier
orb_cycle	335	int32		Cycle
rel_orbit	157	int32		Track
abs_orbit	58229	int32		Orbit
STATE_VECTOR_TIME	23-OCT-2024 10:48:23.1994	uint32	vv	Time of orbit state vector
VECTOR_SOURCE	-	string		State vector source
incidence_near	99999.0	float4	deg	
incidence_far	99999.0	float4	deg	
else_sun	1	int32		Slice number

- Double-click on the [1] product.
- Double click on **Metadata**.
- Double click on **Abstracted\_Metadata**.
- Look at the sensor's parameters.



# Metadata - Subswaths

## 2 Preliminary analysis

The screenshot shows the ScanSAR Metadata viewer interface. On the left, the 'Product Explorer' pane displays a tree structure with nodes like 'Abstracted\_Metadata', 'Original\_Product\_Metadata', 'Vector\_Sources', 'Tie-Point\_Grids', 'Quicklinks', and 'Bands'. The main area, titled 'Abstracted\_Metadata', contains two tabs: 'Metadata' and 'Abstracted\_Metadata'. The 'Abstracted\_Metadata' tab is active, showing a table with columns 'Name', 'Value', 'Type', 'Unit', and 'Description'. The table includes rows for various parameters such as 'PRODUCT\_NAME' (S1A\_IW\_SLC\_1SDV\_20241023T104929\_20241023T104958\_056229\_09824F\_08AF), 'PRODUCT\_TYPE' (SLC), 'CPU\_DESCRIPTOR' (Sentinel-1 WU Level-1 SLC Prod.), 'MISSION' (SENTINEL-1A), 'ACQUISITION\_MODE' (IW), 'BEAMS' (right), 'SWATH' (1), 'PROD\_TIME' (23-OCT-2024 13:05:07.8401), 'PROCESSING\_SYSTEM\_ID' (ESA Sentinel-1 PT 103.80), 'orbit\_cycle' (335), 'REL\_ORBIT' (357), 'ABS\_ORBIT' (56229), 'STATE\_VECTOR\_TIME' (23-OCT-2024 10:48:23.1994), 'VECTOR\_SOURCE' (none), 'incidence\_radar' (99999.0), 'incidence\_fir' (99999.0), and 'slice\_num' (1). A note at the bottom of the table states: 'This tool window is used to manipulate the colouring of images shown in an image view. Right now, there is no selected image view.'

- There are 3 subswaths termed as **Band\_IWx\_xx**.
- The subswaths are linked to the S1 ScanSAR acquisition.
- Each subswath includes two polarimetric channels **VV** and **VH**.



# Metadata - Subswath

## 2 Preliminary analysis

- Double-click on the first subswath to have info:
- It is a matrix of complex number consisting of the in-phase **i<sub>-</sub>** and quadrature **q<sub>-</sub>** components.
- It includes the acquisition data and time.
- It tells you that measurements are complex numbers.
- The **calibration** is NOT (99999.0) applied.



# Metadata

## 2 Preliminary analysis

Name	Value	Type	Unit	Description
PRODUCT	SLA_IW_SLC_150V_20241023T104929_20241023T104958_056229_006124F_06AF	ascii		Product name
PRODUCT_TYPE	iw	ascii		Product type
WPH_DESCRIPTOR	Sentinel-1 (Level-1) SLC Prod.	ascii		Description
MISSION	SENTINEL-1A	ascii		Mission
ACQUISITION_MODE	IW	ascii		Acquisition mode
INTERNAL_POINTING	right	ascii		Right or left facing
RAMAN	-	ascii		Beams used
REFLECTOR	-	ascii		South/north
PROJ_TIME	23-OCT-2024 13:05:07.8401	time32	utc	Processing time
PROCESSING_SYSTEM_ID	ESA Sentinel-1 IW (993.88)	ascii		Processing system identifier
orb_cycle	335	int32		Cycle
REL_CRSIT	557	int32		Track
AMS_CRSIT	56229	int32		Orbit
STATE_VECTOR_TIME	23-OCT-2024 10:48:23.1994	time32	utc	Time of orbit state vector
VECTOR_SOURCE	-	ascii		State vector source
residence_mean	99999.0	float4	deg	
slice_num	99999.0	float4	deg	
slicenum	1	int32		Slice number
data_slice_id	451151	int32		Data slice identifier
first_line_time	23-OCT-2024 10:49:29.1983	time32	utc	First zero deeper azimuth time
last_line_time	23-OCT-2024 10:49:58.9996	time32	utc	Last zero deeper azimuth time
first_near_lat	17.98941705986303	float4	deg	
first_near_leng	108.84207778401097	float4	deg	
first_far_lat	18.5289063958193488	float4	deg	
first_far_leng	111.11111111111114	float4	deg	
last_near_lat	18.499104148610093	float4	deg	
last_near_leng	104.49976425957712	float4	deg	
last_far_lat	20.218168535323958	float4	deg	
last_far_leng	110.81911512560451	float4	deg	
FAIS	40020000	float4		ASCENDING or DESCENDING

- You can see the **name of the product**,
- the **product type** that in this case is a “Single Look Complex”.
- The **acquisition mode** that in this case is “Interferometric Wide” (IW).
- The **antenna pointing direction** that in this case is “right”.



