

Forest SAR & Coherence

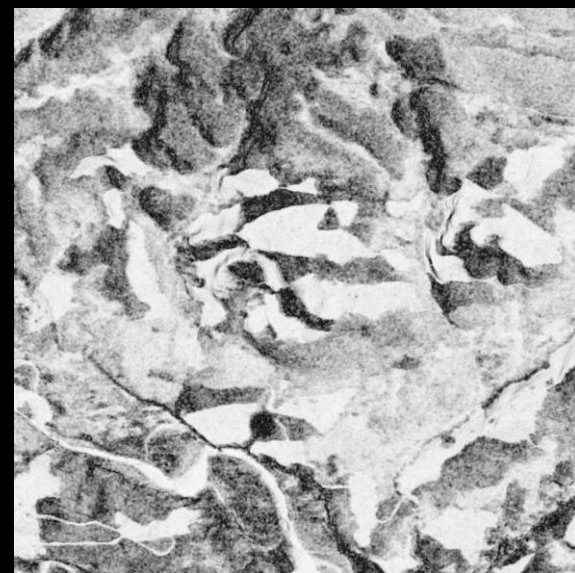
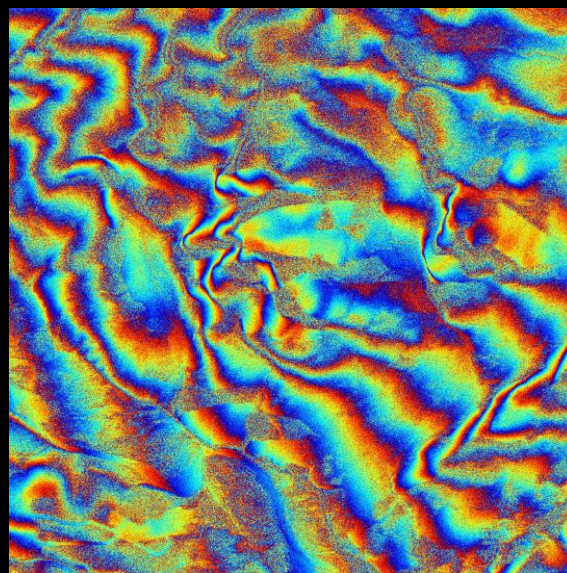
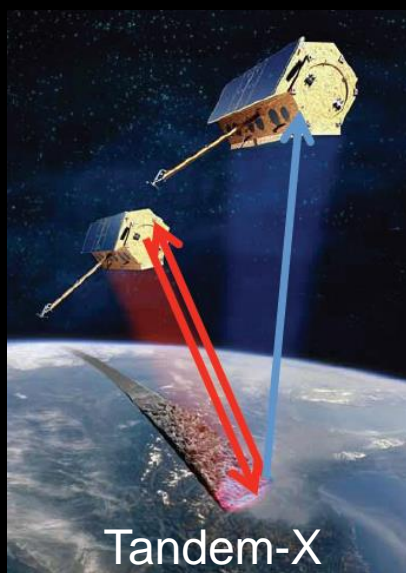
(Practical Session 2)

Erxue Chen Lei Zhao

Chinese Academy of forestry

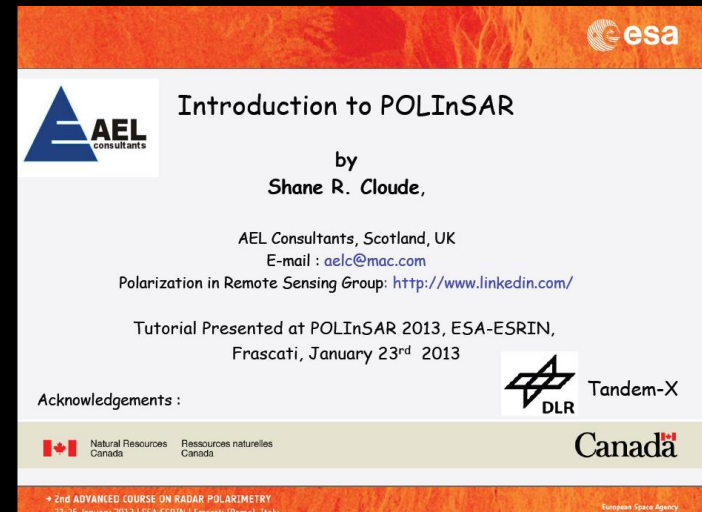
Forest Height inversion Based on Coherence

Software required: PolSARpro & SNAP



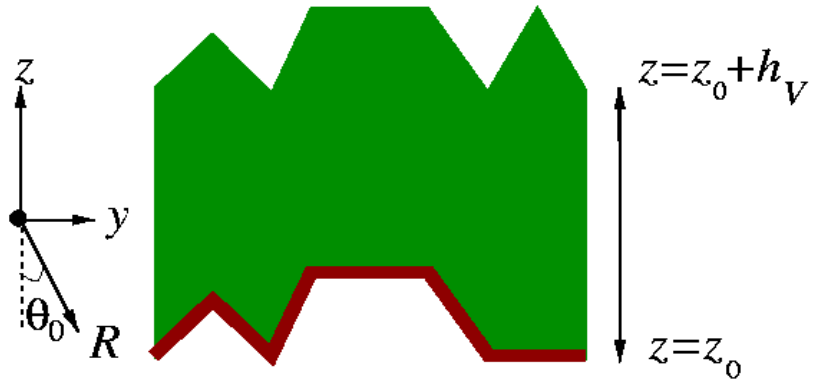
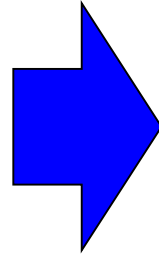
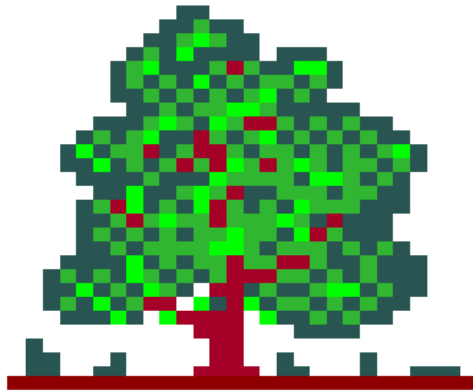
Acknowledgements

- 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



The slide features a white background with an orange header and footer. The header contains the ESA logo. The main content area includes the AEL Consultants logo, the title 'Introduction to POLInSAR', the author's name 'Shane R. Cloude', and contact information for AEL Consultants in Scotland, UK. It also mentions the 'Polarization in Remote Sensing Group' with a LinkedIn link. The presentation location is noted as POLInSAR 2013, ESA-ESRIN, Frascati, Italy, in January 2013. Logos for DLR Tandem-X and the Canadian government (Natural Resources Canada) are displayed. The footer contains course details: '2nd ADVANCED COURSE ON RADAR POLARIMETRY' held from 23-25 January 2013 at ESA-ESRIN, Frascati, Italy, and the ESA logo.

Introduction to POLInSAR
by
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Polarization in Remote Sensing Group: <http://www.linkedin.com/>
Tutorial Presented at POLInSAR 2013, ESA-ESRIN,
Frascati, January 23rd 2013
Acknowledgements :
Canada Natural Resources Canada Ressources naturelles Canada
DLR Tandem-X
Canada
2nd ADVANCED COURSE ON RADAR POLARIMETRY
23-25 January 2013 | ESA-ESRIN | Frascati (Rome), Italy
European Space Agency



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

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.

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

↓ $f(z) = 1$

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

↓

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

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

Only two unknown parameters!

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*)

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

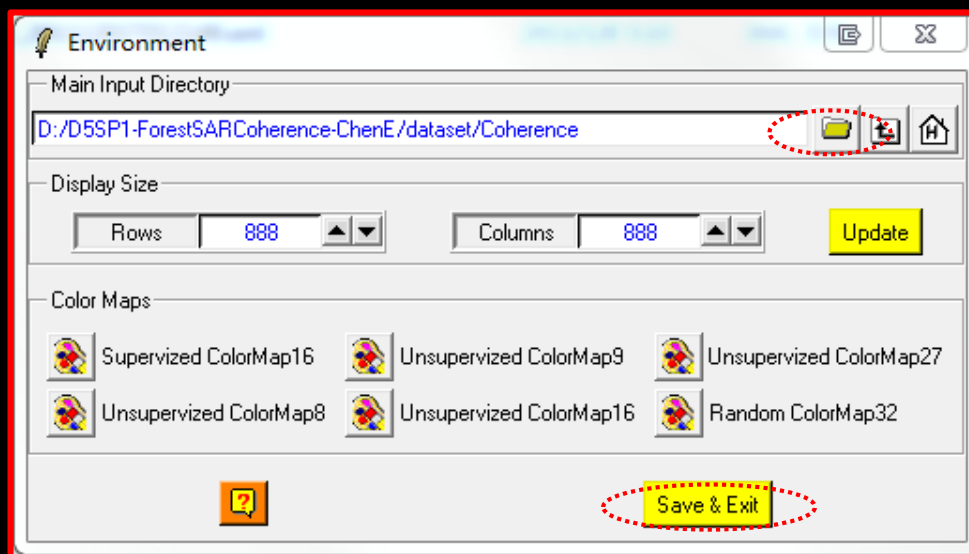
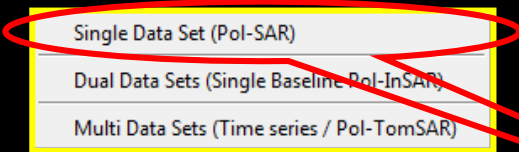
11. Local K_z

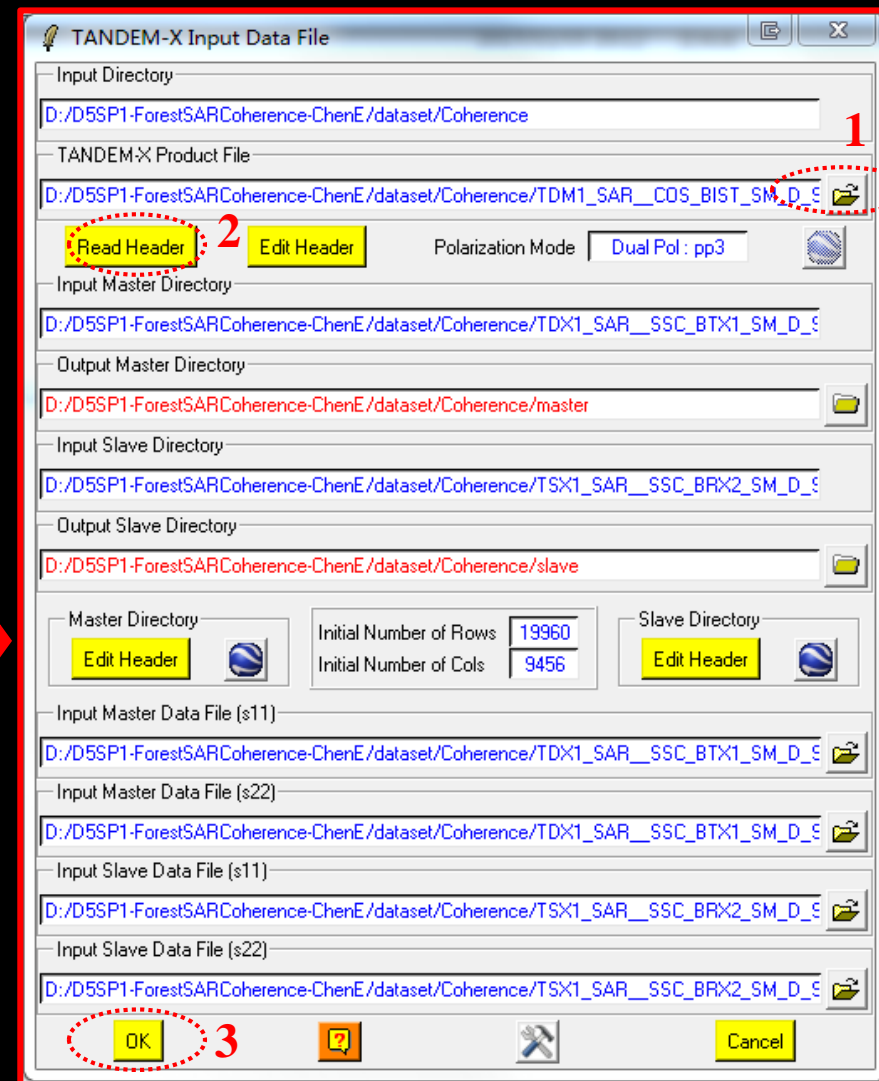
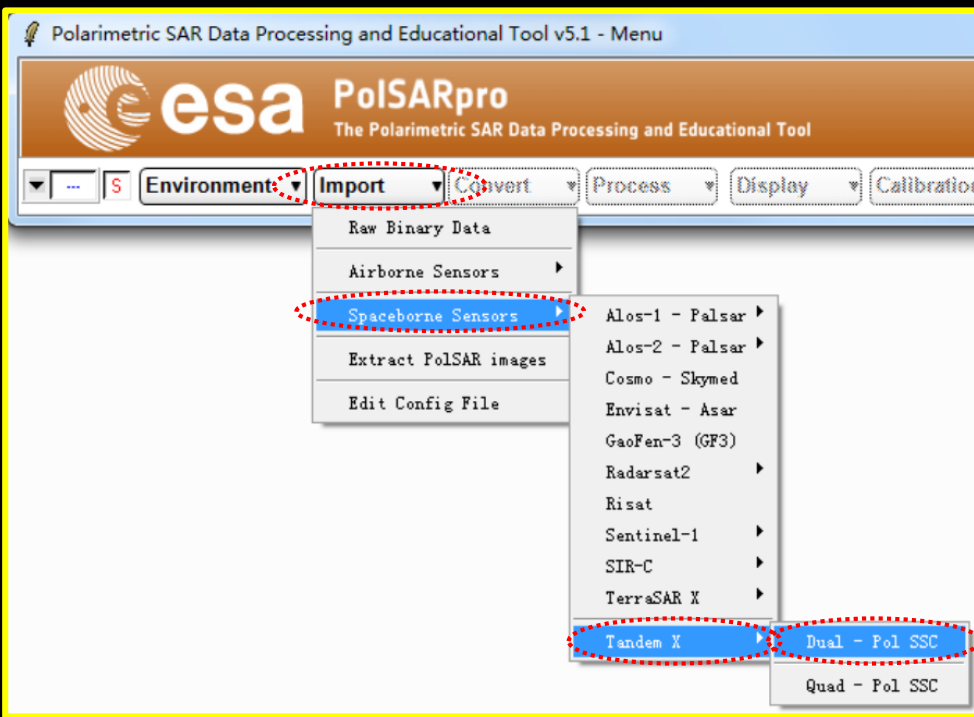
- Local incidence angle file (θ_{loc})
- Angle of incidence center (θ_0)

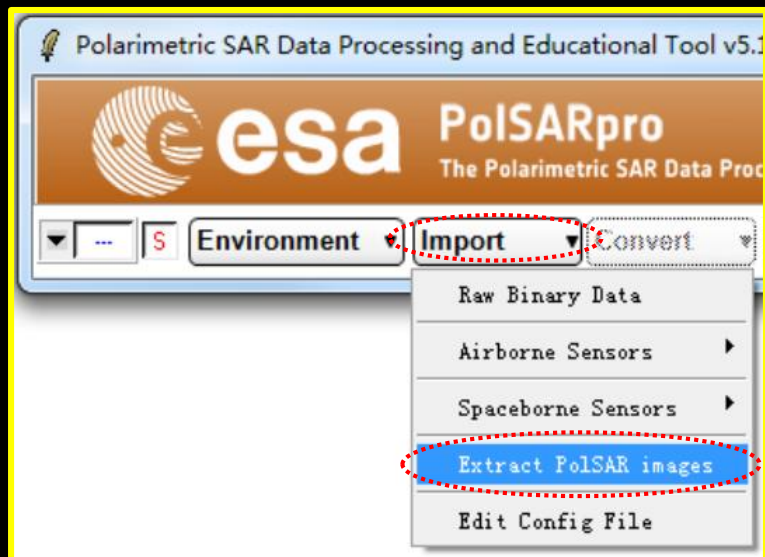
$$k_z = \frac{4\pi\Delta\theta}{\lambda \sin(\theta_{loc})} = \frac{2\pi \sin(\theta_0)}{hoa \cdot \sin(\theta_{loc})}$$

