Forest SAR & Coherence

(Practical Session 2)

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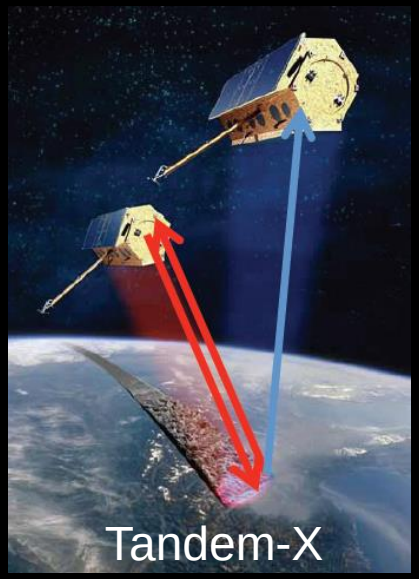
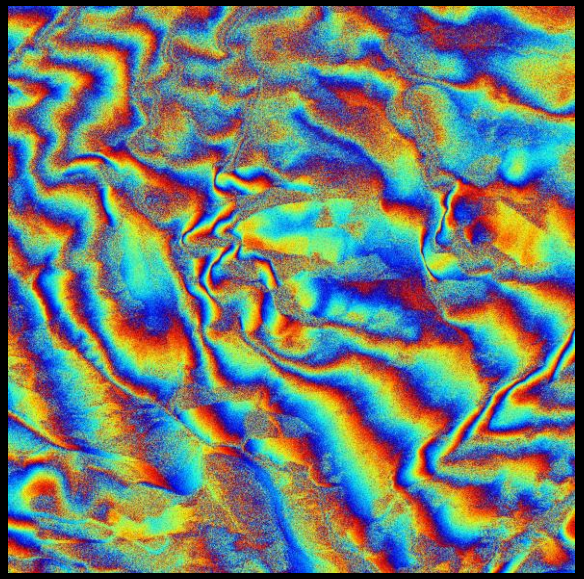
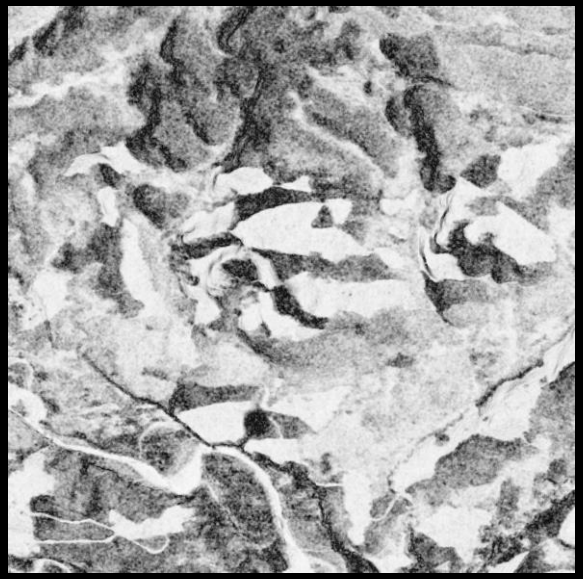
Forest Height inversion Based on Coherence

Software required: PolSARpro & SNAP

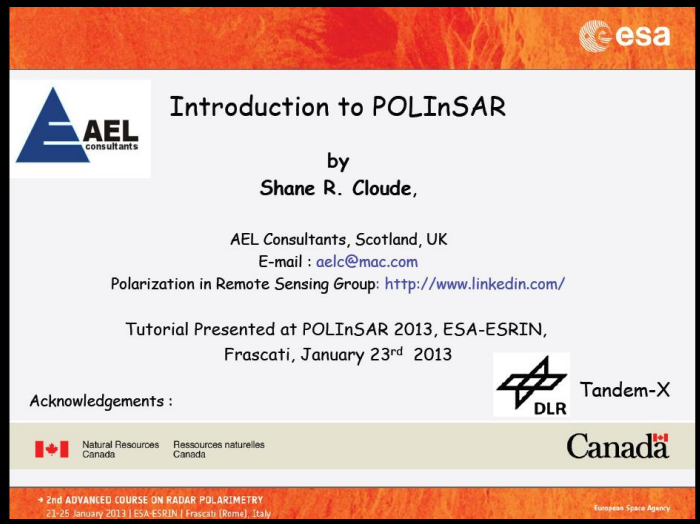




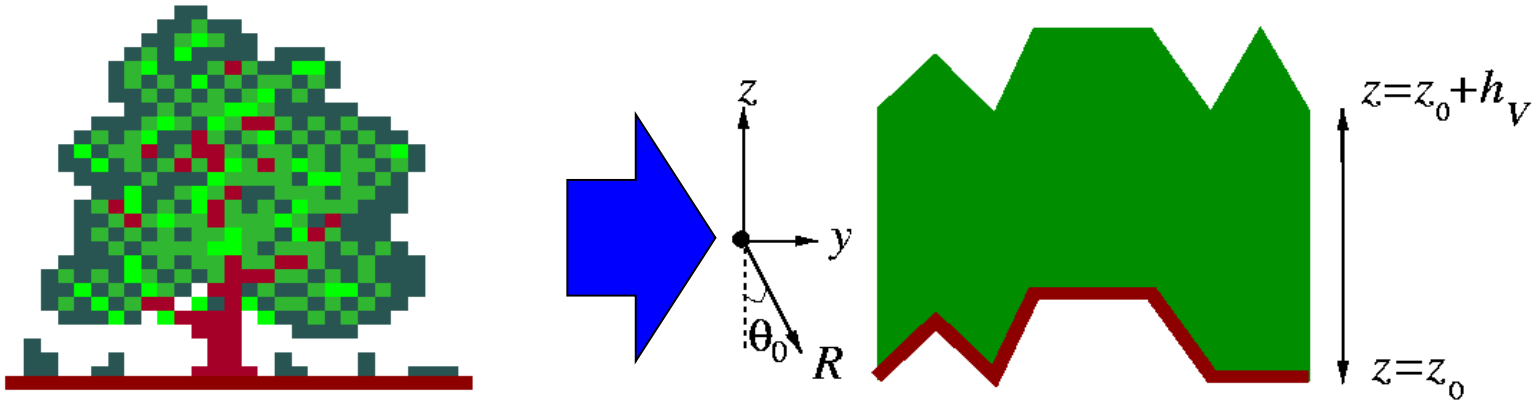


Acknowledgements

- This practical is based on the tutorial presented at POLInSAR 2013. (Prof. Cloude)
- Tandem-X Radar Data provided courtesy of DLR, Germany.
- Lidar Forest height validation Kmz file provided courtesy of Canadian forestry Service, Victoria, BC



VOLUME COHERENCE MODEL



$$\gamma_{VOL} = e^{j\phi_0} \frac{\int_0^{h_v} f(z) e^{jk_z z} dz}{\int_0^{h_v} f(z) dz}$$

Topographic Phase: ϕ_0

Vertical Wavenumber: $k_z = \frac{4\pi\Delta\theta}{\lambda \sin(\theta_0)}$

If *f(z)* = 1 , a constant structure function, the volume coherence model becomes a function only of tree height.

SINC model

$$\gamma_{VOL} = e^{j\varphi_0} \frac{\int_0^{h_v} f(z) e^{jk_z z} dz}{\int_0^{h_v} f(z) dz}$$

Based on the SINC model, forest height can be inverted as long as we obtain k_z and coherence (γ_{VOL}).

$f(z) = 1$

$$\gamma_{VOL} = sinc(k_z h_v / 2)$$

Only two unknown parameters!

$$h_v = 2\pi \left(1 - 2\, asin(|\gamma_{VOL}|^{0.8}) / \pi\right) / k_z$$

Working plan

Part 1. Coherence Estimation

1. Load Tandem-X data
2. Select Sub-Region
3. InSAR set up
4. Interferogram
5. Flat earth estimate
6. Flat earth remove
7. Coherence
8. Save Coherence Magnitude
9. Geocoding Coherence

Part 2. K_z calculation

10. Fixed K_z
    - Ambiguity height (*hoa*)

$$k_z = \frac{4\pi\Delta\theta}{\lambda \sin(\theta_0)} = 2\pi / hoa$$

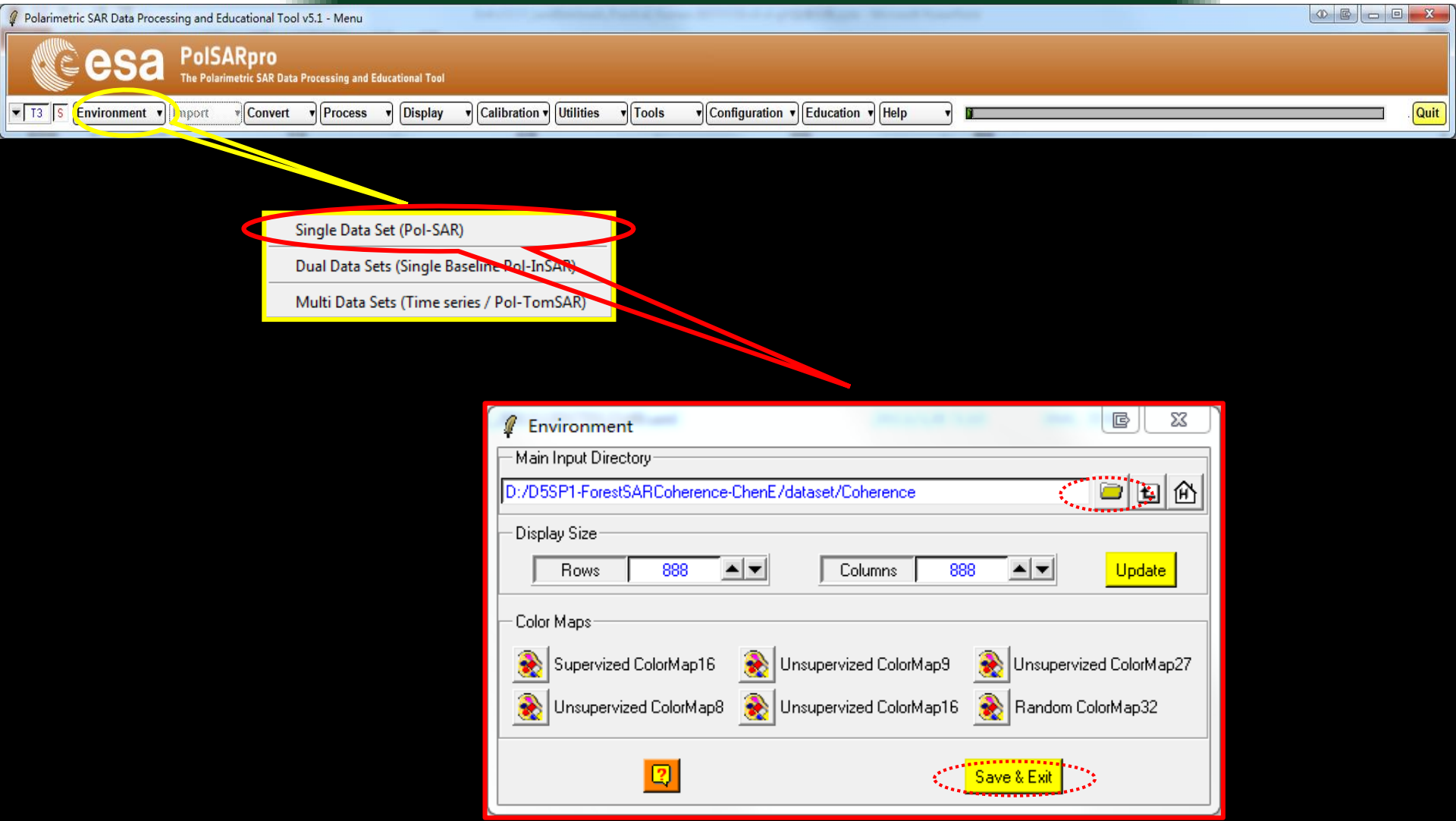
11. Local K_z
    - Local incidence angle file (θ_{loc})
    - Angle of incidence center (θ_0)

$$k_z = \frac{4\pi\Delta\theta}{\lambda \sin(\theta_{loc})} = \frac{2\pi \sin(\theta_0)}{hoa \cdot \sin(\theta_{loc})}$$

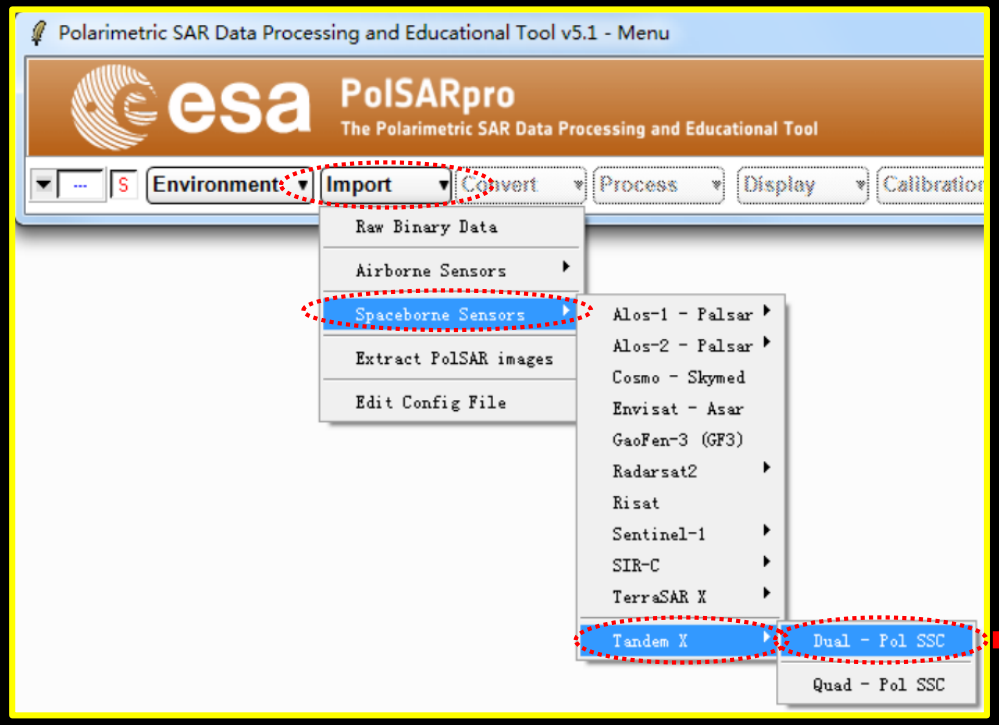
Part 3. Height inversion

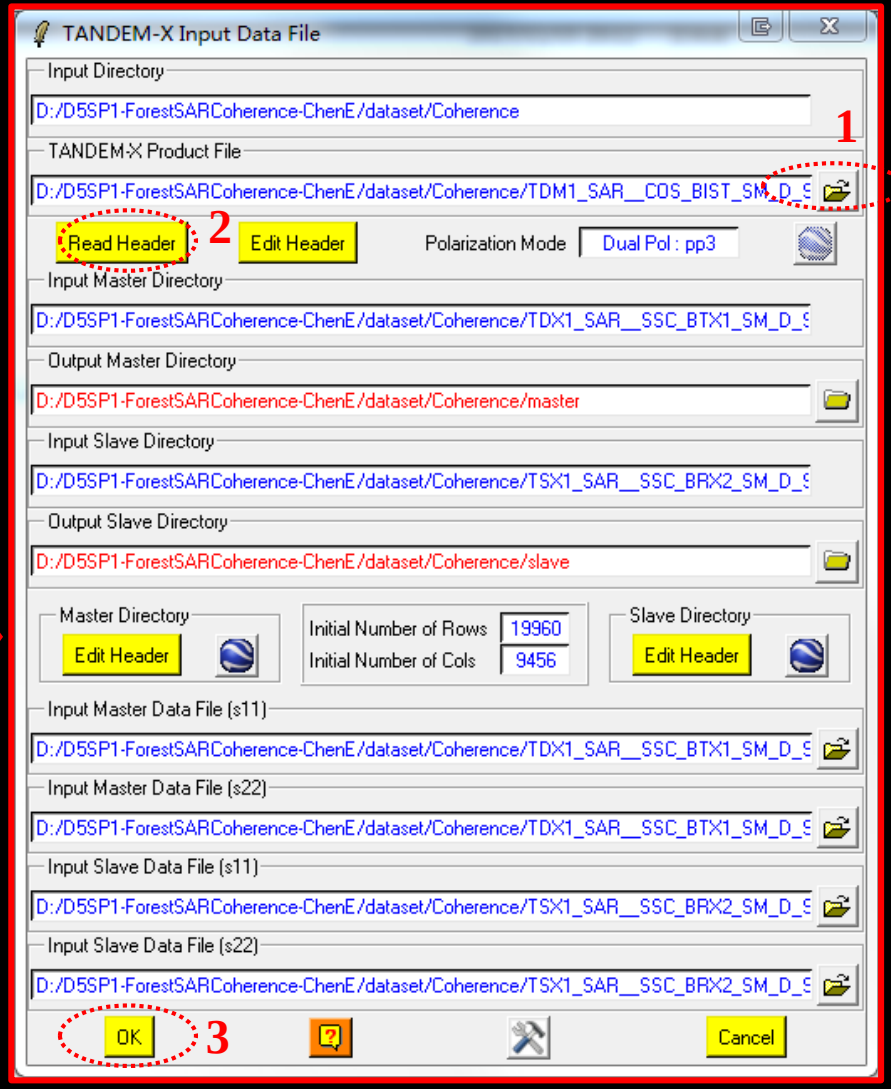
$$h_v = 2\pi\left(1 - 2\,asin(|\gamma|^{0.8}) / \pi\right) / k_z$$

