Satellite Applications

Practical Session: Sentinel-1 ice speed tracking

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1st ESA Advanced Training Course on Remote Sensing of the Cryosphere
13 September 2016, University of Leeds, Leeds, UK

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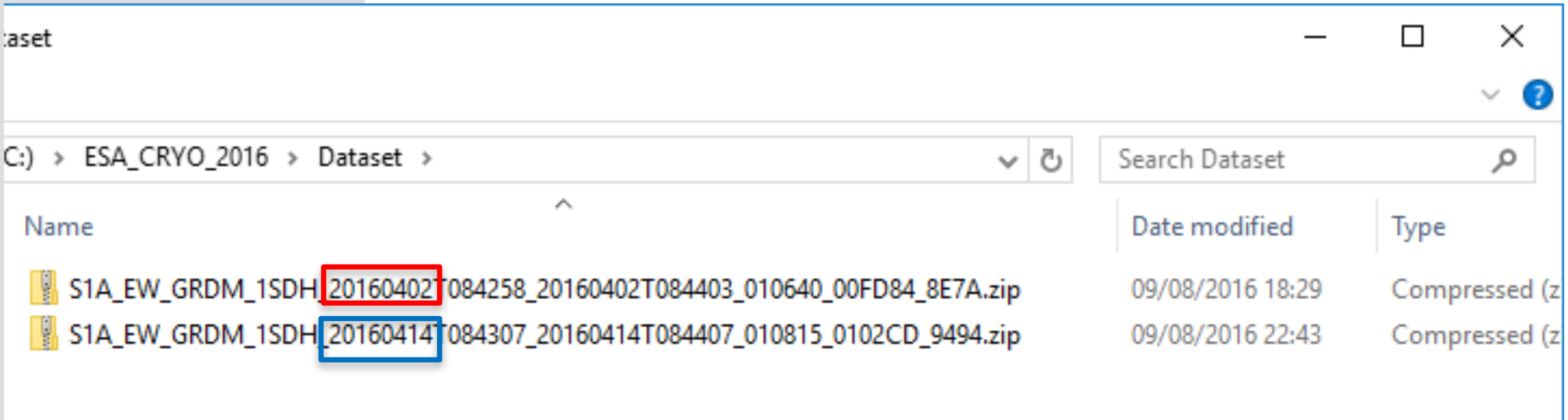
Objective

To show how to derive Ice Velocity by processing a pair (12 days a part) of Sentinel-1 TOPS Extra Wide Swath (EW_GRDM_1SDH) images by using offset tracking technique.

In particular:

- Only HH polarisation is exploited;
- SNAP version 4 is used;
- Exercise will use Graph Builder, Batch Processing, GUI.

Dataset



Product type: EW_GRDM_1SDH

Acquisition mode: Extra Interferometric wide swath
Product type: GRD (detected)
Polarisation: HH and HV
Resolution: 80 m
Orbit: Descending

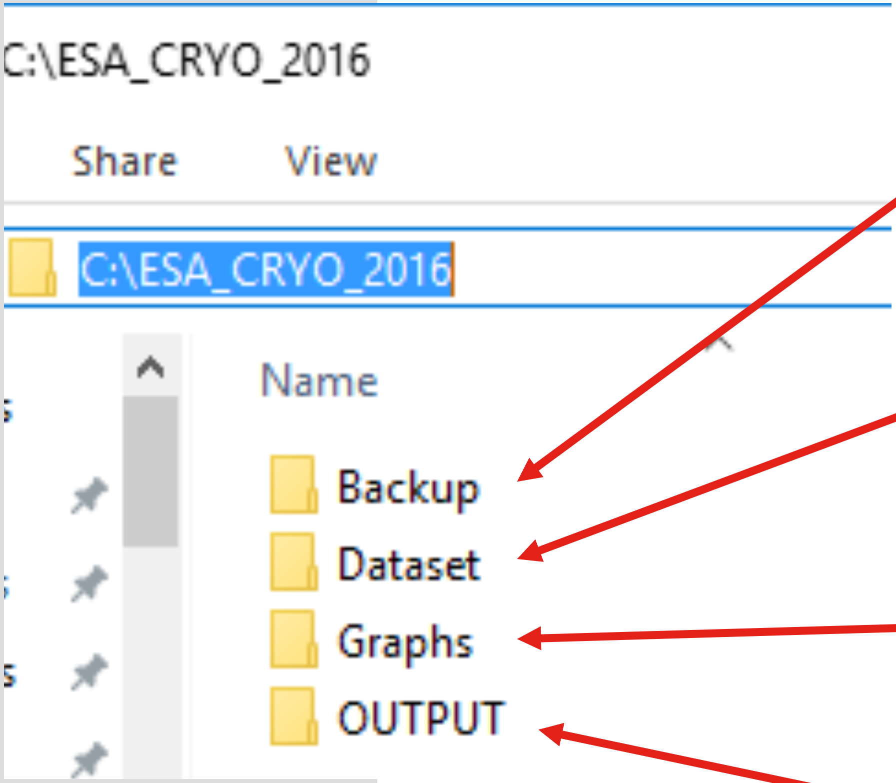
Location: Nioghalvfjerdsfjorden Glacier (Greenland)

Dataset

Q1. What is the repeat period of Sentinel-1a only, and what did this reduce to after the launch of Sentinel-1b?

Q2. During this computer practical you are using Sentinel-1 Extra Wide (EW) swath mode data to measure ice velocity, however; the cryosphere community have requested ESA routinely acquire Interferometric Wide (IW) swath mode Sentinel-1 data over the ice sheet margins. What are 2 major differences between EW and IW mode data, and suggest a reason why IW mode was not used during this practical?

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

Processing Steps

0. Open a Sentinel-1 GRD product — **GUI**

1.a
- Apply Precise Orbit File
- Remove Thermal Noise
- Calibration (HH)

Graph Builder (single product)

1.b Batch processing (2 Products)

Processing Steps

2.

DEM assisted Coregistration

Subset

Graph Builder

3.

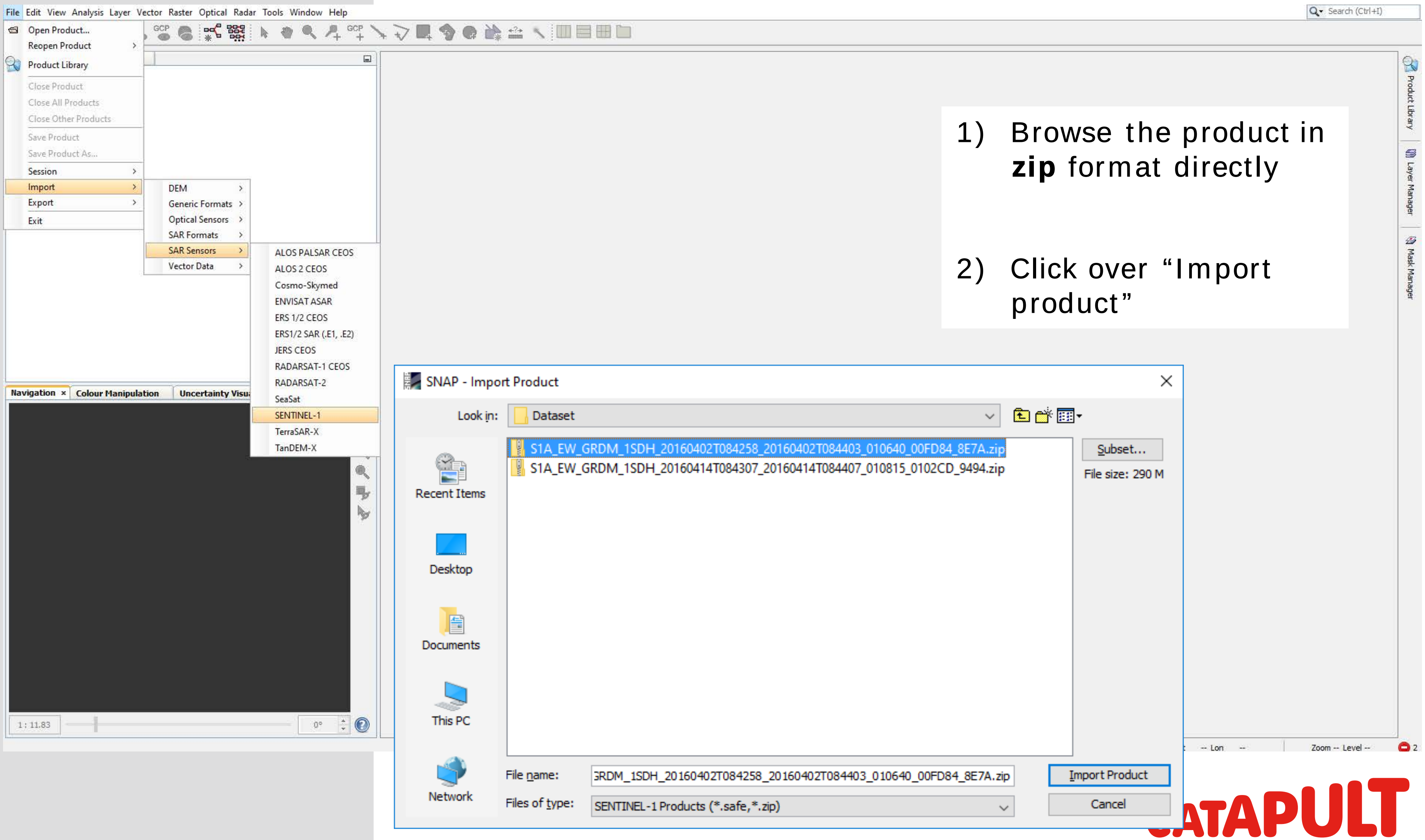
Offset Tracking

Merging Sigma0 and Ice Velocity via Band maths Op

Geocoding: RD Terrain Correction

GUI

Step 0: Open product (02/04/2016)



1) Browse the product in **zip** format directly

2) Click over "Import product"

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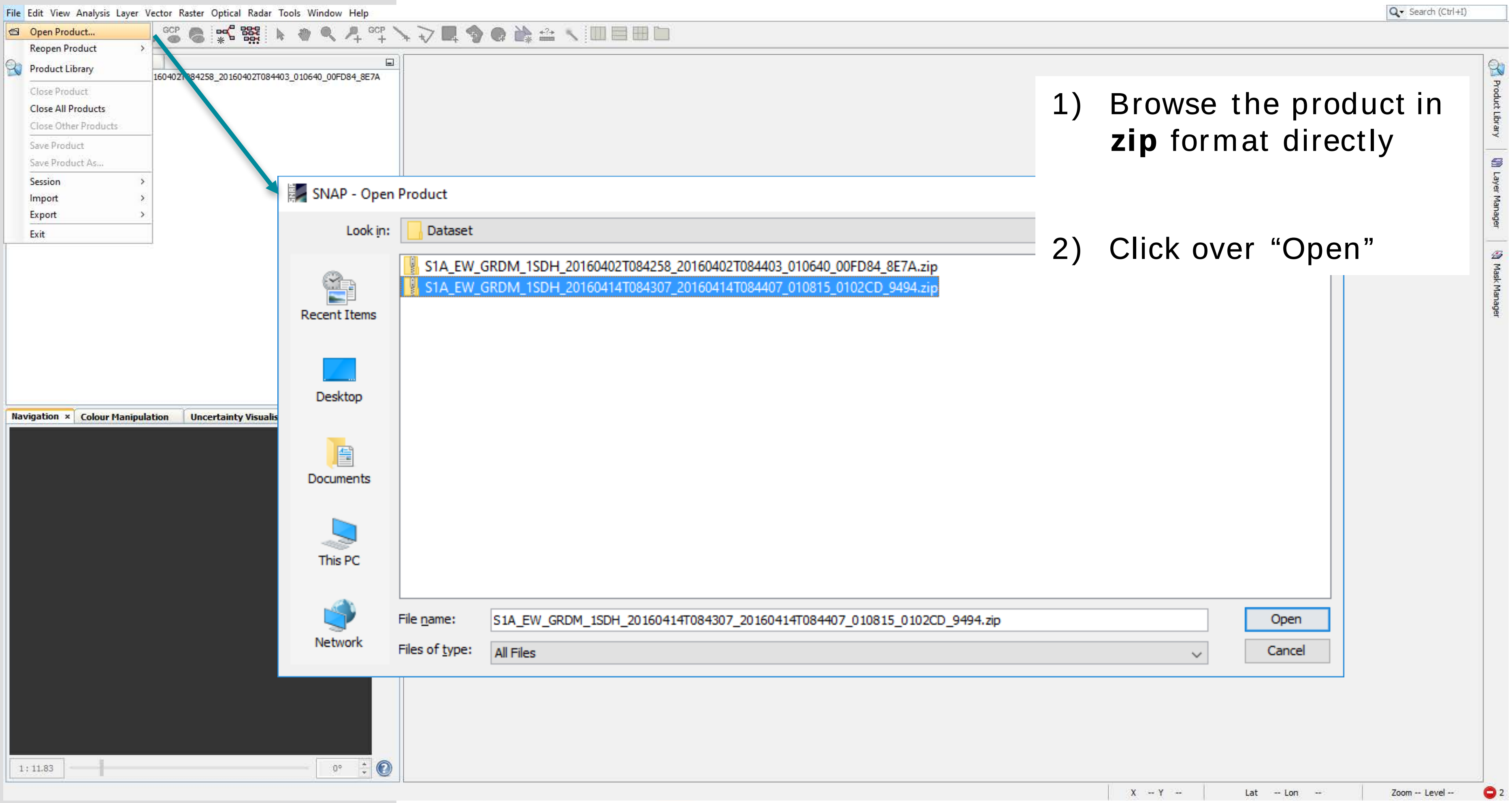
Step 0: Open product (14/04/2016)



1) Browse the product in **zip** format directly

2) Click over "Open"

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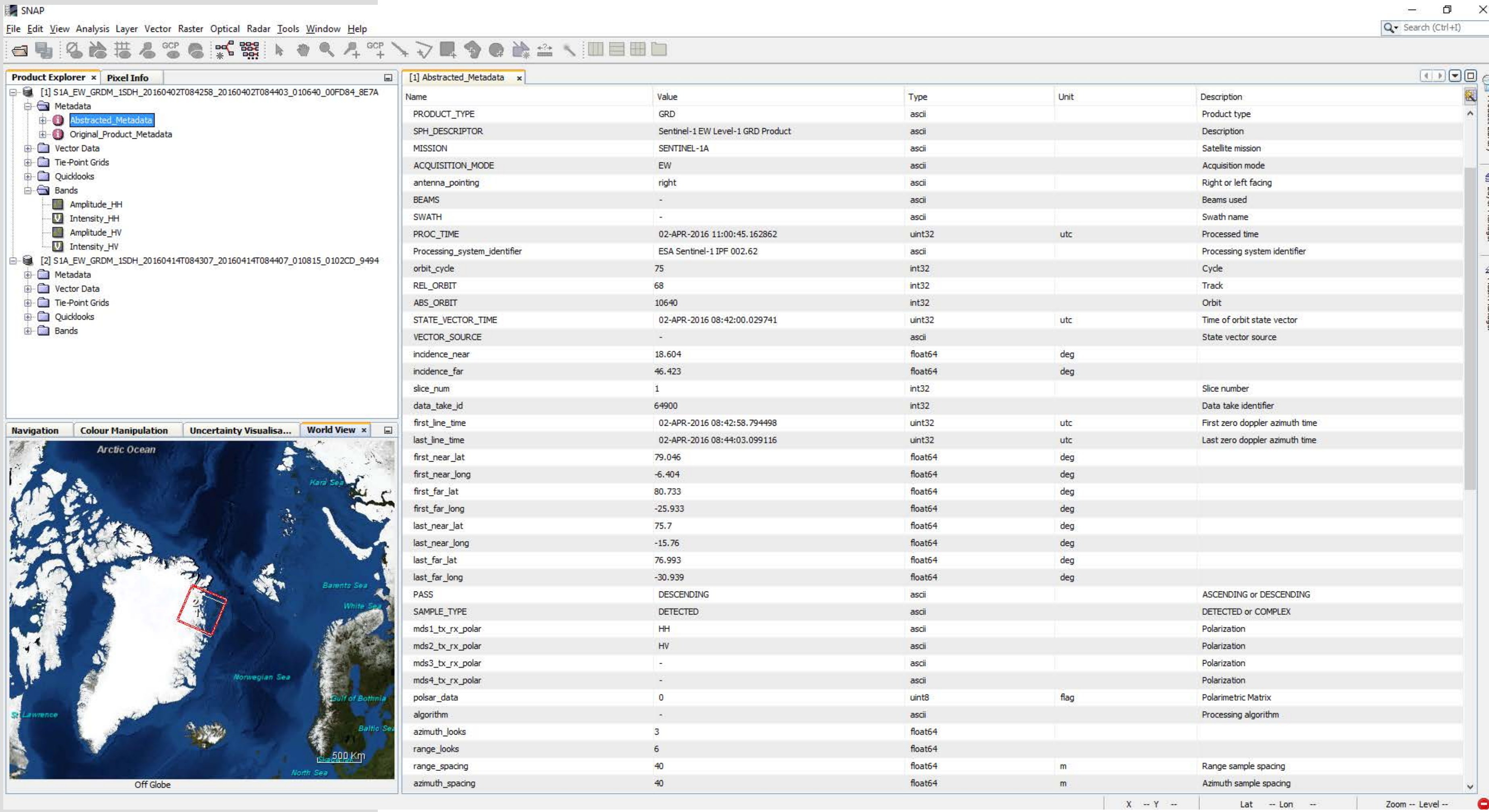
Inspecting the abstracted metadata



Name	Value	Type	Unit	Description
PRODUCT_TYPE	GRD	ascii		Product type
SPH_DESCRIPTOR	Sentinel-1 EW Level-1 GRD Product	ascii		Description
MISSION	SENTINEL-1A	ascii		Satellite mission
ACQUISITION_MODE	EW	ascii		Acquisition mode
antenna_pointing	right	ascii		Right or left facing
BEAMS	-	ascii		Beams used
SWATH	-	ascii		Swath name
PROC_TIME	02-APR-2016 11:00:45.162862	uint32	utc	Processed time
Processing_system_identifier	ESA Sentinel-1 IPF 002.62	ascii		Processing system identifier
orbit_cycle	75	int32		Cycle
REL_ORBIT	68	int32		Track
ABS_ORBIT	10640	int32		Orbit
STATE_VECTOR_TIME	02-APR-2016 08:42:00.029741	uint32	utc	Time of orbit state vector
VECTOR_SOURCE	-	ascii		State vector source
incidence_near	18.604	float64	deg	
incidence_far	46.423	float64	deg	
slice_num	1	int32		Slice number
data_take_id	64900	int32		Data take identifier
first_line_time	02-APR-2016 08:42:58.794498	uint32	utc	First zero doppler azimuth time
last_line_time	02-APR-2016 08:44:03.099116	uint32	utc	Last zero doppler azimuth time
first_near_lat	79.046	float64	deg	
first_near_long	-6.404	float64	deg	
first_far_lat	80.733	float64	deg	
first_far_long	-25.933	float64	deg	
last_near_lat	75.7	float64	deg	
last_near_long	-15.76	float64	deg	
last_far_lat	76.993	float64	deg	
last_far_long	-30.939	float64	deg	
PASS	DESCENDING	ascii		ASCENDING or DESCENDING
SAMPLE_TYPE	DETECTED	ascii		DETECTED or COMPLEX
mds1_tx_rx_polar	HH	ascii		Polarization
mds2_tx_rx_polar	HV	ascii		Polarization
mds3_tx_rx_polar	-	ascii		Polarization
mds4_tx_rx_polar	-	ascii		Polarization
polsar_data	0	uint8	flag	Polarimetric Matrix
algorithm	-	ascii		Processing algorithm
azimuth_looks	3	float64		
range_looks	6	float64		
range_spacing	40	float64	m	Range sample spacing
azimuth_spacing	40	float64	m	Azimuth sample spacing

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Inspecting the abstracted metadata

Q3. During this computer practical you are using Sentinel-1 GRD format data. Why is it not possible to perform interferometry with GRD format data, and which Sentinel-1 data format would you use if you wanted to do interferometry?

Display a band (Amplitude HH)

Display a band (Amplitude HH)

Q4. During this computer practical you are using Sentinel-1 HH polarisation data. What does HH stand for and what 3 other polarisations are acquired by Sentinel-1?

Q5. If you had a single multi-polarisation SAR image acquired over a glacier, what physical properties of the snowpack might influence the radar backscatter from the different polarisations?

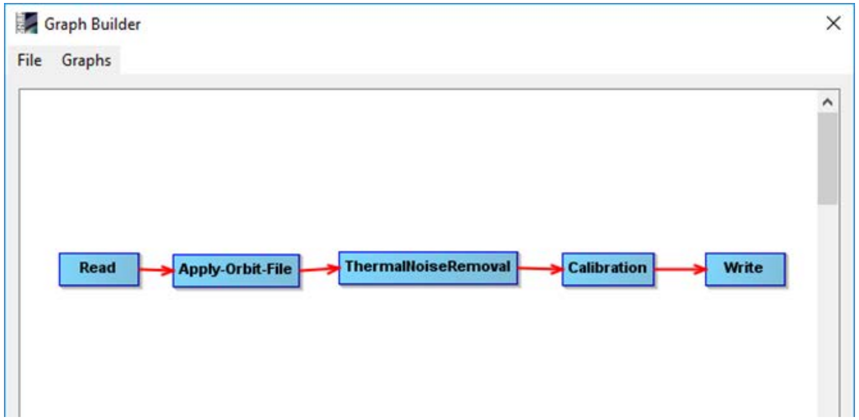
Step 1.a

1.a

- Apply Precise Orbit File
- Remove Thermal Noise
- Calibration (HH)

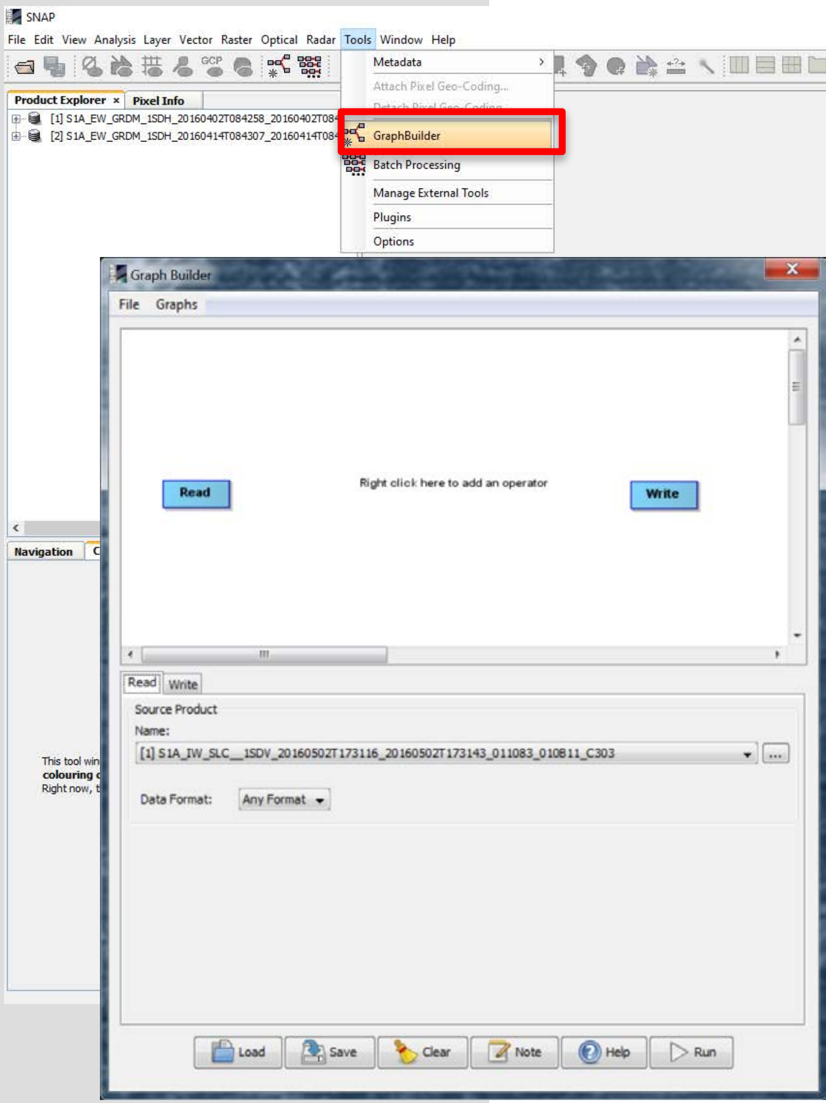
Graph Builder

(single product)



Graph1_HH_PO_CAL.xml

1.a - Buiding the chain → "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

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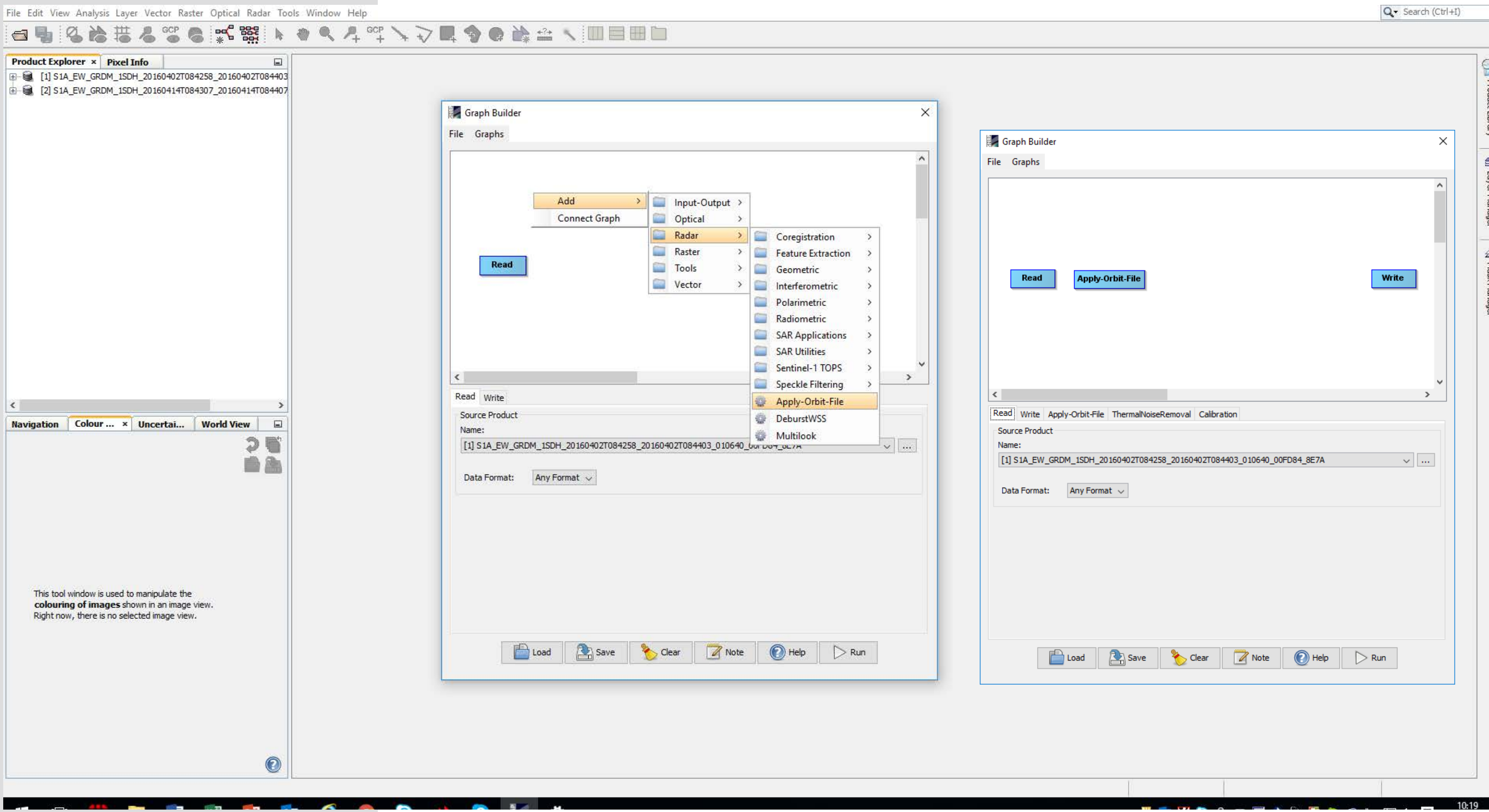
1.a - Buiding the chain → “Apply Orbit File” operator