Part 3. Height inversion

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

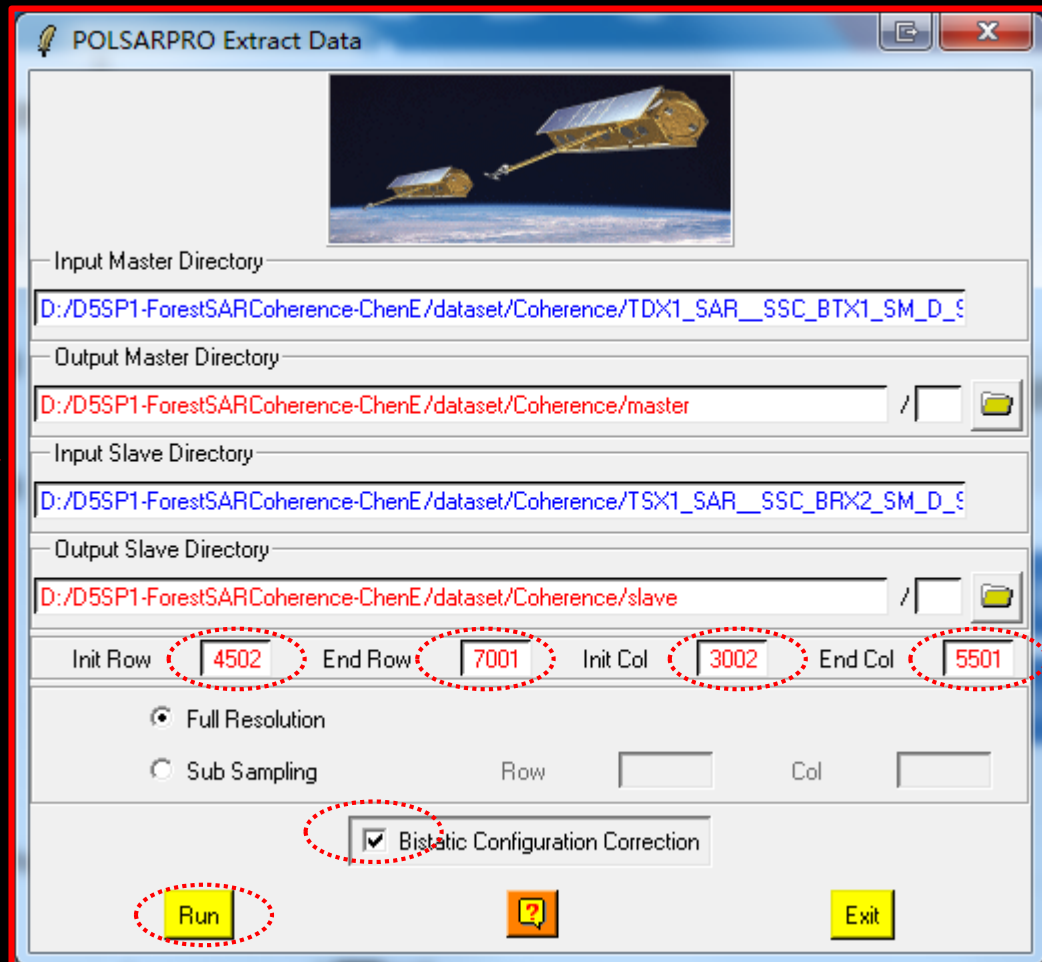


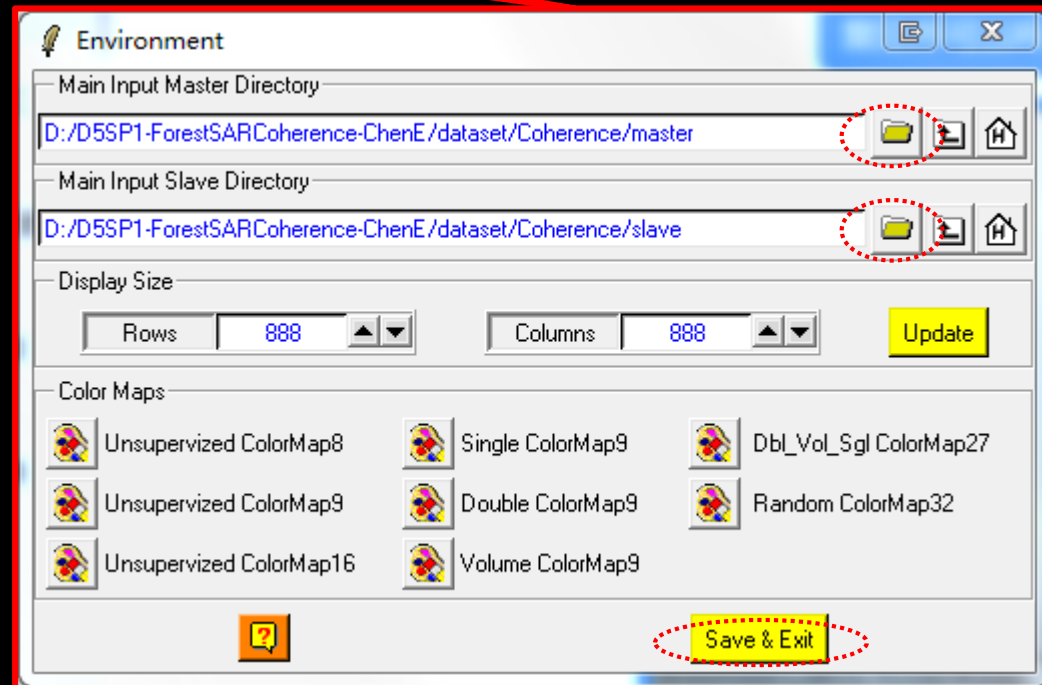
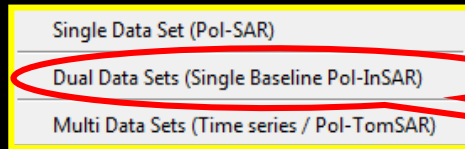


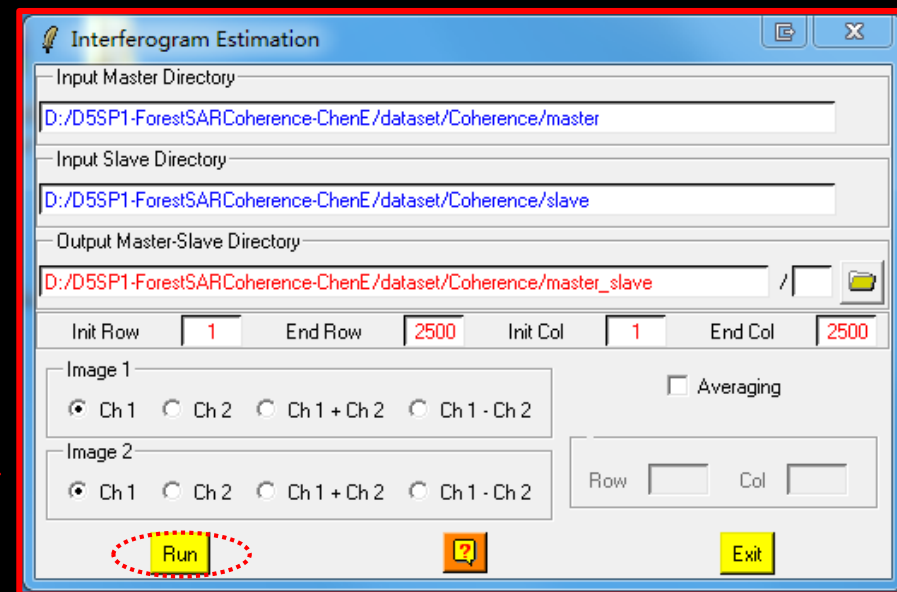
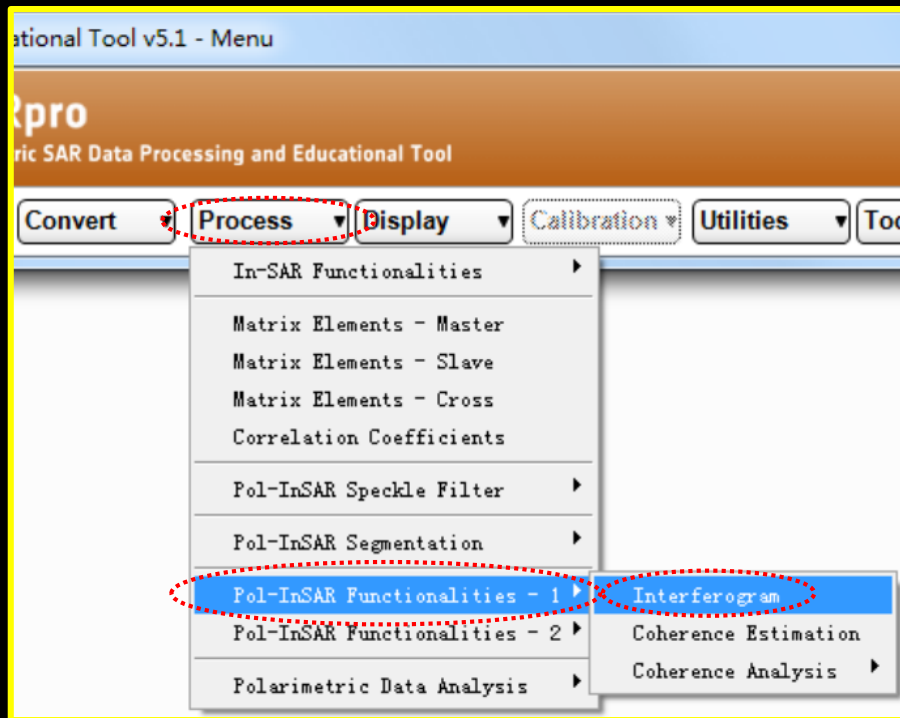


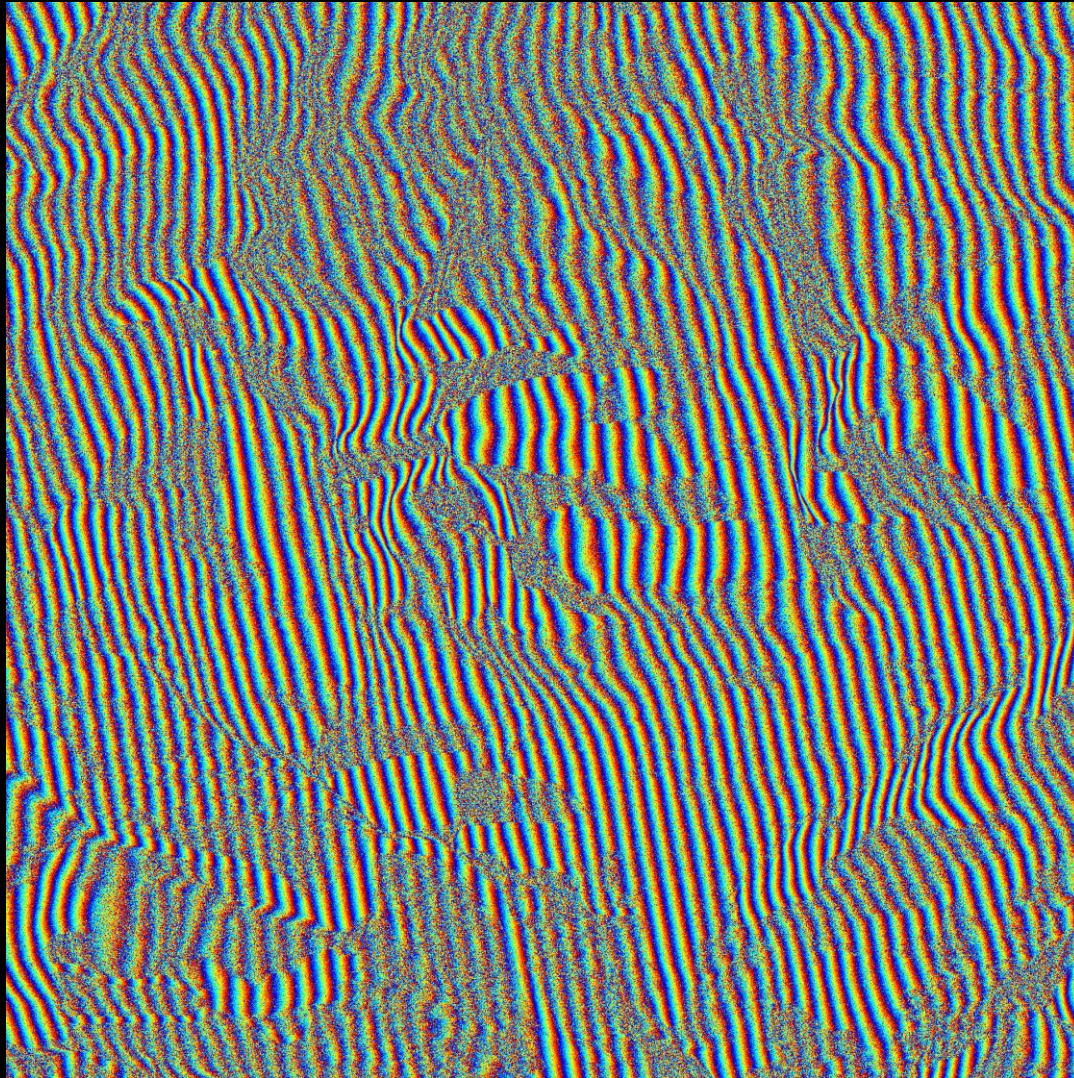
Notes:

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

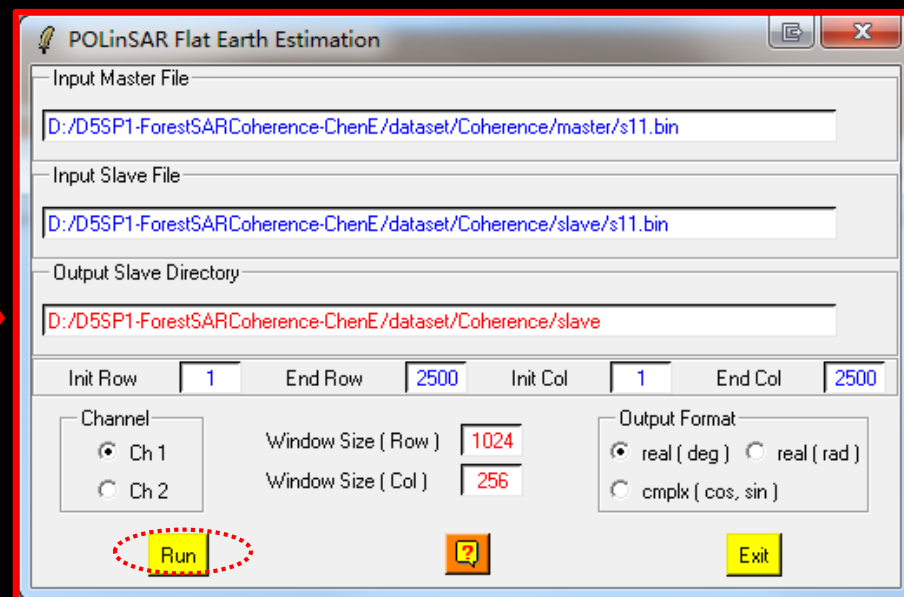
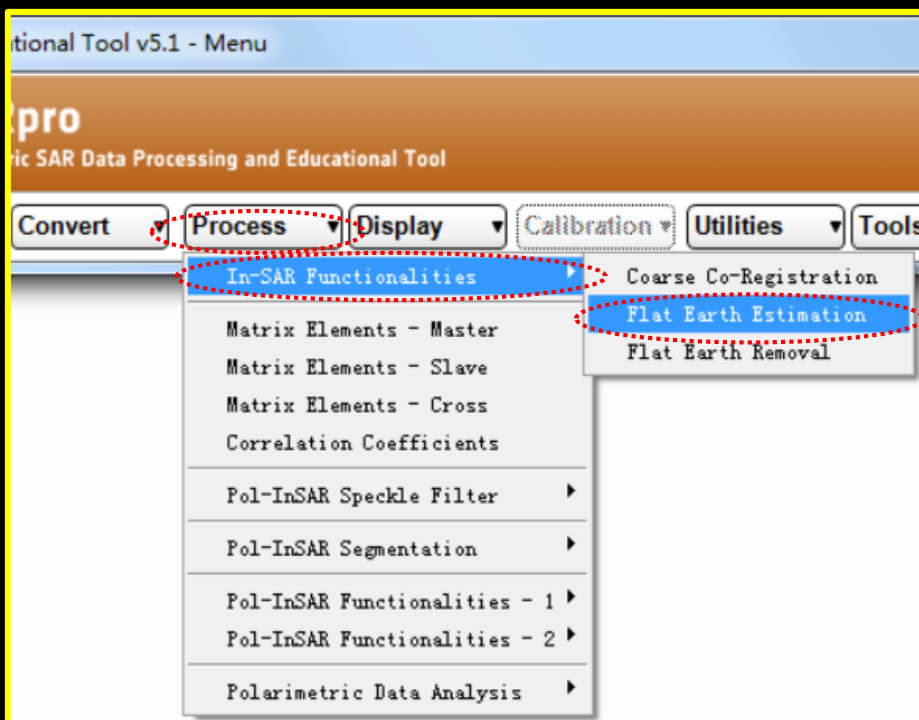






