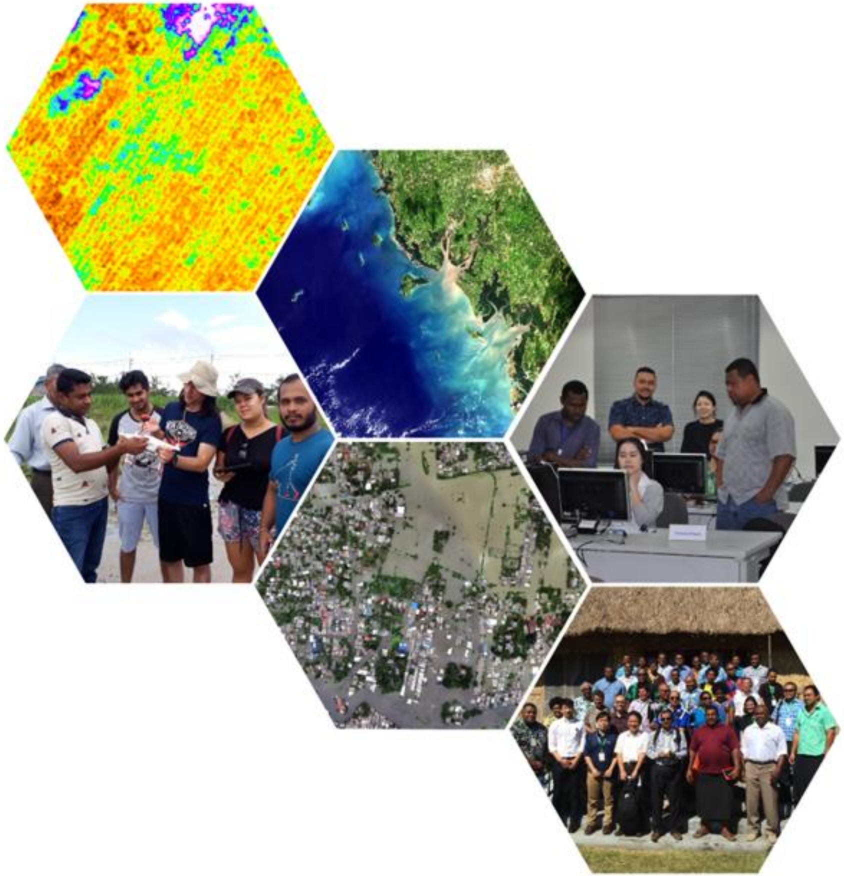


Damage assessment using SAR data (coherence changes)

Geoinformatics Center - AIT

Overview

Coherence change is a crucial parameter for post-disaster assessment and land surface monitoring, especially when using high-resolution L-band SAR data. It allows for the detection of structural damage, land disturbances, and human-induced changes over time.

Two main SAR-based approaches are commonly used for surface change analysis:

1) SAR interferometry (InSAR) to measure surface deformation;
2) Coherence change detection, which compares the similarity of radar backscatter signals between pre- and post-event acquisitions.

In this tutorial, we will apply the coherence change detection method using ALOS-2 PALSAR-2 data.

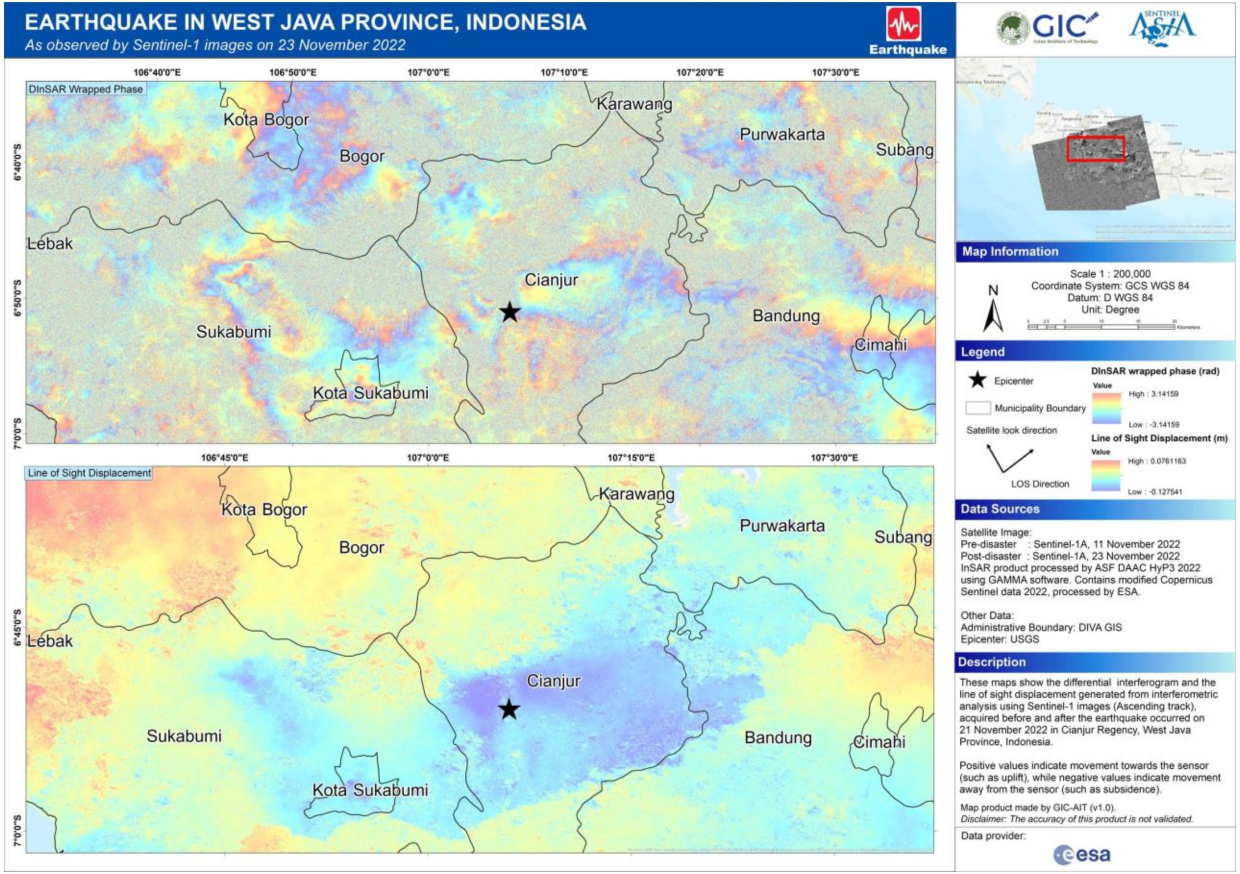
Overview

In this exercise, you will work with SNAP software to analyze coherence change from a pair of ALOS-2 PALSAR-2 data. QGIS will also be used to calculate and visualize the output.

Data:

- ALOS-2 PALSAR-2 on 10 October 2022: ALOS2452677050-221010
- ALOS-2 PALSAR-2 on 7 November 2022 : ALOS2456817050-221107
- ALOS-2 PALSAR-2 on 21 November 2022 : ALOS2458887050-221121

Overview



Sentinel Asia activation:

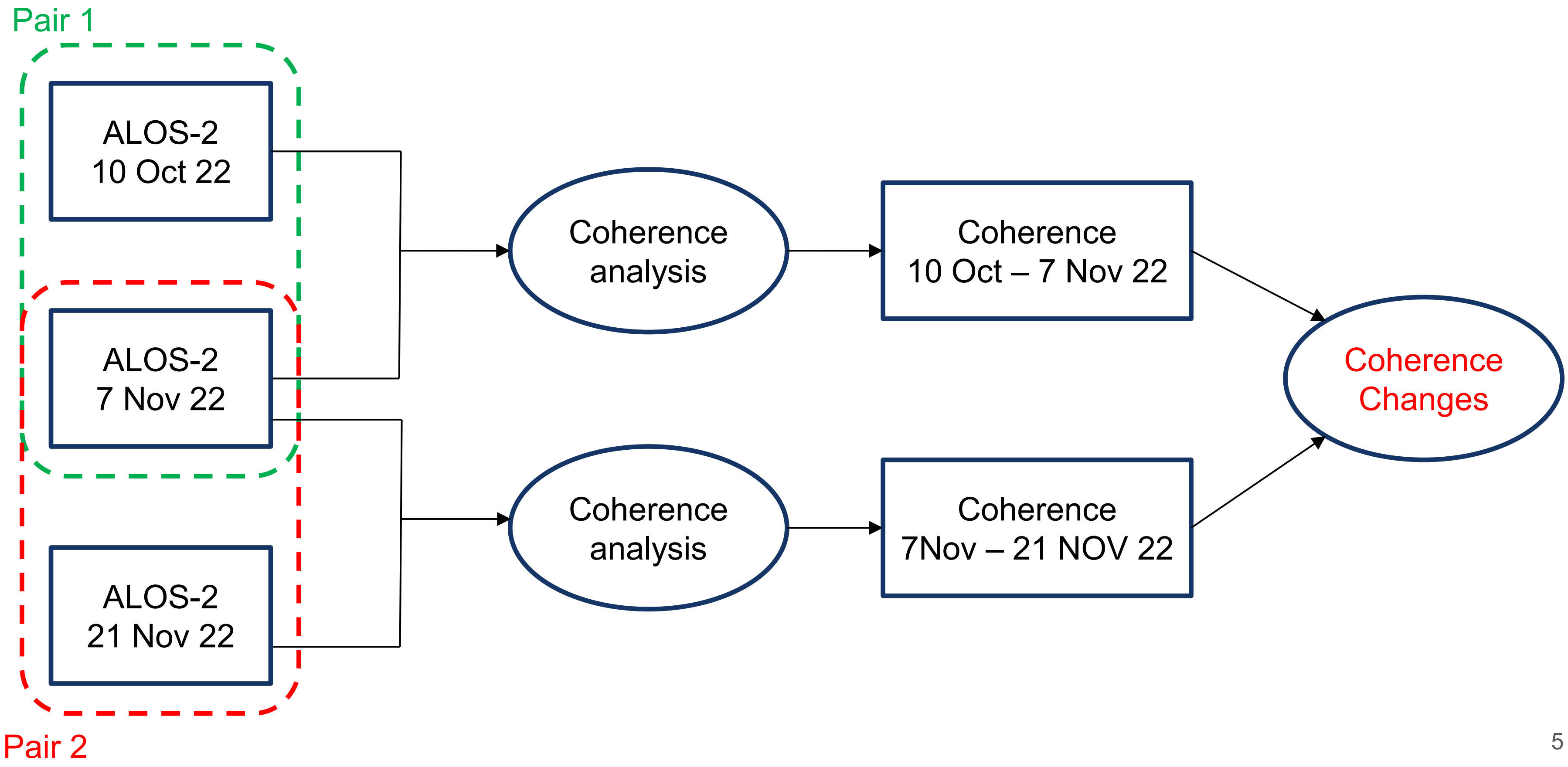
Earthquake in Indonesia

- Occurrence Date (UTC): 21 November, 2022
- SA activation Date(UTC): 22 November, 2022
- Requester: National Research and Innovation Agency (BRIN)