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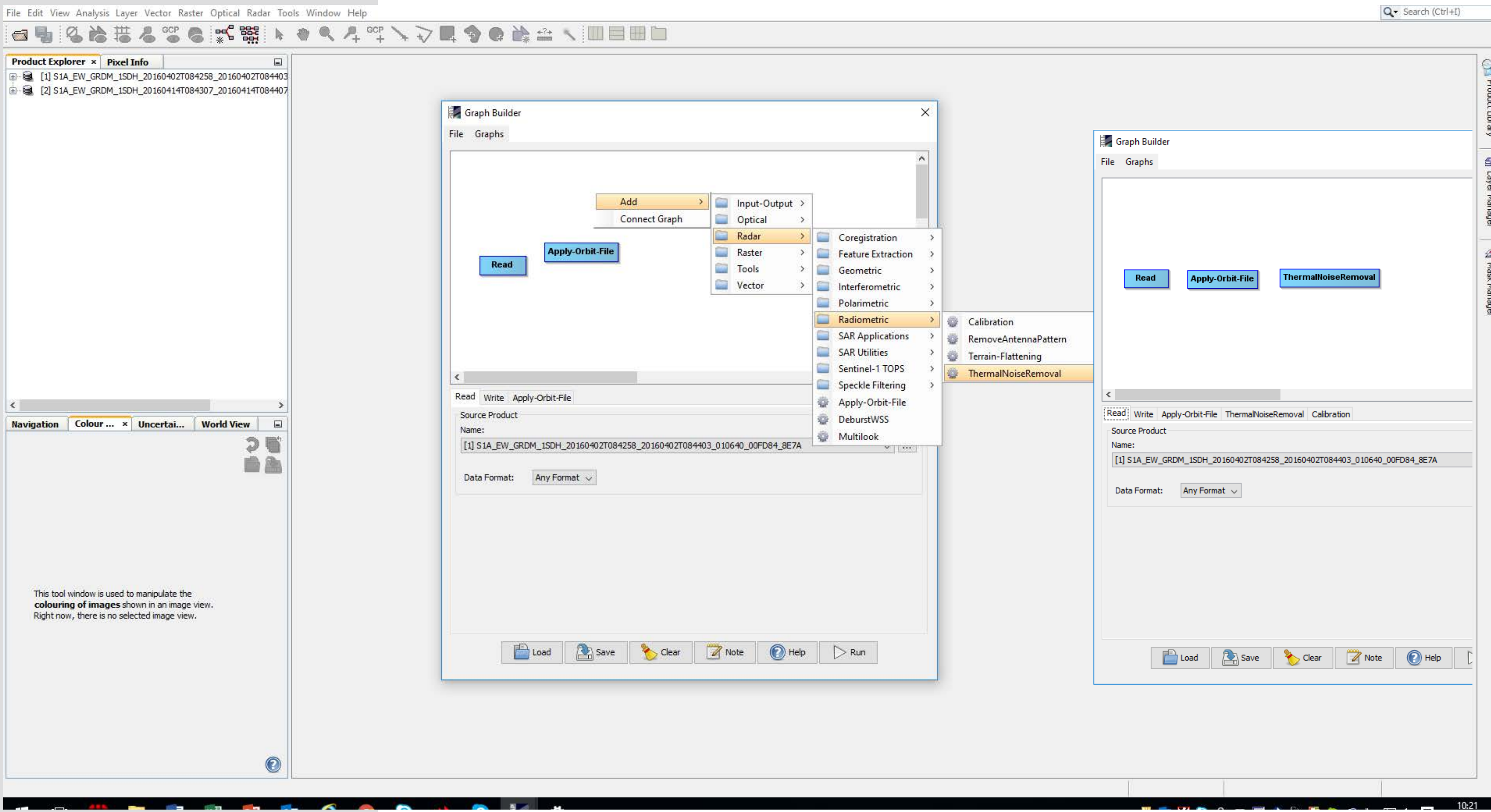
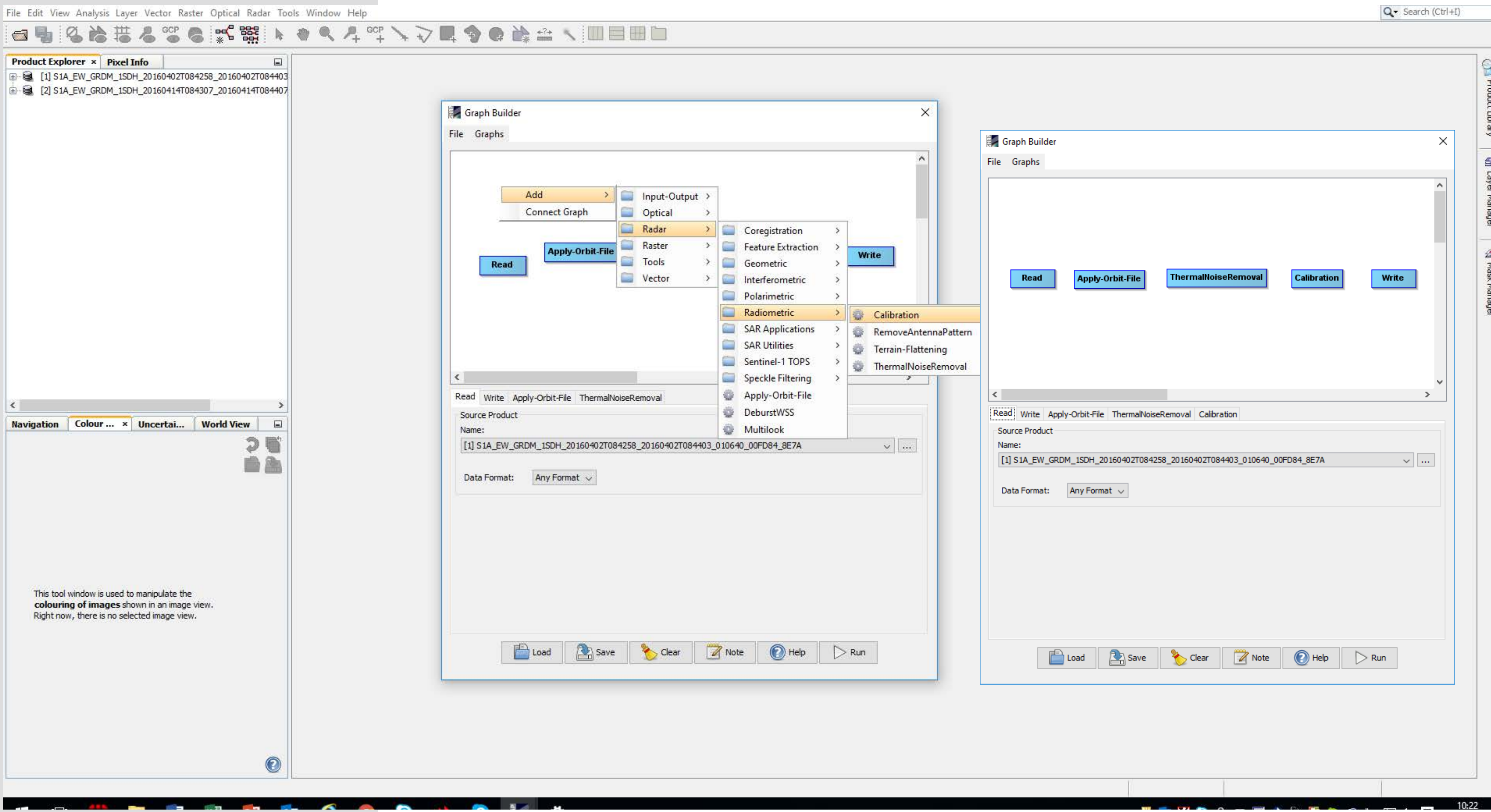
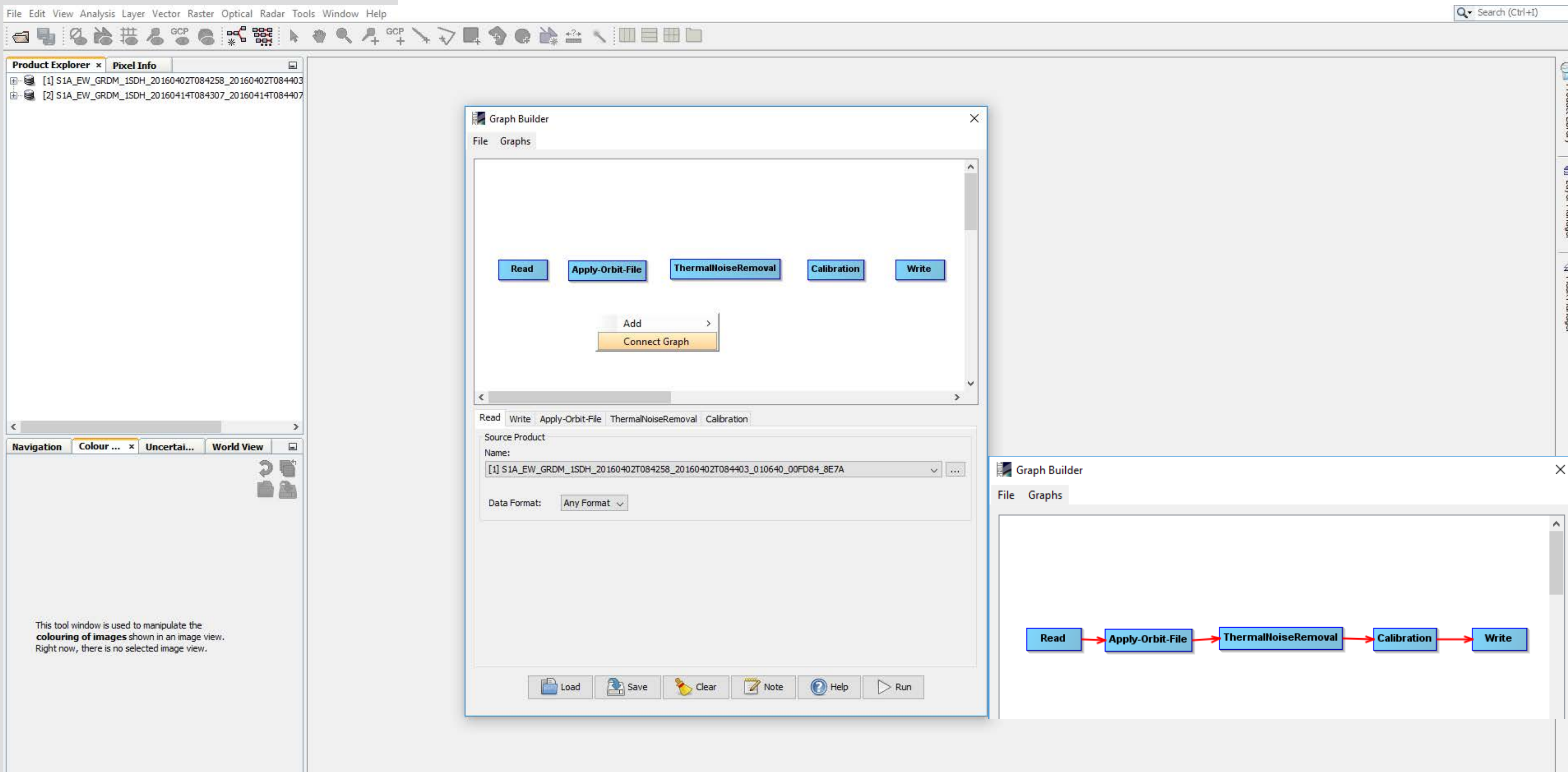
1.a - Buiding the chain → “Thermal Noise Removal” operator



1.a - Buiding the chain → "Calibration" operator

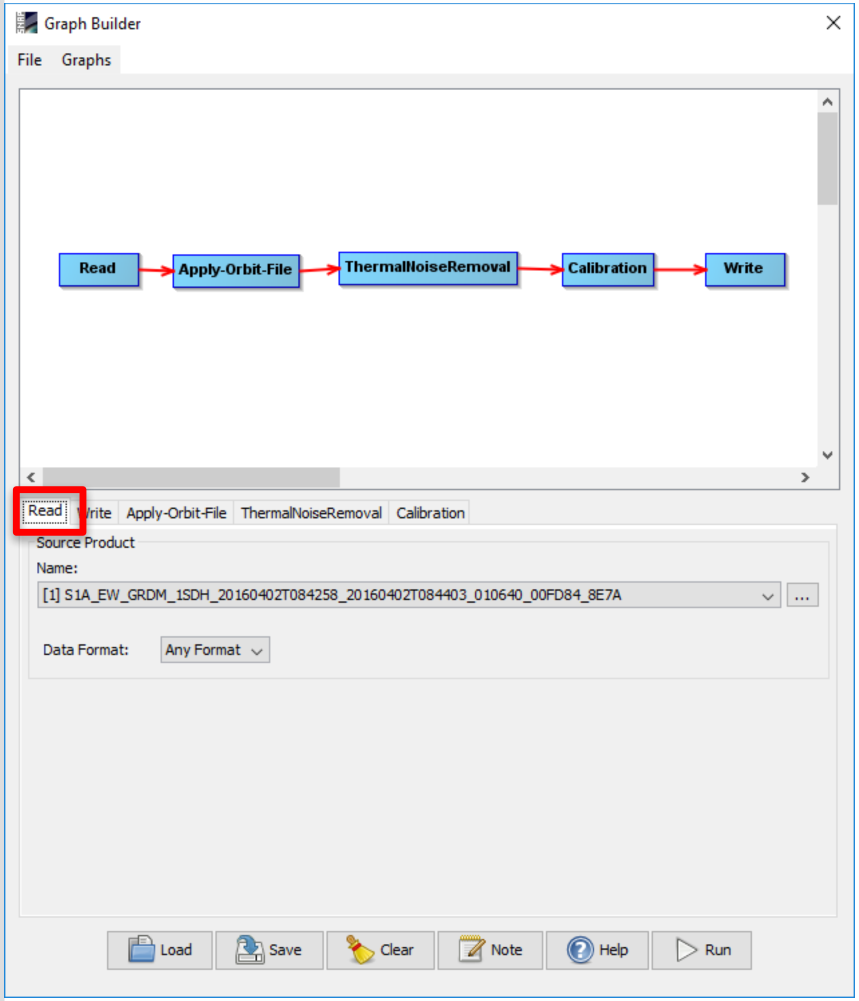


1.a - GB: Connecting the blocks

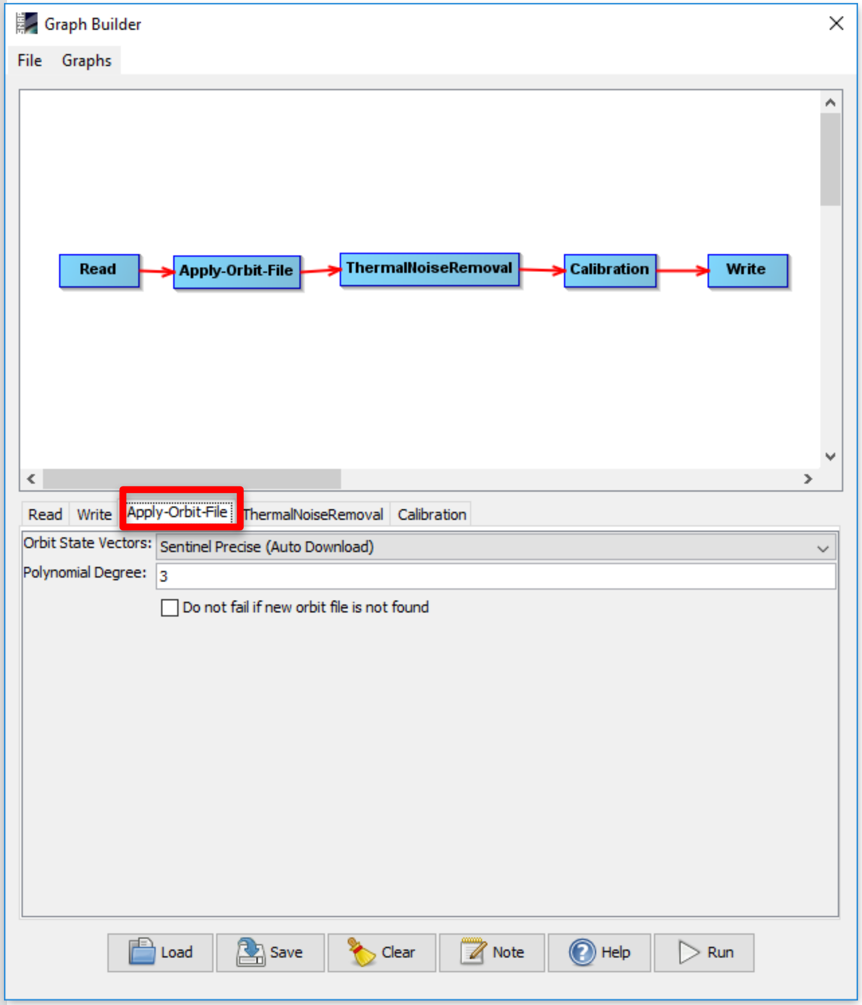


Having the mouse on the white space, click on mouse right button to access the MENU of operators → CLICK on “**CONNECT GRAPH**”

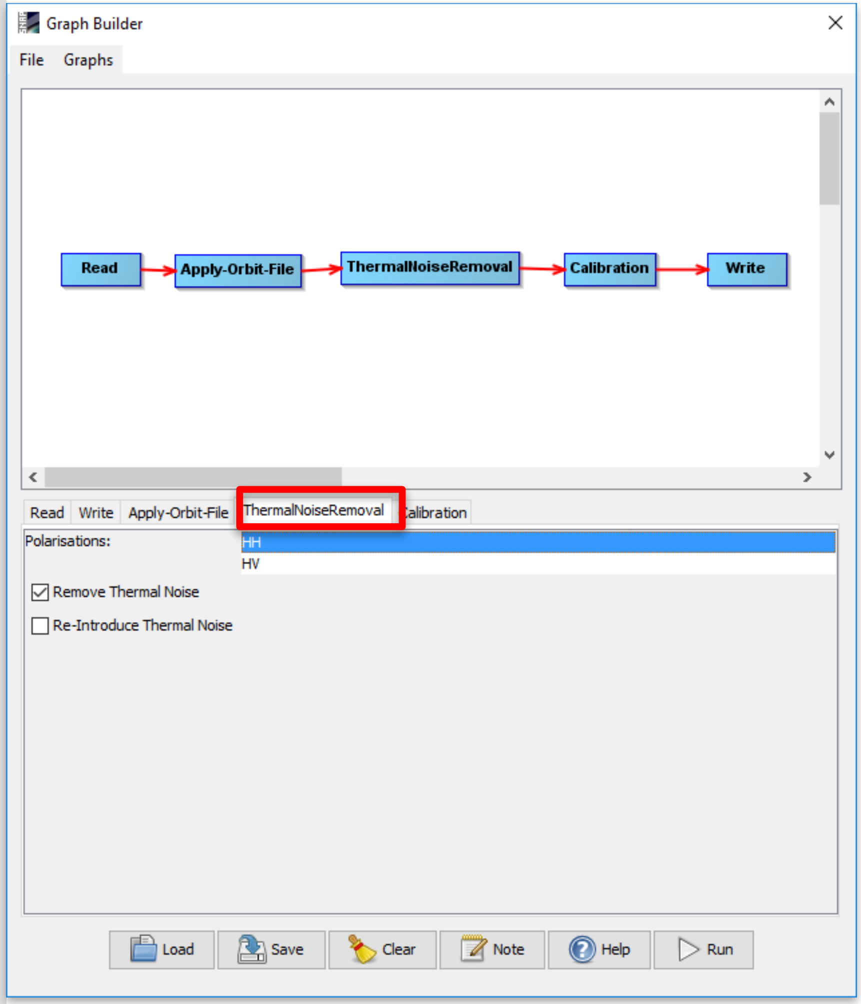
1.a - GB: Inserting the parameters



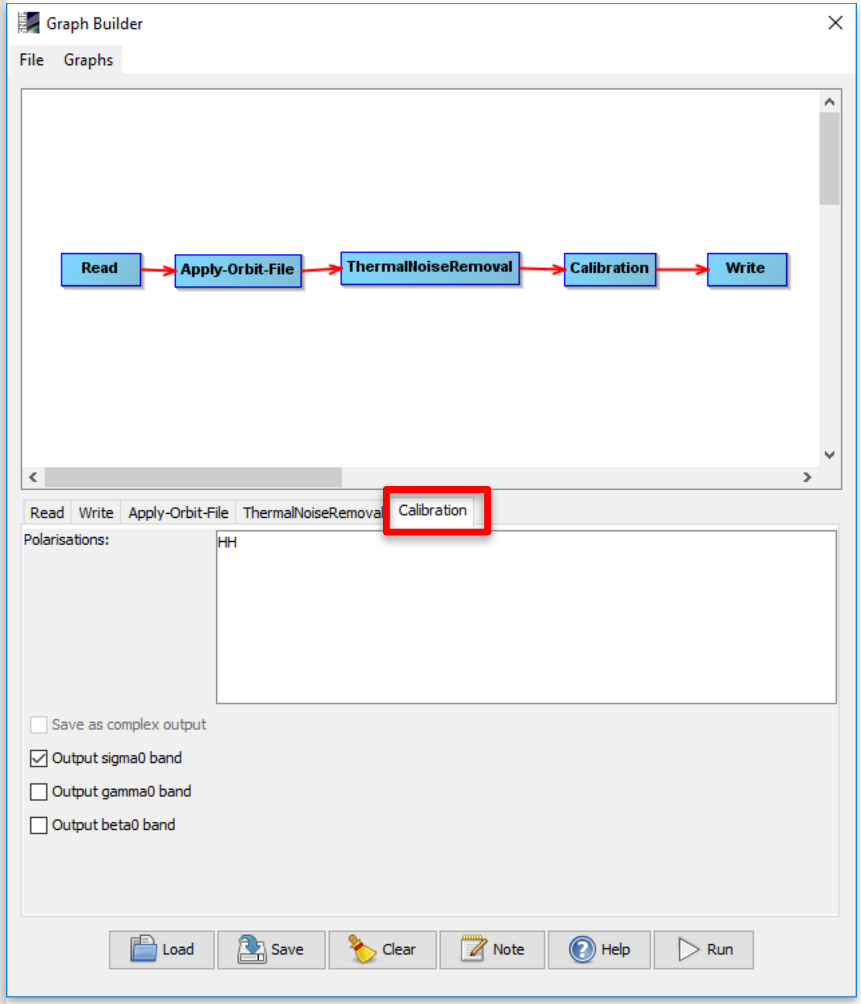
1.a - GB: Inserting the parameters



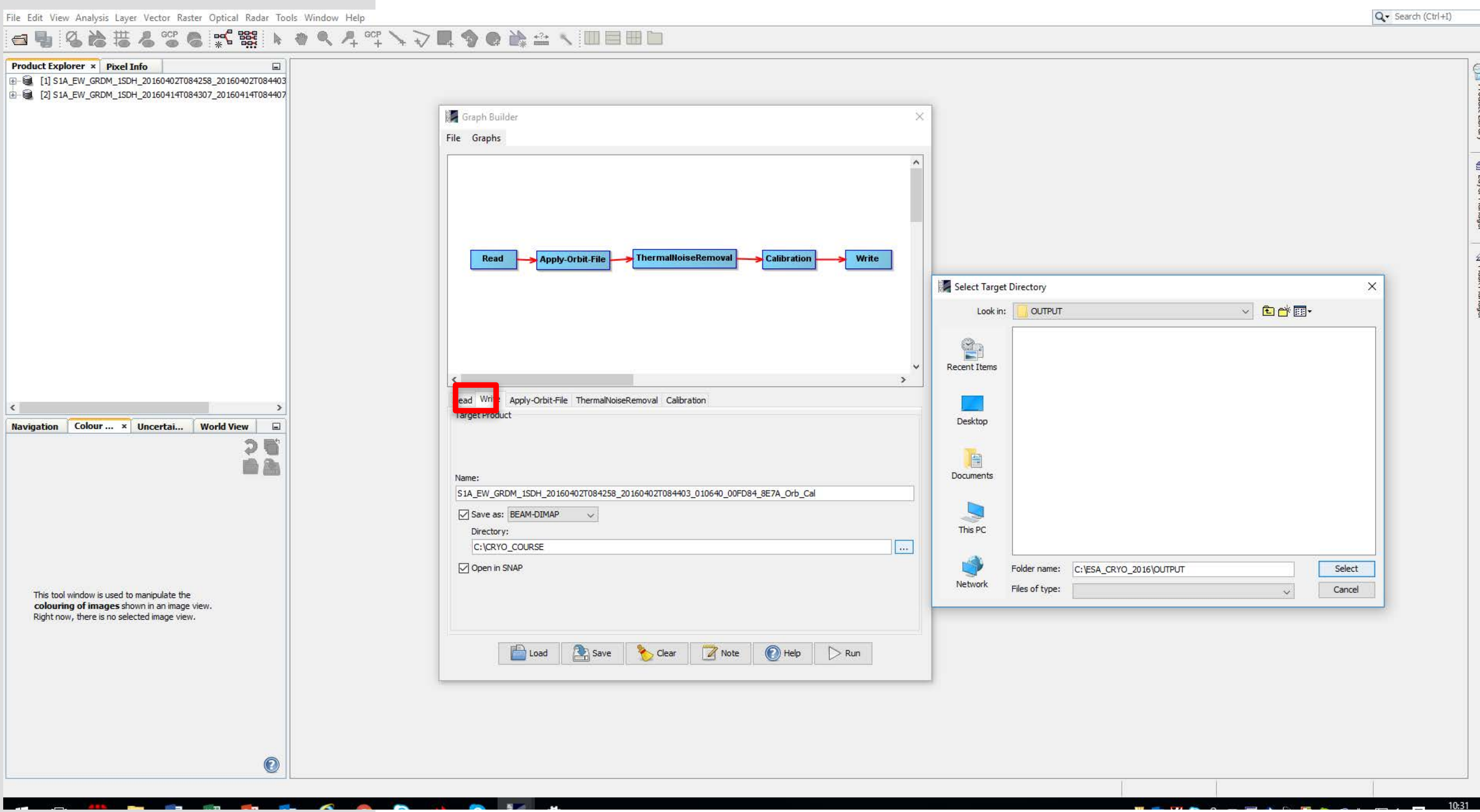
1.a - GB: Inserting the parameters



1.a - GB: Inserting the parameters



1.a - GB: Inserting the parameters



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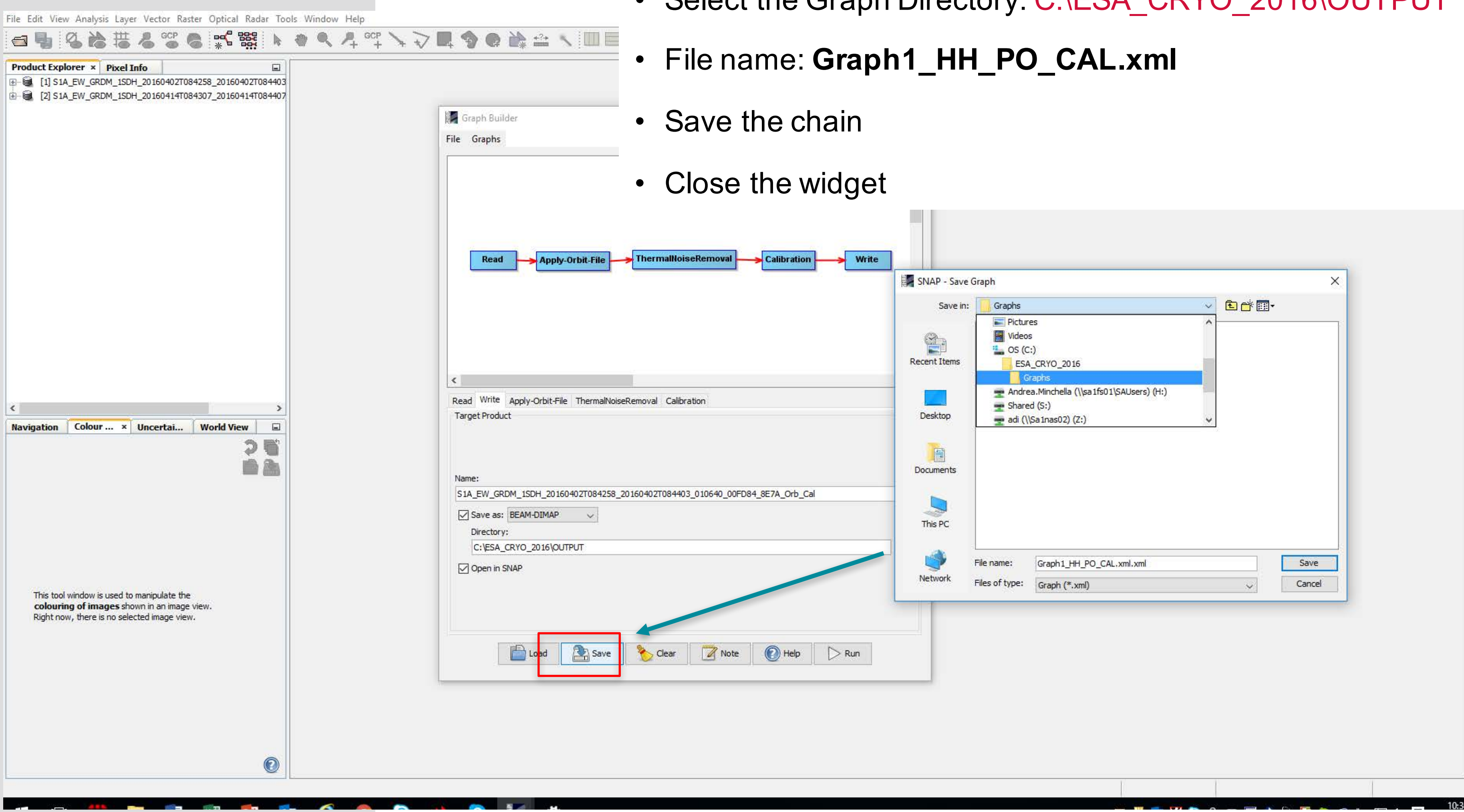
1.a - GB: Saving the chain

- Select the Graph Directory: C:\ESA_CRYO_2016\OUTPUT"
- File name: **Graph1_HH_PO_CAL.xml**
- Save the chain
- Close the widget



Step 1.b: Batch processing Tool

The Chain “**Graph1_SbSVV_PO_CAL.xml**” has been defined for one product.

