Pol-InSAR Exercises with PolSARpro – Biomass Edition v6

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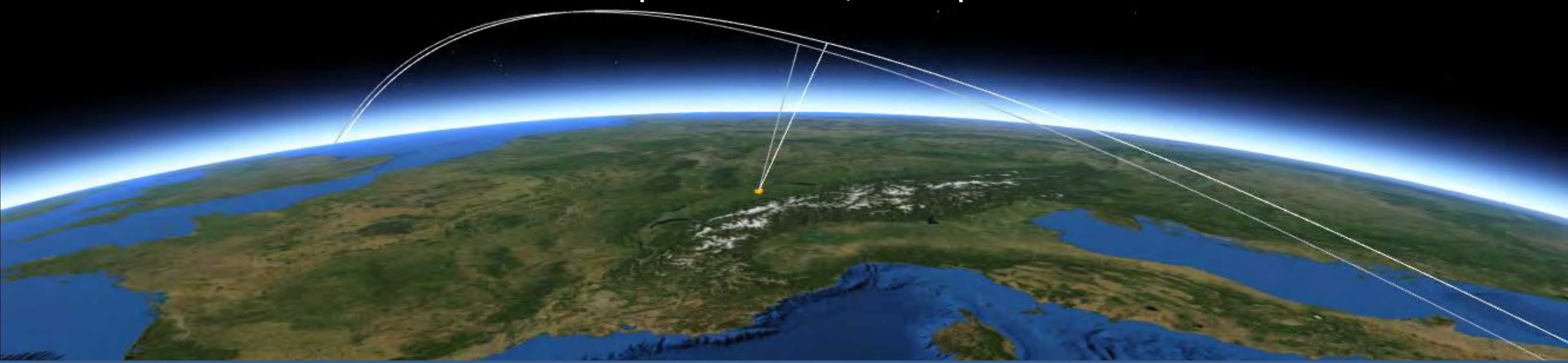

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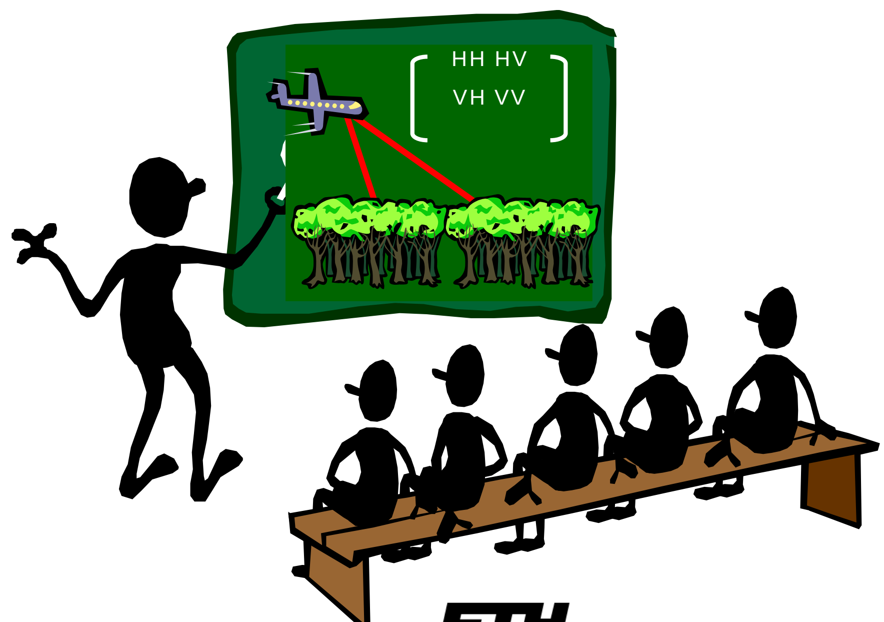
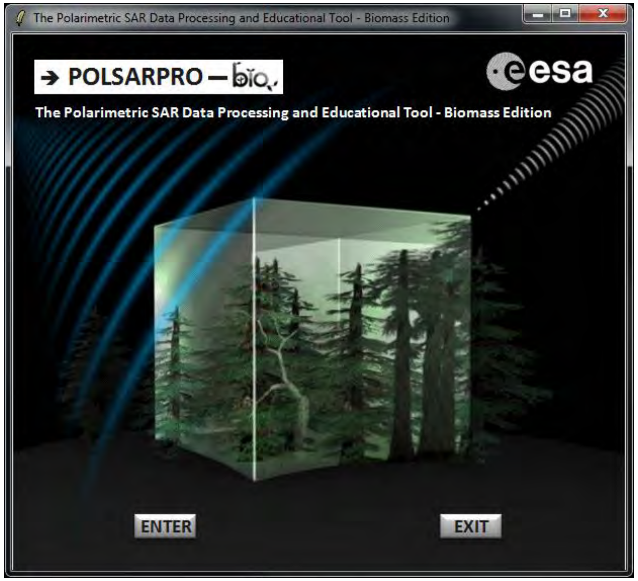
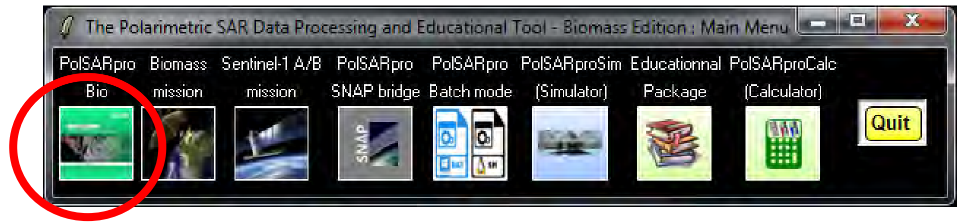
Outline – Polarimetric SAR Interferometry

- Generation of an Interferometric and Polarimetric simulated data set
  - Decidous Forest @ PolSAR Pro SIM
- Generation of the Complex Coherence
  - Display and interpretation
- Flat Earth removal & renew generation of complex coherence
  - Display and interpretation
- Interferometric Coherence generation @ diff polarisations
  - Linear polarisation coherences
  - Optimisation of coherences
  - Display and interpretation
- Volume height derivation
  - Interferometric phase
  - Coherence phase
  - Analysis and interpretation
  - Statistical Analysis



PolSARpro-Biomass Edition V6 (January 2019)





PolSARpro - Bio SOFTWARE

WEB-LINK: http://earth.esa.int/polsarpro/

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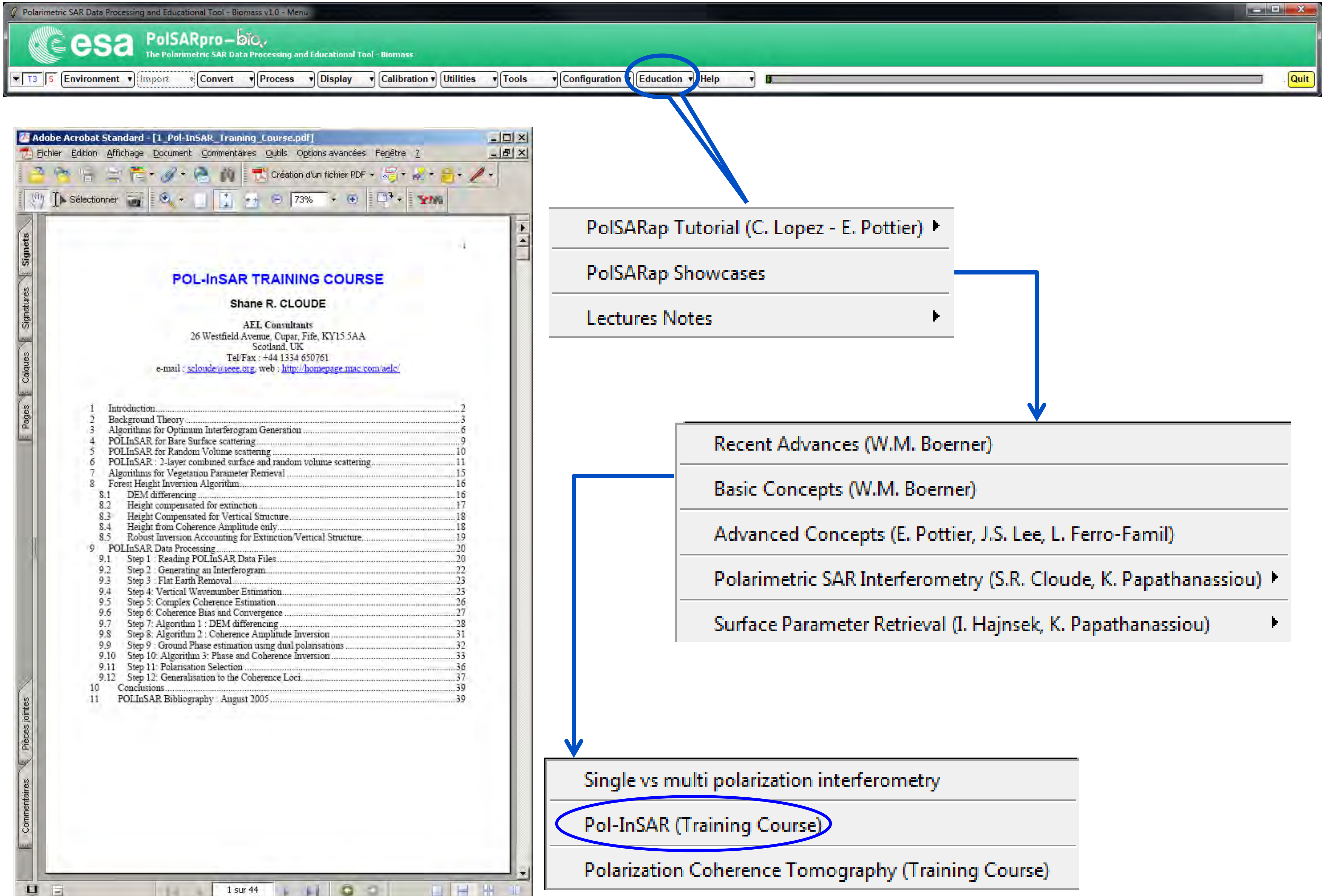

POL-InSAR TRAINING COURSE

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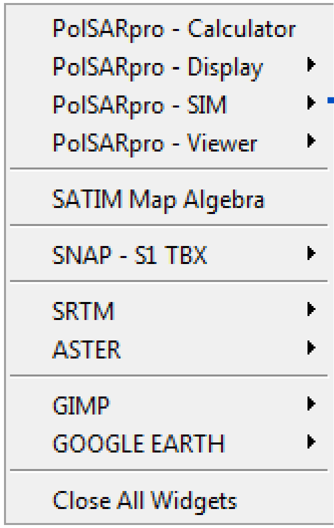

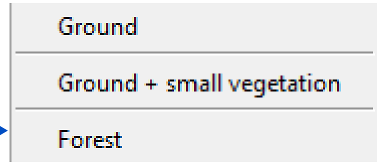

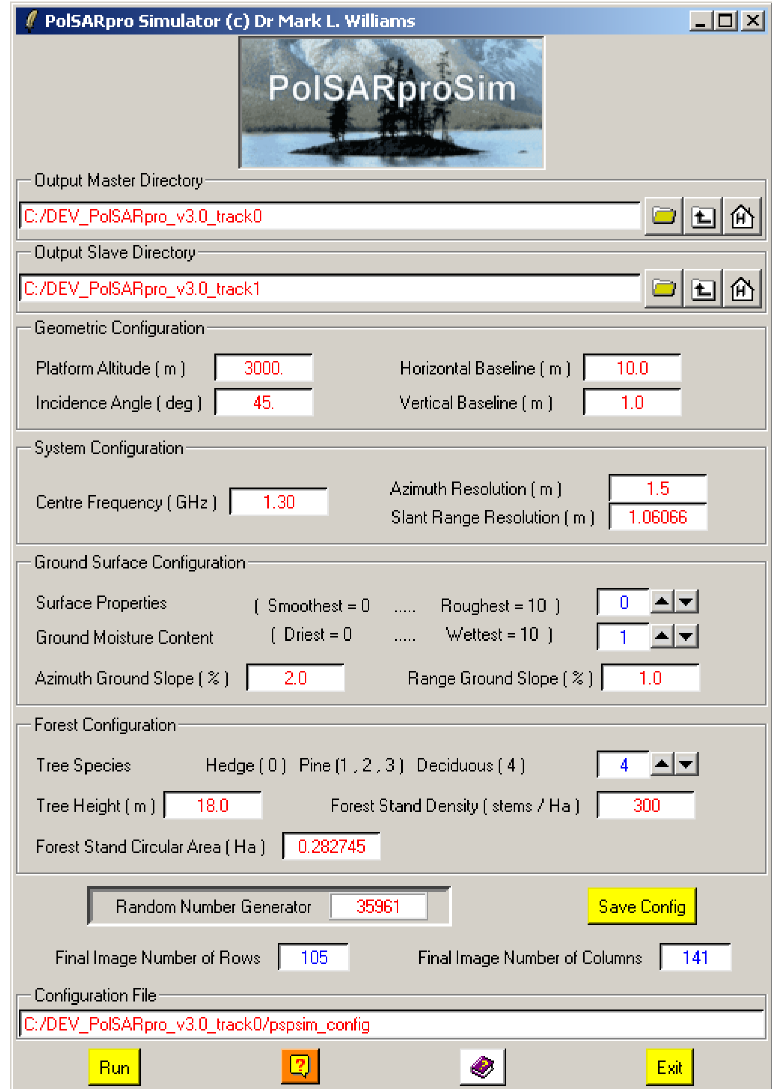

PolSARproSim

rapid, coherent, fully polarimetric and interferometric SAR simulation of forest.