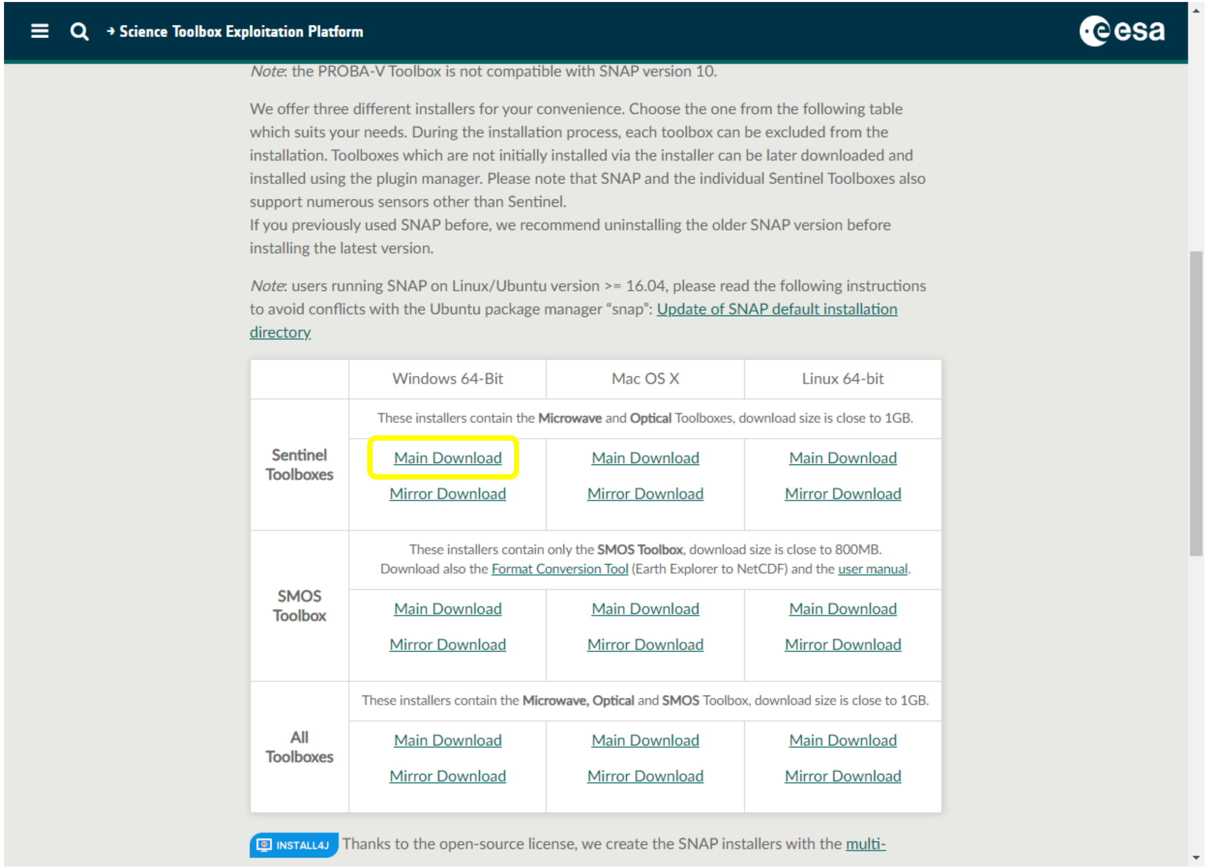
Overview

Earthquake in Indonesia

- Occurrence Date (UTC): 21 November, 2022



1. Install SNAP Software



Science Toolbox Exploitation Platform

esa

Note: the PROBA-V Toolbox is not compatible with SNAP version 10.

We offer three different installers for your convenience. Choose the one from the following table which suits your needs. During the installation process, each toolbox can be excluded from the installation. Toolboxes which are not initially installed via the installer can be later downloaded and installed using the plugin manager. Please note that SNAP and the individual Sentinel Toolboxes also support numerous sensors other than Sentinel.
If you previously used SNAP before, we recommend uninstalling the older SNAP version before installing the latest version.

Note: users running SNAP on Linux/Ubuntu version >= 16.04, please read the following instructions to avoid conflicts with the Ubuntu package manager "snap": Update of SNAP default installation directory

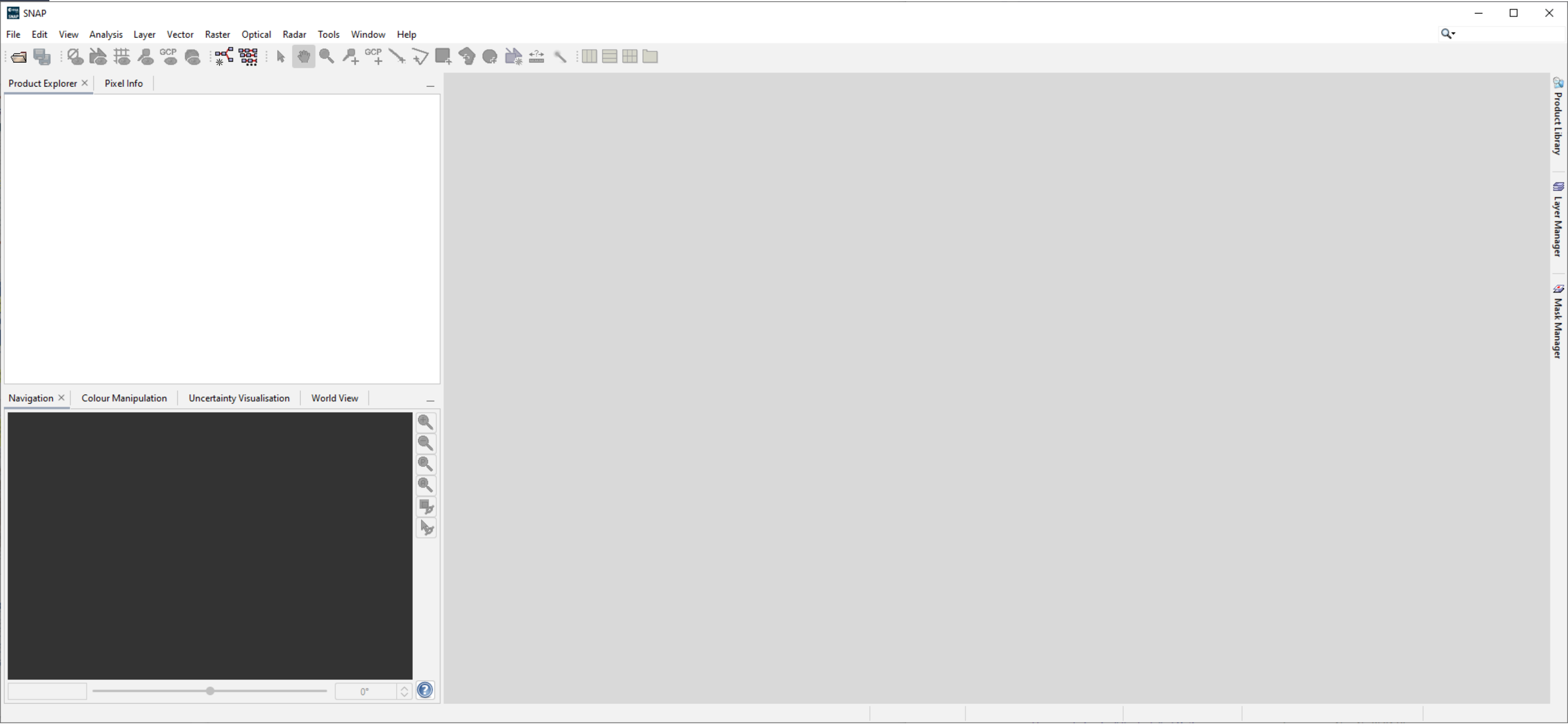
	Windows 64-Bit	Mac OS X	Linux 64-bit
Sentinel Toolboxes	These installers contain the **Microwave** and **Optical** Toolboxes, download size is close to 1GB.		
	Main Download Mirror Download	Main Download Mirror Download	Main Download Mirror Download
SMOS Toolbox	These installers contain only the **SMOS Toolbox**, download size is close to 800MB. Download also the Format Conversion Tool (Earth Explorer to NetCDF) and the user manual.		
	Main Download Mirror Download	Main Download Mirror Download	Main Download Mirror Download
All Toolboxes	These installers contain the **Microwave, Optical** and **SMOS** Toolbox, download size is close to 1GB.		
	Main Download Mirror Download	Main Download Mirror Download	Main Download Mirror Download

INSTALL4J Thanks to the open-source license, we create the SNAP installers with the multi-

https://step.esa.int/main/download/snap-download/

- Download the latest SNAP software from ESA. SNAP supports installers for Windows 64-bit, Mac OS X, and Linux 64-bit. **Note**: We've downloaded the installer for Windows 64-bit in the training folder.
- Install the software. Use the default configuration.
- Once the installation is finished, update all suggested plugins.

2. Open SNAP Software

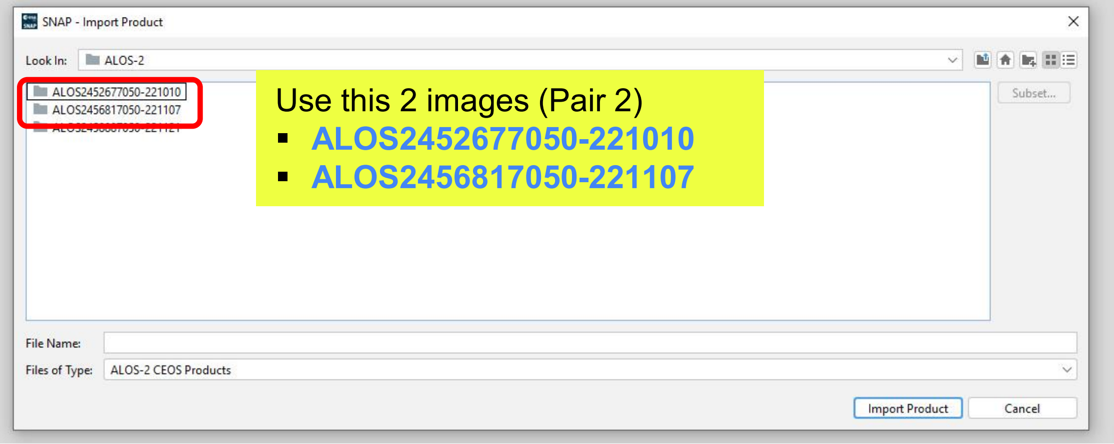


Processing Pair 1: 10 October 2022 and 7 November 2022

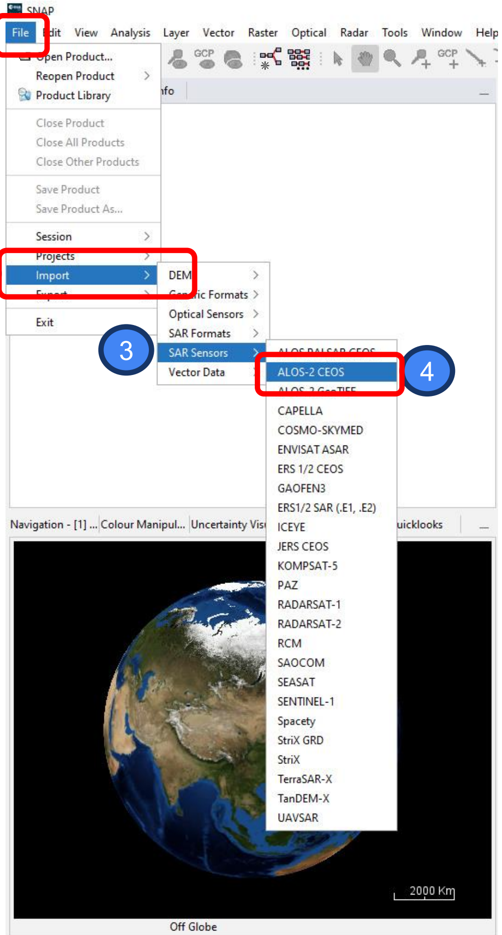
- ALOS-2 PALSAR-2 on 10 October 2022: ALOS2452677050-221010
- ALOS-2 PALSAR-2 on 7 November 2022 : ALOS2456817050-221107