Step1: Load Tandem-X data

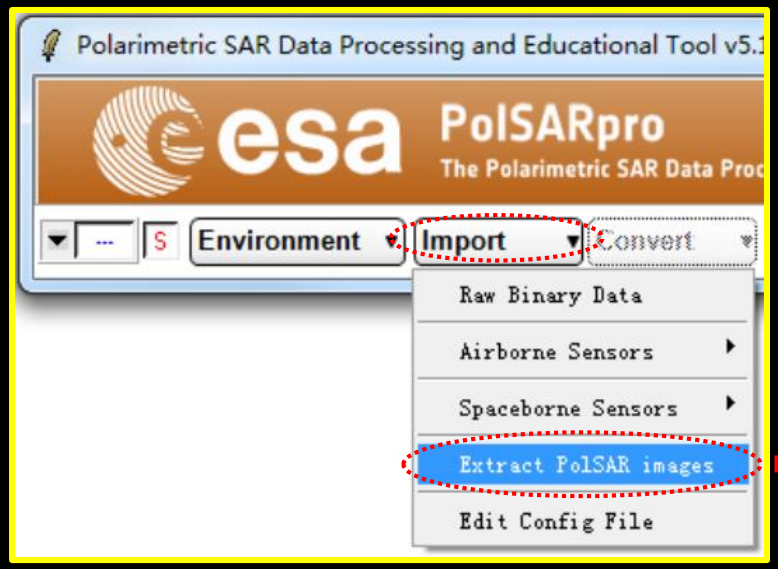


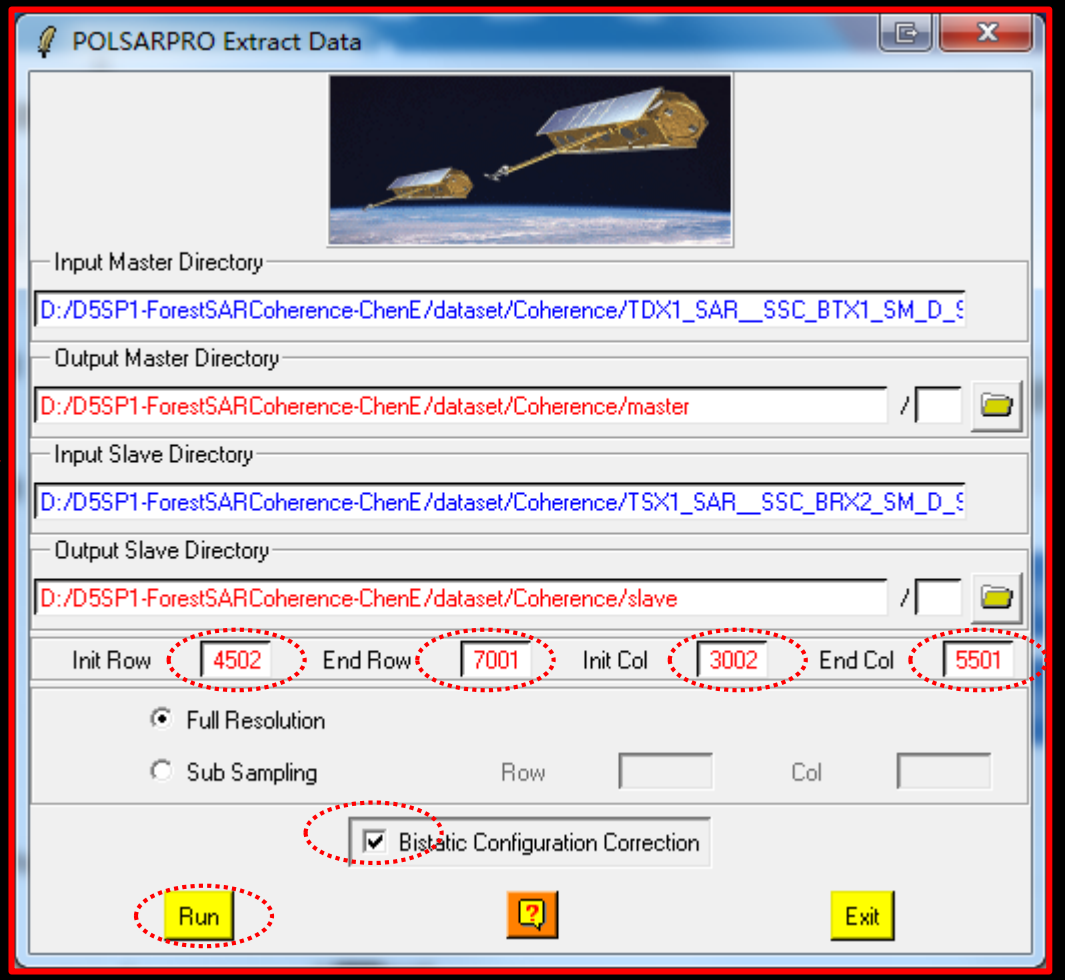
Step1: Load Tandem-X data





Step2: Select Sub-region

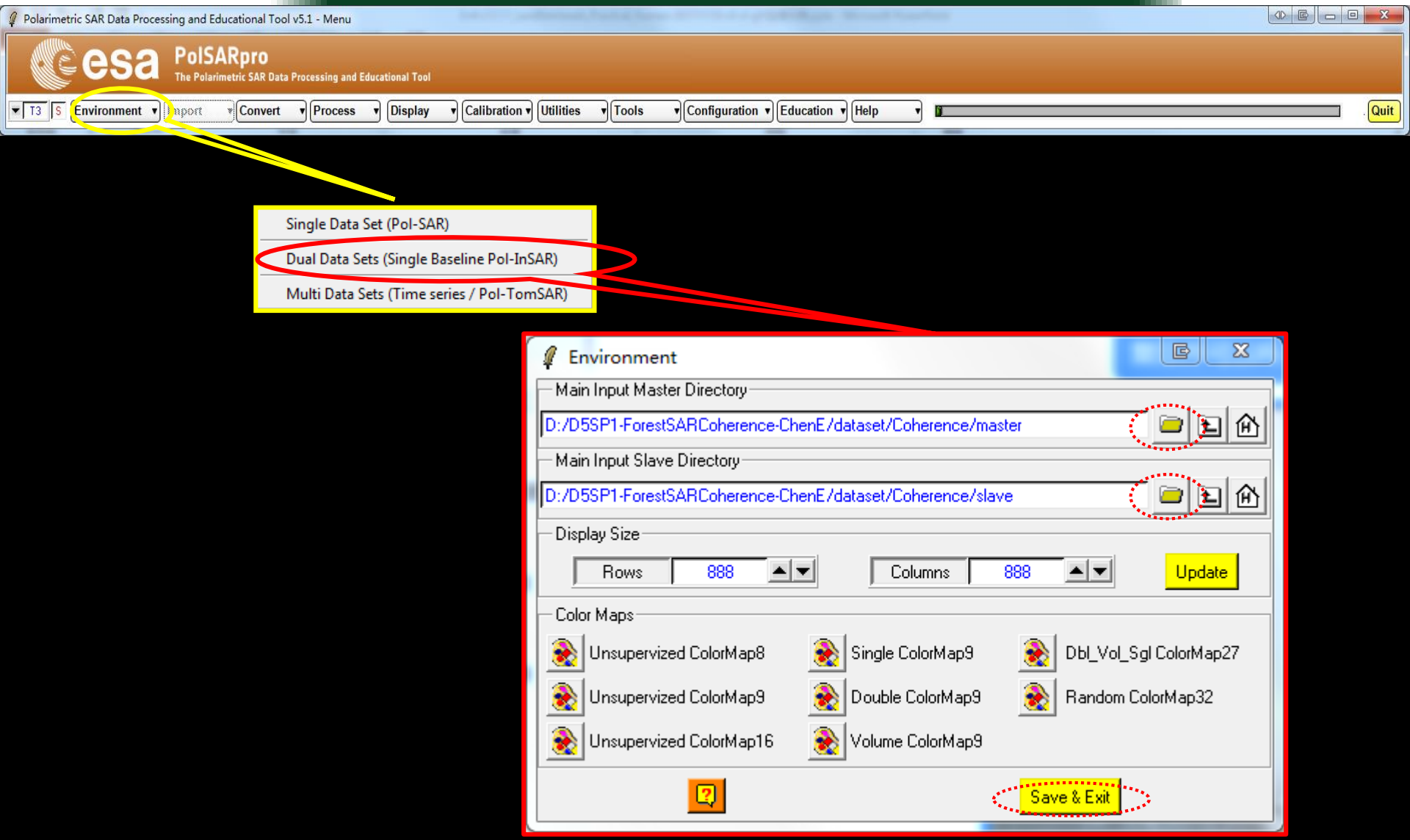




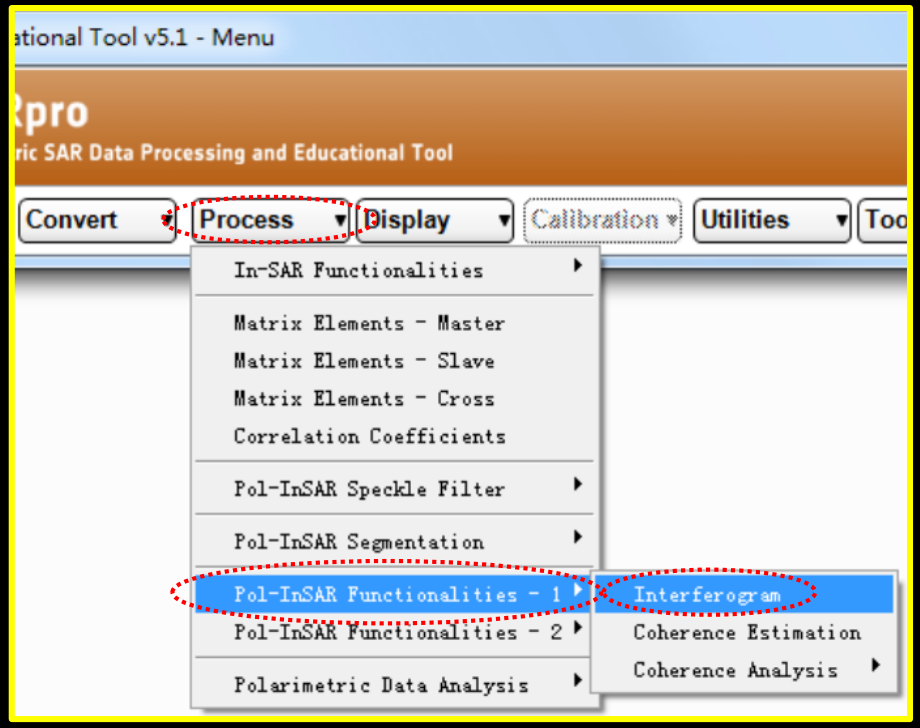
Notes:

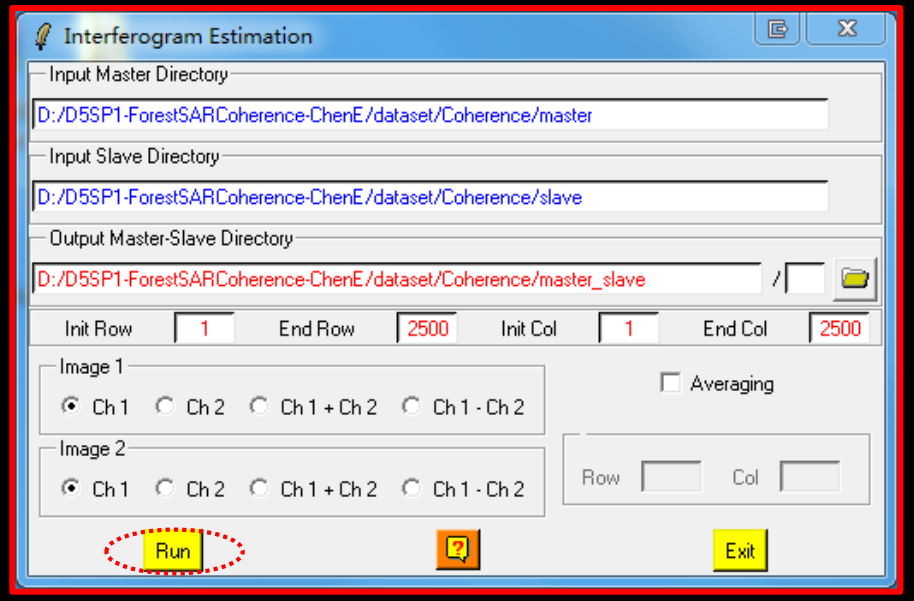
- **Select region 2500×2500 pixels**
  - **4502 – 7001 row select**
  - **3002 – 5501 column select**
- **Be sure to select 'Bistatic Configuration Correction'**