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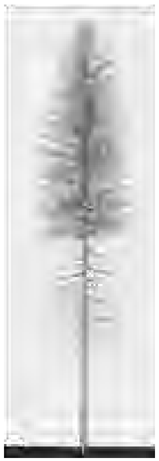
PolSARpro – SIM

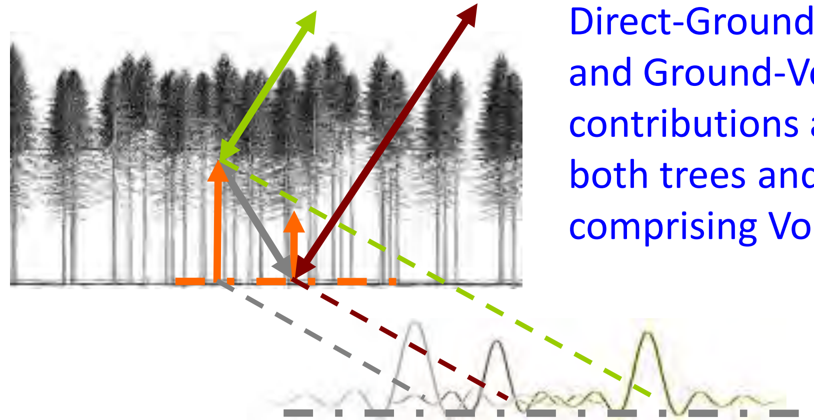
The SAR image is evaluated as a coherent sum of scattering events from small elements of the scene



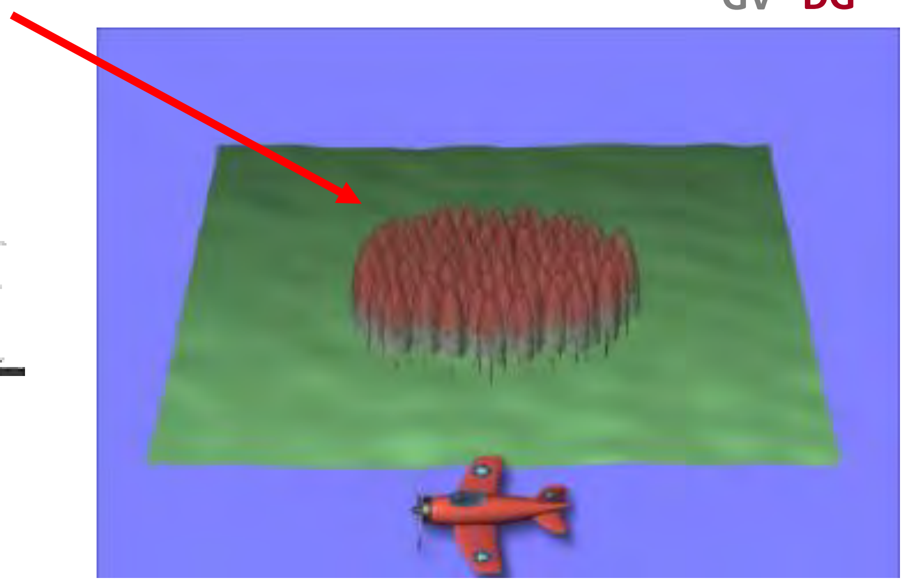
PINE

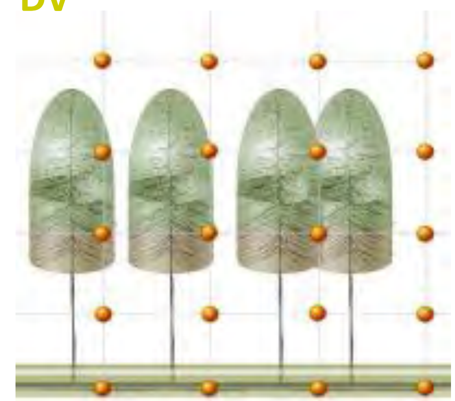
DECIDUOUS

RANDOM HEDGE



Direct-Ground, Direct-Volume and Ground-Volume contributions are included, with both trees and short vegetation comprising Volume terms.



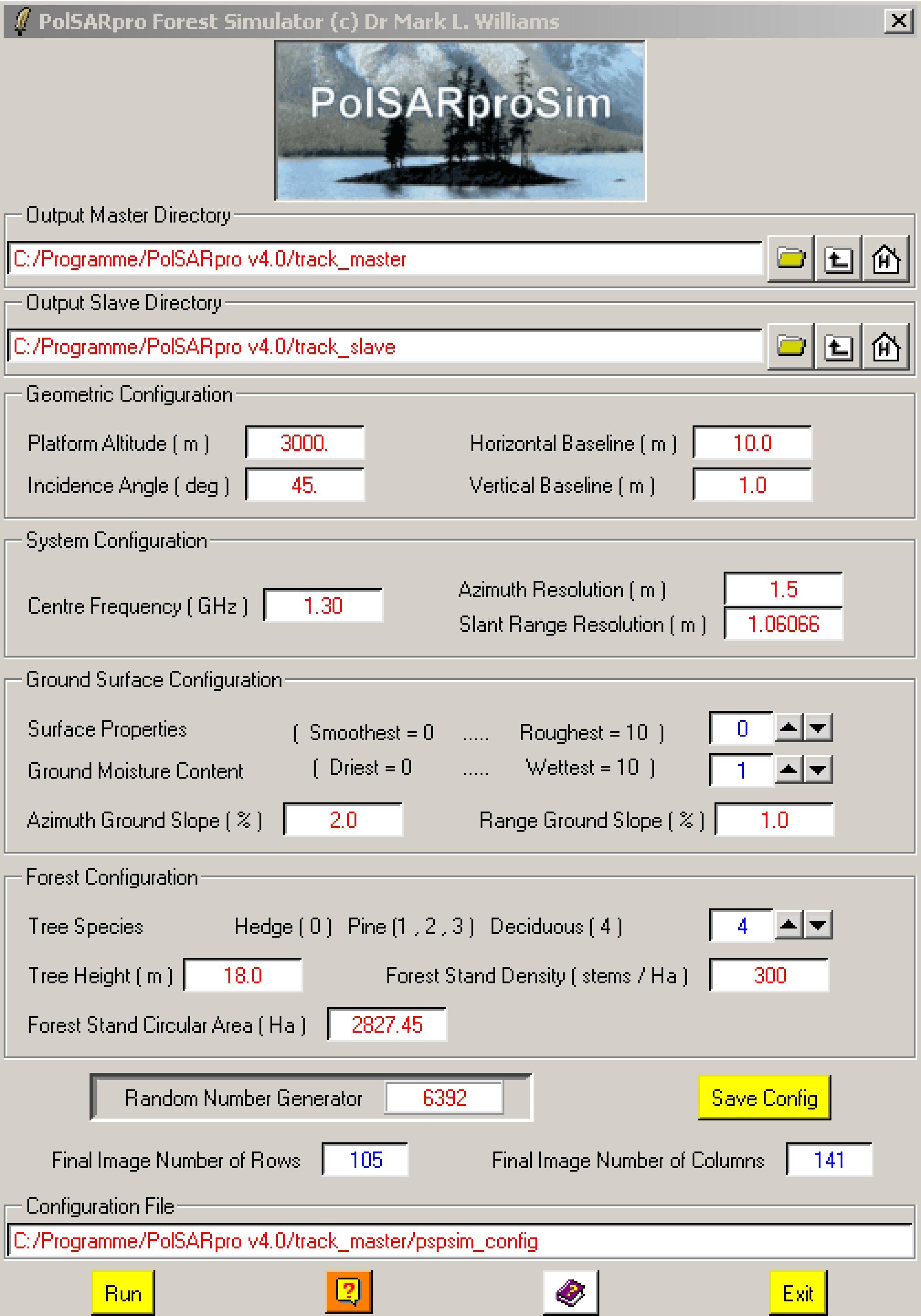


Given the map of tree locations and dimensions a grid of points is used to sample the attenuation of the coherent wave in 3D

Simulation of a Deciduous Forest Stand

Parameter space:

- Baseline (horizontal) 10 m
- Flight height 3 km
- AOI 45 degree
- Forest type: deciduous
- Forest height 18 m
- Density (stems/ha) 300
- Smooth surface
- Low soil moisture
- Spatial resolution 1.5 x 1.06 m



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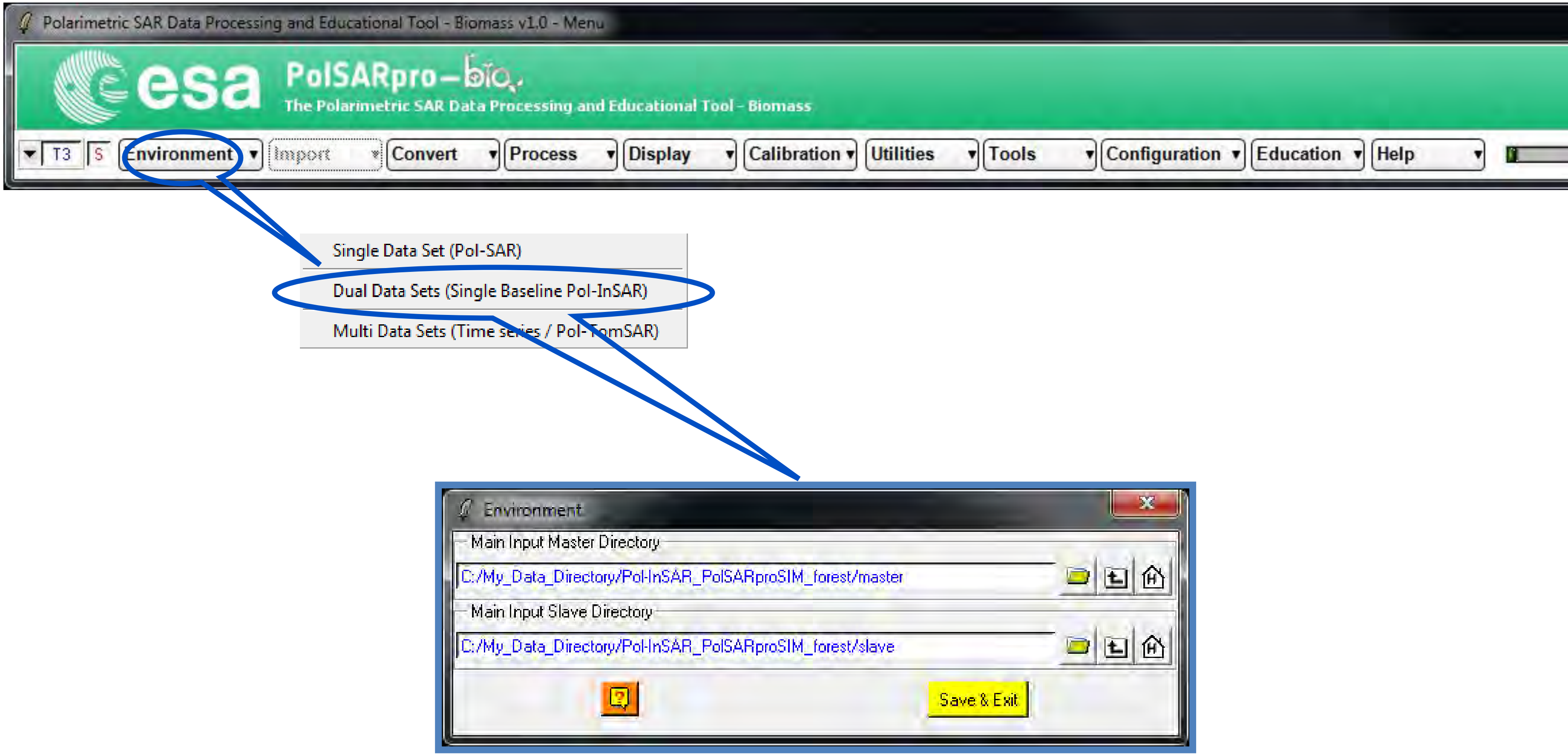
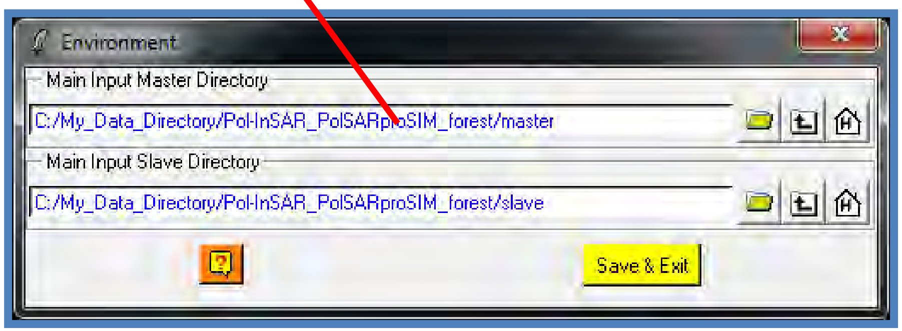
Process the Data Interferometricaly