Apply Precise Orbit File

Remove Thermal Noise

Calibration (HH)

Now we want to run the chain over the

2 GRD dataset via

batch processing tool

Remember we work with **HH** polarisation only

Batch processing
(2 Products)

Step 1.b: Batch processing Tool

Q6. You have just created a pre-coregistration processing chain which should be applied to each SAR frame before they are coregistered. What were the 3 key steps in this chain, and what was the main reason why you did each step?

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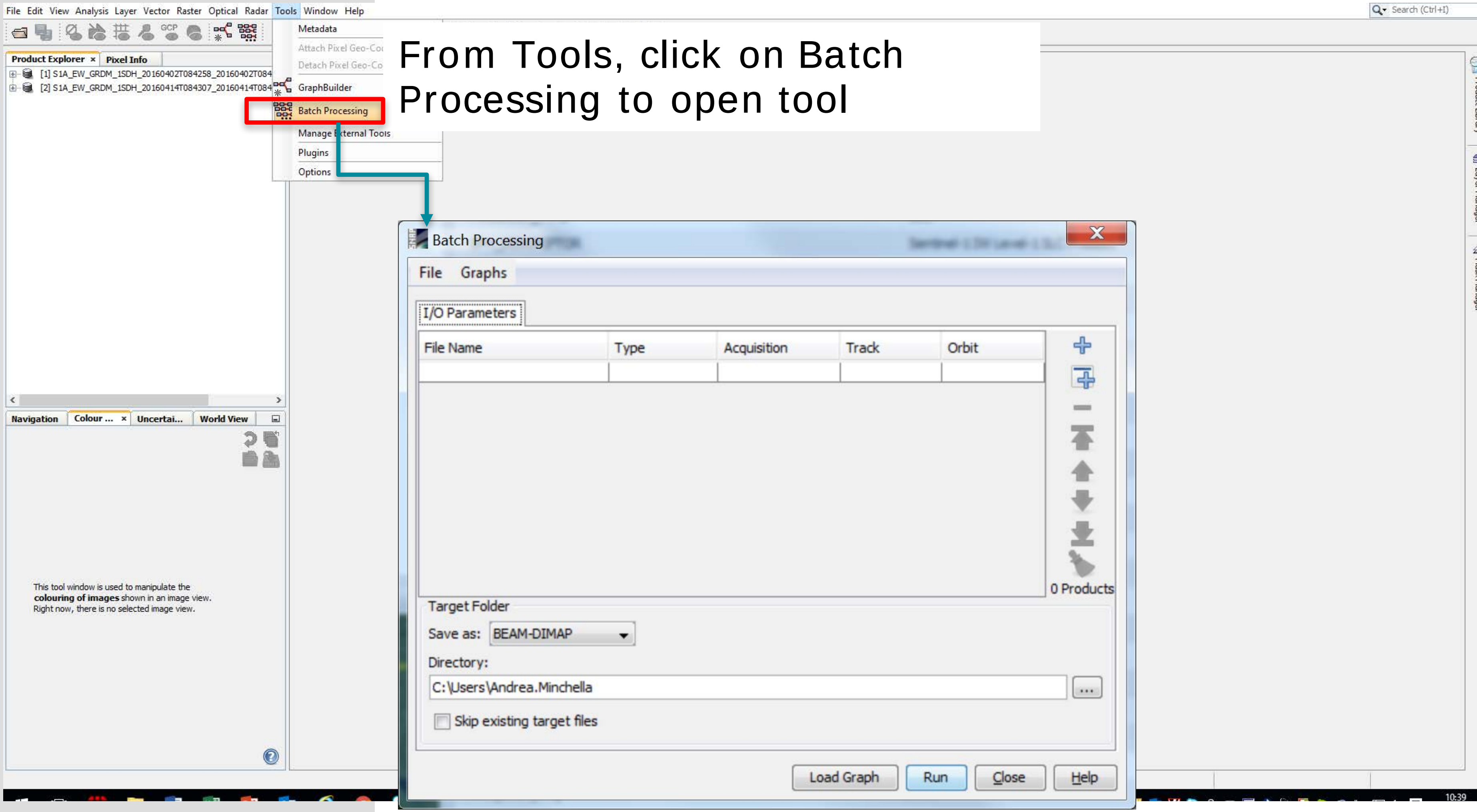
1.b - Batch Processing Tool

From Tools, click on Batch Processing to open tool



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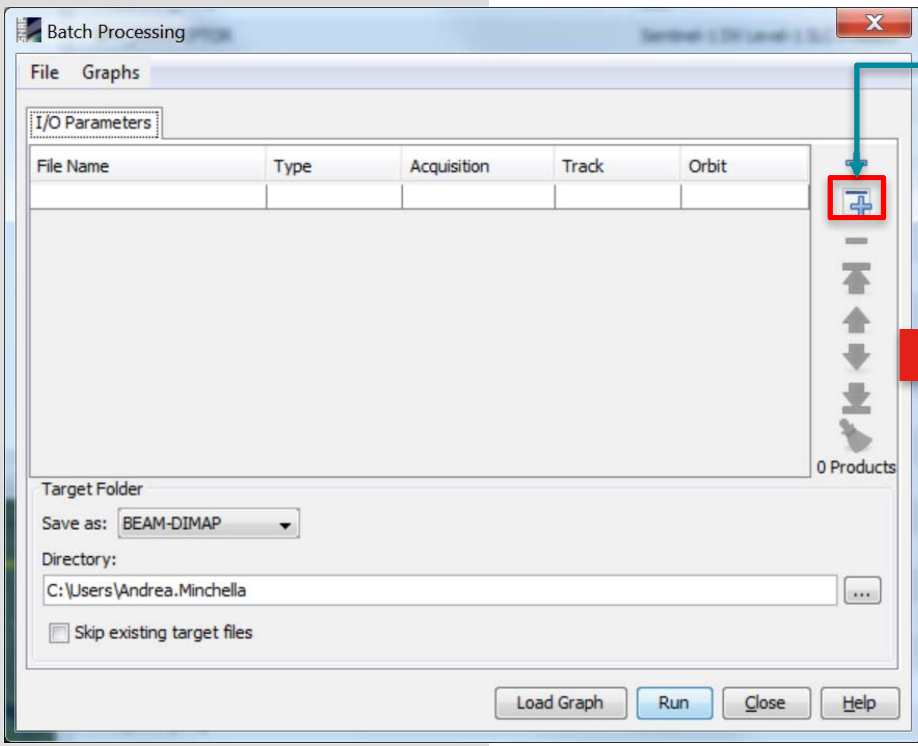
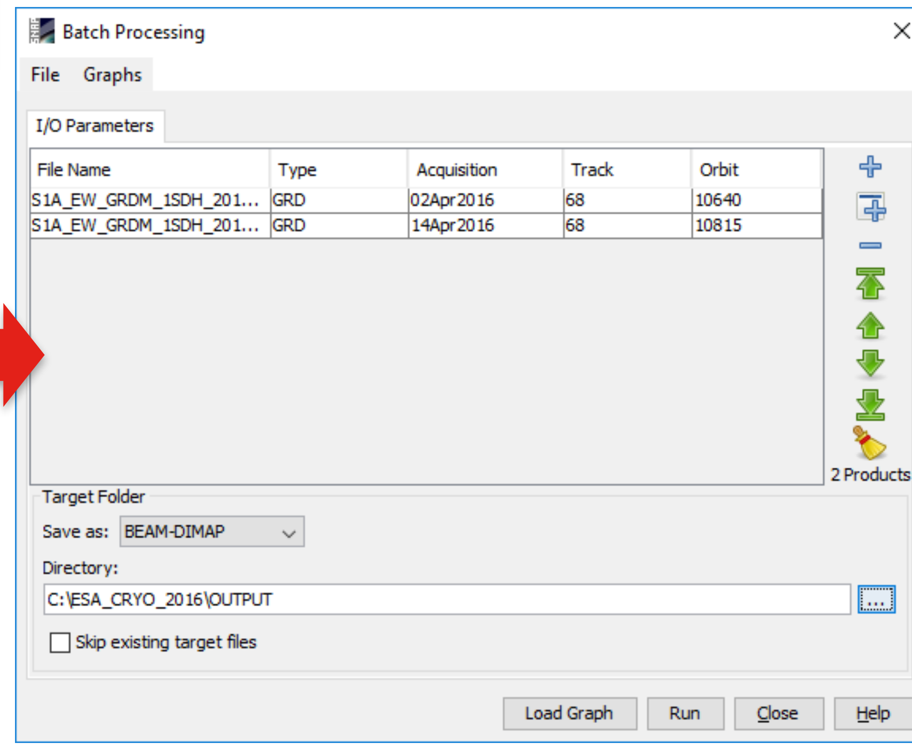
1.b - Batch processing

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





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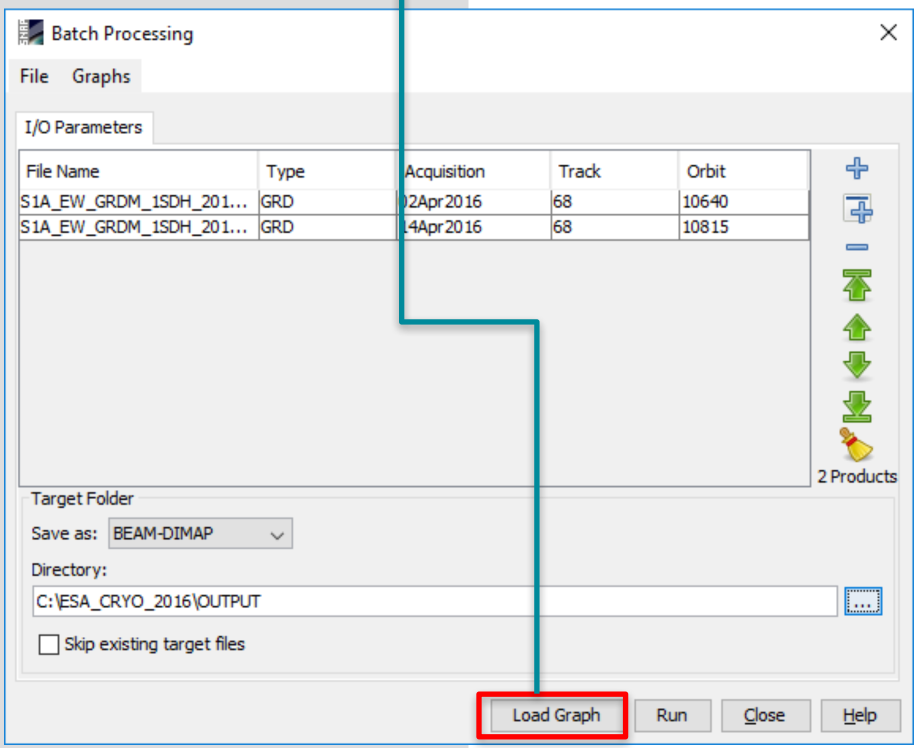
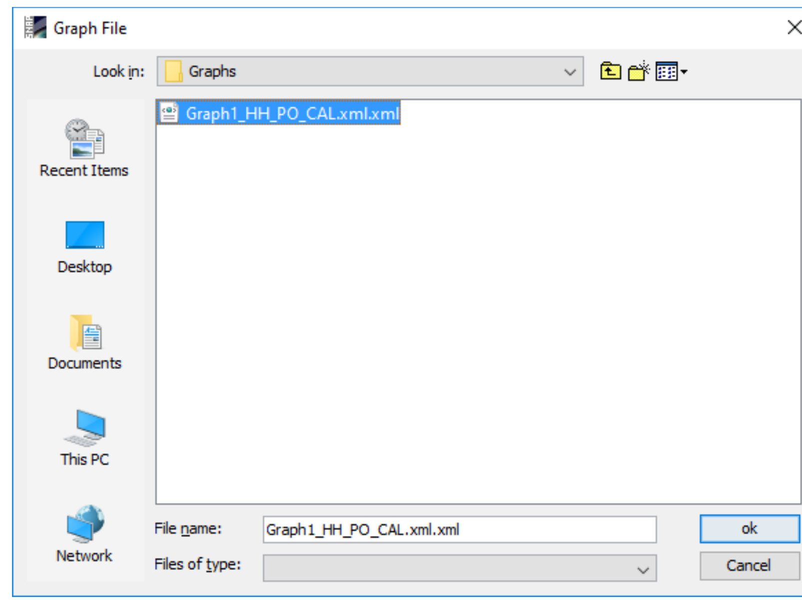
1.b - BP: Loading the graph (.xml)

1. By using "**LOAD GRAPH**", select the created chain *Graph1_HH_PO_CAL.xml* from "C:\ESA_CRYO_2016\Graphs"





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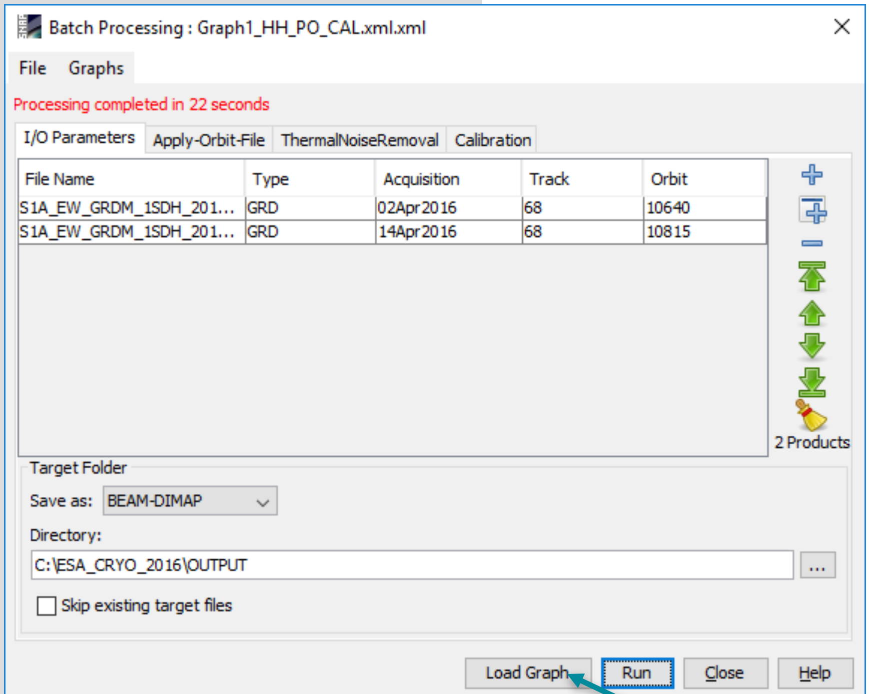
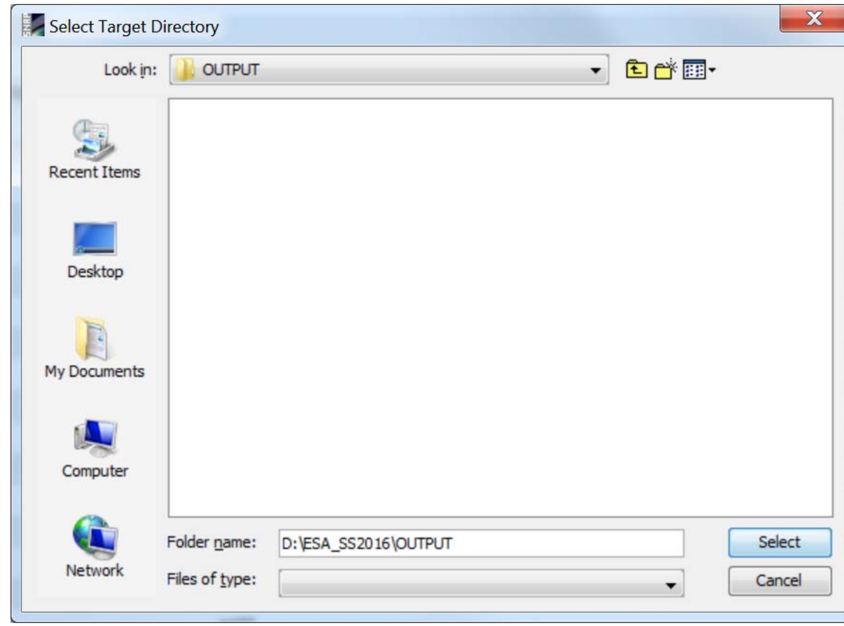
1.b - BP: executing the graph (.xml)

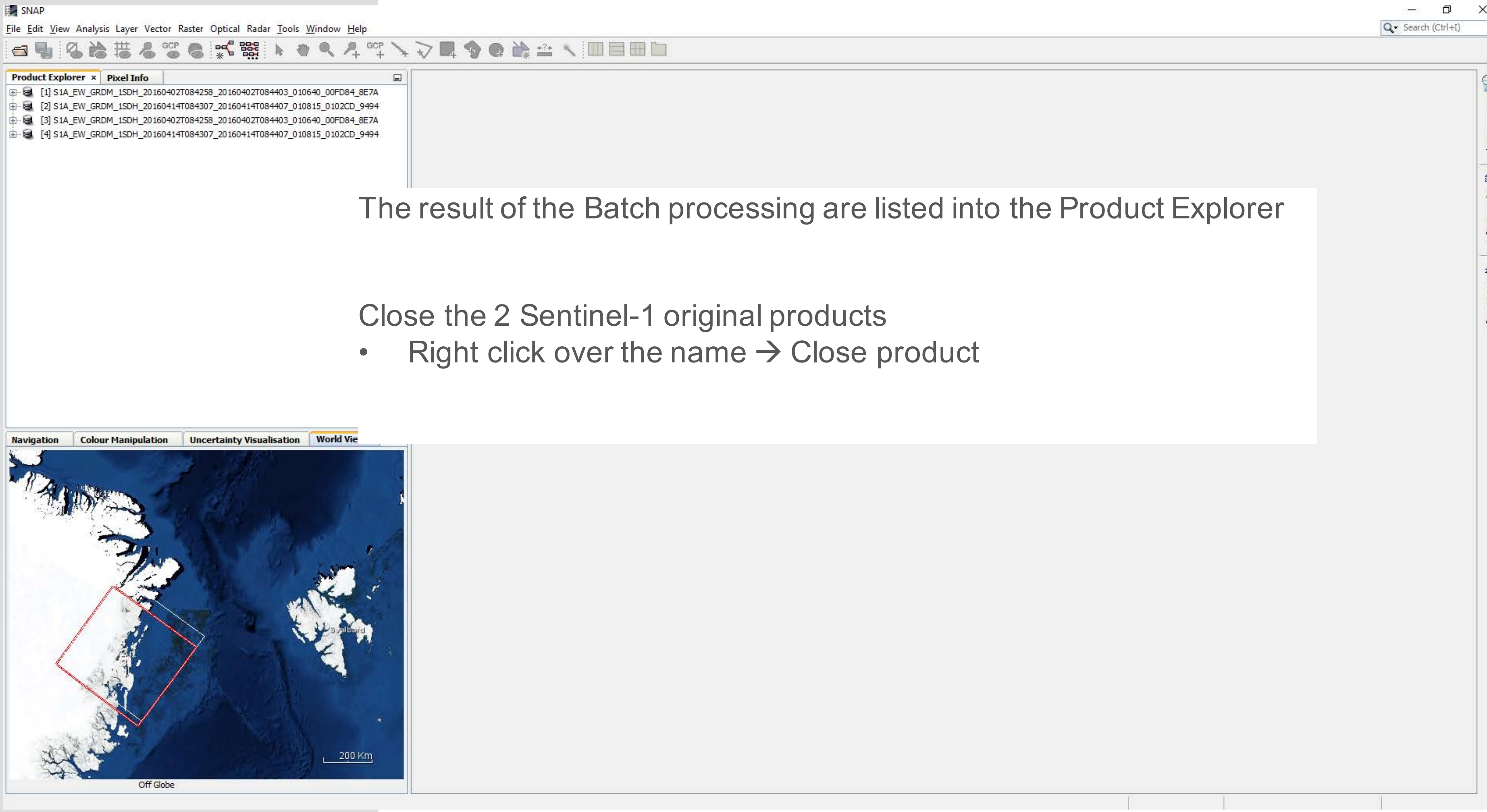




2. Select the OUTPUT directory
3. Cross Check parameters (recommended)
4. Click Run

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

1.b - Batch processing: results

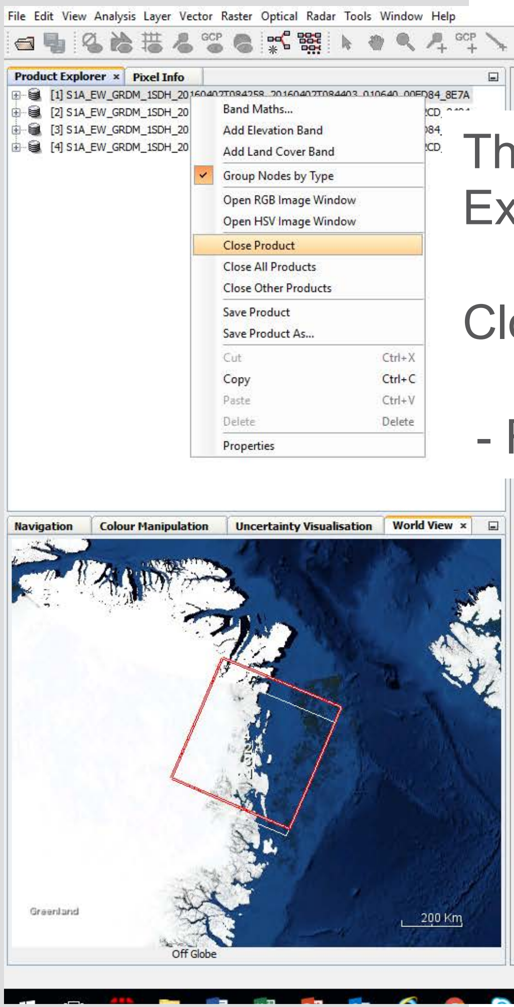


The result of the Batch processing are listed into the Product Explorer

Close the 2 Sentinel-1 original products

- Right click over the name → Close product

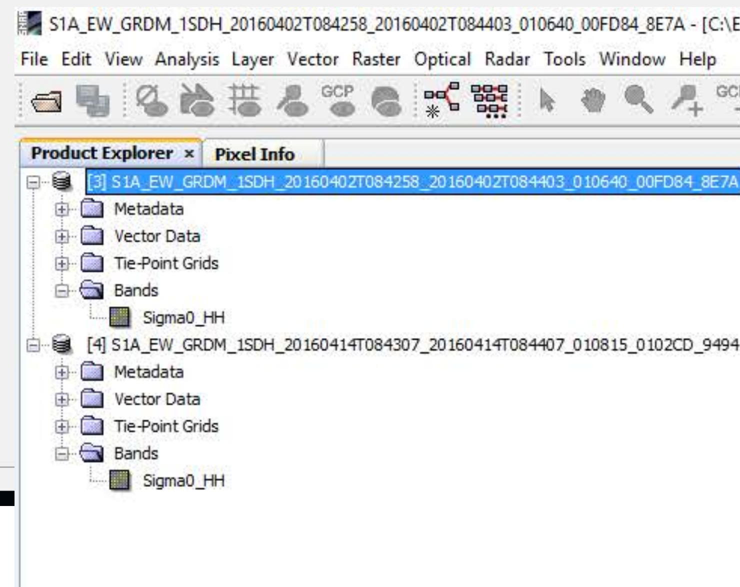
1.b - Batch processing: results



The result of the Batch processing are listed into the Product Explorer

Close the 2 Sentinel-1 original products

- Right click over the product name → Close product



Step 2: Coregistration and Subset via GPT

MASTER

- Apply Precise Orbit File
- Remove Thermal Noise
- Calibration (HH)

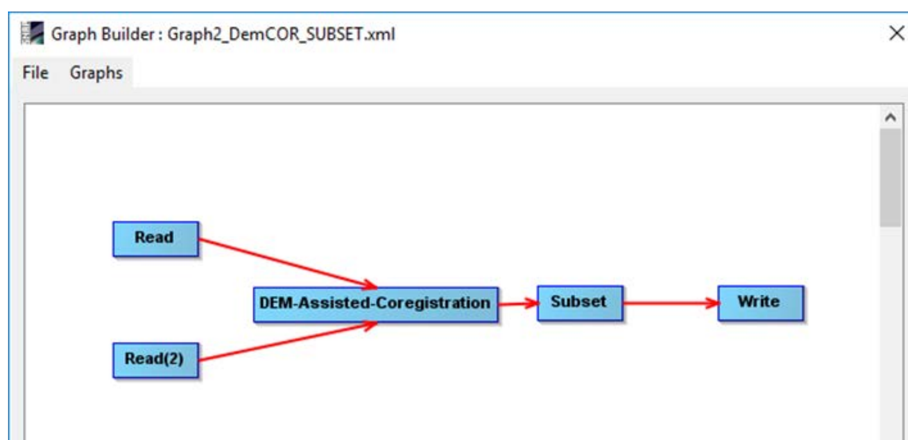
SLAVE

- Apply Precise Orbit File
- Remove Thermal Noise
- Calibration (HH)

2.

- DEM assisted Coregistration
- Subset

Graph Builder



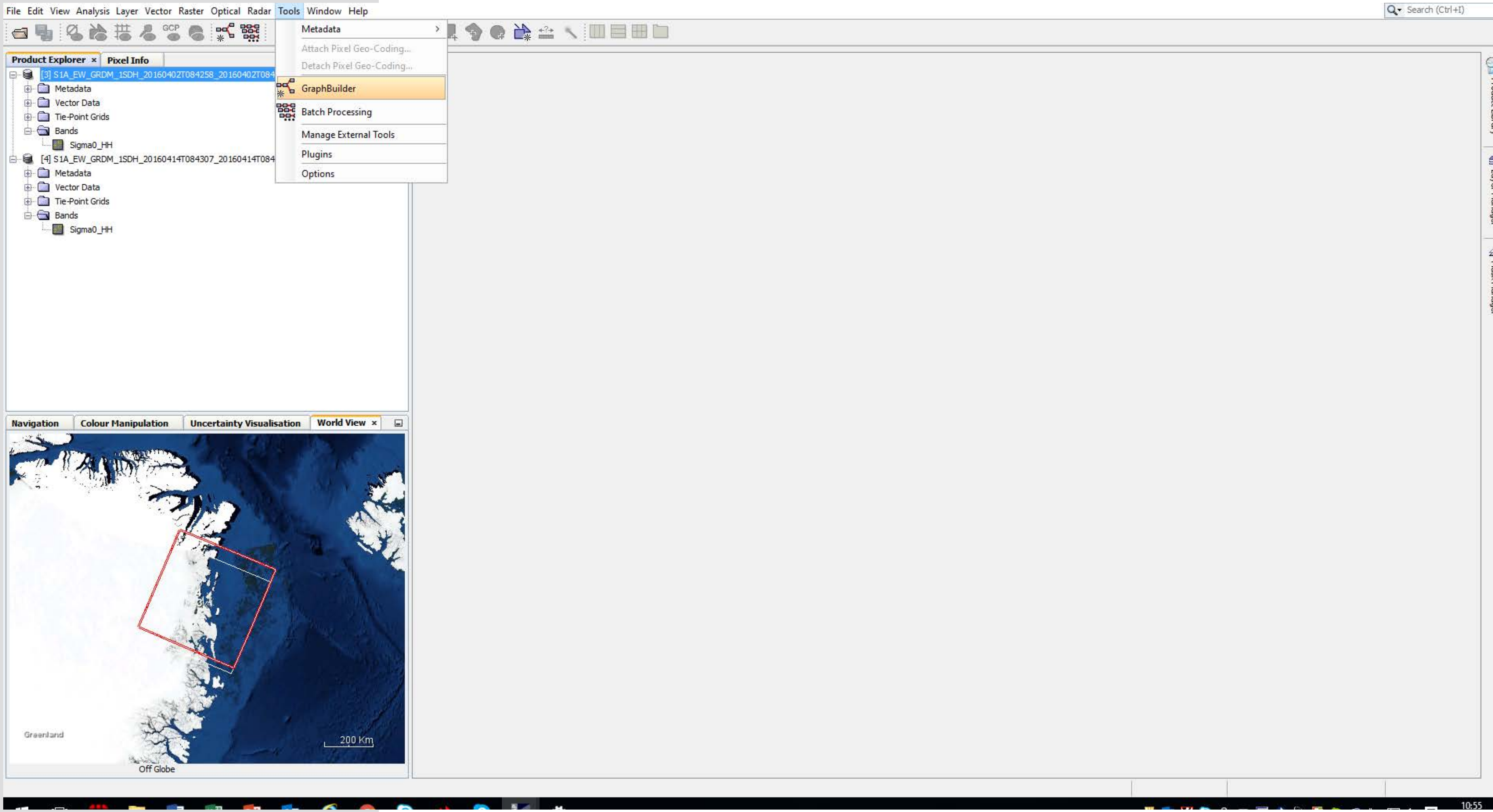
Step 2: Coregistration and Subset via GPT

Q7. What is the purpose of the coregistration step?