Step3: InSAR set up

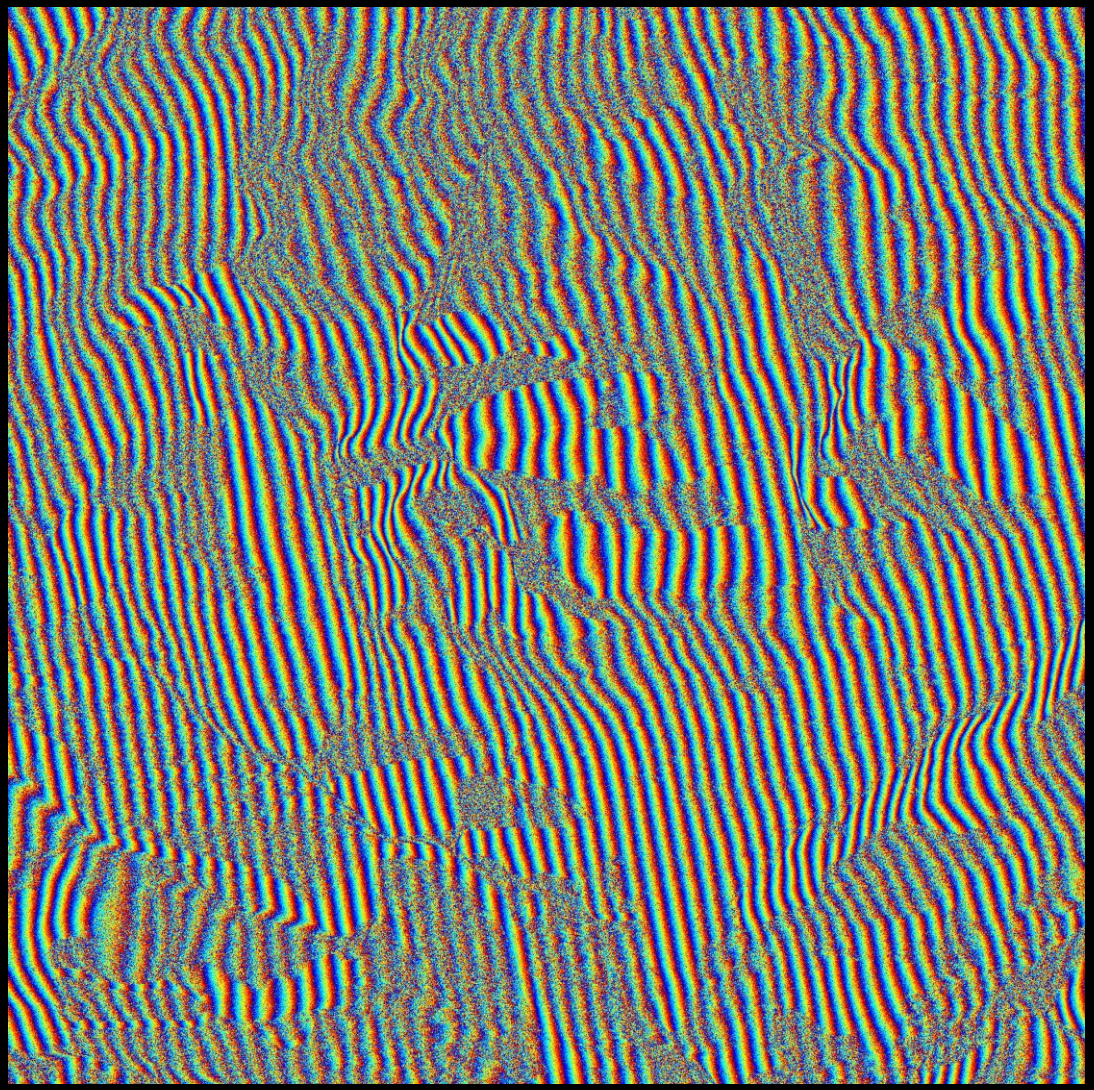


Step4: Interferogram



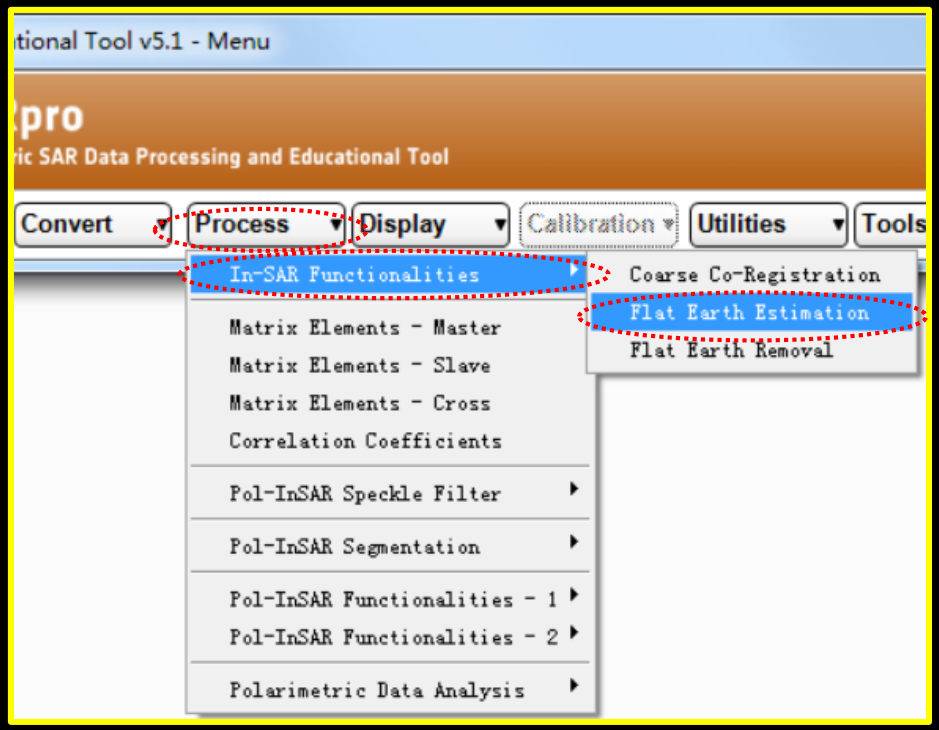


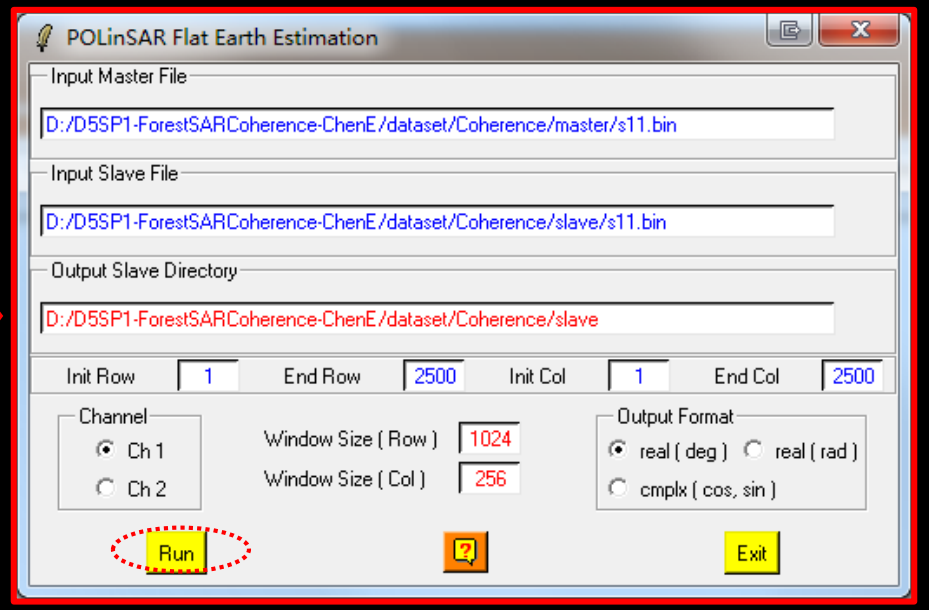
Step4: Interferogram



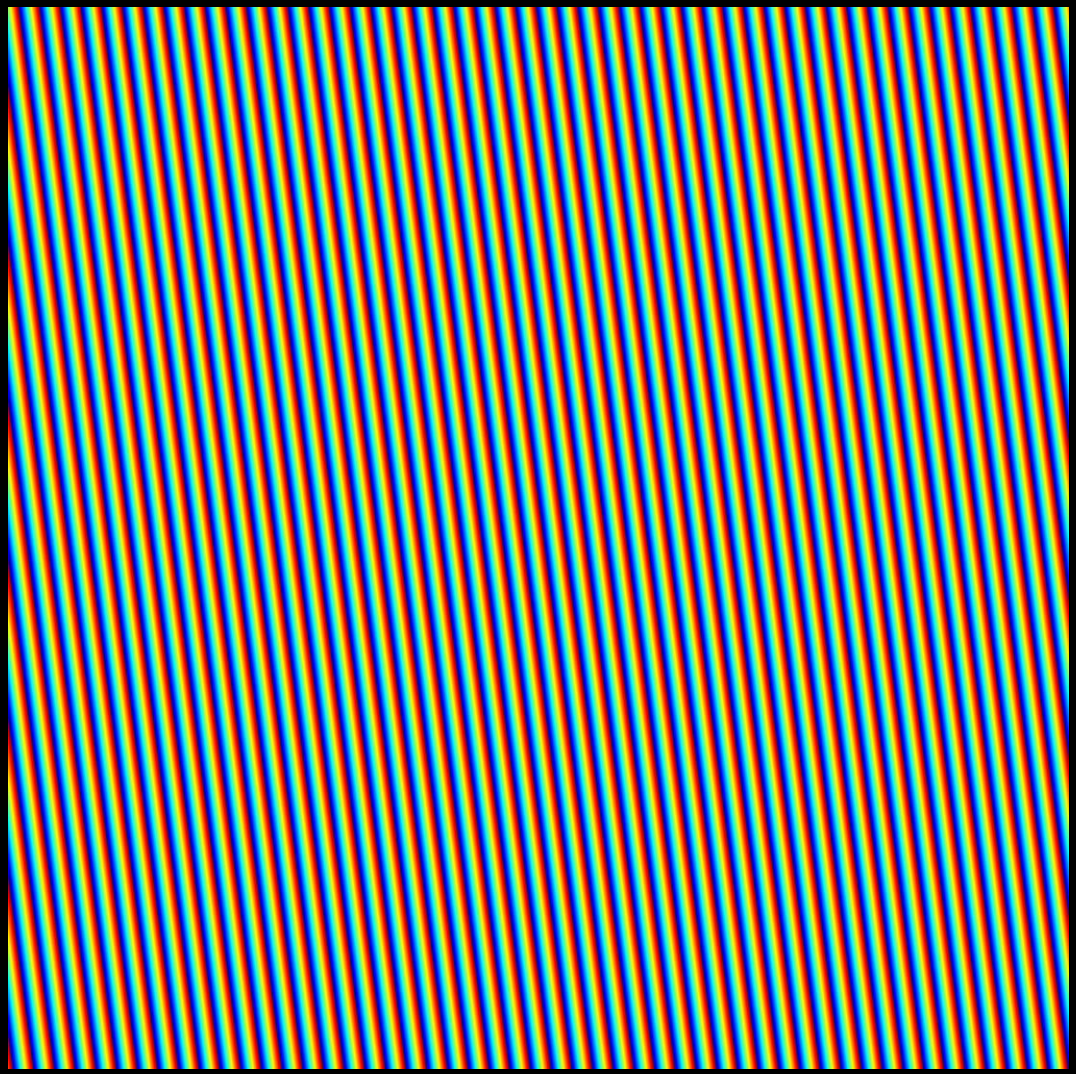
interferogram_Ch1_Ch1.bmp

Step5: Flat earth estimate



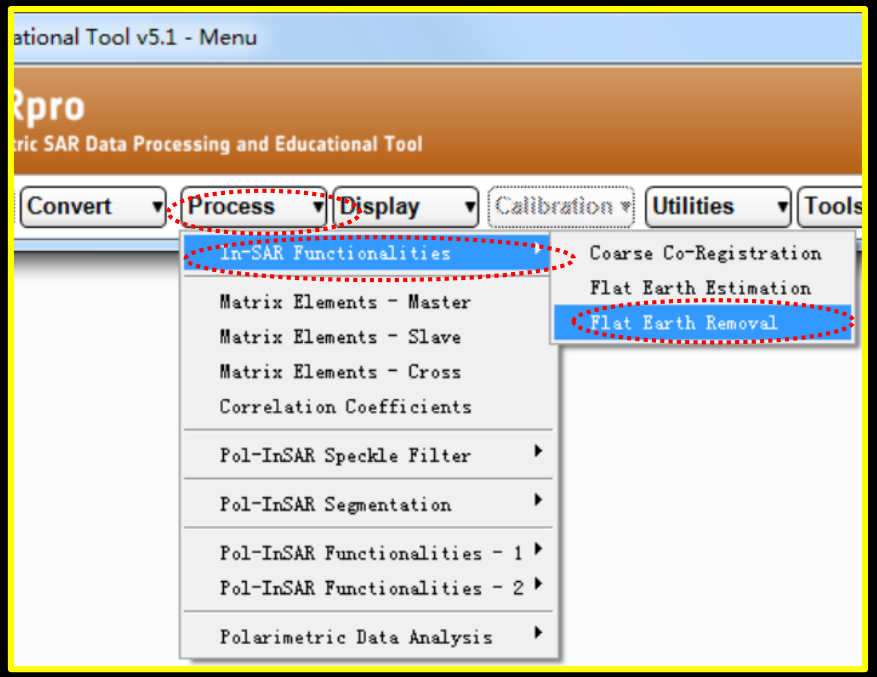


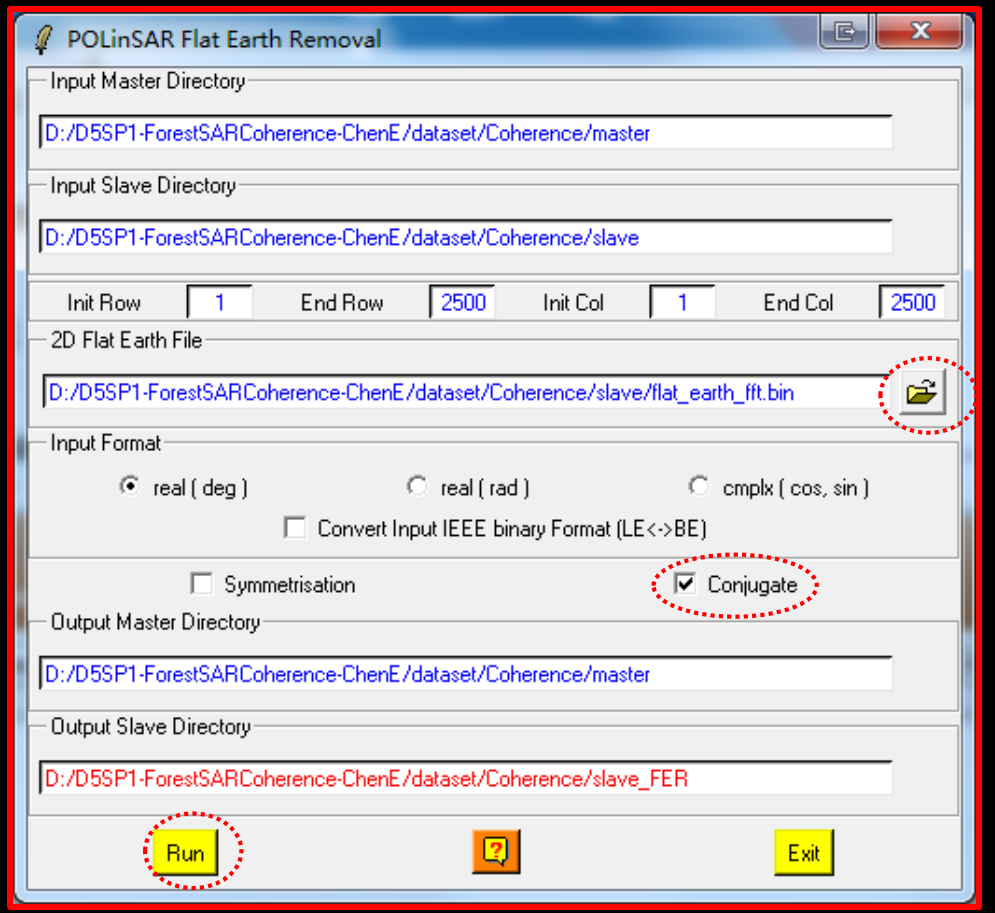
Step5: Flat earth estimate



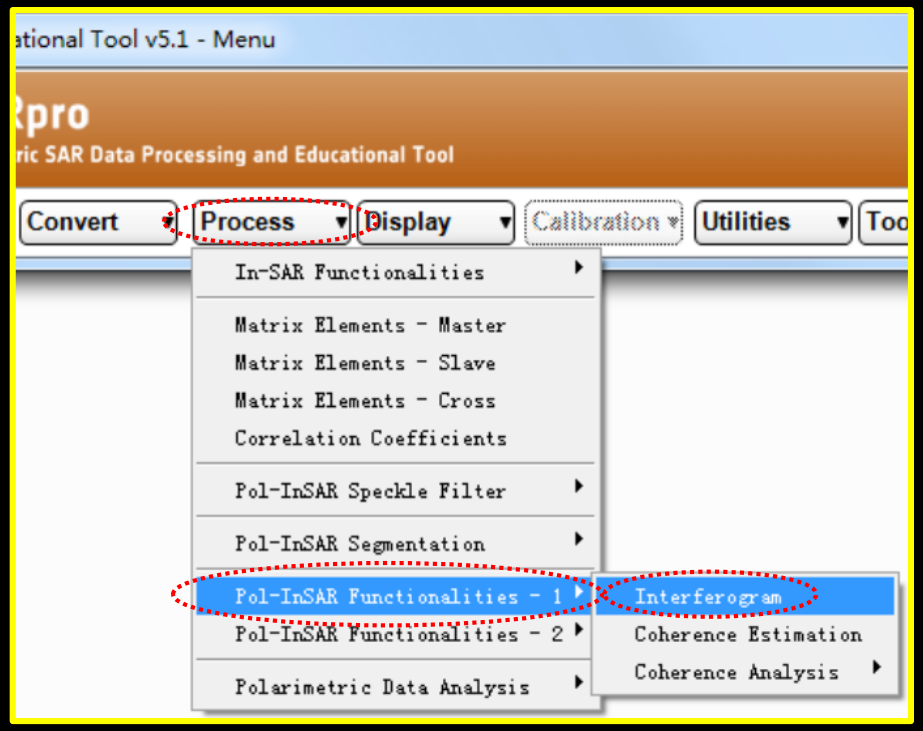
flat_earth_fft.bmp

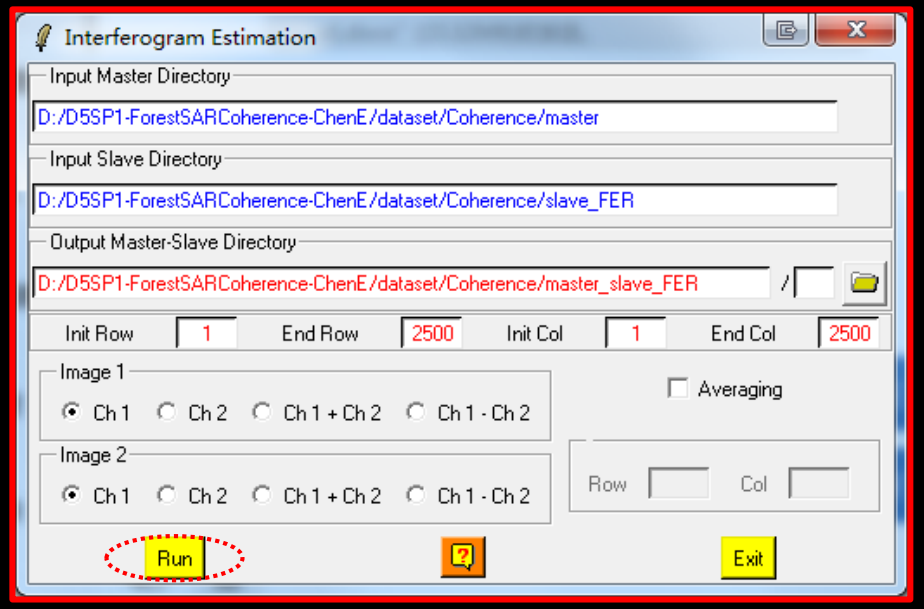
Step6: Flat earth remove





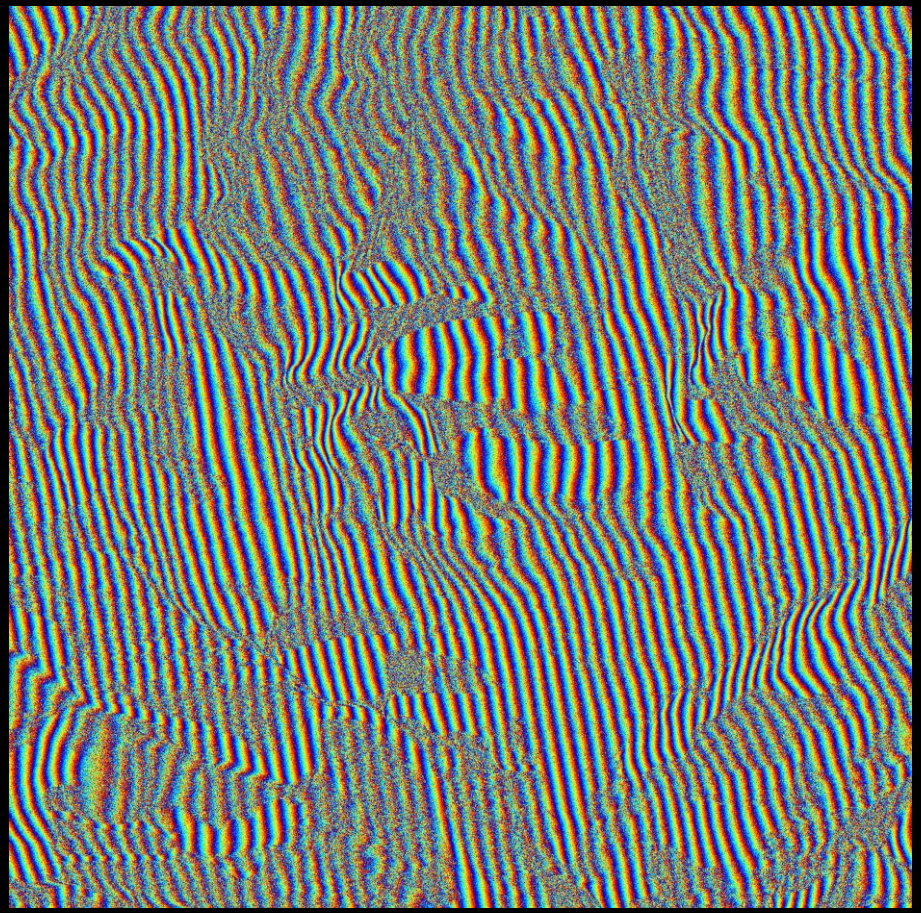
Step6: Flat earth remove