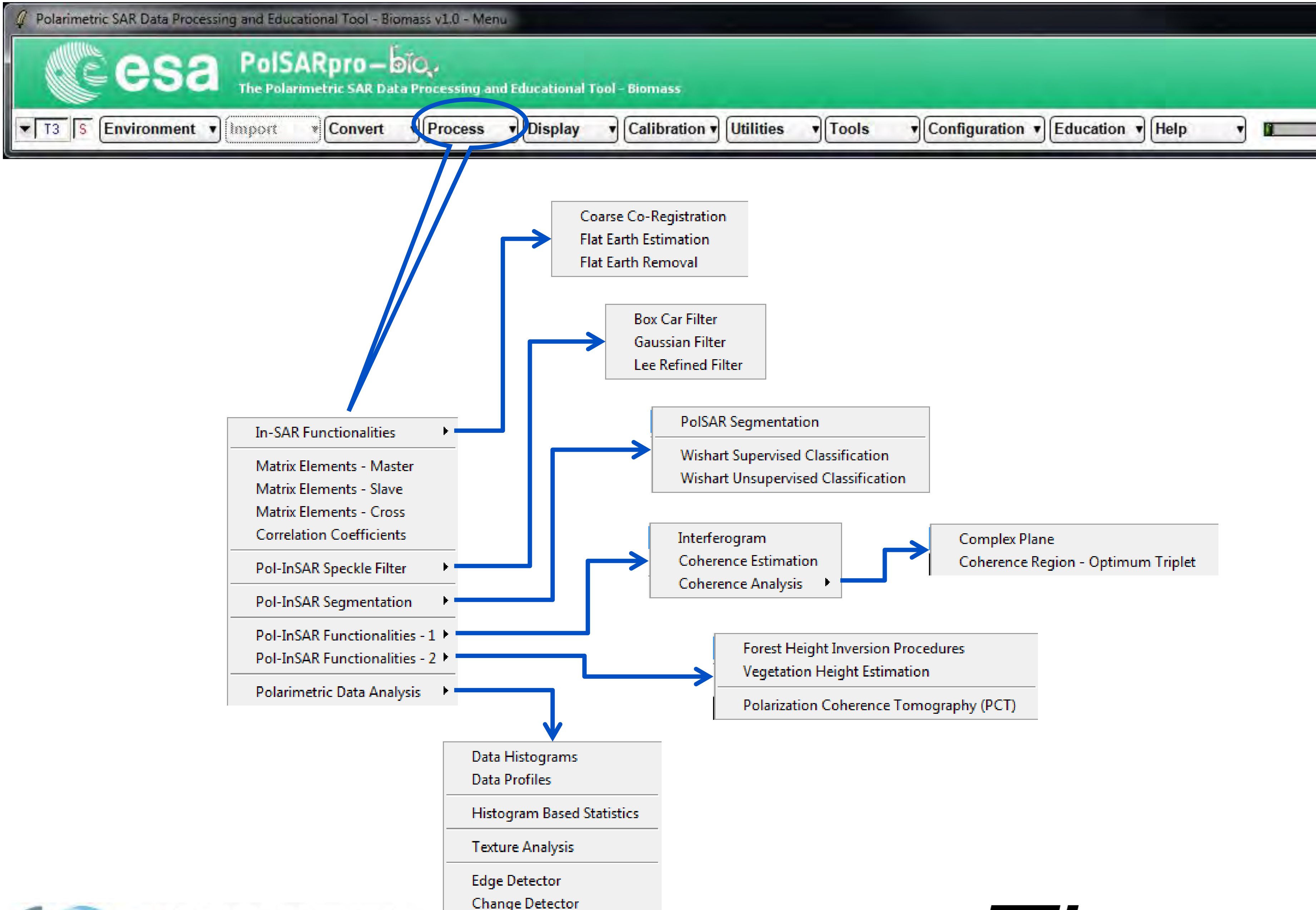


Configure Data Main Directories location



Input Master Directory: C:/… /Pol-InSAR_Training_Course/Master_Track

Input Slave Directory: C:/… /Pol-InSAR_Training_Course/Slave_Track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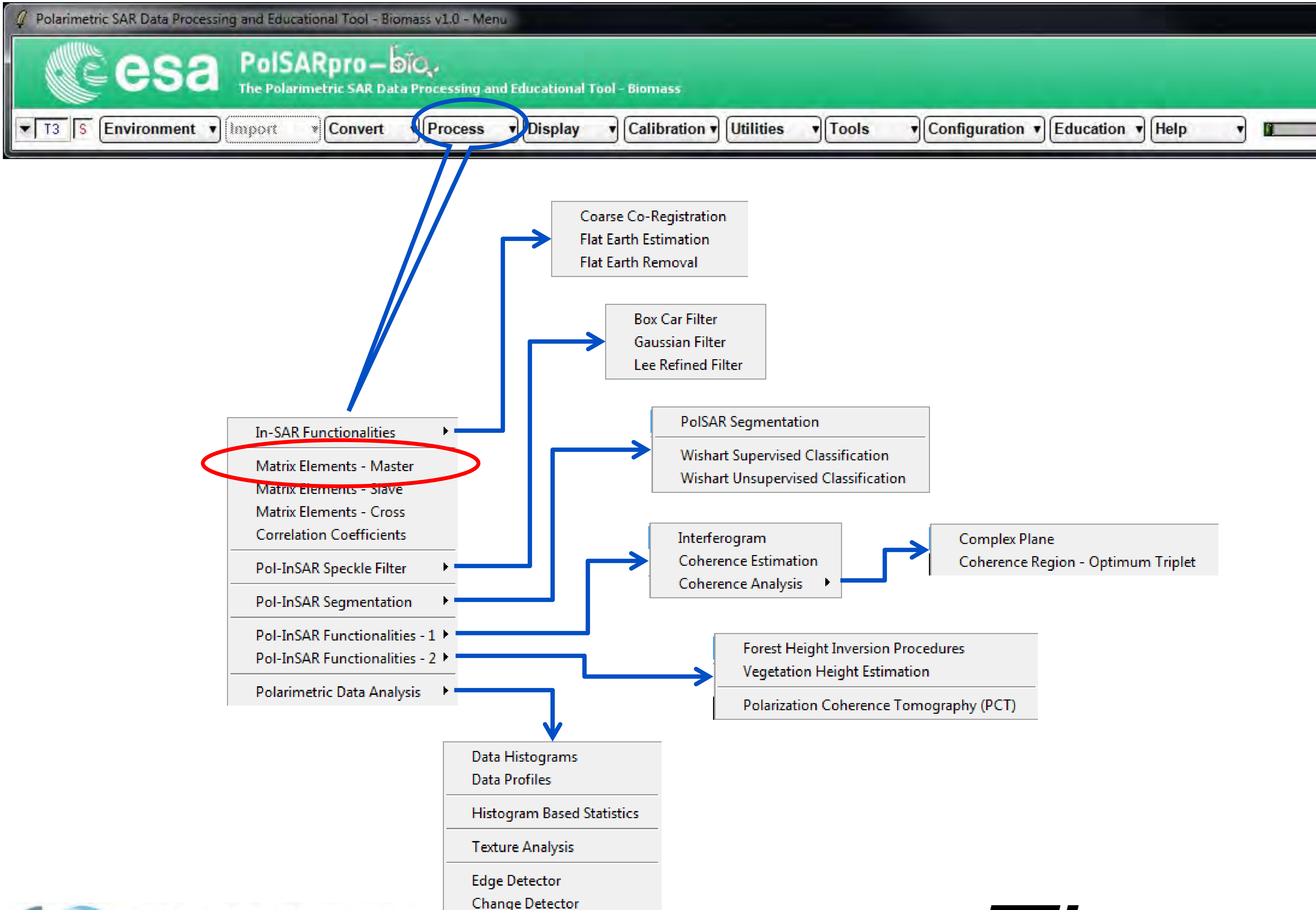
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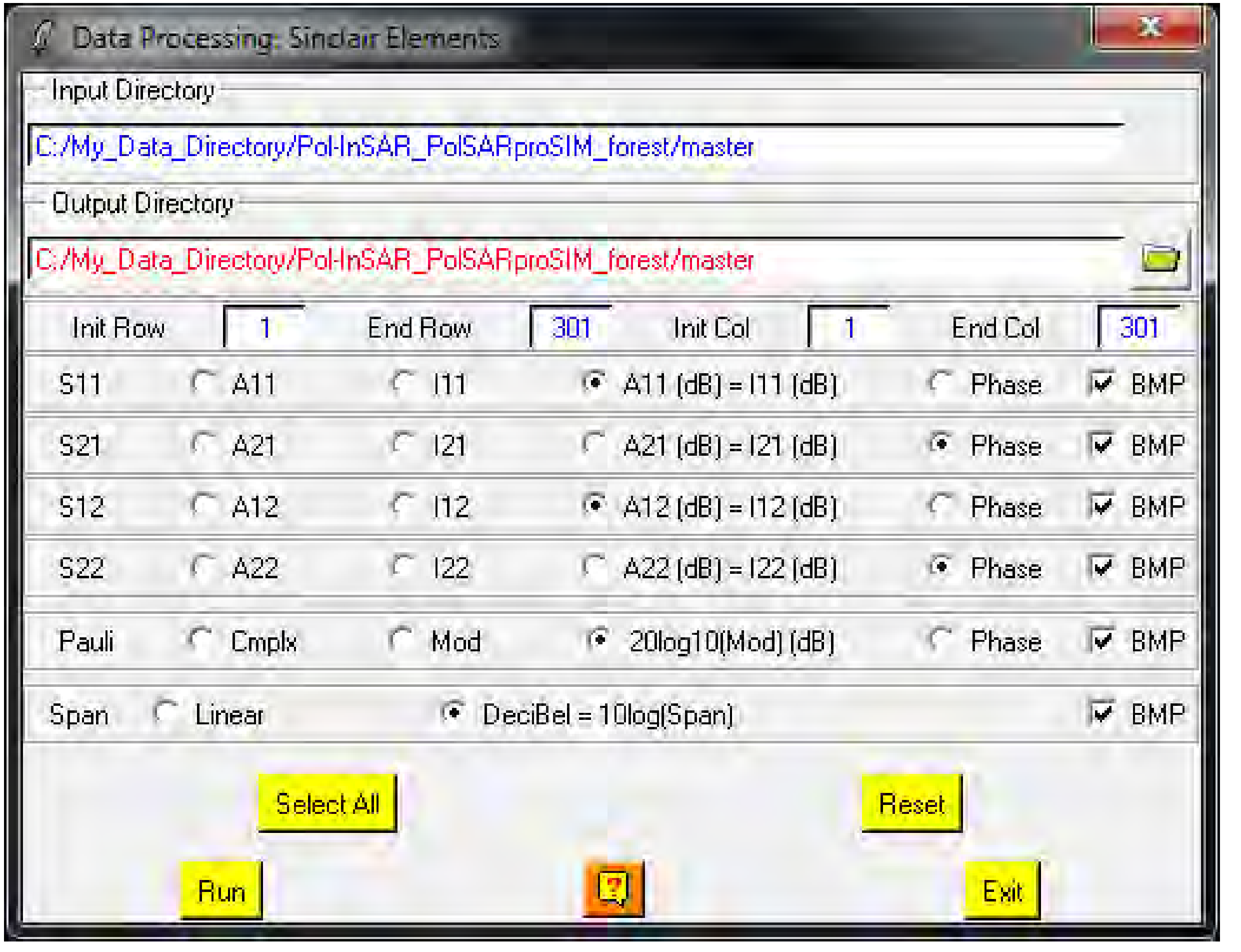
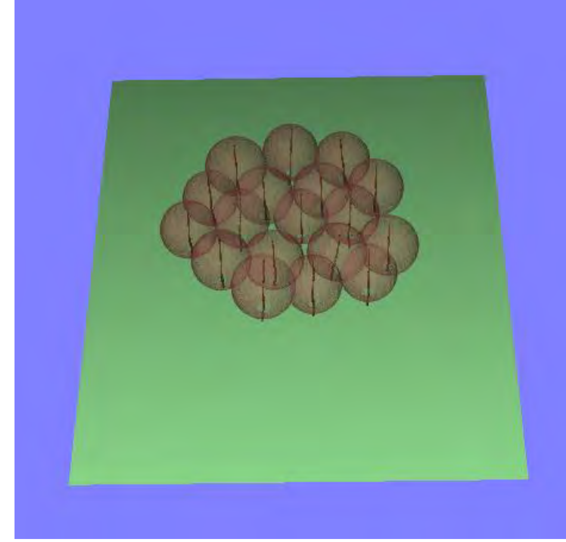
Generate the Scattering Matrix of the Master

- Processes to BMP File



Display Master Files with GIMP

Forest Simulation



[S11]

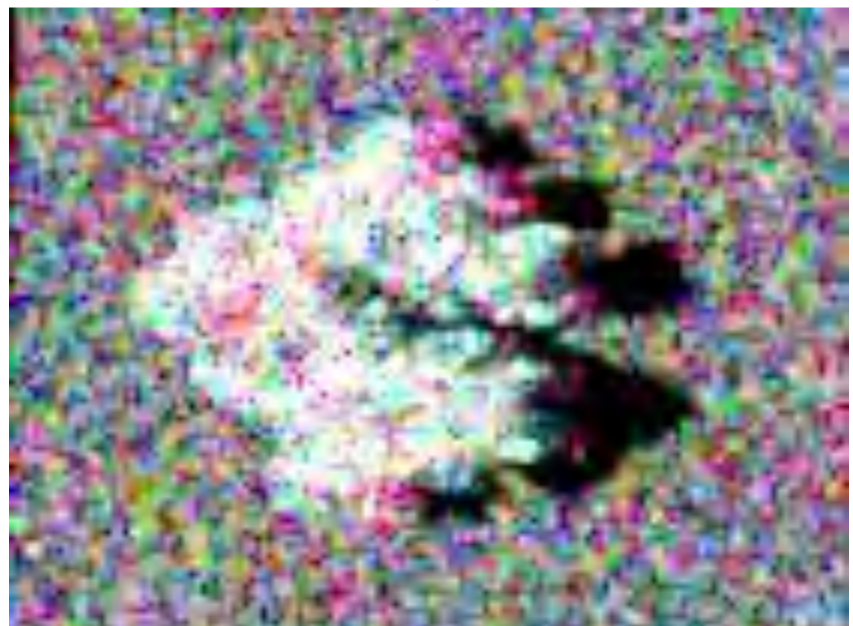
[S12]

Span

[S21]

[S22]