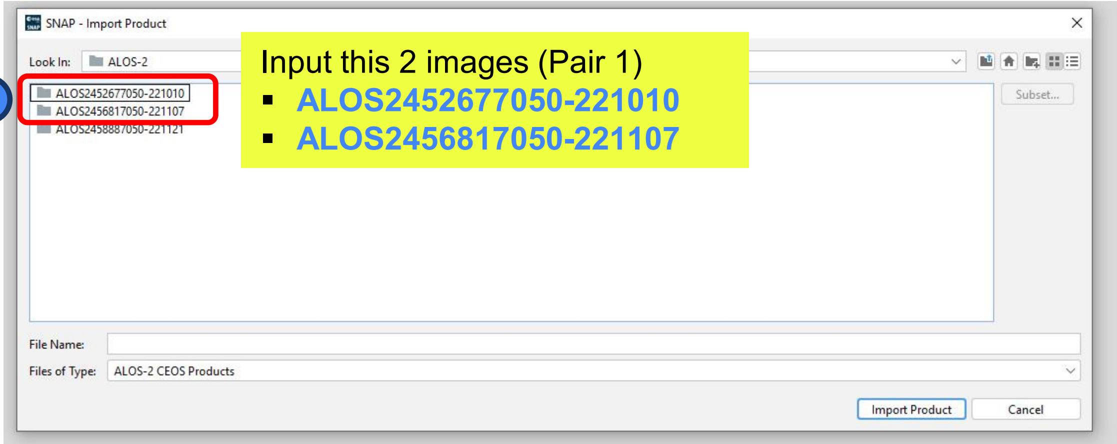
Pair 1

- ALOS-2 PALSAR-2 on 21 November 2022 : ALOS2458887050-221121

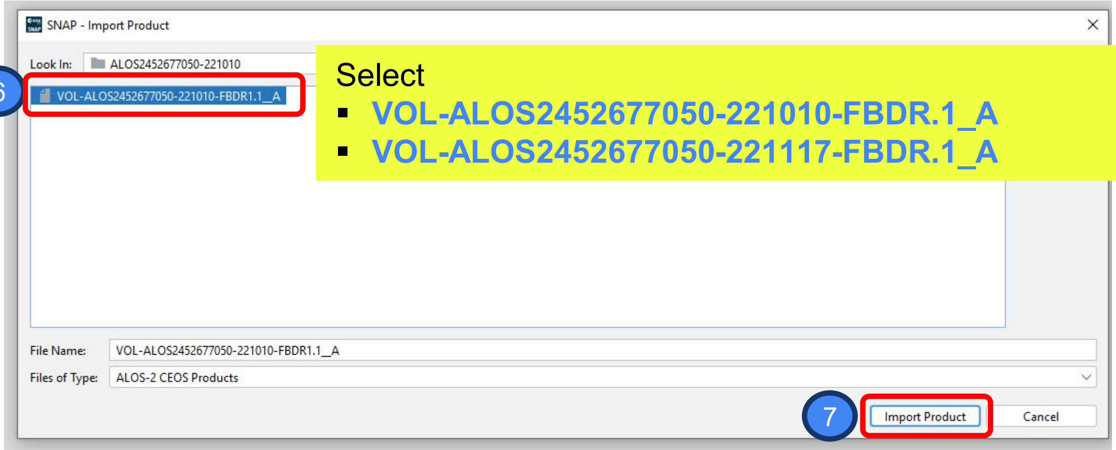


3. Import ALOS-2 Data in SNAP



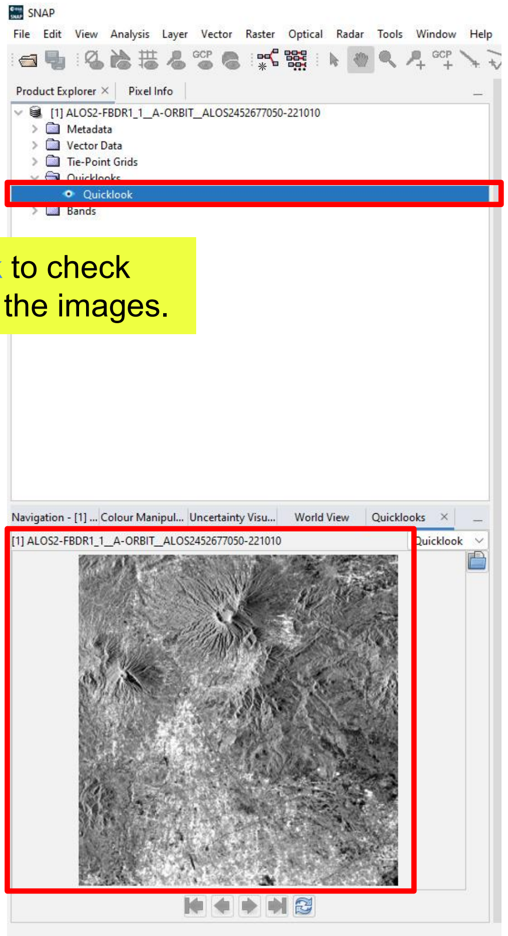


Input this 2 images (Pair 1)
- **ALOS2452677050-221010**
- **ALOS2456817050-221107**

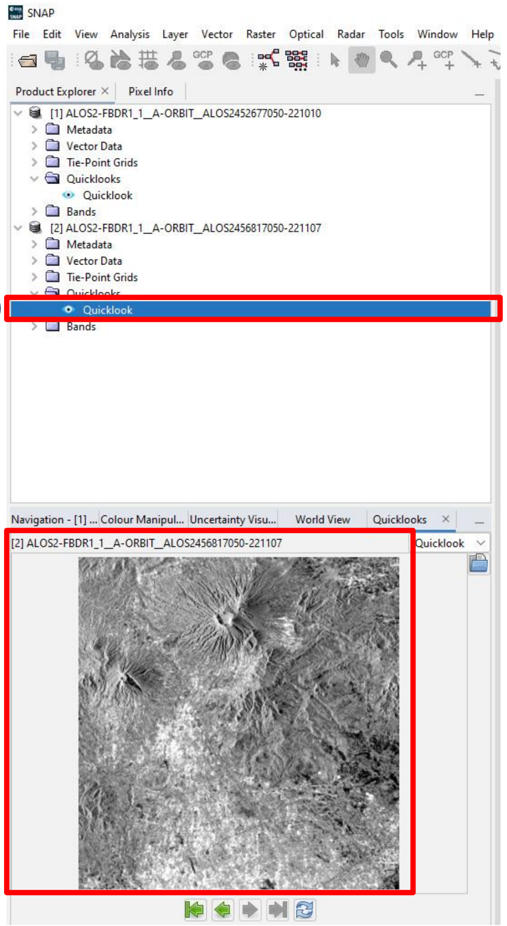


Select
- **VOL-ALOS2452677050-221010-FBDR.1_A**
- **VOL-ALOS2452677050-221117-FBDR.1_A**

4. Check the location of ALOS-2 Data

1


Use Quicklook to check the location of the images.

2


Coregistration

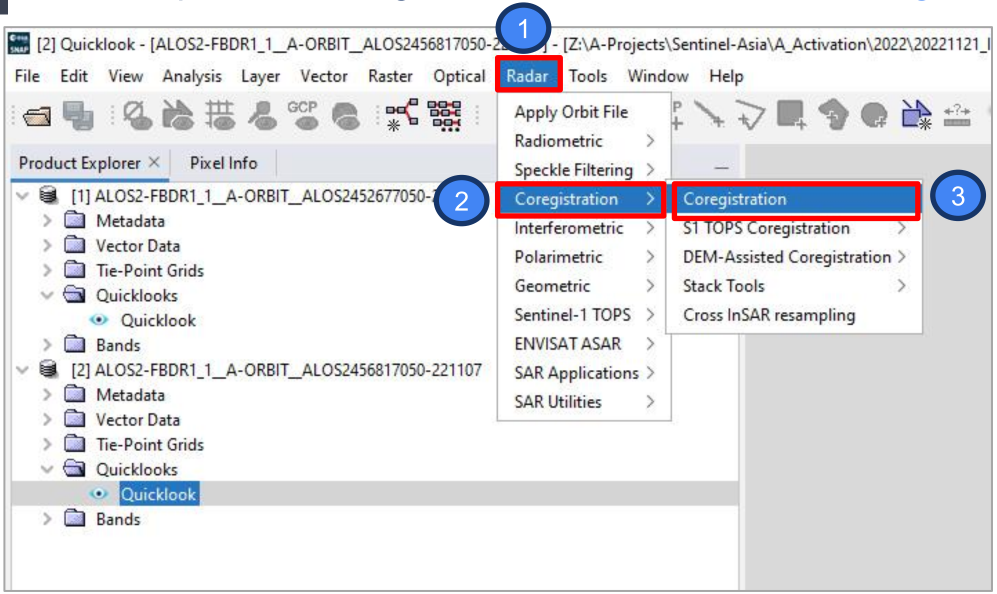
Ensures pixel-to-pixel alignment between image pairs so that coherence is computed between corresponding ground points.

If images are not coregistered, pixel comparison will be spatially incorrect, leading to faulty coherence values.

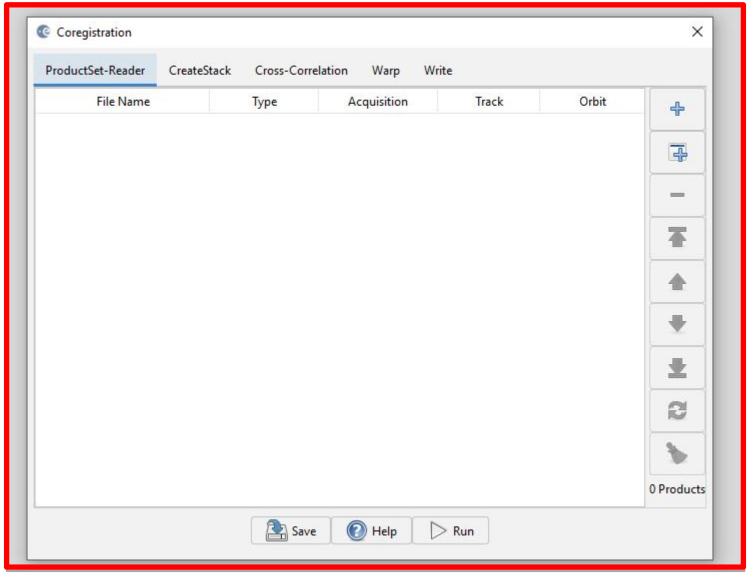
Pairwise alignment allows for analyzing change at specific intervals.