# Metadata

## 2 Preliminary analysis

This tool window is used to manipulate the colouring of images shown in an image view. Right now, there is no selected image view.

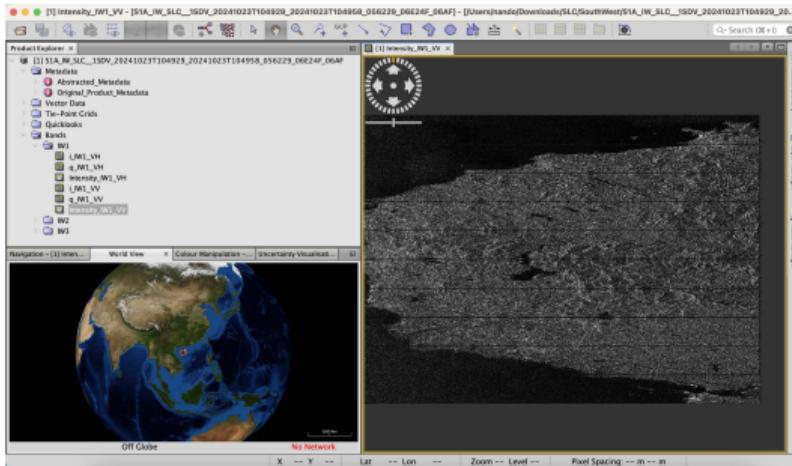
Name	Value	Type	Unit	Description
SIGK_Coefficients	-	asc8	-	Coupler_Central_Coeffs
Coupler_Central_Coeffs	-	asc8	-	-
Bend_WL_VH	-	asc8	-	Bend_WL_VH
Bend_WL_VV	-	asc8	-	Bend_WL_VV
Bend_M2_VH	-	asc8	-	Bend_M2_VH
Bend_M2_VV	-	asc8	-	Bend_M2_VV
Bend_M3_VH	-	asc8	-	Bend_M3_VH
Bend_M3_VV	-	asc8	-	Bend_M3_VV
SLC_VV	S1A_IW_SLC_1SDV_20241023	asc8	-	Product name
PRODUCT_TYPE	S1A_IW_SLC_1SDV_20241023T045298_016229_06824F_06AF	asc8	-	Product type
SPN_DESCRIPTOR	Sentinel-1 W Level-1 SLC Prod	asc8	-	Description
MISSION	SENTINEL-1A	asc8	-	Satellite mission
ACQUISITION_MODE	W	asc8	-	Acquisition mode
antenna_pointing	right	asc8	-	Right or left looking
BEAMS	-	asc8	-	Beams used
SWATH	-	asc8	-	Search name
PROC_TIME	23-OCT-2024 13:05:07.8401	utc32	-	Processed time
Processing_system_id	ESA Sentinel-1 PF 003.80	asc8	-	Processing system identifier
orbit_cycle	335	int32	-	Orbit cycle
REL_ORBIT	157	int32	-	Track
ABS_ORBIT	56229	int32	-	Orbit
STATE_VECTOR_TIME	23-OCT-2024 10:48:23.1994	utc32	-	Time of orbit state vector
VECTOR_SOURCE	-	asc8	-	State vector source
velocity_rear	99999.0	float64	deg	-
acceleration_flt	99999.0	float64	deg	-
slice_numb	1	int32	-	Slice number
first_line_of	493131	int32	-	Data slice identifier
first_line_time	23-OCT-2024 10:49:29.1961	utc32	-	First zero day after azimuth time
last_line_time	23-OCT-2024 10:49:58.9998	utc32	-	Last zero day after azimuth time
first_near_int	17.08417705099355	float64	deg	-

- The **orbiting pass is “ascending”**
- The **azimuth looks and range looks** are both equal to “1” implying the no multi-looking was done.
- The **range spacing and azimuth spacing** that are linked to the spatial resolution and they indicate that a non-square pixel is available.