RGB



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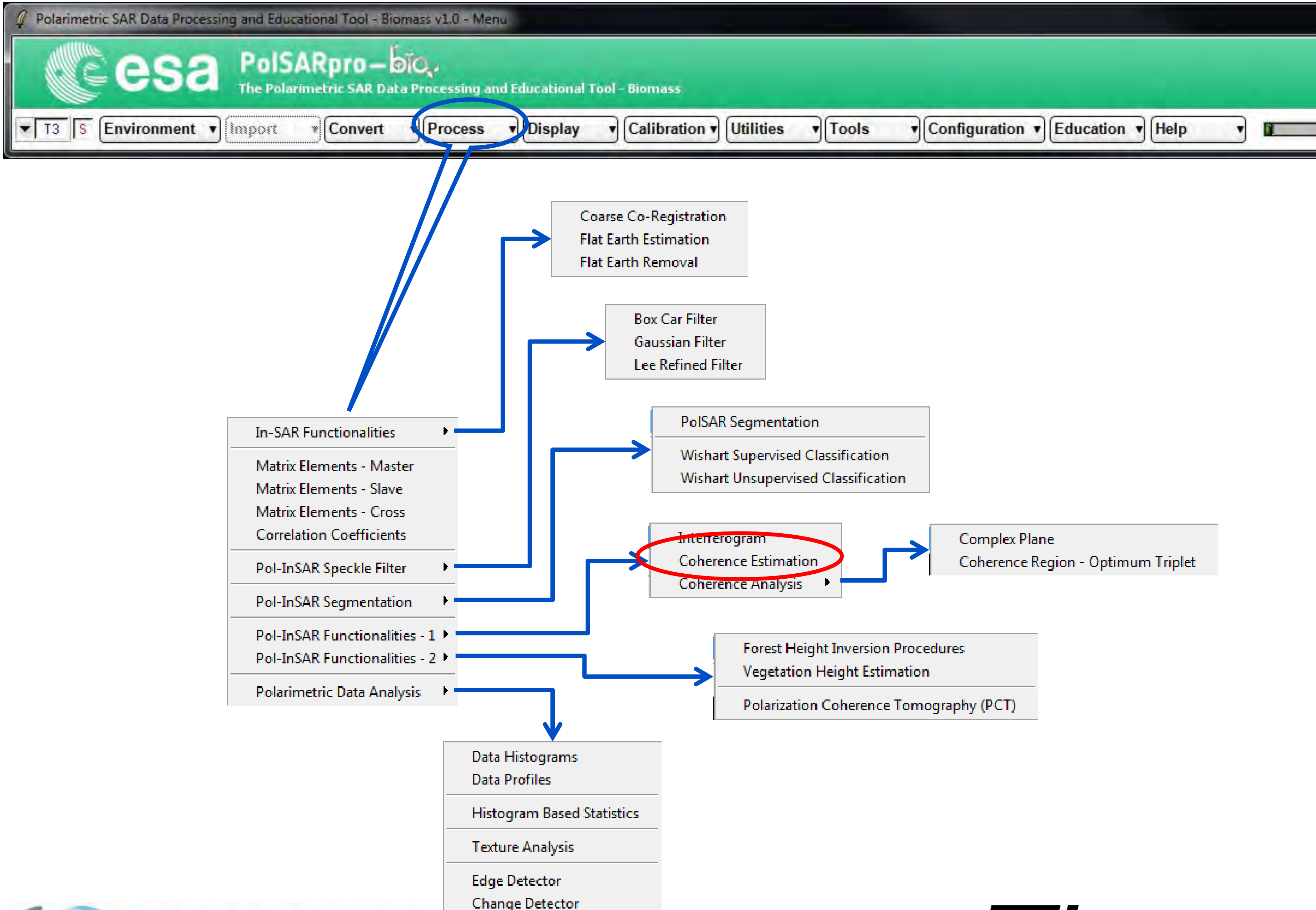
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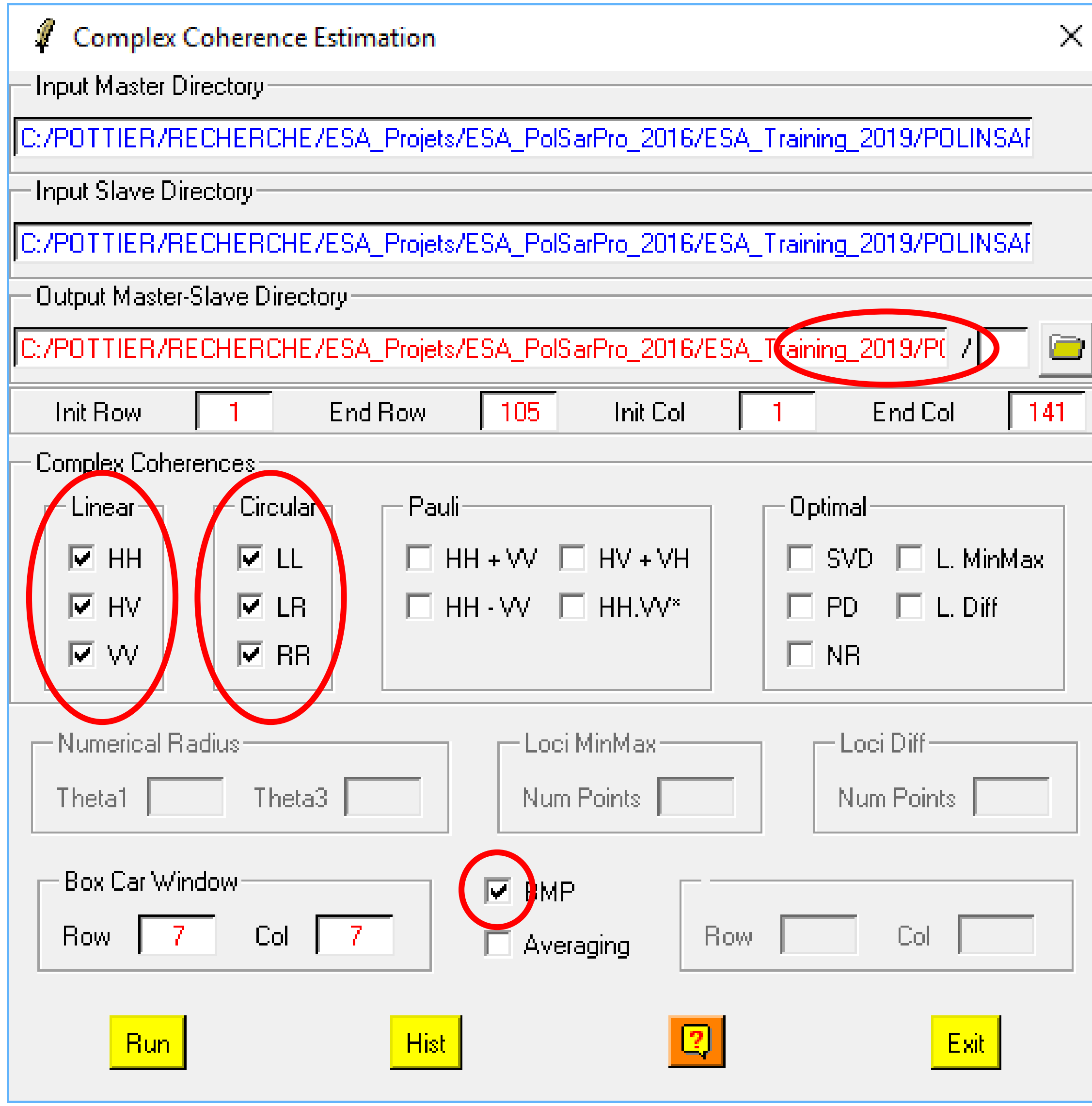
Generation of the Complex Coherence

- Go to Process
  - Coherence Estimation



Note:
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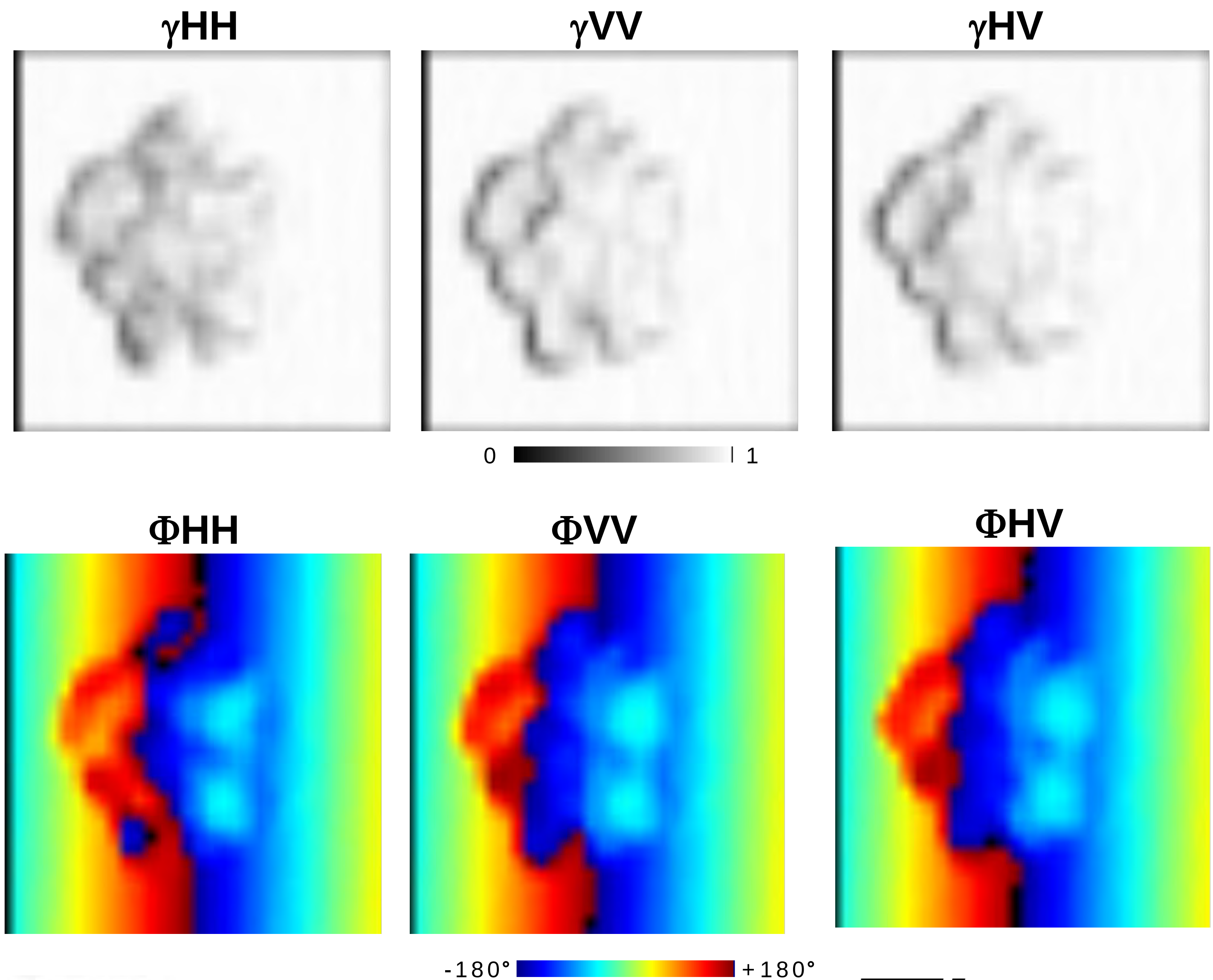
track_master_track_slave