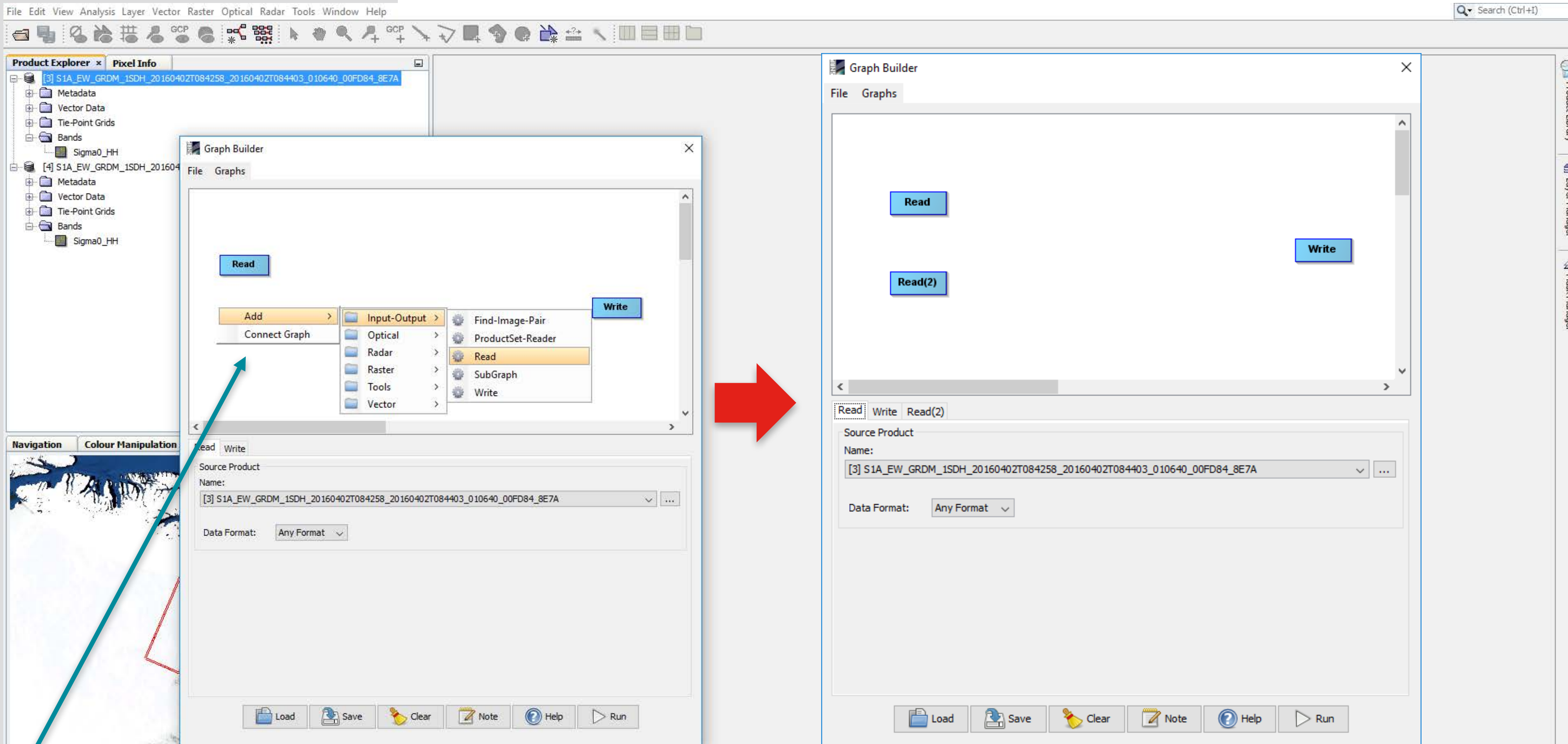
Q8. What are the 2 main calculations performed during image coregistration?

Q9. is it possible to coregister 2 SAR images without a DEM, and if so what information is used?

Step 2: Coregistration and Subset via GPT

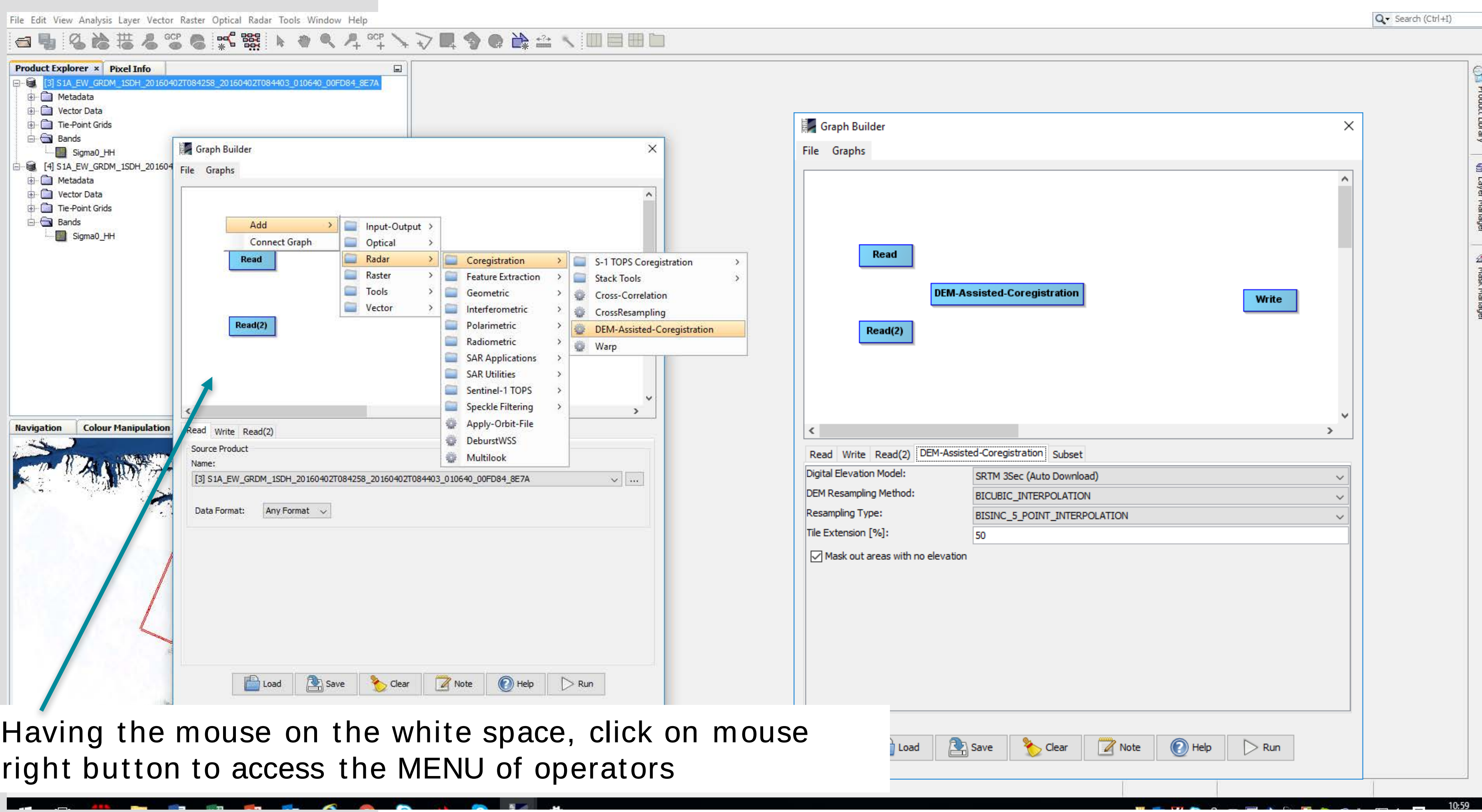


Step 2: Coregistration and Subset via GPT



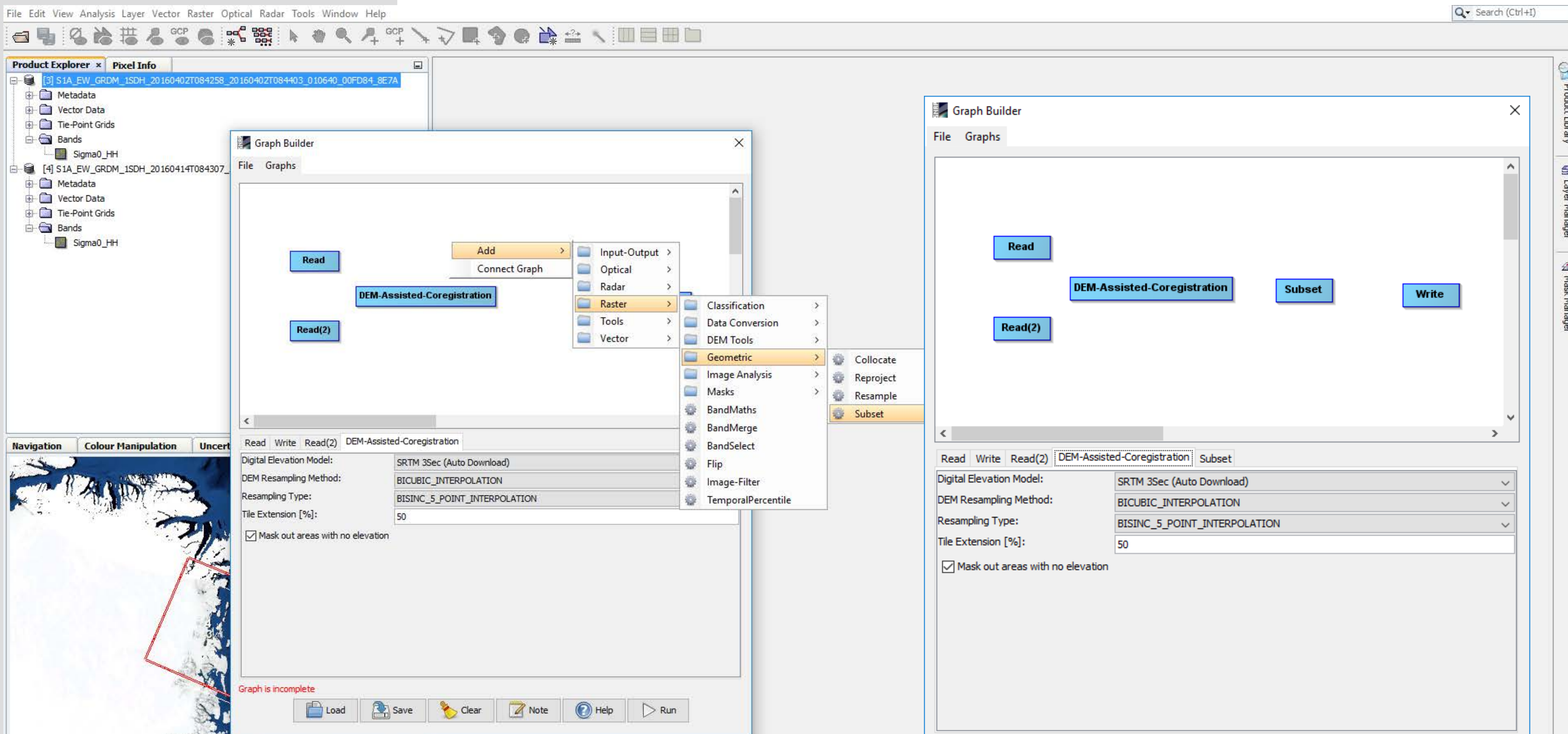
Having the mouse on the white space, click on mouse right button to access the MENU of operators

Step 2: DEM assisted Coregistration



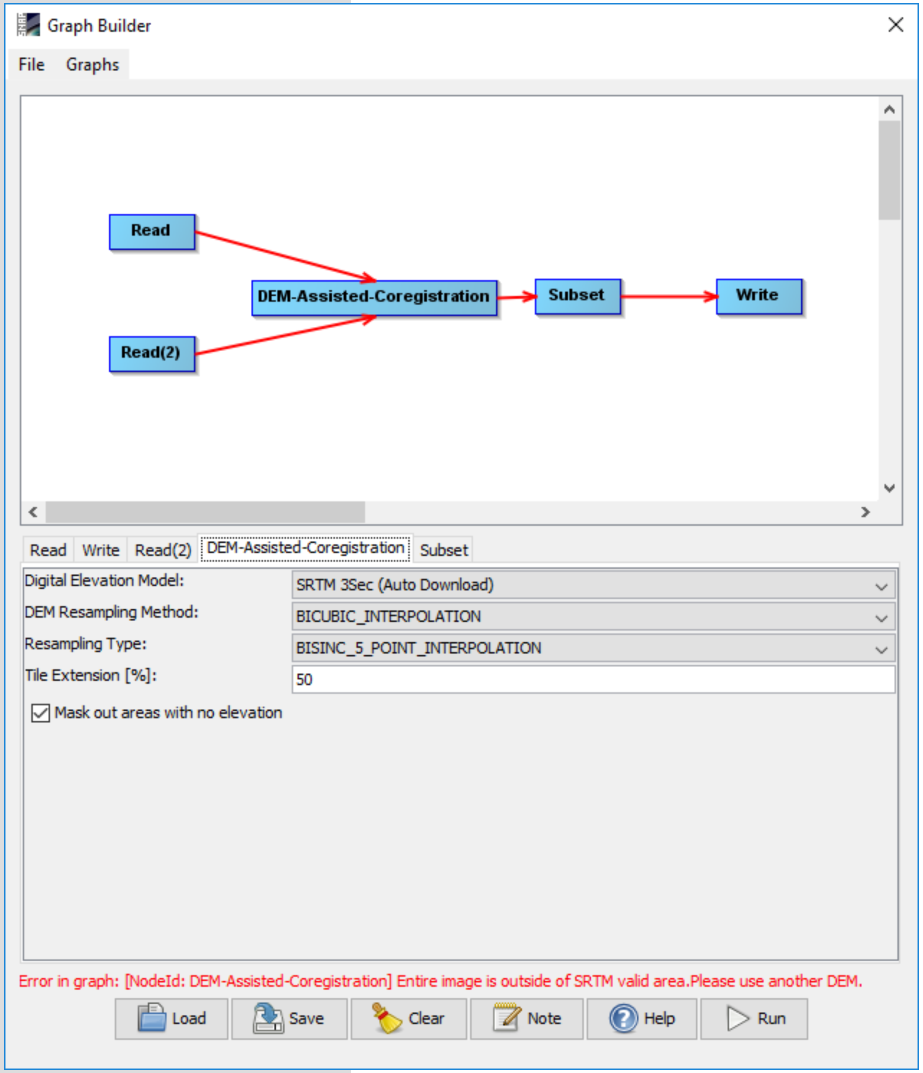
Having the mouse on the white space, click on mouse right button to access the MENU of operators

Step 2: SUBSET



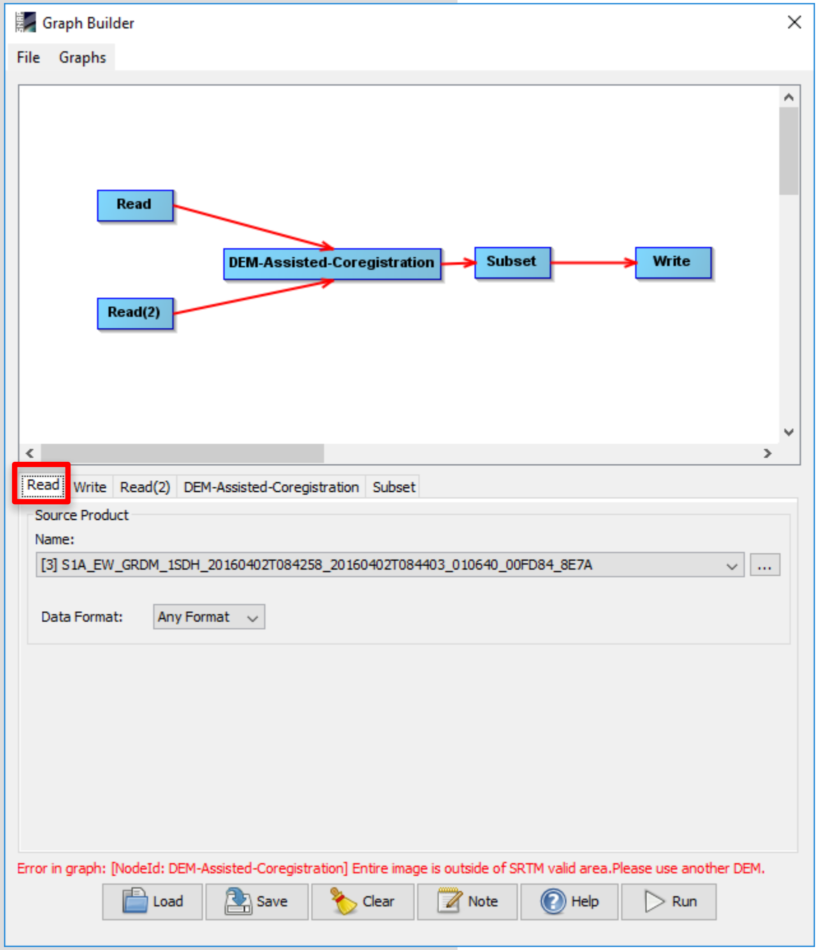
Having the mouse on the white space, click on mouse right button to access the MENU of operators

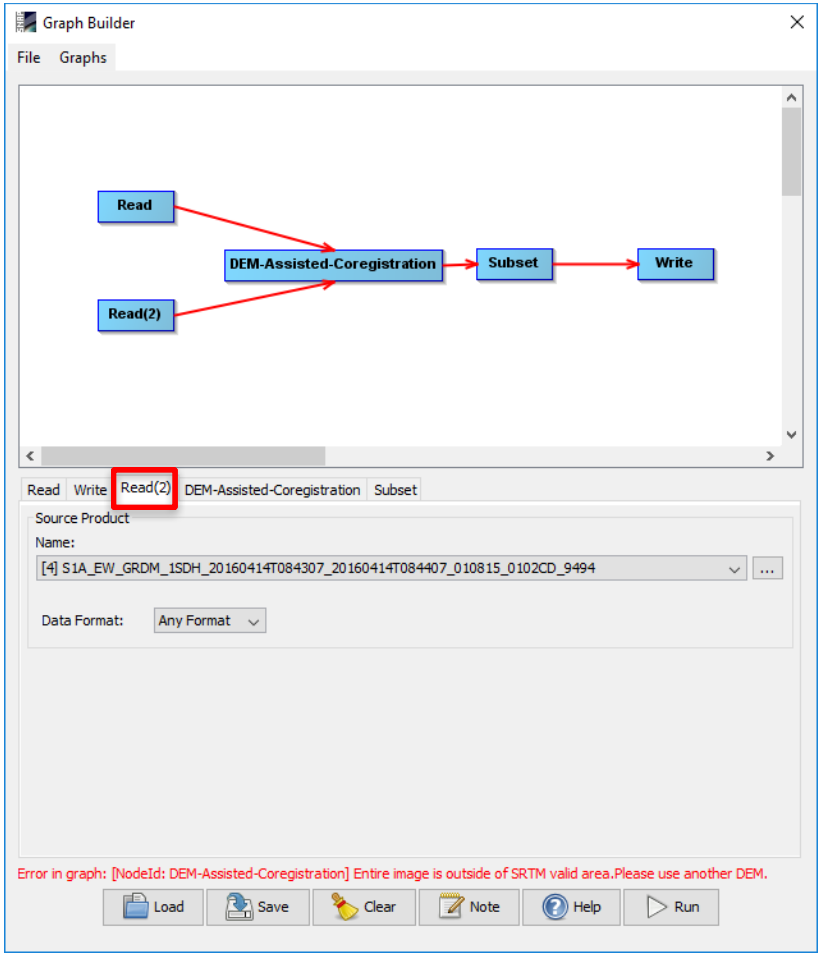
Step 2: Coregistration and Subset via GPT



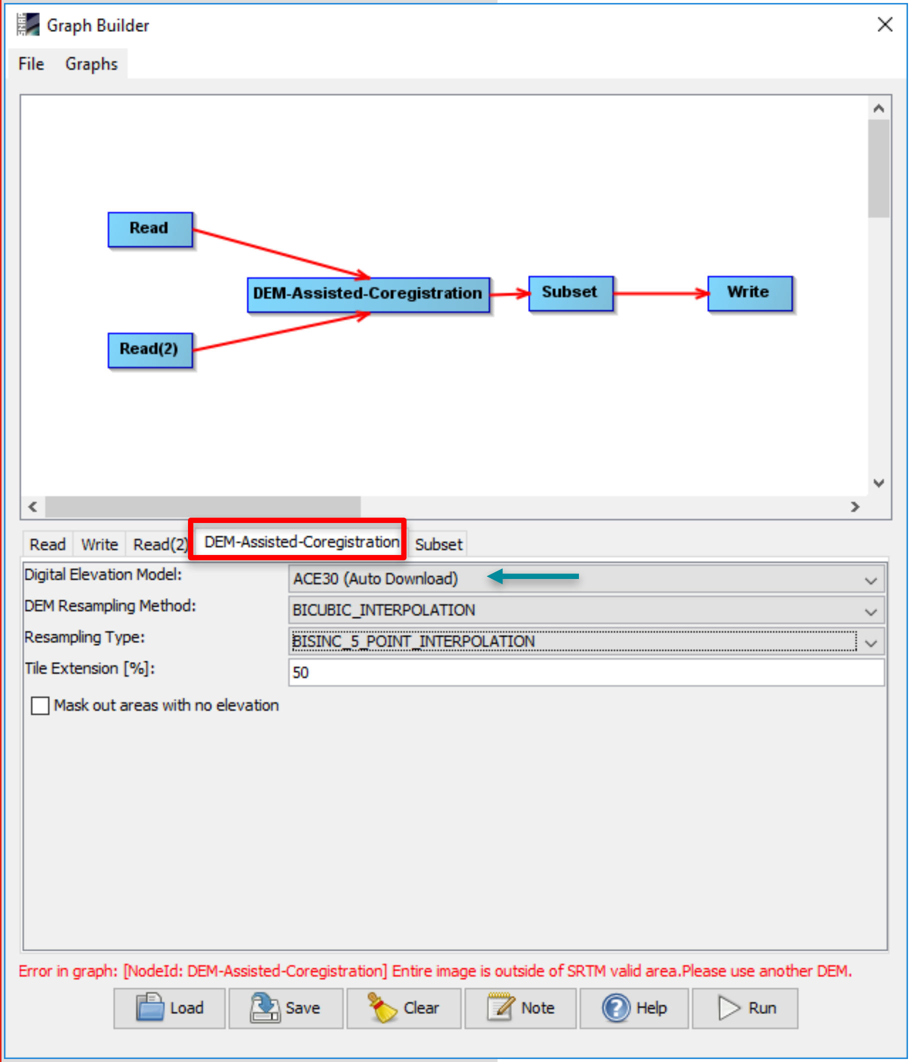
Connect the blocks manually

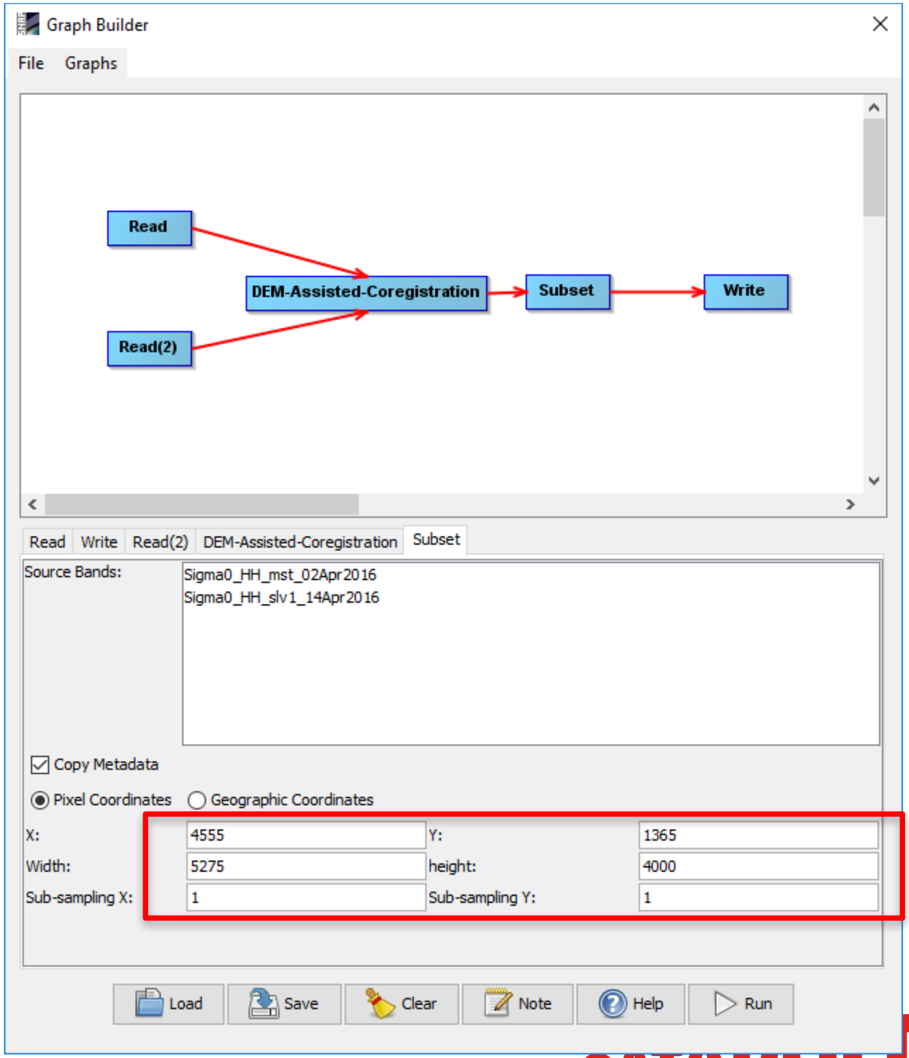
Inserting the parameters





Inserting the parameters





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Inserting the parameters

After inserting the parameters in the operators, execute the chain

N.B.: in the backup folder Graph2_DemCOR_SUBSET.xml

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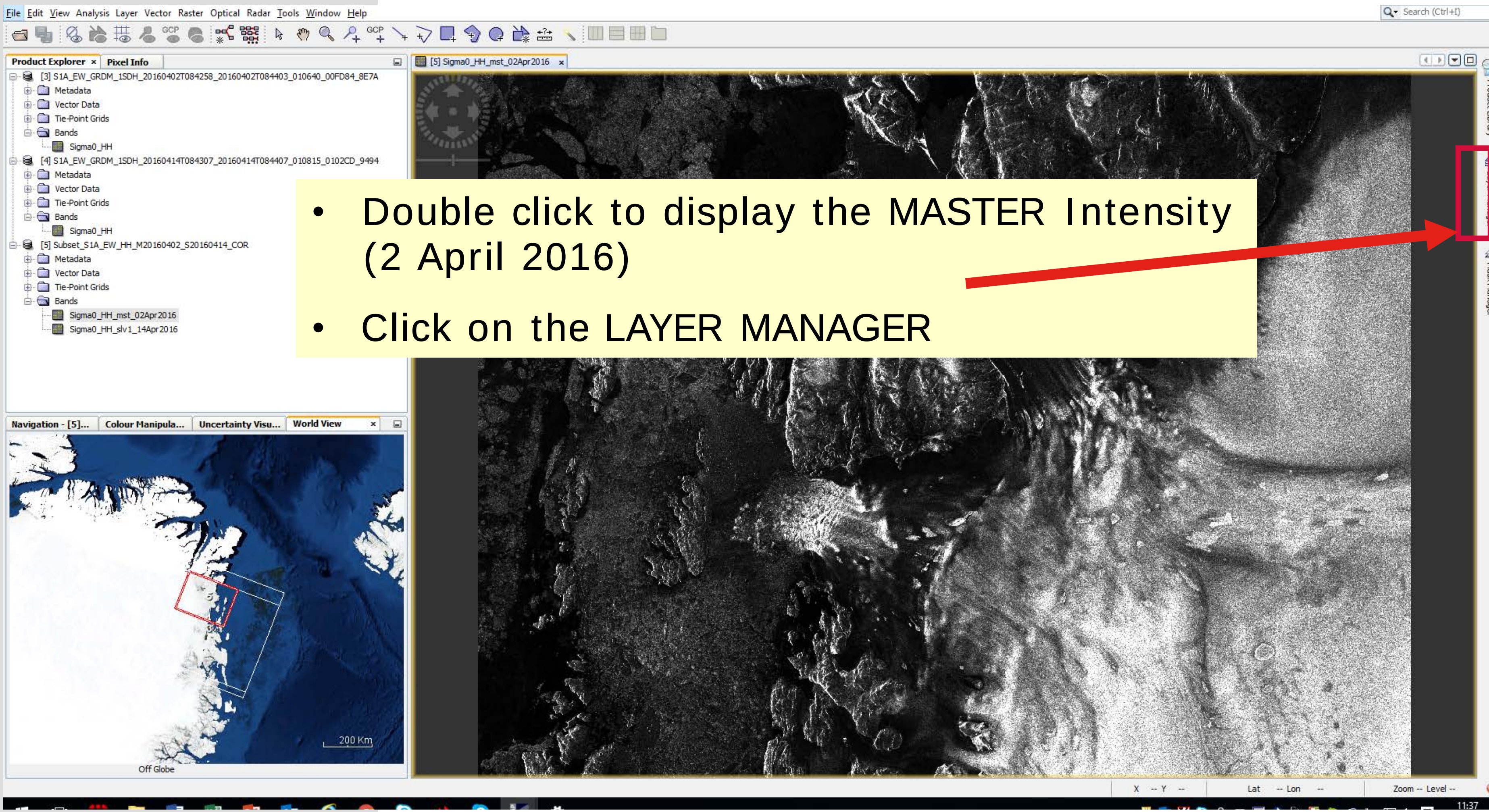
Overlay Master and Slave: the Layer Manager