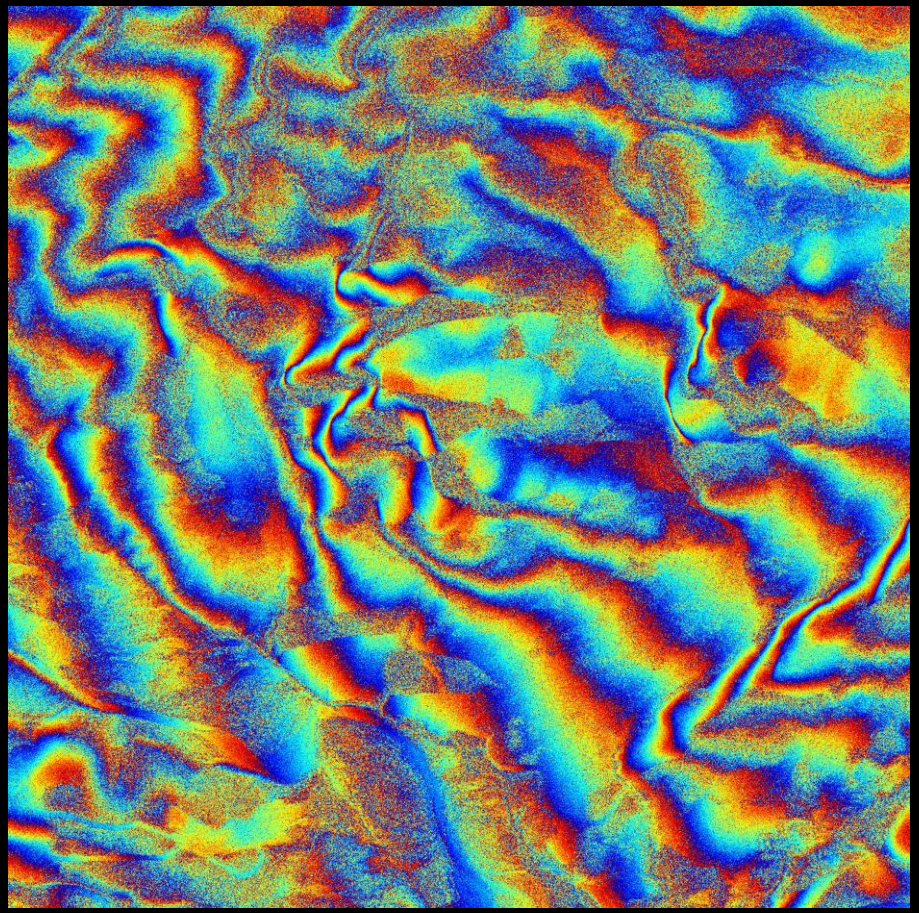




Check the effect of flat earth remove

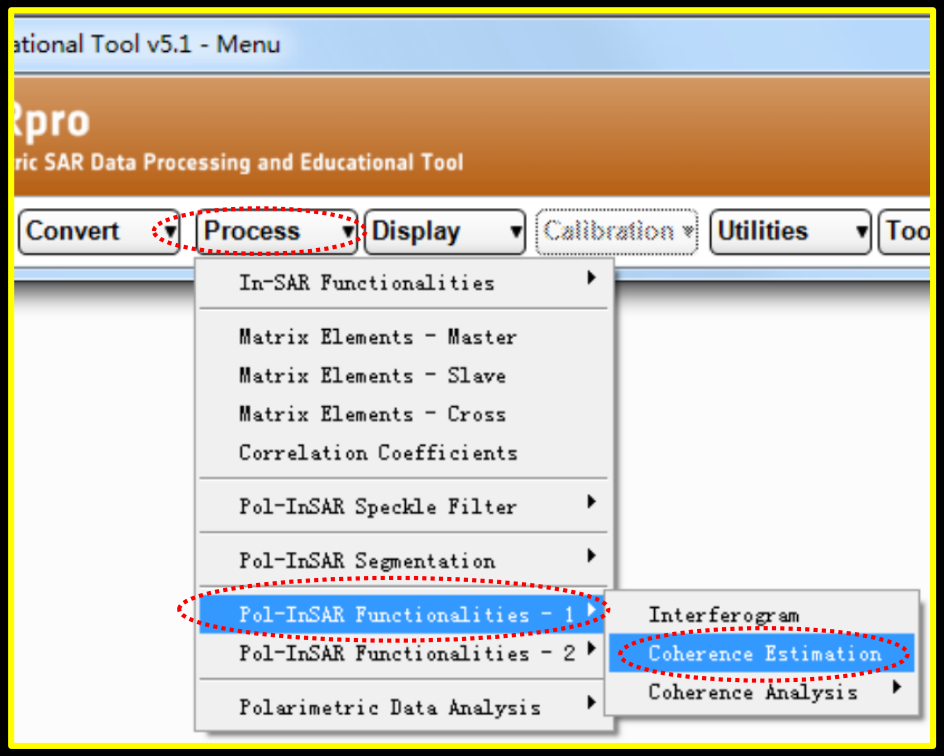
Step6: Flat earth remove

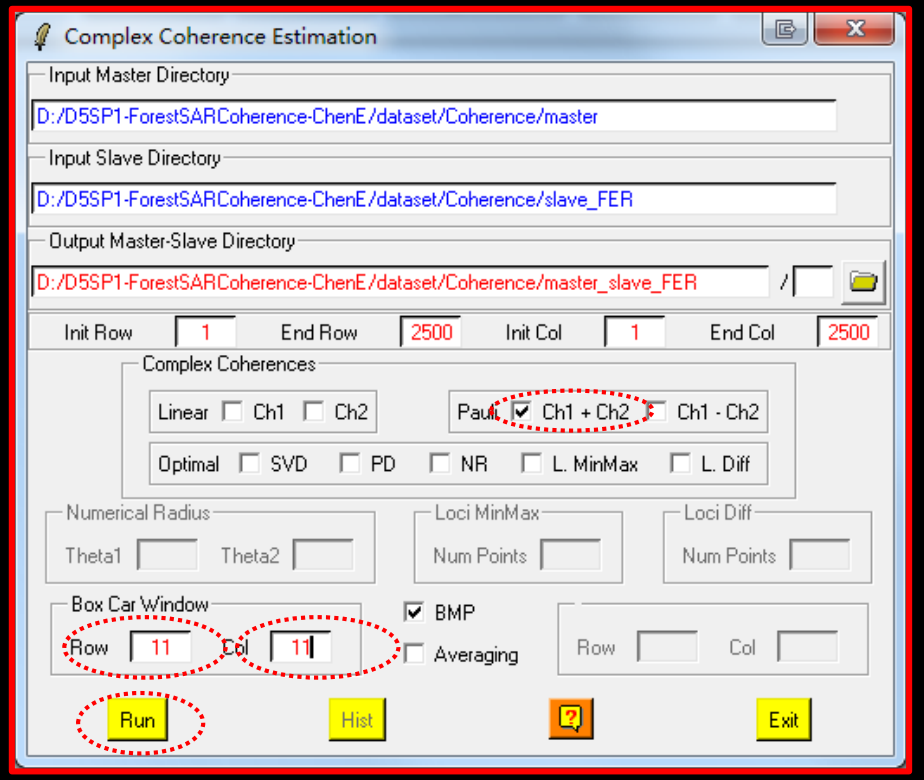




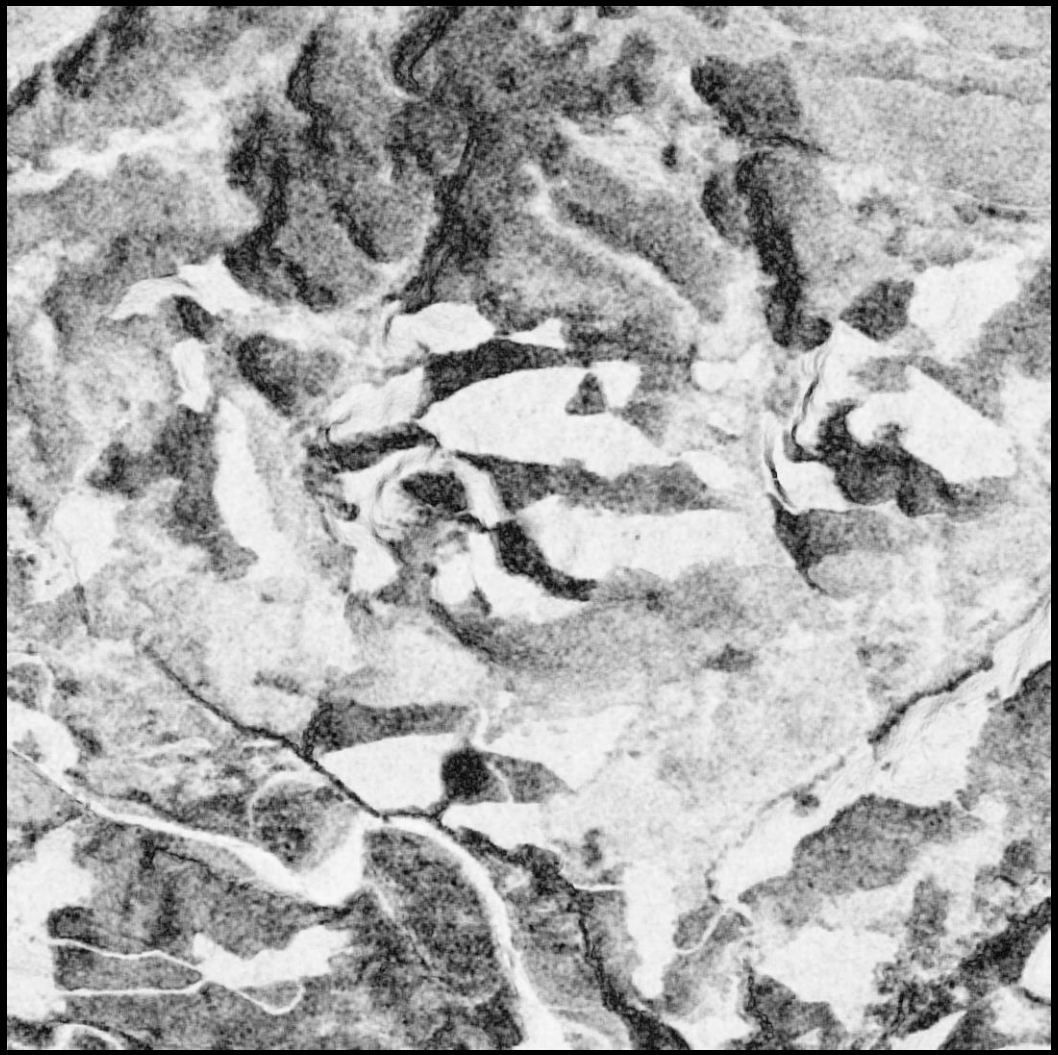
Check the effect of flat earth remove

Step7: Coherence Estimation



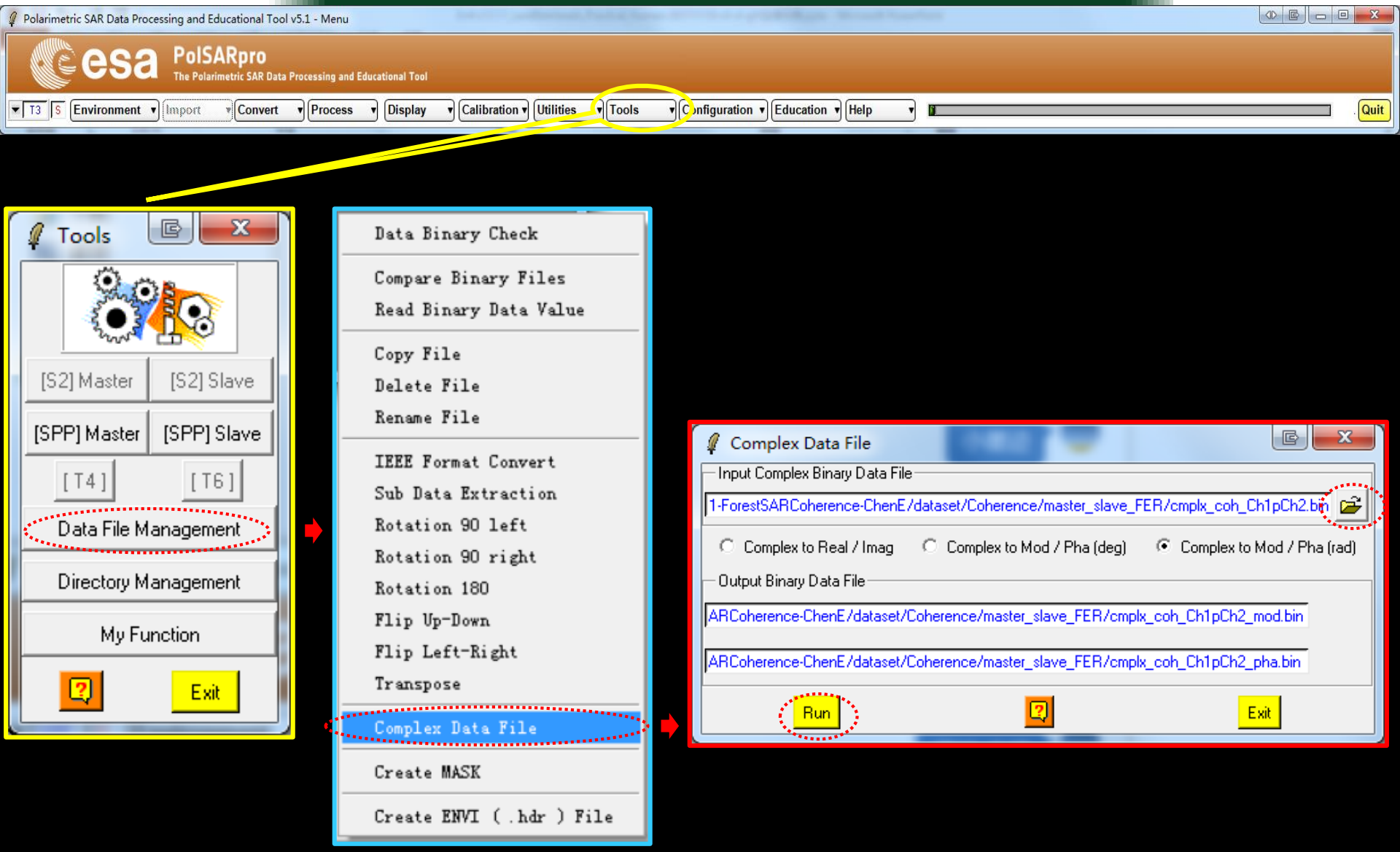


Step7: Coherence Estimation



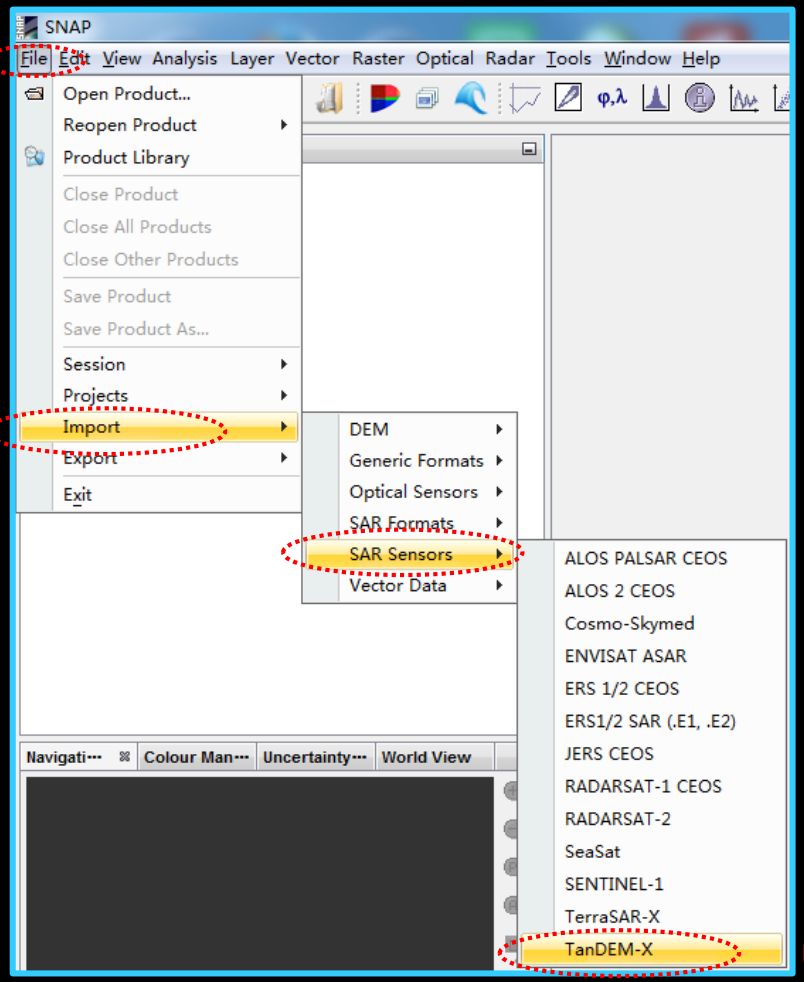
cmplx_coh_Ch1pCh2_mod.bmp

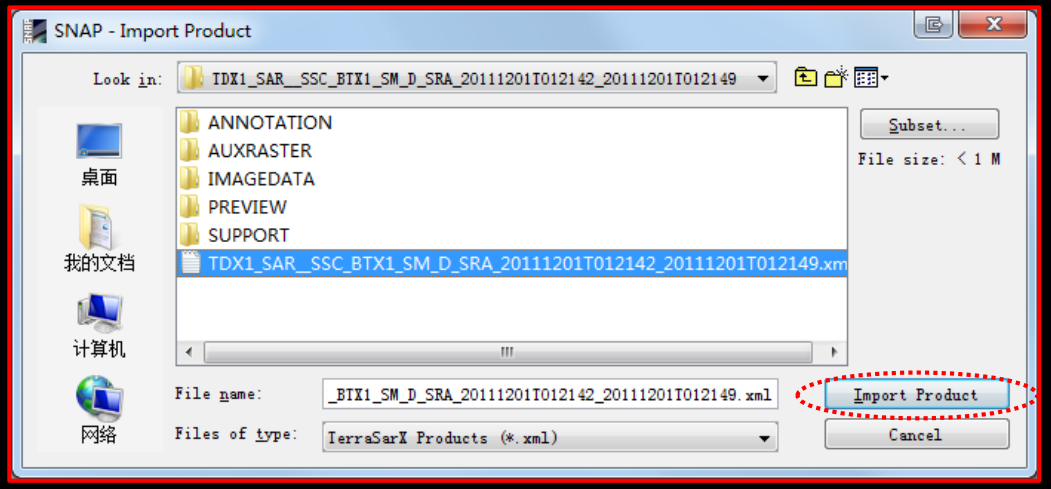
Step8: Save Coherence



Step9: Geocoding Coherence

Step 9.1 : Sub-region Header File Ready (Orbit data).