Display Complex Coherences with GIMP

Coherence Magnitude

Coherence Phase ~ Inter-ferometric Phase



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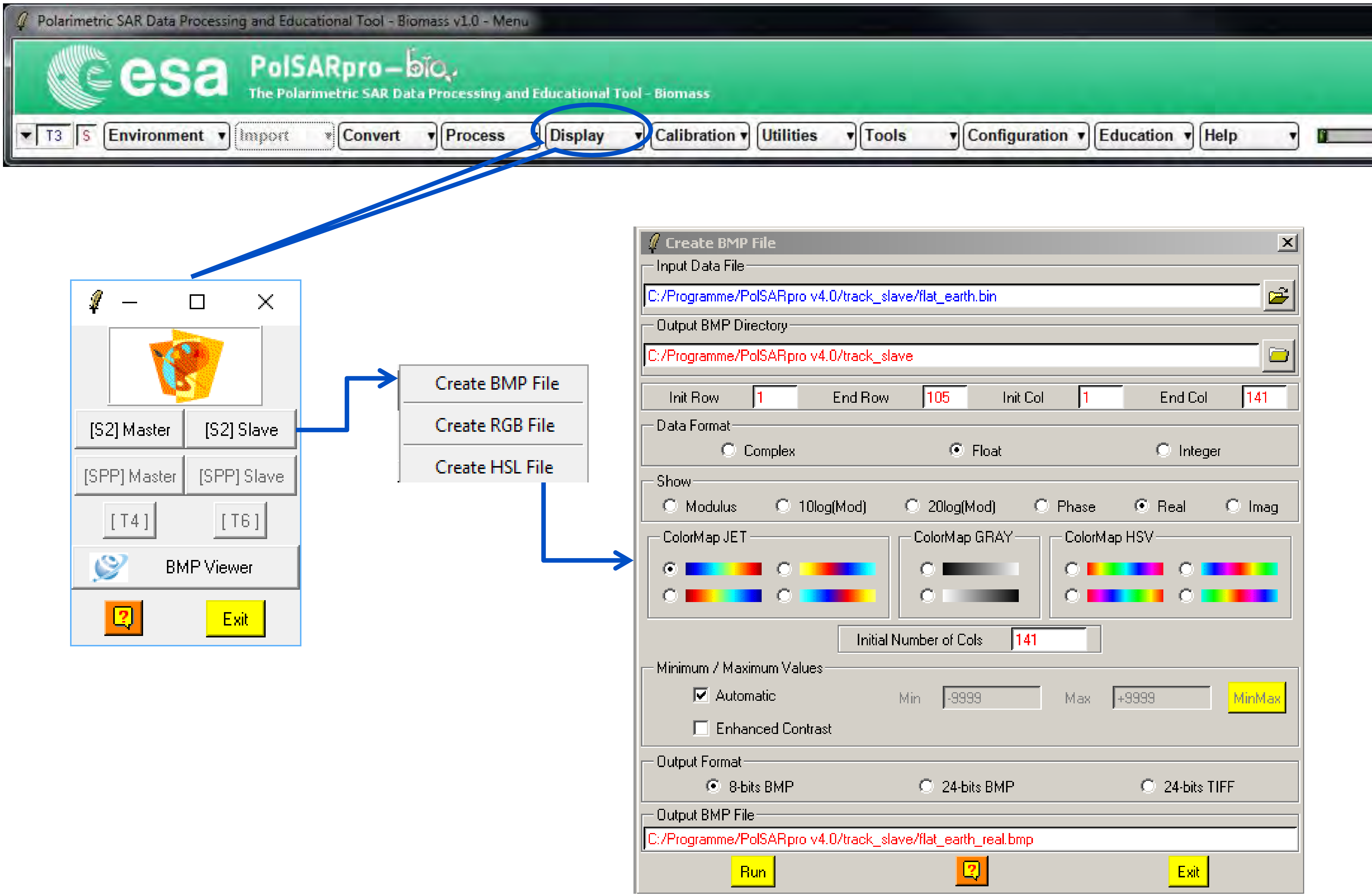
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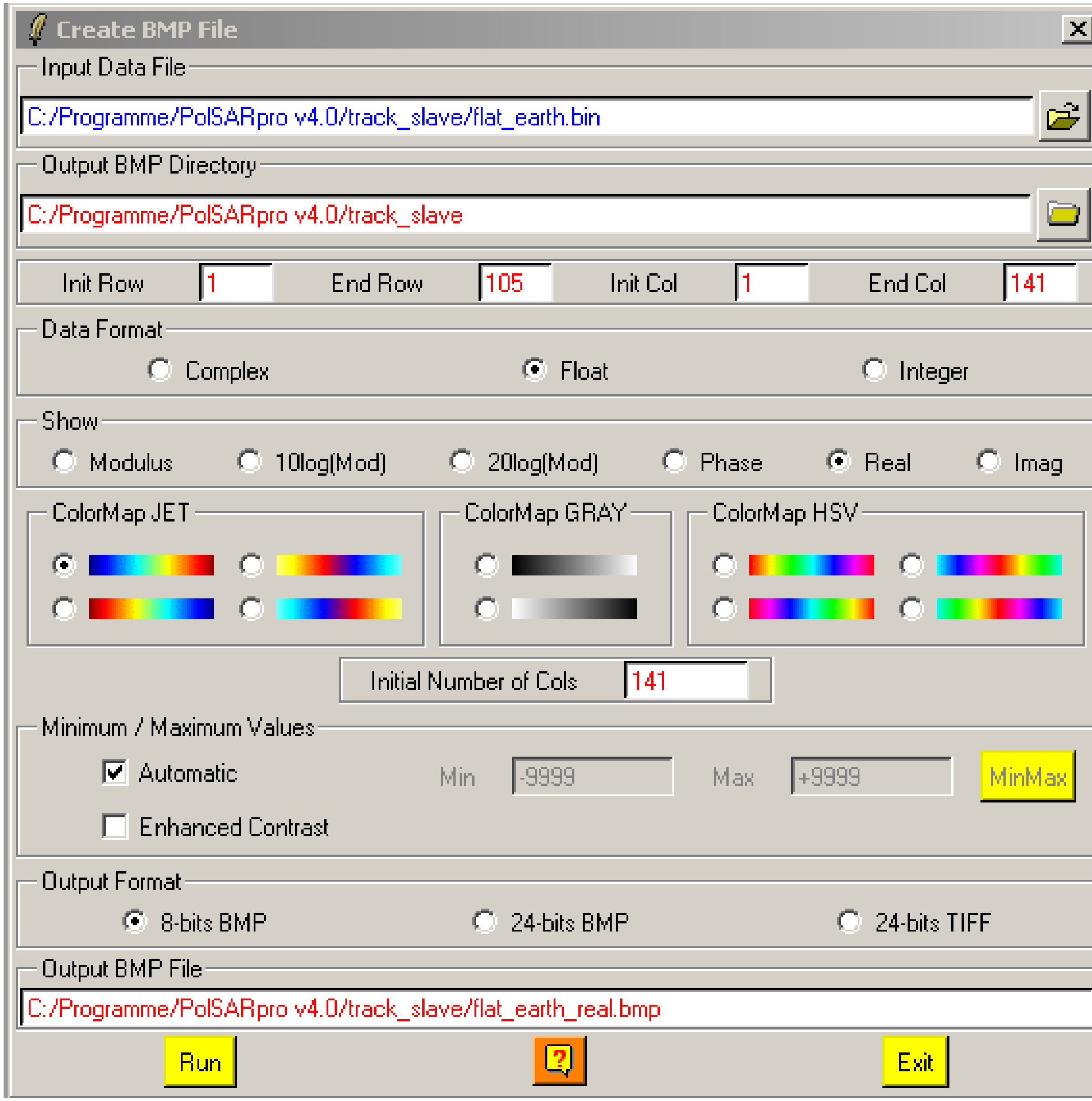
BMP Viewer
Exit
Create BMP File
Create RGB File
Create HSL File
Create BMP File
Input Data File
C:/Programme/PolSARpro v4.0/track_slave/flat_earth.bin
Output BMP Directory
C:/Programme/PolSARpro v4.0/track_slave
Init Row 1
End Row 105
Init Col 1
End Col 141
Data Format
Complex
Float
Integer
Show
Modulus
10log(Mod)
20log(Mod)
Phase
Real
Imag
ColorMap JET
ColorMap GRAY
ColorMap HSV
Initial Number of Cols 141
Minimum / Maximum Values
Automatic
Min -9999
Max +9999
MinMax
Enhanced Contrast
Output Format
8-bits BMP
24-bits BMP
24-bits TIFF
Output BMP File
C:/Programme/PolSARpro v4.0/track_slave/flat_earth_real.bmp
Run
Exit

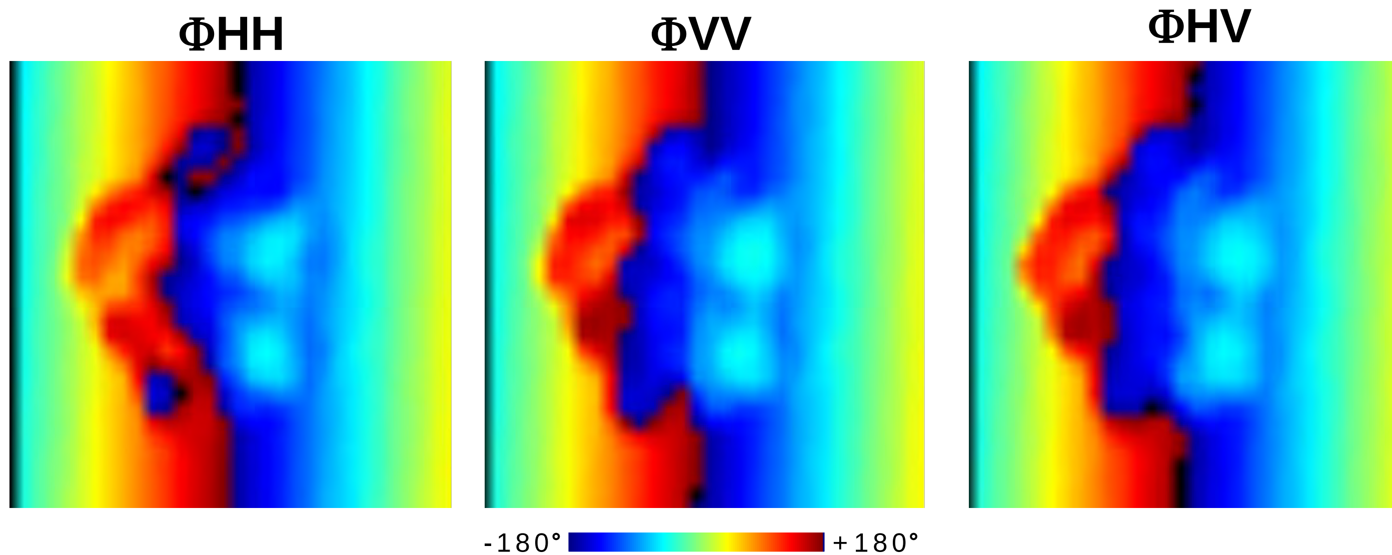
Display Flat Earth

- The flat earth is the dominant frequency component due to the side looking geometry (range direction)
- Flat Earth for the simulation data were already estimated during the PolSARPro Sim
- Go to Display and create a .bmp file

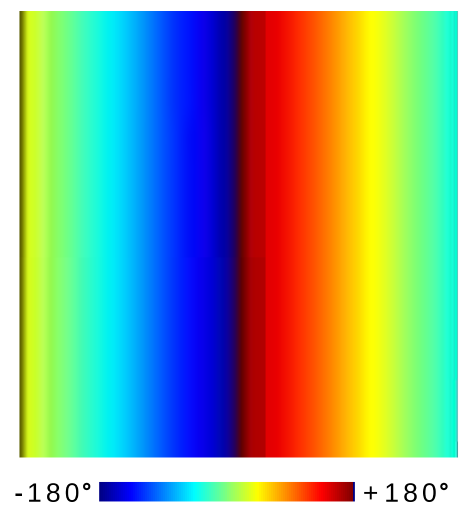


Display Flat Earth Earth & Store as .bmp

Coherence Phase ~ Inter-ferometric Phase



Flat Earth: regular fringe pattern in range



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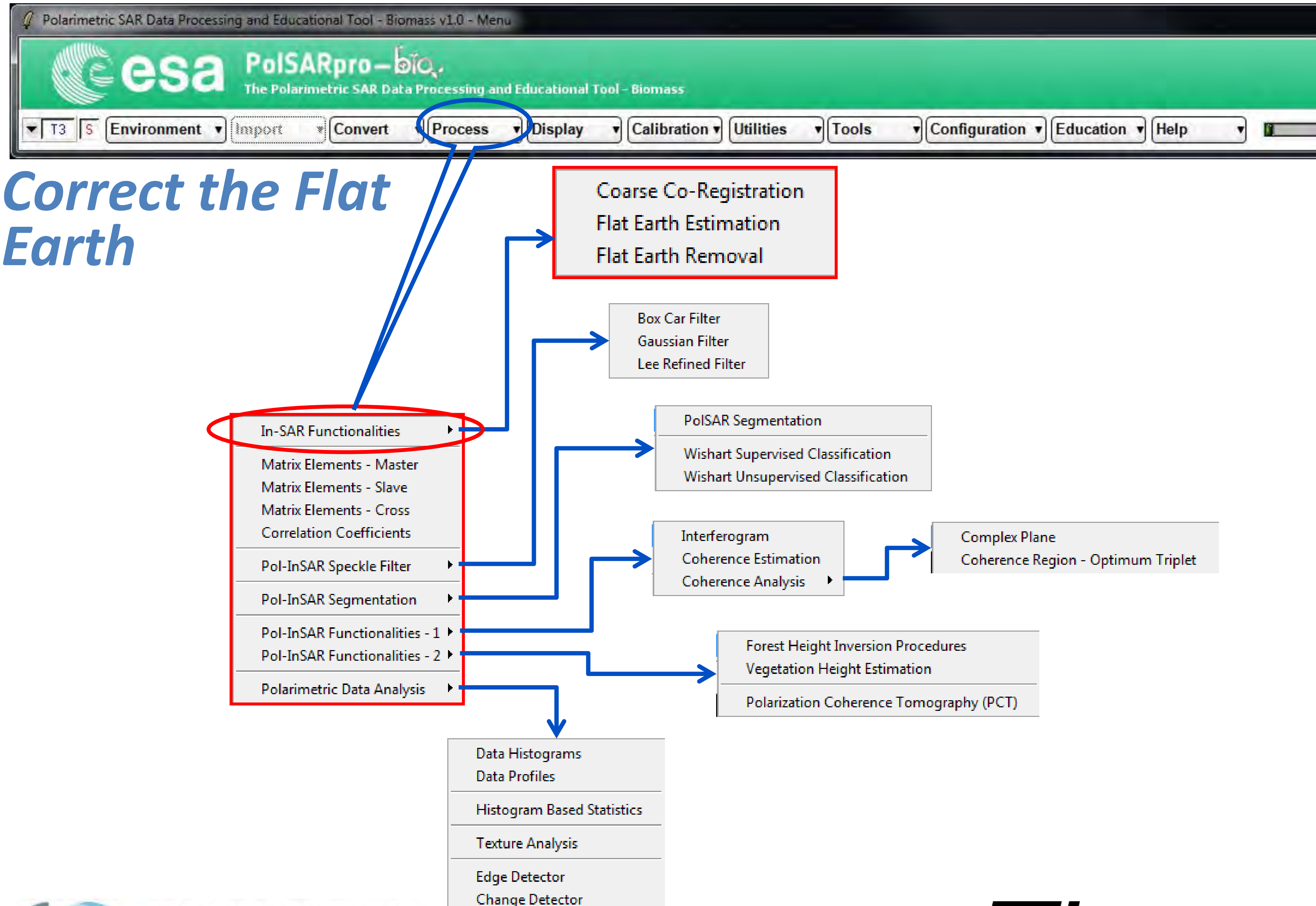
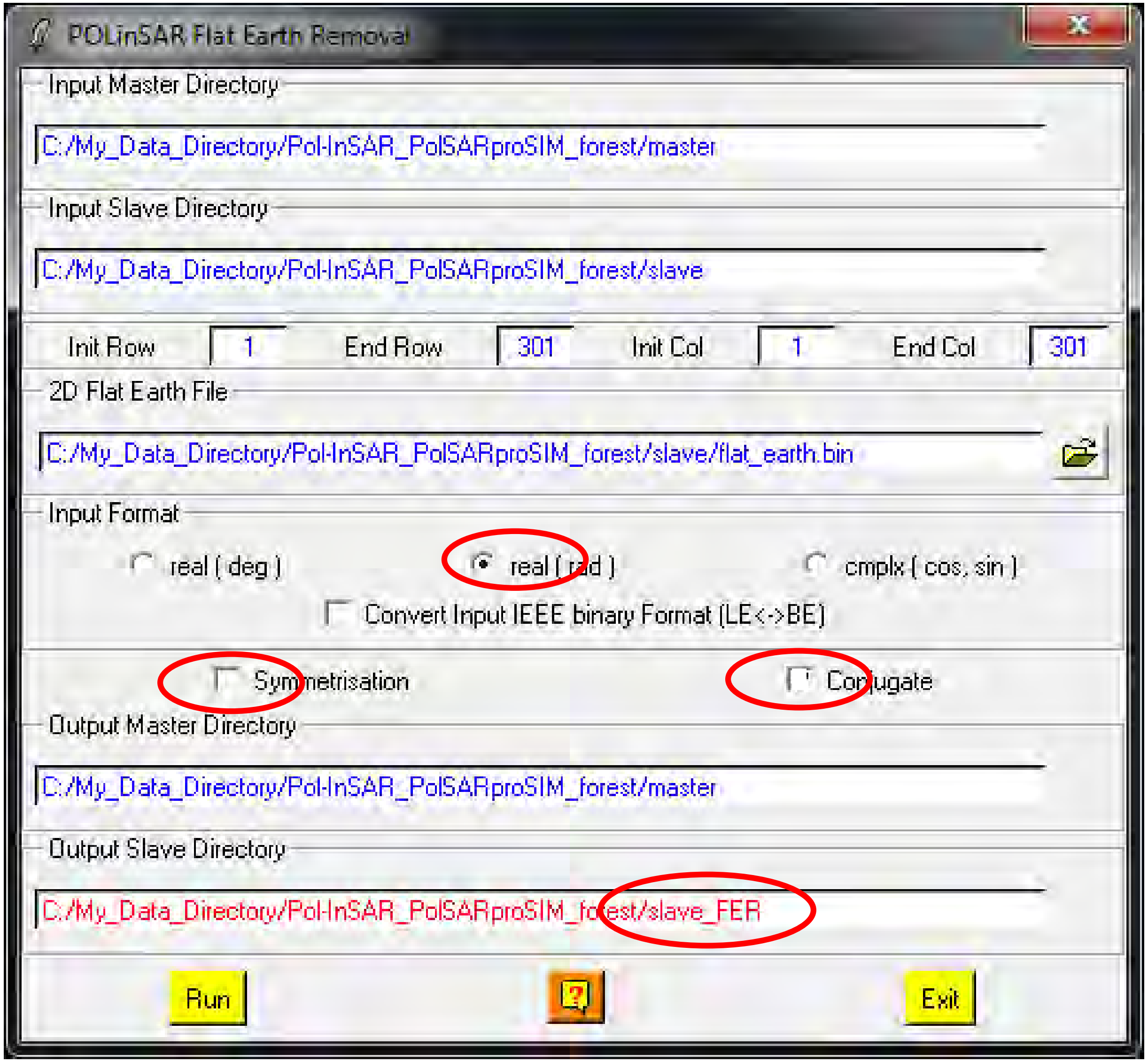
Correct the Flat Earth