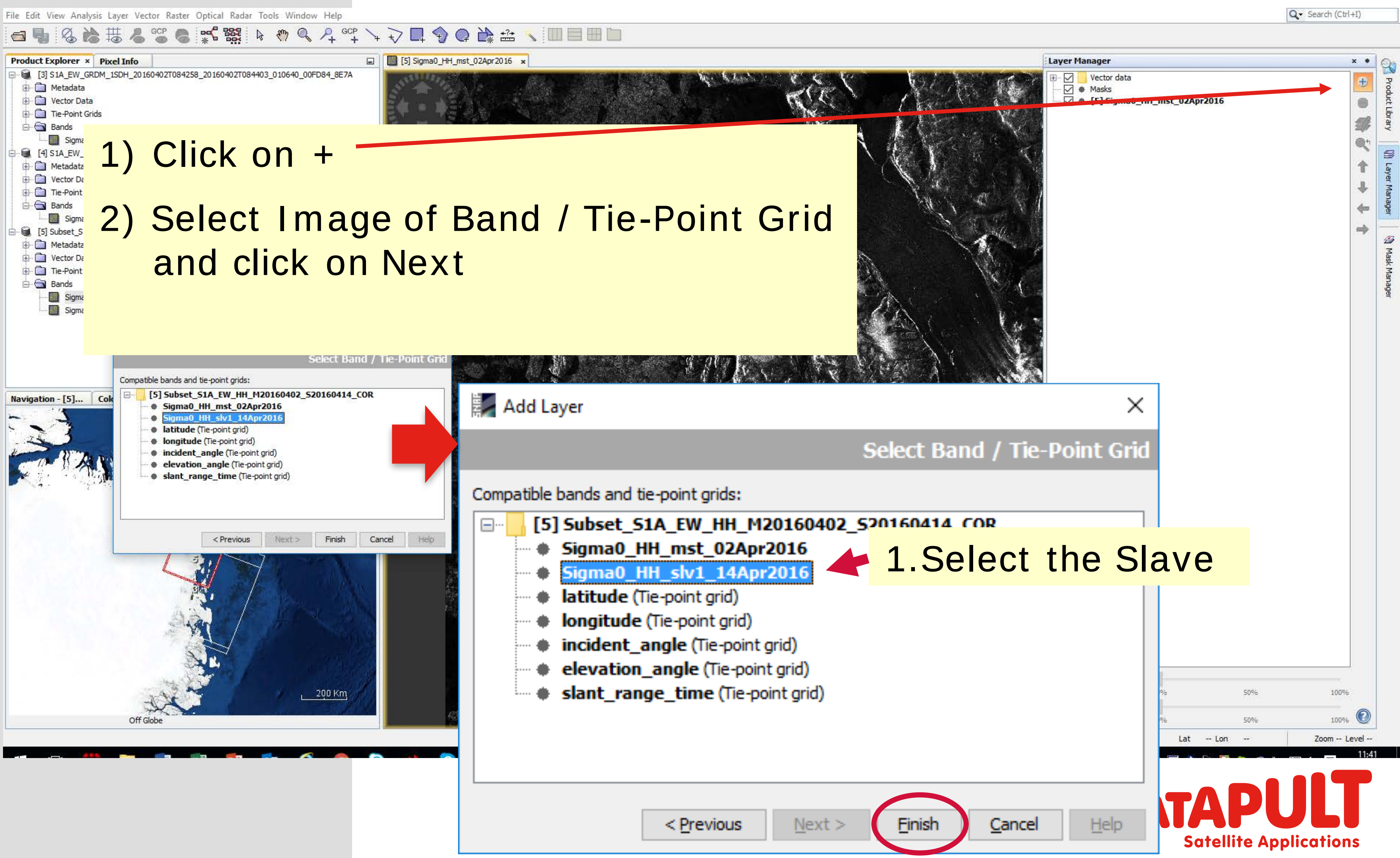


- Double click to display the MASTER Intensity (2 April 2016)
- Click on the LAYER MANAGER

Overlay Master and Slave: the Layer Manager

Q10. We have asked you to extract a subset of the full Sentinel-1 image to work with for the rest of this computer practical. Suggest a reason why we have done this?

Overlay Master and Slave: the Layer Manager



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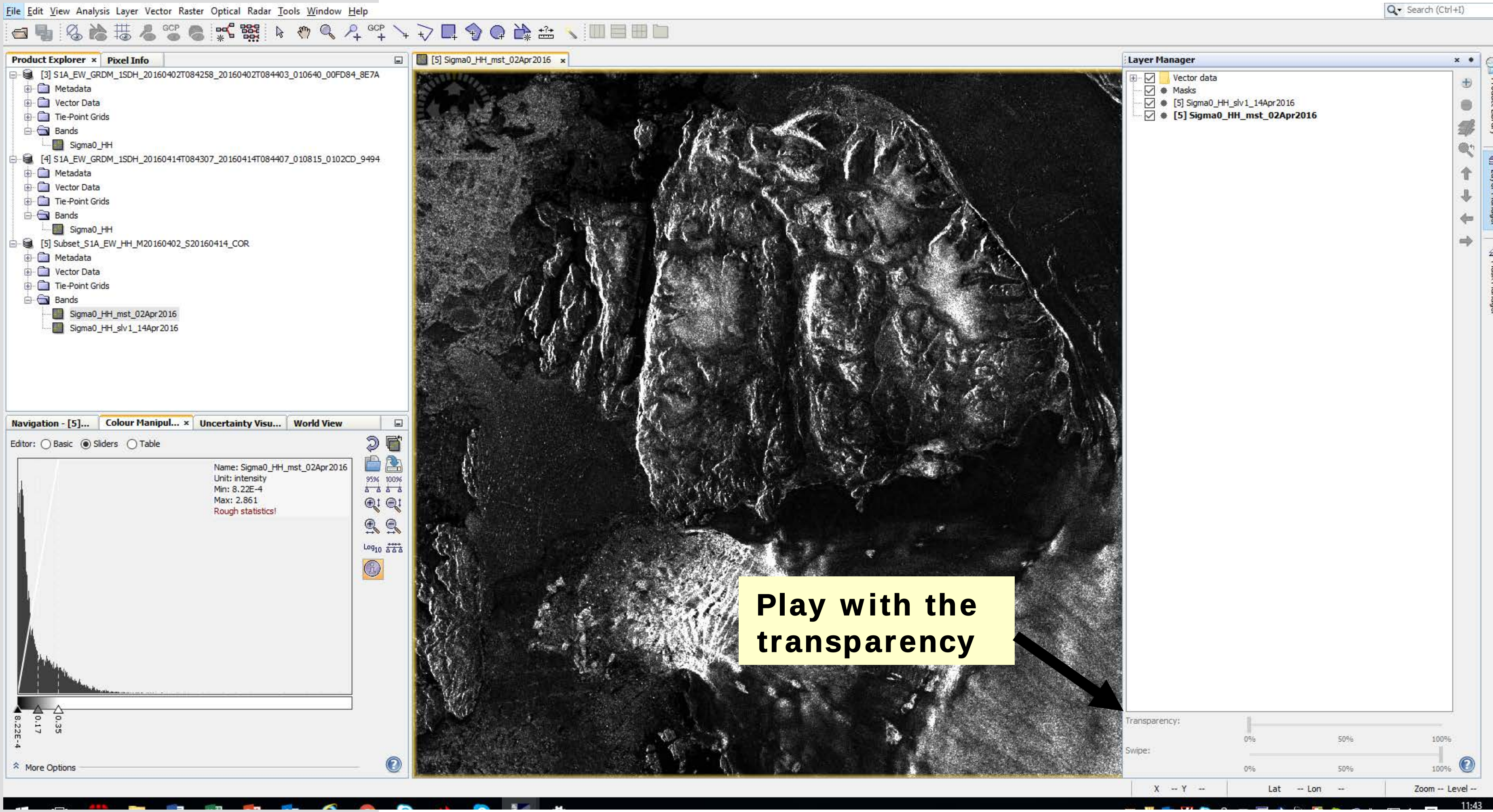
Overlay Master and Slave via the Layer Manager



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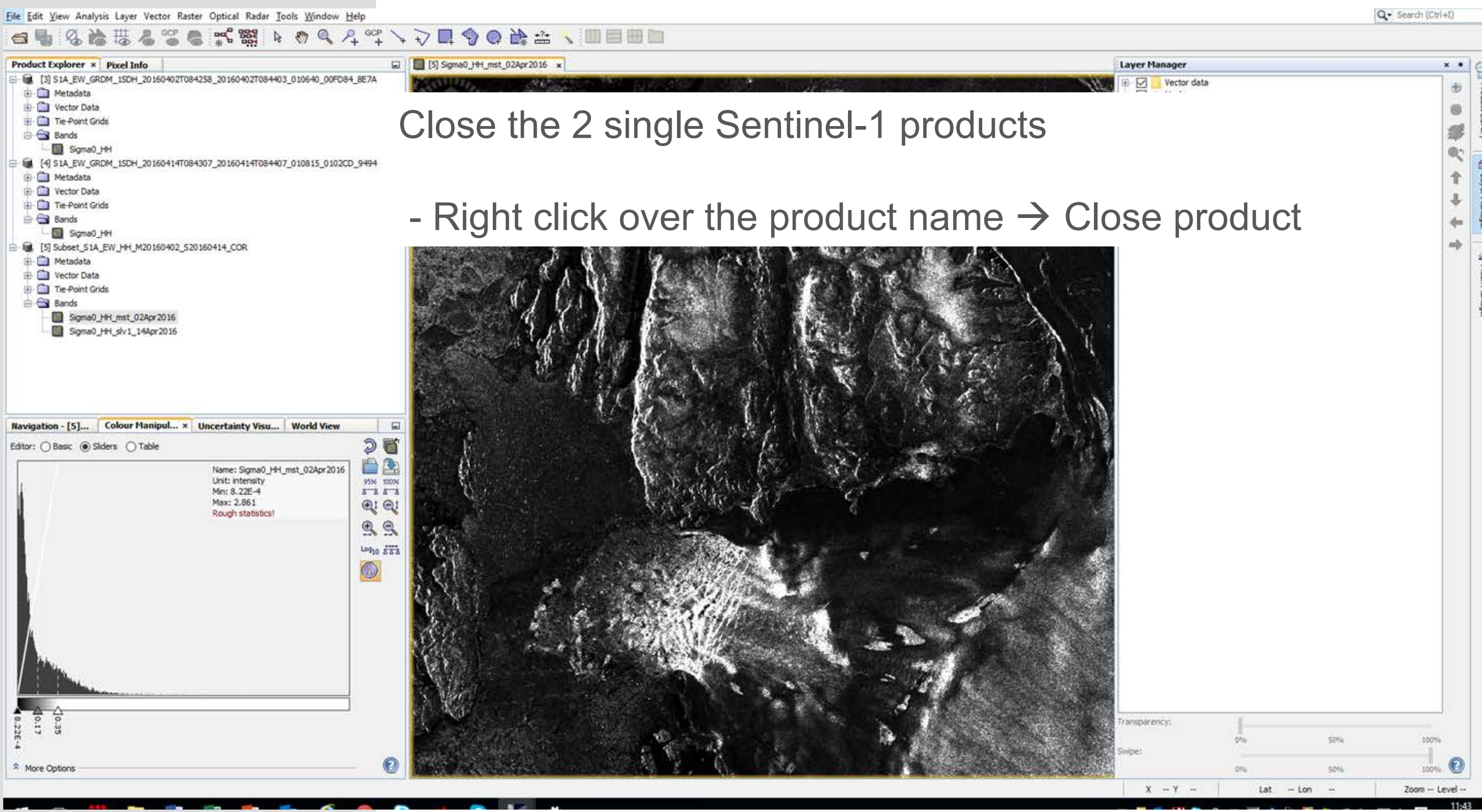
Coregistered Pair



Close the 2 single Sentinel-1 products

- Right click over the product name → Close product

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Step 3

2.

DEM assisted Coregistration

Subset

Graph Builder

3.

Offset Tracking

Merging Sigma0 and Ice Velocity via Band maths Op

Geocoding: RD Terrain Correction

GUI

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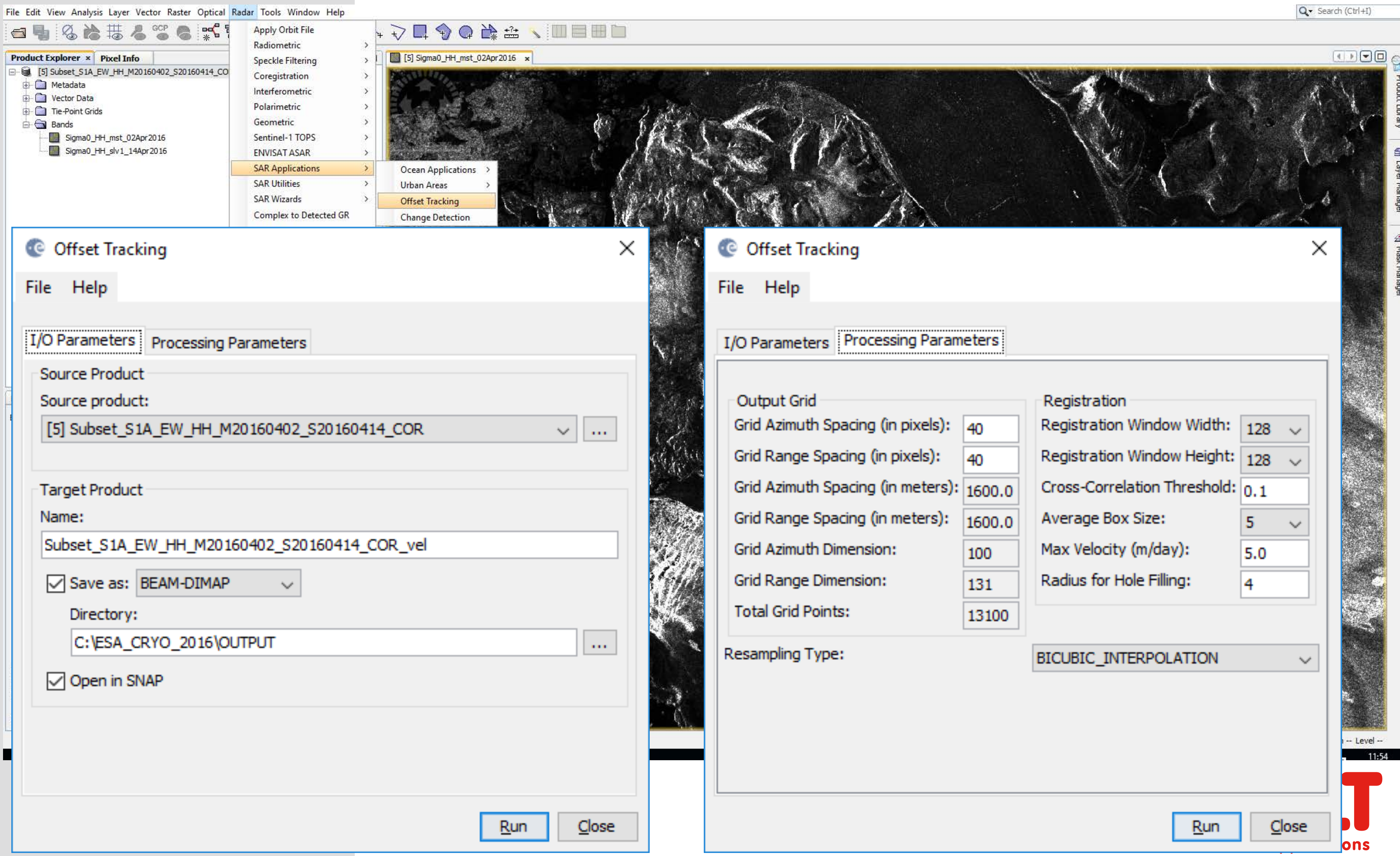
Step: Offset tracking



Step: Offset tracking

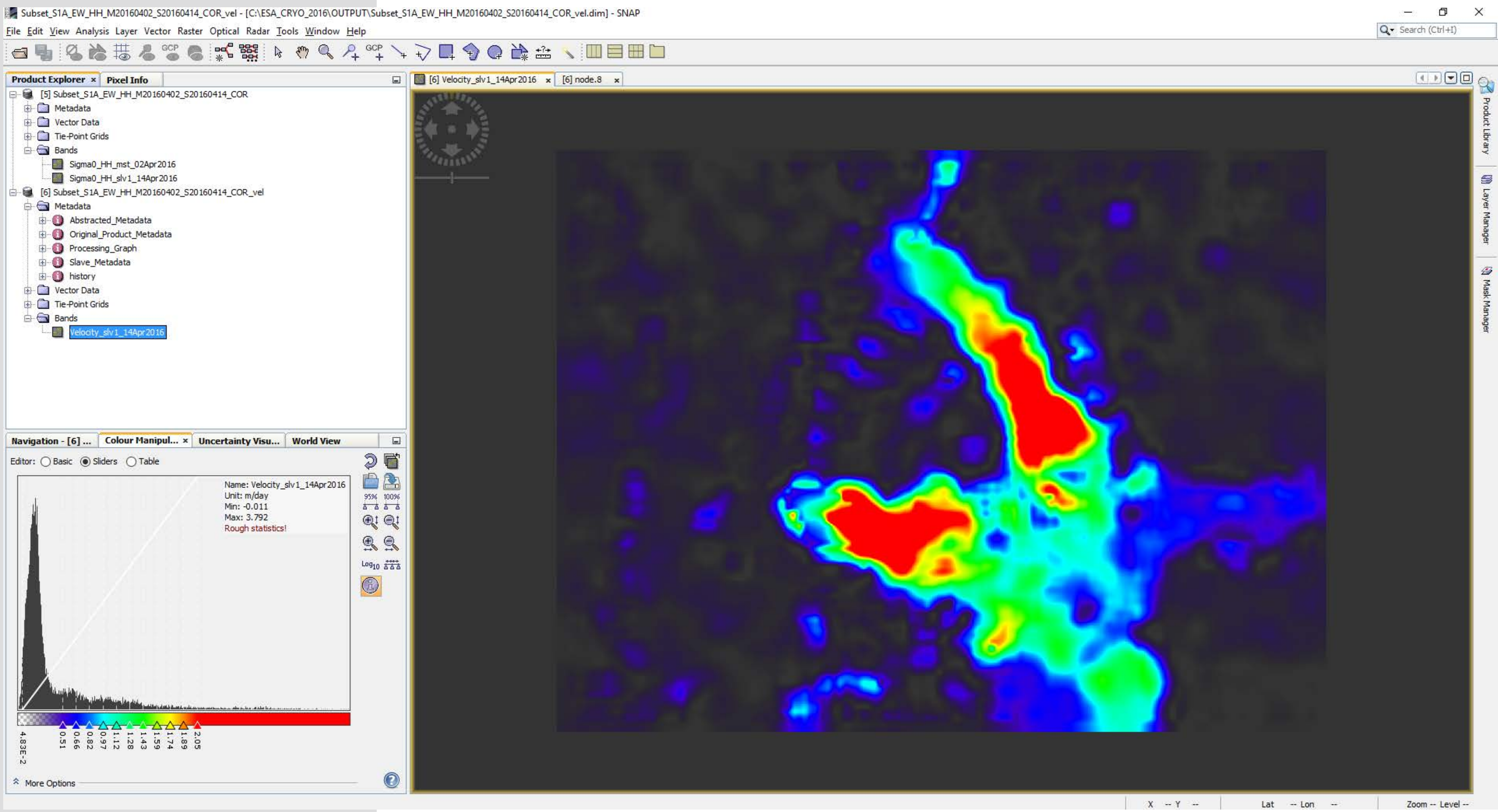
Q11. You have used a step size of 40, and a window size of 128.

a) what are the units of these two numbers?

b) which number would you need to change if you wanted to produce a finer spatial resolution ice velocity product?

c) would you increase or decrease this number if you wanted to produce a finer spatial resolution ice velocity product?

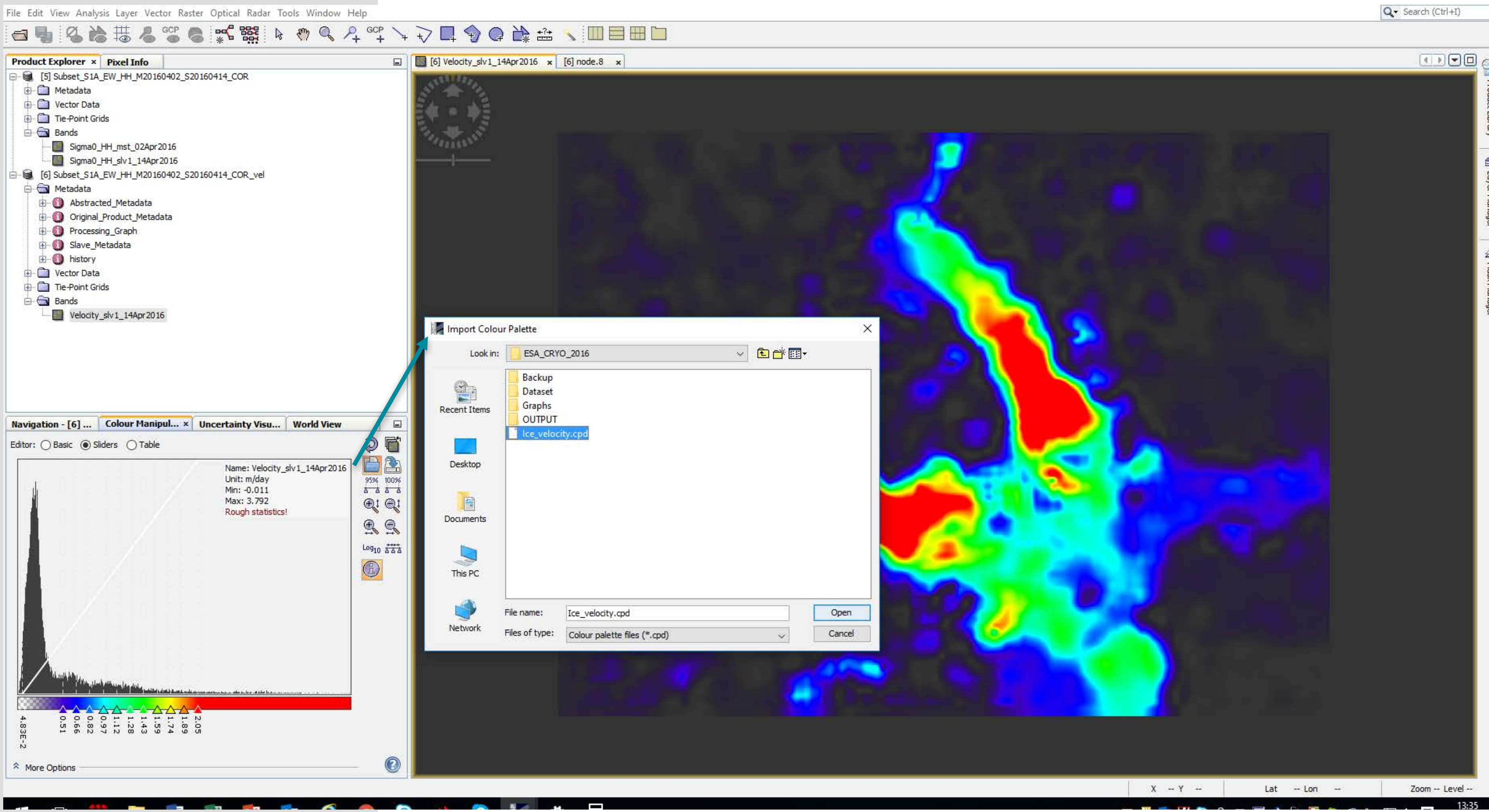
Step: Offset tracking → Ice velocity



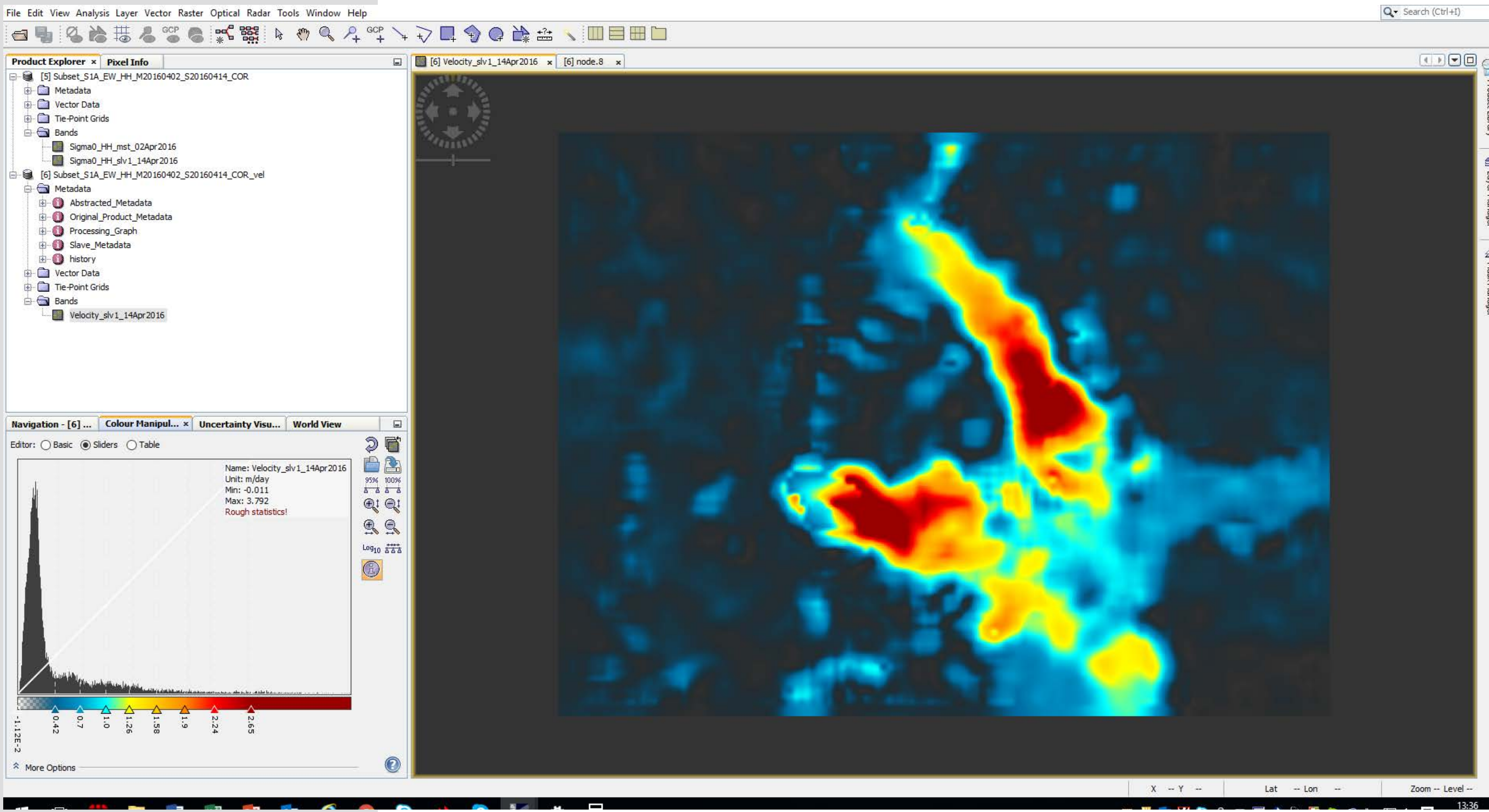
Step: Offset tracking → Ice velocity

Q12. What is the maximum ice speed you have measured?

