



ESA-MOST Dragon 4 Cooperation

ADVANCED LAND REMOTE SENSING INTERNATIONAL TRAINING COURSE

“龙计划4”高级陆地遥感国际培训班

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2017年11月20日—11月25日
云南师范大学, 中国, 昆明

GLACIER - SAR InSAR DATA PROCESSING IN SNAP

By Zhou Jianmin & Li Zhen

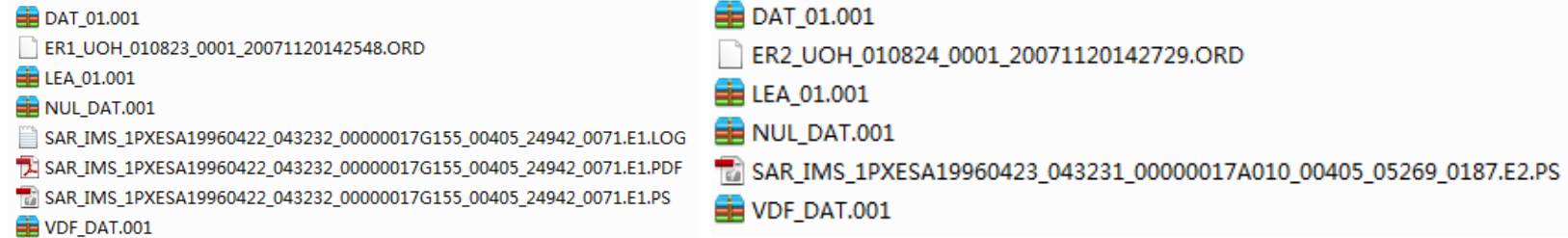
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Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing, China

- Familiarize with ESA SNAP
- Training on Glacier InSAR data Using Differential Interferometry (DInSAR)
- Provide instruction on step-by-step processing of ALOS1 data
(incl. parameters, tips etc.)
- End-to-End show case



— A set of ERS SLCs



— Digital Elevation Model (DEM) dataset from SRTM 3 arc-sec covering the Area of Interest(auxiliary data)

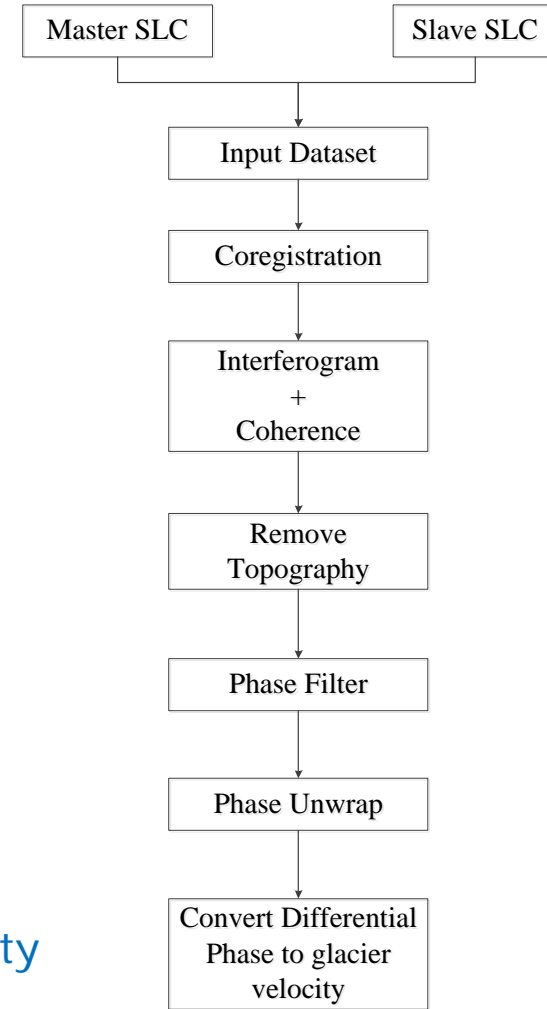
[srtm_55_06.zip](#)

[stored locally @ C:\Users\#username#\snap\auxdata\dem\SRTM 3Sec]



Processing Steps

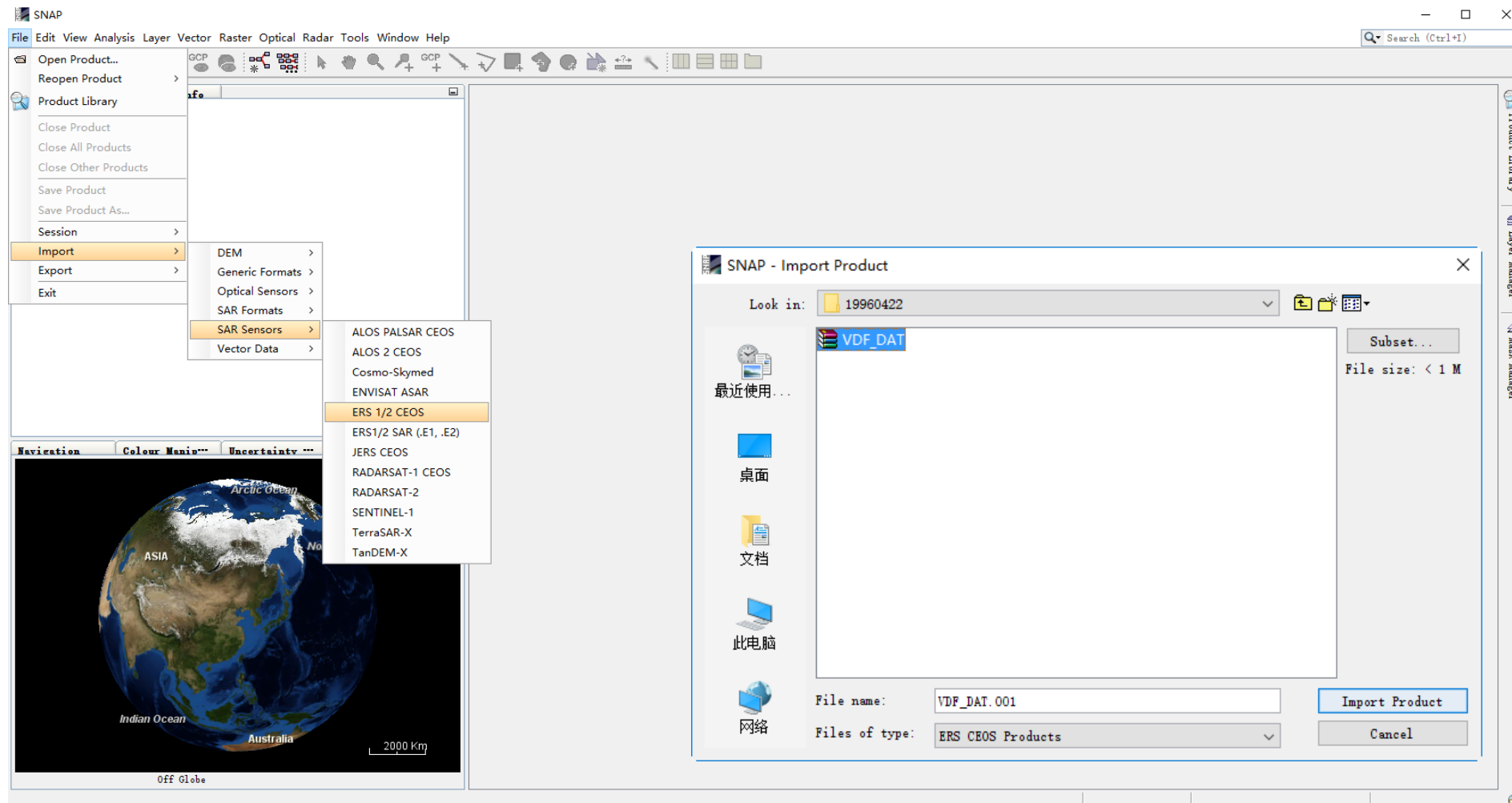
- Open a pair of ERS SLC Products
- Apply InSAR Optimized Coregistration
- Generate Interferogram and Coherence
- Apply Topographic Phase Removal
- Goldstein Phase Filtering
- Phase Unwrapping(SANPHU)
- Convert Differential Phase to glacier velocity



Part one: Open a pair of ERS SLC products

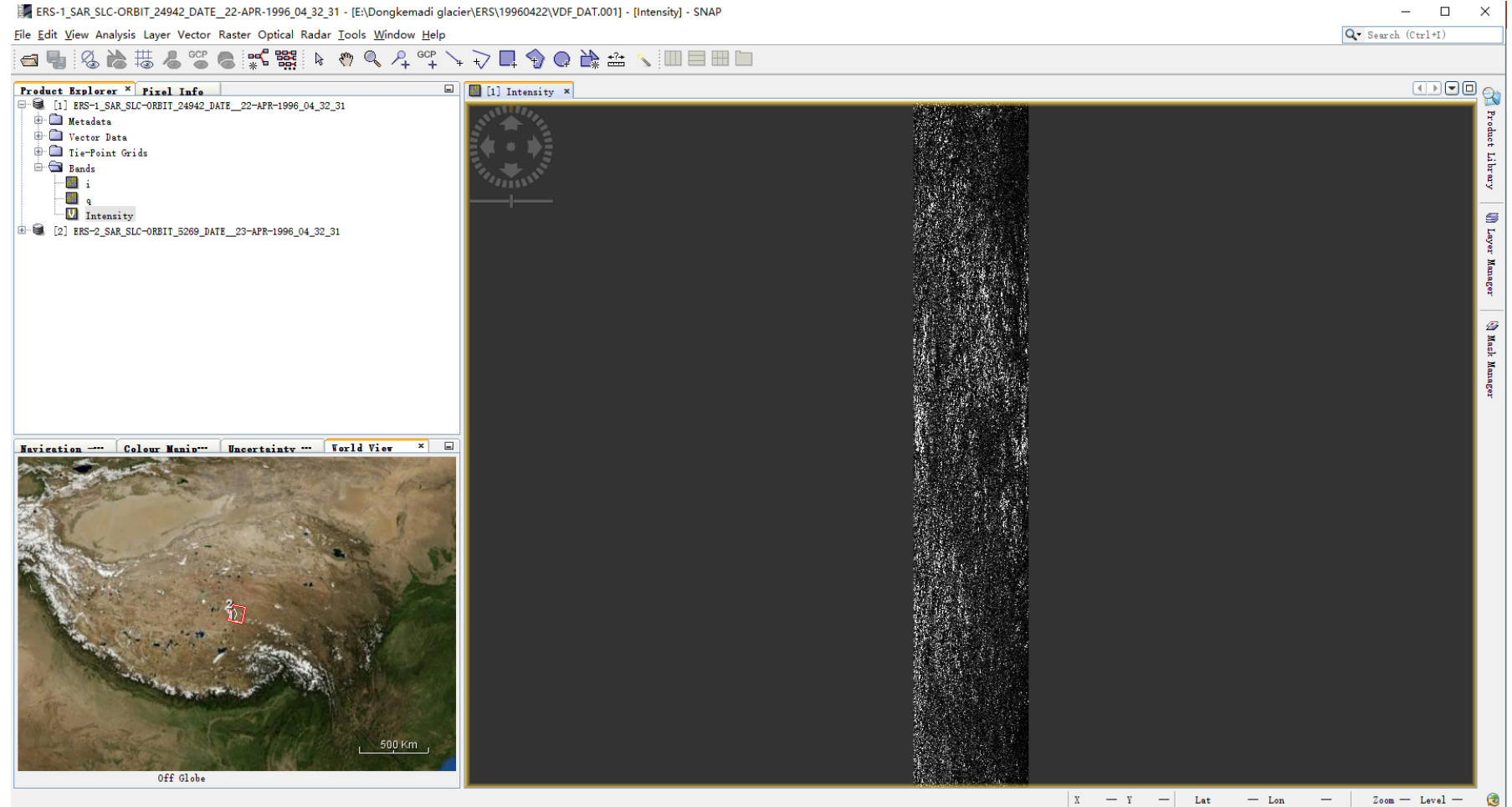
Step1-Open the products:

Use the **Import** button in the top toolbar and browse for the location of the products. Select the **ERS 1/2 CEOS** file from the product folder and press **Import Product**.



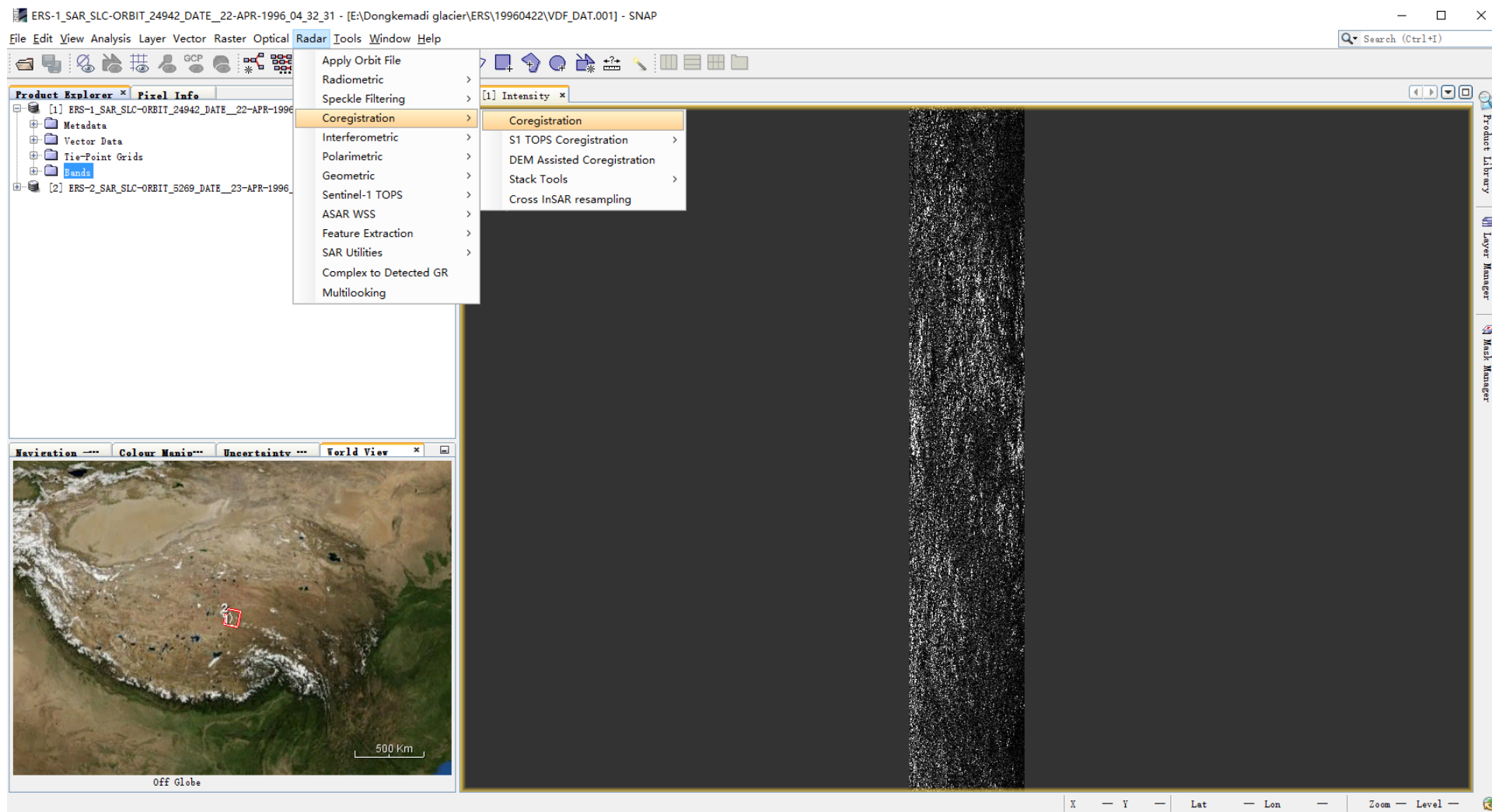
Step2-View the product:

In the Products View you will see the opened products. Within the product bands, you will find three bands containing the real(i), imaginary(q) and intensity.