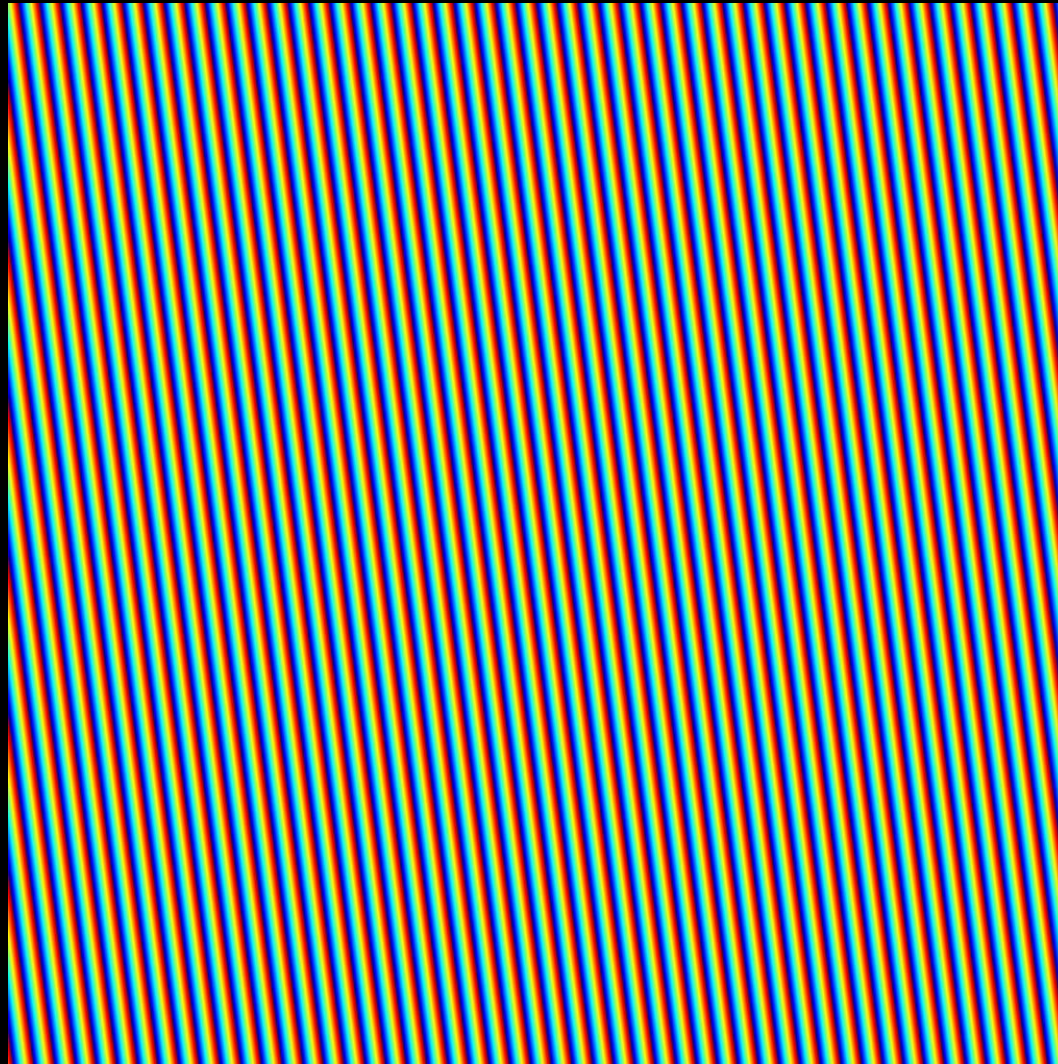


interferogram_Ch1_Ch1.bmp

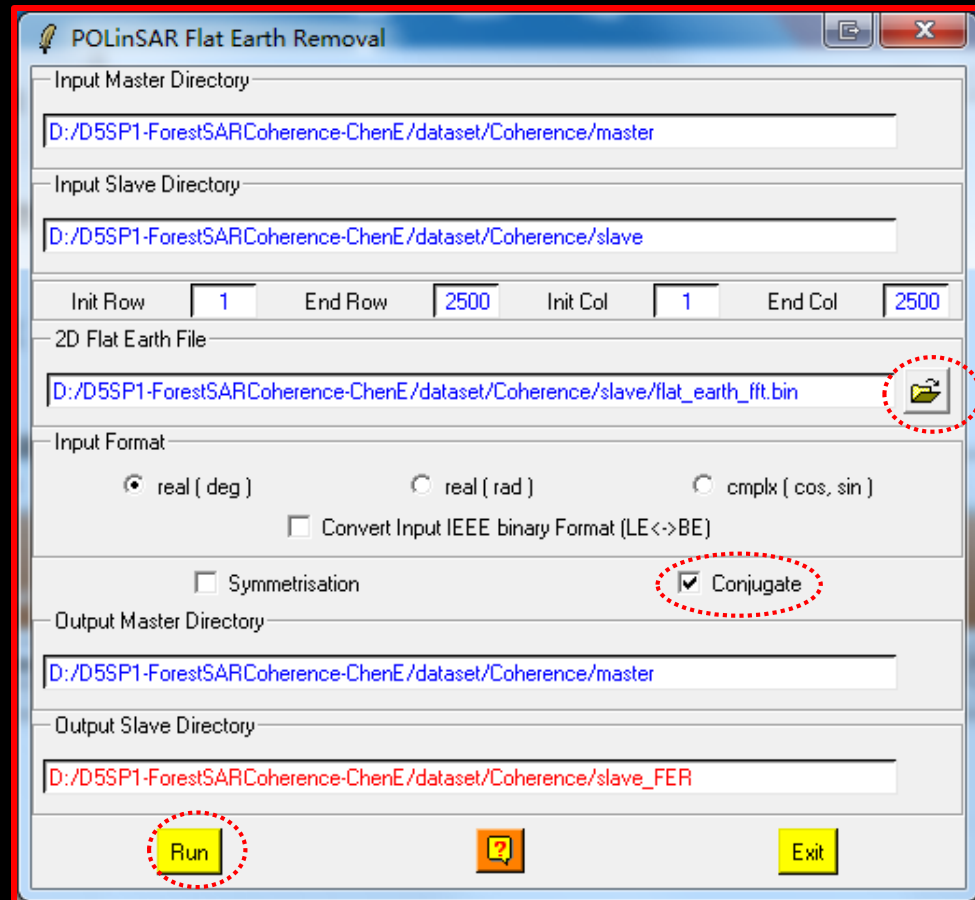
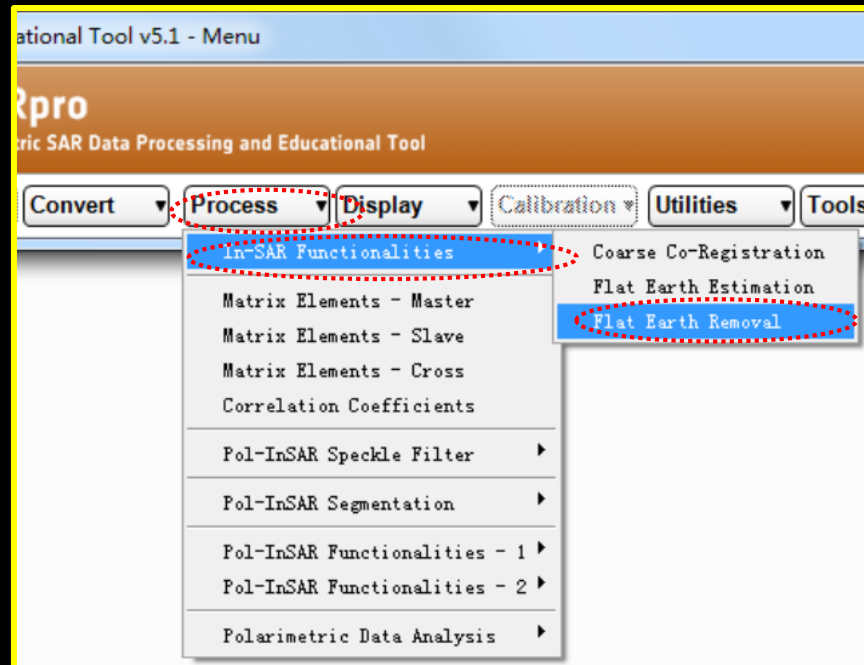


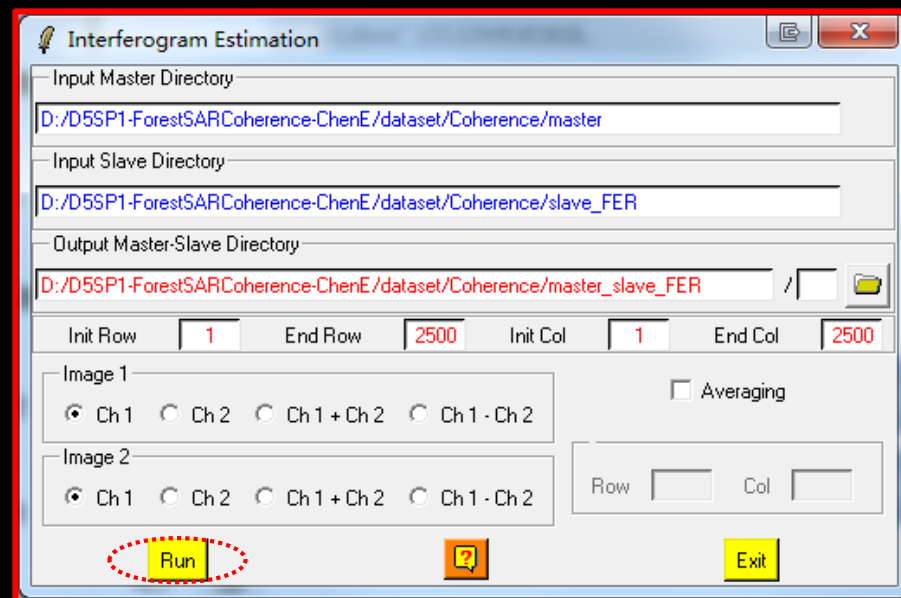
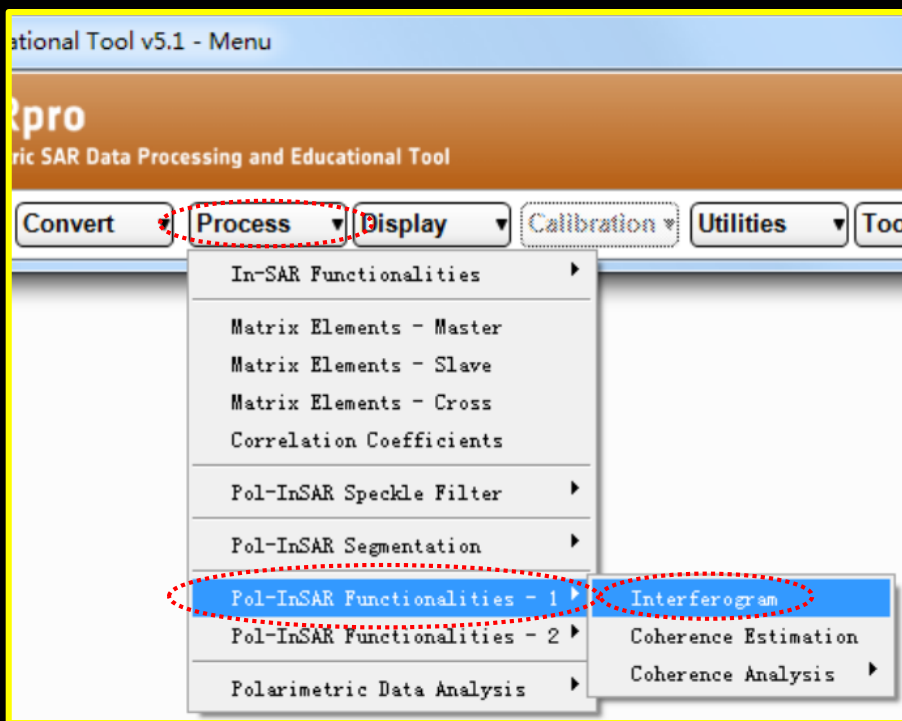


Step5: Flat earth estimate

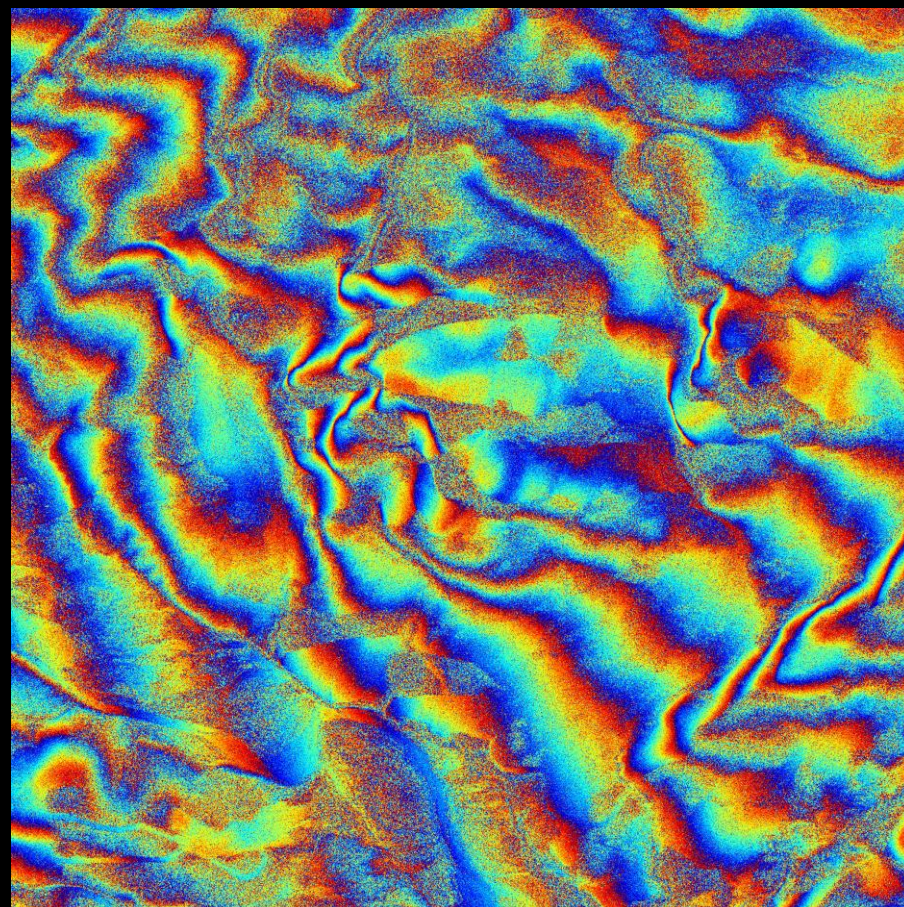
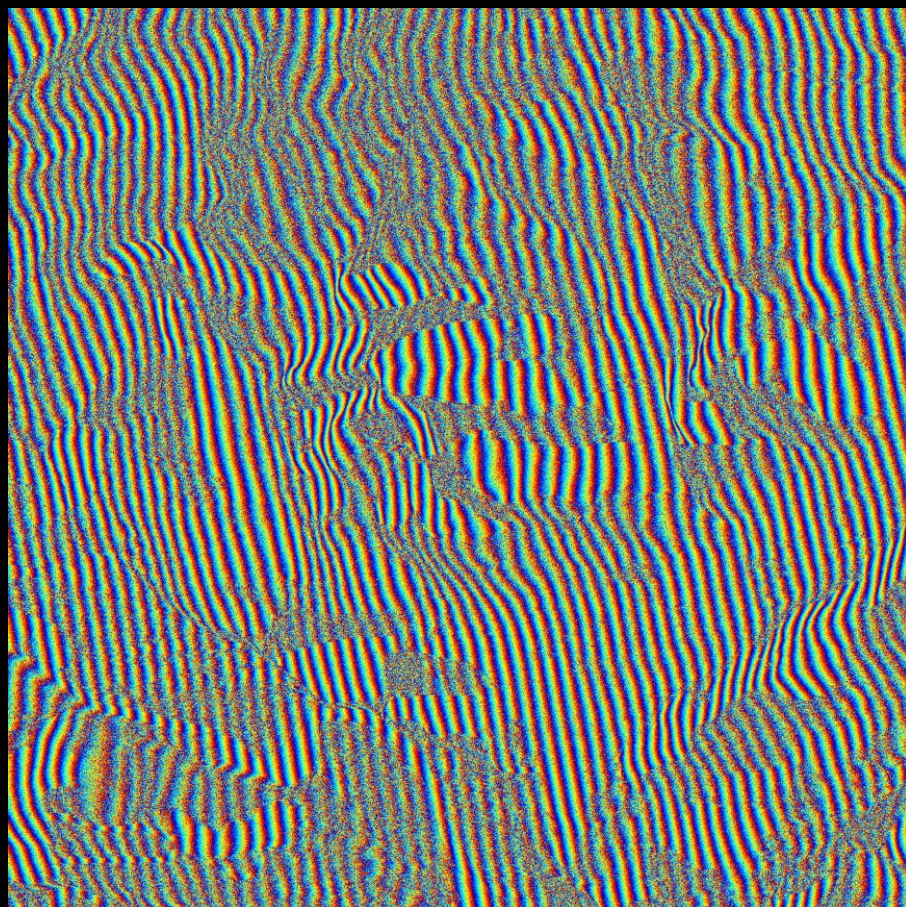


flat_earth_fft.bmp

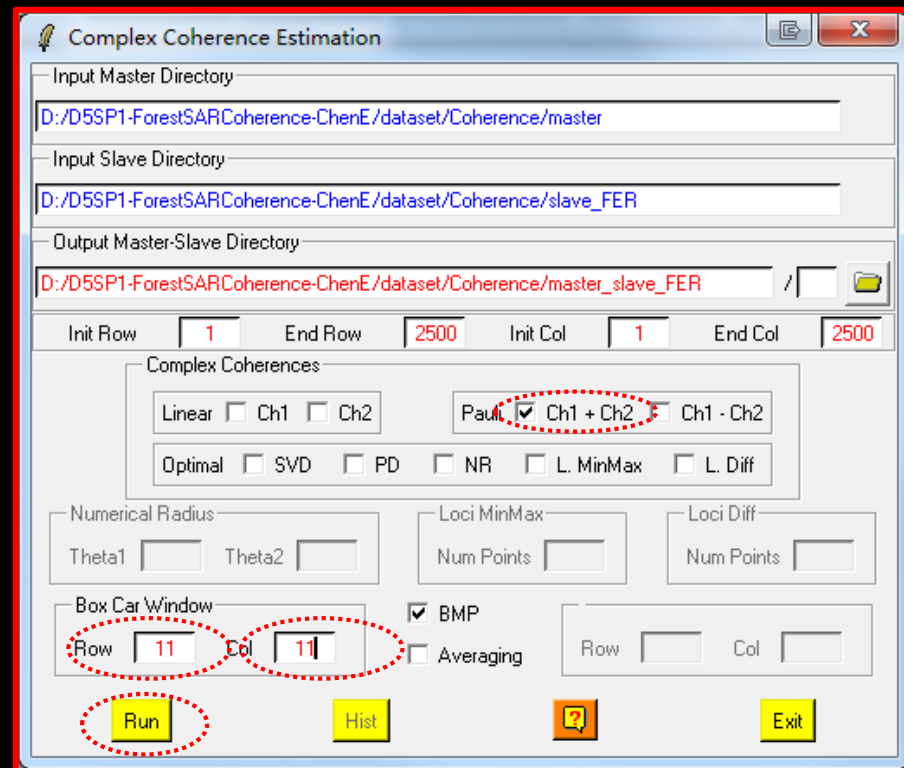
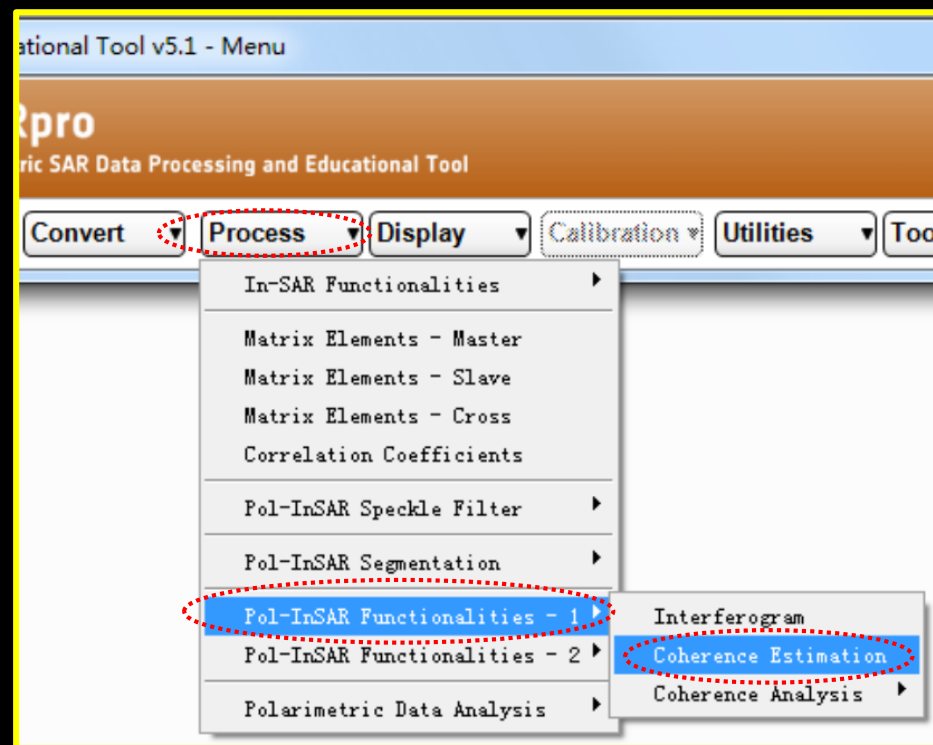