Correct the Flat Earth

- Go to Processes
  - Flat Earth Removal



Note:
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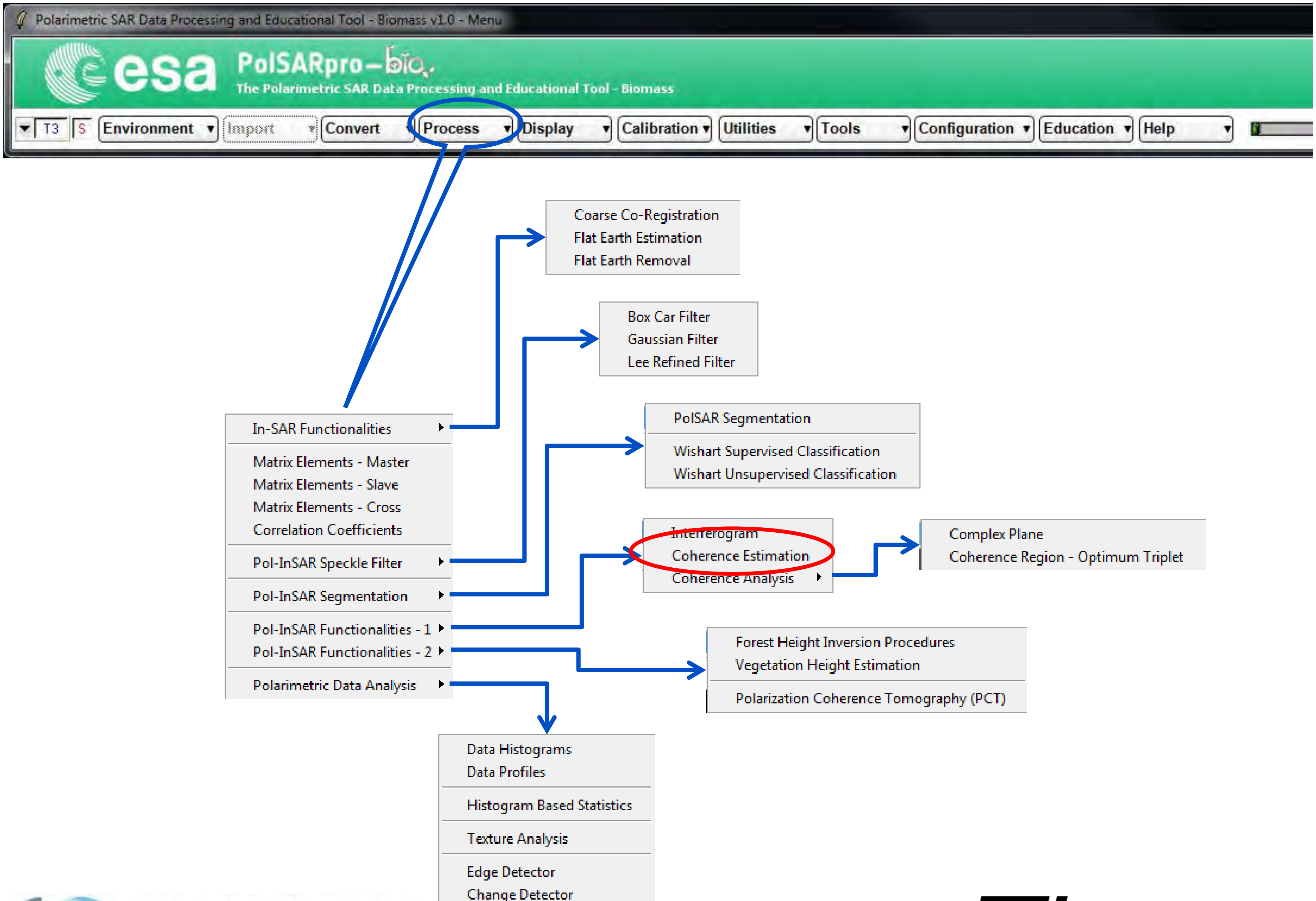
track_slave_FER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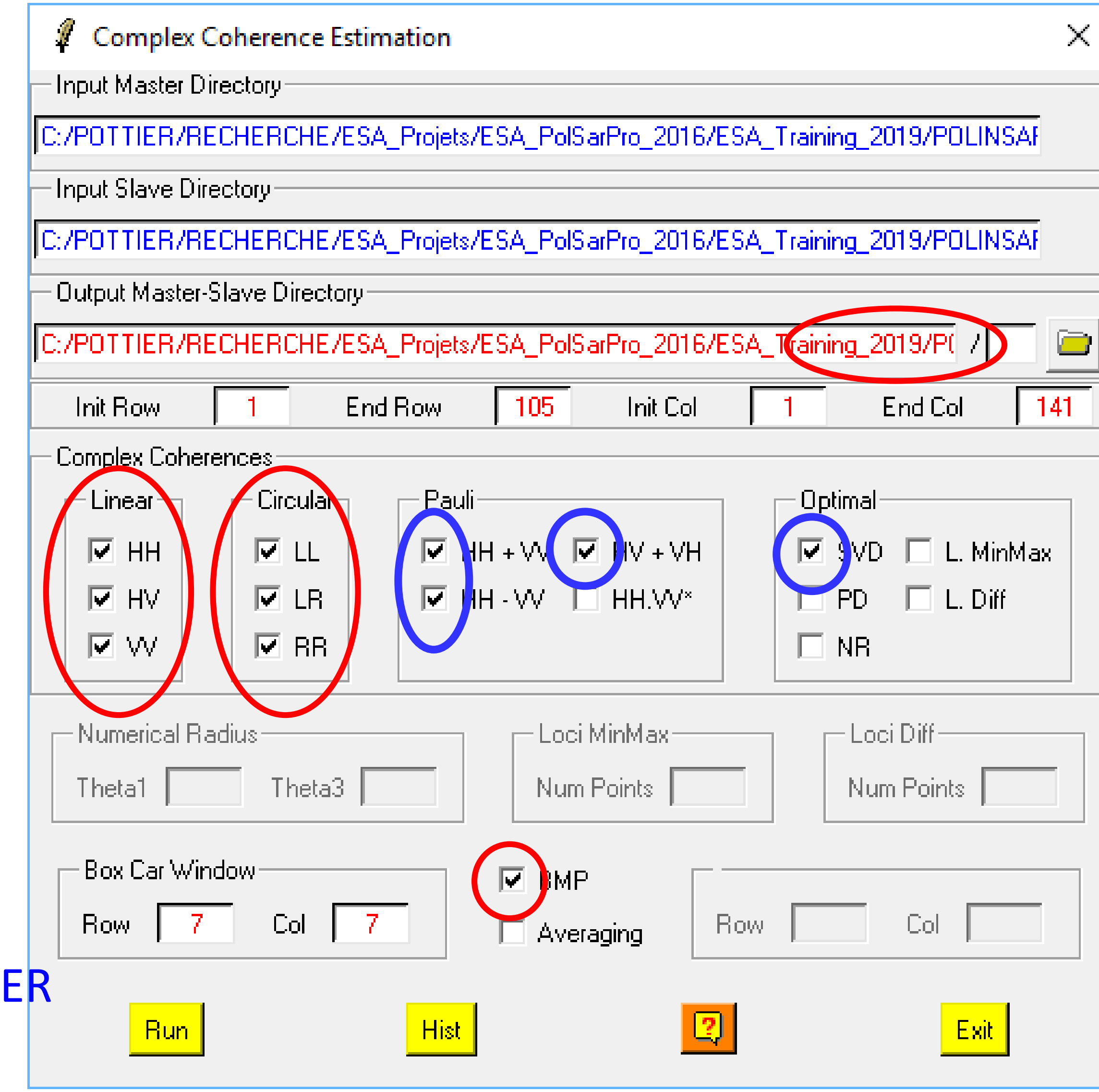
Run again the Coherence Estimation

- Go to Process
  - Coherence Estimation



Note:
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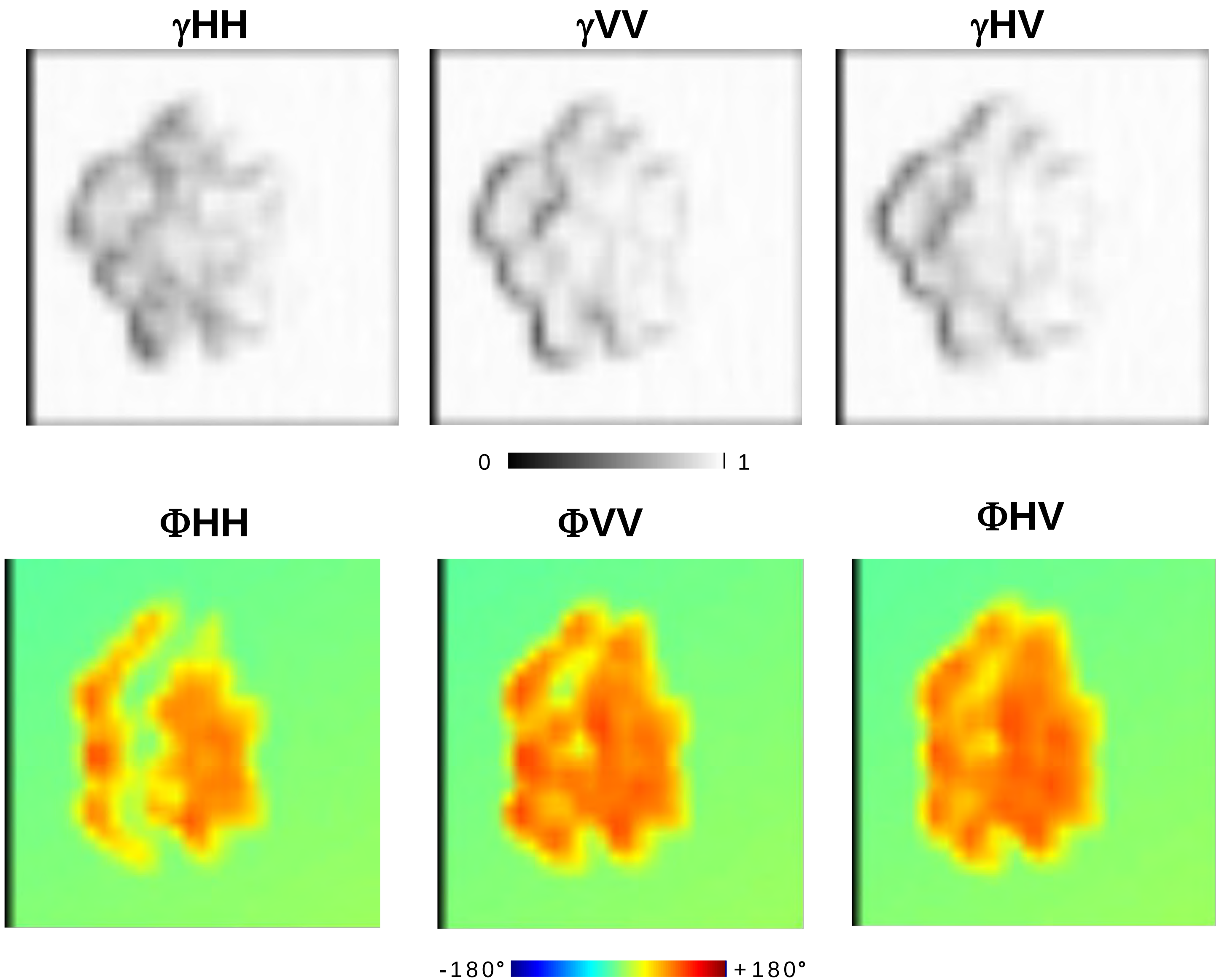
Display Complex Coherences with GIMP – After FE Correction