Products View

Step3-Coregister the images into a stack:
Select **Coregistration** in the Coregistration menu.



Select Coregistration

Part two: Coregistering the Data

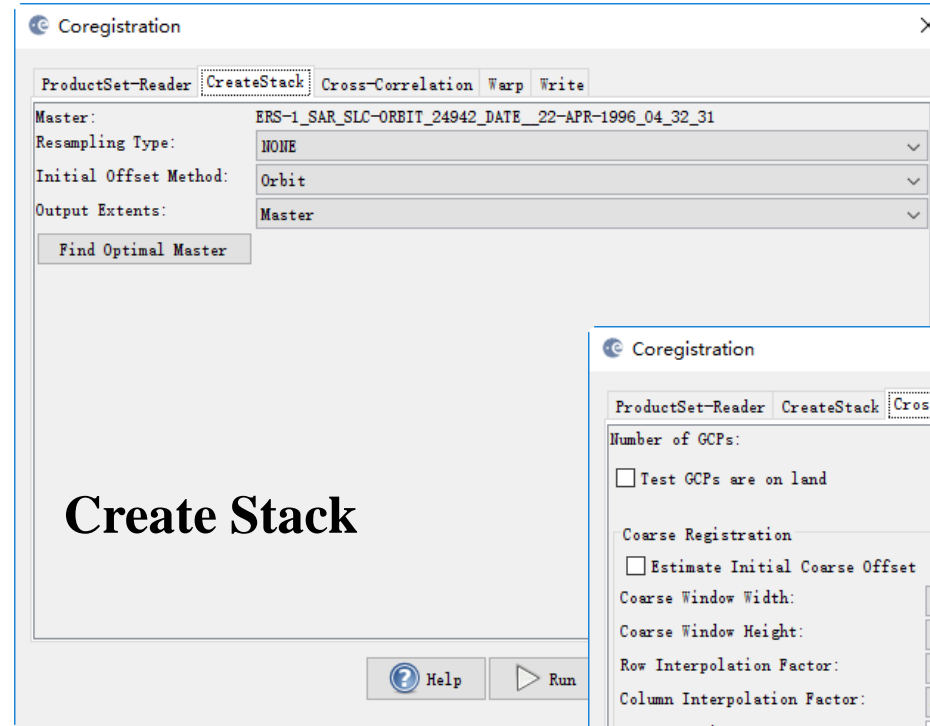
Drag and drop first the subset product. This will be your **master** image. Then drag and drop the other product. This will be your **slave** image.

File Name	Type	Acquisition	Track	Orbit
ERS-1_SAR_SLC-ORBIT_249...	ERS1. SAR. SLC	22Apr1996	405	24942
ERS-2_SAR_SLC-ORBIT_526...	ERS2. SAR. SLC	23Apr1996	405	5269

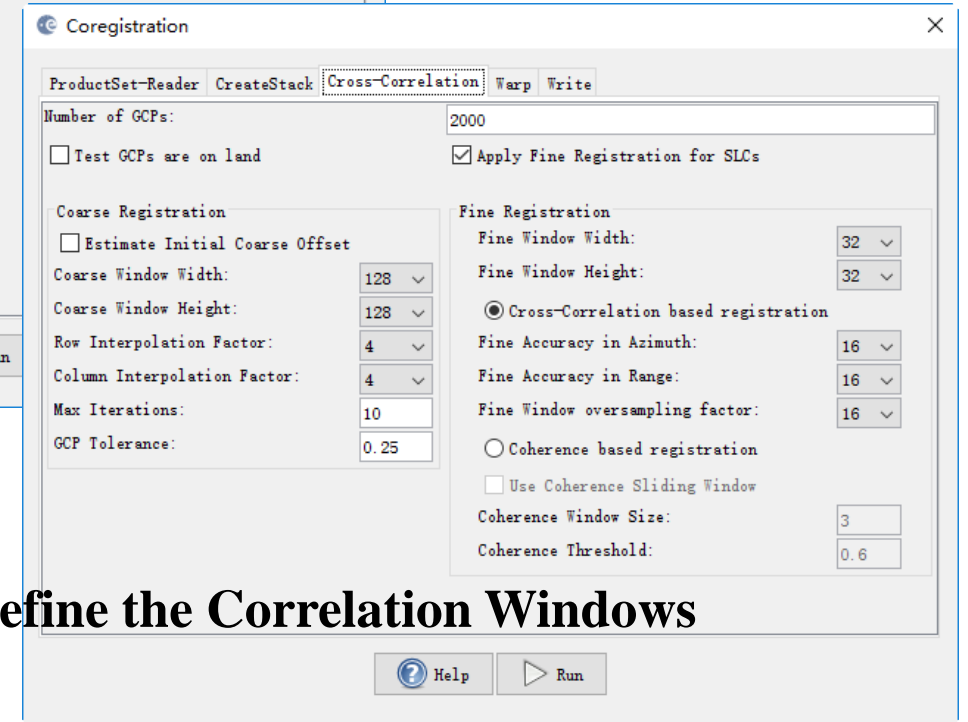
Add products into the Coregistration Dialog

In the **Create Stack** tab, the bands for master image and slave images should already be selected for you based on the order of the products given in the previous table.

In the **Cross-Correlation** tab, specify the number of Ground Control Points (GCPs) to use. The GCPs will be used as the center of a cross correlation window which will find the corresponding position from the slave image to the master image.



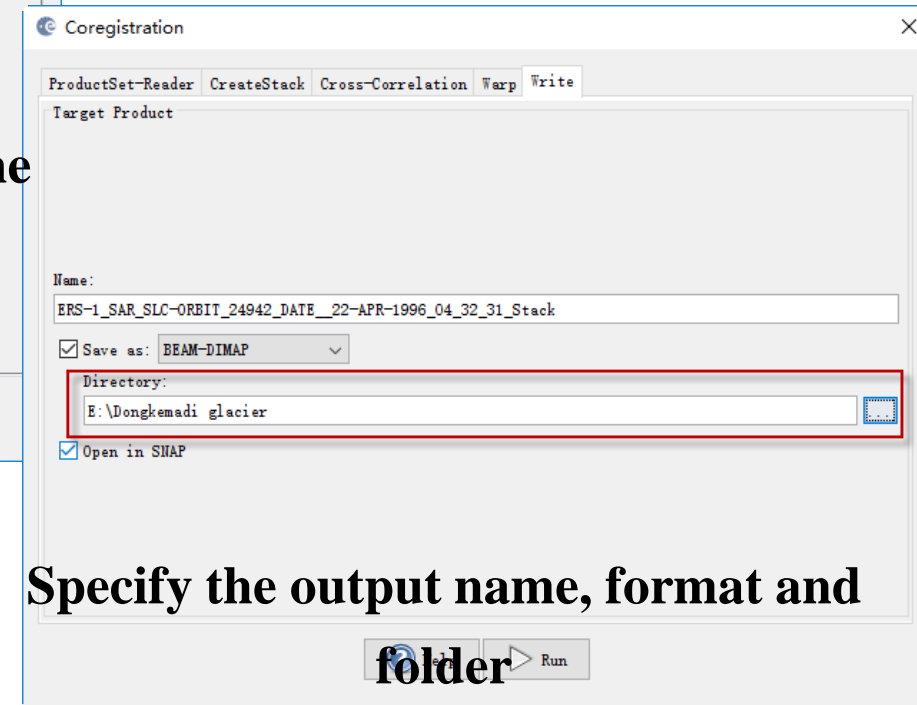
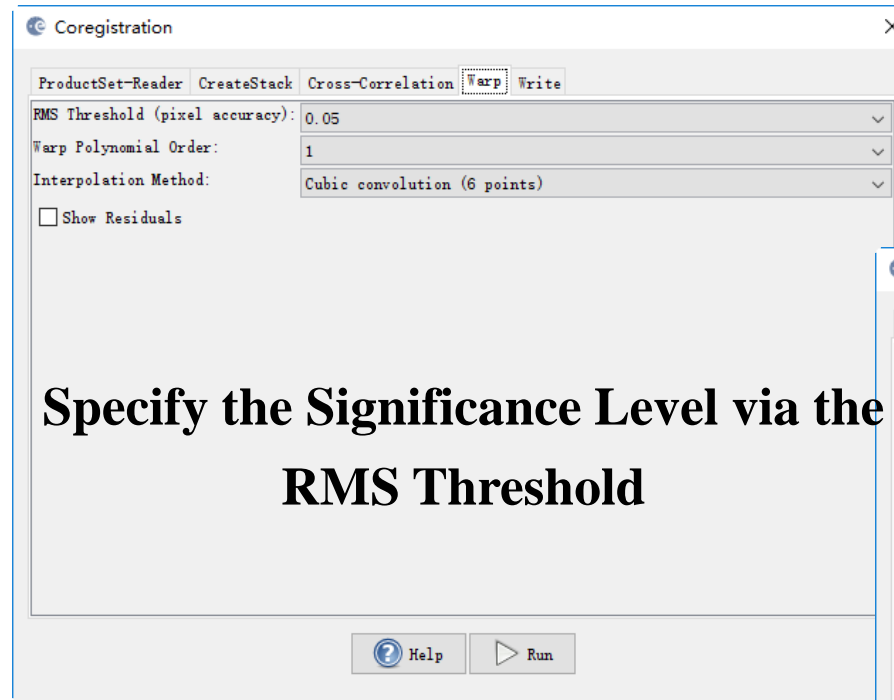
Create Stack



Define the Correlation Windows

In the **Warp** tab, the warp polynomial order applies a linear translation for order 1. Higher order warps should only be used when the images have been greatly distorted.

In the **Write** tab, specify the output folder and the target product name.



Part three: Interferogram Formation and Coherence Estimation

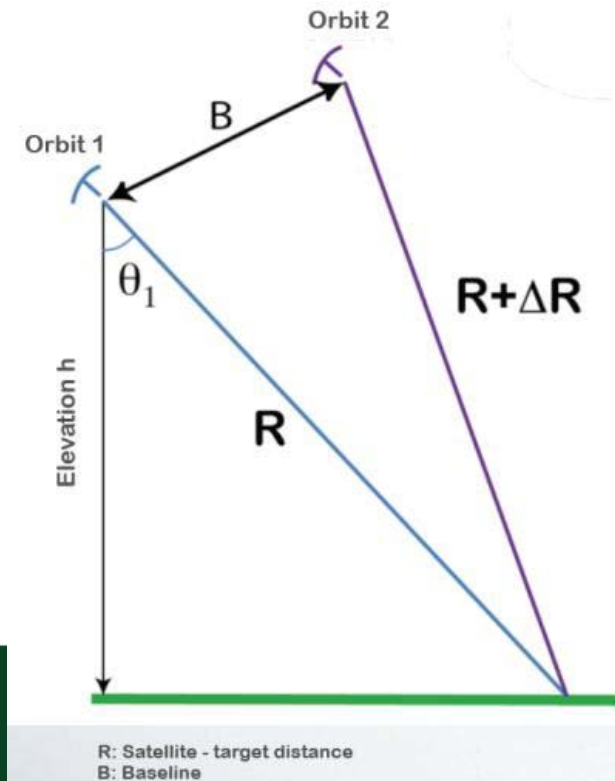
The interferogram is formed by cross multiplying the master image with the complex conjugate of the slave. The amplitude of both images is multiplied while the phase represents the phase difference between the two images.

The interferometric phase variation $\Delta\phi$ is then proportional to ΔR divided by the transmitted wavelength λ .

$$\phi_1 = \frac{4\pi R}{\lambda}$$

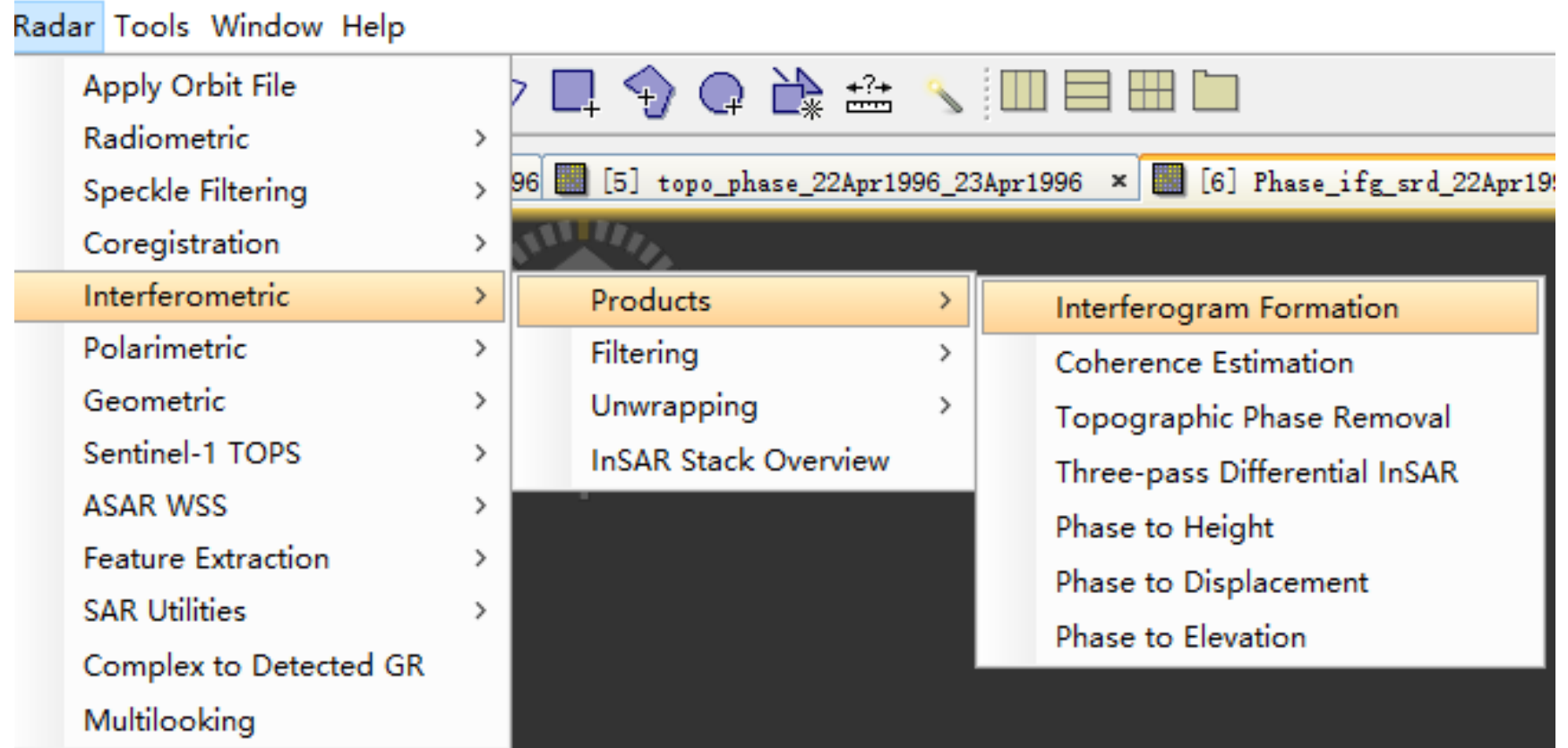
$$\phi_2 = \frac{4\pi(R + \Delta R)}{\lambda}$$