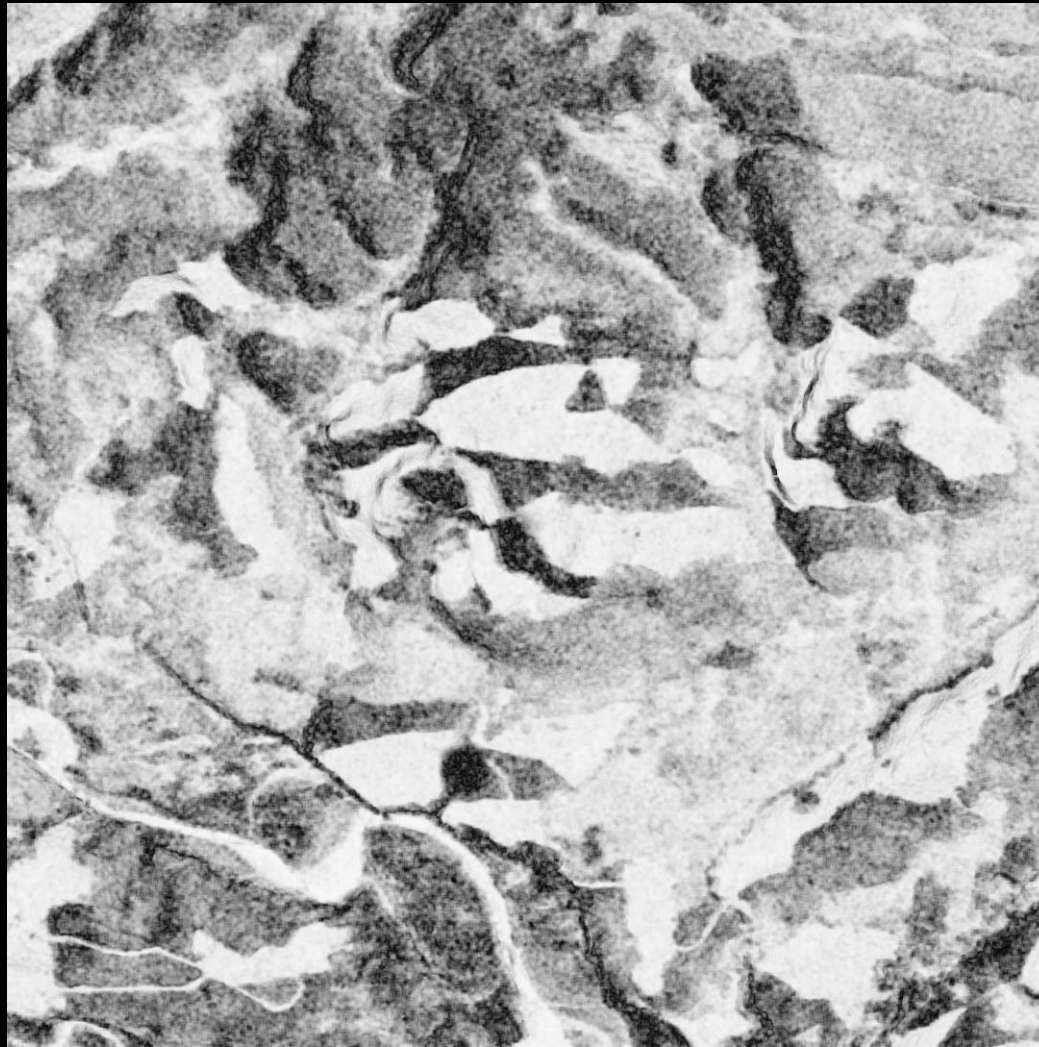


Check the effect of flat earth remove



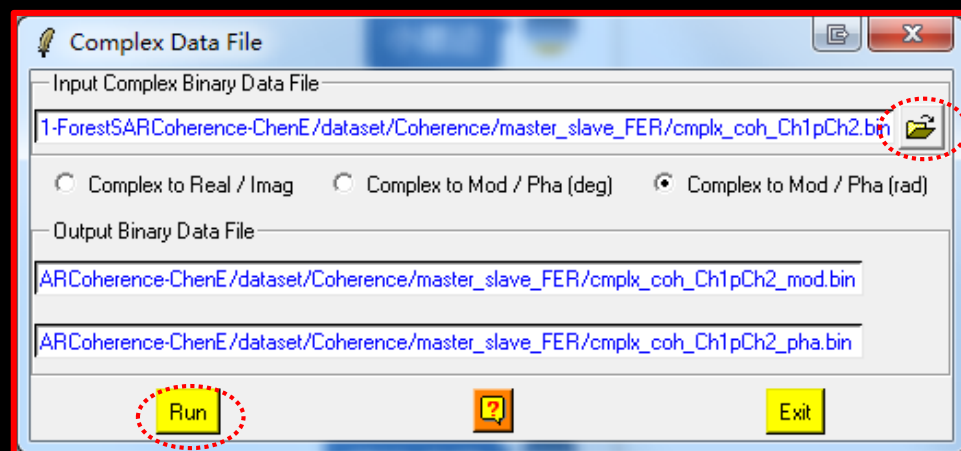
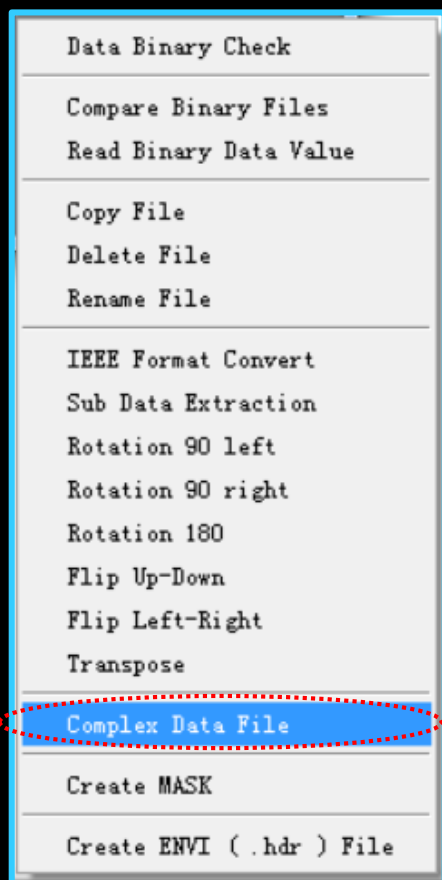
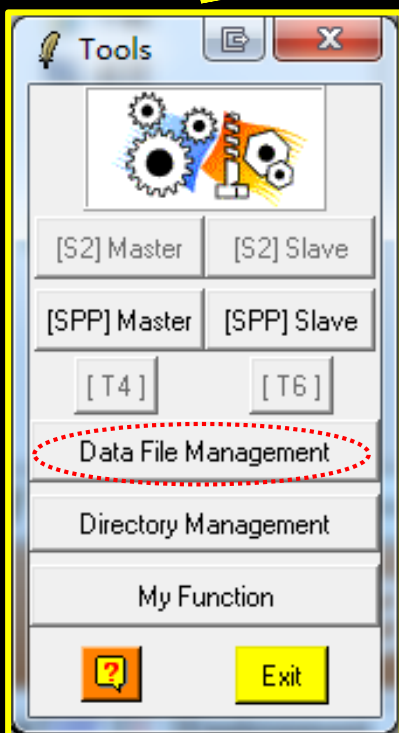
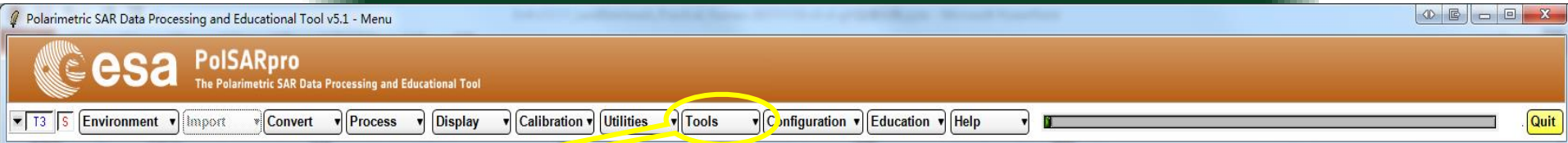
Check the effect of flat earth remove



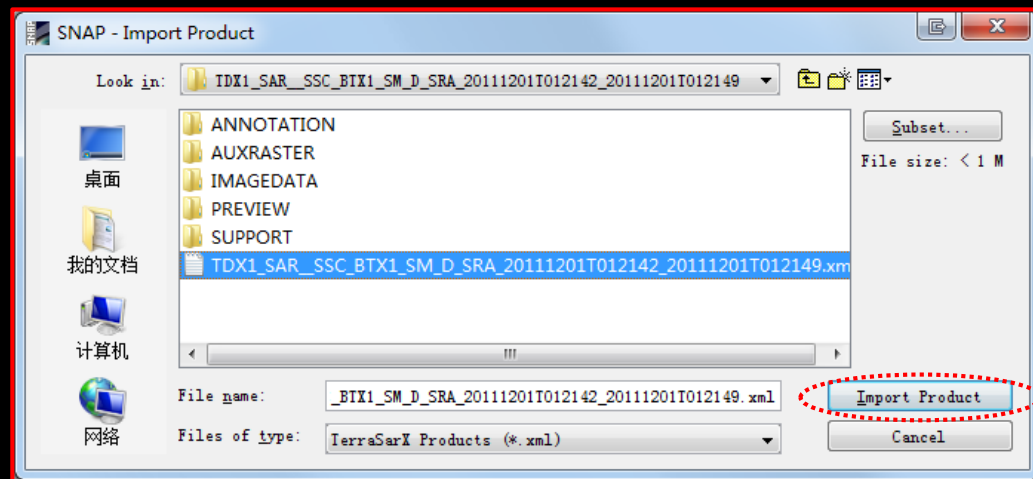
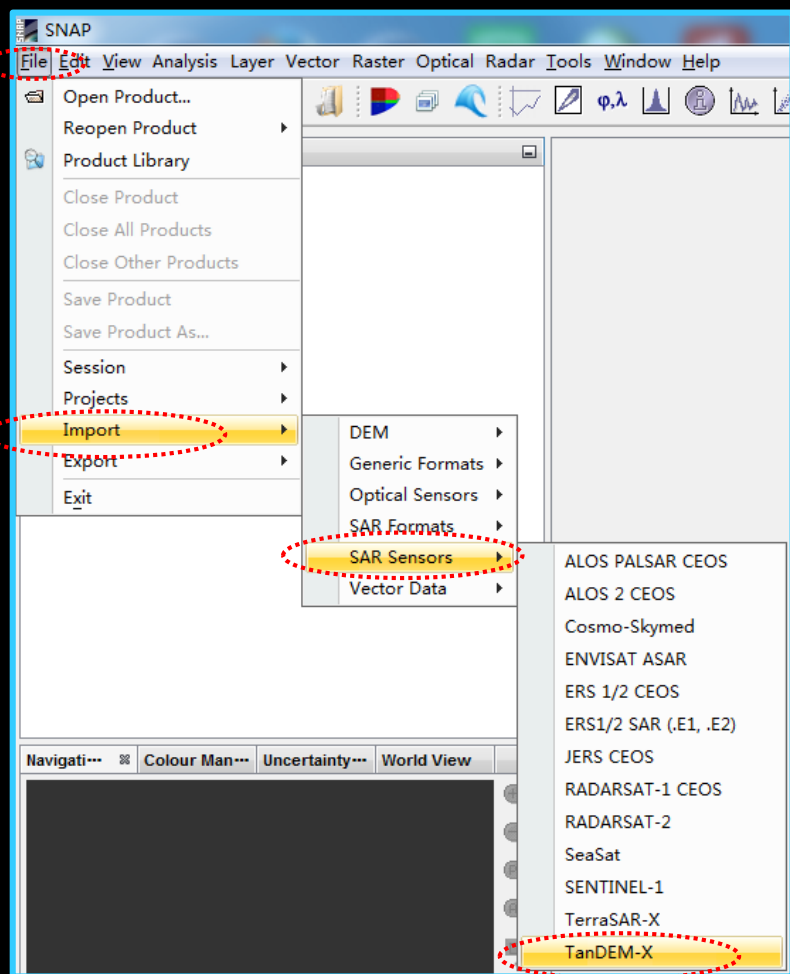


cmplx_coh_Ch1pCh2_mod.bmp

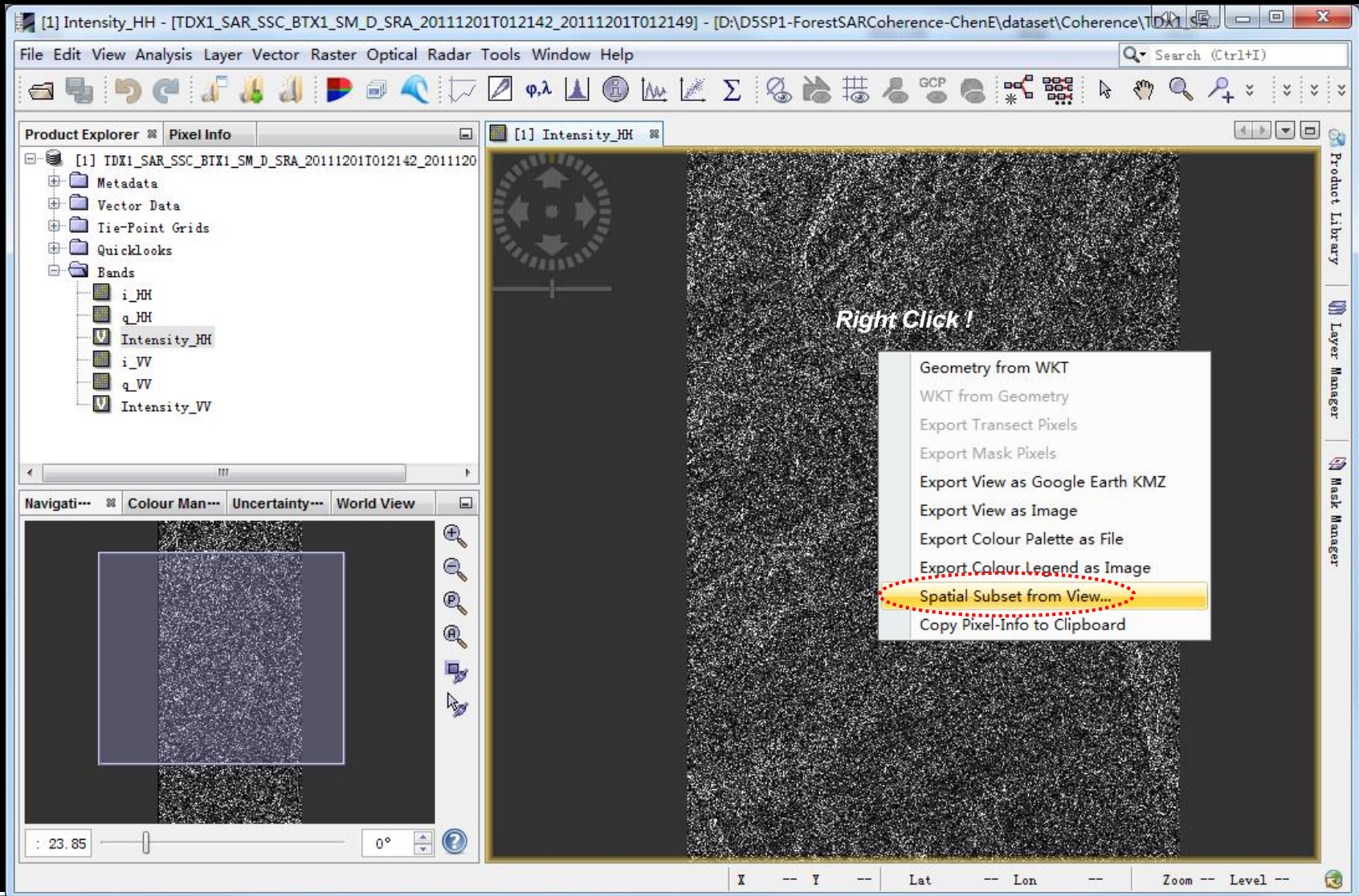
Step8: Save Coherence



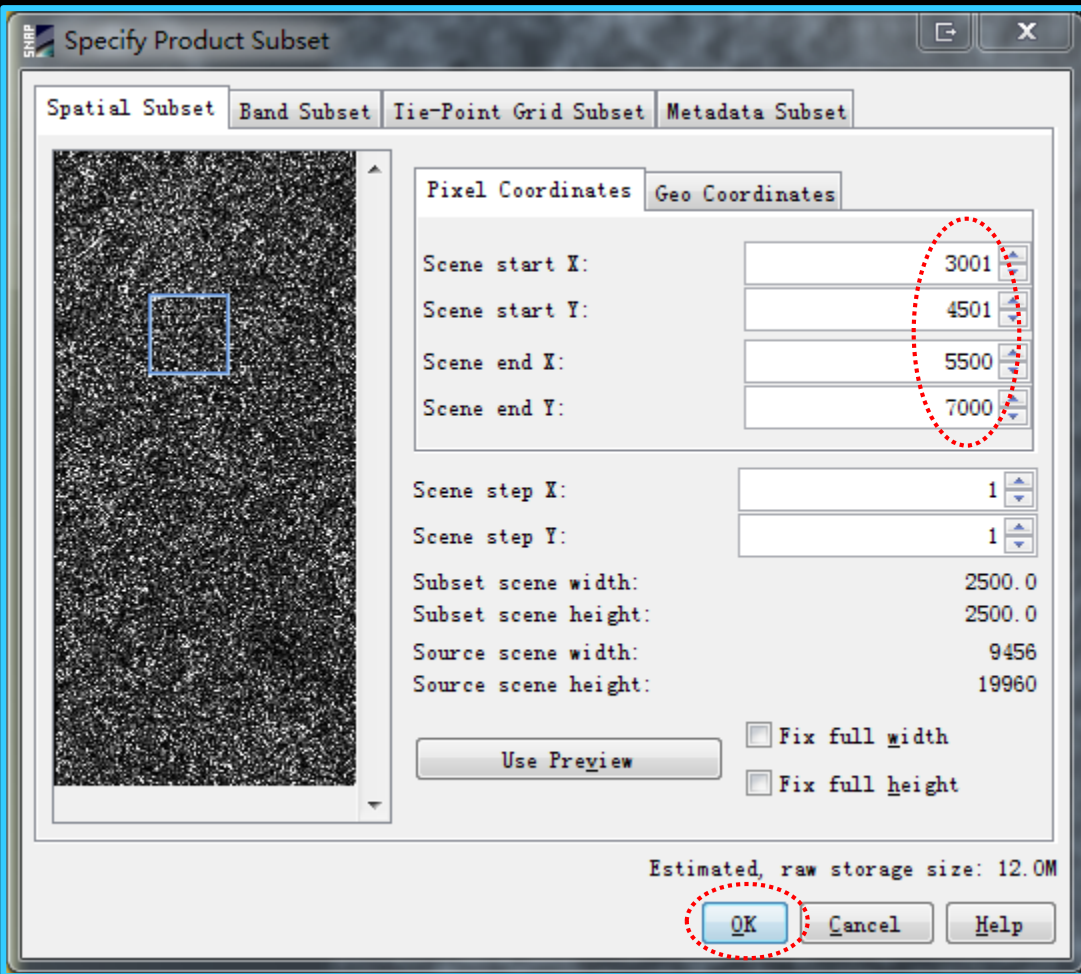
Step 9.1 : Sub-region Header File Ready (Orbit data).