# Bands

## 2 Preliminary analysis

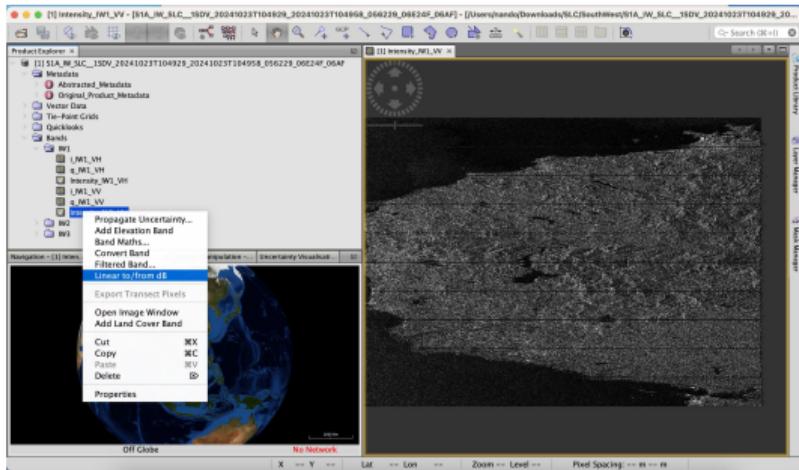


- Double-click on **Bands**.
- Double-click on **IW1** subswath.
- You have in-phase and quadrature components of both VV and VH channels together with their intensity.
- Double-click on **Intensity\_IW1\_VV** band.
- By moving the mouse in the top-left corner of the image you can zoom-in and navigate the image.
- The bottom-left **World View** panel shows the image location.



# Linear to dB

## 2 Preliminary analysis

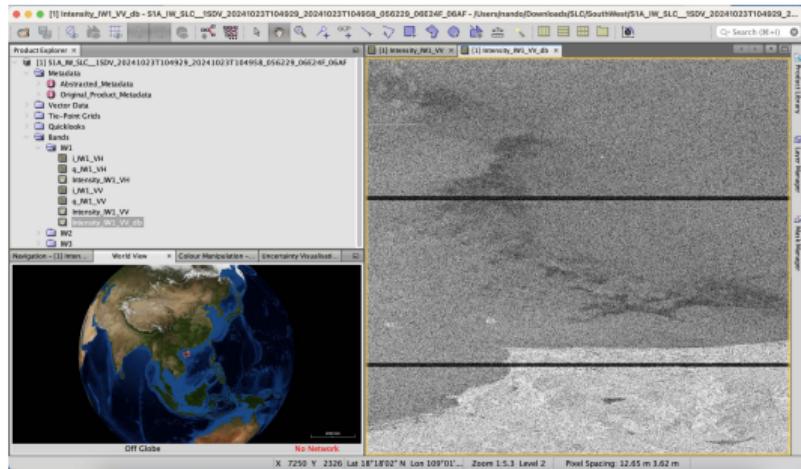


- Right-click on **intensity\_IW1\_VV**.
- Click on **Linear to/from dB** to generate a “virtual band” that includes the dB ( $10 \cdot \log_{10}(\text{intensity IW1 VV})$ ) version of the image to better visualize it.



# Linear to dB

## 2 Preliminary analysis



- Double-click the **Intensity\_IW\_VV\_db** to show the dB image.
- Zoom-in and navigate to show some coastal features and processes.
- You can also see “Dark horizontal stripes” related to the “azimuth bursts”.
- Those dark lines need to be removed.



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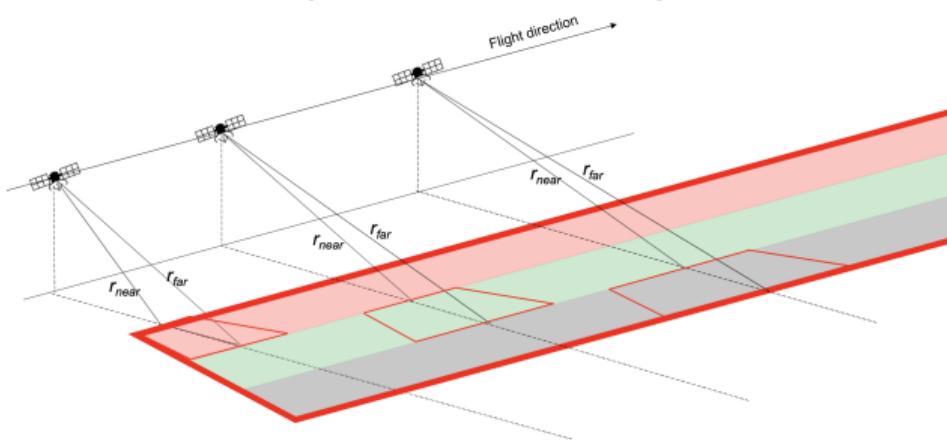
- Terrain correction