5. Coregistration

- Open the Coregistration window Radar > Coregistration > Coregistration

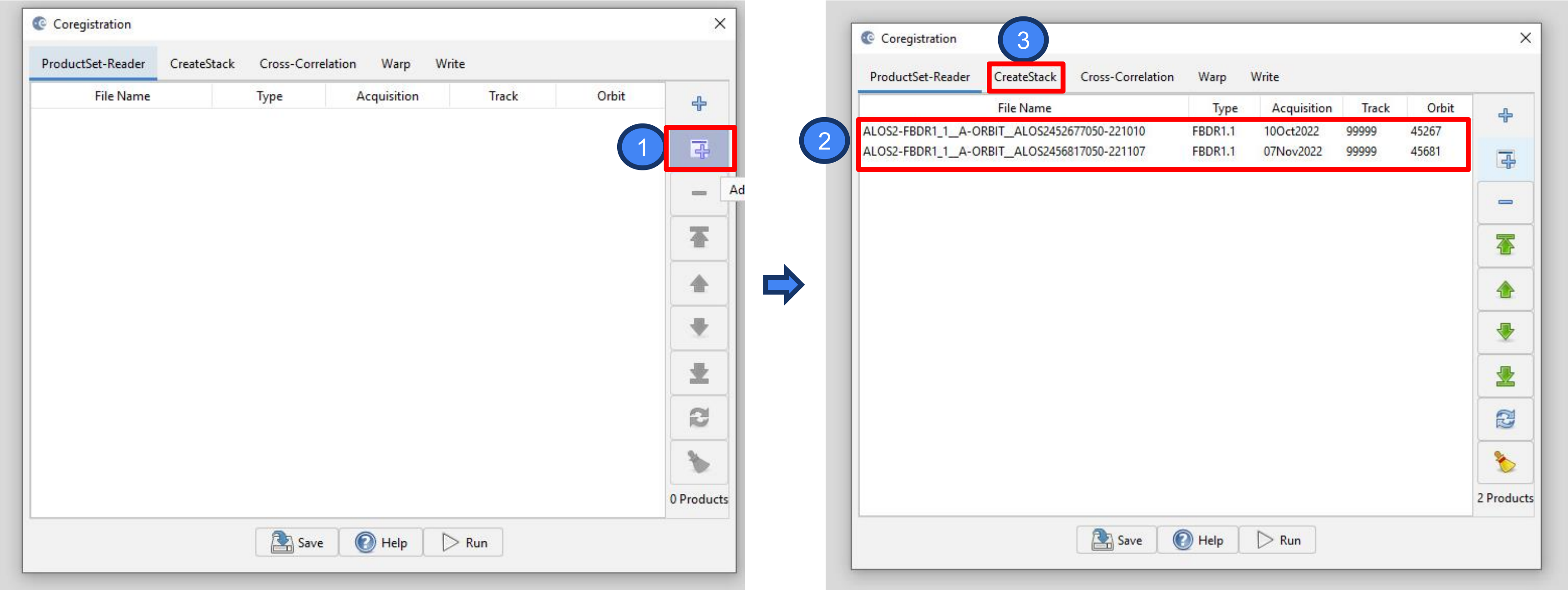


Coregistration window



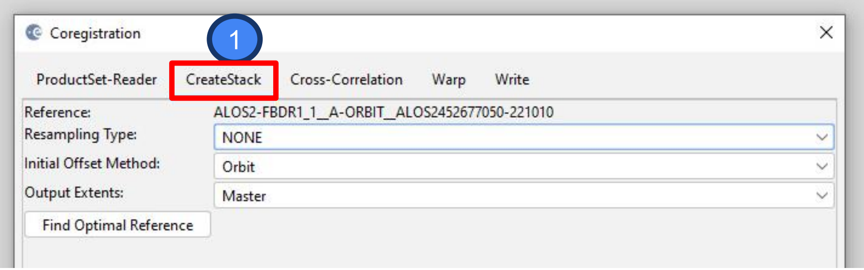
5. Coregistration

➤ Input the data ALOS2452677050-221010 and ALOS2456817050-221107

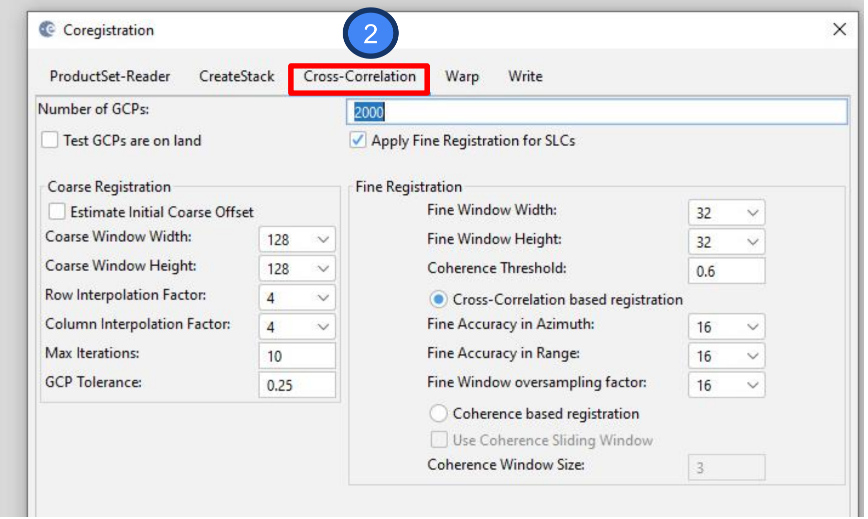


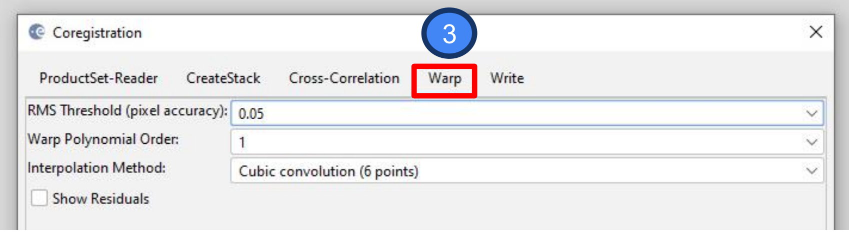
5. Coregistration

➢ Setting Up CreateStack, Cross-Correlation, and Warping



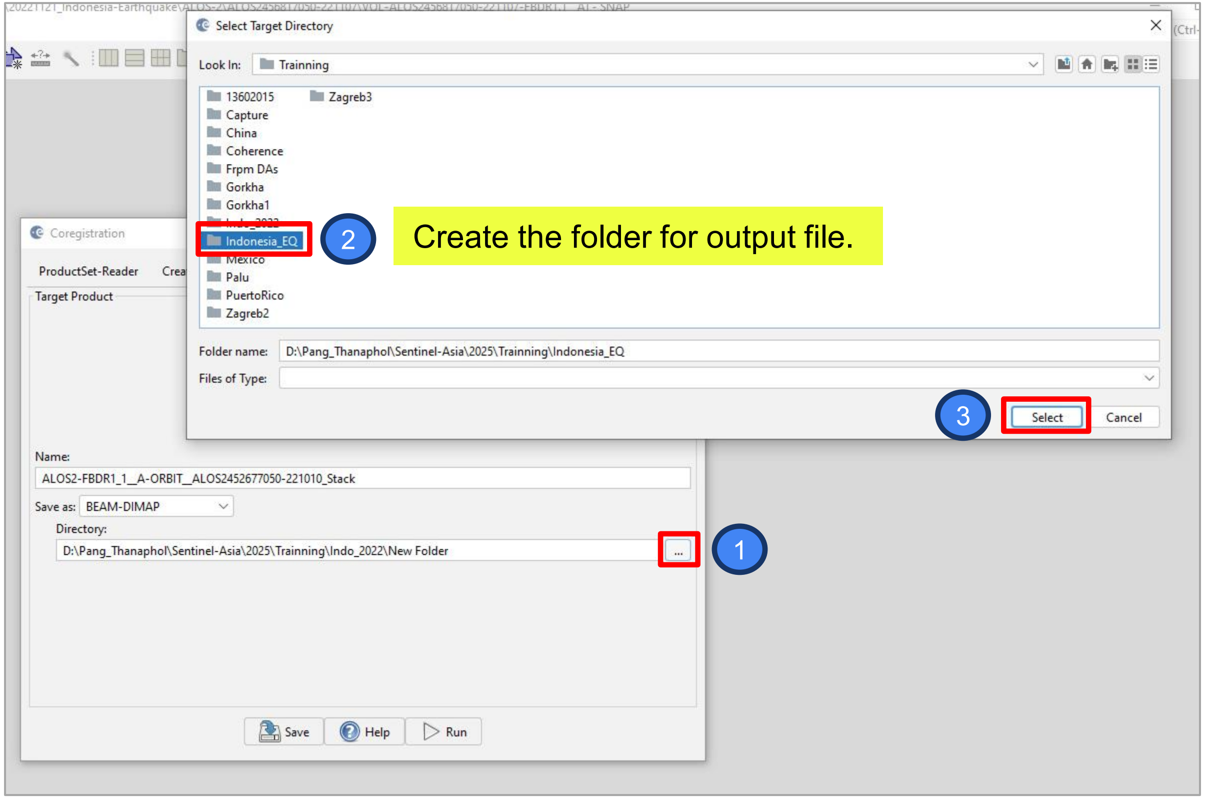
Use the default settings provided by the program.





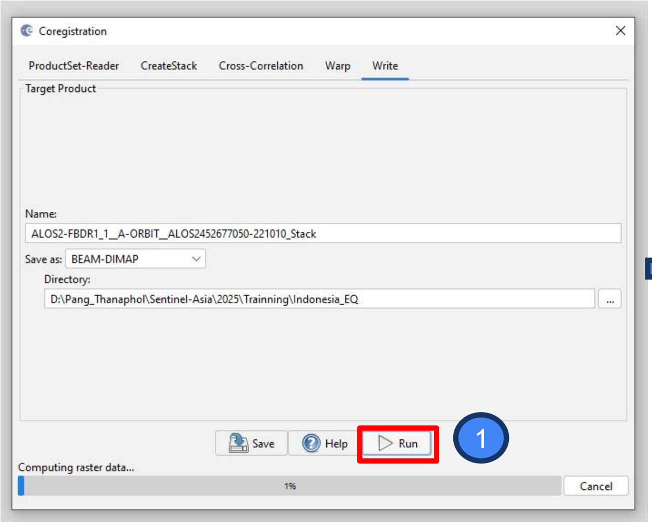
5. Coregistration

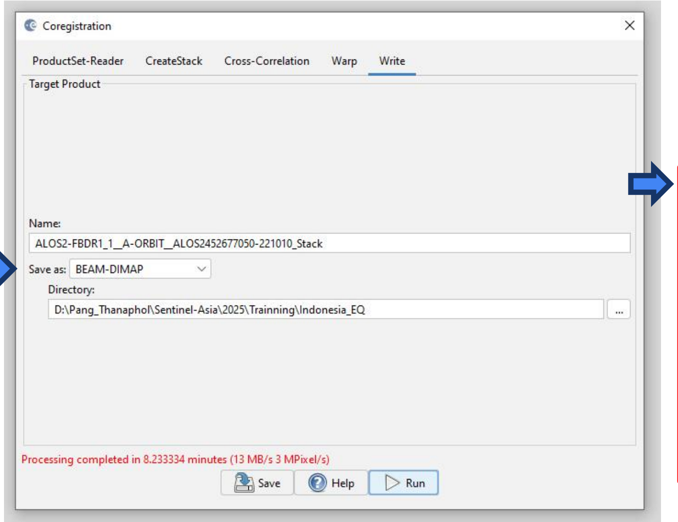
- Set the destination folder for output files.