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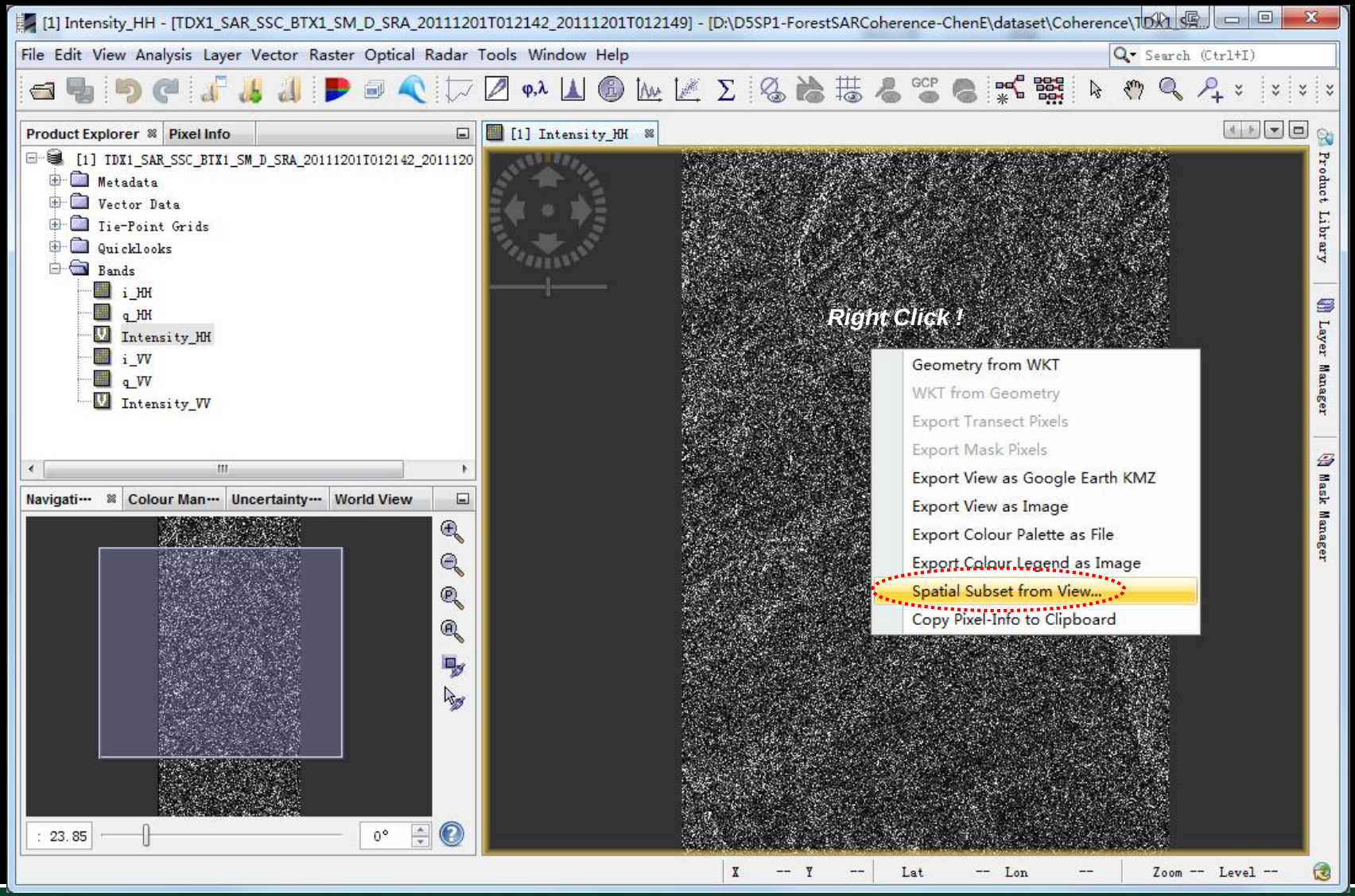

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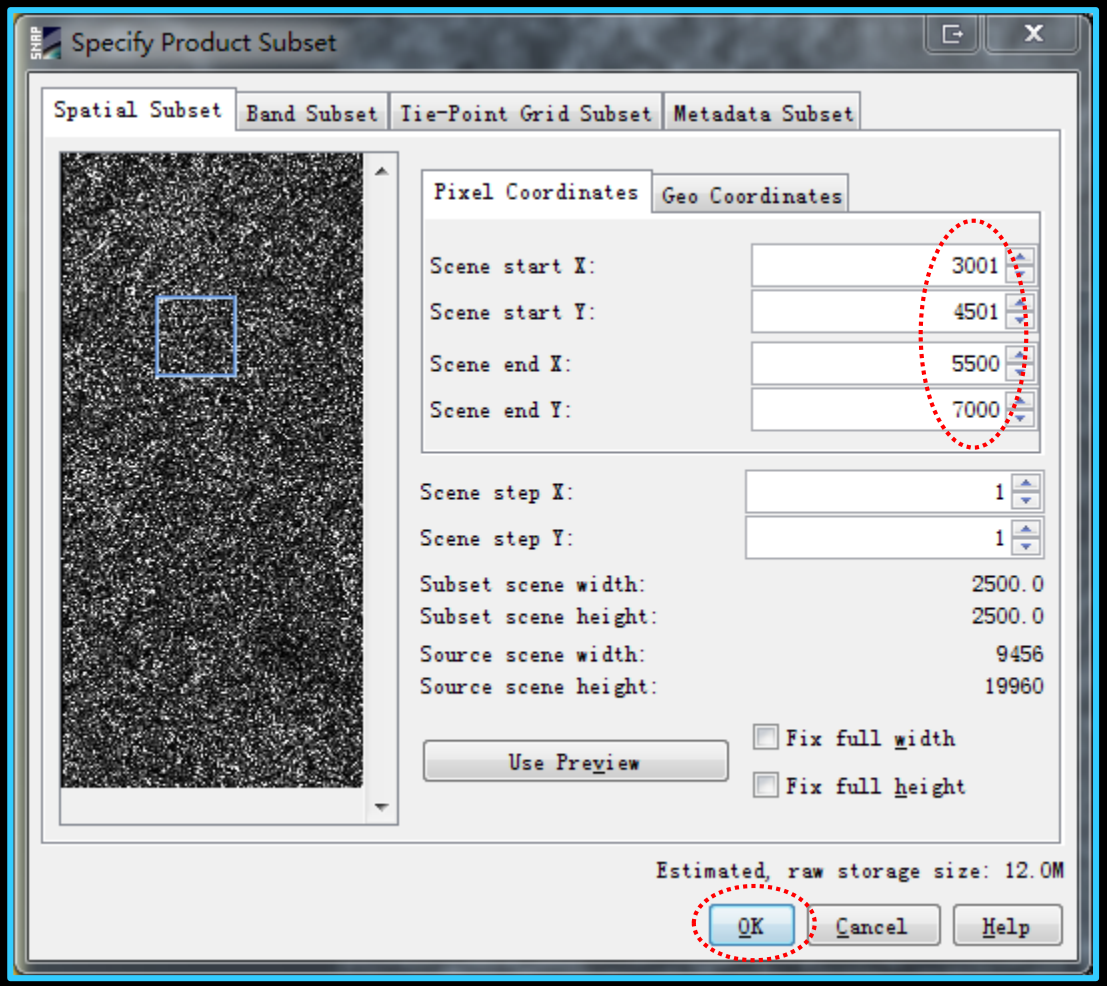
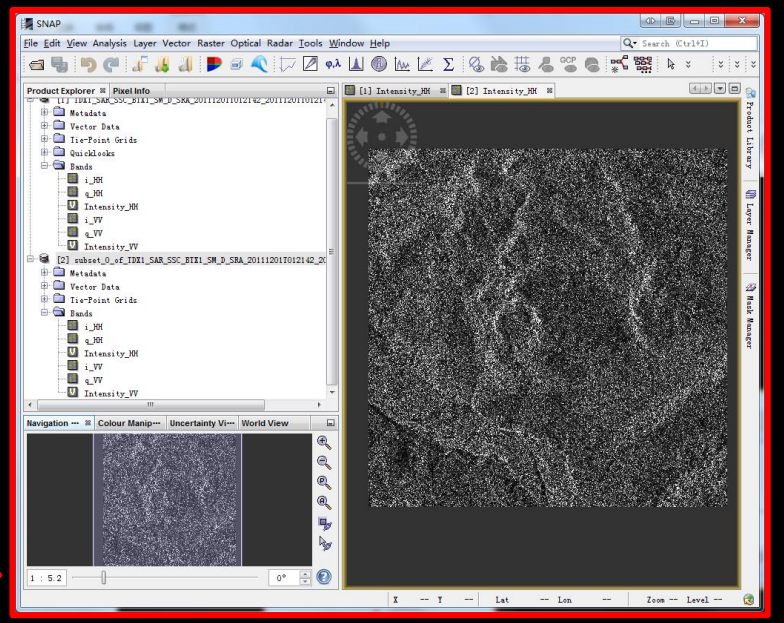


Notes:

- **Select region 2500×2500 pixels**
  - **Y : 4501 – 7000 select**
  - **X：3001 – 5500 select**



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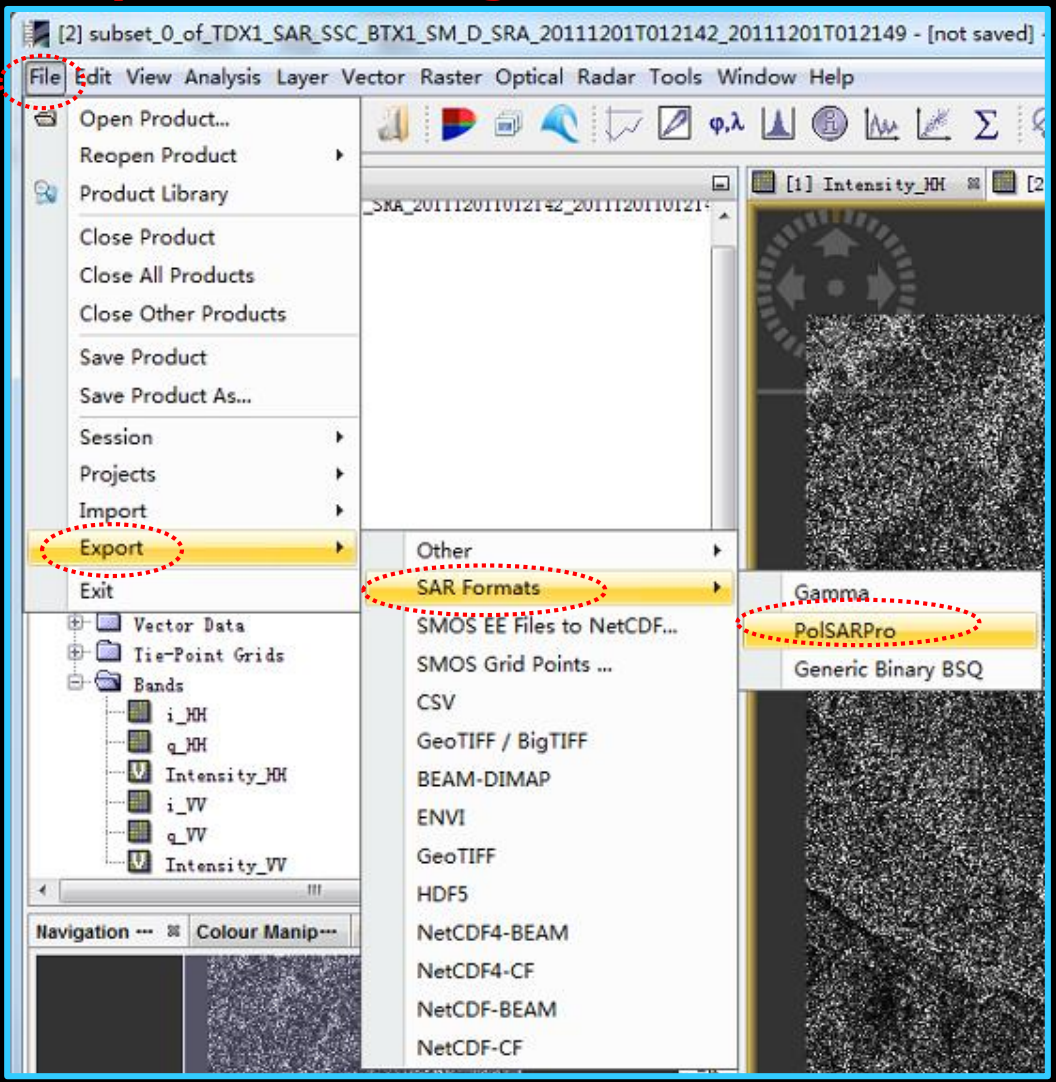
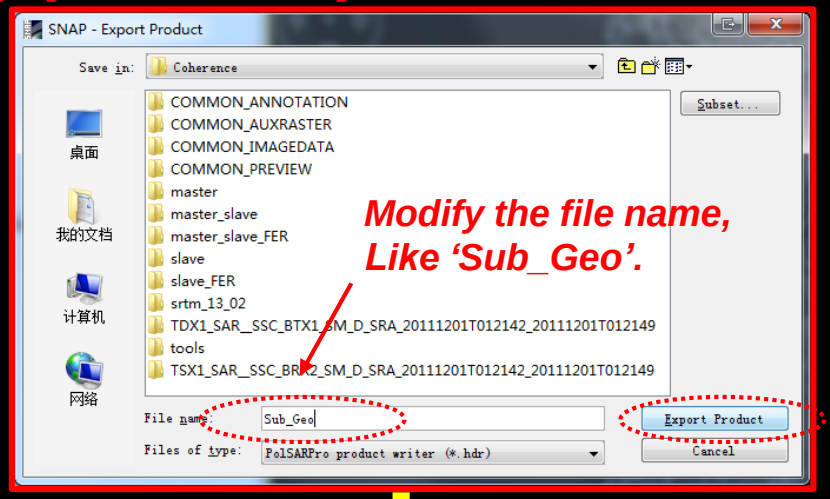
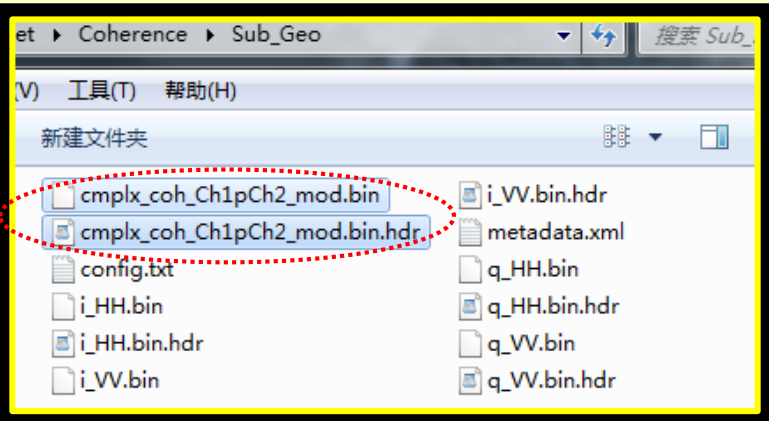


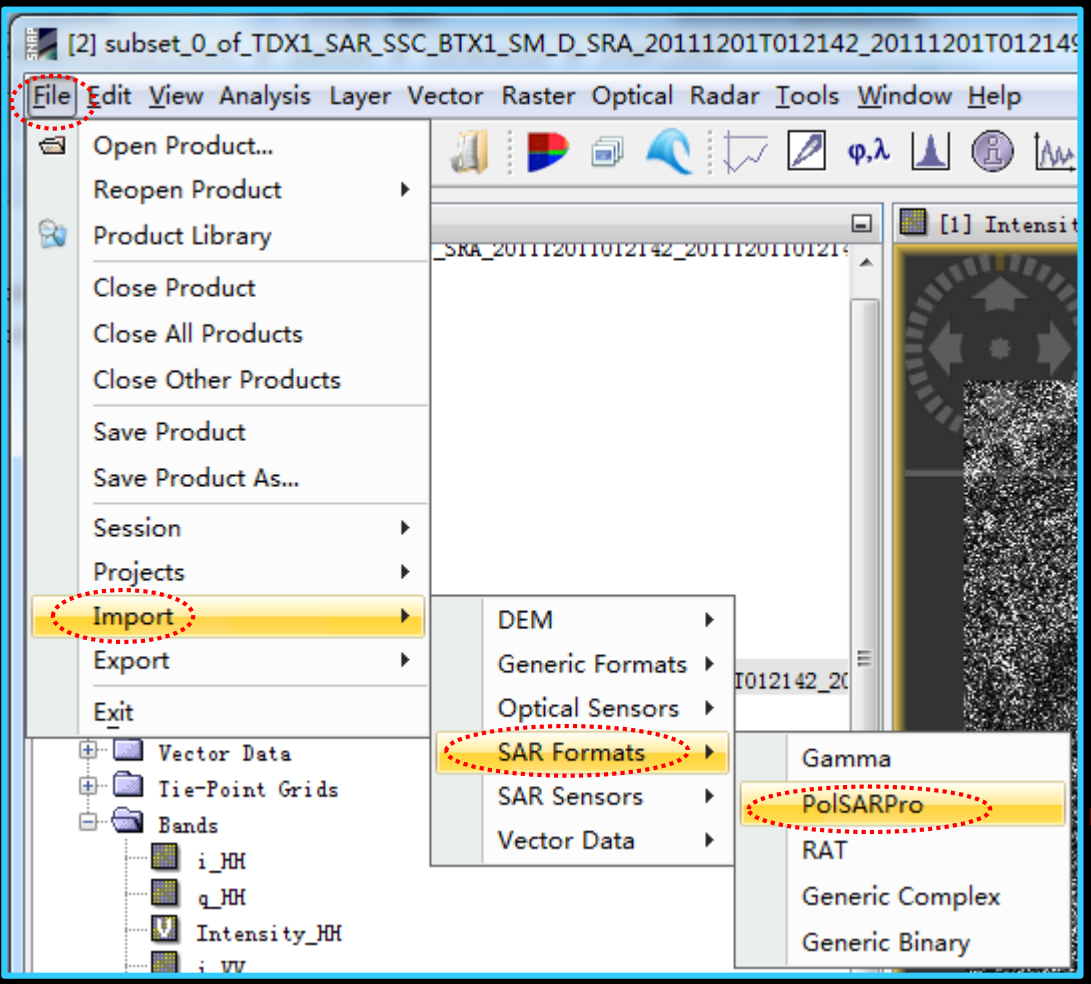


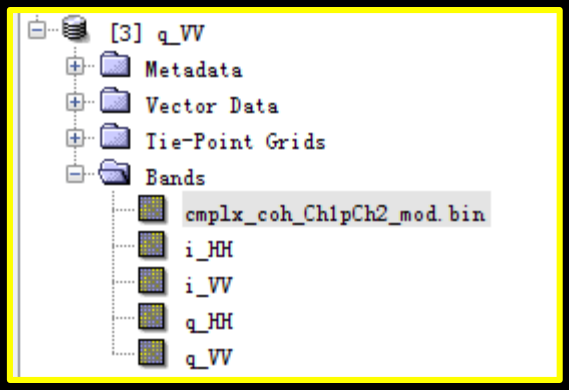
Copy the '**cmplx_coh_Ch1pCh2_mod.bin**' and '**cmplx_coh_Ch1pCh2_mod.bin.hdr**' to '**Sub_Geo**' folder.