Import a colour palette



Import a colour palette



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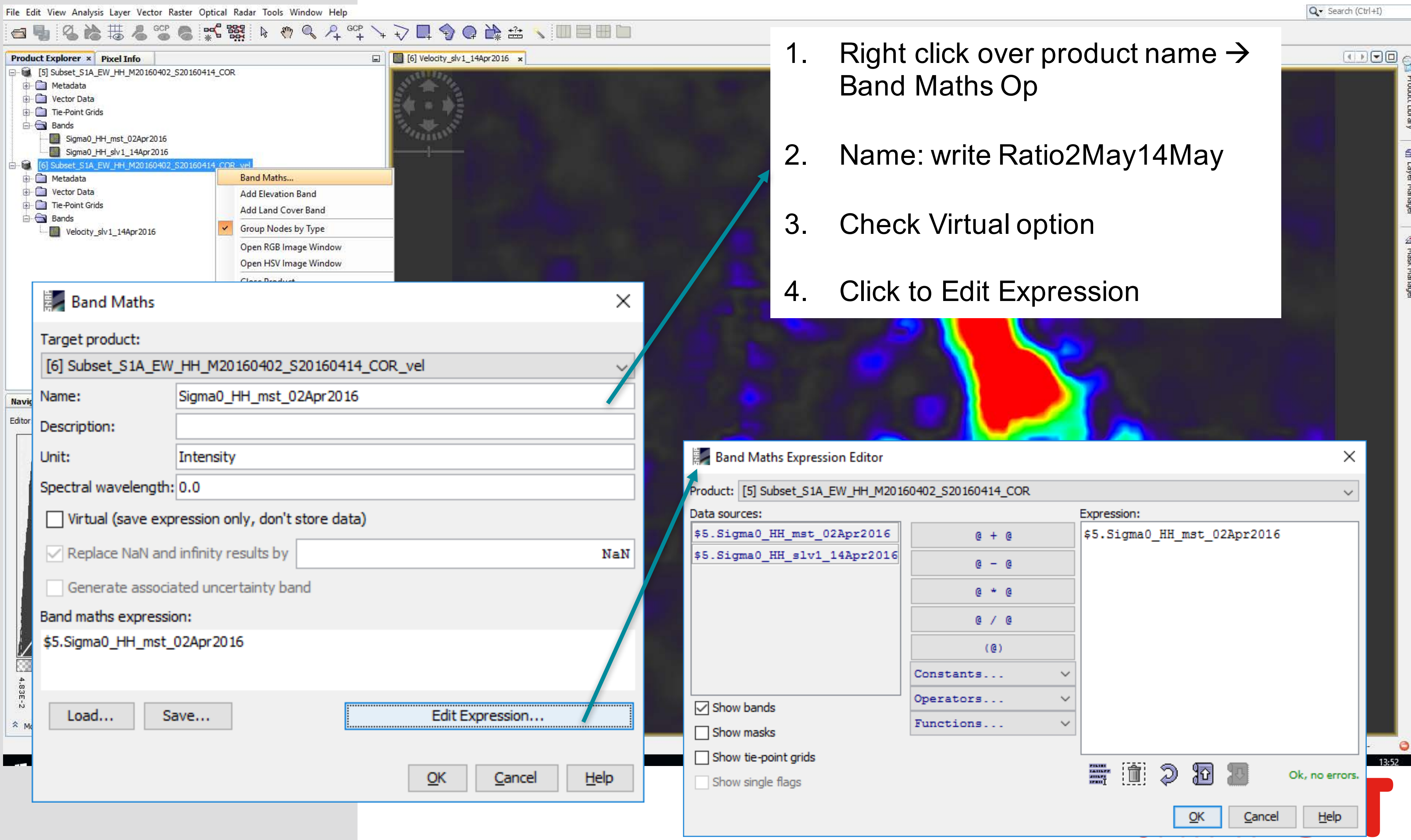
Step 3: Merging Sigma0 and Ice Velocity via Band Maths Op

1. Right click over product name → Band Maths Op
2. Name: write Ratio2May14May
3. Check Virtual option
4. Click to Edit Expression



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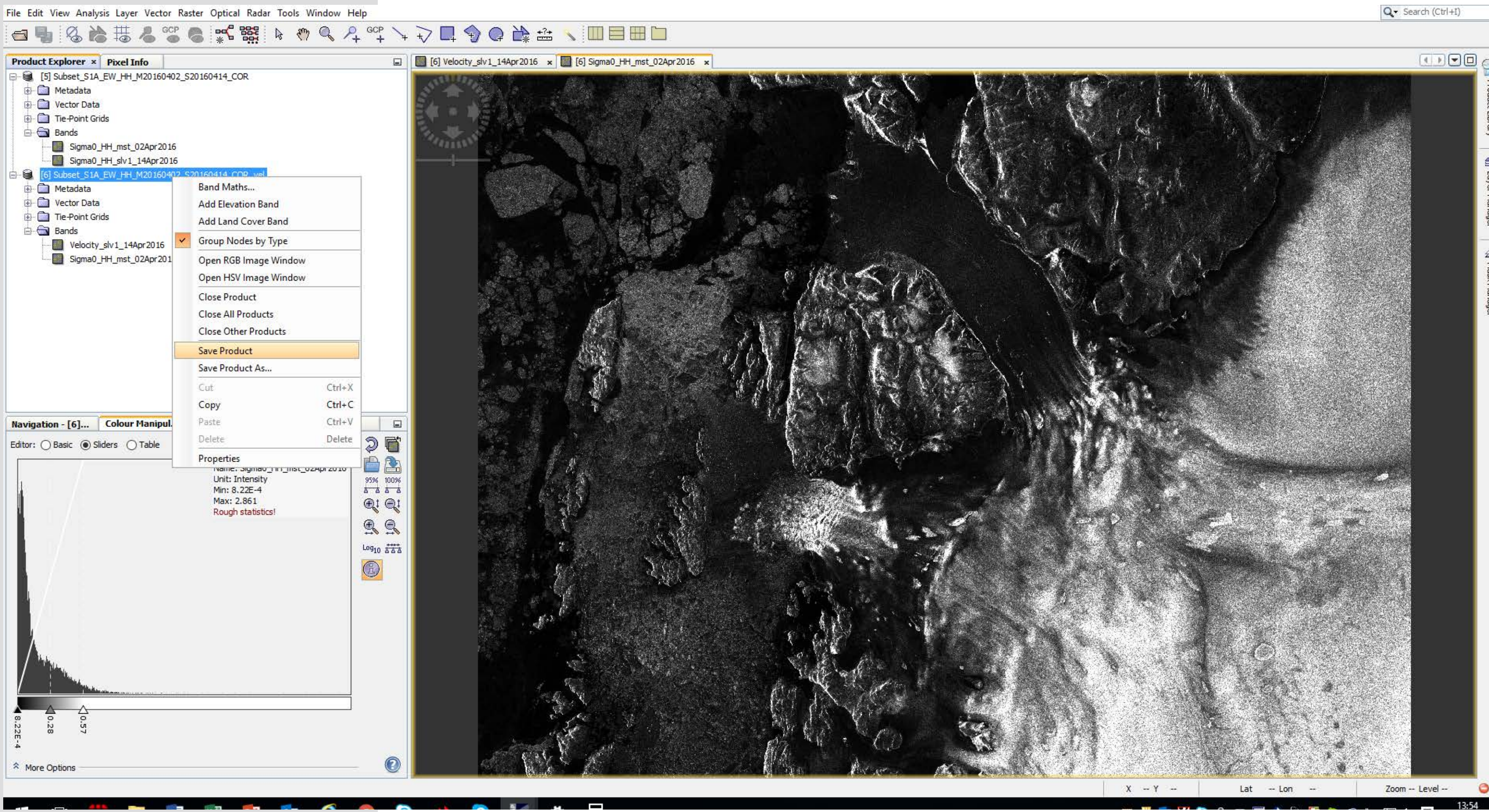
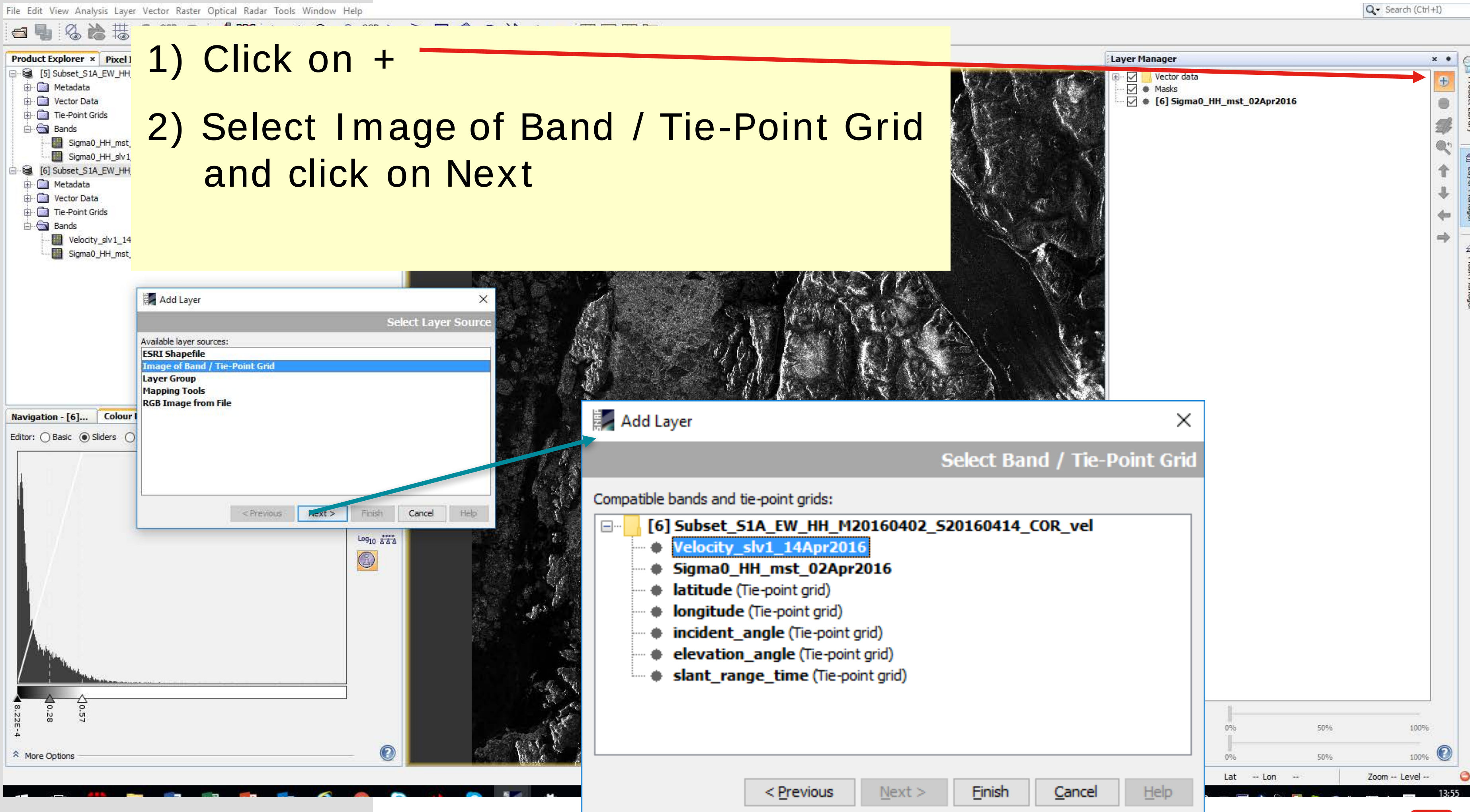
Merging Sigma0 and Ice Velocity



Overlay Sigma0 and Ice Velocity via the Layer Manager

1) Click on +

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



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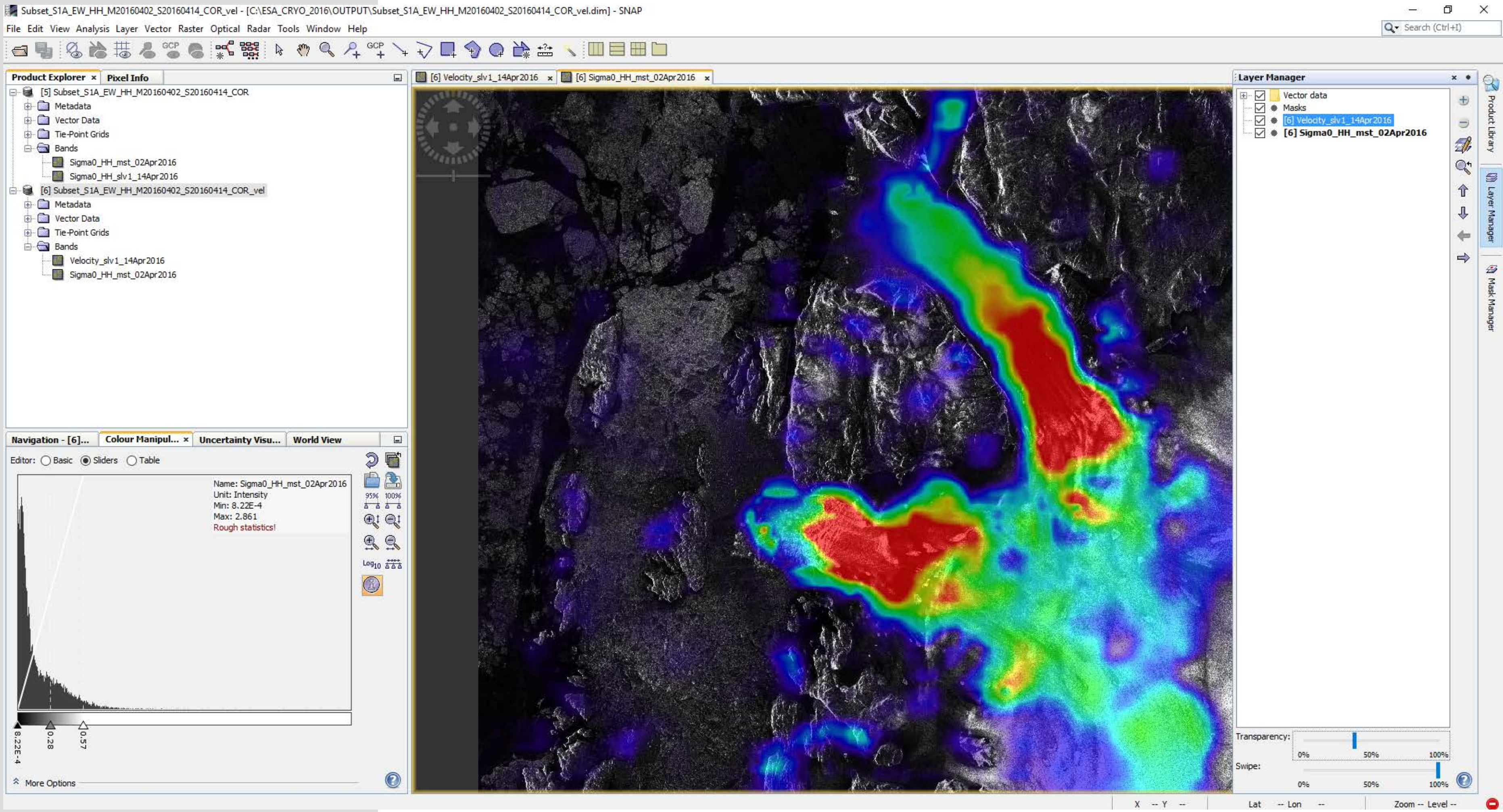
Overlay Sigma0 and Ice Velocity via the Layer Manager



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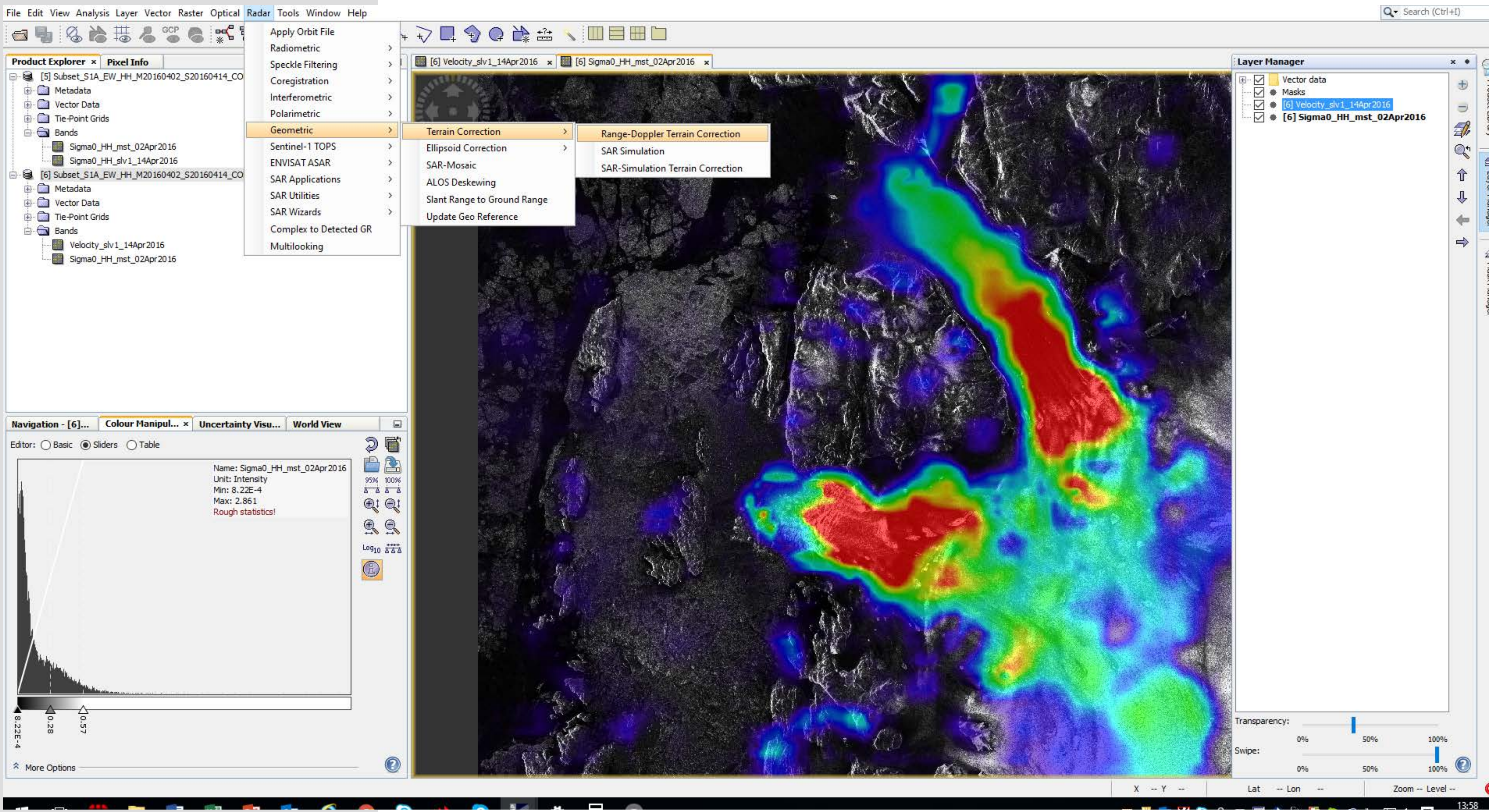
Step 3: Geocoding: RD Terrain Correction



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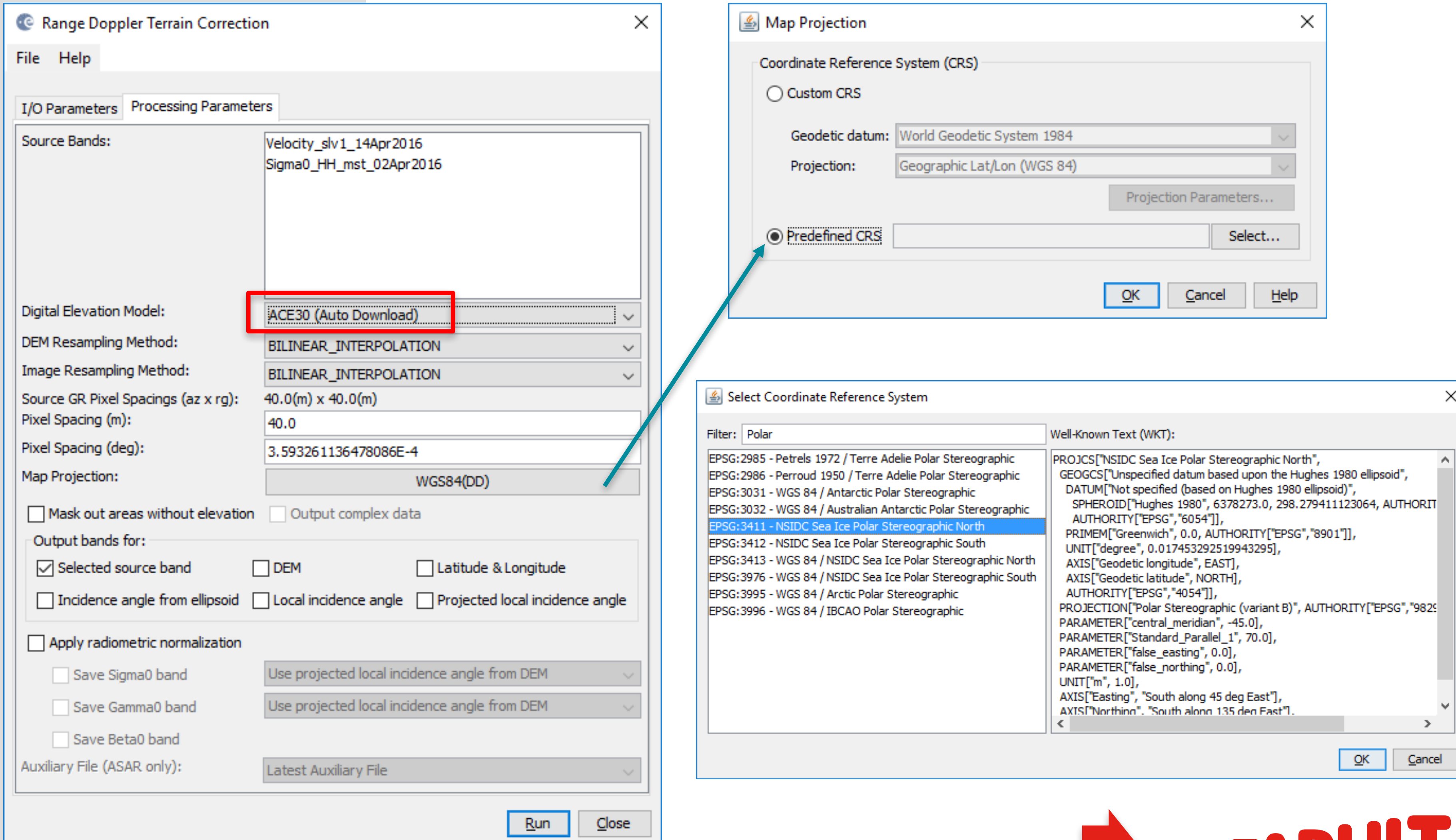
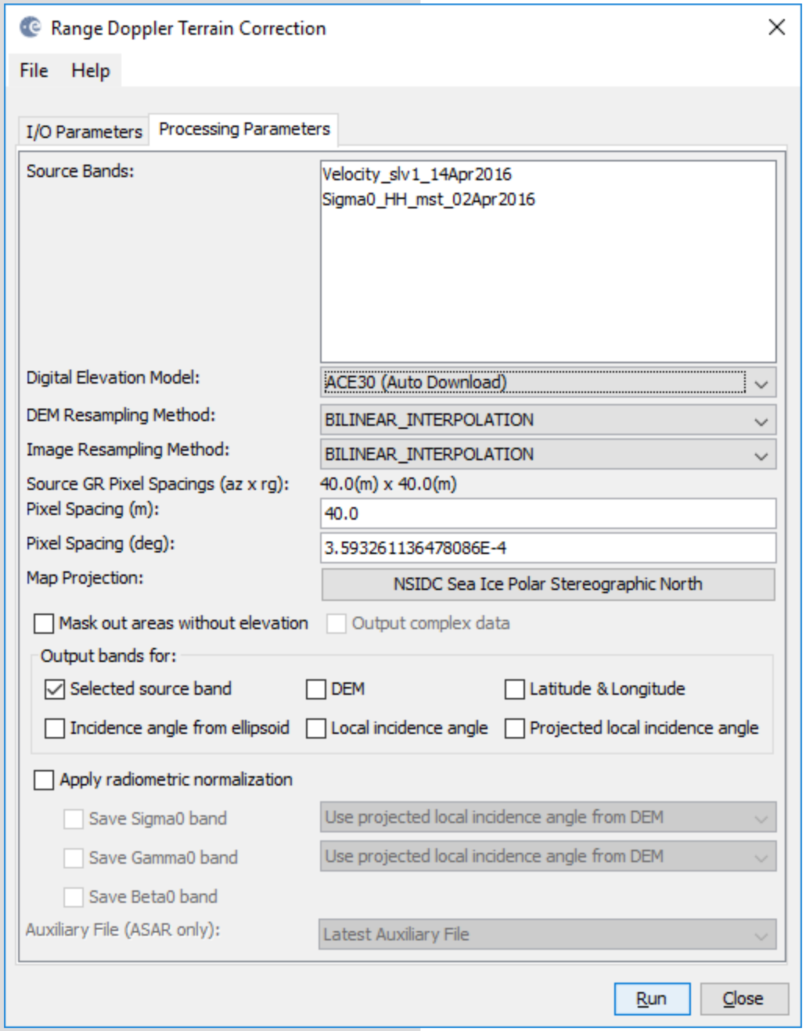
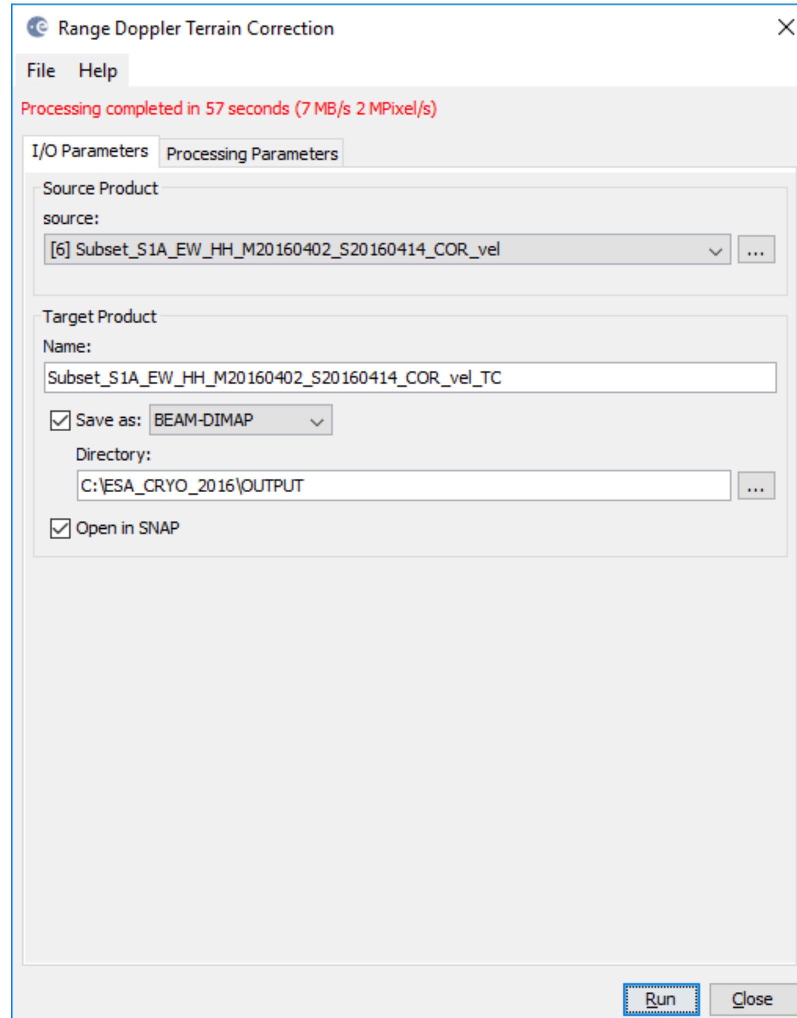
Step 3: Geocoding: RD Terrain Correction