$$\Delta\phi = \phi_2 - \phi_1 = \frac{4\pi\Delta R}{\lambda}$$



Part three: Interferogram Formation and Coherence Estimation

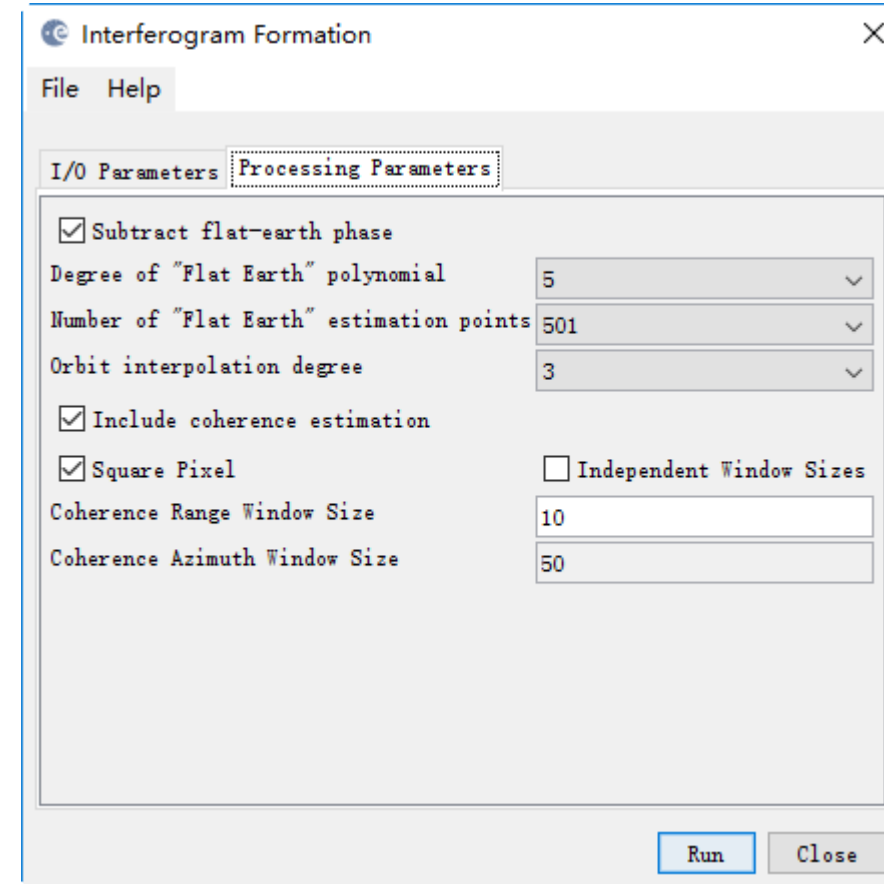
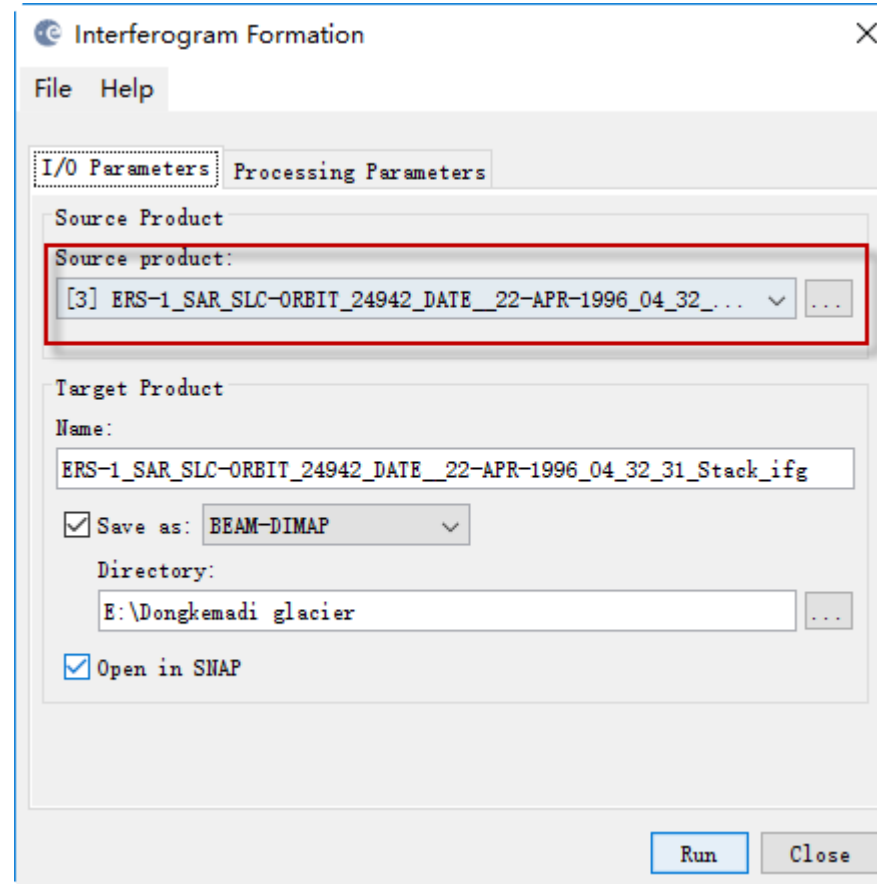
Step4-Form the Interferogram: Select the stack and select Interferogram Formation from the InSAR Products menu



Select Interferogram Formation

Part three: Interferogram Formation and Coherence Estimation

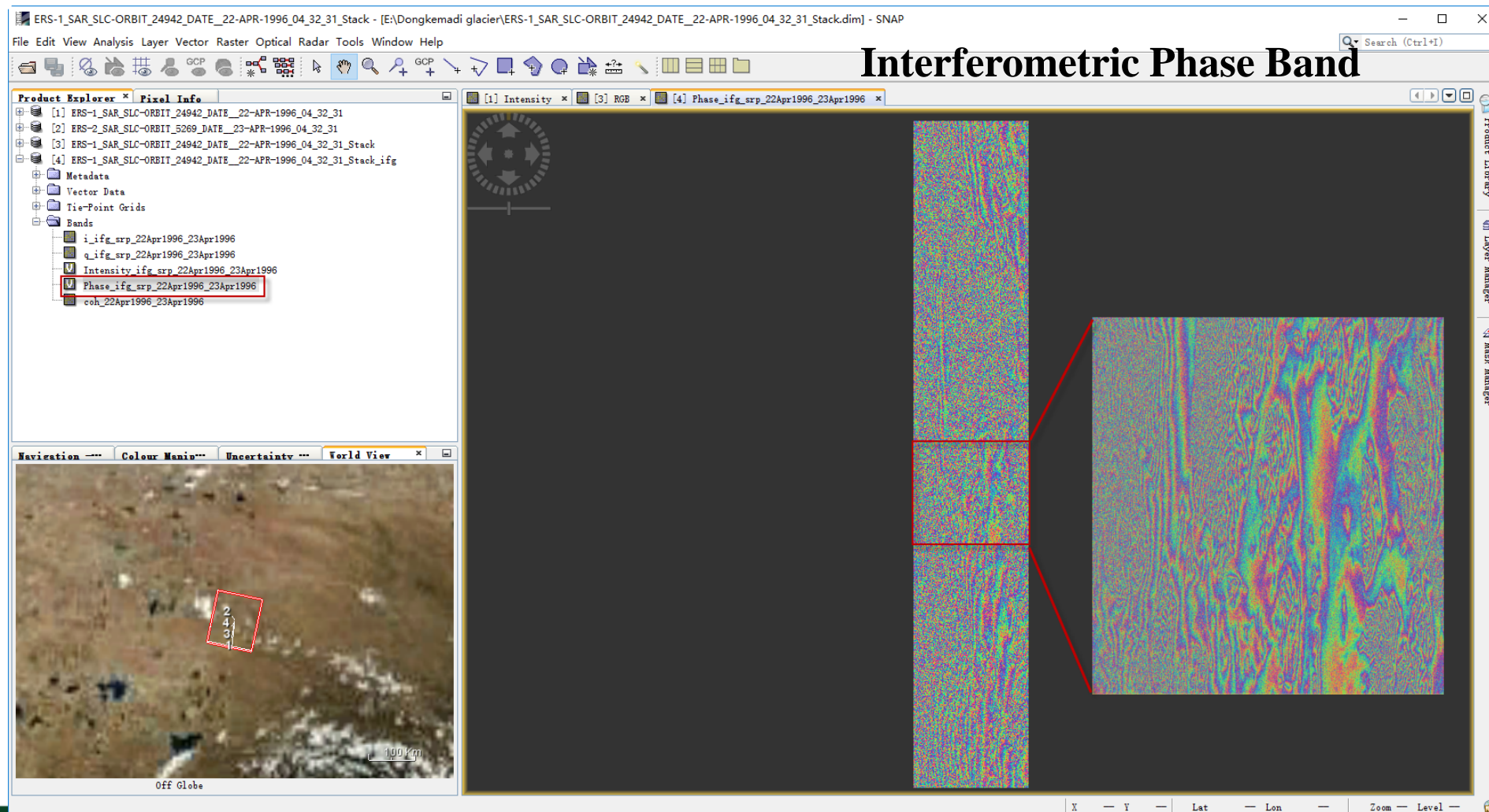
In the interferogram formation step we shall remove the flat-Earth phase. The flat-Earth phase is the phase present in the interferometric signal due to the curvature of the reference surface.



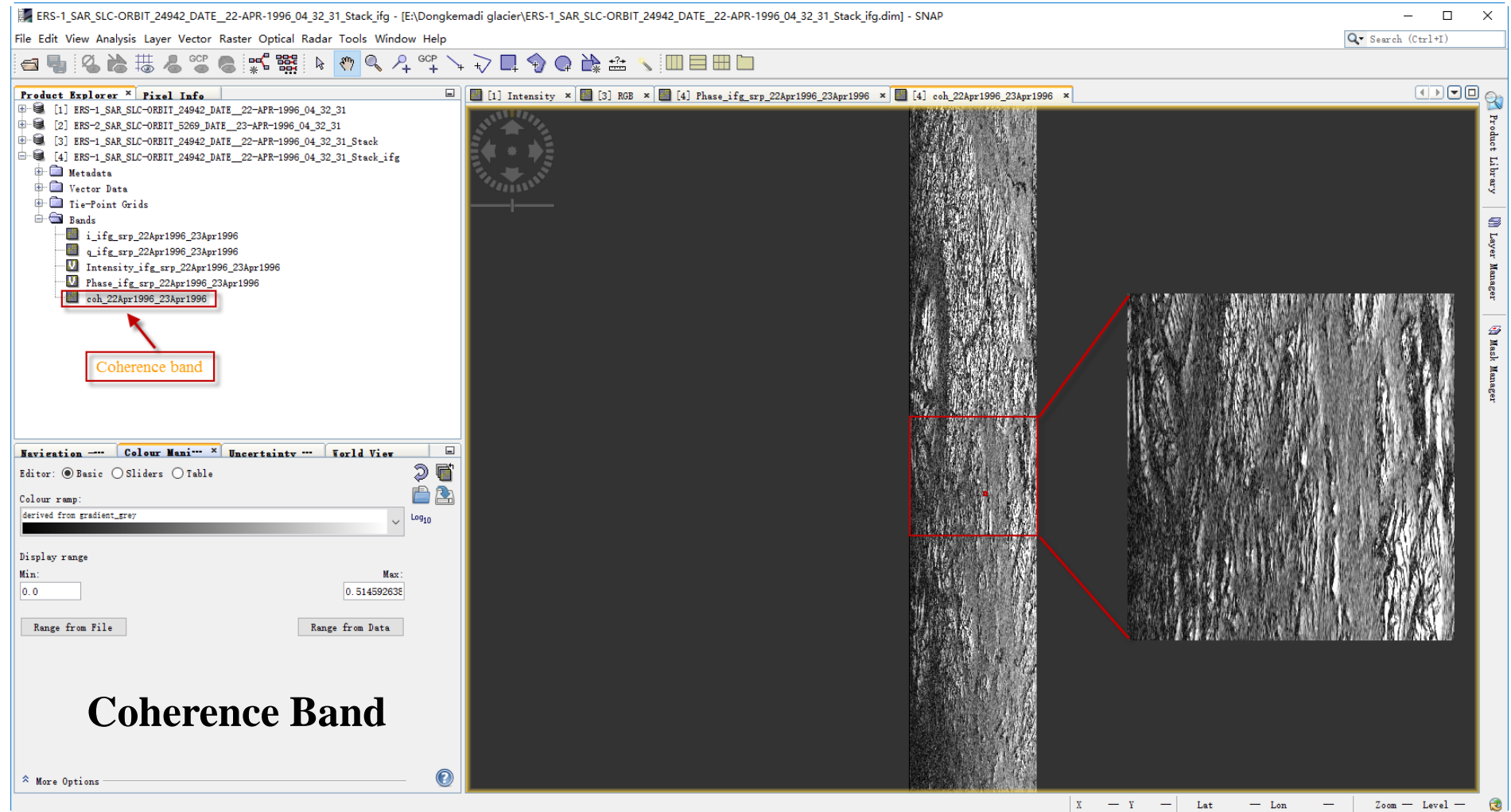
Interferogram Dialog

Part three: Interferogram Formation and Coherence Estimation

The interferogram product produced will contain a band for the interferometric phase.

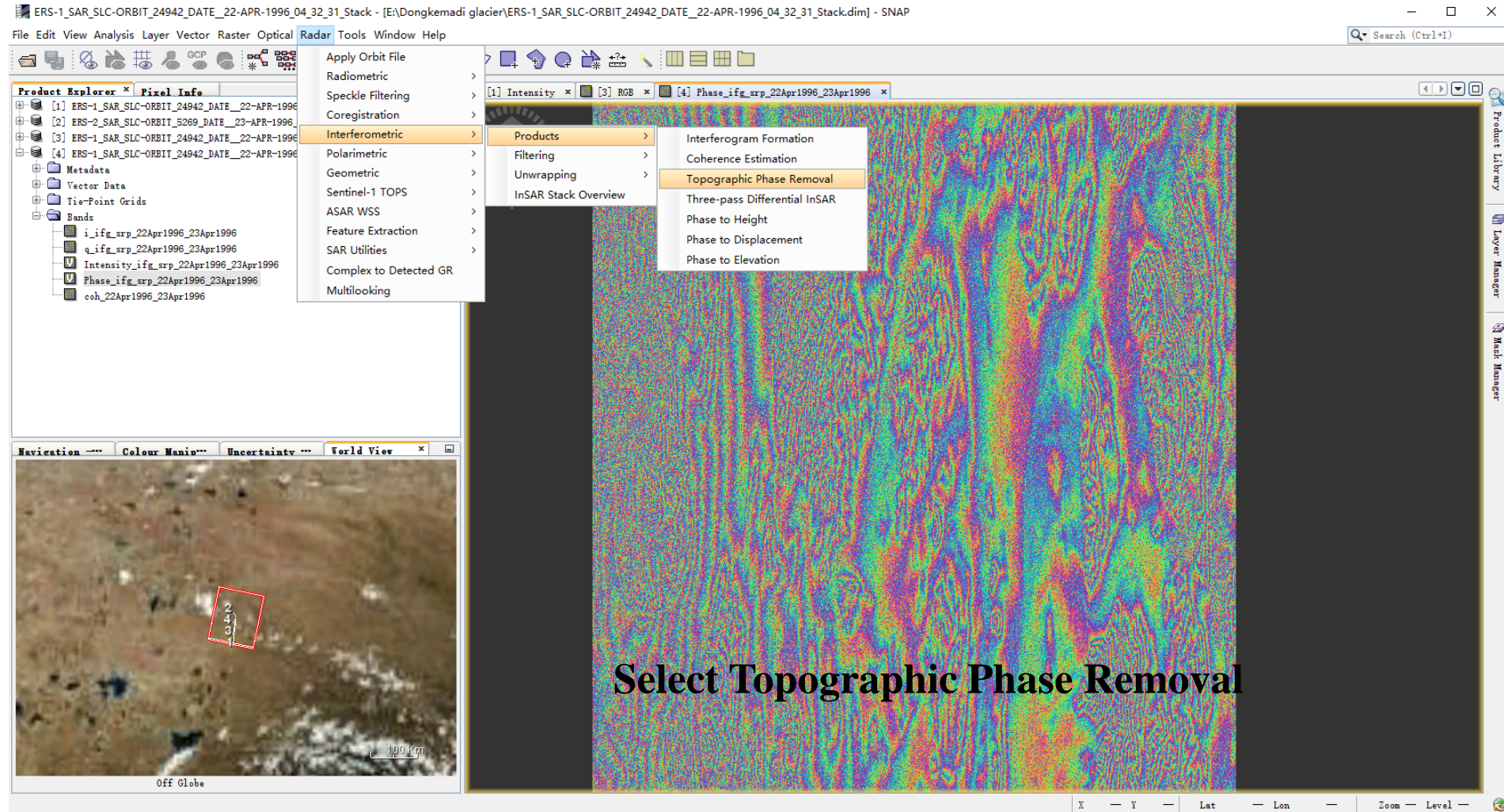


The interferogram product produced will contain a band for the coherence phase.