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

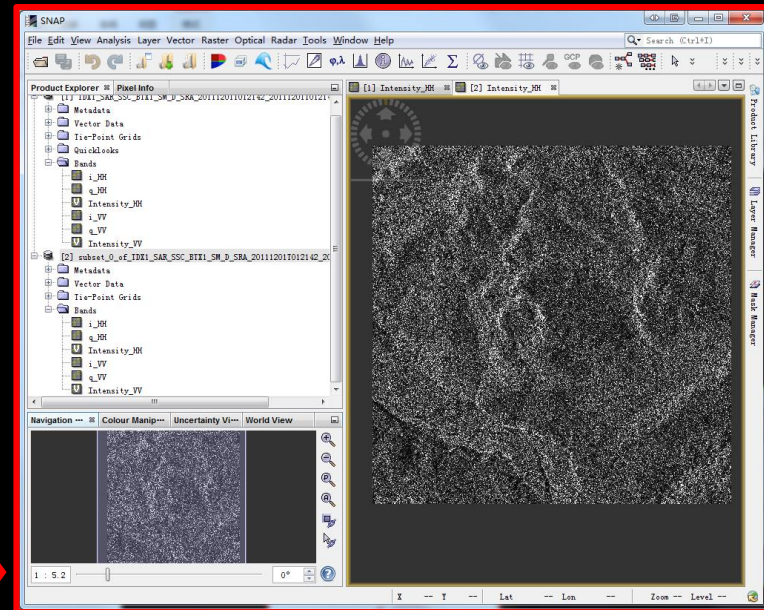


Step 9.1 : Sub-region Header File Ready (Orbit data).

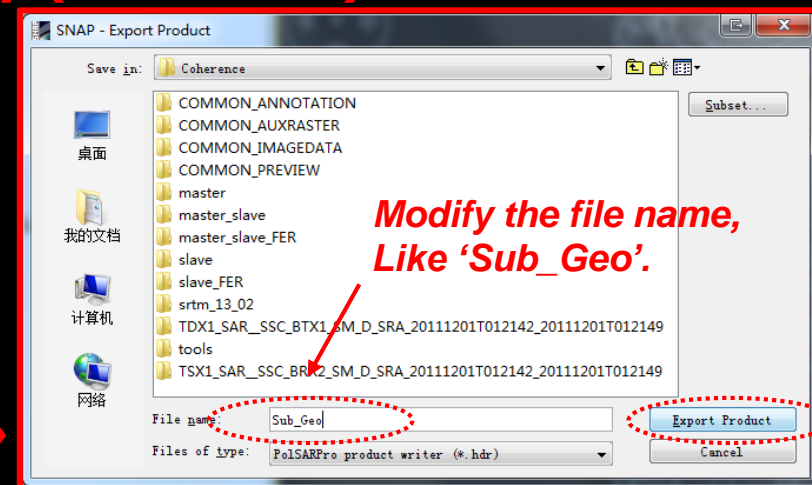
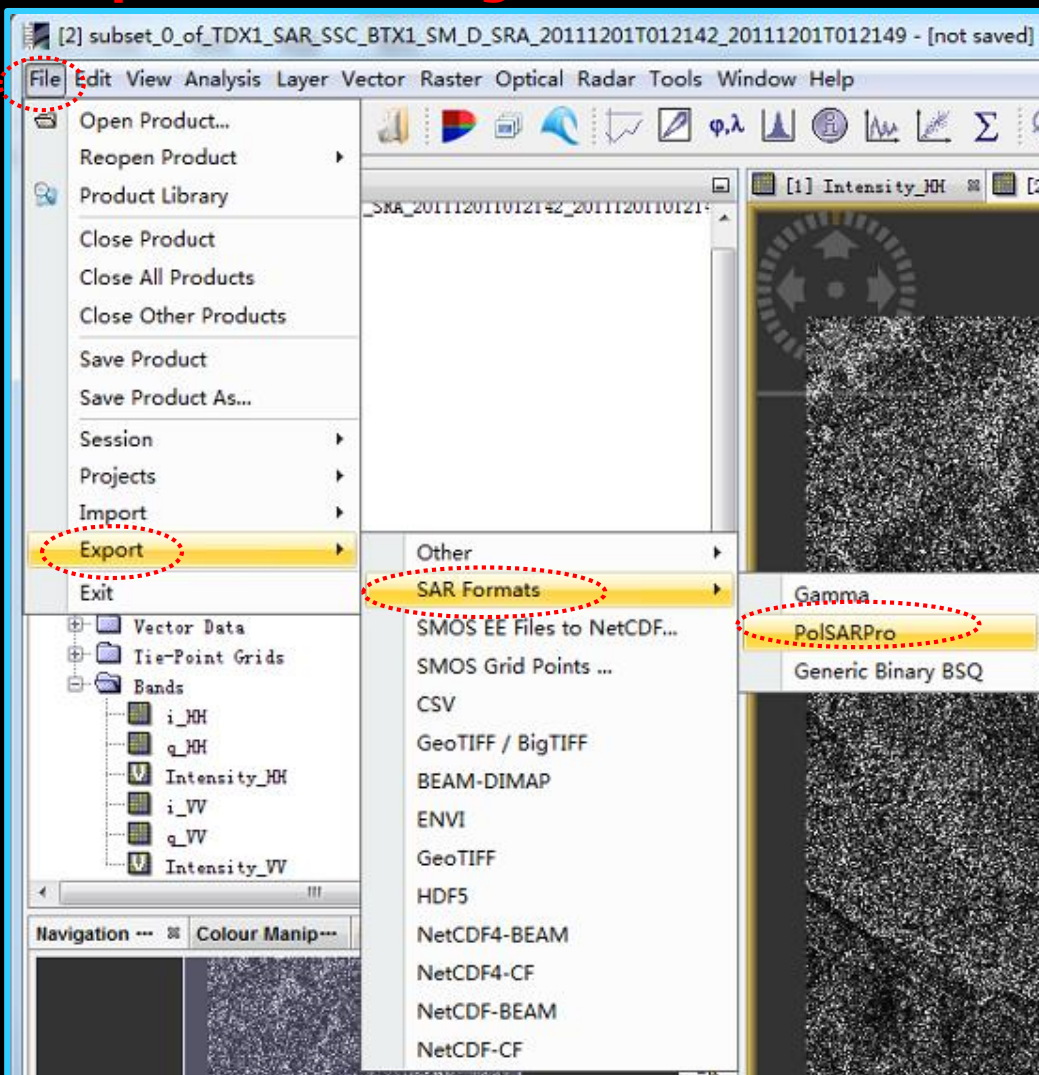


Notes:

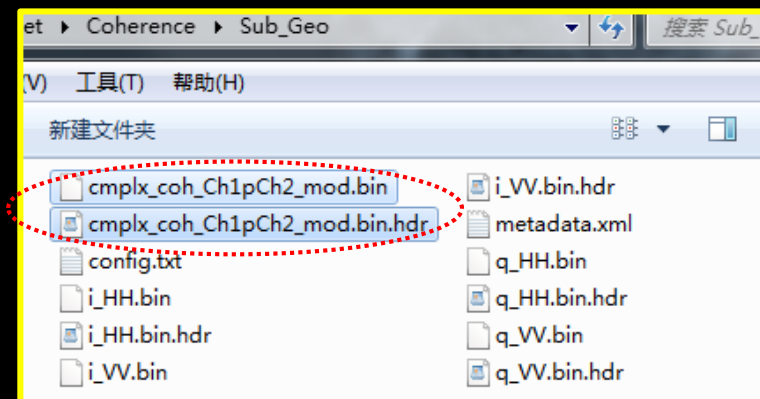
- Select region 2500×2500 pixels
- Y : 4501 – 7000 select
- X: 3001 – 5500 select



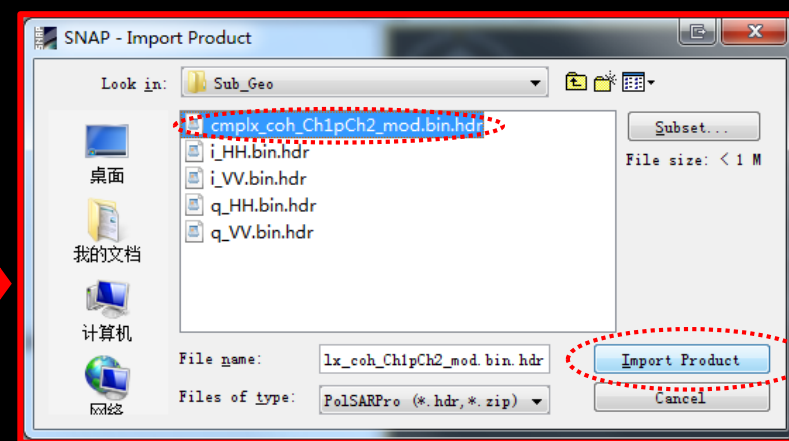
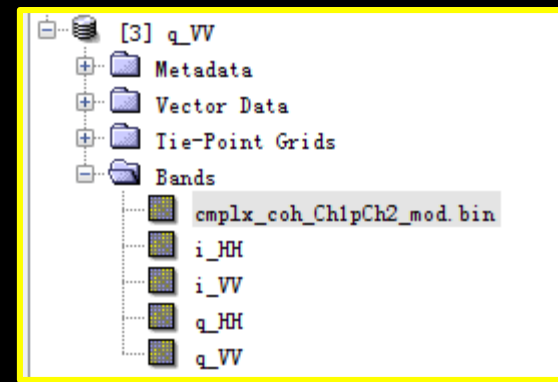
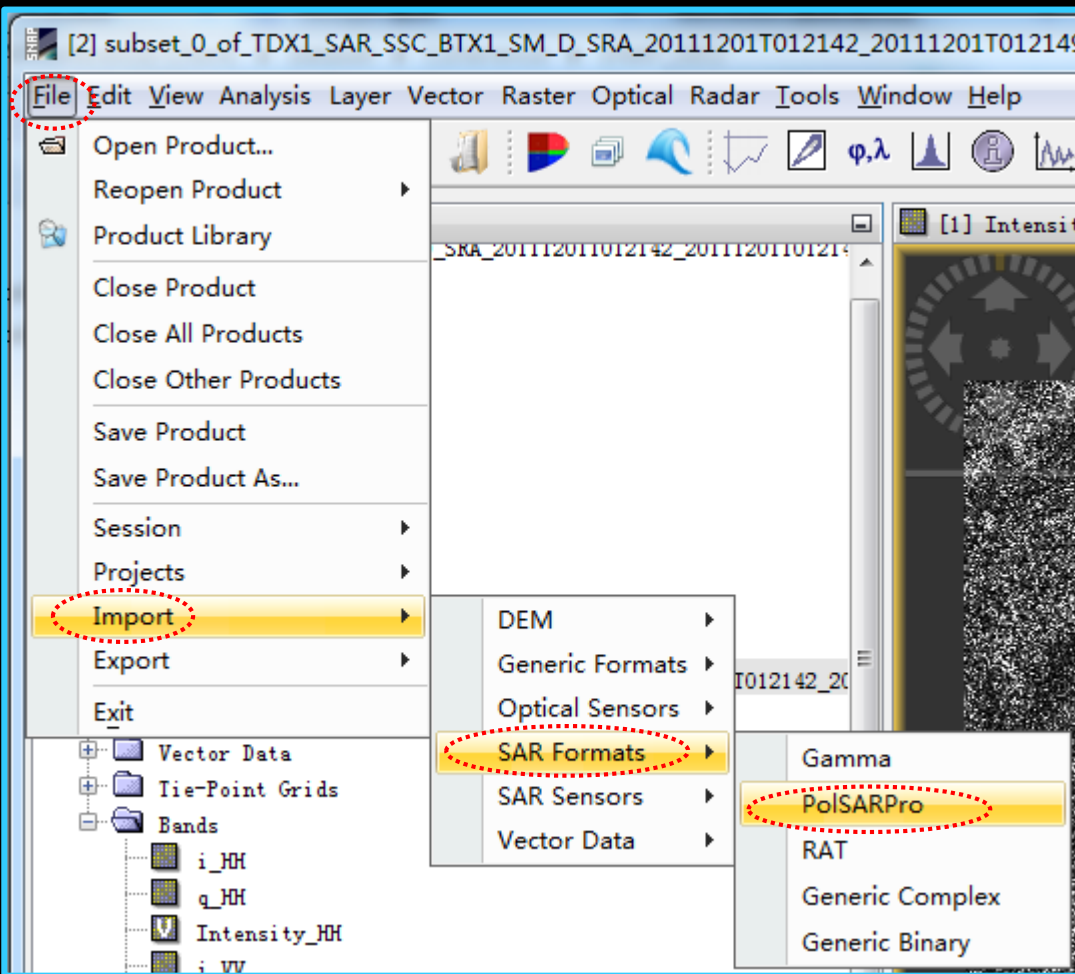
Step 9.1 : Sub-region Header File Ready (Orbit data).



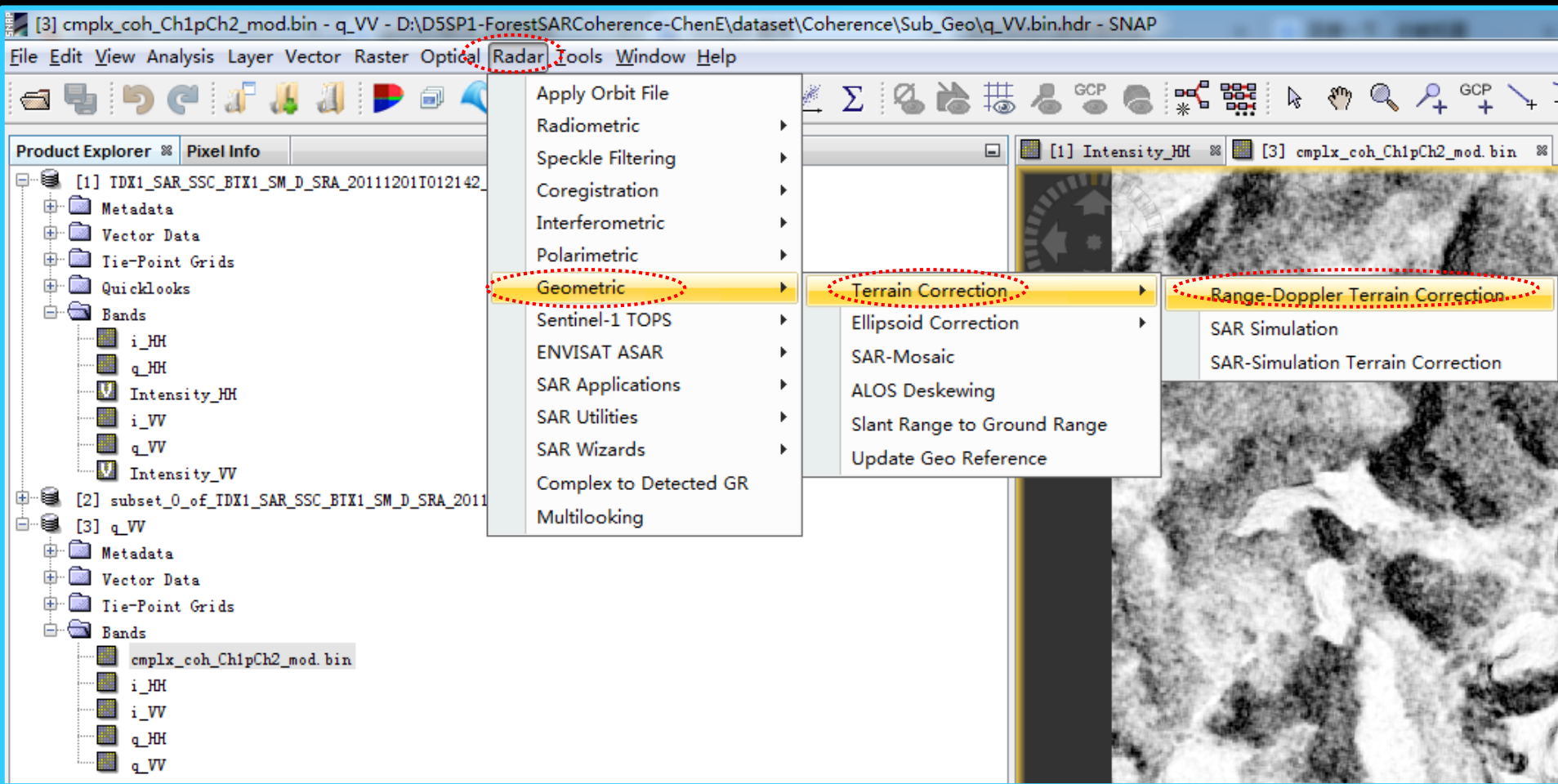
Copy the 'cmplx_coh_Ch1pCh2_mod.bin' and 'cmplx_coh_Ch1pCh2_mod.bin.hdr' to 'Sub_Geo' folder.