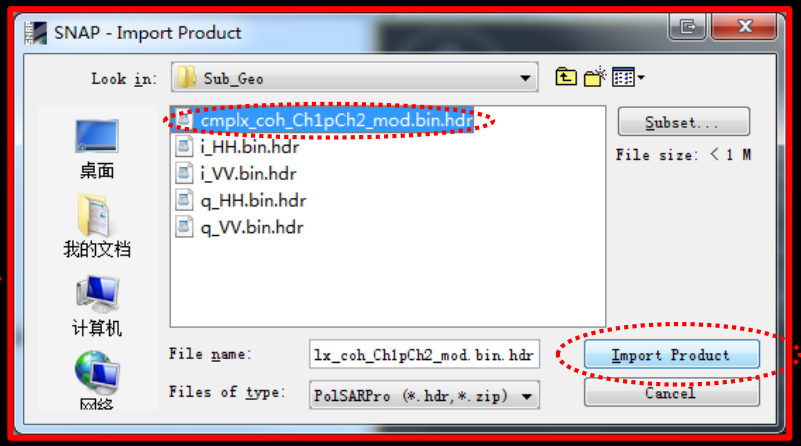


Step9: Geocoding Coherence

Step 9.2 : Coherence Geocoding

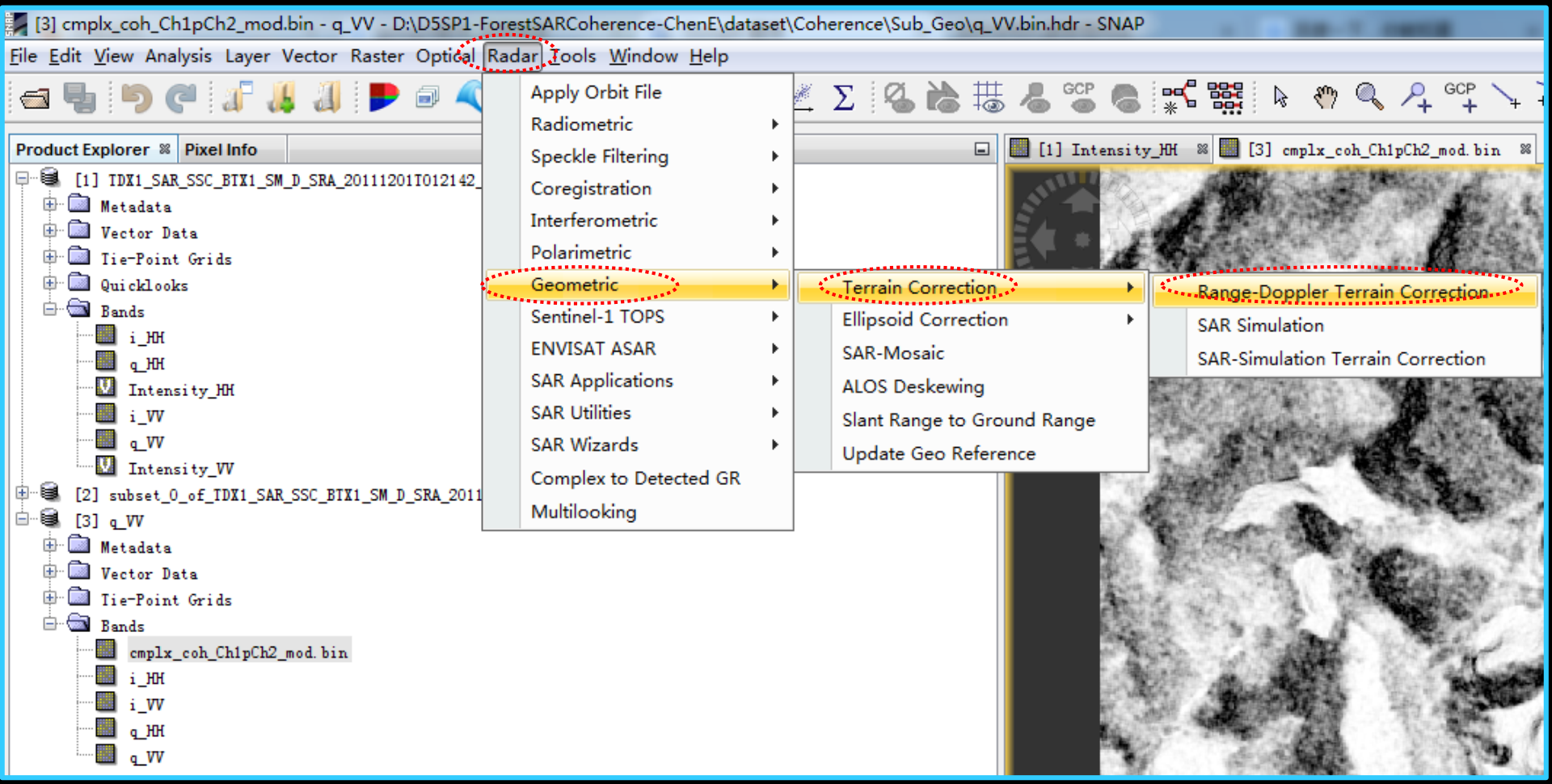






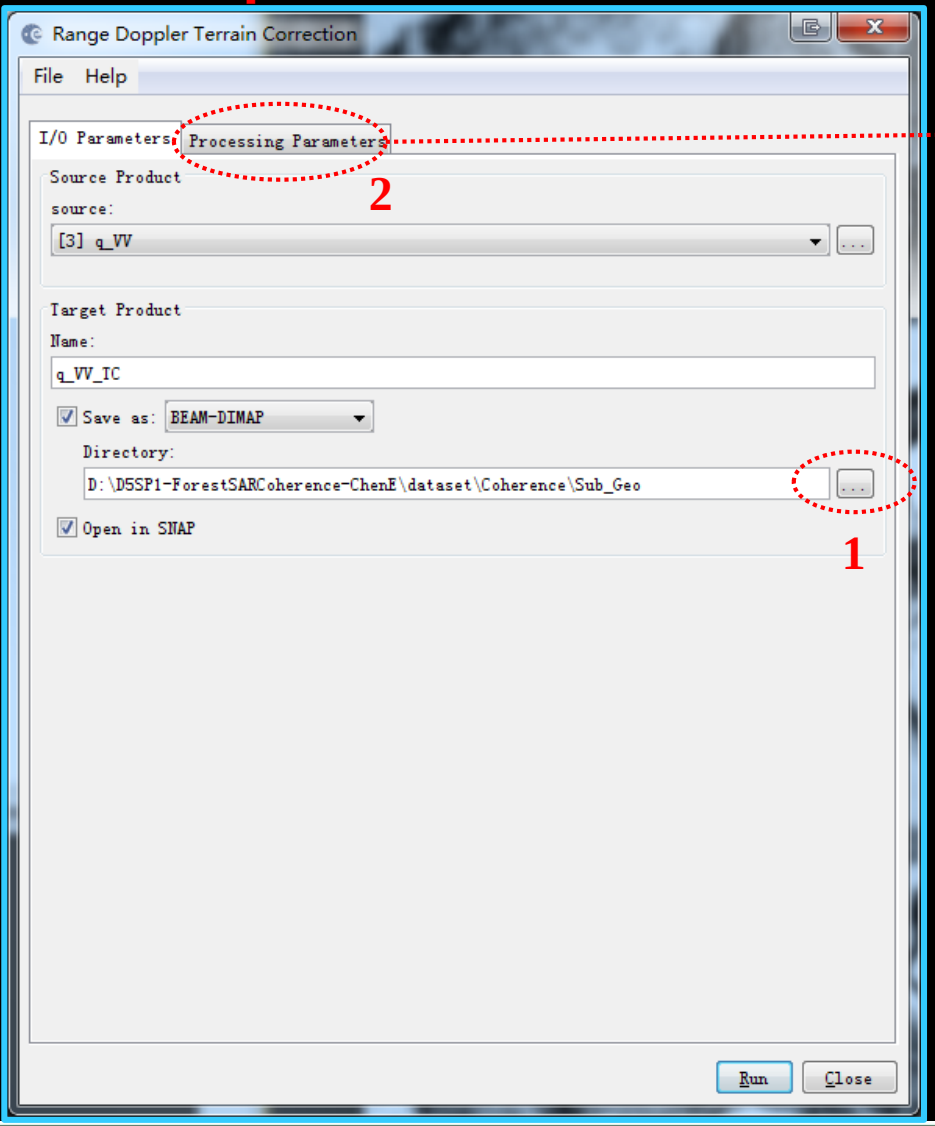
Step9: Geocoding Coherence

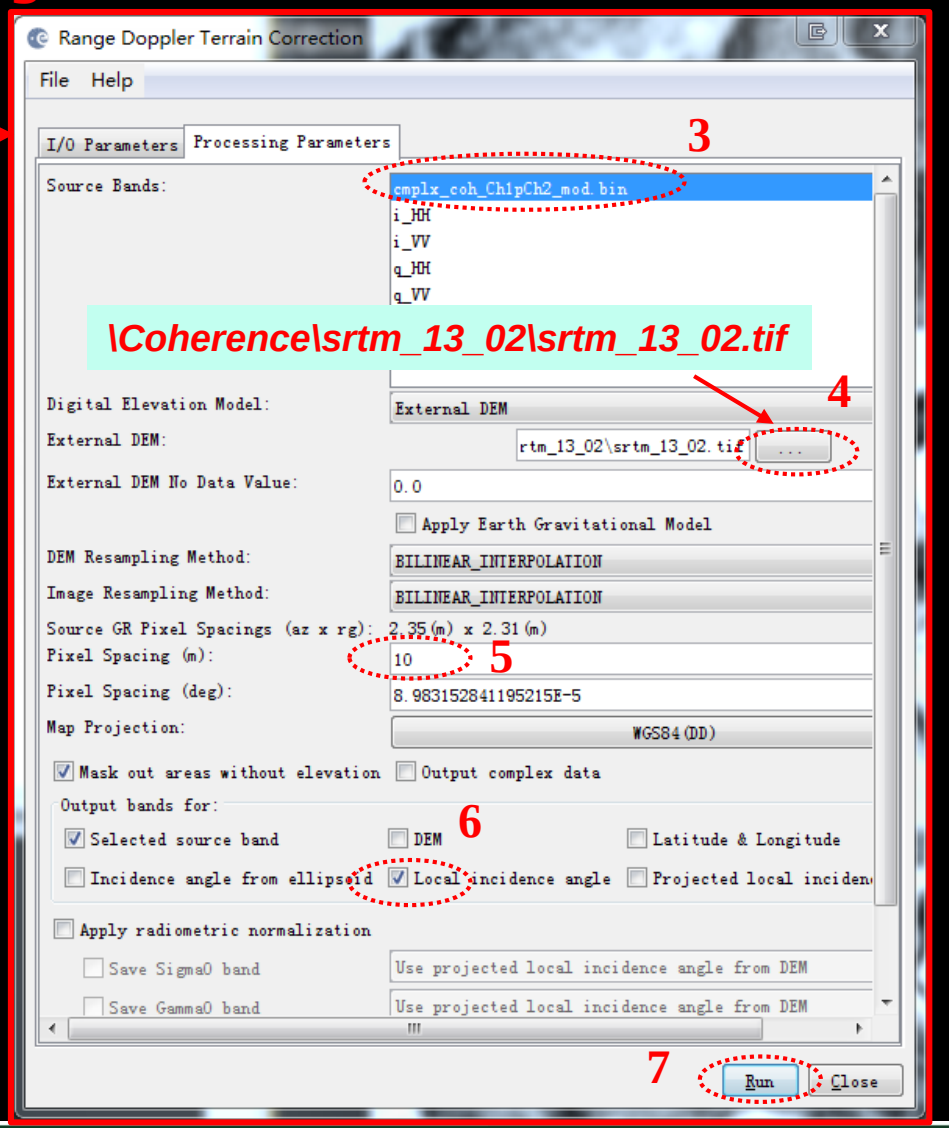
Step 9.2 : Coherence Geocoding



Step9: Geocoding Coherence

Step 9.2 : Coherence Geocoding

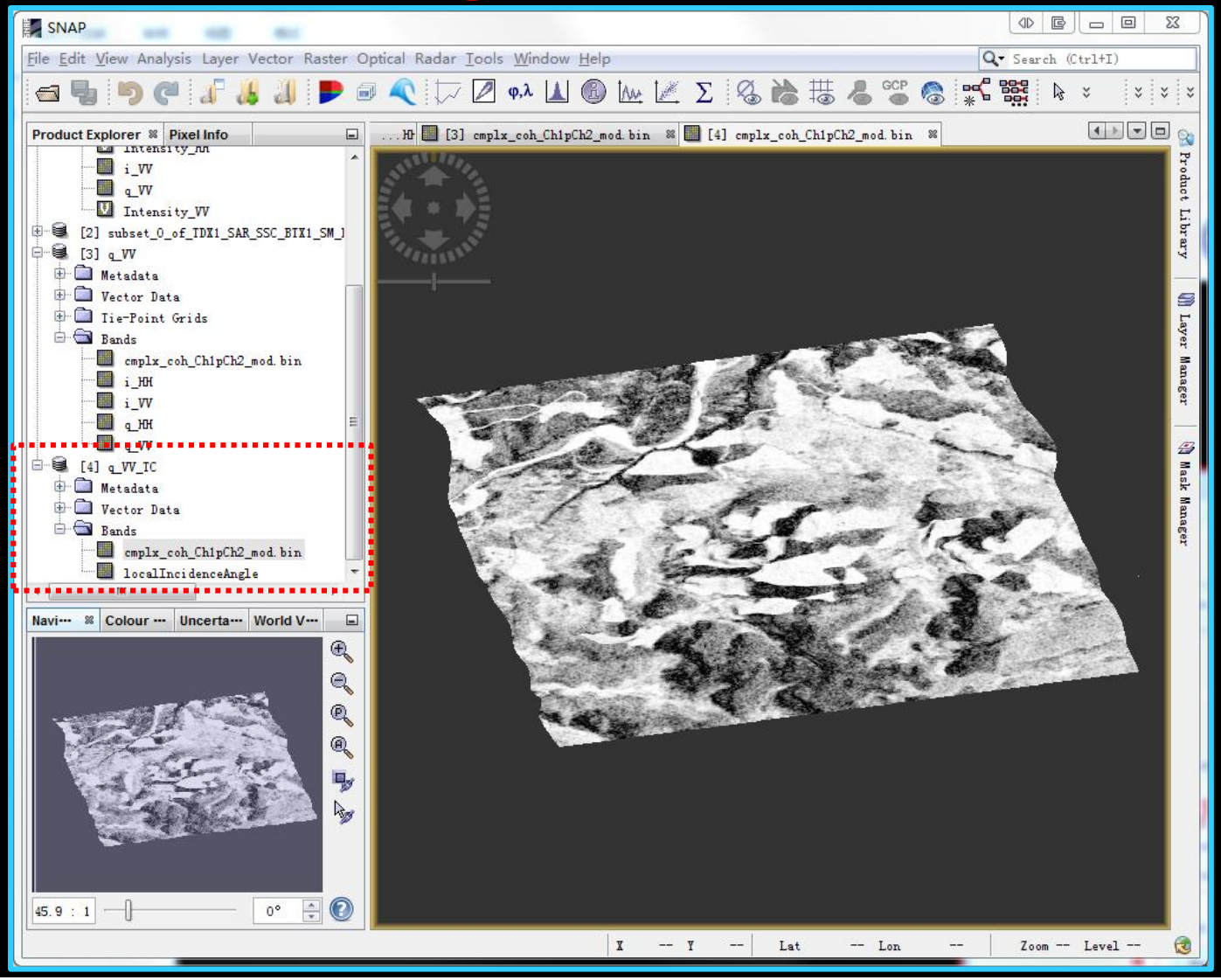




Step9: Geocoding Coherence

Step 9.2 : Coherence Geocoding

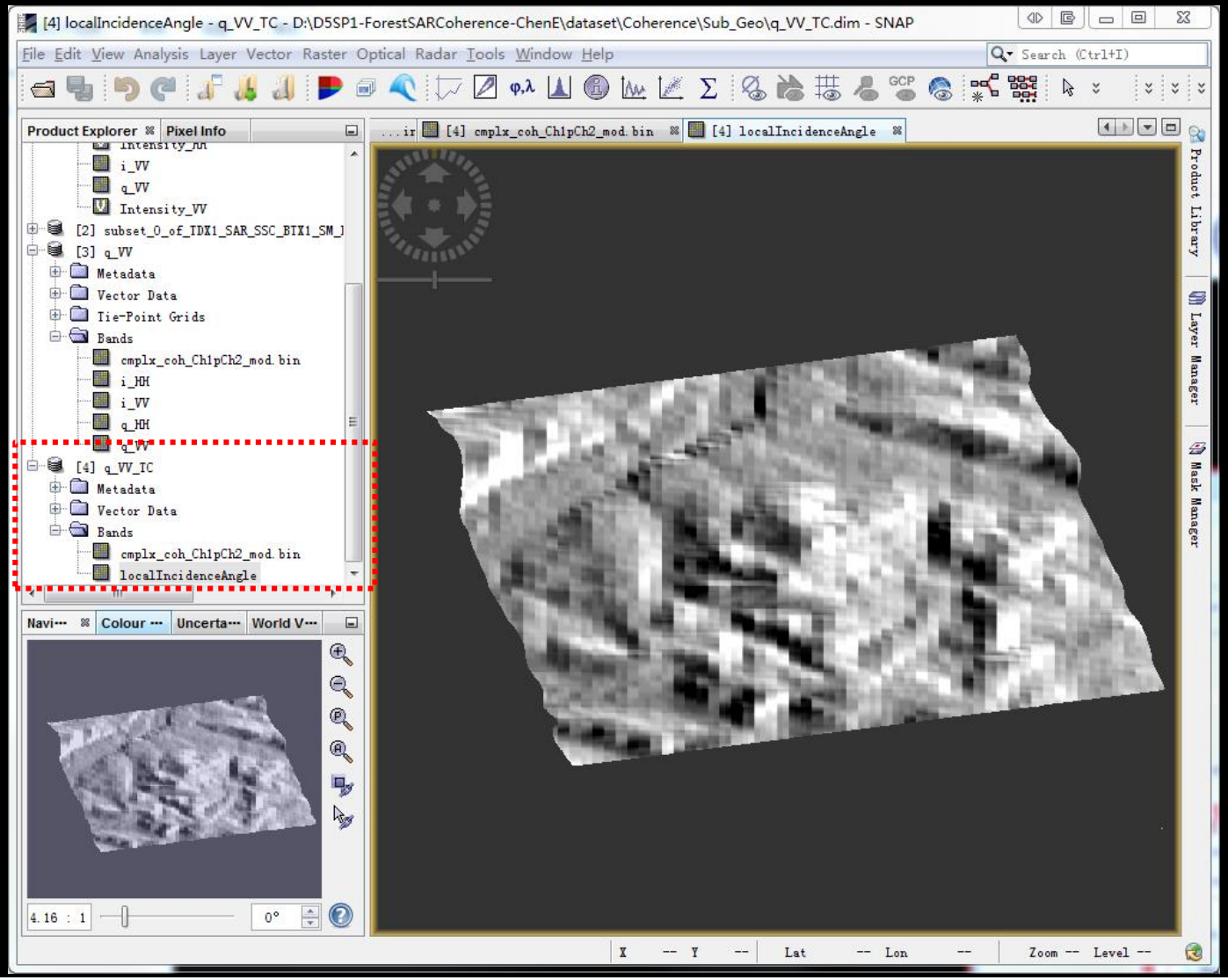
Geocode Coherence



Step9: Geocoding Coherence

Step 9.2 : Coherence Geocoding

Geocode local incidence angle



Step10: Fixed K_z

10. Fixed K_z
    - Ambiguity height (*hoa*)

$$k_z = \frac{4\pi\Delta\theta}{\lambda \sin(\theta_0)} = 2\pi / hoa$$

Fixed K_z = 0.176

hoa **can be find in the header file of Tandem-X data:**

TDM1_SAR__COS_BIST_SM_D_SRA_20111201T012142_20111201T012149.xml

```
</operationsInfo>
<acquisitionGeometry>
  <effectiveBaseline>9.69027865924443148E+01</effectiveBaseline>
  <heightOfAmbiguity>3.57081071461824919E+01</heightOfAmbiguity>
  <distanceActivePos>2.47298218615243513E+02</distanceActivePos>
  <distanceTracks>2.16355824070961262E+02</distanceTracks>
  <orbitDirection>A</orbitDirection>
  <lookDirection>R</lookDirection>
```