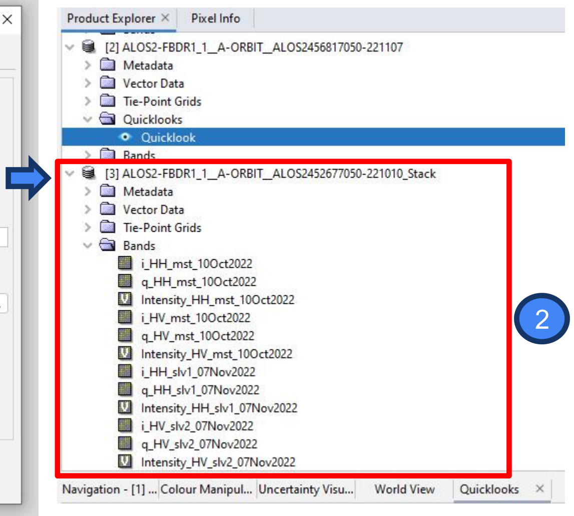


5. Coregistration

➢ Run







Click Run, It take time about 8 minutes

The results for Coregistration

Coherence Estimation

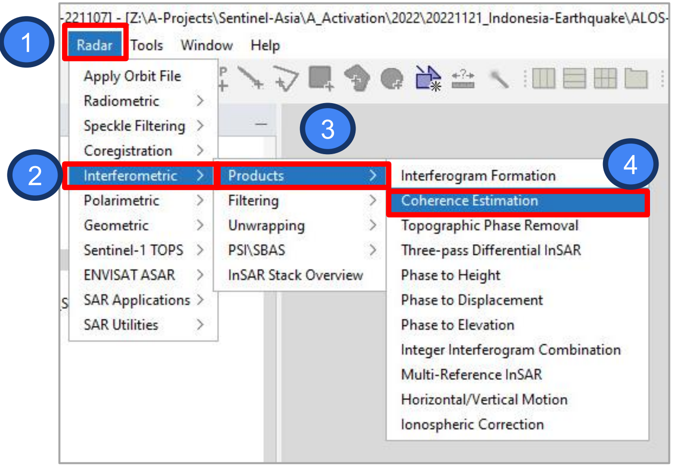
Interferometric Coherence measures how well radar signal phases match between two images, ranging from 0 (no correlation) to 1 (perfect correlation).

High coherence (~0.8–1.0) indicates stable surfaces with little or no change, meaning buildings and ground structures remain intact.

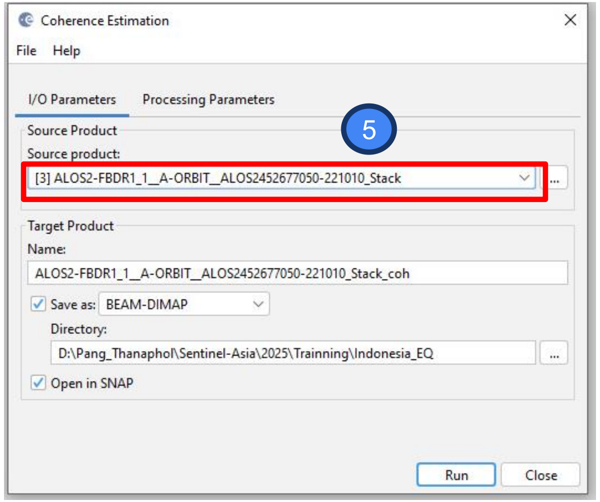
Low coherence (<0.5) signals surface changes such as building collapse, landslides, cracked roads, or disturbed vegetation, making it crucial for earthquake damage detection.

6. Coherence Estimation

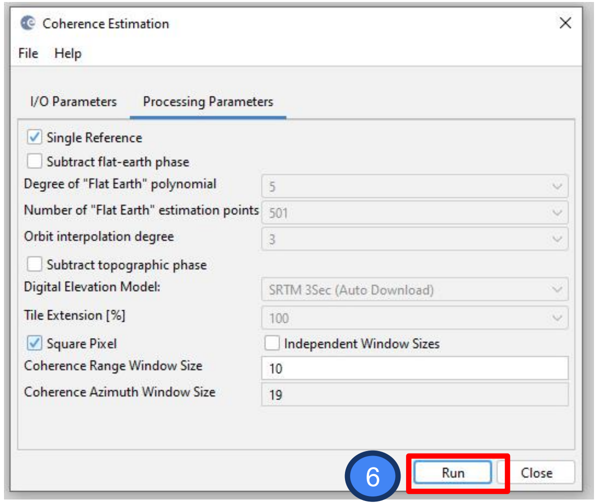
➢ Input Stacked File and Set Up Coherence Processing



Go to Radar > Interferometric > Products>Coherence Estimation



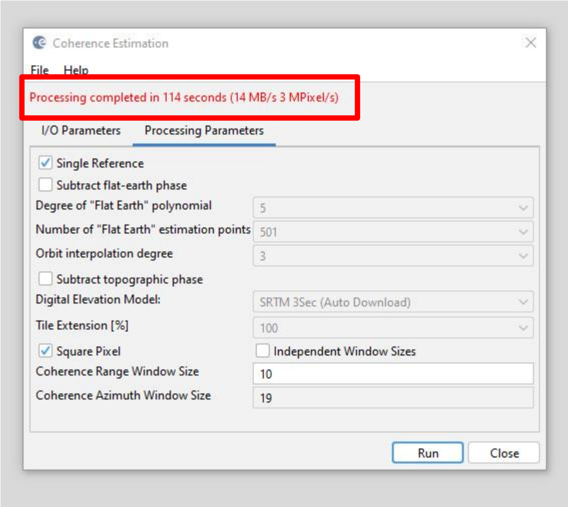
Select ALOS2452677050-221010_Stack file



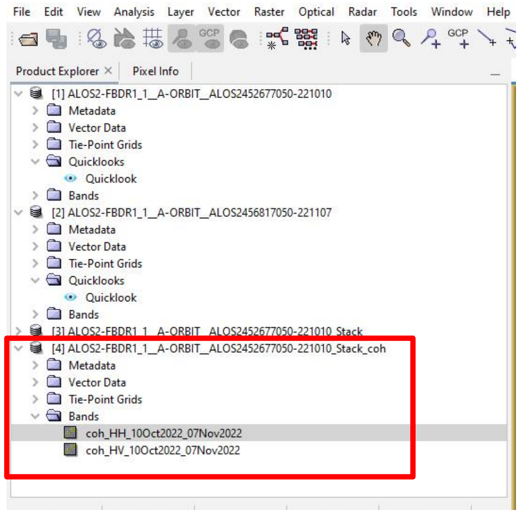
Click RUN to process

6. Coherence Estimation

- The results for Coherence Estimation



Processing completed in 2 minutes



Output file: ALOS-FBDR1_1_A-ORBIT_ALOS2452677050-221010_Stack_coh

The results for Coherence Estimation are available, but the geometric properties are not yet correct.

7. Multilooking

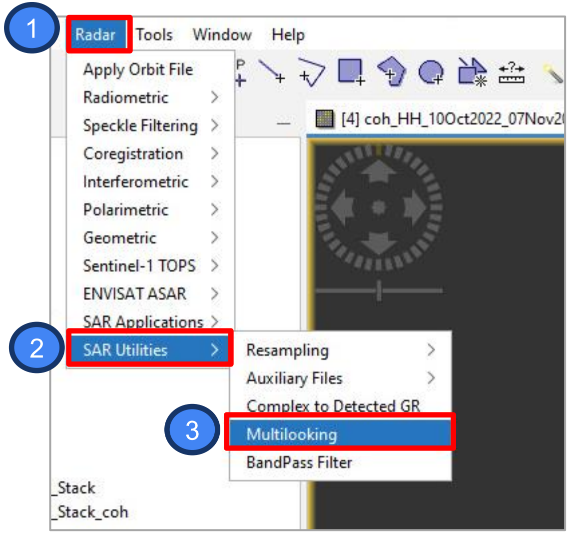
Multilooking is a technique used to reduce speckle noise in SAR images and to achieve more square-shaped pixels by averaging multiple "looks" of the same target area.

Process: This technique involves averaging multiple independent "looks" or samples of the same target area. This averaging helps to smooth out the random components of speckle noise while often leading to more isotropic (square-shaped) pixels.

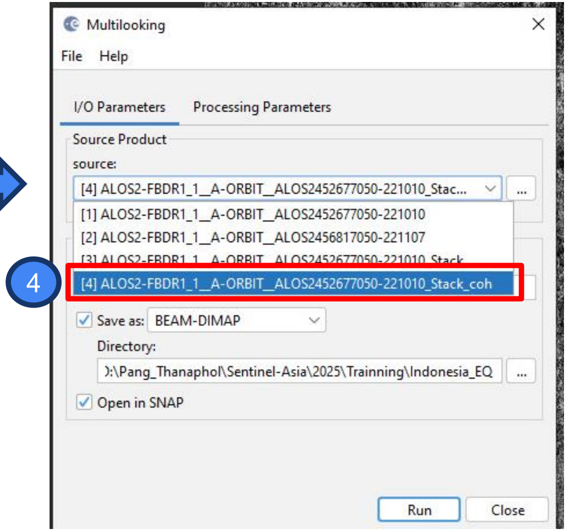
Result: Produces a smoother image, though it slightly reduces spatial resolution.

7. Multilooking

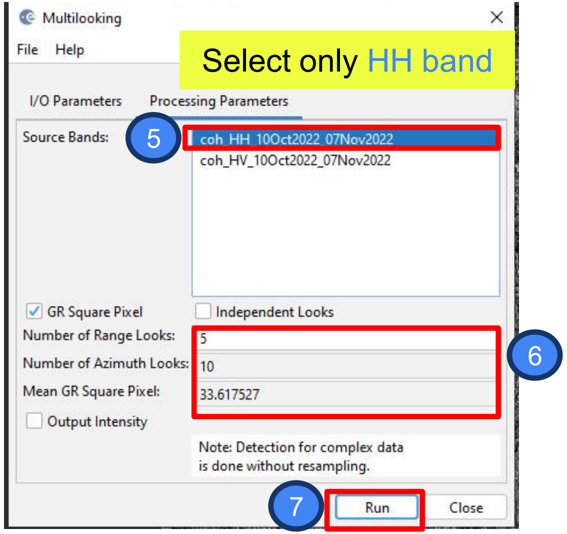
➢ Input ALOS2452677050-221010_Stack_coh File and Set Up Multilook Processing



Go to Radar > SAR Utilities > Multilook



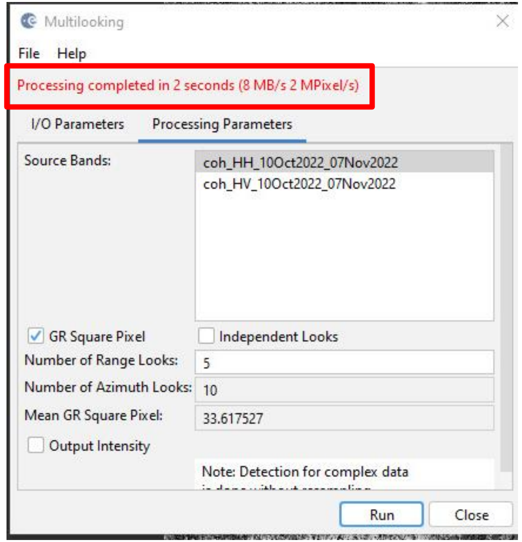
Select ALOS2452677050-221010_Stack_coh file



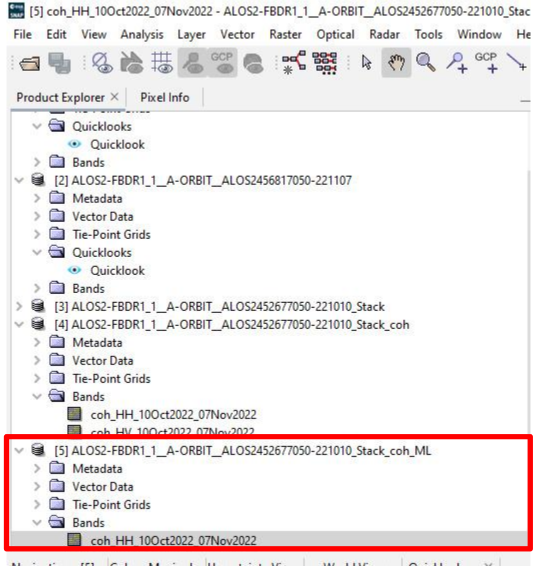
Click RUN to process

7. Multilooking

➢ The results for Multilooking



Processing completed in 2 Seconds



Output file: ALOS-FBDR1_1_A-ORBIT_ALOS2452677050-221010_Stack_coh_ML

The results for Multilooking are available, but the geometric properties are not yet correct.