# ScanSAR

## 3 TOPS processing

The Sentinel-1 IW acquisition mode is a special ScanSAR mode

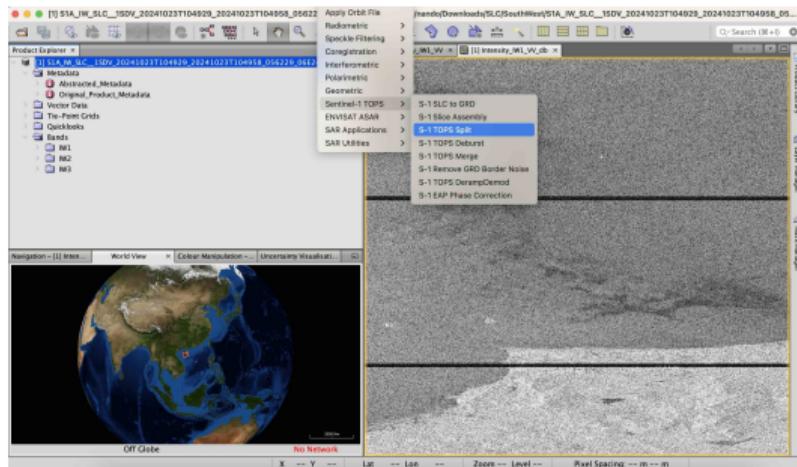


- The three stripes colored in red, green and gray stand for three subswaths that allow extending the swath in the range direction.
- Each subswath includes bursts that aligned in the azimuth direction.



# TOPS processing

## 3 TOPS processing

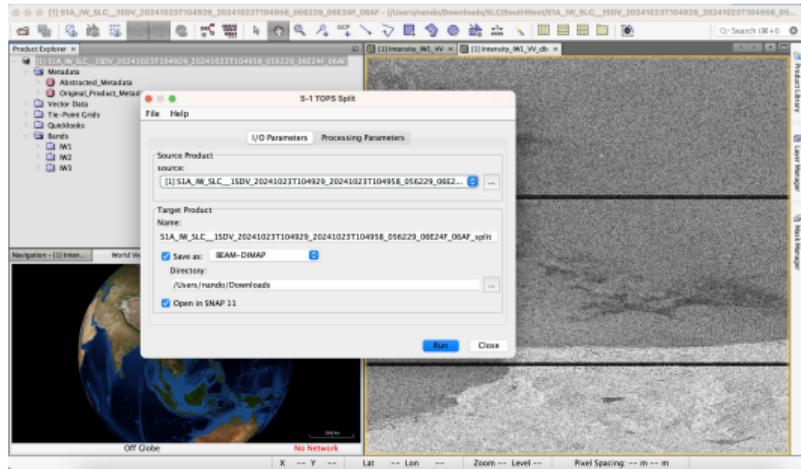


- To play with “subswaths” and “bursts” use the **Radar** menu.
- Go to the **Sentinel-1 TOPS** menu.
- Go to the **S-1 TOPS Split** menu to select the subswaths and bursts you want to process.



# TOPS processing

## 3 TOPS processing

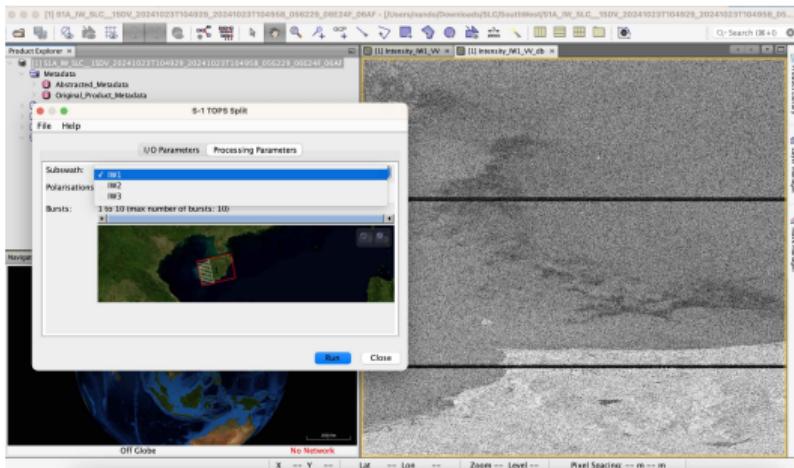


- Click on the **S-1 TOPS Deburst** menu to open the dialog window.
- The **I/O parameters** window is ok.
- Click on the **Processing Parameters** window.