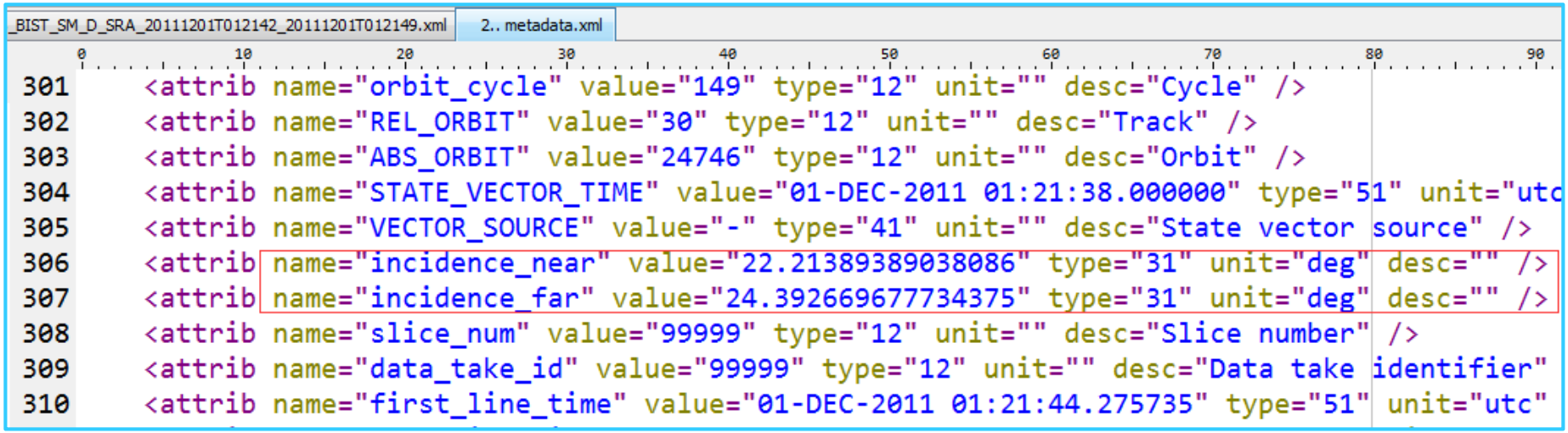
Step11: Local K_z

11. Local K_z
    - Local incidence angle file (θ_{loc})
    - Angle of incidence center (θ_0)

$$k_z = \frac{4\pi\Delta\theta}{\lambda \sin(\theta_{loc})} = \frac{2\pi \sin(\theta_0)}{hoa \cdot \sin(\theta_{loc})}$$

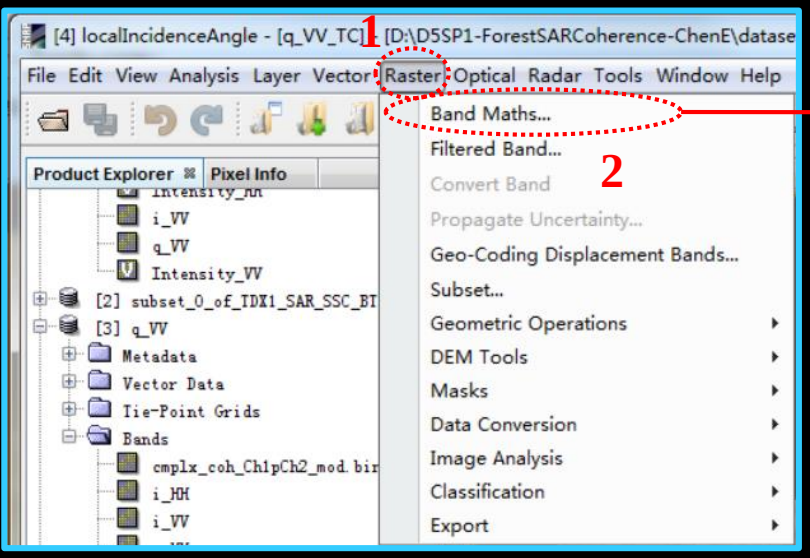
θ_0 can be find in the header file of Sub-region data:

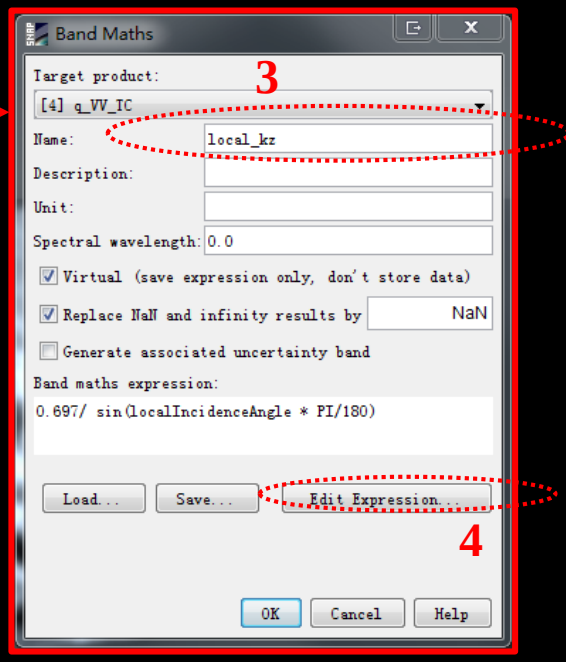
..\Coherence\Sub_Geo\metadata.xml

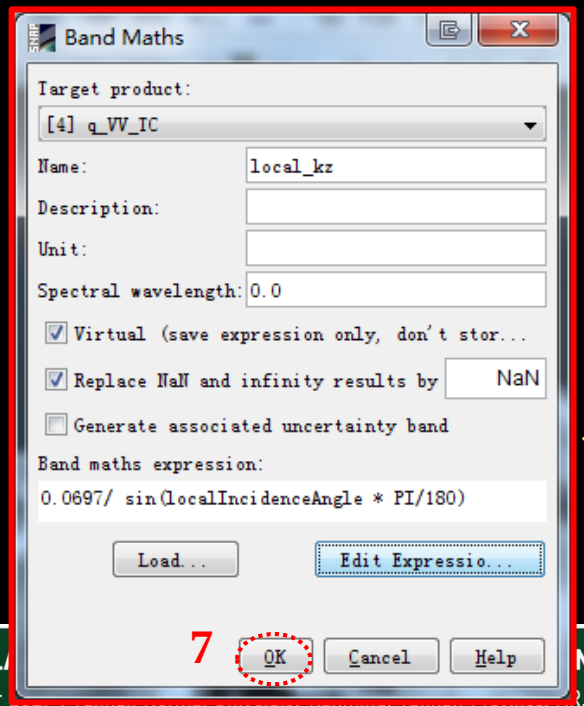


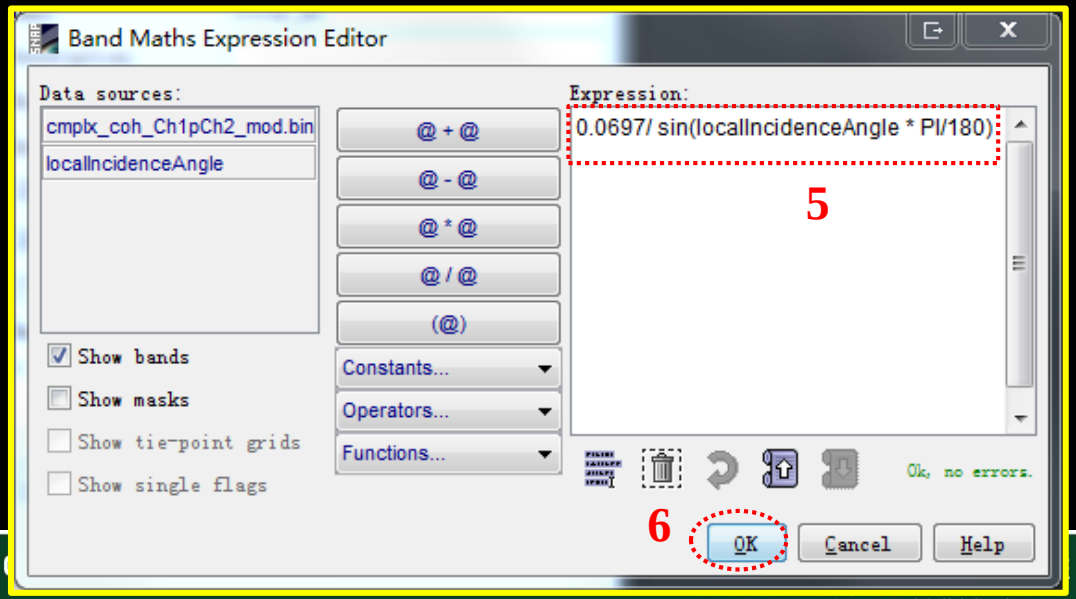
θ_0 = (22.2138 + 24.3927)/2 = 23.3033 $\qquad$ 2 π sin(θ_0) /hoa = 0.0697