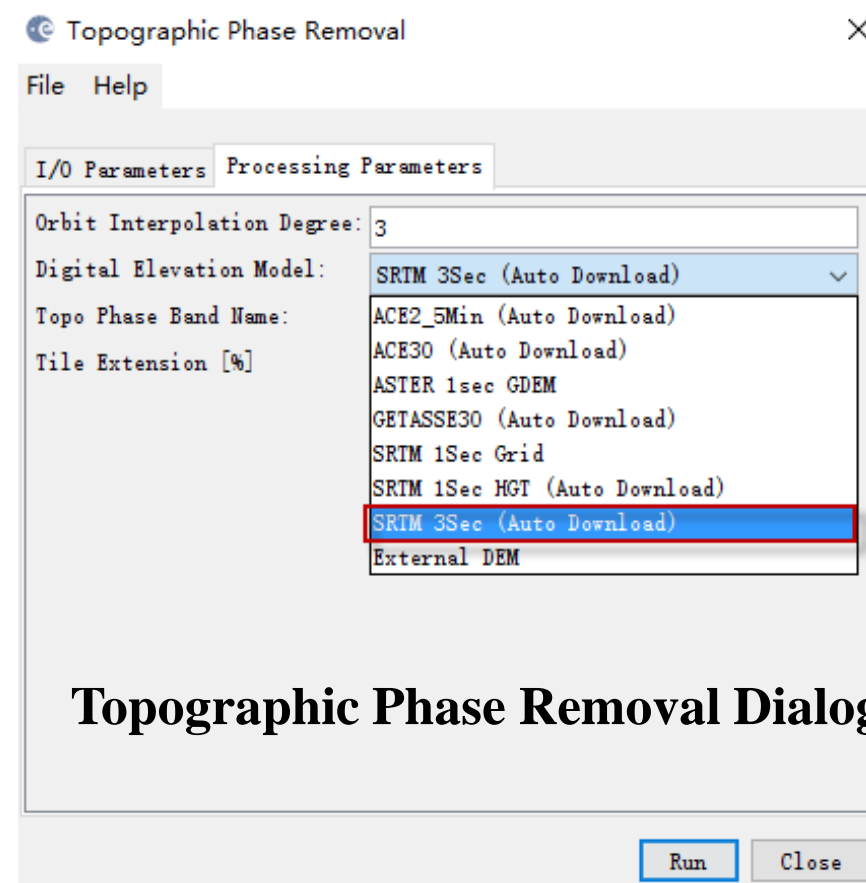
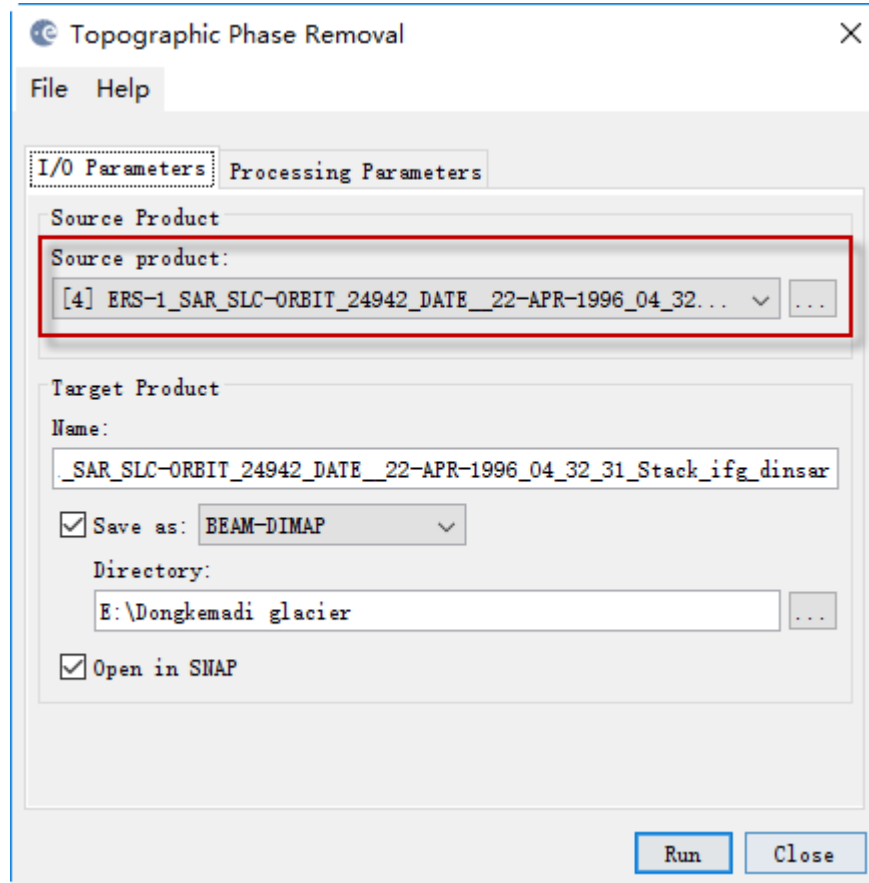


Part four: Topographic Phase Removal

Step5-Remove Topographic Phase: Select the interferogram product and go to the **Interferometric Products** menu. Select **Topographic Phase Removal**.



Part four: Topographic Phase Removal



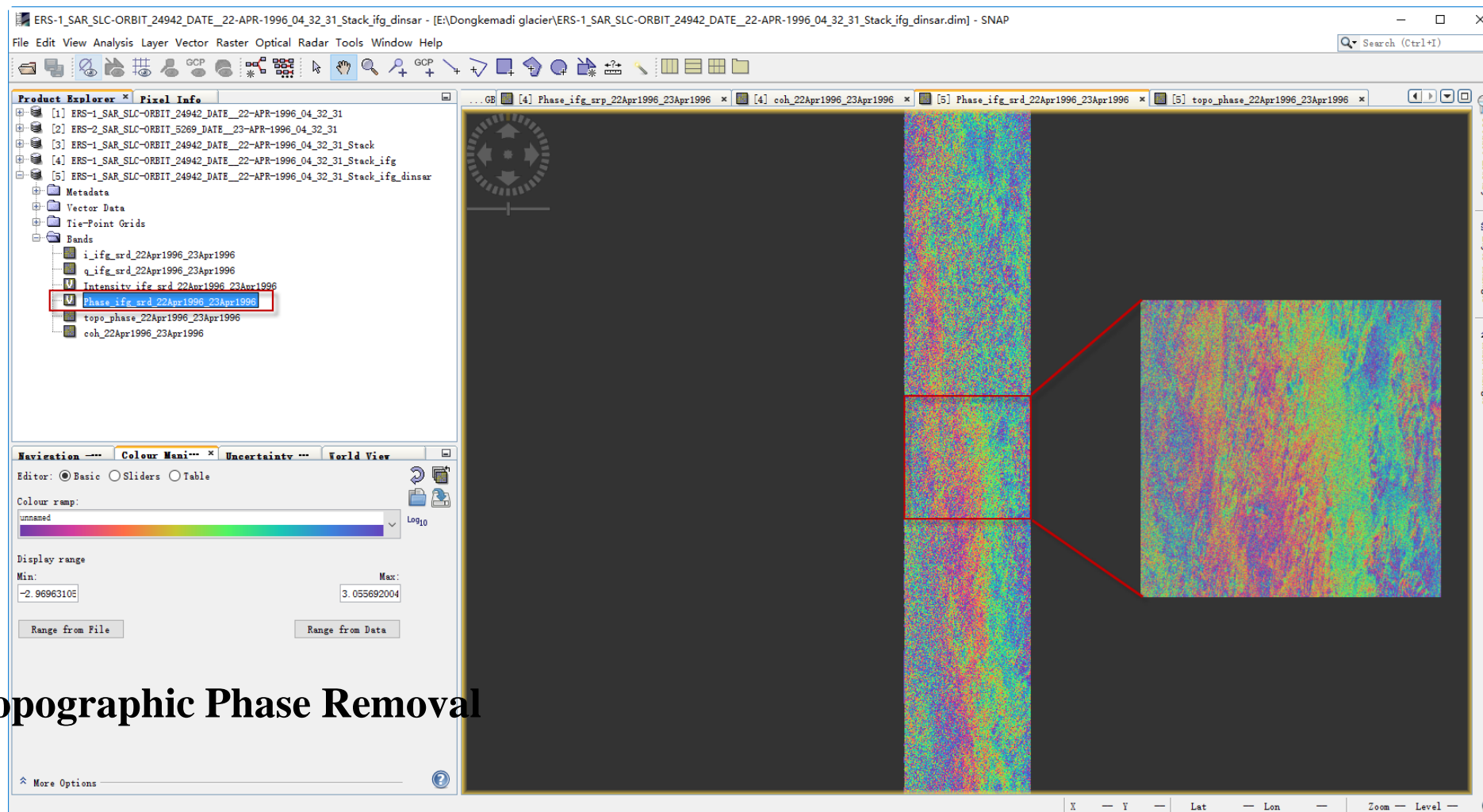
Topographic Phase Removal Dialog

Part four: Topographic Phase Removal

The screenshot displays the SNAP (Scientific Data Processing) software interface. The main window shows a color-coded phase map of a glacier area. The Product Explorer on the left lists several layers, with 'topo_phase_22Apr1996_23Apr1996' highlighted in a red box and labeled 'Topographic Phase Band'. Below the Product Explorer, the 'Colour Manager' panel is visible, showing a color ramp and display range settings. The main view shows a color-coded phase map with a red box highlighting a specific region, which is magnified in an inset view on the right.