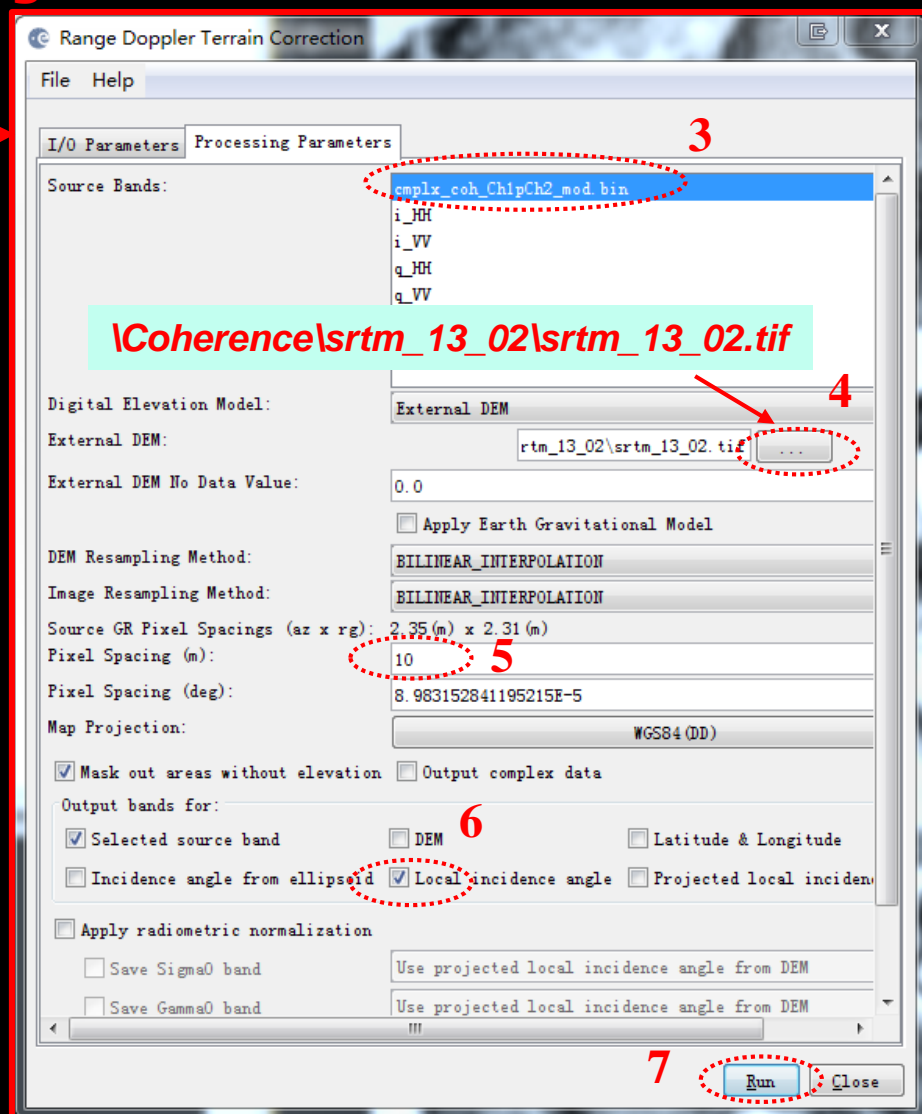
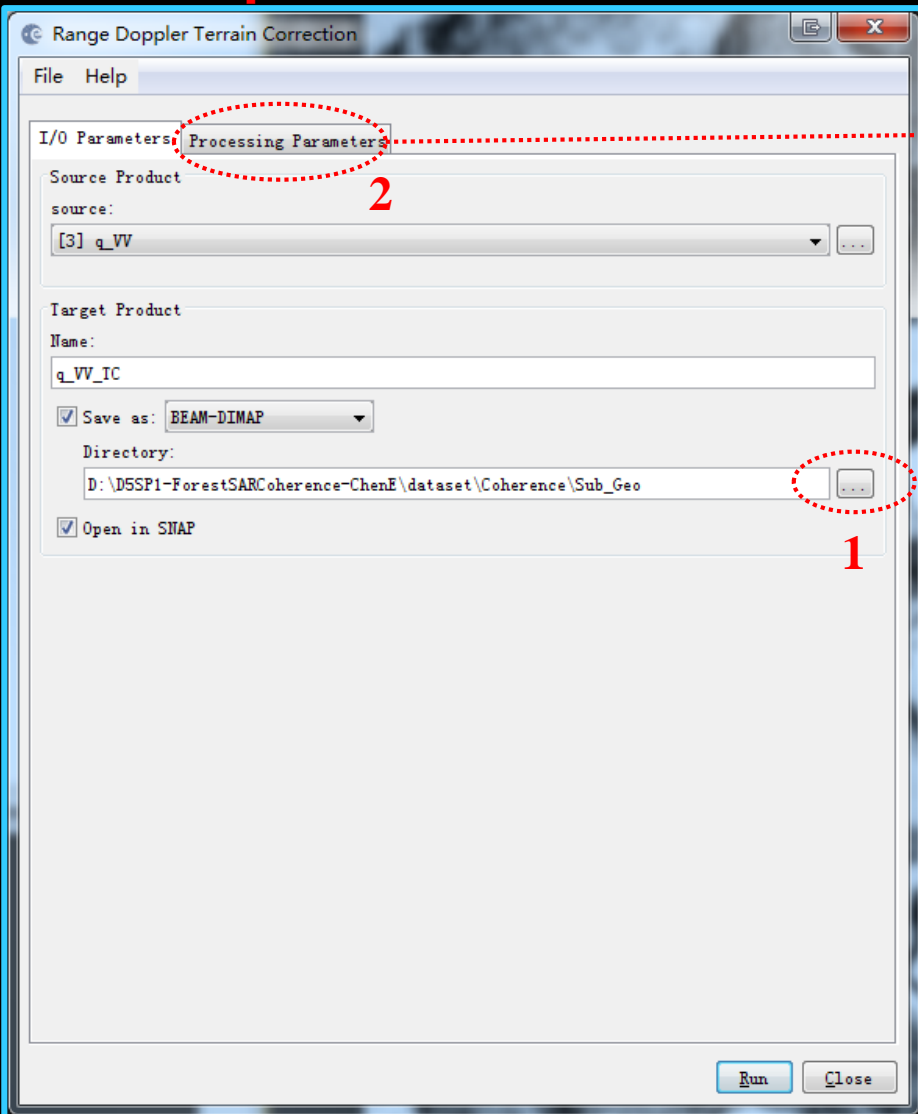
Step 9.2 : Coherence Geocoding



Step 9.2 : Coherence Geocoding



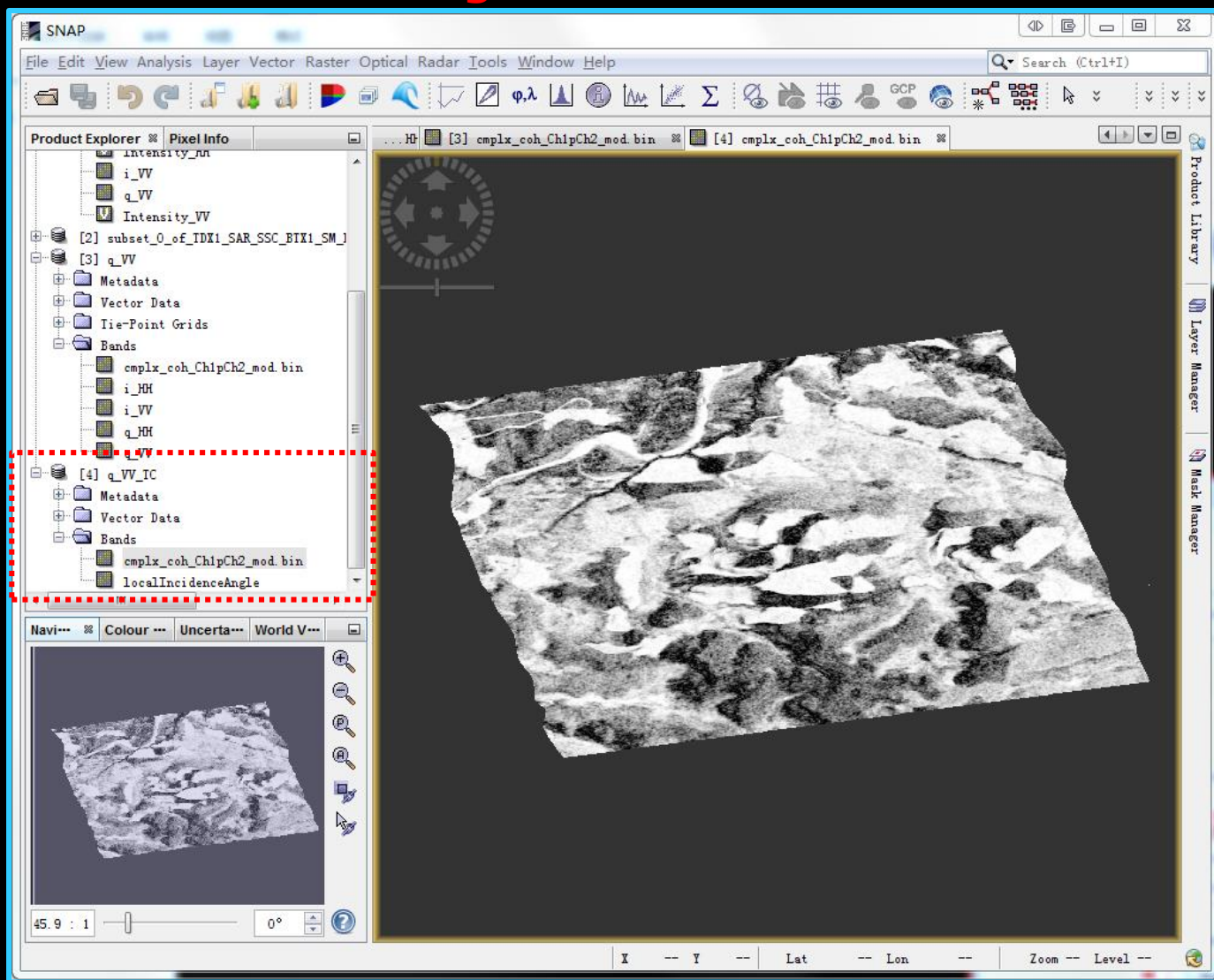
Step 9.2 : Coherence Geocoding



Coherence\srtm_13_02\srtm_13_02.tif

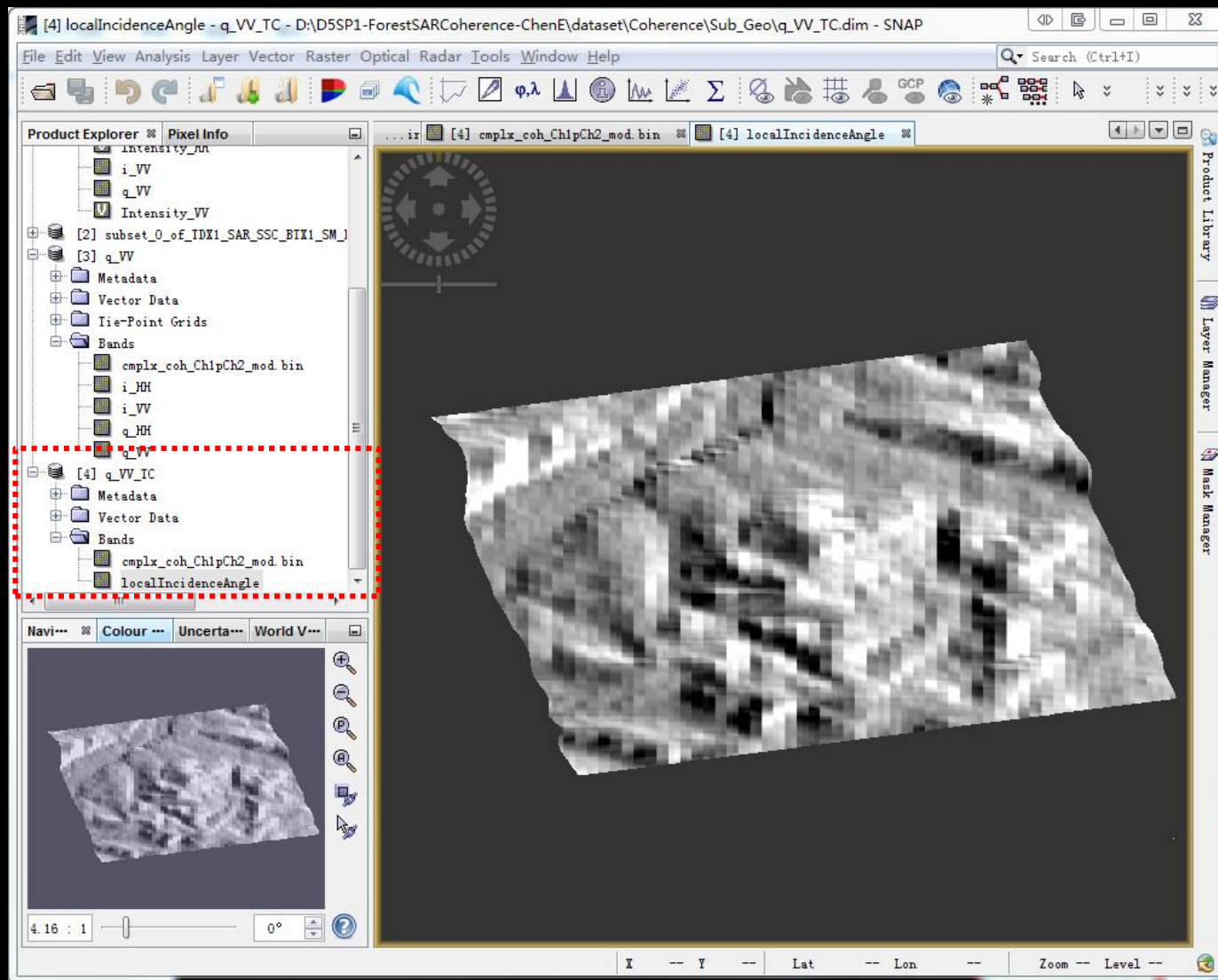
Step 9.2 : Coherence Geocoding

Geocode
Coherence



Step 9.2 : Coherence Geocoding

Geocode local incidence angle



10. Fixed K_z

- Ambiguity height (*hoa*)

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

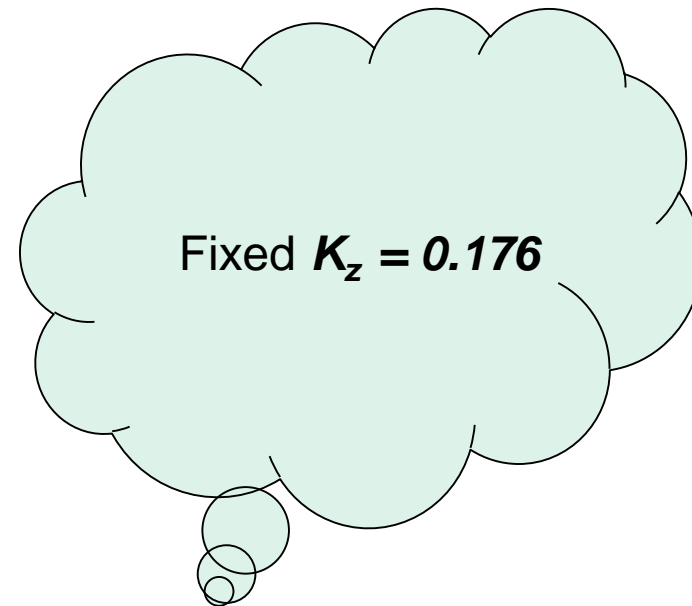
hoa can be find in the header file of Tandem-X data:

**TDM1_SAR_COS_BIST_SM_D_SRA_2011
1201T012142_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>
  
```



Fixed $K_z = 0.176$

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



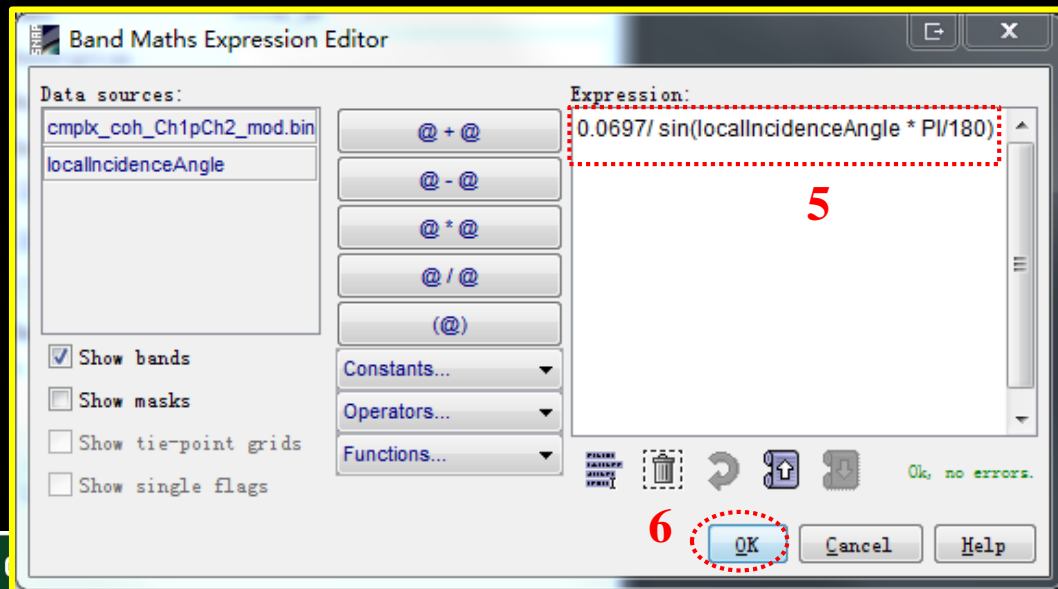
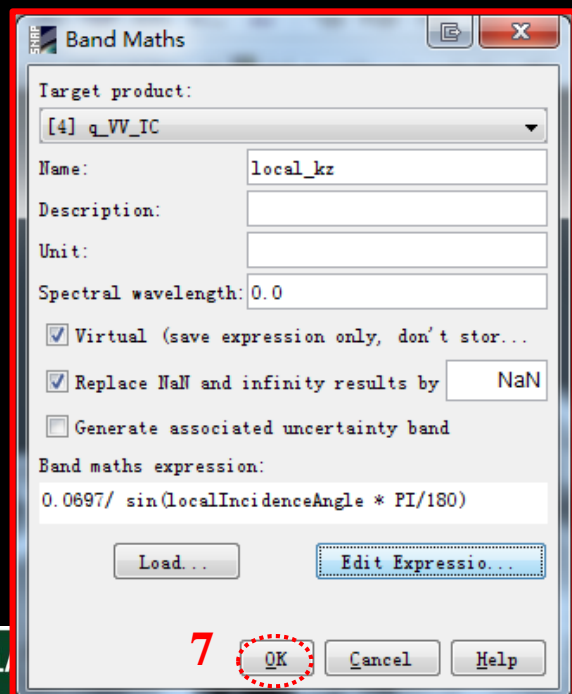
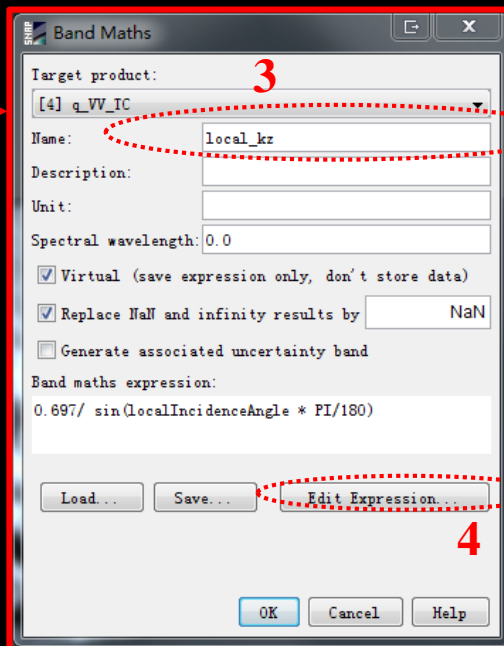
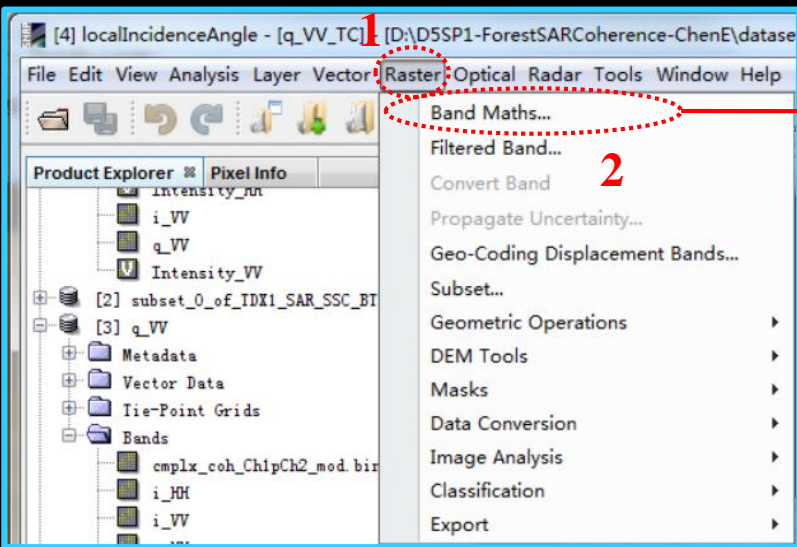
```

BIST_SM_D_SRA_20111201T012142_20111201T012149.xml  2.. metadata.xml
0          10          20          30          40          50          60          70          80          90
301  <attrib name="orbit_cycle" value="149" type="12" unit="" desc="Cycle" />
302  <attrib name="REL_ORBIT" value="30" type="12" unit="" desc="Track" />
303  <attrib name="ABS_ORBIT" value="24746" type="12" unit="" desc="Orbit" />
304  <attrib name="STATE_VECTOR_TIME" value="01-DEC-2011 01:21:38.000000" type="51" unit="utc" />
305  <attrib name="VECTOR_SOURCE" value="-" type="41" unit="" desc="State vector source" />
306  <attrib name="incidence_near" value="22.21389389038086" type="31" unit="deg" desc="" />
307  <attrib name="incidence_far" value="24.392669677734375" type="31" unit="deg" desc="" />
308  <attrib name="slice_num" value="99999" type="12" unit="" desc="Slice number" />
309  <attrib name="data_take_id" value="99999" type="12" unit="" desc="Data take identifier" />
310  <attrib name="first_line_time" value="01-DEC-2011 01:21:44.275735" type="51" unit="utc" />
    