Step11: Local K_z

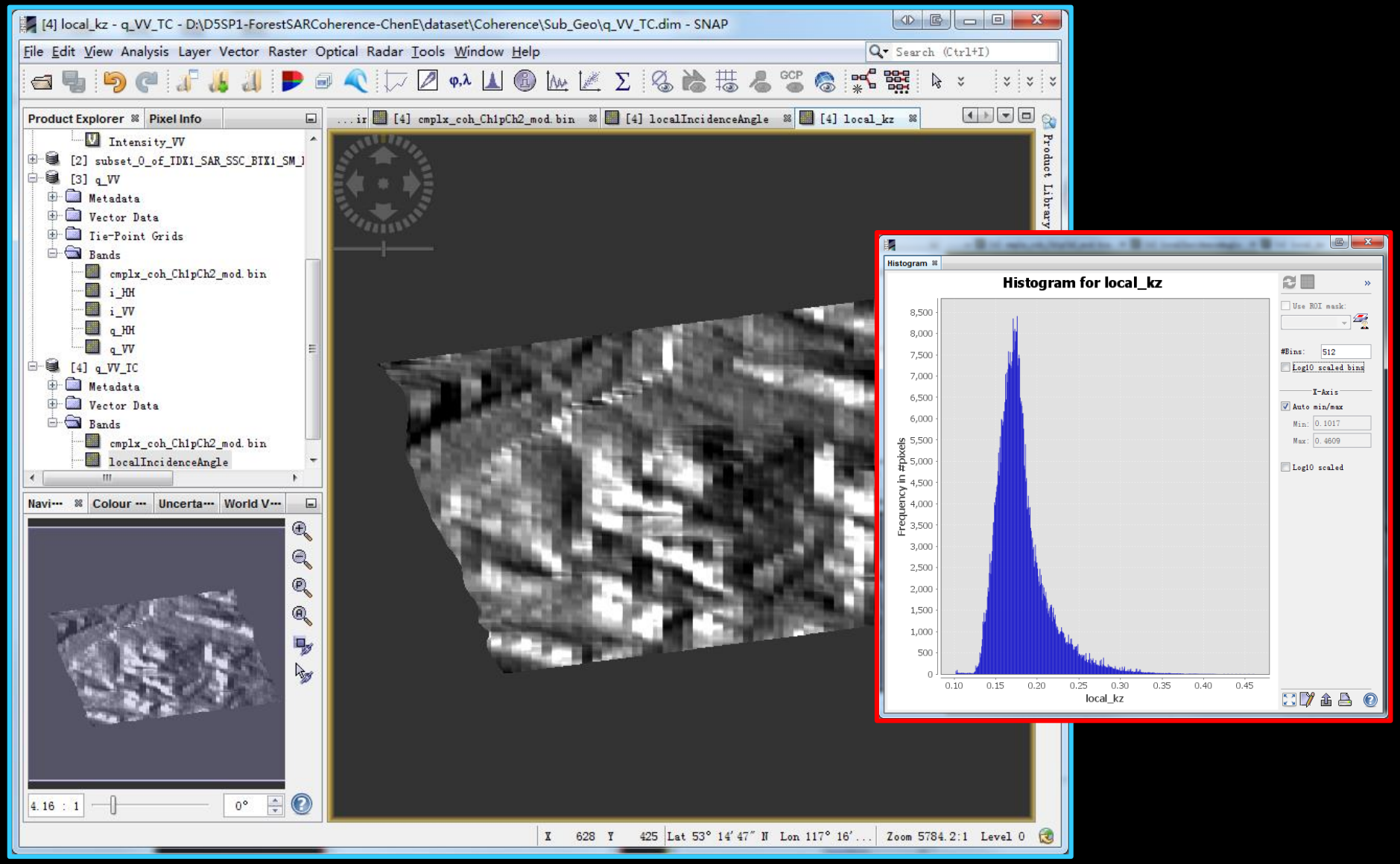








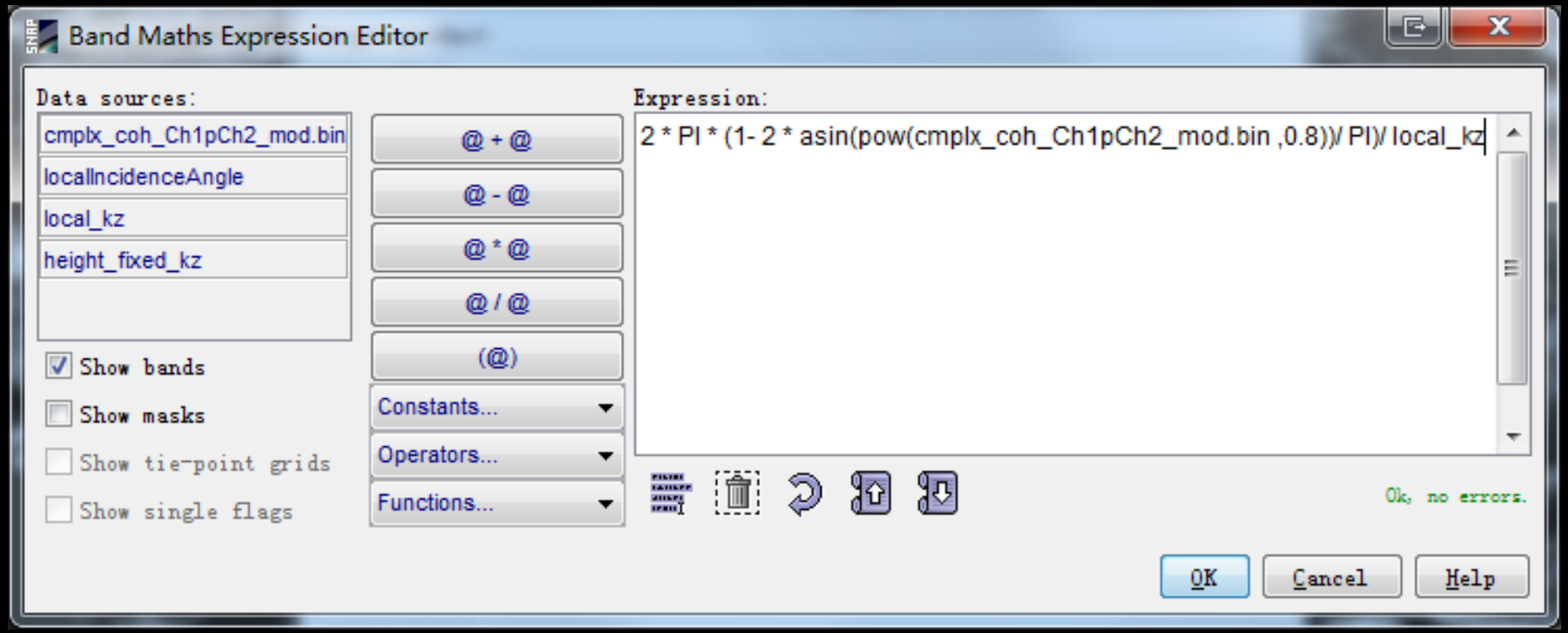
Step11: Local K_z



Step12: Height inversion

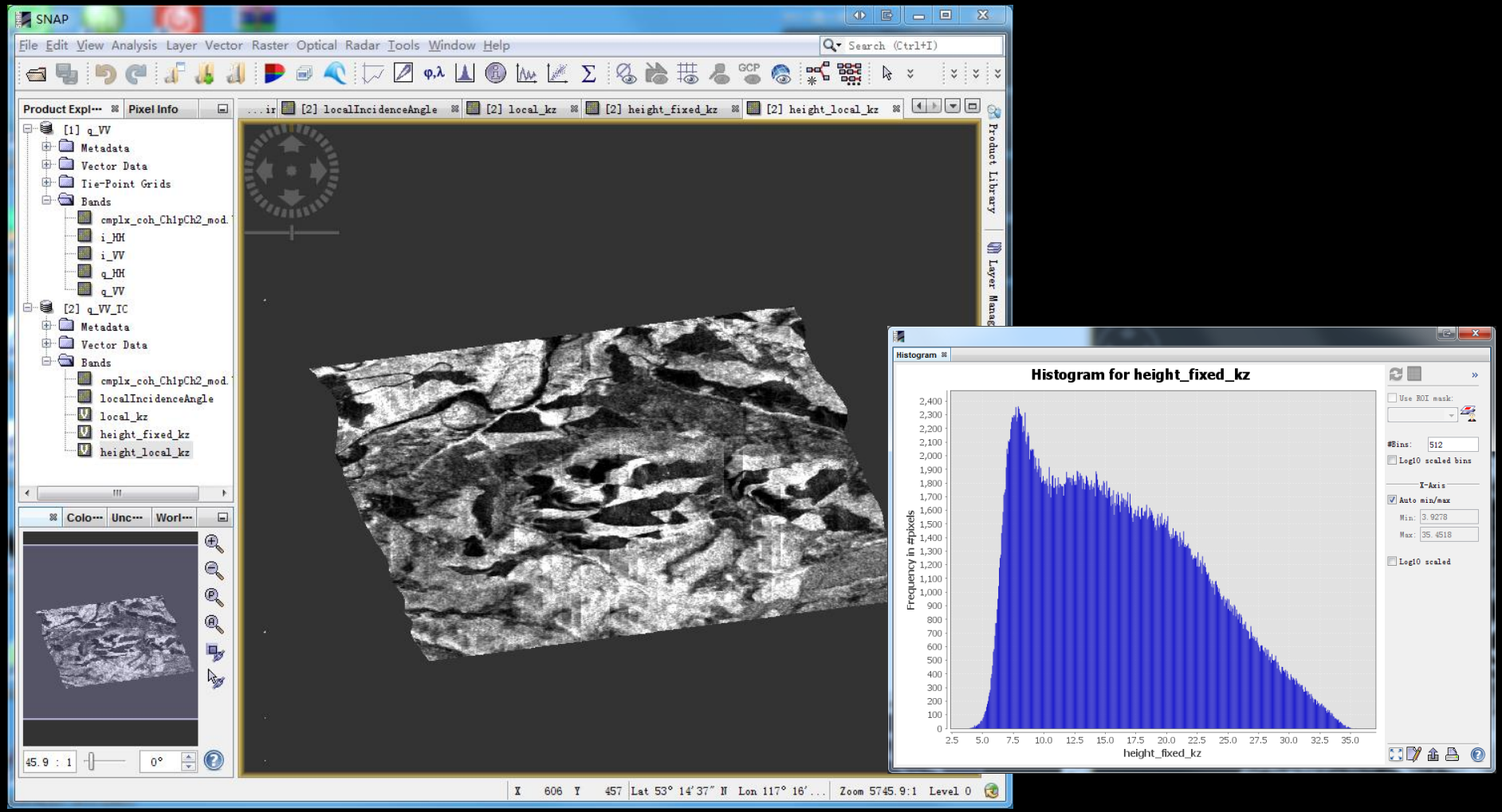
$$h_v = 2\pi\left(1 - 2\,asin(|\gamma|^{0.8})/\pi\right)/k_z$$

Based on Fixed K_Z :



Step12: Height inversion

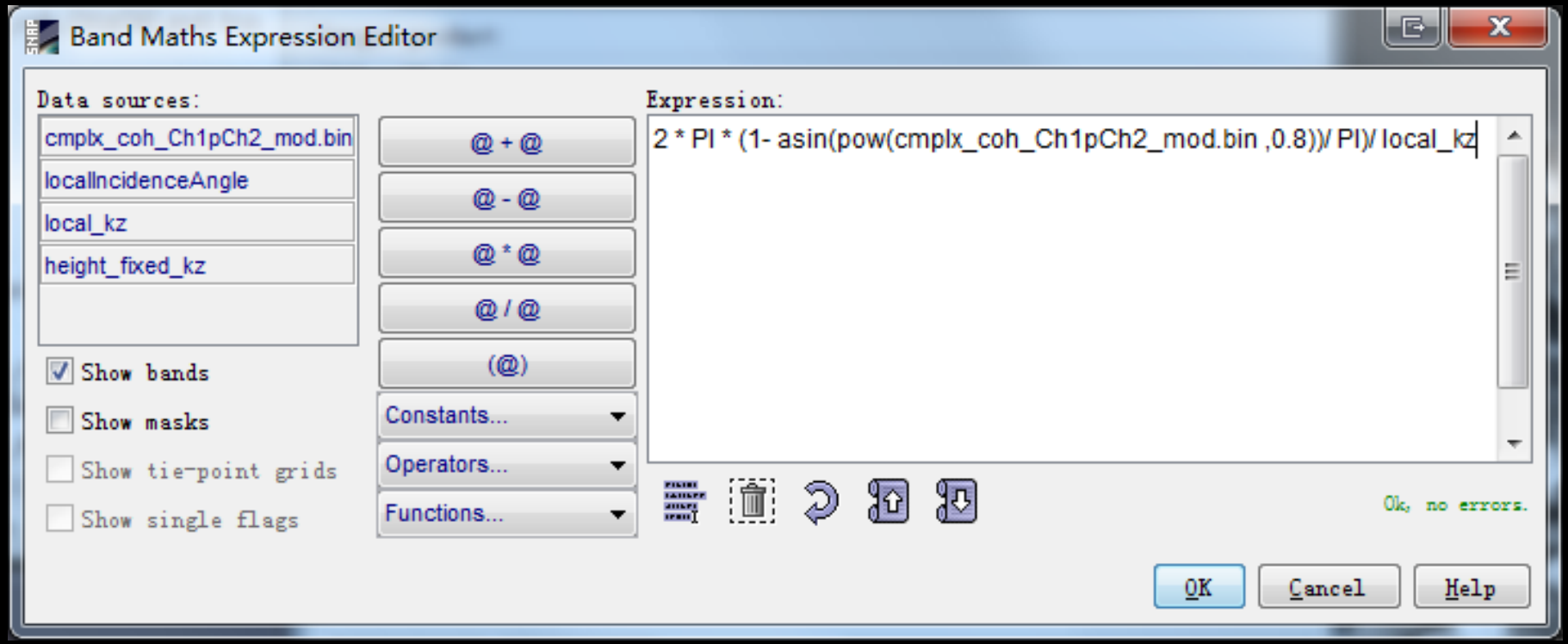
Based on Fixed K_z :



Step12: Height inversion

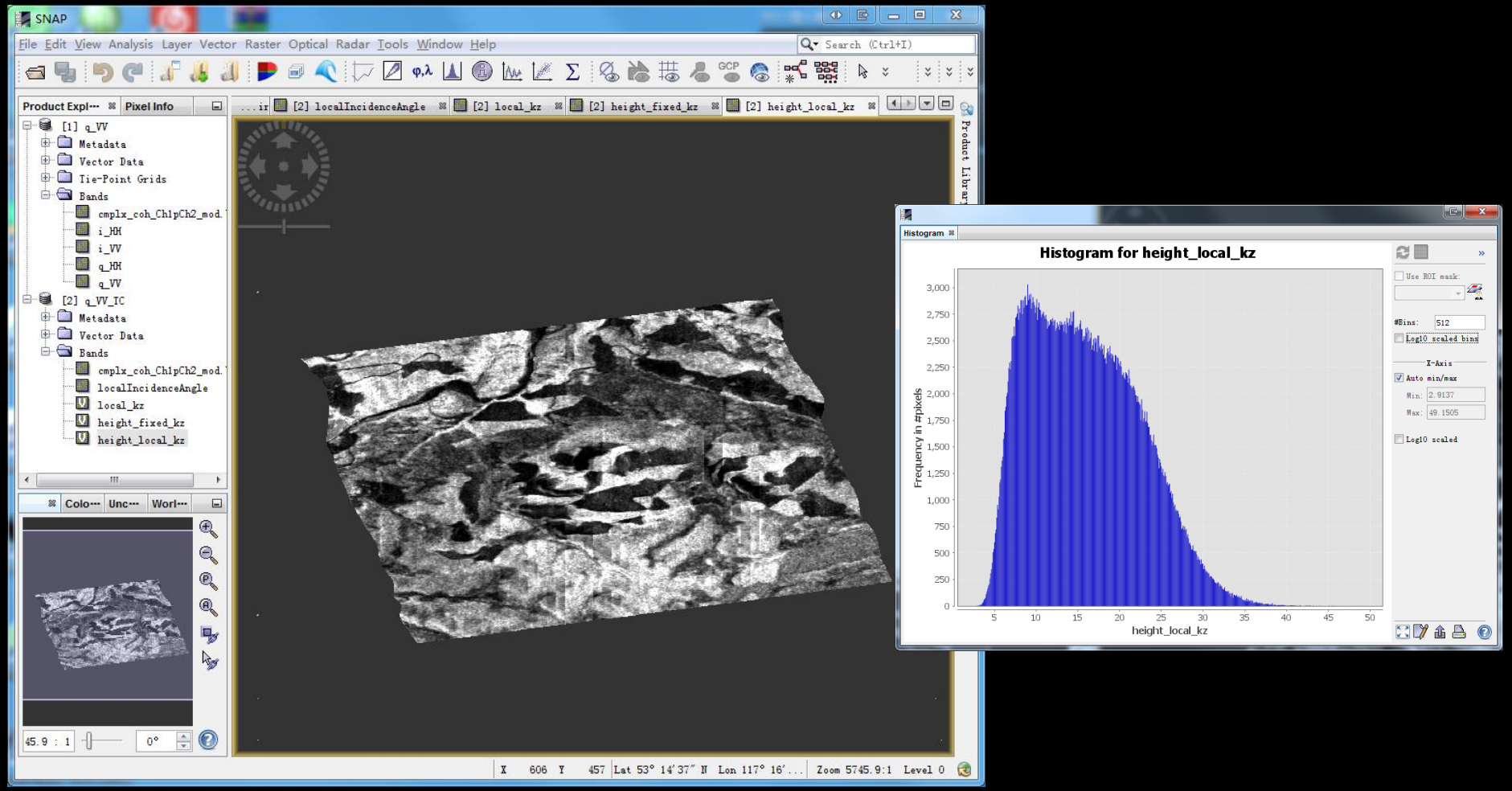
$$h_v = 2\pi\left(1 - 2\,asin(|\gamma|^{0.8})/\pi\right)/k_z$$

Based on Local K_z :

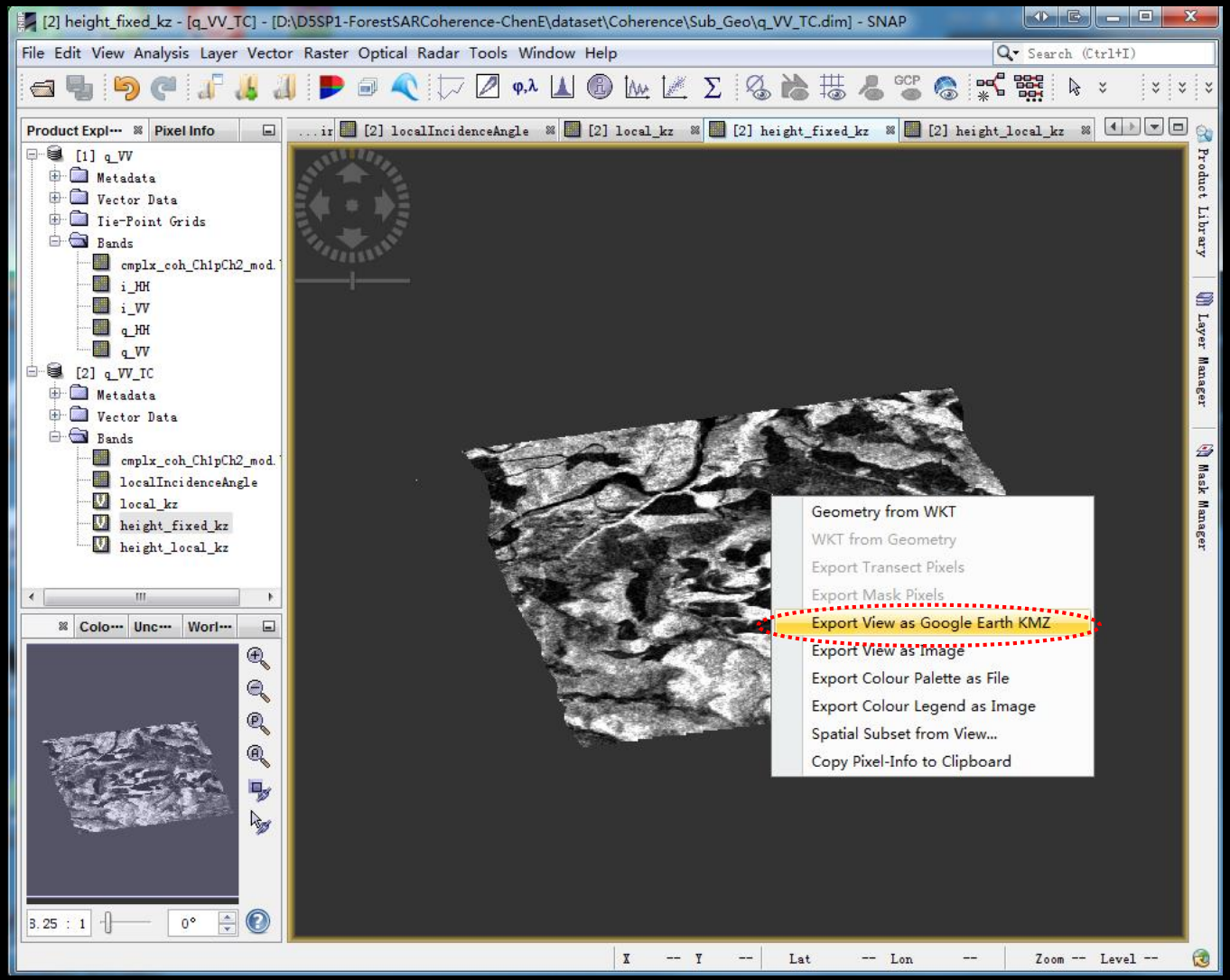


Step12: Height inversion

Based on Local K_z :



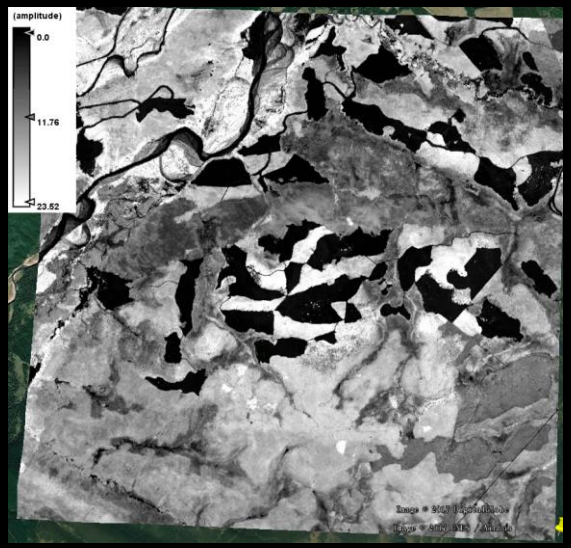
Step12: Height inversion



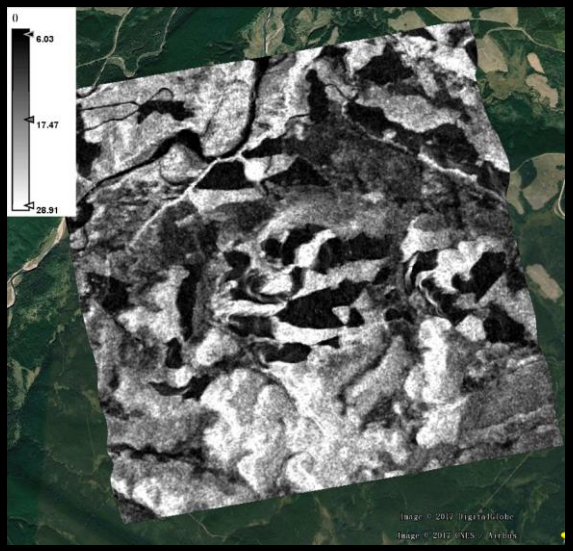
Convert the height inversion result to kmz file.

Step12: Height inversion

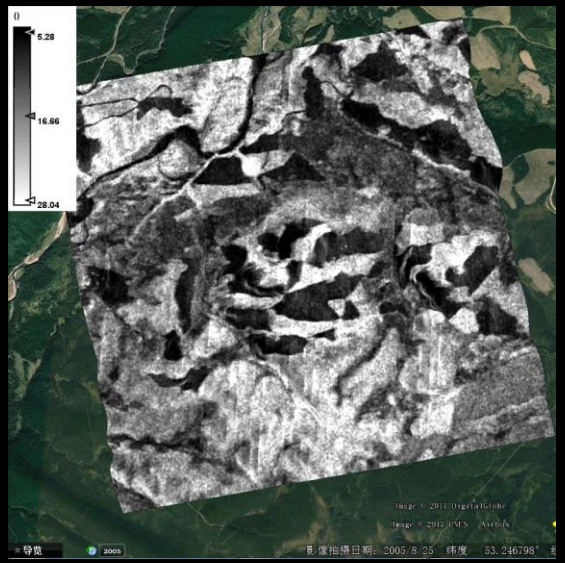
LiDAR Height



Based on Fixed Kz



Based on Local Kz



Questions ?