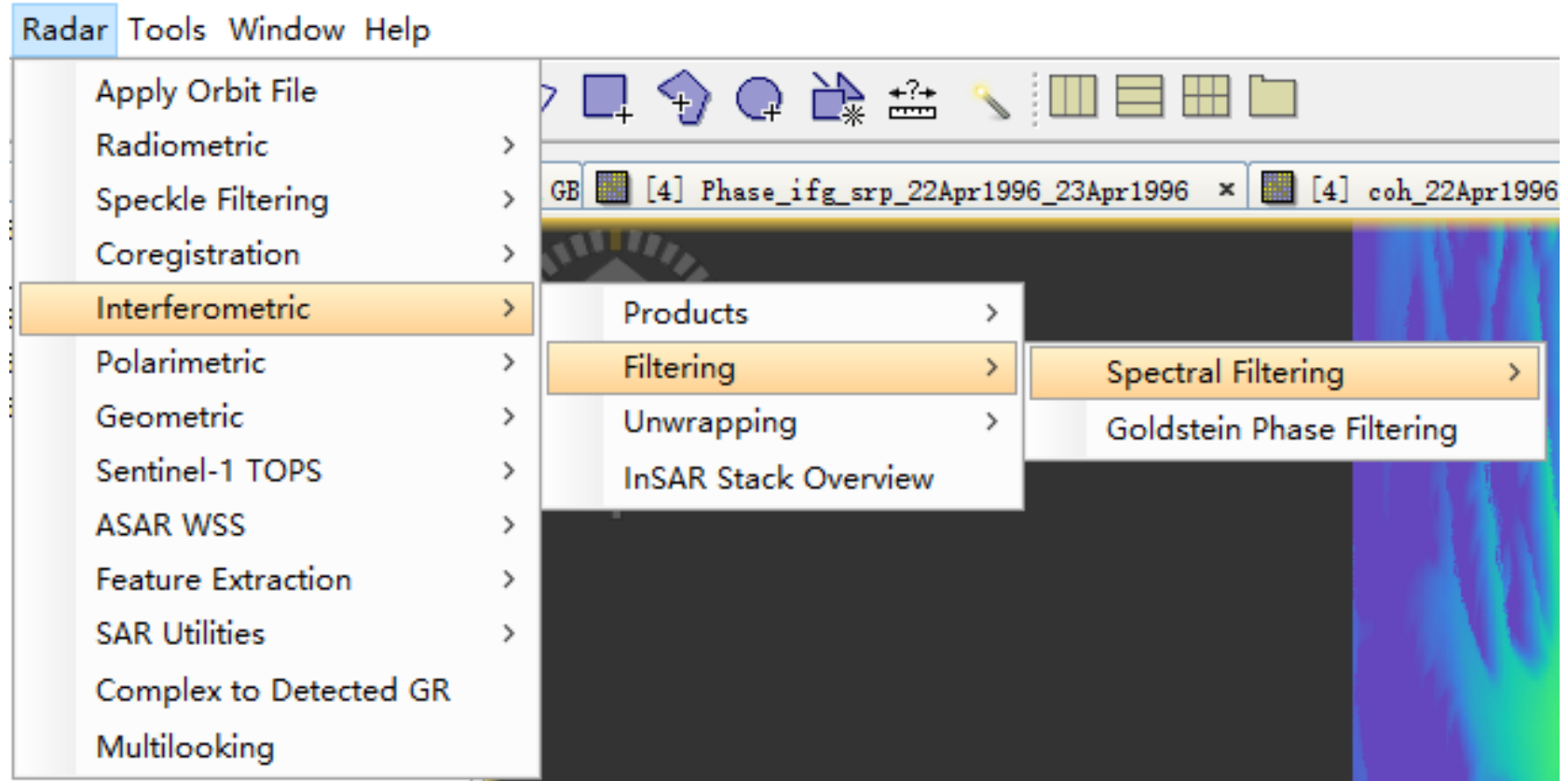
Topographic Phase Band

Part four: Topographic Phase Removal

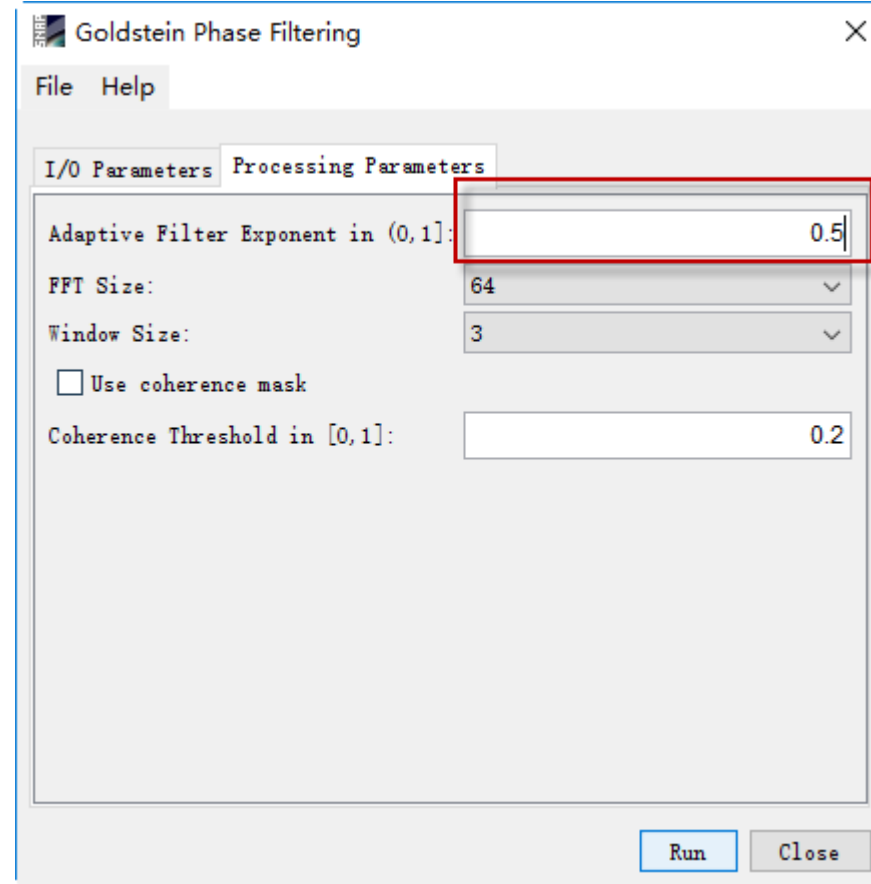
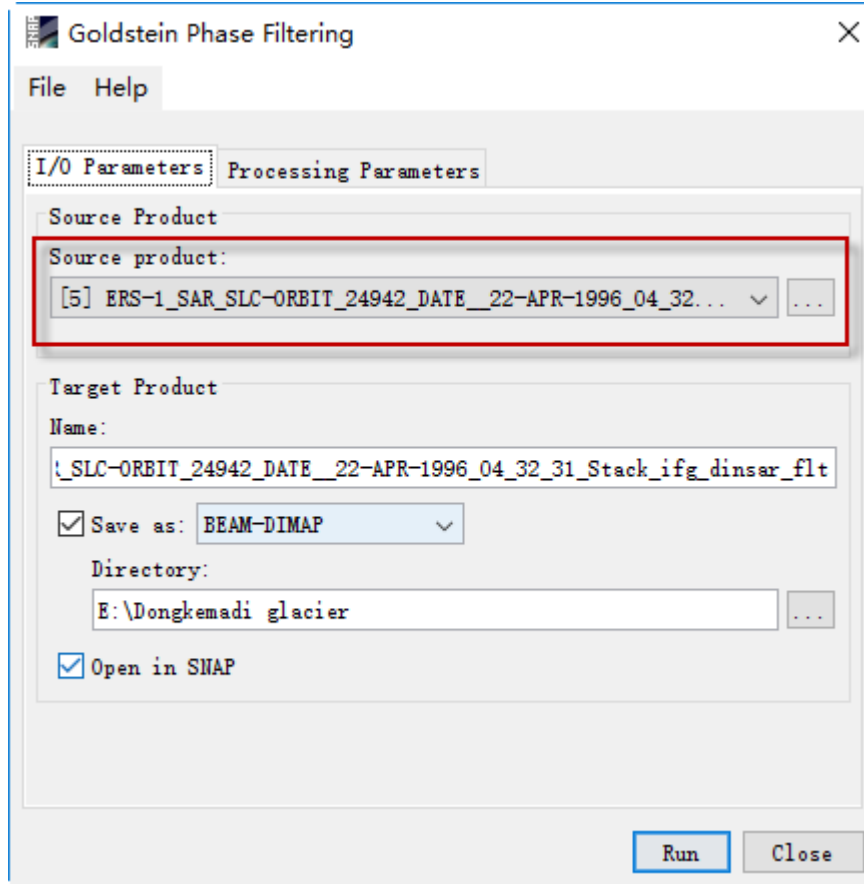


Topographic Phase Removal

Step6-Phase Filtering: Select the Interferogram product and go to the **InSAR Tools** menu. Select **Goldstein Phase Filtering**.



Select Phase Filtering



Phase Filtering Dialog

Part five: Phase Filtering

ERS-1_SAR_SLC-ORBIT_24942_DATE_22-APR-1996_04_32_31_Stack_ifg_dinsar_fit - [E:\Dongkemadi glacier\ERS-1_SAR_SLC-ORBIT_24942_DATE_22-APR-1996_04_32_31_Stack_ifg_dinsar_fit.dim] - SNAP

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Product Explorer **Pixel Info**

- [1] ERS-1_SAR_SLC-ORBIT_24942_DATE_22-APR-1996_04_32_31
- [2] ERS-2_SAR_SLC-ORBIT_5269_DATE_23-APR-1996_04_32_31
- [3] ERS-1_SAR_SLC-ORBIT_24942_DATE_22-APR-1996_04_32_31_Stack
- [4] ERS-1_SAR_SLC-ORBIT_24942_DATE_22-APR-1996_04_32_31_Stack_ifg
- [5] ERS-1_SAR_SLC-ORBIT_24942_DATE_22-APR-1996_04_32_31_Stack_ifg_dinsar
- [6] ERS-1_SAR_SLC-ORBIT_24942_DATE_22-APR-1996_04_32_31_Stack_ifg_dinsar_fit
- Metadata
- Vector Data
- Tie-Point Grids
- Bands
 - i_ifg_srd_22Apr1996_23Apr1996
 - q_ifg_srd_22Apr1996_23Apr1996
 - Intensity_ifg_srd_22Apr1996_23Apr1996**
 - Phase_ifg_srd_22Apr1996_23Apr1996**
 - topo_phase_22Apr1996_23Apr1996
 - coh_22Apr1996_23Apr1996

Navigation **Colour Mani...** **Uncertainty...** **World View**

Editor: Basic Sliders Table

Colour ramp: unnamed Log₁₀

Display range
 Min: -2.9329003E Max: 2.95749707E
 Range from File Range from Data

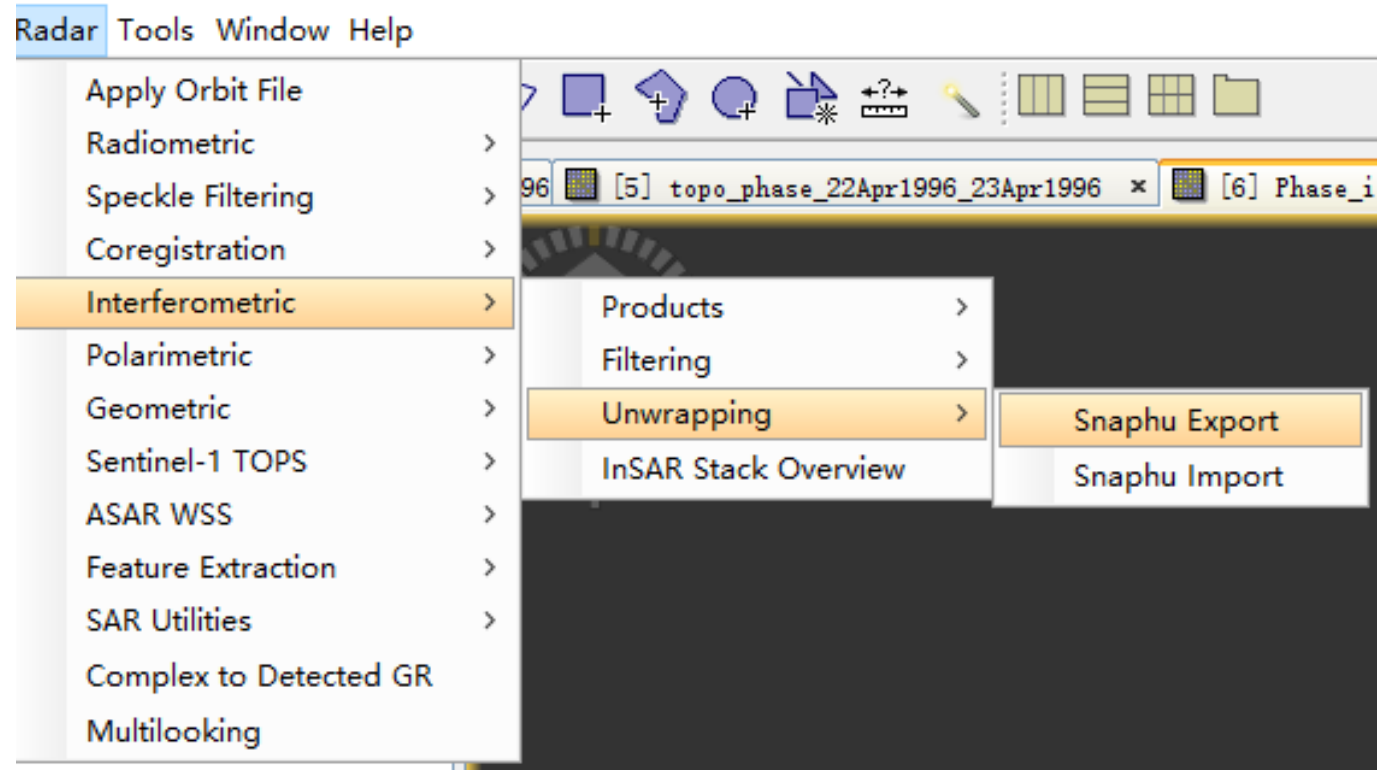
Filtered Phase Band

Product Library Layer Manager Mask Manager

X Y Lat Lon Zoom Level

Part six: Phase Unwrapping

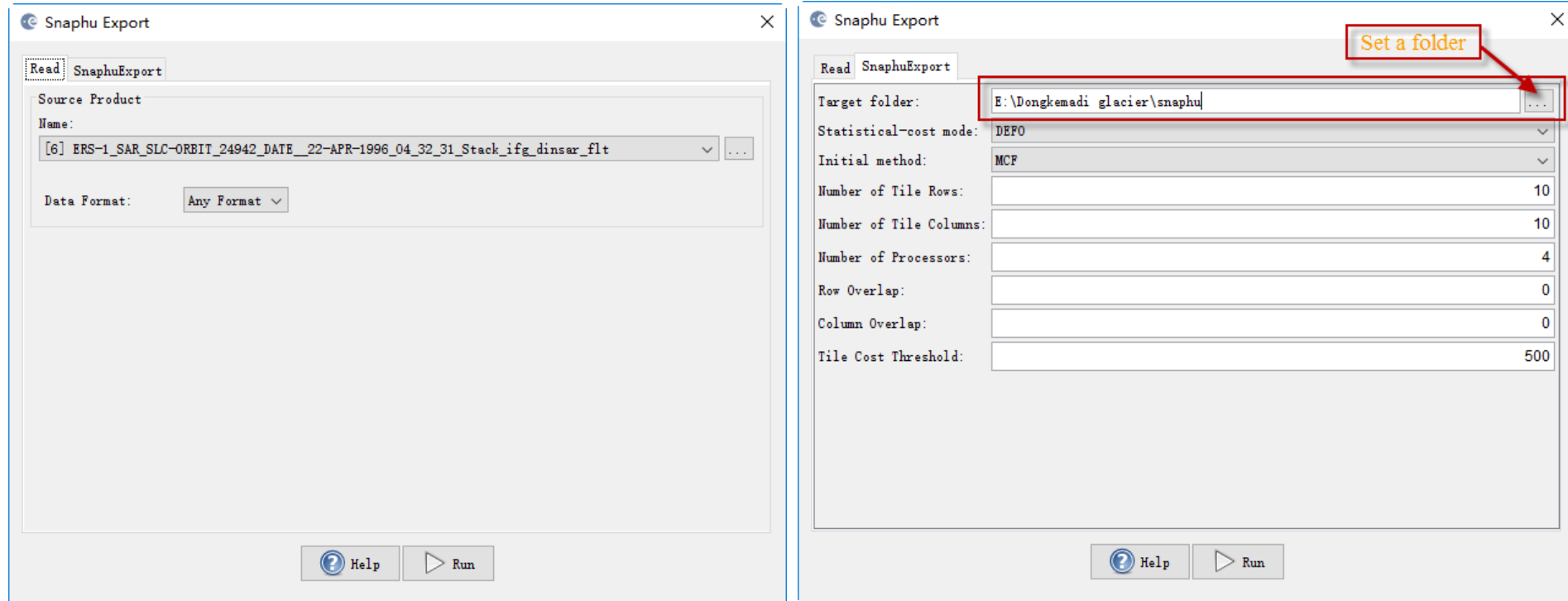
Step7-Export to
 Snaphu: Export
 the filtered
 flattened
 interferogram to
 SNAPHU.



Export to Snaphu

Part six: Phase Unwrapping

Select **DEFO** for deformation mapping.



Snaphu Export

Part seven: Unwrapping with SNAPHU

Snaphu is available for **Linux** only. Linux users simply need to install the software package by

```
apt-get install snaphu
```

Windows users can download a Linux VMWare virtual machine and use it to unwrap the phase.

http://sourceforge.net/projects/s1tbx/files/snaphu_vm/SAR%20Mint%2064.zip/download

The free VMWare Workstation Player can be downloaded from

<https://my.vmware.com/web/vmware/downloads>

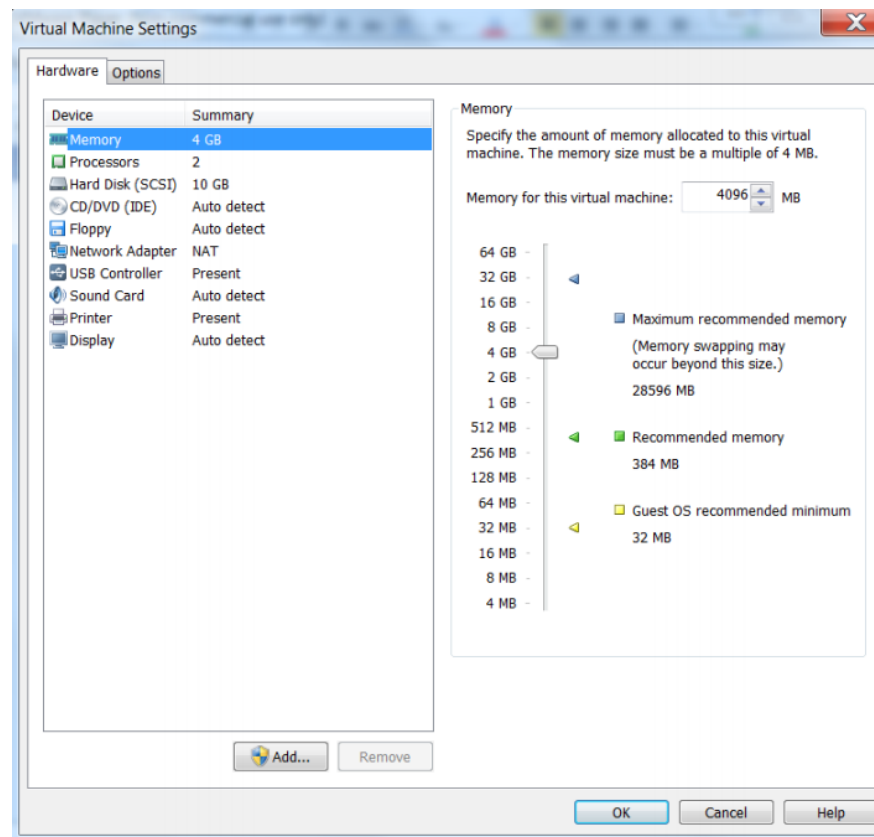
Open the VMware player and browse for the virtual machine.