Step 3: Geocoding: RD Terrain Correction





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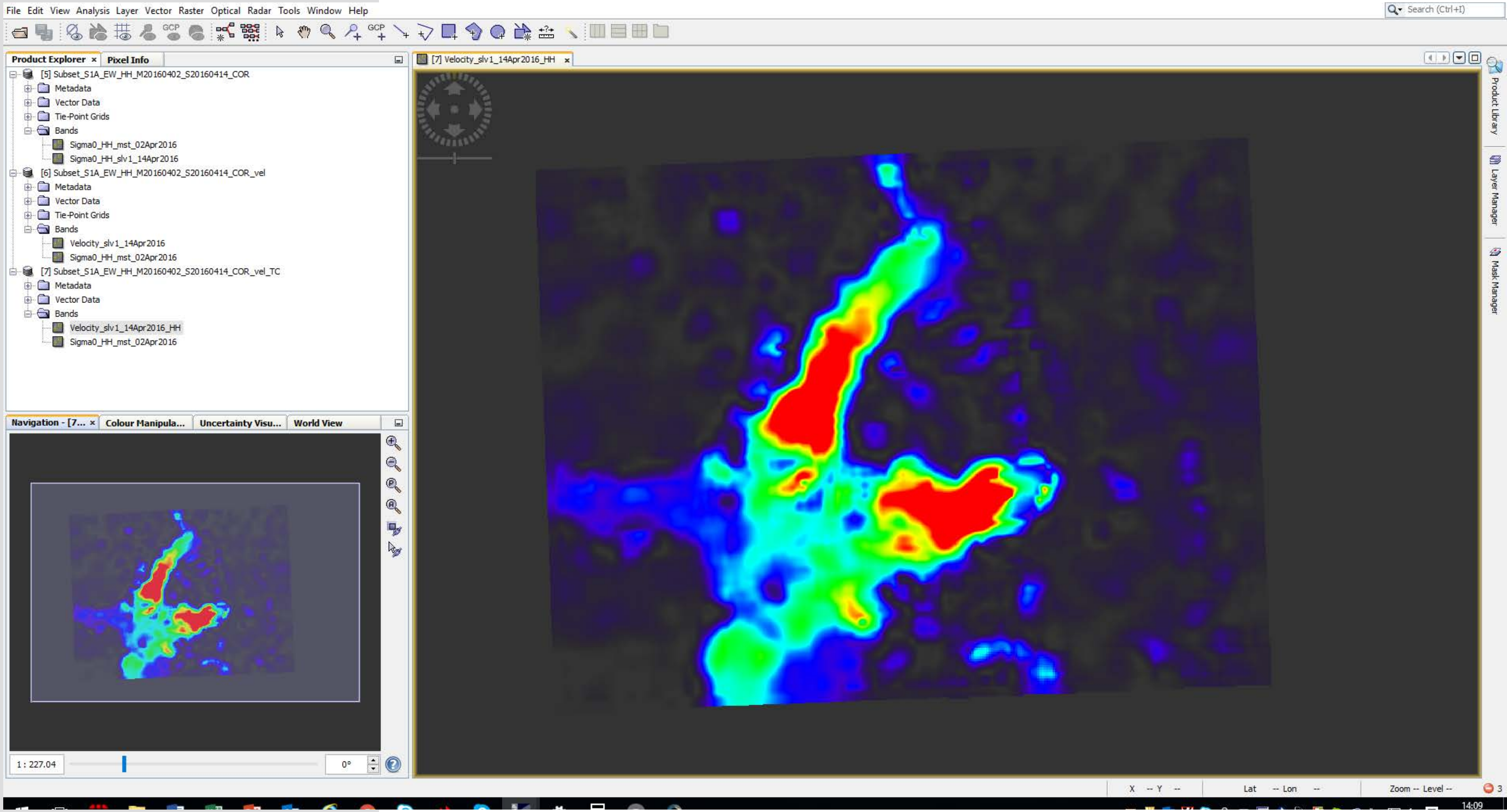
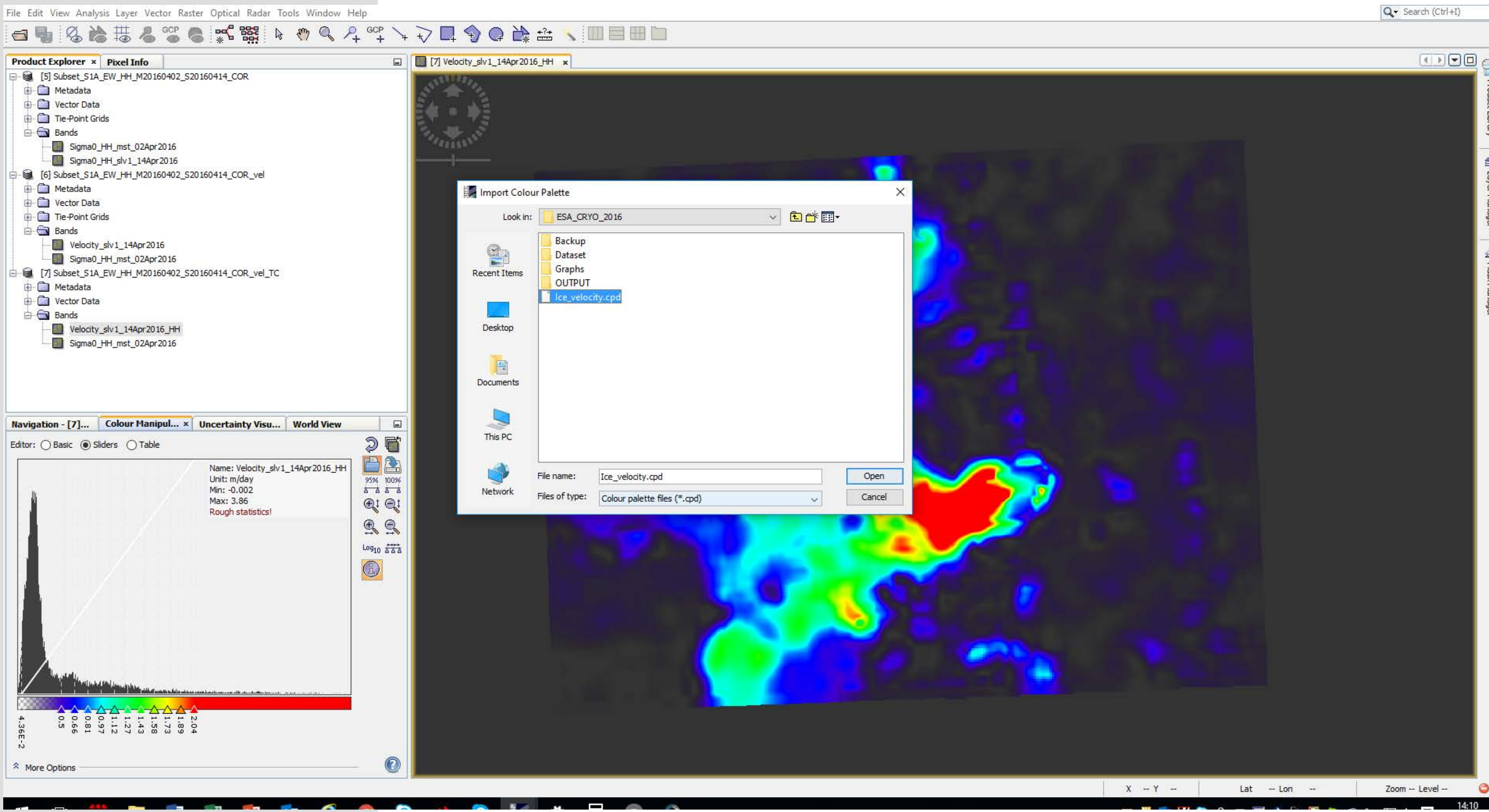
Step 3: Geocoding: RD Terrain Correction



Step 3: Geocoding: RD Terrain Correction

Q13. What is the purpose of geocoding an image?

Import a Colour Palette



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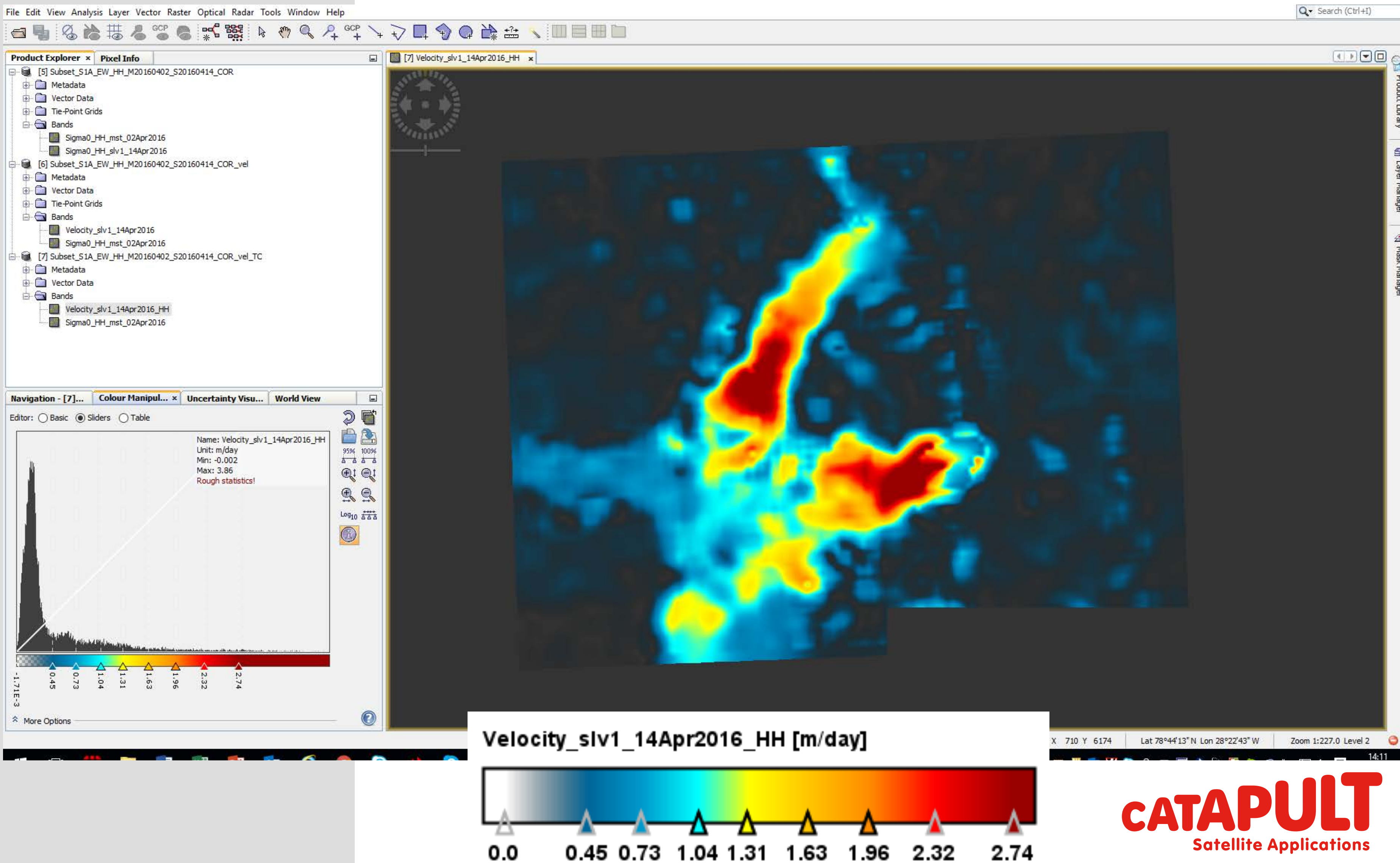
Import a Colour Palette



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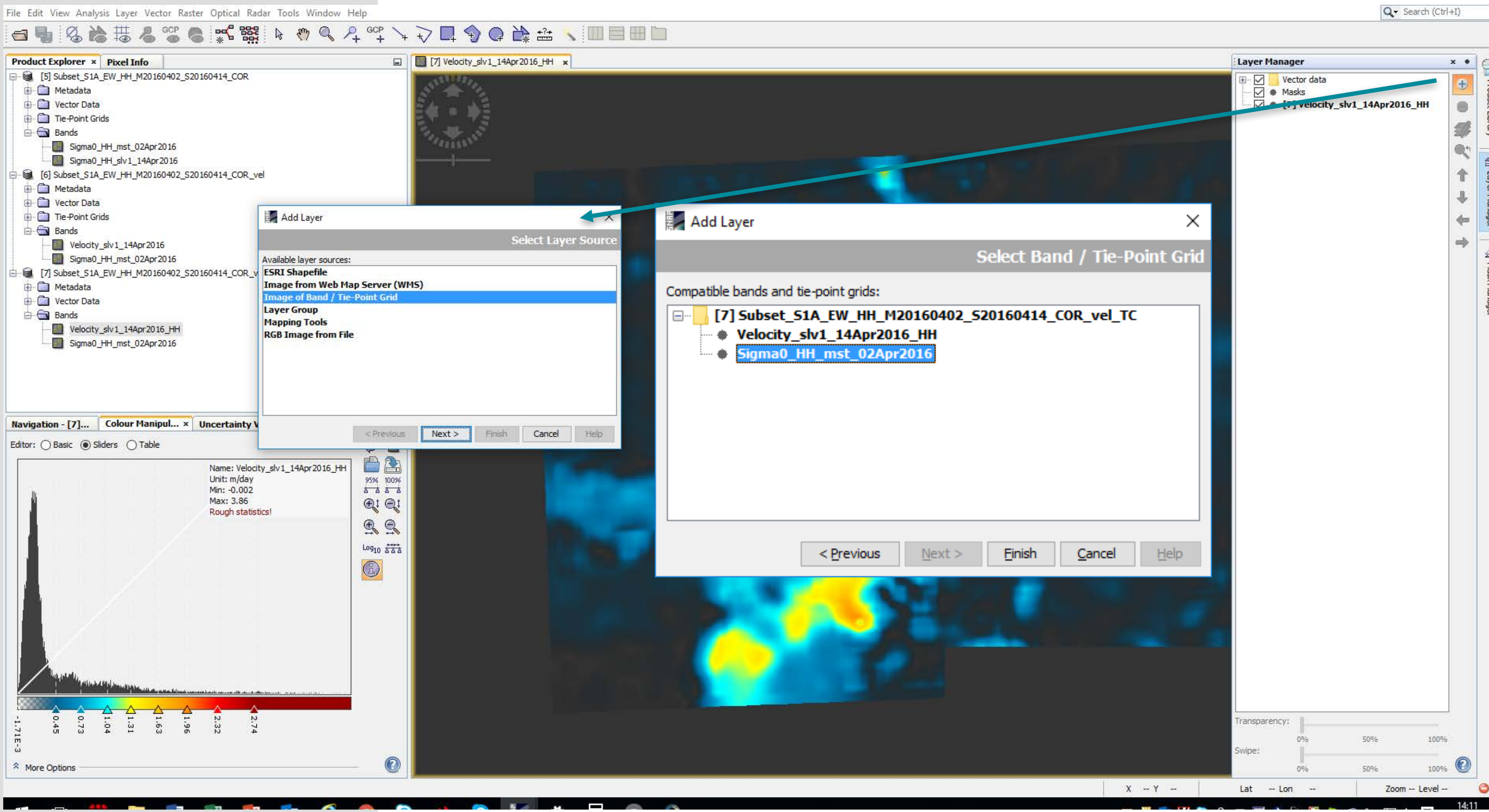
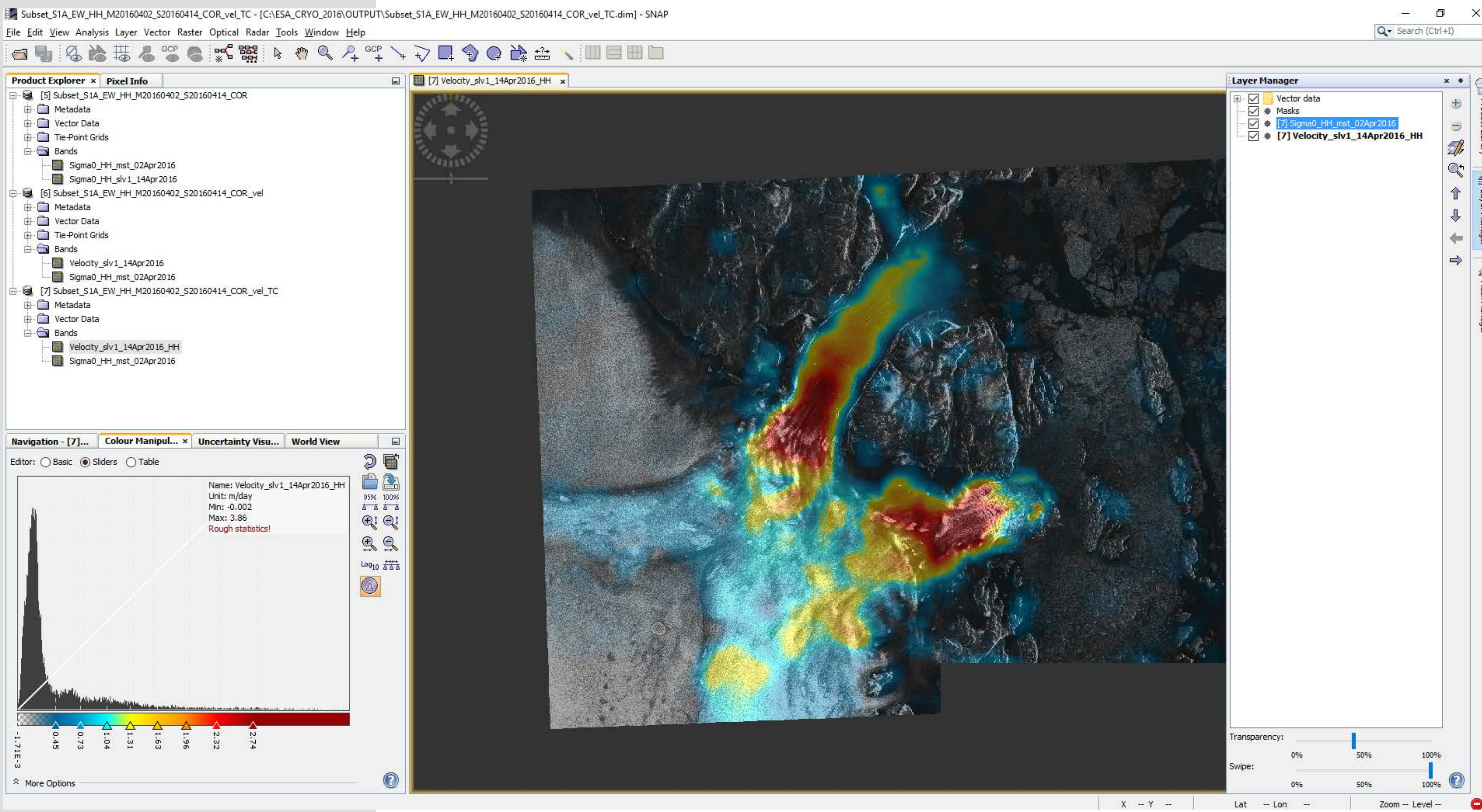
Overlay geocoded Sigma0 and Ice Velocity via the Layer Manager



Overlay geocoded Sigma0 and Ice Velocity via the Layer Manager



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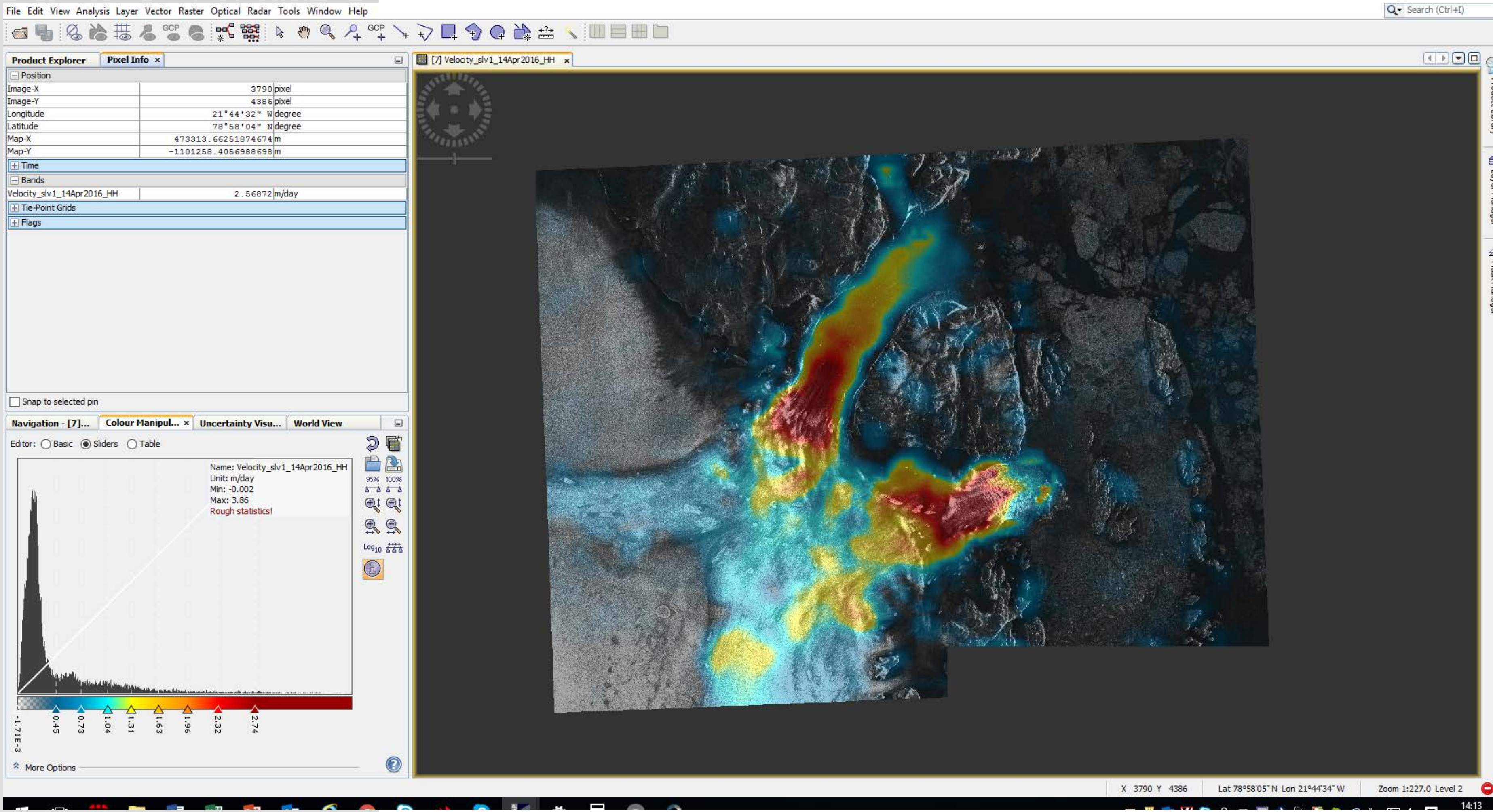
Looking at the Ice Velocity Values



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Comparison with ice velocity from CPOM NRT IV website

CPOM have build a Near Real Time (NRT) ice velocity monitoring service. Through this data portal, we distribute frequent maps of ice speed for 5 key outlet glaciers of the Antarctic and Greenland ice sheets, using SAR data acquired by the European Space Agency's Sentinel-1 satellite.

You can visit the website by following this link: http://www.cpom.ucl.ac.uk/csopr/iv/

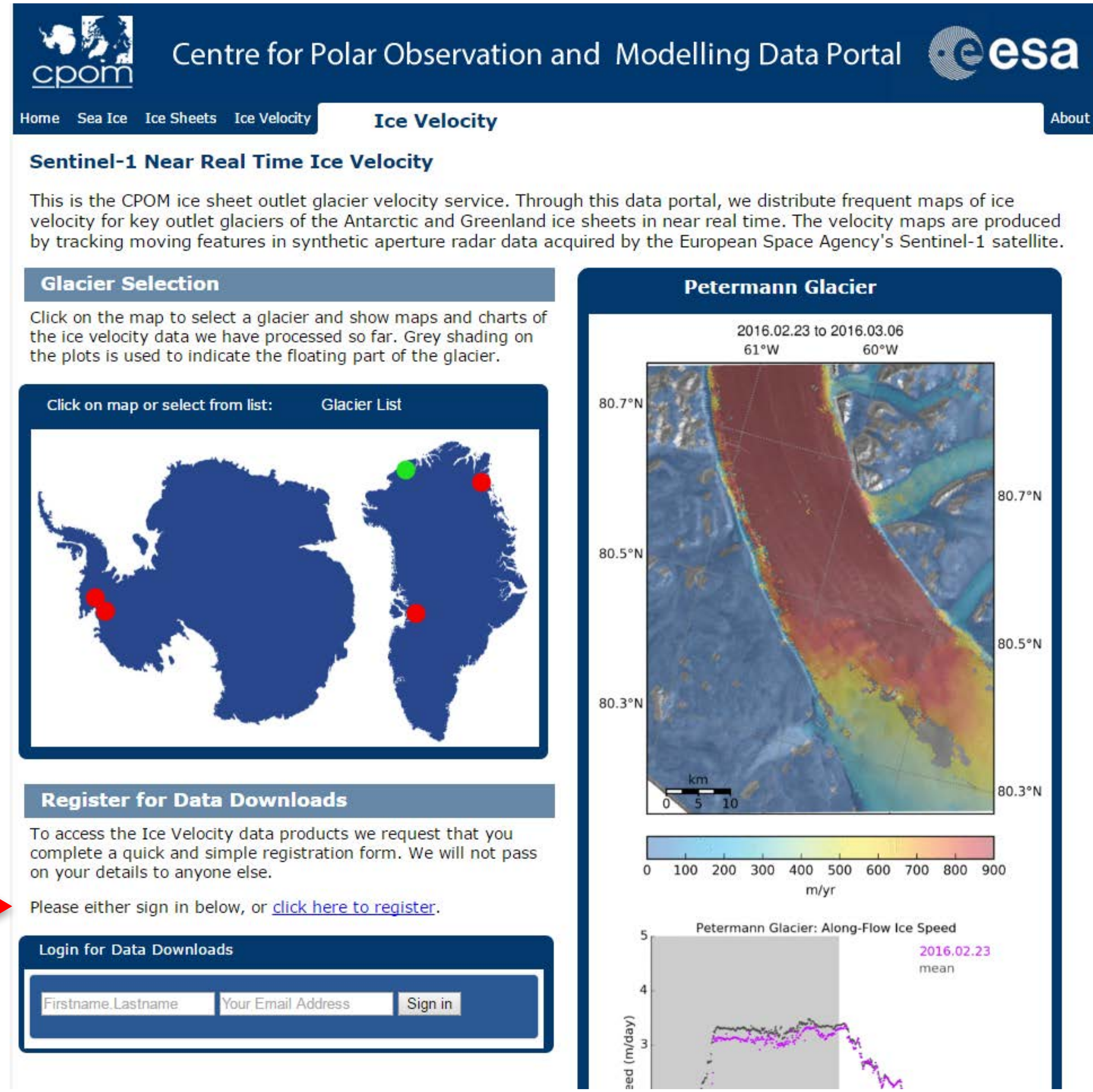
Q14. Which 5 glaciers does the CPOM IV data portal provide data for?

Comparison with ice velocity from CPOM NRT IV website

To make sure we are able to notify users of any improvements or issues with out data, we request that you complete a simple online registration form to gain access.

This gives you access to instantly download grids and transects of ice velocity data on all 5 ice streams.

Please register on the website in the area indicated below:



Comparison with ice velocity from CPOM NRT IV website

Once you have registered for the service, you are also able to make special requests for SAR data products not already provided on the CPOM NRT IV service.