Terrain Correction (Range-Doppler Terrain Correction)

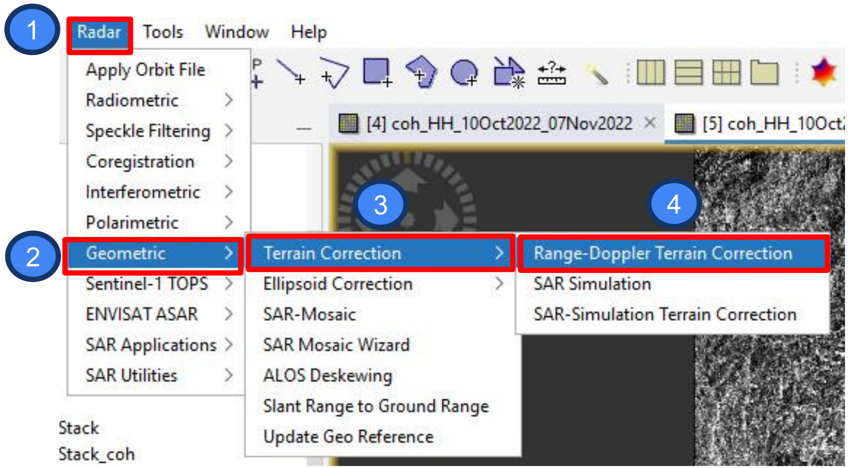
To correct geometric distortions (such as foreshortening, layover, and shadow) inherent in SAR images, which arise from the sensor's side-looking geometry and varying terrain elevations.

Using a high-resolution Digital Elevation Model (DEM) and precise satellite orbit data, this step accurately maps each SAR pixel from its native slant range geometry to a standard geocoded map projection (e.g., UTM or WGS84 latitude/longitude).

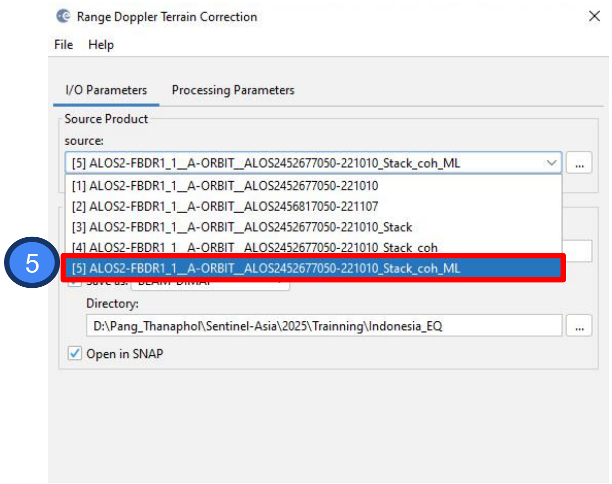
This crucial processing ensures that the radar image is geographically accurate and aligns perfectly with other geospatial data, making it suitable for direct overlay, comparison, and integration into GIS for reliable damage assessment.

8. Terrain Correction (Range-Doppler Terrain Correction)

➢ Open Range-Doppler Terrain Correction Tool and Input ALOS2452677050-221010_Stack_coh_ML File



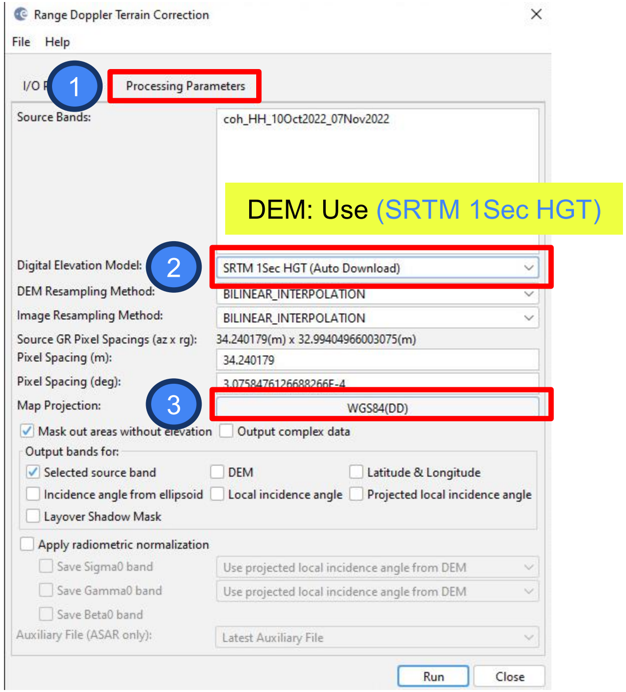
Go to Radar > Geometric > Terrain Correction > Range-Doppler Terrain Correction

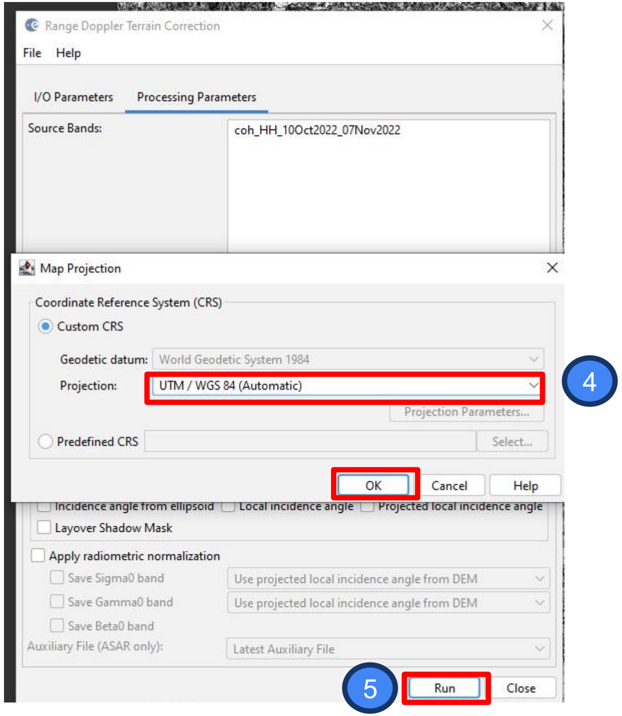


Select ALOS2452677050-221010_Stack_coh_ML file

8. Terrain Correction (Range-Doppler Terrain Correction)

➢ Set Up DEM and Map Projection



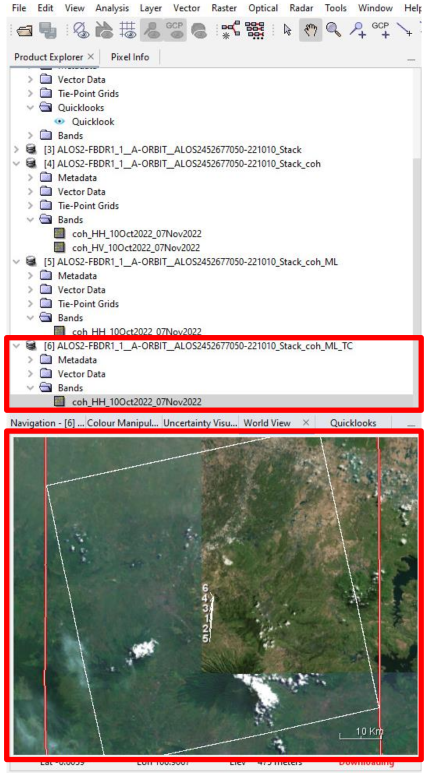


DEM: Use the same DEM as in coregistration (e.g., SRTM 1Sec HGT (Auto Download))

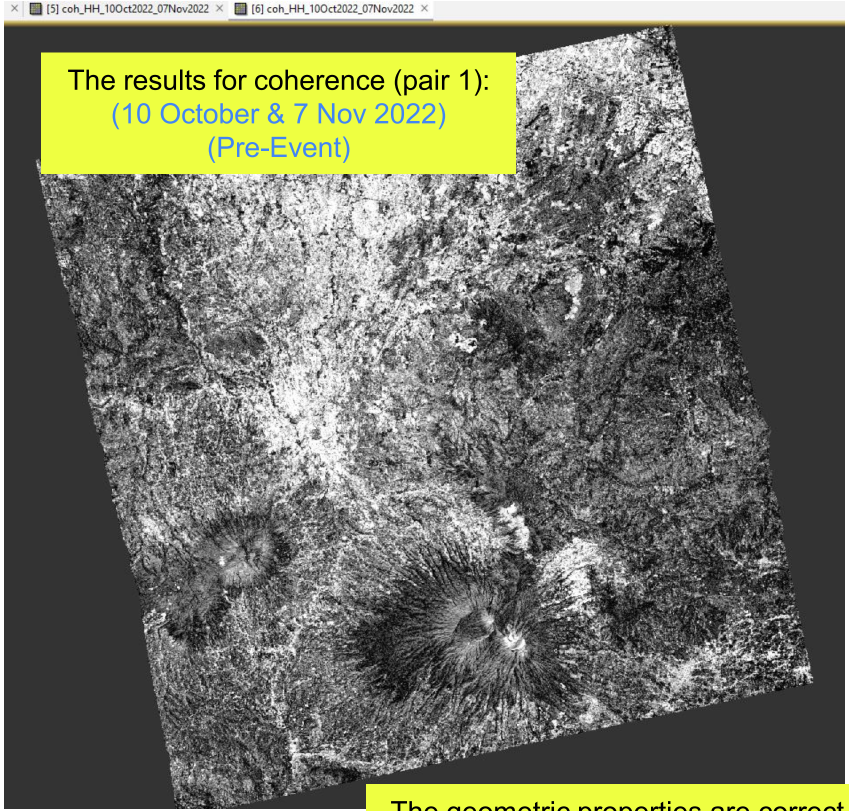
Map Projection: Choose your desired map projection (UTM / WGS84 (Auto)

8. Terrain Correction (Range-Doppler Terrain Correction)

➢ The results for Terrain Correction



Output file: ALOS-FBDR1_1_A-ORBIT_ALOS2452677050-221010_Stack_coh_ML_TC



The results for coherence (pair 1):
(10 October & 7 Nov 2022)
(Pre-Event)

The geometric properties are correct.