Part seven: Unwrapping with SNAPHU

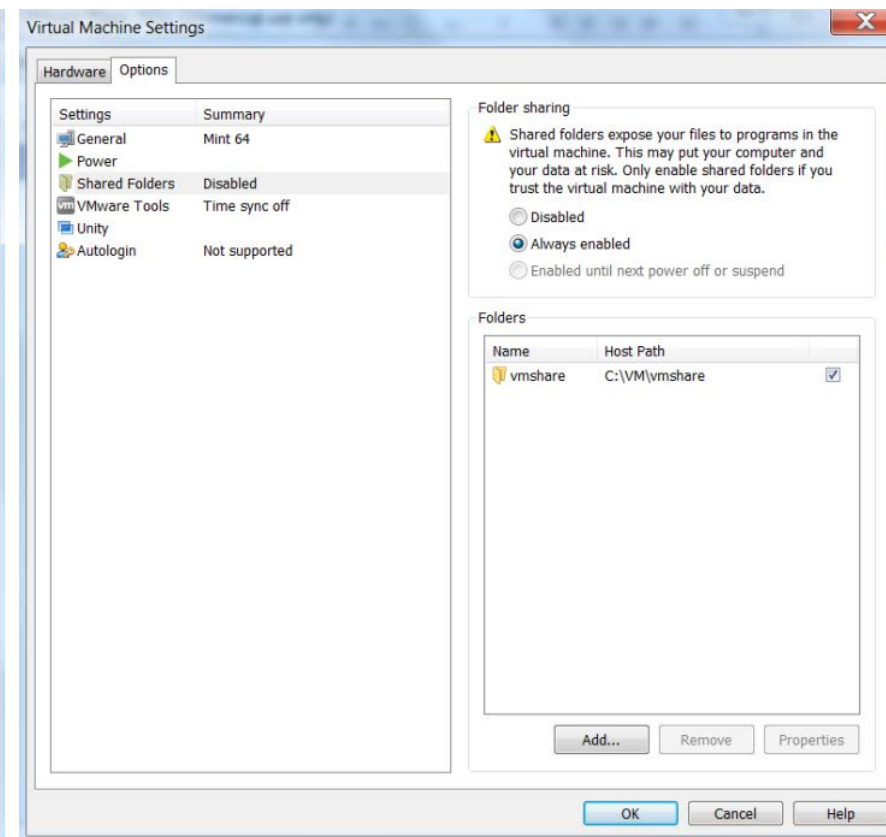


Edit Virtual Machine Settings

Increase the memory to suit your computer. Depending on the size of your images, you may need at least **8GB**. Under the **options** tabs, add a shared folder. Select **‘Always Enable’**.

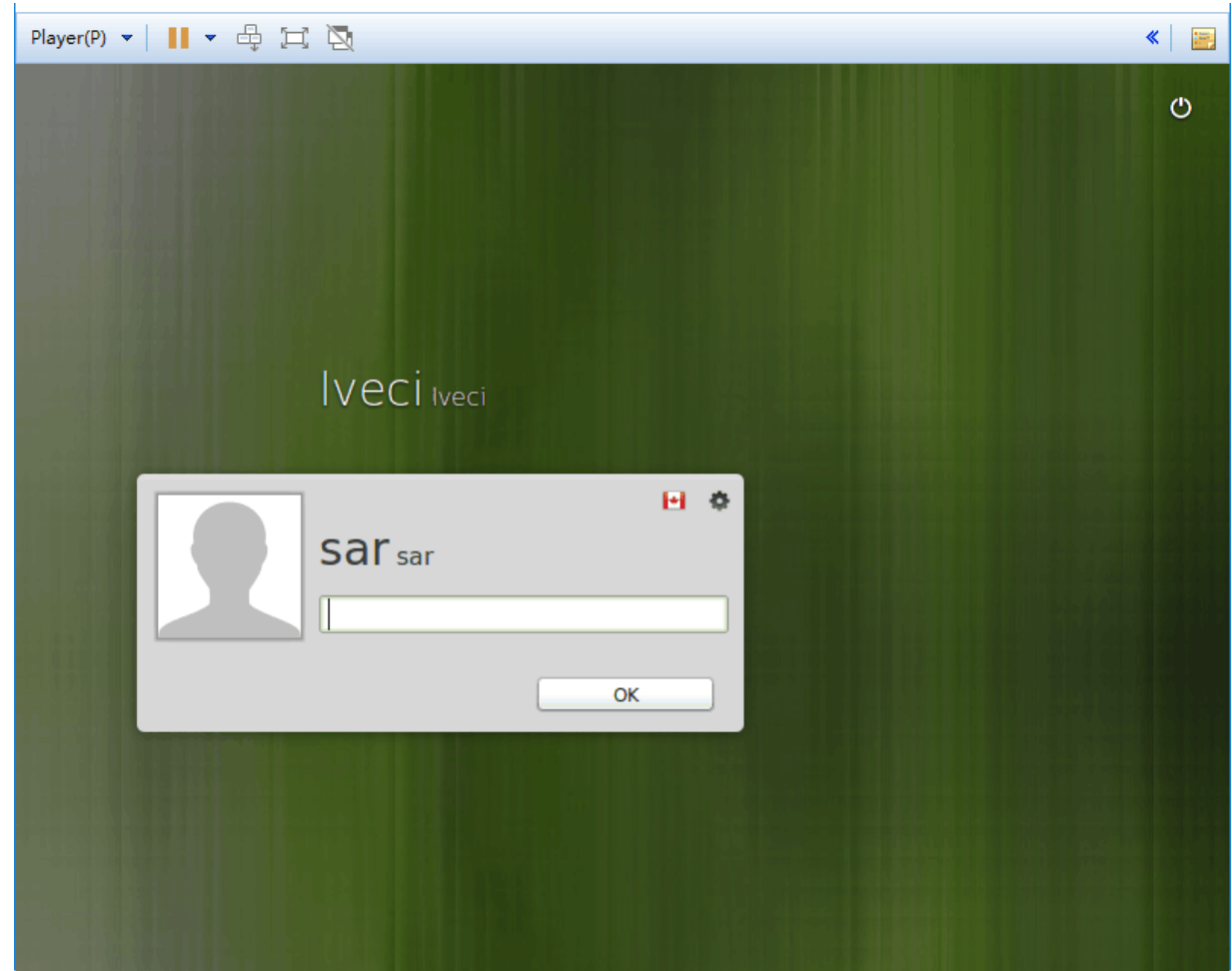


Increase Memory



Enable a Shared Folder

Part seven: Unwrapping with SNAPHU



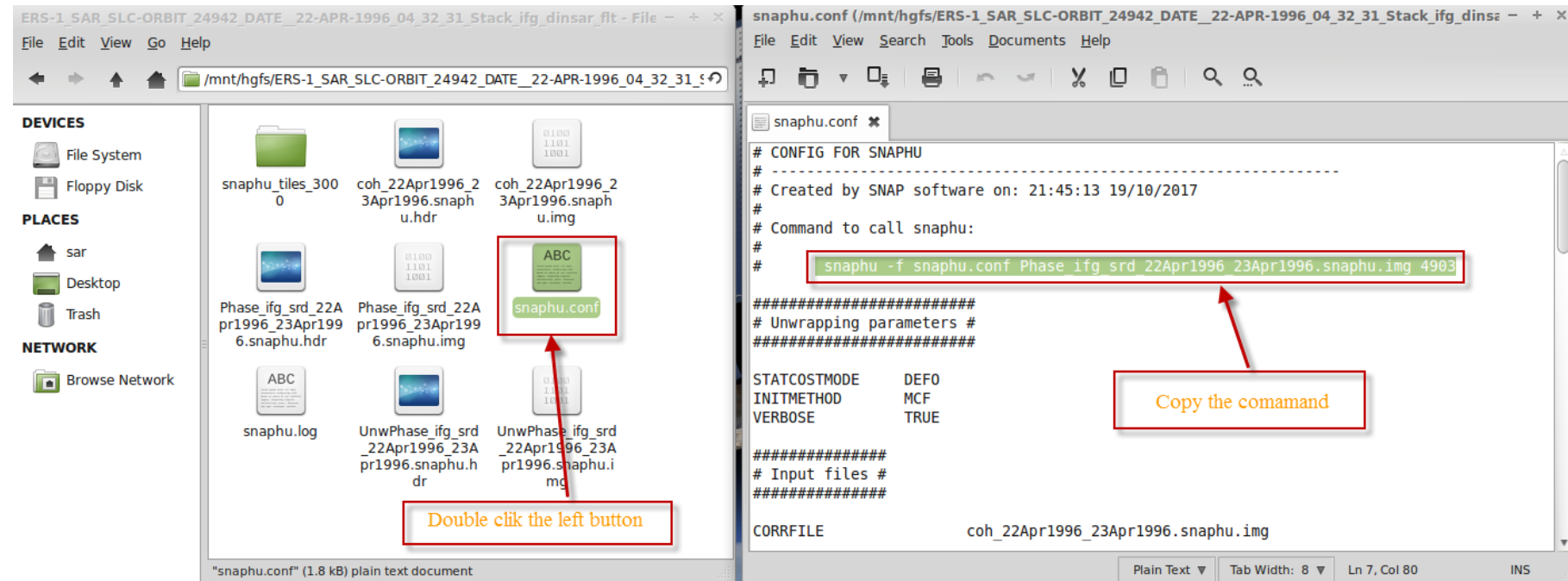
Login: sar

Password: sar01

Go to the data folder in `/mnt/hgfs/` and open the `snaphu.conf` file.

`cd /mnt/hgfs/vmshare/data/target_snaphu/`

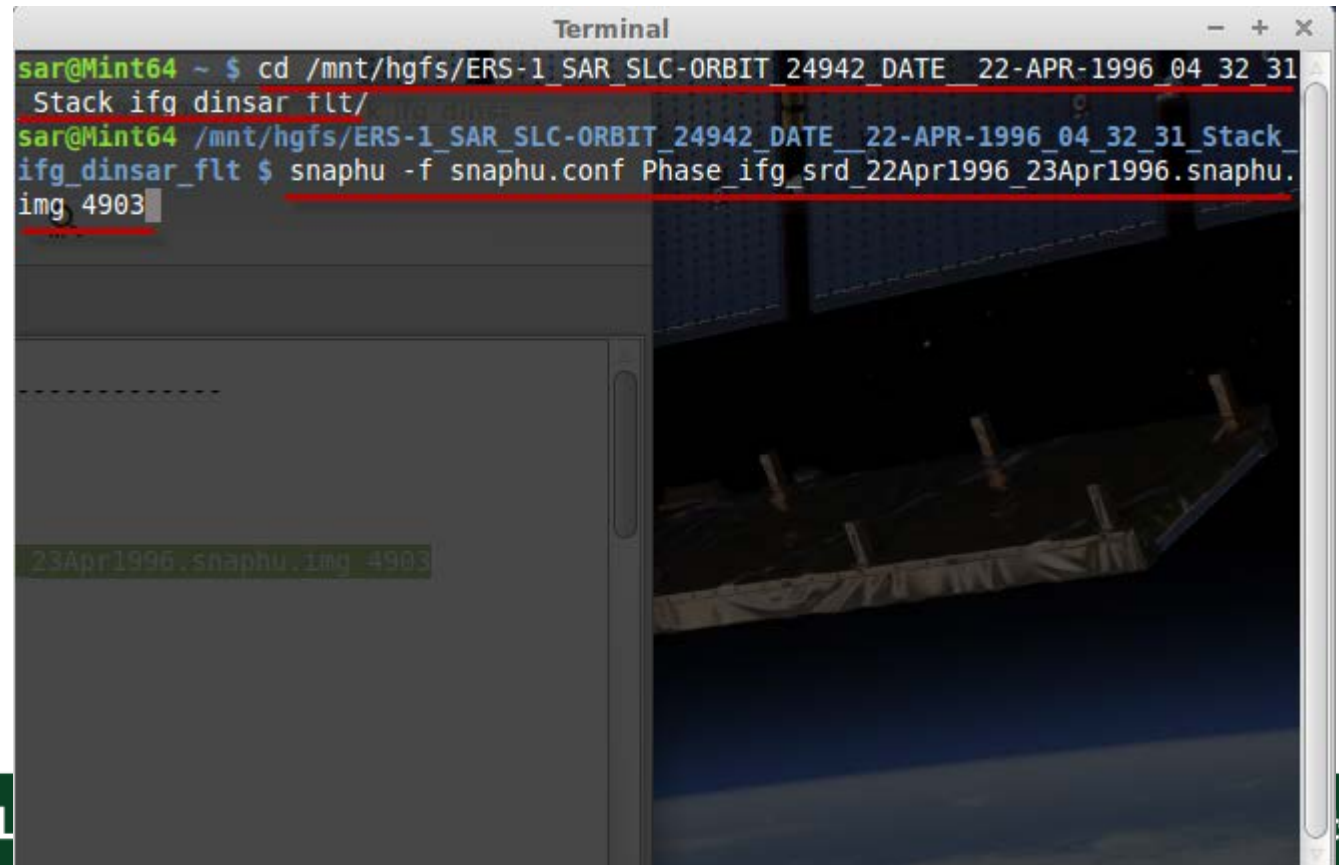
`gedit snaphu.conf`



Part seven: Unwrapping with SNAPHU

Copy the snaphu command and paste it into the command terminal and then run it.

```
snaphu -f snaphu.conf Phase_ifg_srd_22Apr1996_23Apr1996.snaphu.img 4903
```



```
Terminal
sar@Mint64 ~ $ cd /mnt/hgfs/ERS-1_SAR_SLC-ORBIT_24942_DATE_22-APR-1996_04_32_31_Stack_ifg_dinsarflt/
sar@Mint64 /mnt/hgfs/ERS-1_SAR_SLC-ORBIT_24942_DATE_22-APR-1996_04_32_31_Stack_ifg_dinsarflt $ snaphu -f snaphu.conf Phase_ifg_srd_22Apr1996_23Apr1996.snaphu.img 4903
```

Part seven: Unwrapping with SNAPHU

SNAPHU uses an iterative optimization procedure; its execution time depends on the difficulty of the interferogram.