# TOPS processing

## 3 TOPS processing

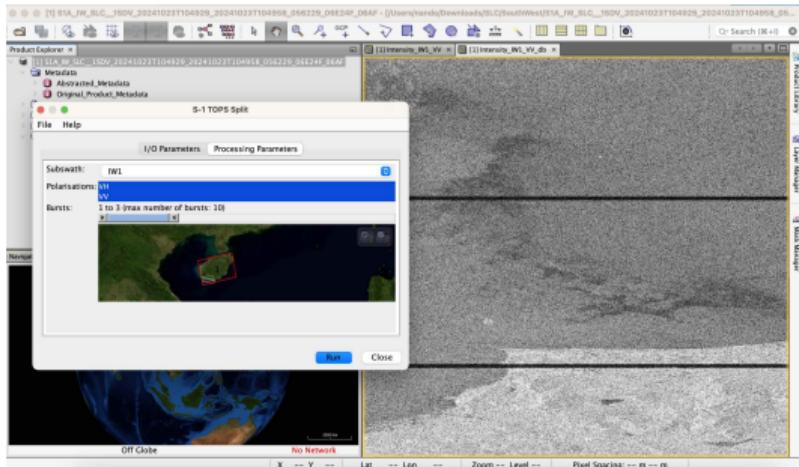


- Scroll the **Subswath** menu to select the subswaths to be processed.
- You can visually inspect the location of the selected subswaths in the below panel.
- Click on the **Processing Parameters** window.
- You can also decide to select all the available subswaths (this is the choice made when delivering the GRD product).



# TOPS processing

## 3 TOPS processing

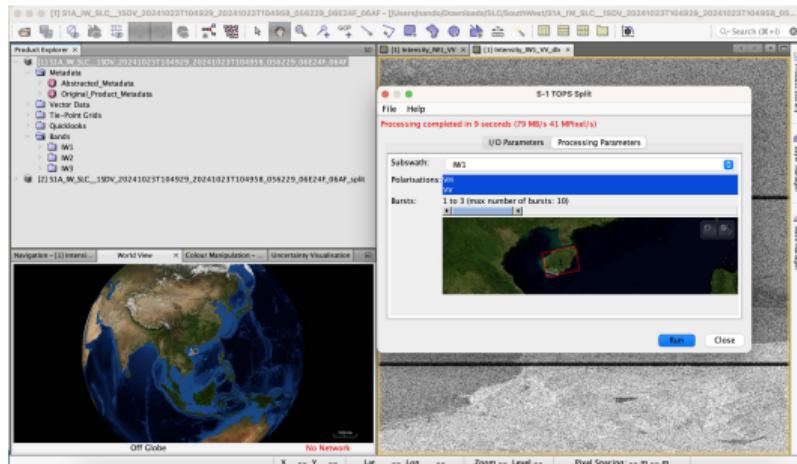


- Let's assume to select the subswath IW1.
- Select the two polarization channels VH and VV.
- By moving the right and left arrows in the **Bursts** section you can select the number of bursts to be processed.
- You can also process all the bursts (this is the choice made when delivering the GRD product).
- Let's assume to select 3 bursts (you can see them highlighted in white)



# Splitting

## 3 TOPS processing

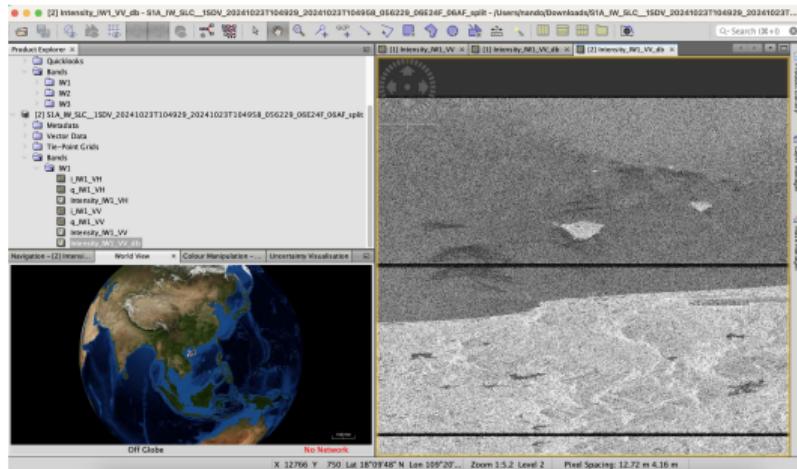


- After pushing the **Run** button.
- A new product **[2]** appears in the Product Explorer window.
- Click on the **[2]** product to see the bands it consists of.
- Now just one subswath **IW1** appears which consists of three bursts.