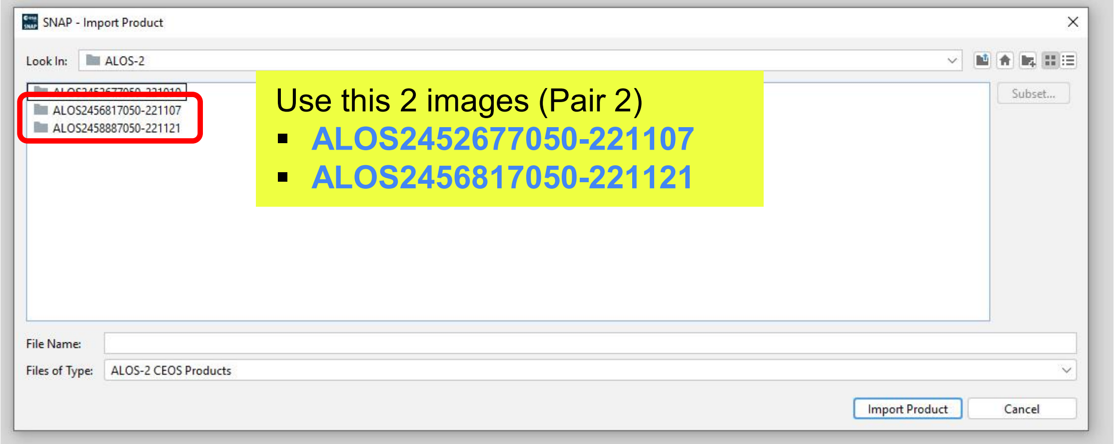
Processing Pair 2: 7 November 2022 and 21 November 20

- ALOS-2 PALSAR-2 on 10 October 2022: ALOS2452677050-221010
- ALOS-2 PALSAR-2 on 7 November 2022 : ALOS2456817050-221107
- ALOS-2 PALSAR-2 on 21 November 2022 : ALOS2458887050-221121

Pair 2

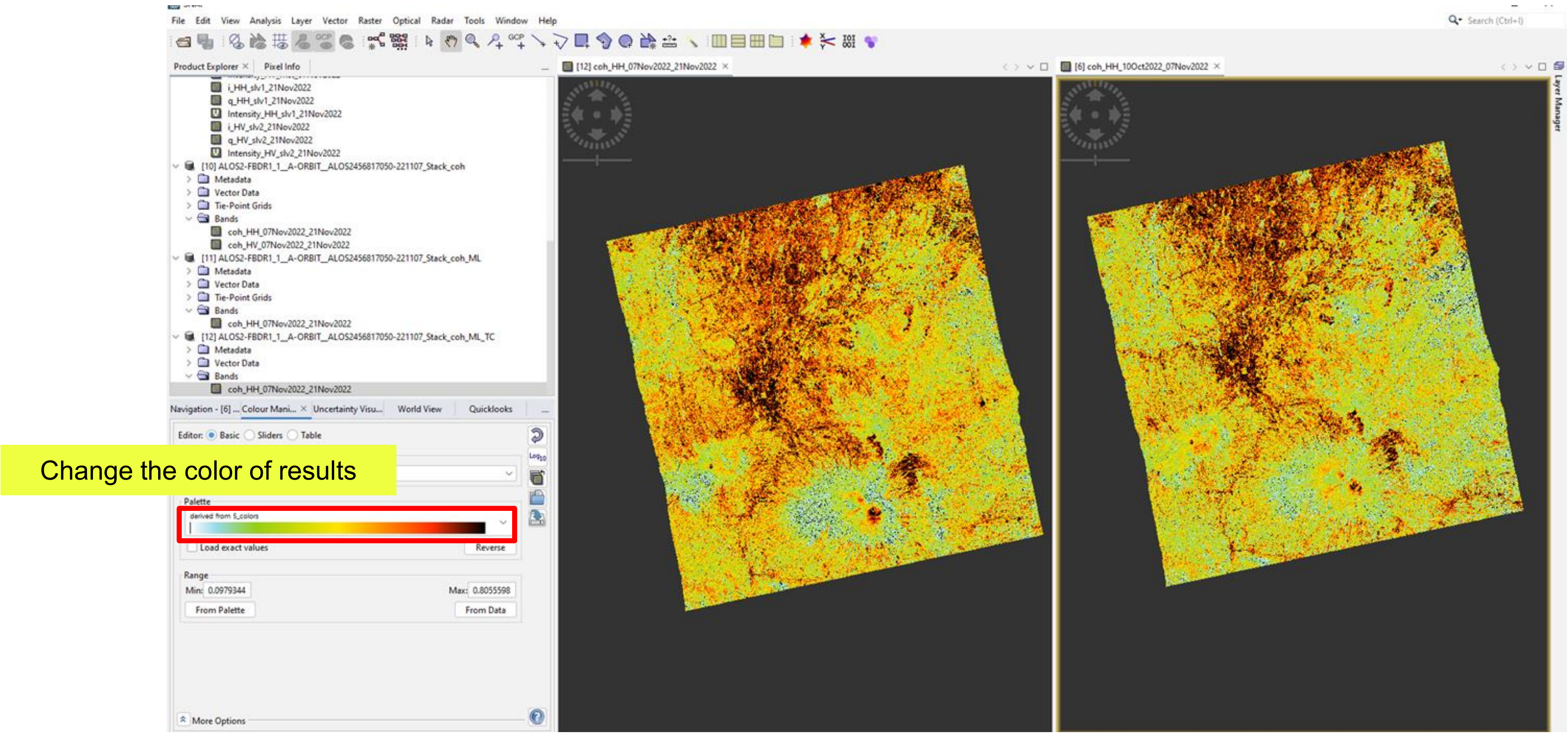
Just apply all the same steps as Pair 1, but with Pair 2 data.

1. Import ALOS-2 Data in SNAP
2. Coregistration
3. Coherence Estimation
4. Multilooking
5. Terrain Correction



9. Compare the result between Pair 1 and 2

- After finishing processing for pair 2, we can open the results for pair 1 to compare

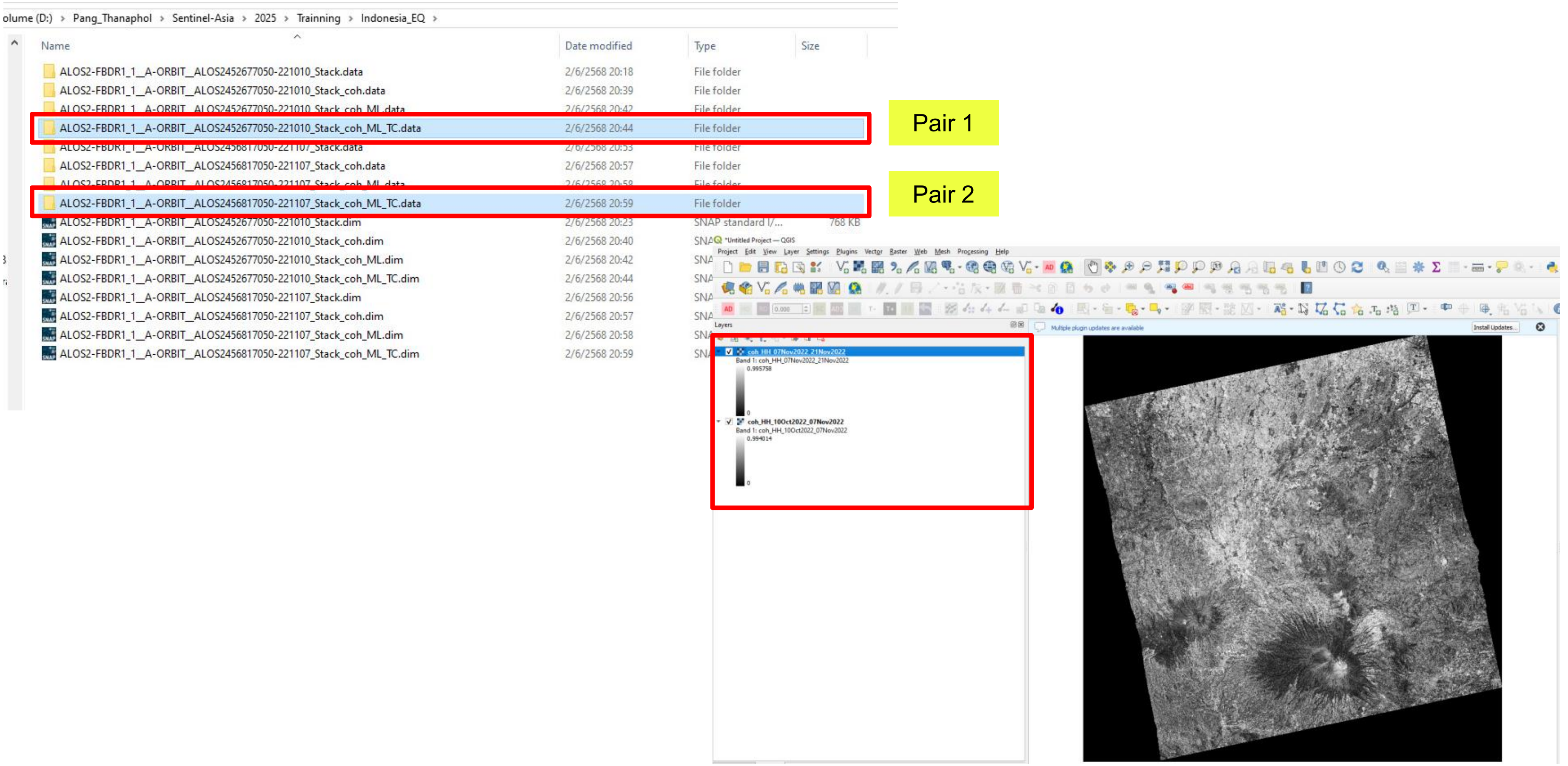


Coherence Changes Calculation

To quantify the impact of the November 21, 2022, event on coherence. This involves comparing the coherence calculated from Pair 2 (the post-event period) with a pre-event baseline coherence (which would be the coherence calculated from Pair 1: October 10 - November 7). This highlights the actual change caused by the event.

The resulting "coherence change" map is your primary tool for damage assessment. Areas showing a significant drop in coherence in this final map are strong indicators of damage or significant surface alteration directly related to the event, as stable features would have lost their consistent radar scattering properties.

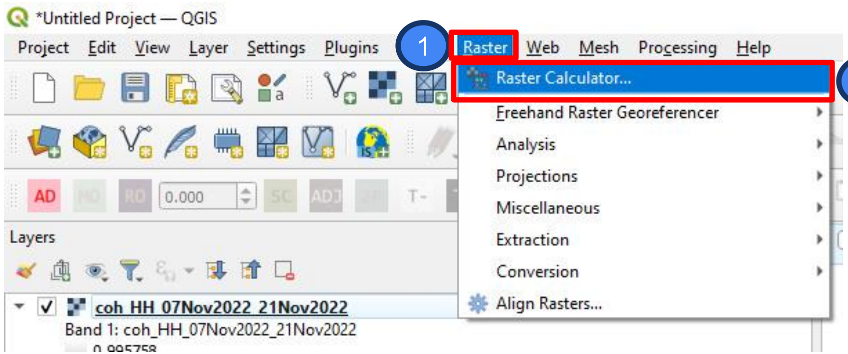
10. Input Coherence results form Pair 1 and 2 in QGIS