Q15. Name 3 other glaciologically useful data products that could be produced from SAR data?

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CPOM SAR Facility Data Request Form

Requestor Information

Name*	
Email*	
Organisation*	
Contact Number*	

Dataset Information

Please supply as much information as possible about your requirements. We will aim to fulfil your request based on the data we have access to and will inform you if we cannot fulfil your request. Certain tasks may have a longer lead time as the facility expands its capability. Should this affect your request, we will inform you by email.

Area Of Interest, Name*	
Centre Lat, Lon*	
Approximate bounding box lat,lons. From top left, clockwise	
Period of Interest*	
Number of images	☐ Single image ☐ Time series Approx. temporal spacing ____________ ☐ Other
Satellite (if known)	
Data Type (select all that apply)	☐ Geocoded Amplitude Image ☐ Velocity Data (total magnitude only) ☐ Velocity Data (2D x and y velocity components)

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Comparison with ice velocity from CPOM NRT IV website

Navigate to the same image pair that you have just processed on the 79 fjorden ice stream, (otherwise known as Nioghalvfjerdsfjorden). Either use the website, or click on the link below to reach it directly:

http://www.cpom.ucl.ac.uk/csopr/iv/index.html?glacier_number=0&image_date=160402_160414#output

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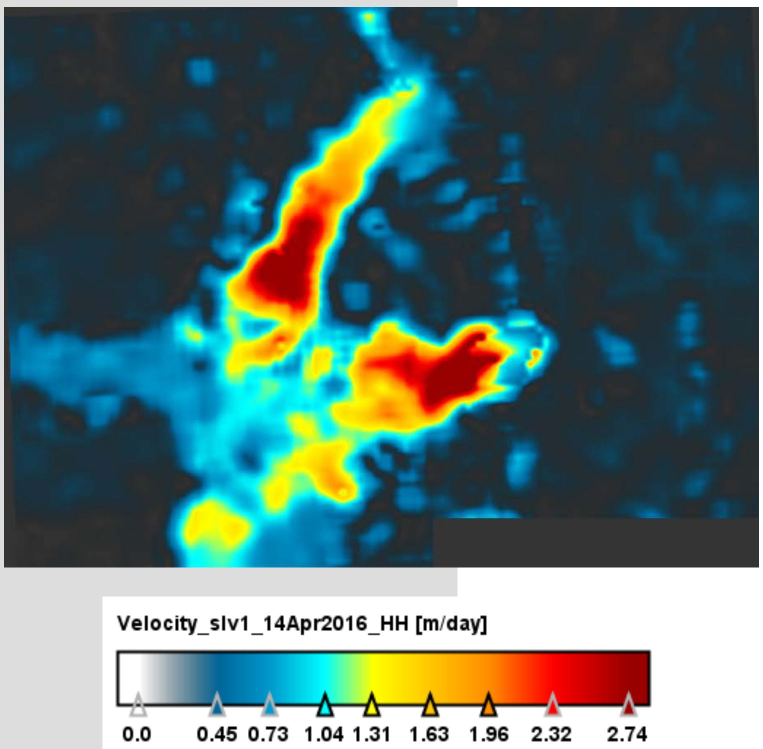
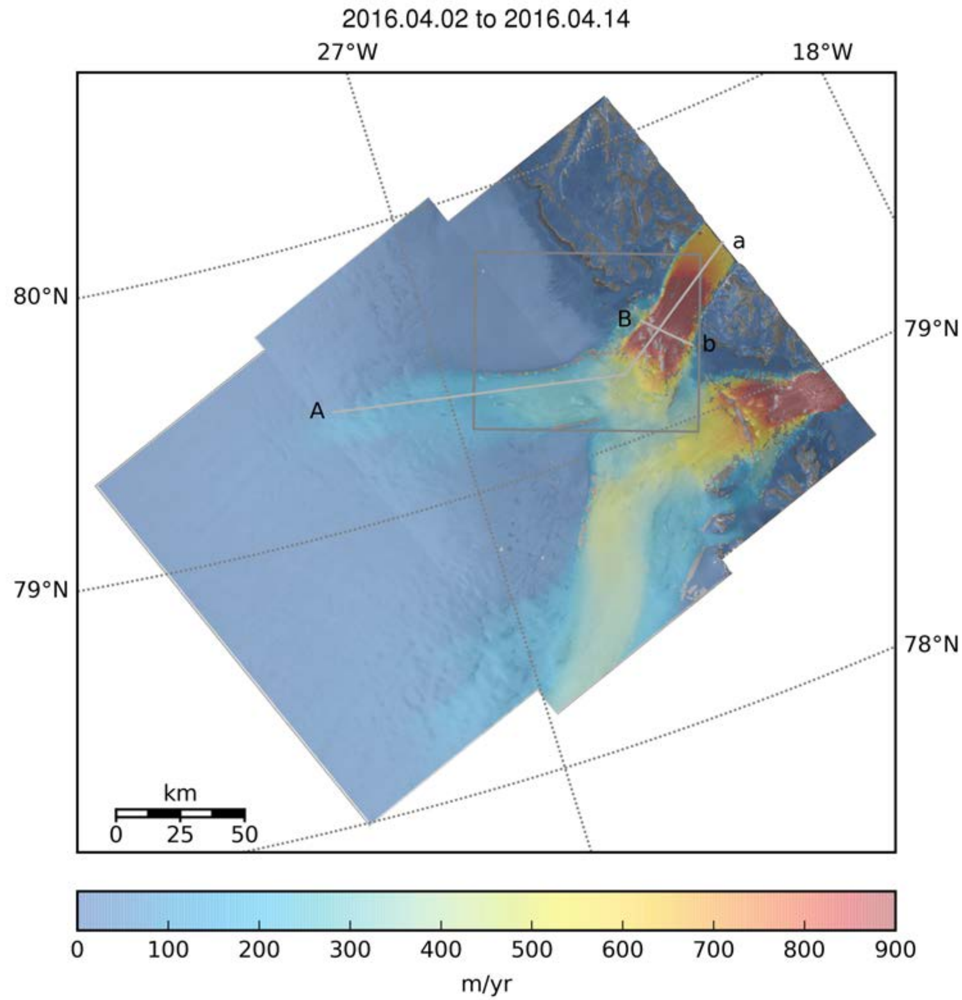
Comparison with ice velocity from CPOM NRT IV website

http://www.cpom.ucl.ac.uk/csopr/iv/index.html?glacier_number=0&image_date=160402_160414#output

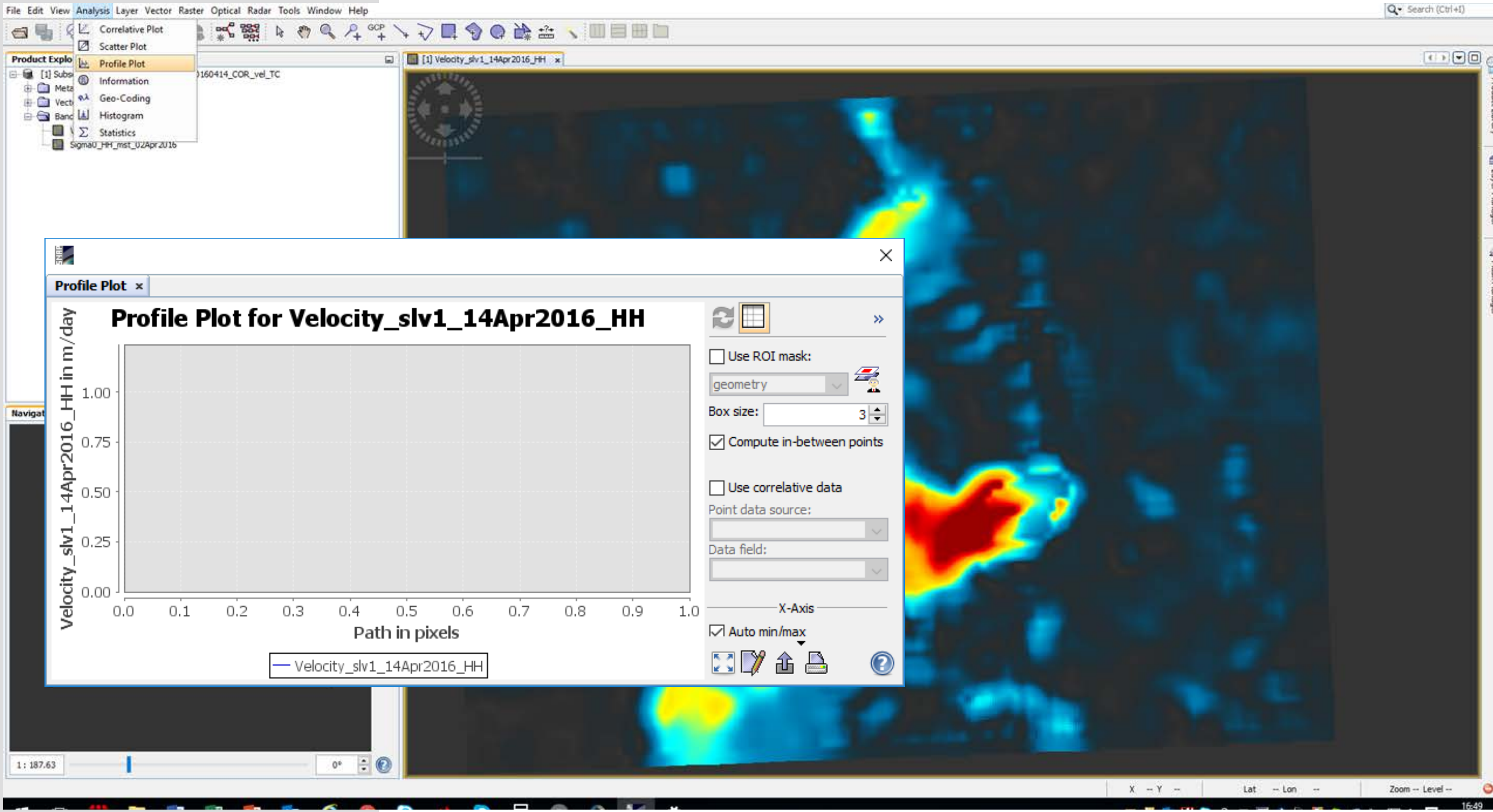




Comparison with ice velocity from CPOM NRT IV website

Q16. Briefly describe the differences you can see between the ice velocity measurements you have produced, and the ice velocity data produced from the same image pair on the CPOM NRT IV website (i.e. the two images on the previous slide)?
Q17. Suggest 2 reasons why these differences have occurred?

Transect A – Profile Plot



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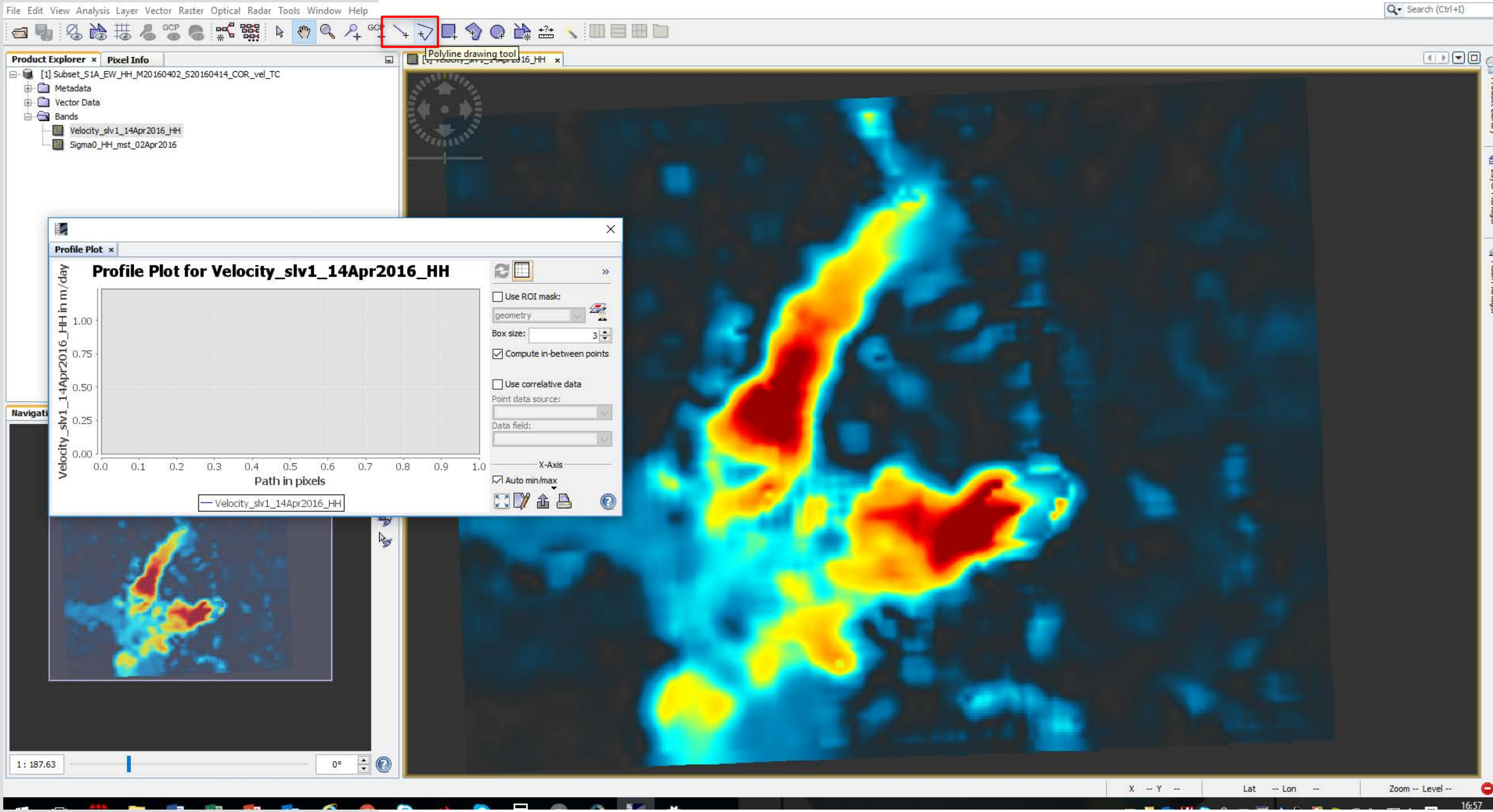
Transect A – Profile Plot



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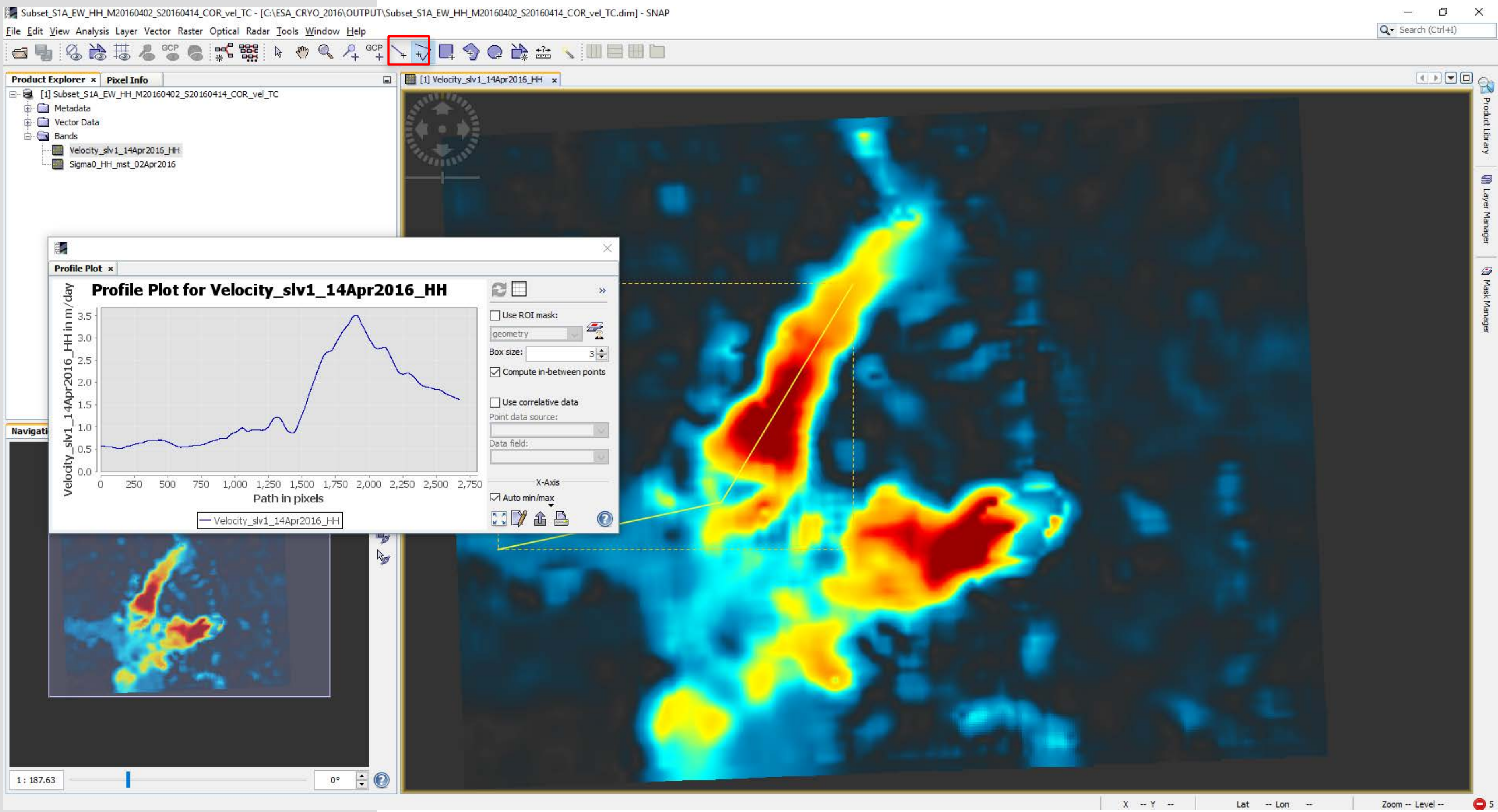
Transect A – Profile Plot



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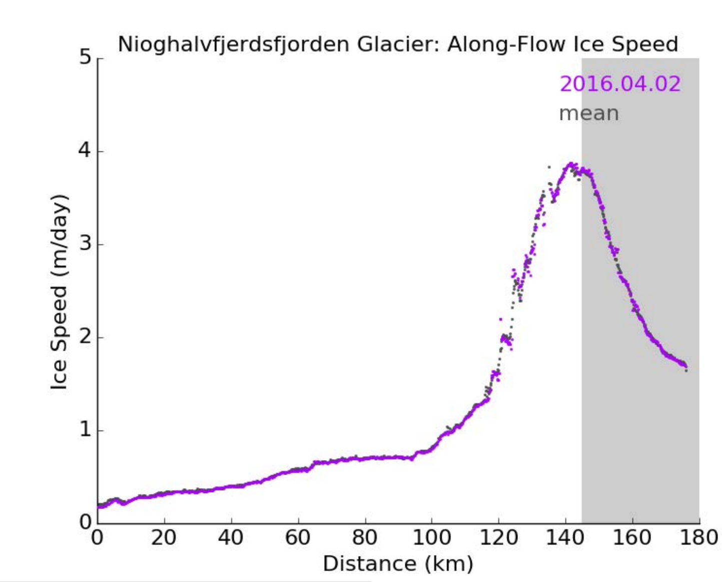
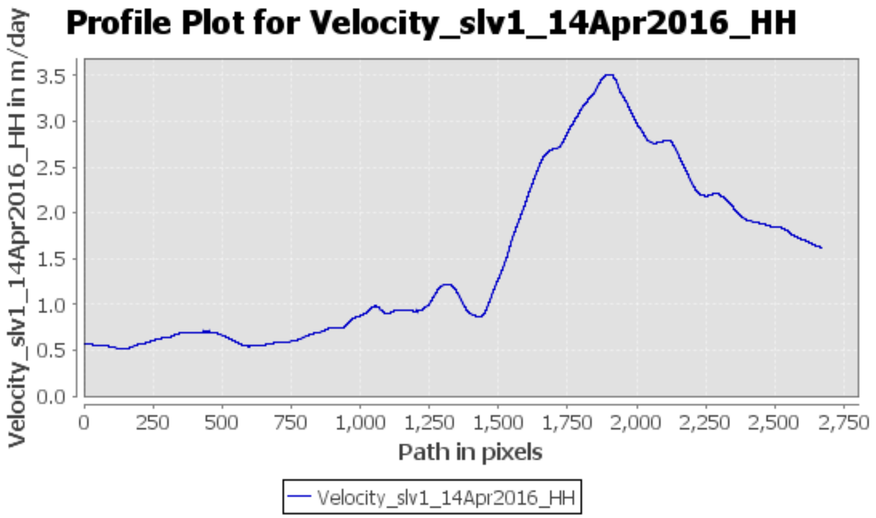
Comparison transect A

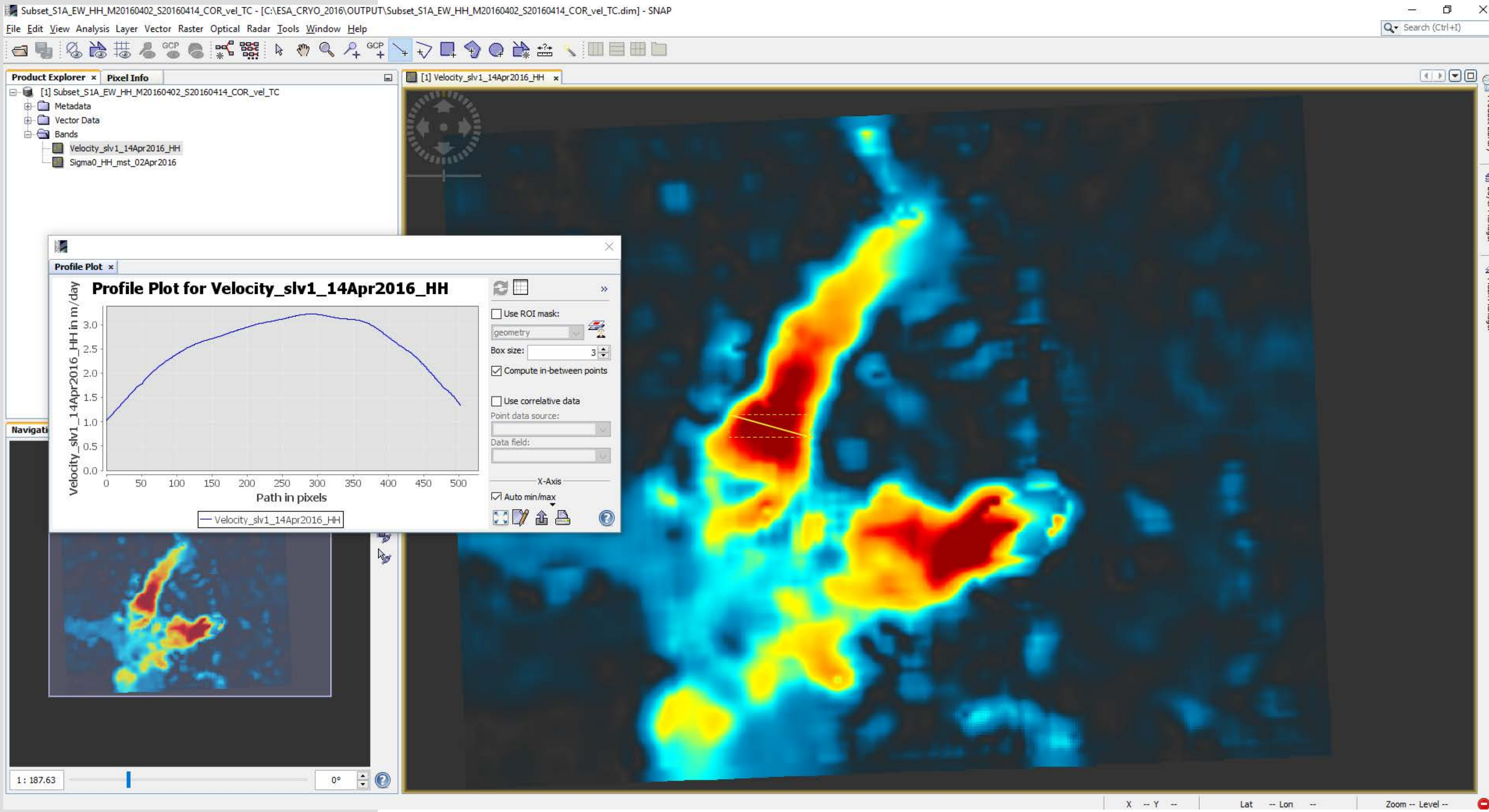




Comparison transect A

Q18. Do you think the ice velocity extracted along the two flow line transects looks the same? Which data product would you use and why?

Transect B


Subset_S1A_EW_HH_M20160402_S20160414_COR_vel_TC - [C:\ESA_CRYO_2016\OUTPUT\Subset_S1A_EW_HH_M20160402_S20160414_COR_vel_TC.dim] - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
[1] Subset_S1A_EW_HH_M20160402_S20160414_COR_vel_TC
Metadata
Vector Data
Bands
Velocity_slv1_14Apr2016_HH
Sigma0_HH_mst_02Apr2016
[1] Velocity_slv1_14Apr2016_HH
Profile Plot
Profile Plot for Velocity_slv1_14Apr2016_HH
Velocity_slv1_14Apr2016_HH in m/day
Path in pixels
Velocity_slv1_14Apr2016_HH
Use ROI mask:
Box size:
Compute in-between points
Use correlative data
Point data source:
Data field:
X-Axis
Auto min/max
1 : 187.63

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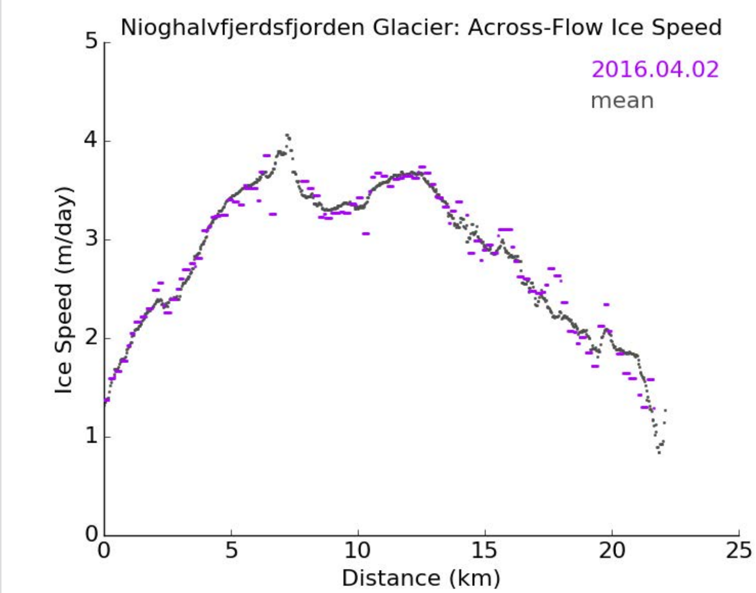
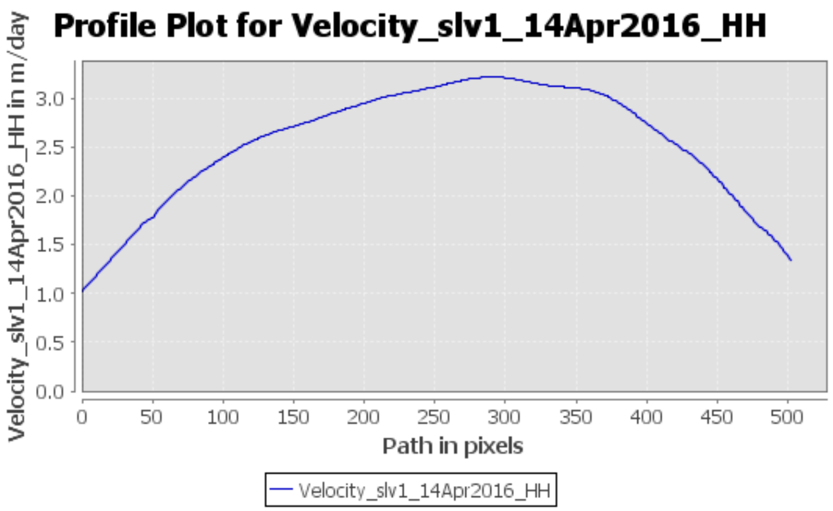
Comparison transect B





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Comparison transect B

Q19. What method of mass balance estimation are 'gate' ice velocity transects often used for, and where would the gate ideally be located?
Q20. If you were to download all the flow line transects for 79 fjorden (or look at them in the animation at the top of the CPOM NRT IV website, do you think there has been a long term change in ice speed over the sentinel-1 period of operation?

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