# Splitting

## 3 TOPS processing

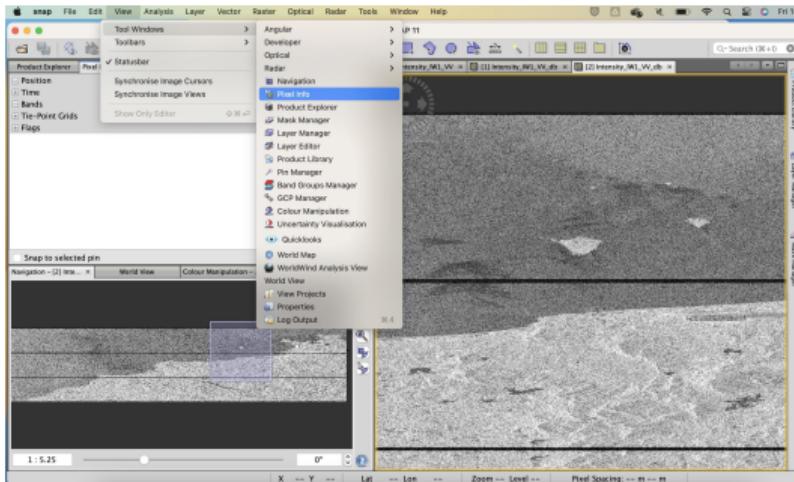


- Click on the **Intensity\_IW\_VV** band to show the intensity VV image.



# Splitting

## 3 TOPS processing

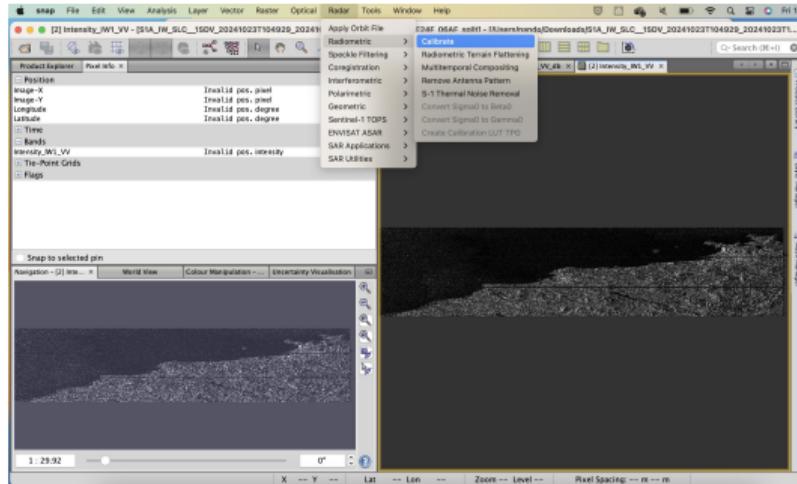


- Click on the **View** menu and then on **Tool Windows** to select **Pixel info**.
- The **Pixel Info** windows appear.
- Surfing the image the intensity value is displayed on the Pixel Info window.
- The values observed are all integers, in the radar jargon they are Digital Numbers (DN).
- Calibration is needed to convert DN into floating points.



# Calibration

## 3 TOPS processing

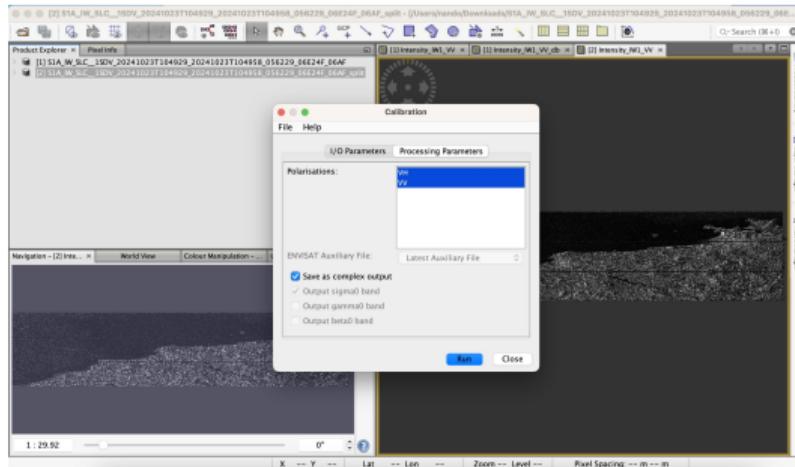


- Click on the **Radar** menu and then on **Radiometric** menu to select **Calibrate** function.



# Calibration

## 3 TOPS processing

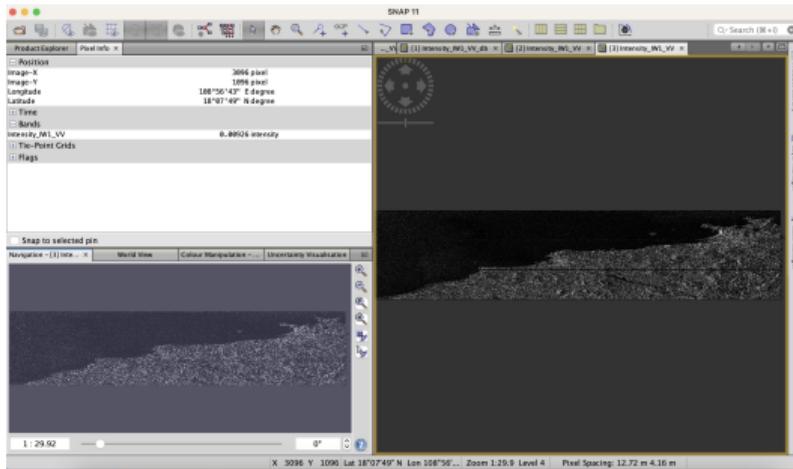


- The calibration window appears.
- Click on the **Input Parameters** menu to select the VV and VH channels.
- Select the **Save as a complex output** function to save the complex channels together with the intensity.