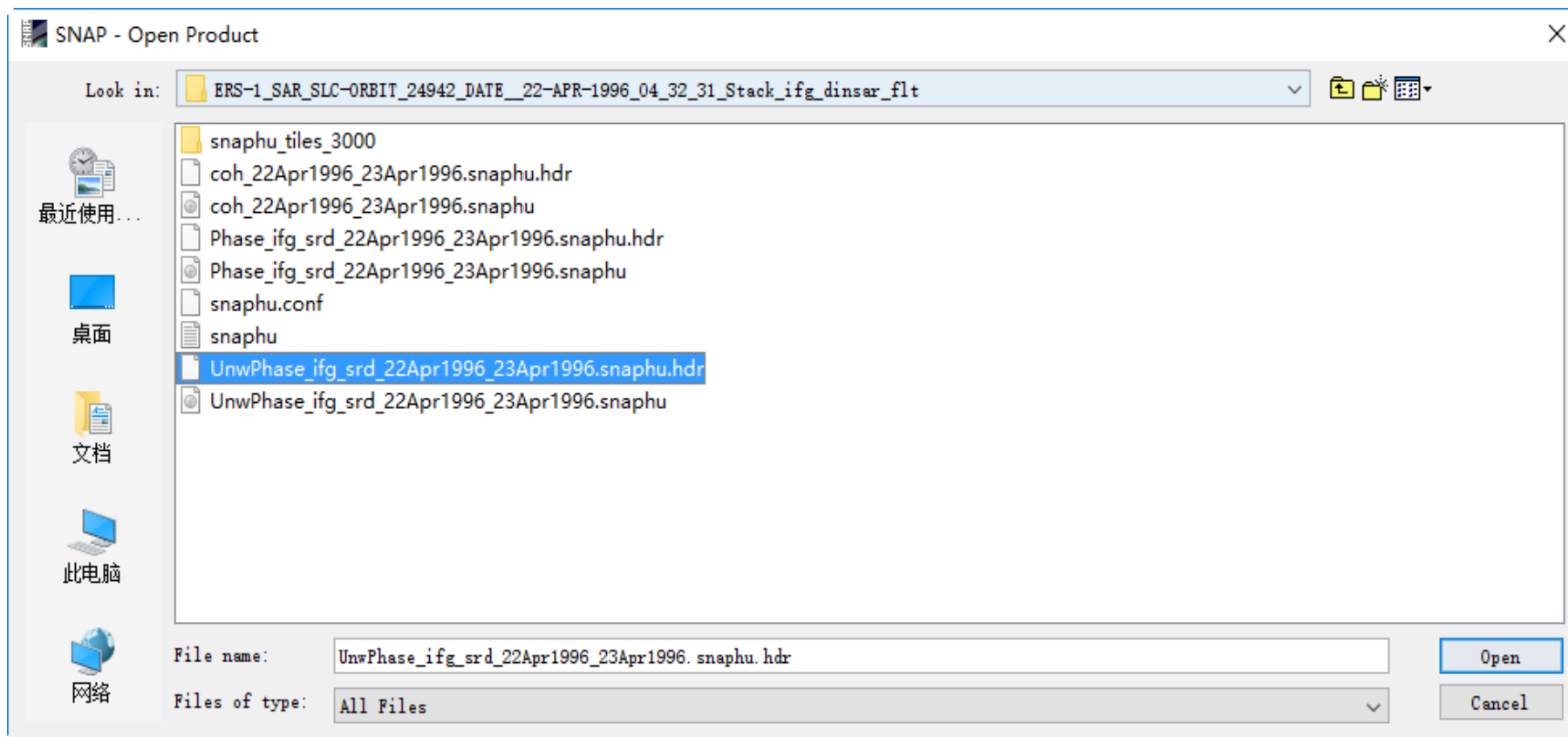
Unwrapping can use a lot of memory. If the unwrapping fails due to there being not enough memory, you could create a subset of your area of interest and try with SNAPHU again.

```

Terminal
Unwrapping tile at row 9, column 7 (pid 3434)
Unwrapping tile at row 9, column 8 (pid 3436)
Unwrapping tile at row 9, column 9 (pid 3438)
Assembling tiles
Running optimizer for secondary network -----
Flow increment: 1 (Total improvements: 70)
765 incremental costs clipped to avoid overflow (0.001%)
Treesize: 402188 Pivots: 3312980 Improvements: 39890
Flow increment: 2 (Total improvements: 39890)
145 incremental costs clipped to avoid overflow (0.000%)
Treesize: 402188 Pivots: 53 Improvements: 0
Flow increment: 3 (Total improvements: 39890)
144 incremental costs clipped to avoid overflow (0.000%)
Treesize: 402188 Pivots: 1 Improvements: 0
Flow increment: 4 (Total improvements: 39890)
144 incremental costs clipped to avoid overflow (0.000%)
Treesize: 402188 Pivots: 0 Improvements: 0
Integrating secondary flows
Output written to file UnwPhase_ifg_srd_22Apr1996_23Apr1996.snaphu.img
Program snaphu done
Elapsed processor time: 3:43:32.16
Elapsed wall clock time: 0:58:48
sar@Mint64 /mnt/hgfs/ERS-1_SAR_SLC-ORBIT_24942_DATE_22-APR-1996_04_32_31_Stack_
ifg_dinsarflt$ cat 22Apr1996_23Apr1996.snaphu.img
  
```


Part eight: Import Snaphu Umwrapped Phase

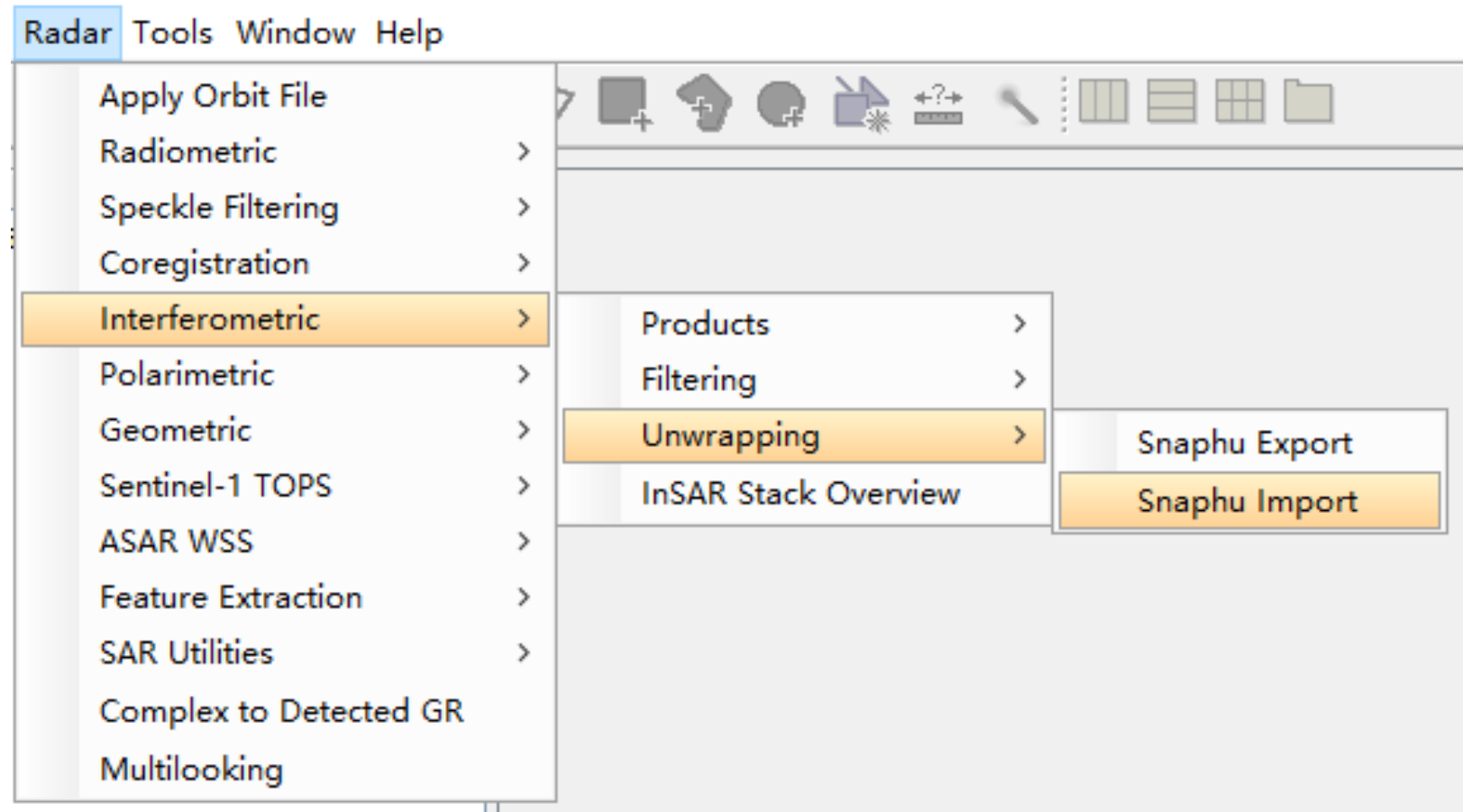
Step8-Open the Unwrapped phase hdr file



Open Unwrapped Phase Dialog

Part eight: Import Snaphu Umwrapped Phase

Step9-Import the Unwrapped phase:
 Select Snaphu Import from the interferometric menu

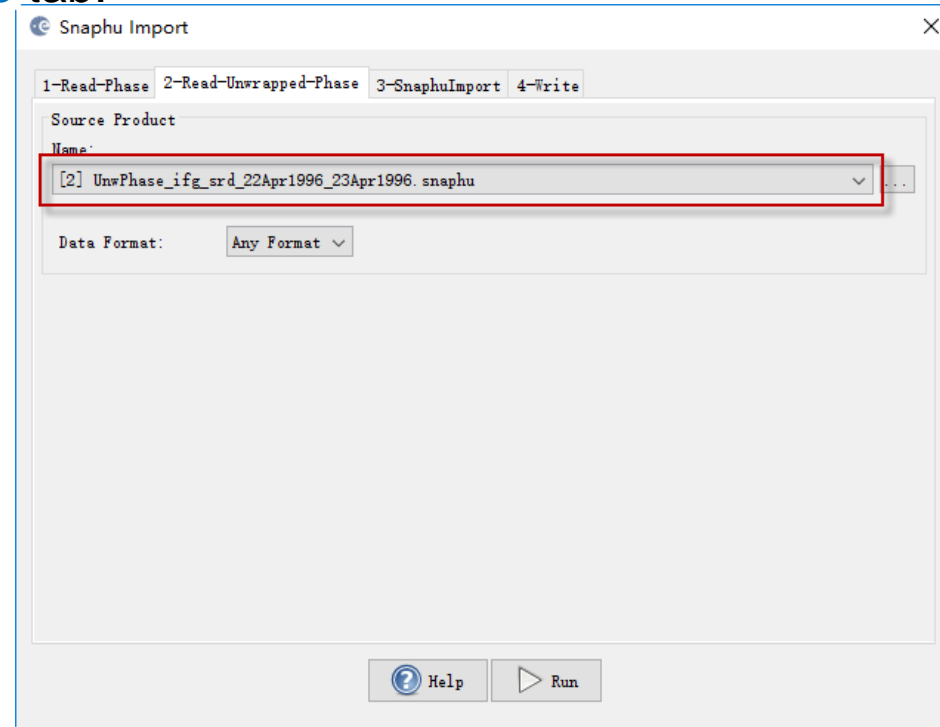
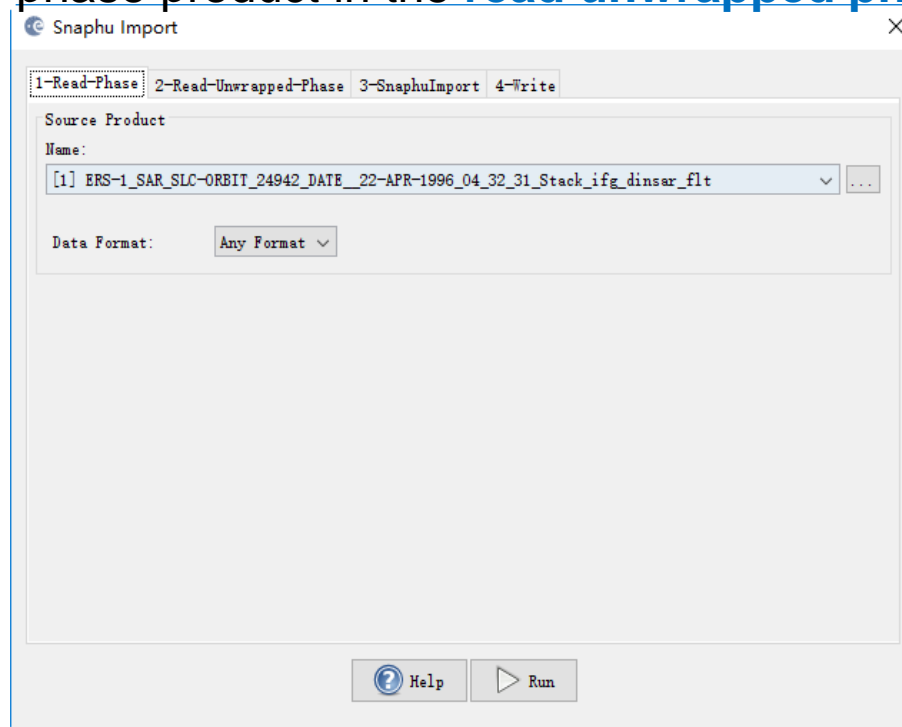


Import Unwrapped Phase Dialog

Part eight: Import Snaphu Umwrapped Phase

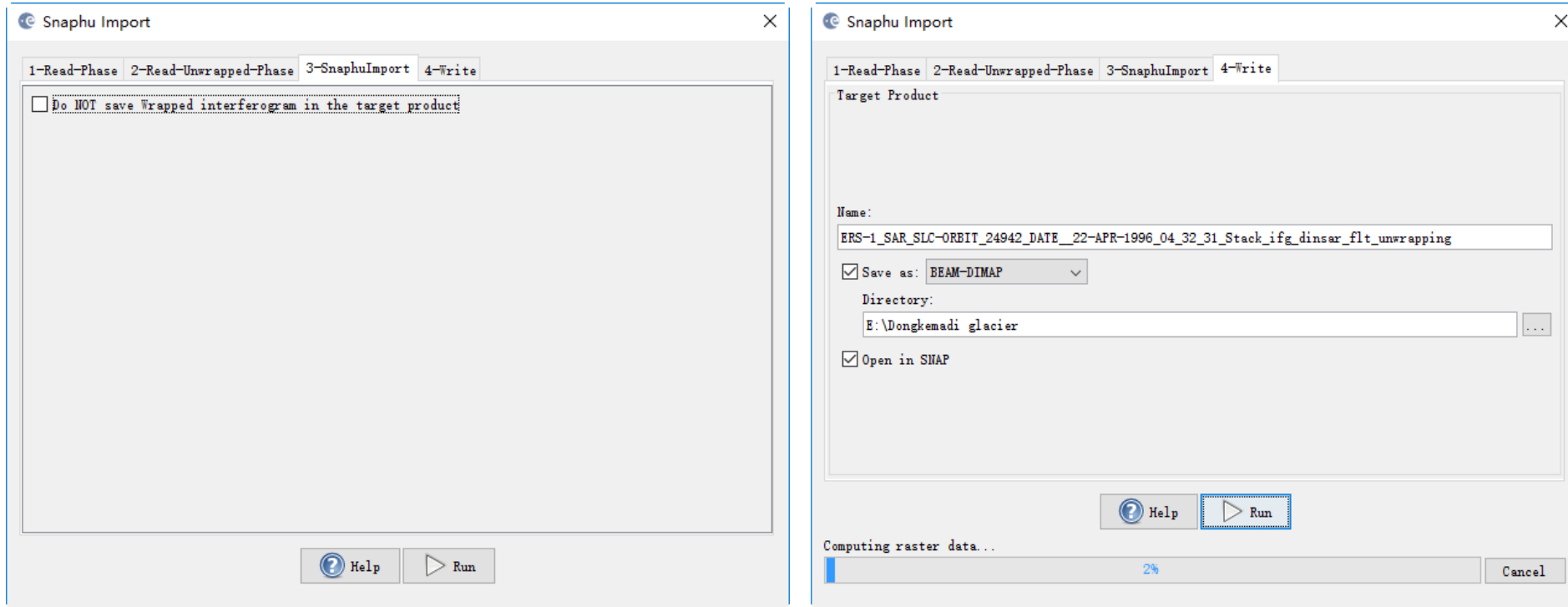
Select the wrapped phase in the **read phase** tab.

Select the unwrapped phase product in the **read unwrapped phase** tab.