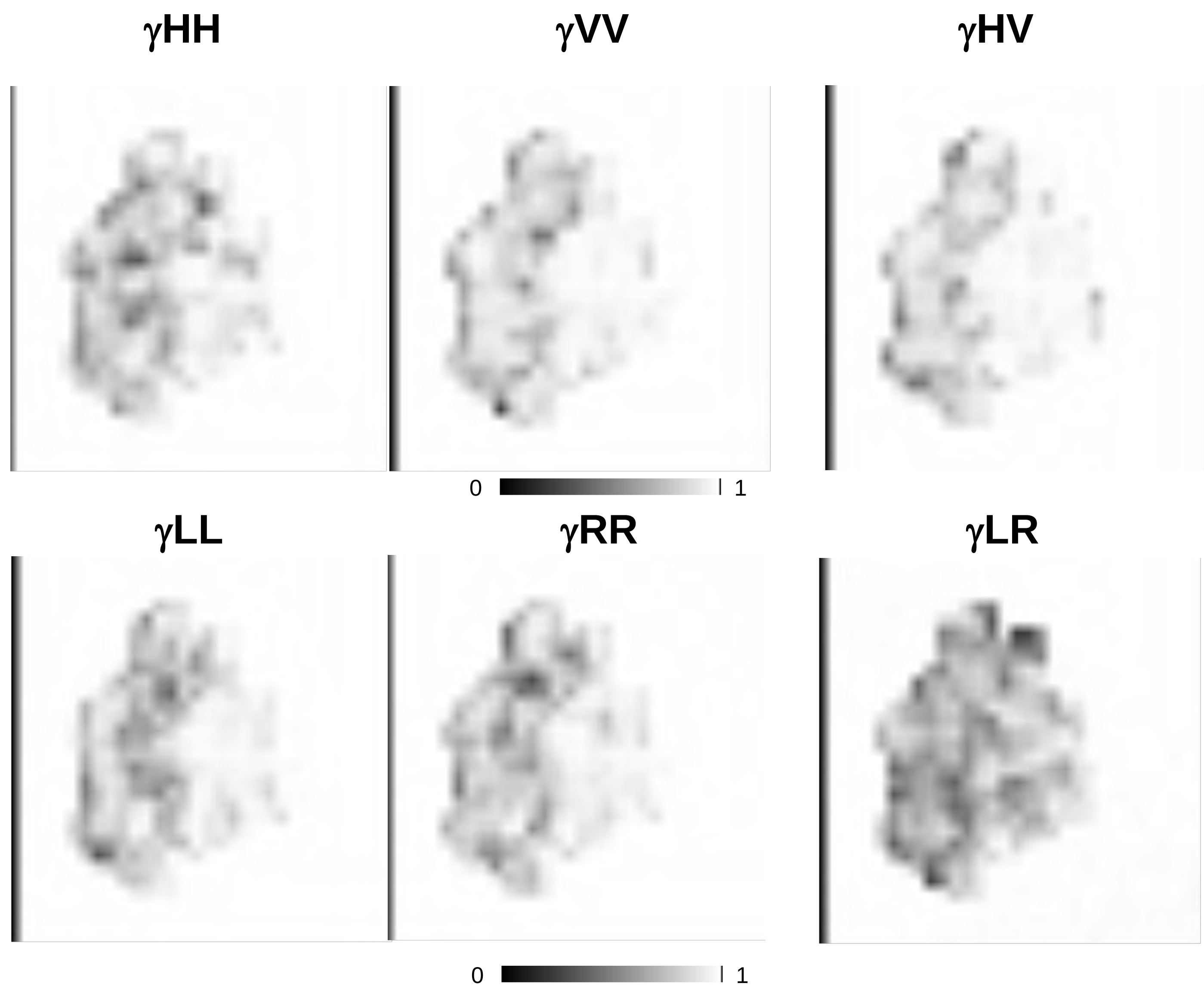
Coherence Magnitude

Coherence Phase ~ Inter-ferometric Phase



Display Complex Coherences with GIMP – After FE Correction

Coherence Magnitude



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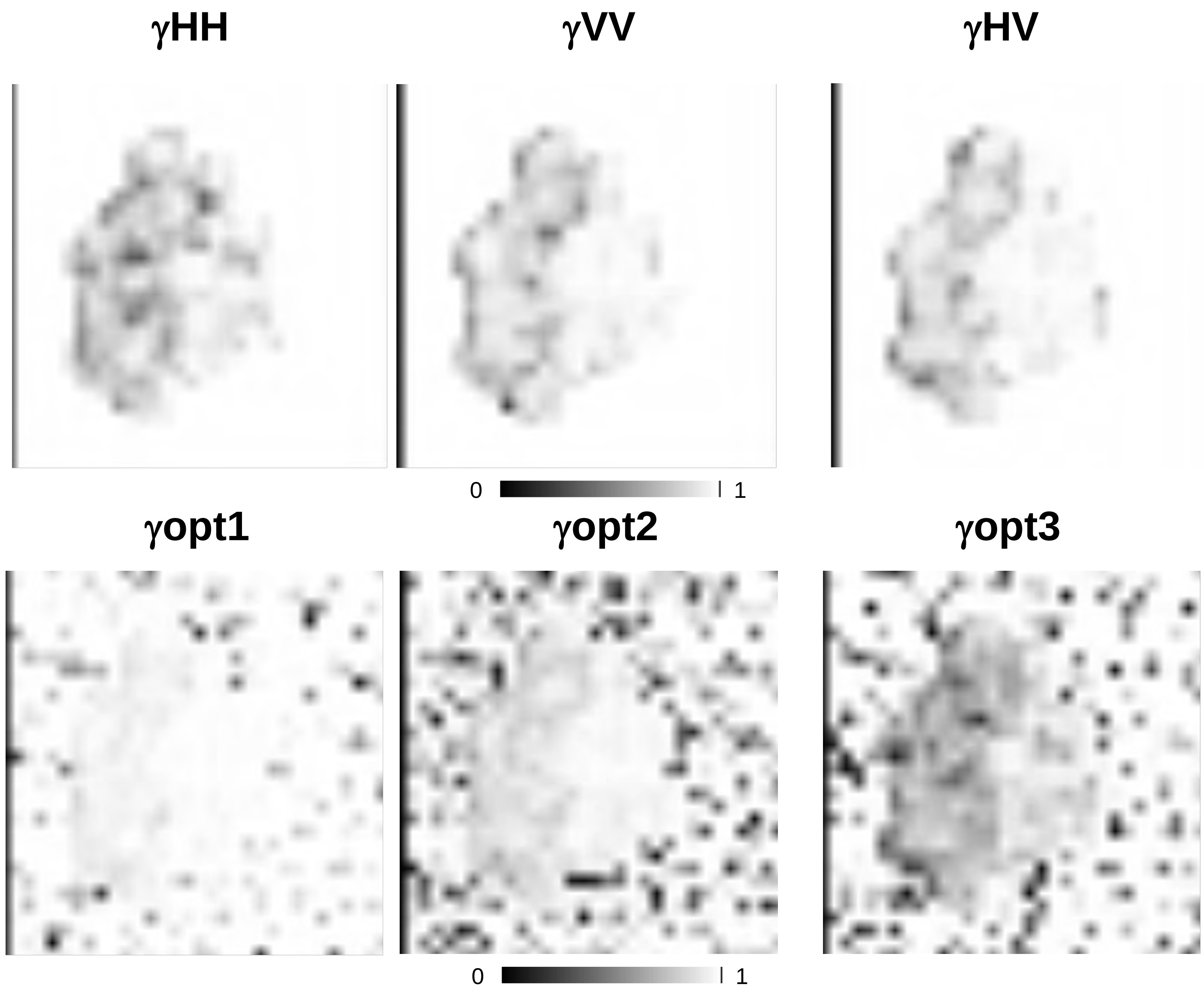
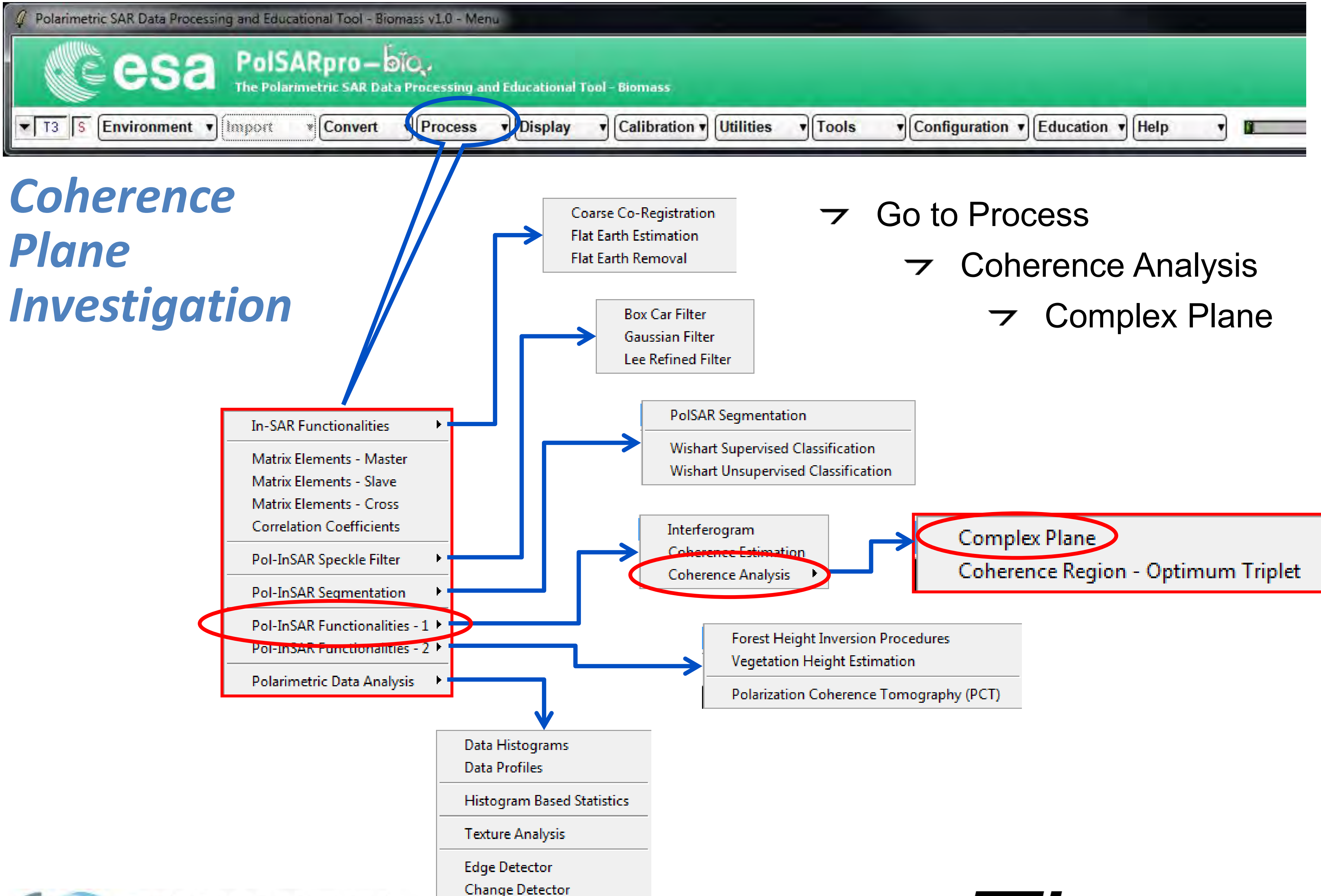
Coherence Magnitude