# Calibration

## 3 TOPS processing

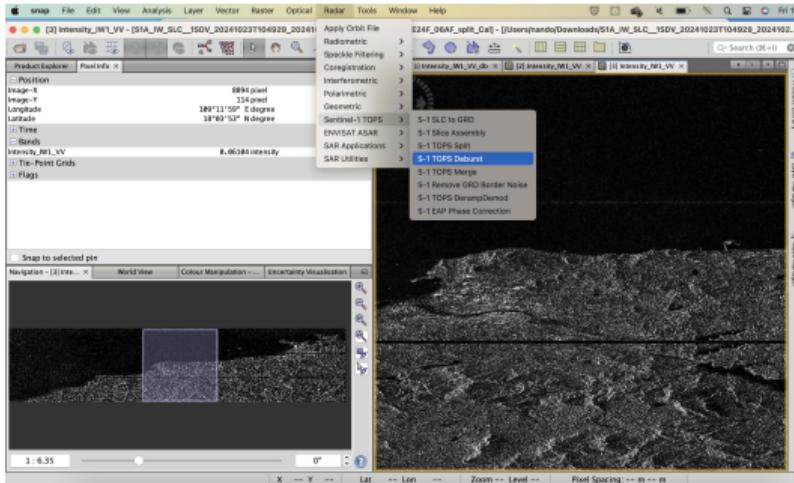


- After pressing the run button, a new product [3] appears in the Product Explorer window.
- Click on the **Intensity\_IW1\_VV** band to show the intensity product.
- Open the **Pixel Info** window and surf the image.
- The intensity image consists now of **calibrated** “floating point” numbers.



# Debursting

## 3 TOPS processing

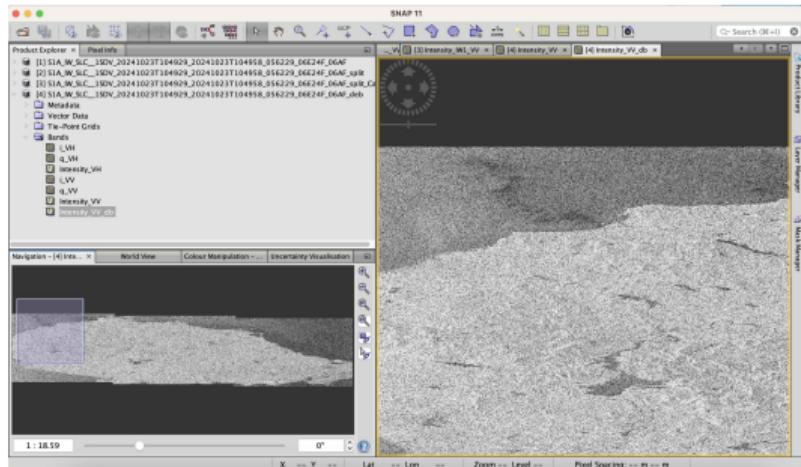


- To deal with the horizontal bars in the image the **de-bursting** is needed.
- Go to the **Sentinel-1 TOPS** menu.
- Go to the **S-1 TOPS Deburst** menu to run debursting.
- In the **Processing parameters** window select the VV and VH polarimetric channels.



# Debursting

## 3 TOPS processing

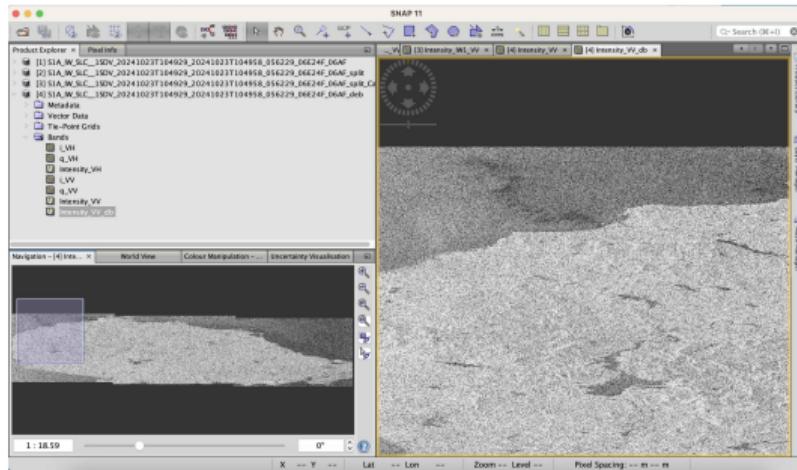


- After pressing the run button a new product [4] appears in the Product Explorer window.
- By clicking on the Intensity band in dB the image appearing does not contain any horizontal bar.