Snaphu Import Dialog

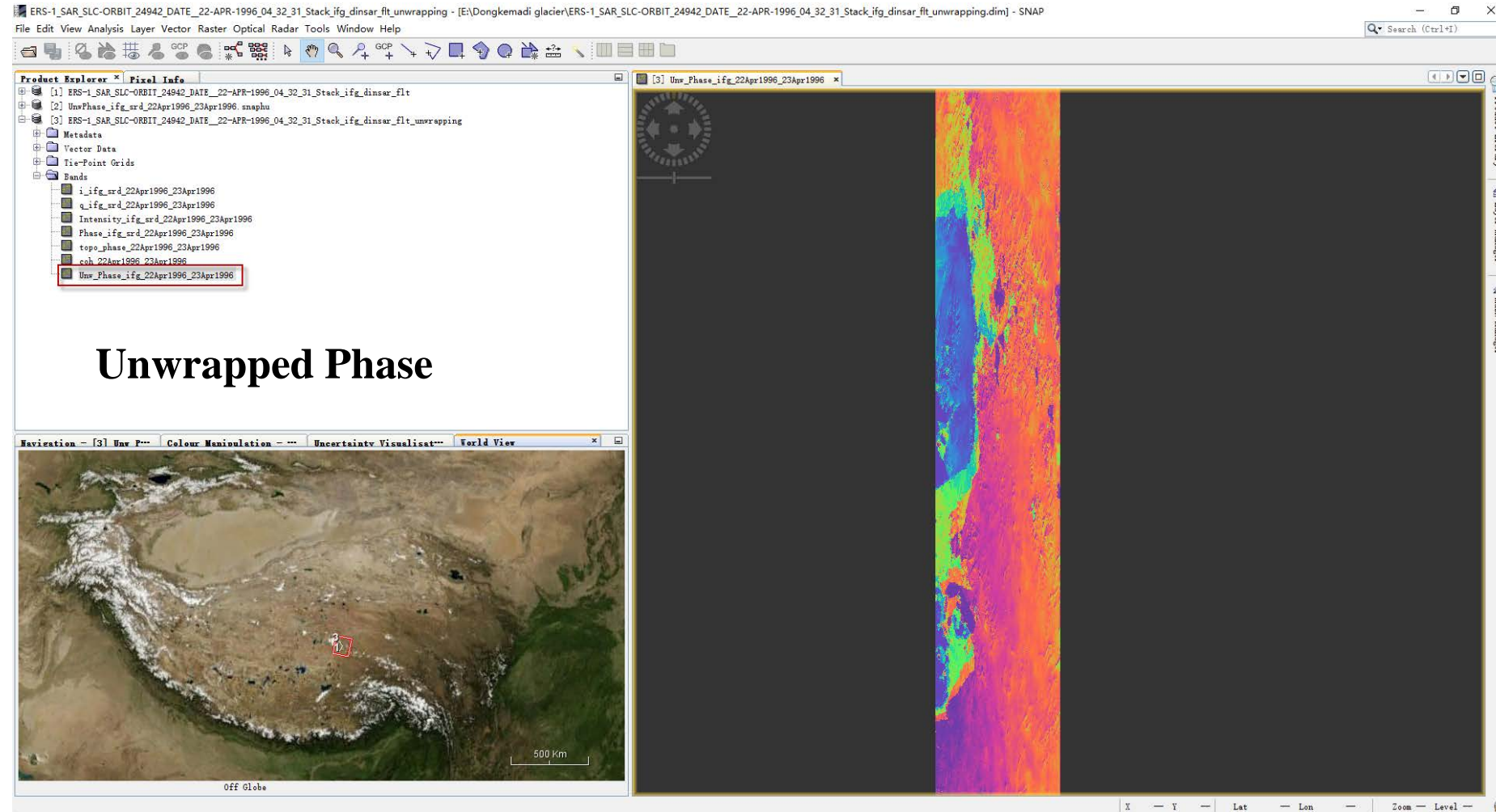
Part eight: Import Snaphu Umwrapped Phase



Snaphu Import Dialog

Part eight: Unwrapped Phase

Process and display the output unwrapped phase



Unwrapped Phase

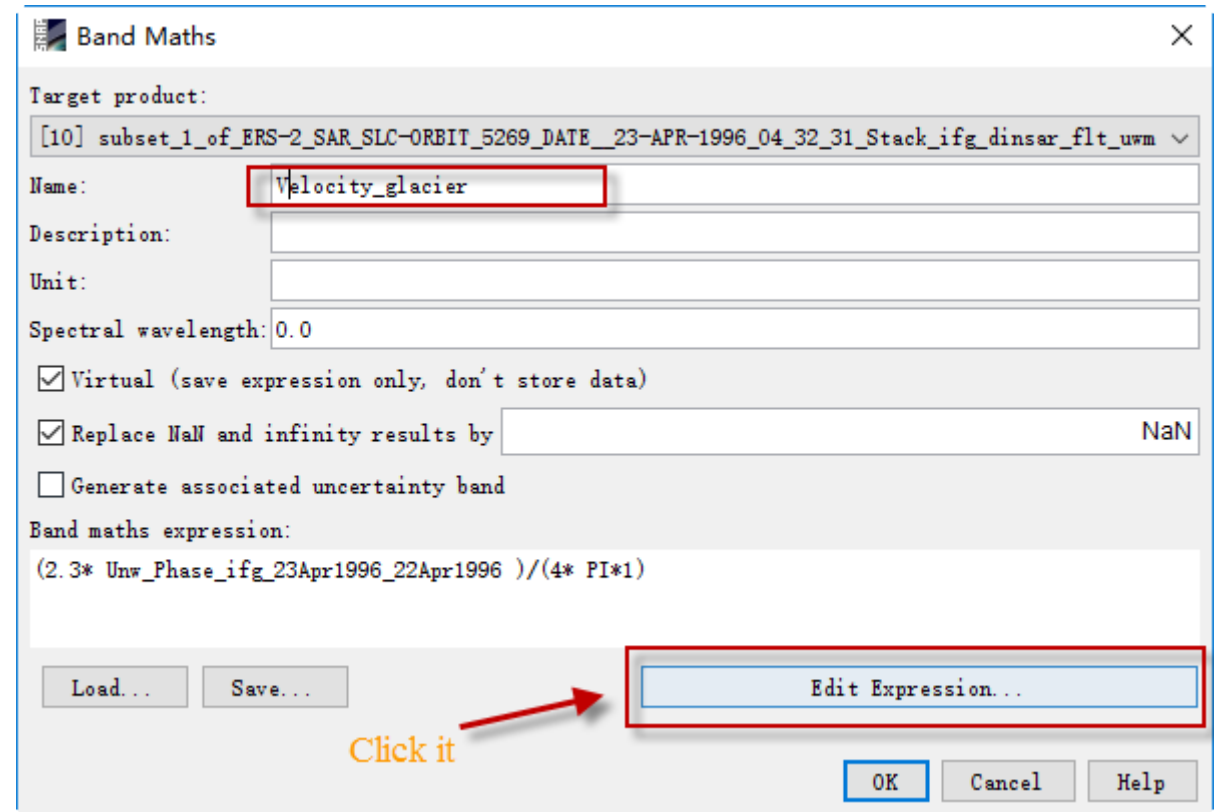
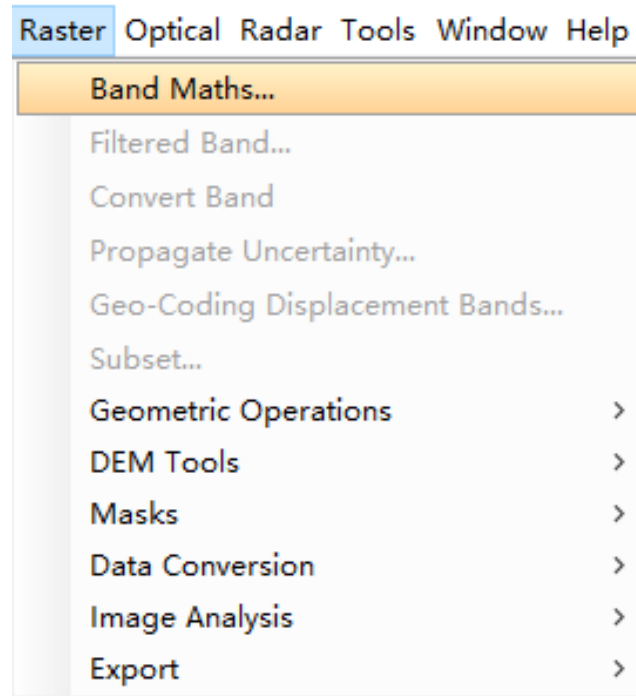
Part nine: Convert the Differential phase to glacier velocity

Using the ENVI bandmath tools to process

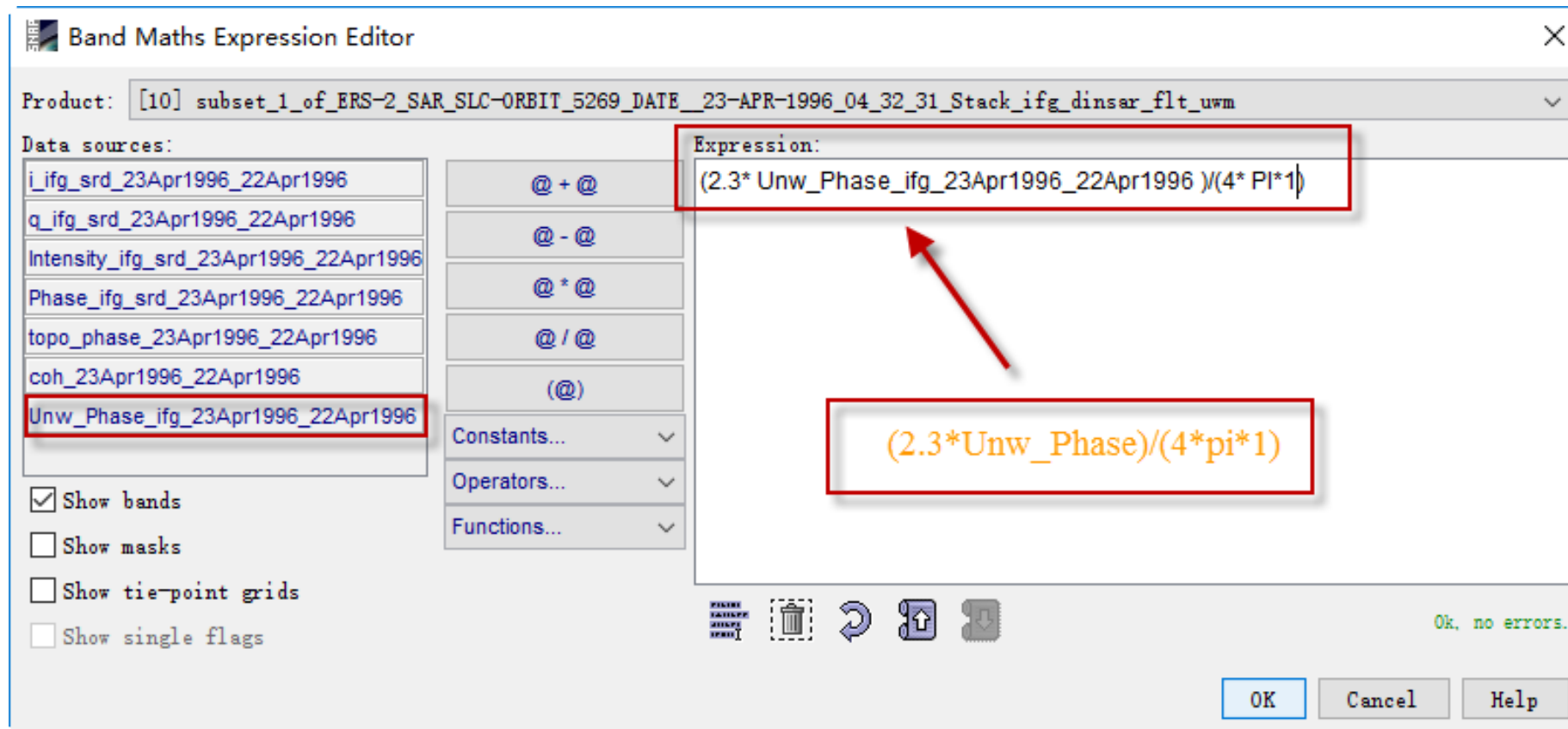
$$\Delta\phi_{disp} = -\frac{4\pi}{\lambda} \Delta r = -\frac{4\pi}{\lambda} v_l \Delta t$$

$$v_l = -\frac{\lambda \Delta\phi_{disp}}{4\pi \Delta t}$$

Part nine: Convert the Differential phase to glacier velocity

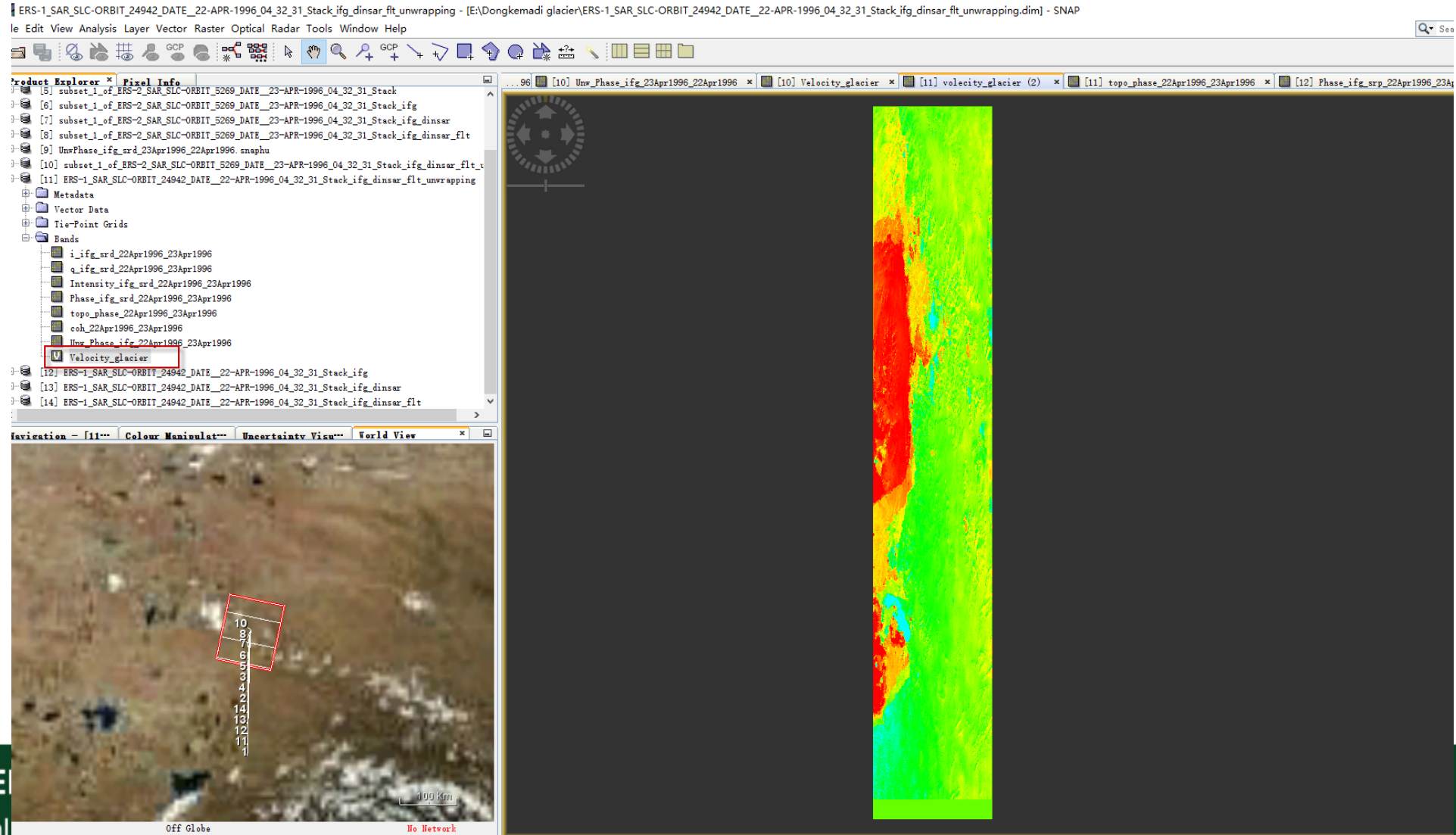


Part nine: Convert the Differential phase to glacier velocity



Band Maths Expression Editor Dialog

Part nine: Convert the Differential phase to glacier velocity



Glacier Velocity



THANKS

ADVANCED LAND REMOTE SENSING INTERNATIONAL TRAINING COURSE

20–25 November 2017 | Yunnan Normal University Kunming, Yunnan Province, P.R. China

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2017年11月20日—11月25日 云南师范大学, 中国, 昆明