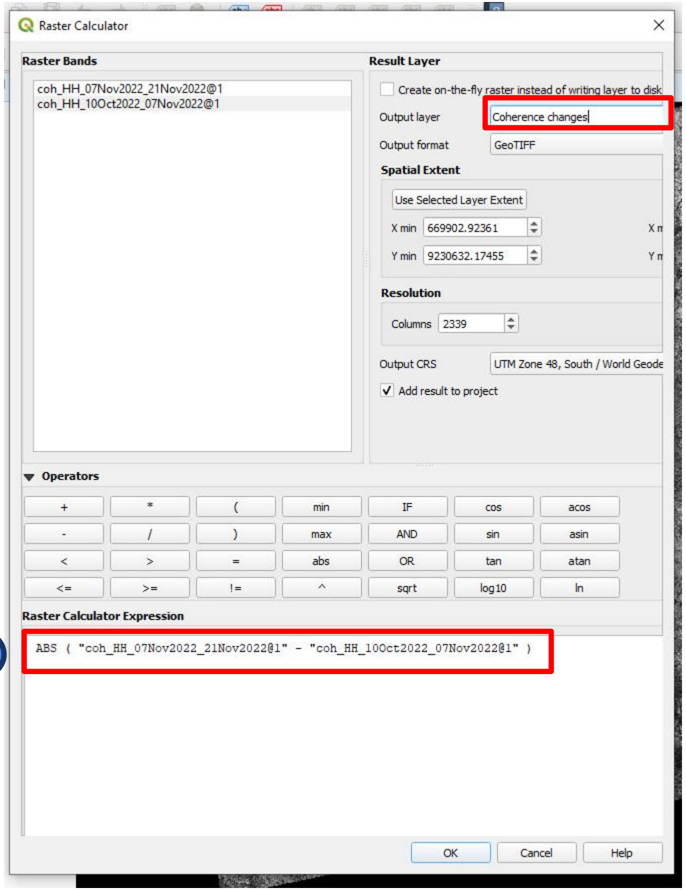


11. Coherence Changes Calculation

- Using Raster Calculator tool in QGIS

Goto Raster > Raster Calculator

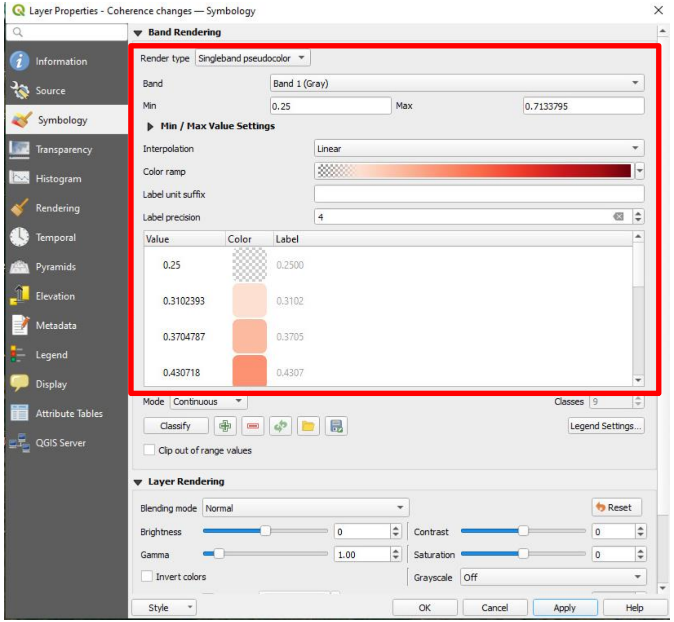


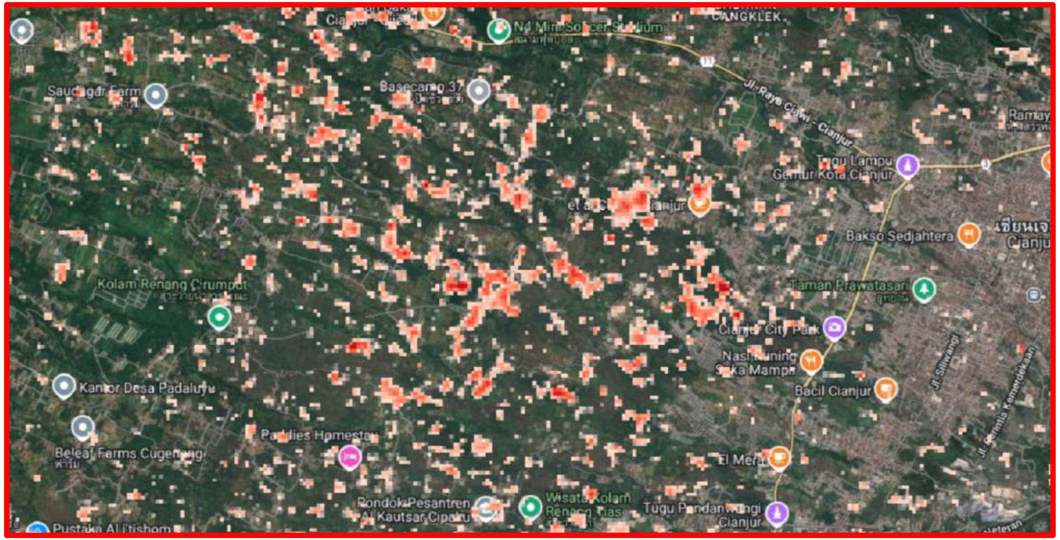


Equation:
ABS (“coh_HH_07Nov2022_21Nov2022@1” – “coh_HH_10Oct2022_07Nov2022@1)

12. The results

- Set color scale from 0.25 to max to clearly show affected areas



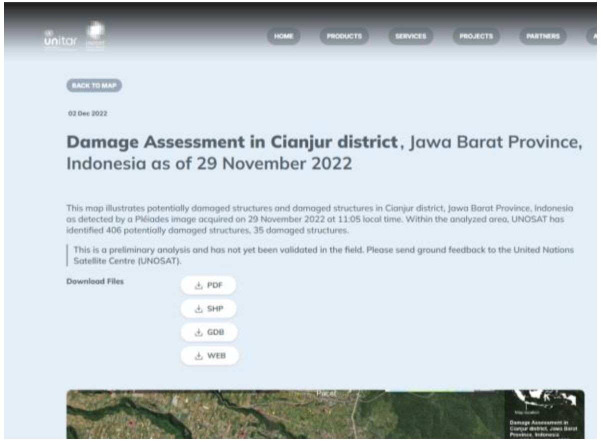


Set the color scale to display from a minimum value of 0.25 to the maximum value, in order to clearly show the affected areas.

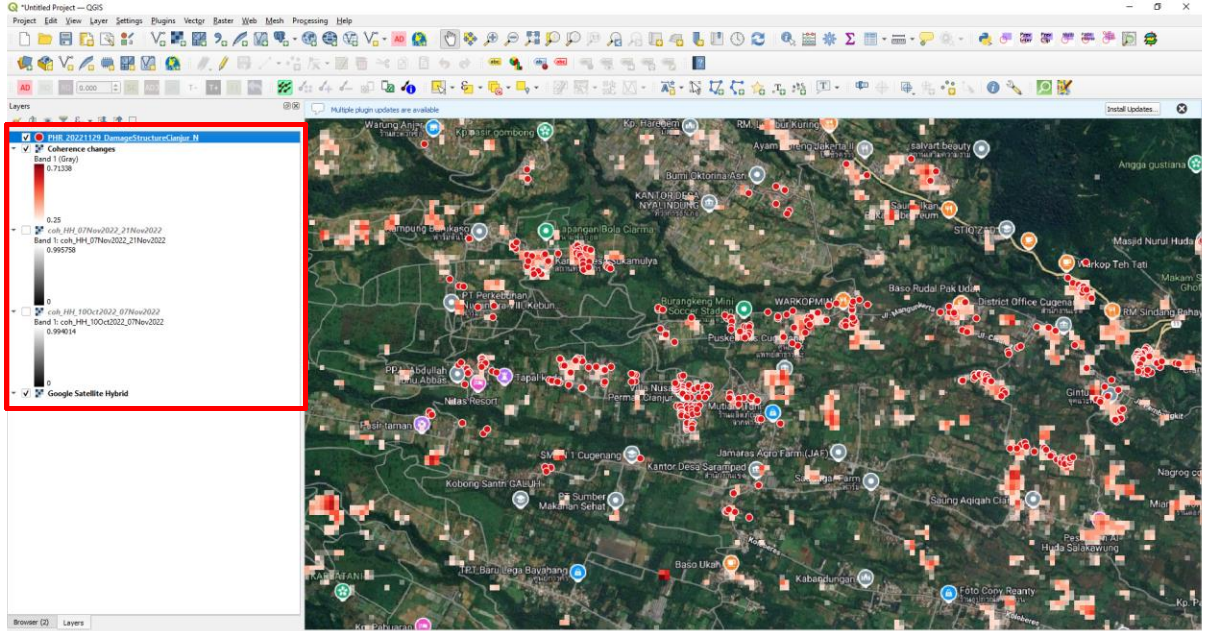
Change the color of the results to make them easier to view/understand

13. Compare our results with UNOSAT data.

➢ Import UNOSAT high-resolution earthquake impact data for comparison

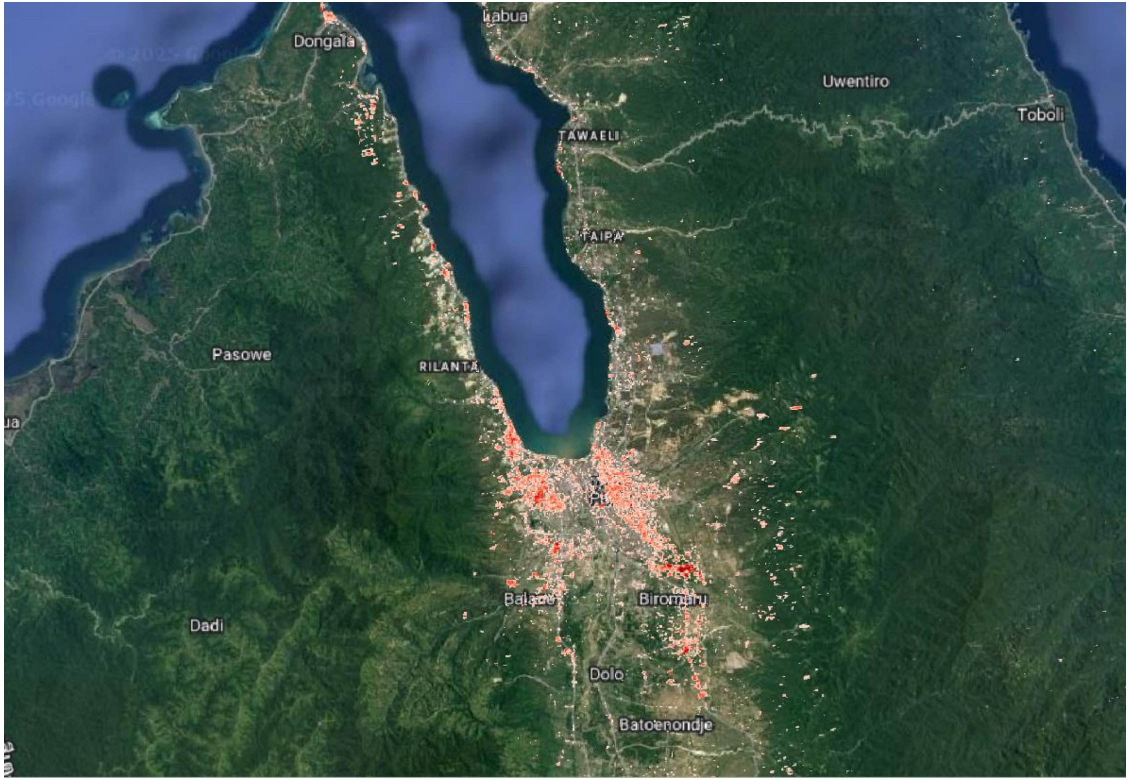


Import earthquake impact data from high-resolution satellite imagery from UNOSAT to compare the results.



Exercise

- Create a coherence changes image to detect damage caused by the earthquake event.



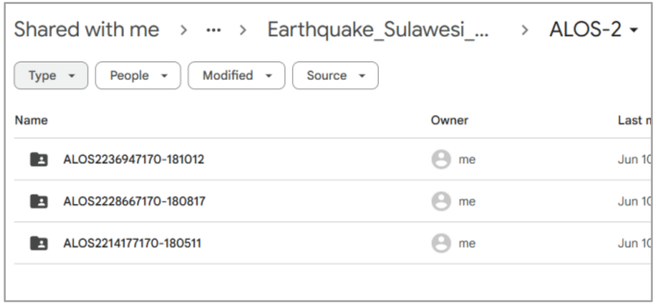
Sentinel Asia activation:

Earthquake in Palu, Indonesia

- Occurrence Date (UTC): 28 September, 2018

- ALOS-2 data in this link.

https://drive.google.com/drive/folders/1am05cvIyc5p8hNEI-nn4cANSTm8w7FKa



THANK YOU

Geoinformatics Center, Asian Institute of Technology