# Terrain correction

## 3 TOPS processing



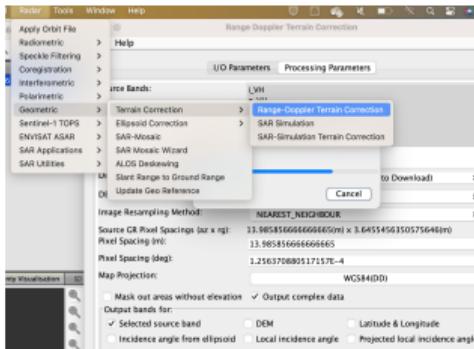
- This step is particular useful when dealing with coastal areas.
- It consists of properly reprojecting on to a geo-map (e.g. WGS84, UTM, ...) the measurements.
- Click the **Radar** menu, then **Geometric** menu, then the **Terrain correction** menu and, finally, the **Range-Doppler terrain correction** function.



# Terrain correction (1)

## 3 TOPS processing

- Click the **Processing Parameters** window to:
- Select the input bands (both intensity and i-q components can be selected).
- Select the **Digital Elevation Model** (DEM) to be used in the land area. A fair option is “Copernicus 30m”.
- Select the **Resampling Method**. An accurate enough option is the “Nearest\_neighbour” method for both DEM and Image resampling. Note that keeping the default “Bilinear” interpolation may result in artifact when exporting the imagery in Matlab

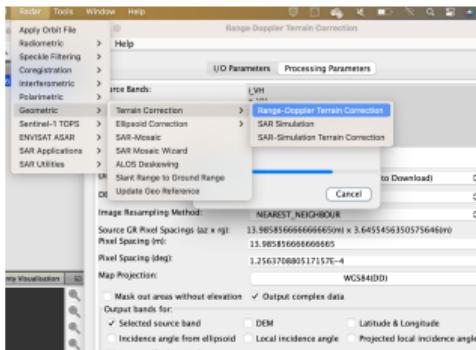




# Terrain correction (2)

## 3 TOPS processing

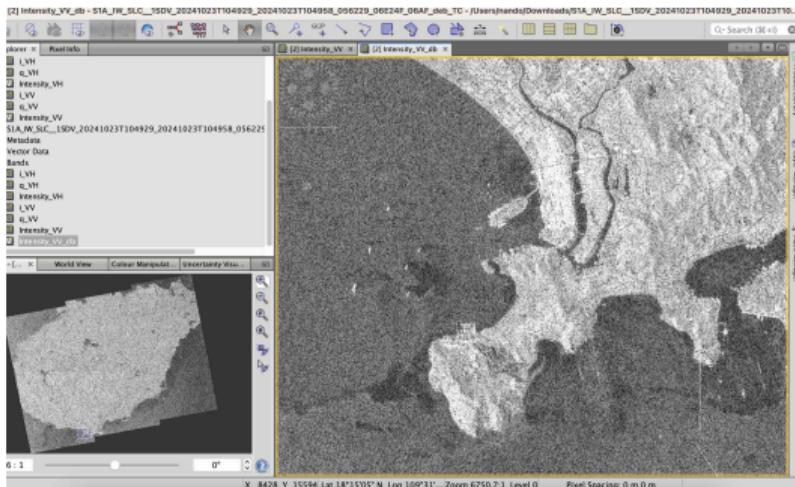
- Note that the native pixel is rectangular (i.e., the pixel spacing is around  $14 \times 4\text{m}$ ). By this processing a square pixel is obtained. The default **pixel spacing** is around  $14 \times 14\text{m}$ . A different value can be selected to resample the image.
- The **Map projection** bar allows selecting the map to be used for the reprojection. The default “WGS84” is ok.
- **De-select** the button “Mask out areas without elevation” to avoid masking out ocean.
- **Select** the button “Output complex data” to generate an output products that includes the i-q components.





# Terrain correction

## 3 TOPS processing



- After pressing the run button a new product [5] appears in the Product Explorer window.
- By clicking on the Intensity band in dB the image appears correctly projected on the geographic grid.
- The Sanya city is on the bottom part of the image and by zooming-in it can be well-recognized.
- The two rivers, the harbor together with some bright metallic targets and few dark areas can be visualized.