```

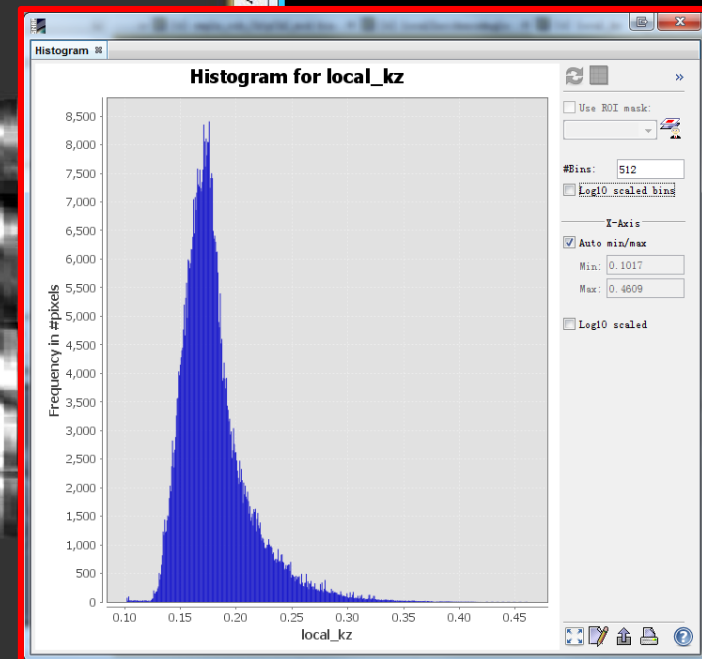
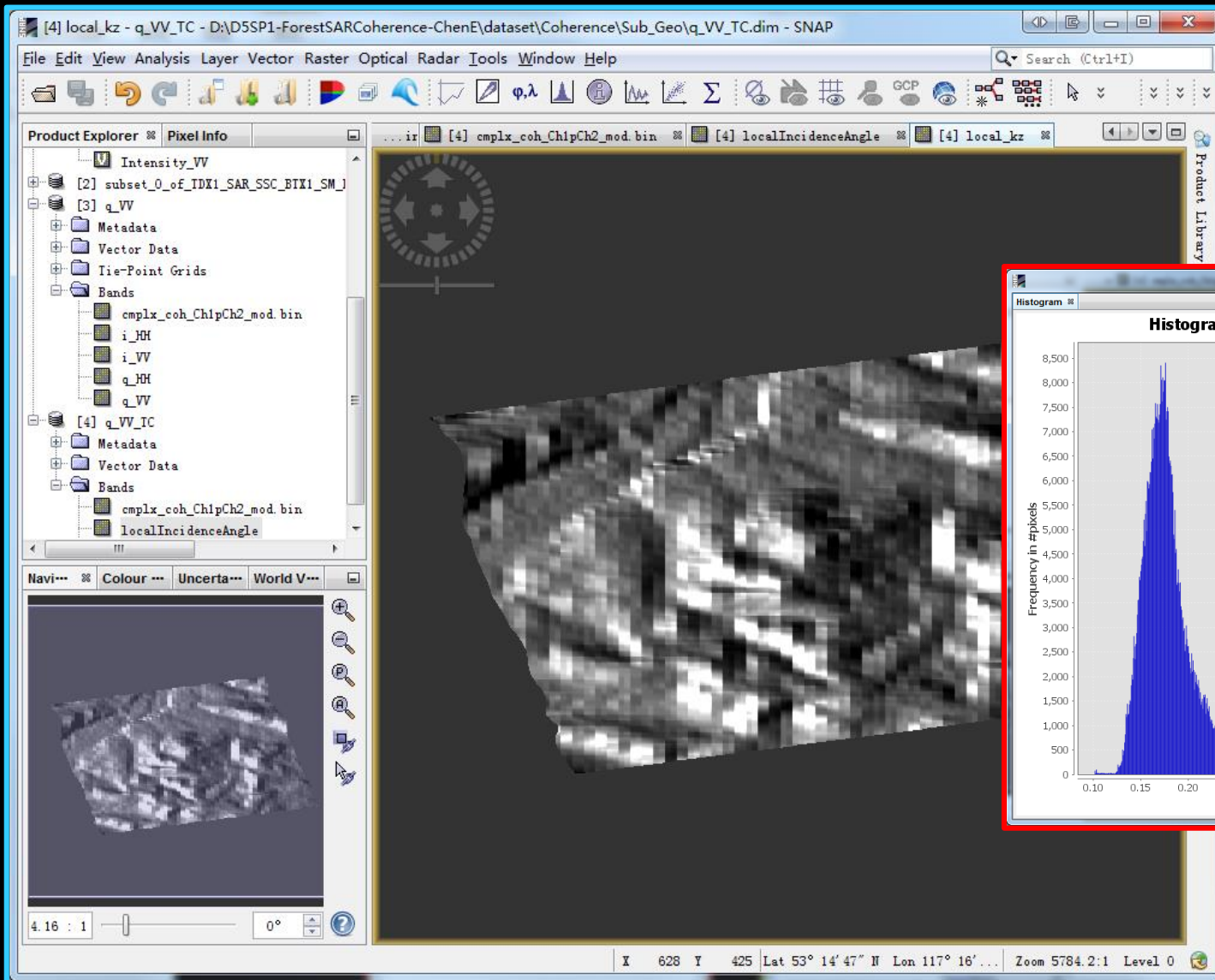


$$\theta_0 = (22.2138 + 24.3927)/2 = 23.3033 \qquad 2 \pi \sin(\theta_0) / hoa = 0.0697$$

Step 11: Local K_z

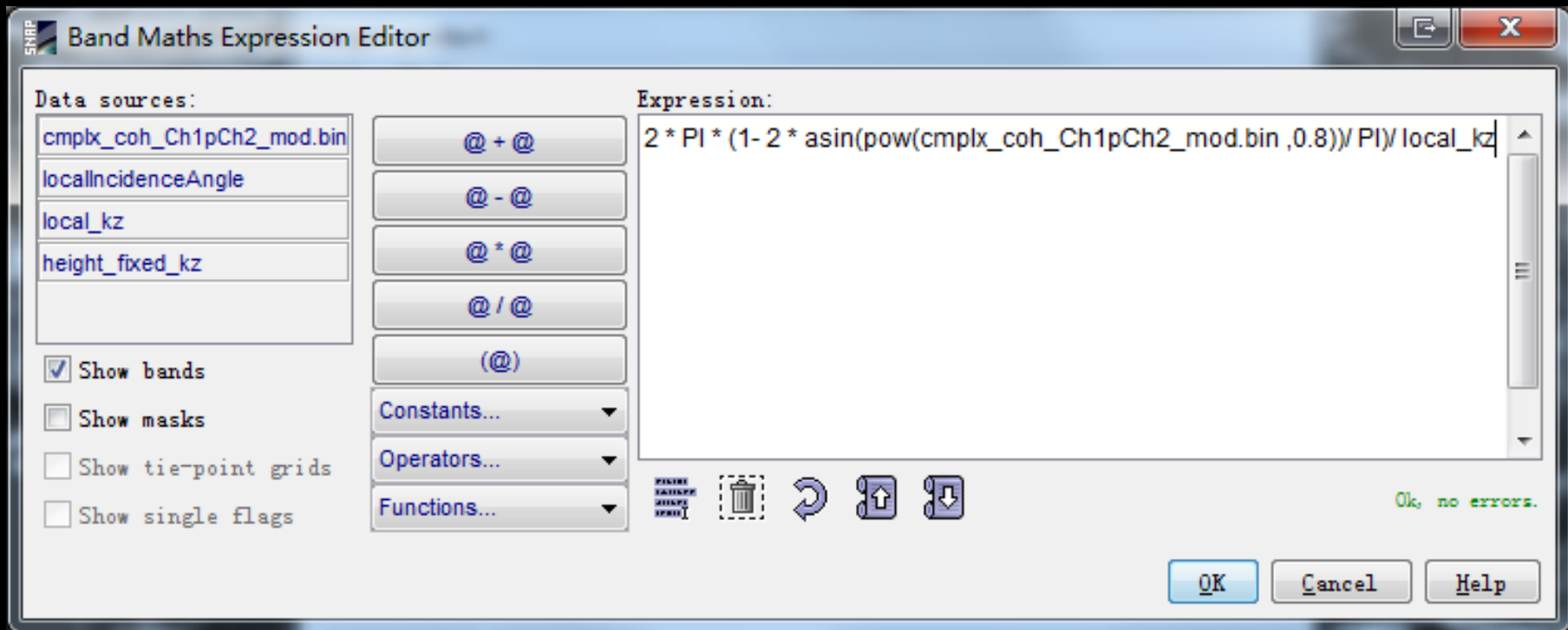


Step11: Local K_z

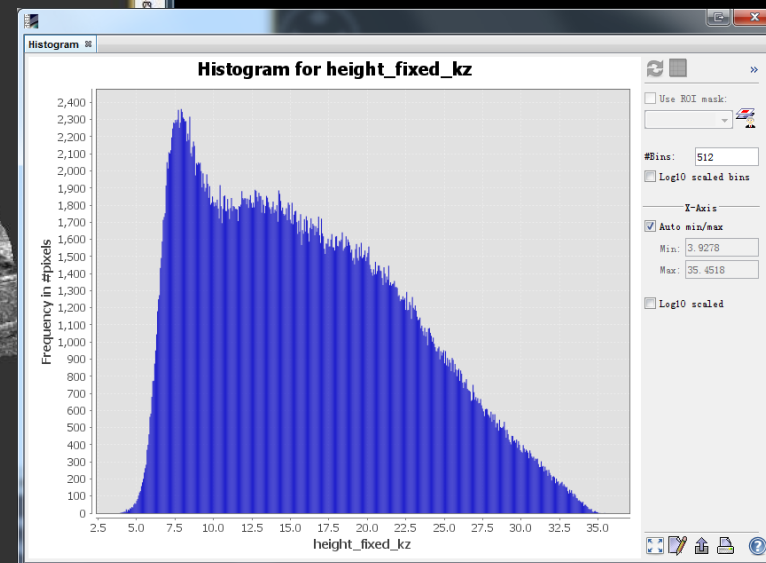
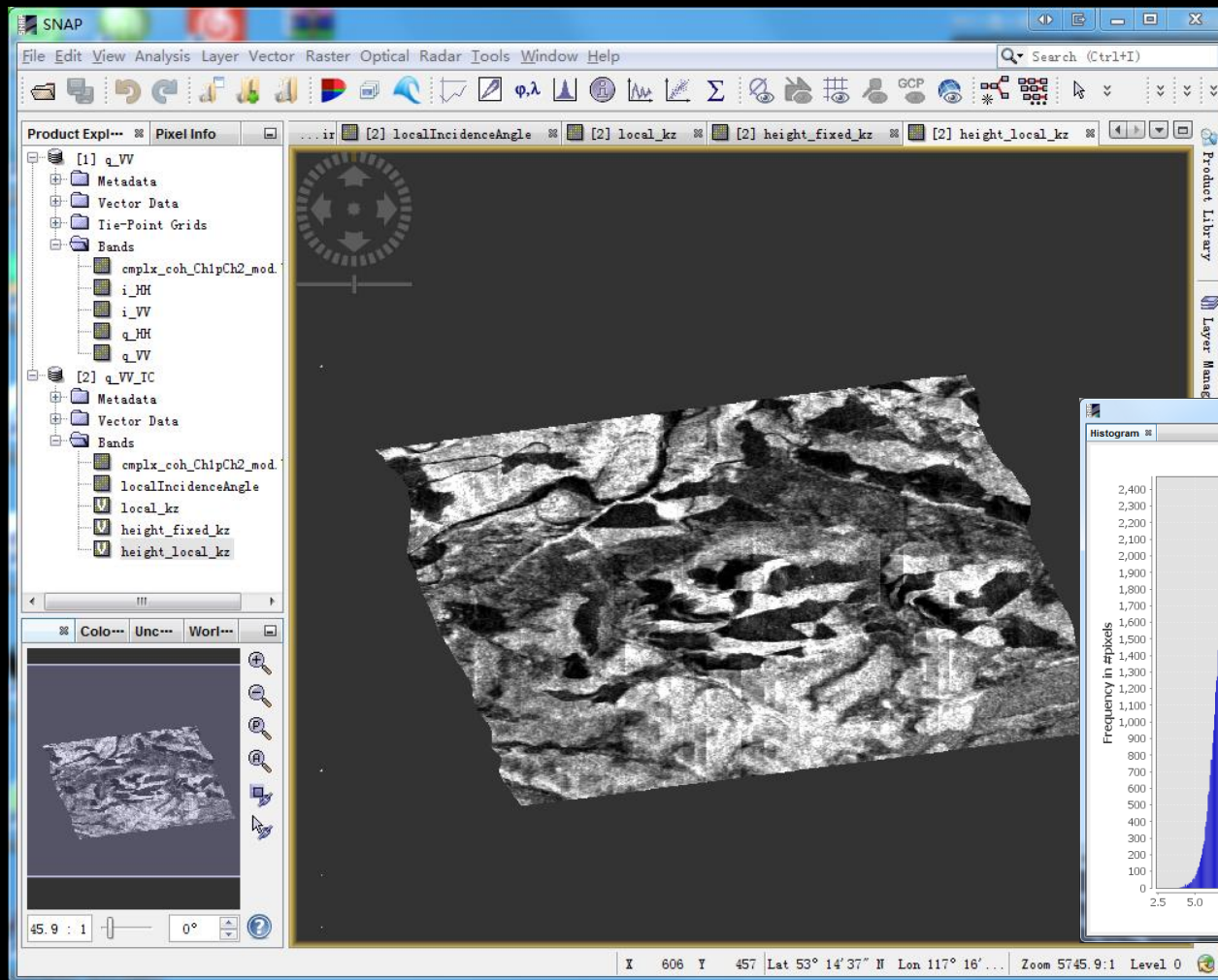


$$h_v = 2\pi \left(1 - 2 \operatorname{asin}(|\gamma|^{0.8}) / \pi \right) / k_z$$

Based on Fixed K_z :

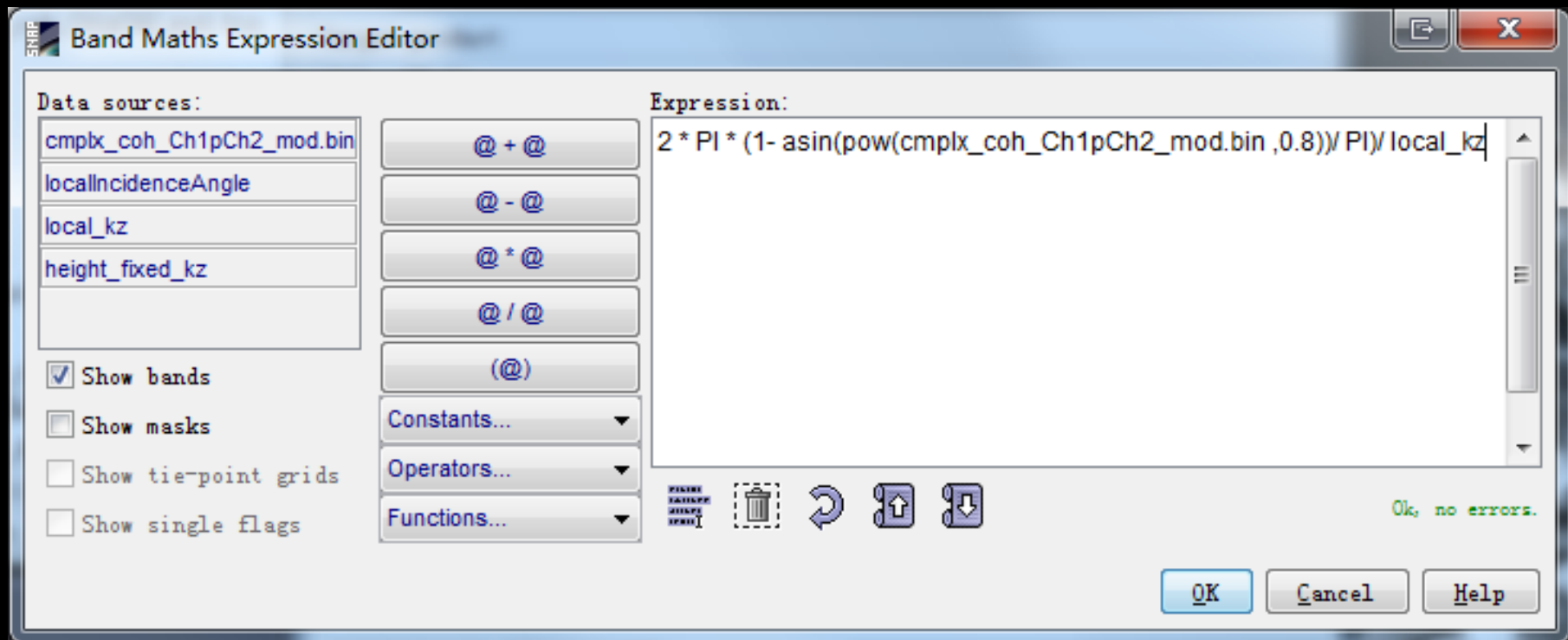


Based on Fixed K_z :



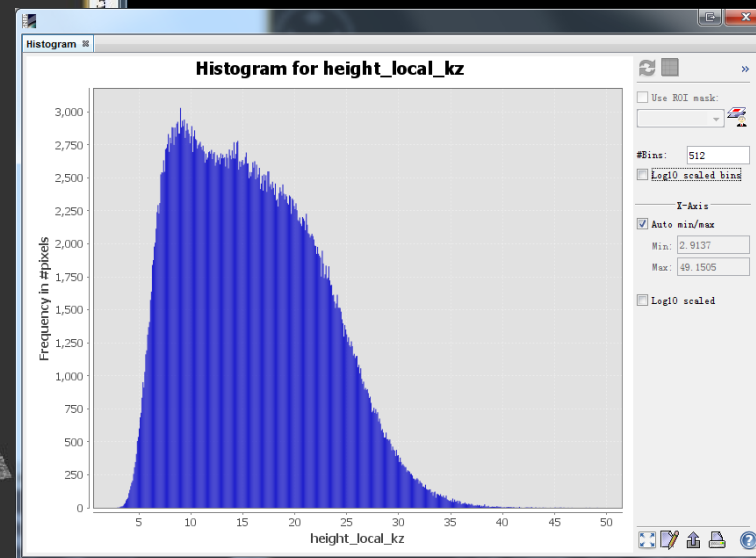
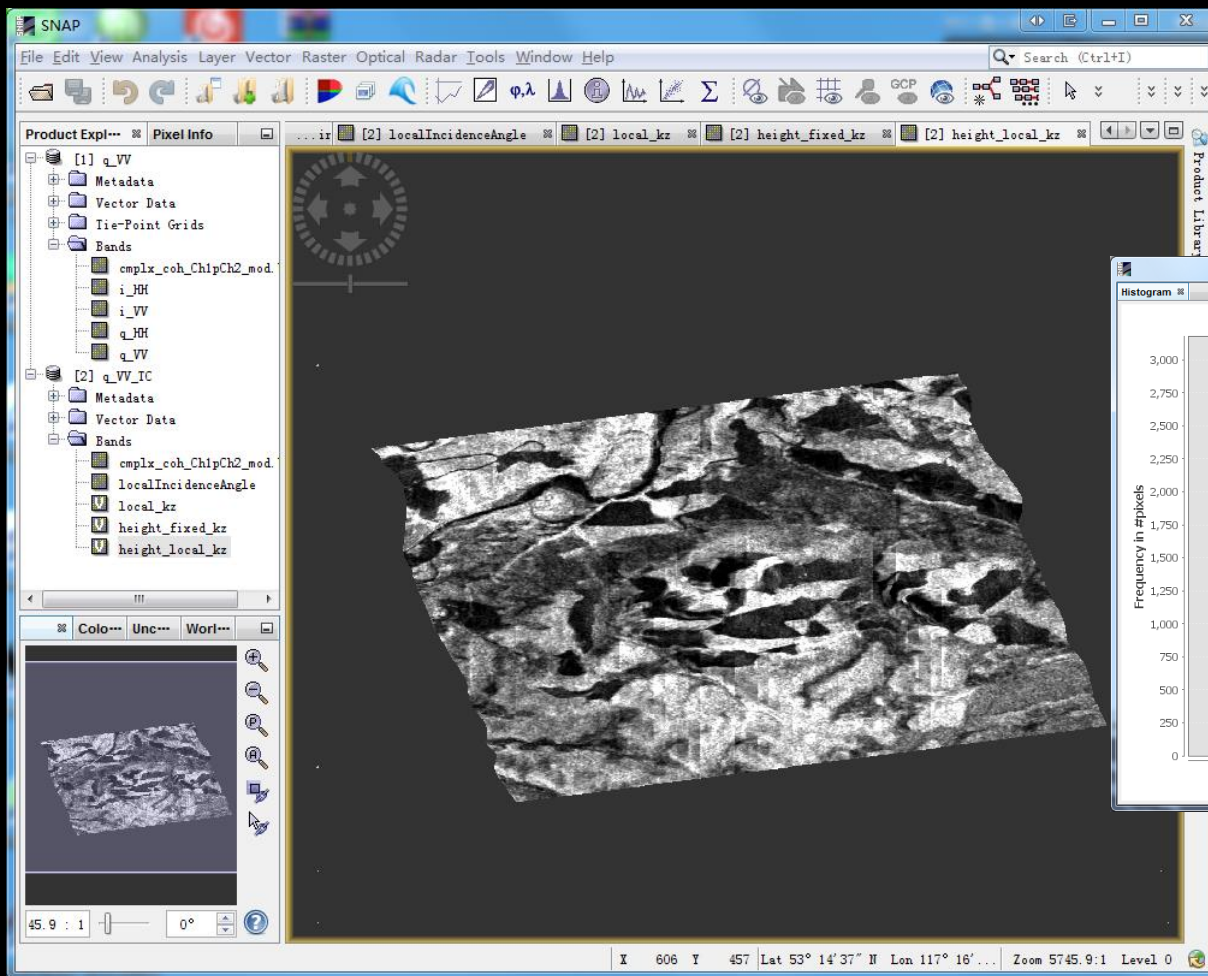
$$h_v = 2\pi \left(1 - 2 \operatorname{asin}(|\gamma|^{0.8}) / \pi \right) / k_z$$

Based on Local K_z :

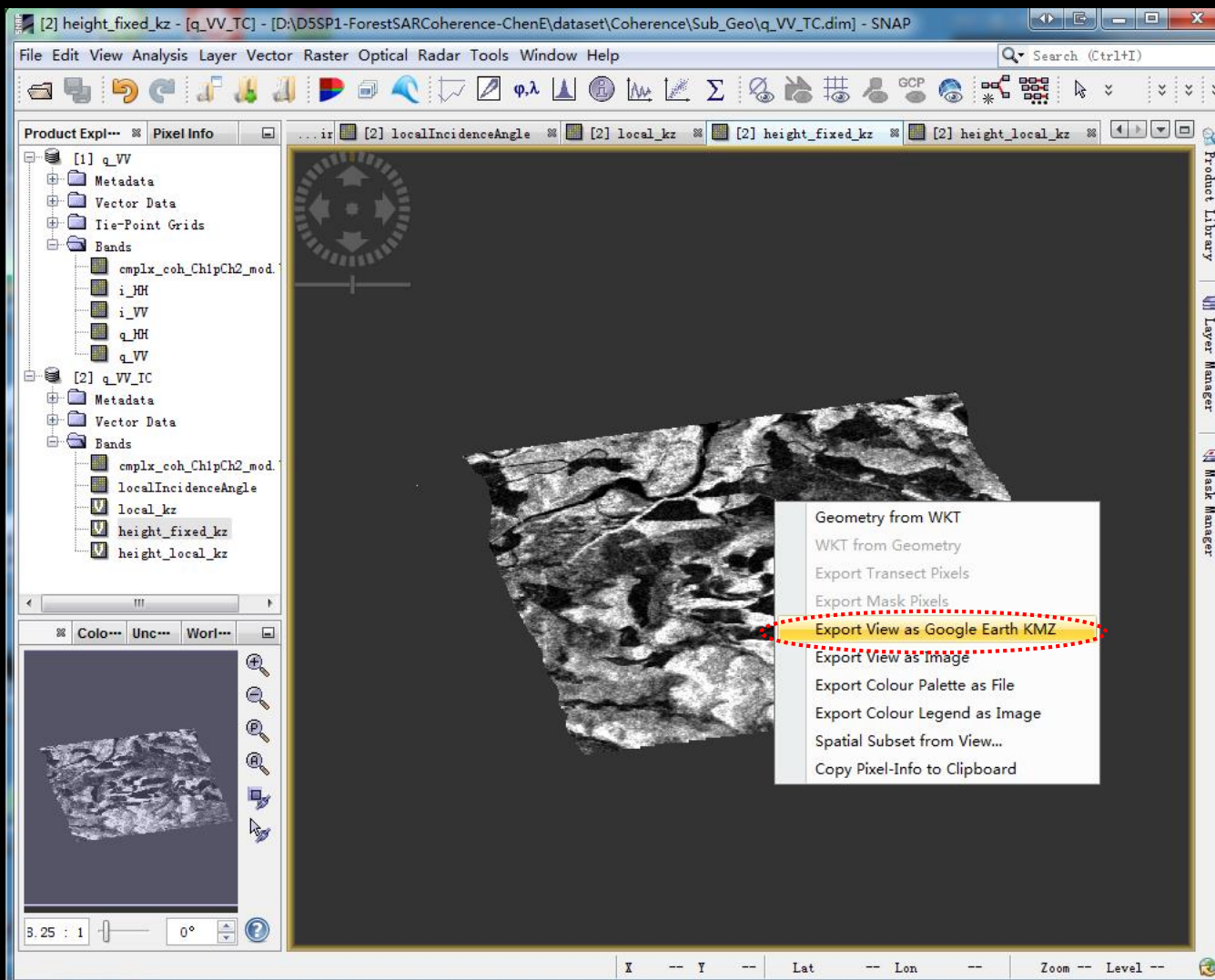


The screenshot shows the 'Band Maths Expression Editor' window. On the left, under 'Data sources', there is a list containing 'cmplx_coh_Ch1pCh2_mod.bin', 'localIncidenceAngle', 'local_kz', and 'height_fixed_kz'. Below this list are four checkboxes: 'Show bands' (checked), 'Show masks', 'Show tie-point grids', and 'Show single flags'. In the center, there are buttons for mathematical operators: '@ + @', '@ - @', '@ * @', '@ / @', and '(@)', along with dropdown menus for 'Constants...', 'Operators...', and 'Functions...'. On the right, the 'Expression:' field contains the formula: `2 * PI * (1 - asin(pow(cmplx_coh_Ch1pCh2_mod.bin ,0.8))/ PI) / local_kz`. At the bottom right, there is a status bar that says 'Ok, no errors.' and three buttons: 'OK', 'Cancel', and 'Help'.

Based on Local K_z :

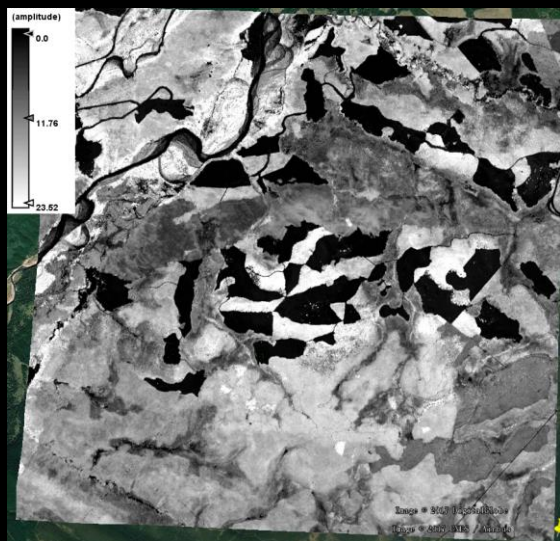


Step12: Height inversion

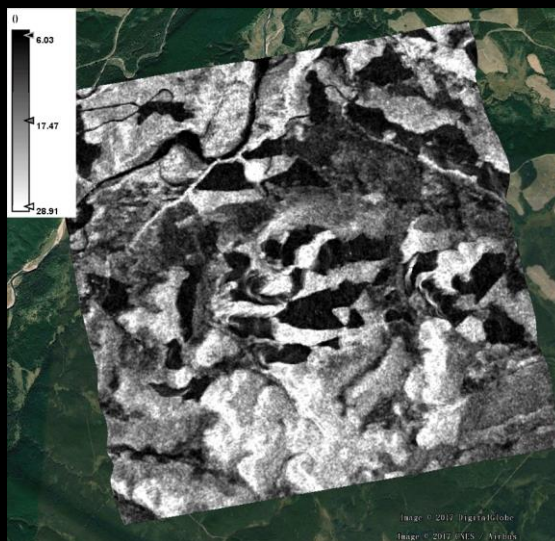


Convert the height inversion result to kmz file.

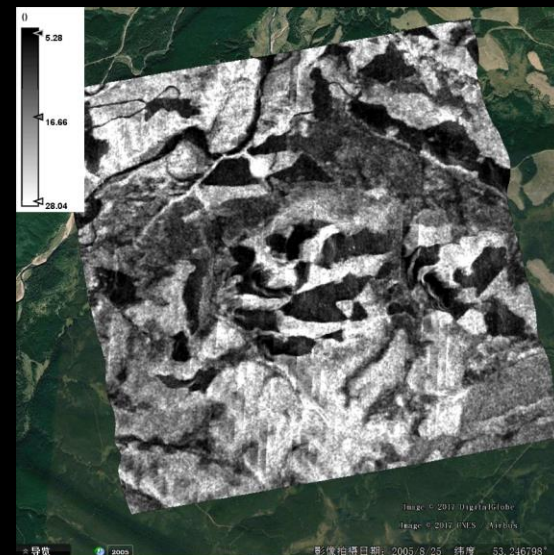
LiDAR Height



Based on Fixed Kz



Based on Local Kz



Questions ?



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