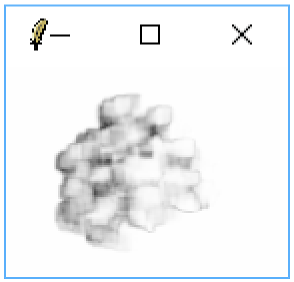
Coherence Plane Investigation

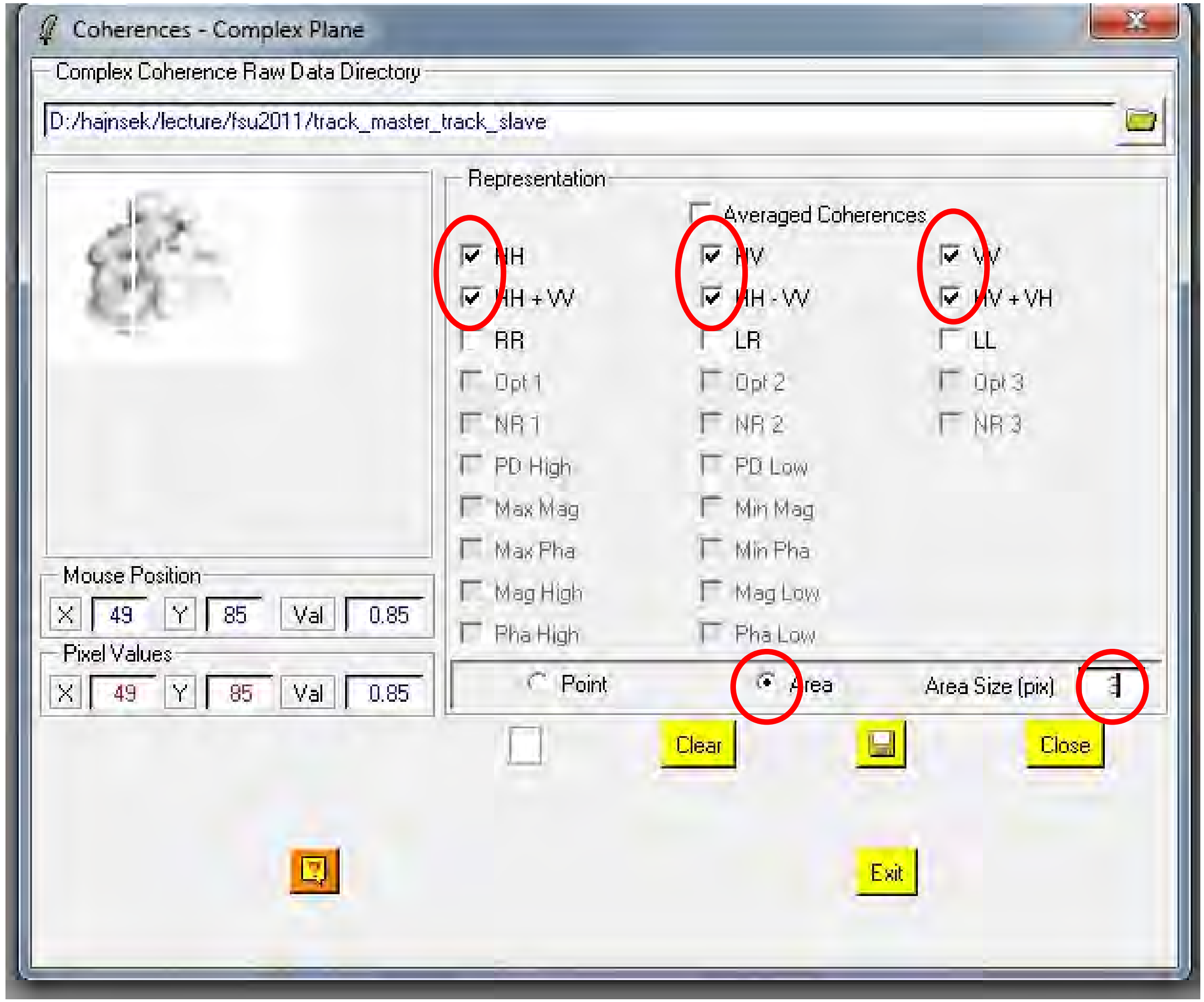


- Go to Process
  - Coherence Analysis
    - Complex Plane

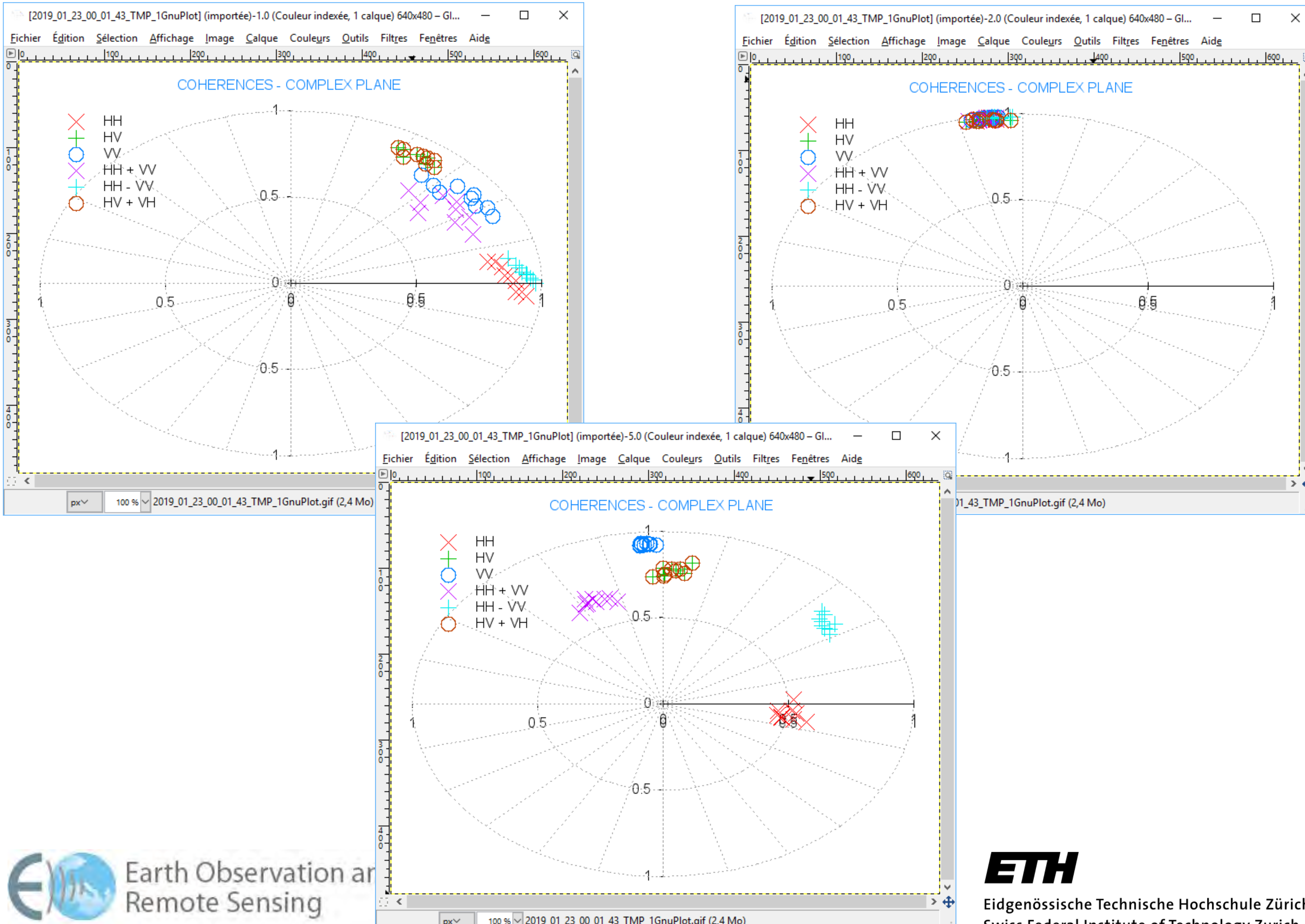
Coherence Plane Investigation

- Select an area
- Save the plot with the complex circle





Complex Unit Circle



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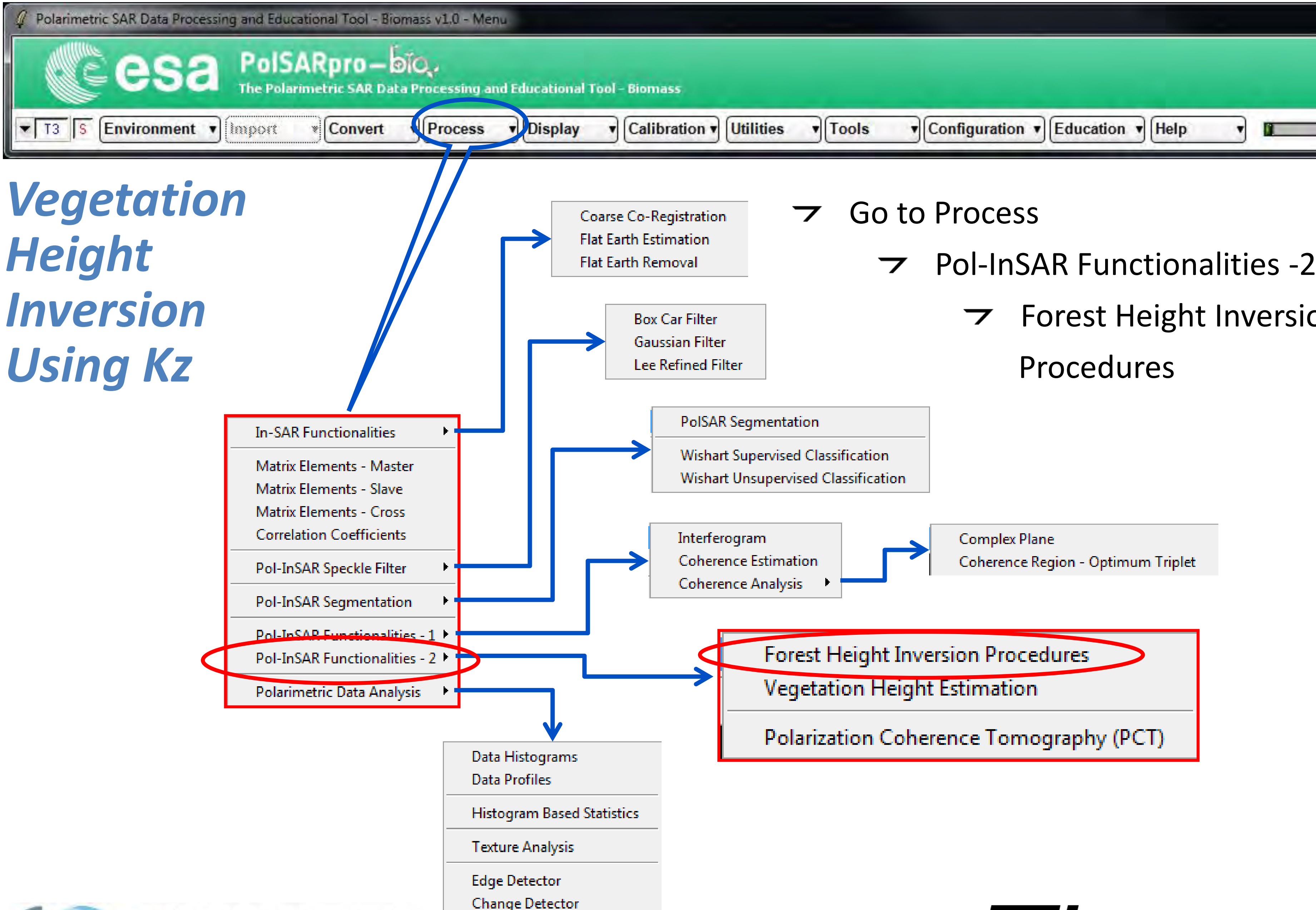
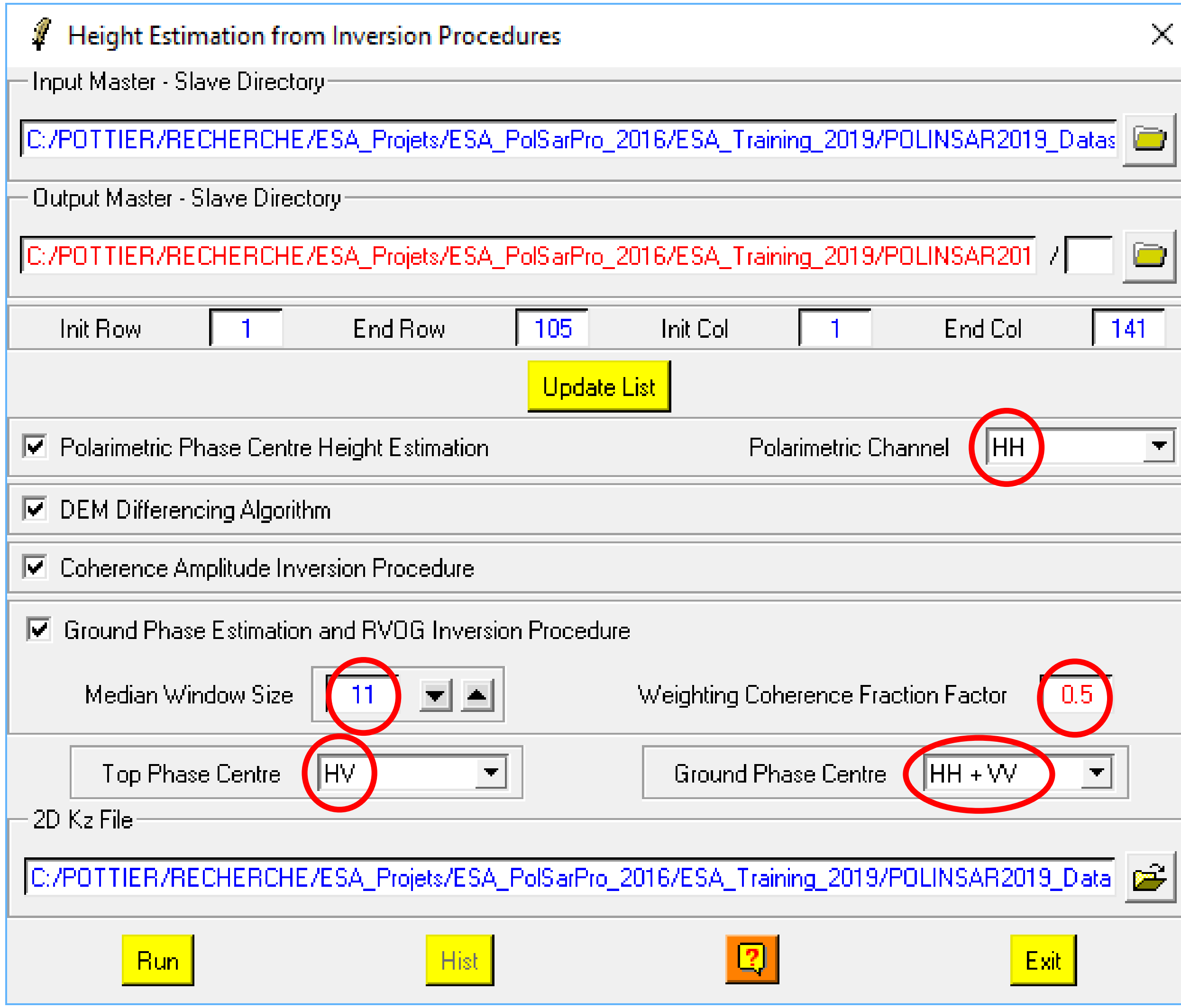
Vegetation Height Inversion Using Kz

- Go to Process
  - Pol-InSAR Functionalities -2
    - Forest Height Inversion Procedures



Vegetation Height Inversion Using Kz

- Use the ‚inversion procedure‘



Height Inversion using different Methods

- RVoG Inversion

↗ 2-Layer inversion model (standard): Parameter space: groung/volume ratio, underlying topography, height, extinction

- Coherence Height

↗ Amplitude inversion, assumption only volume scattering is present, procedure uses coherence to kz (0 s) inversion according to a sinc funtion

- Phase Center Heights (HH)

↗ Based on the inversion of the scattering phase centers – simple conversion into height

- DEM Difference Heights

↗ Based on the difference of two polarisation channels (phase location between volume and ground)

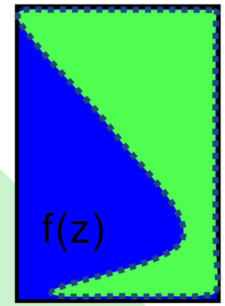
S_1 S_2

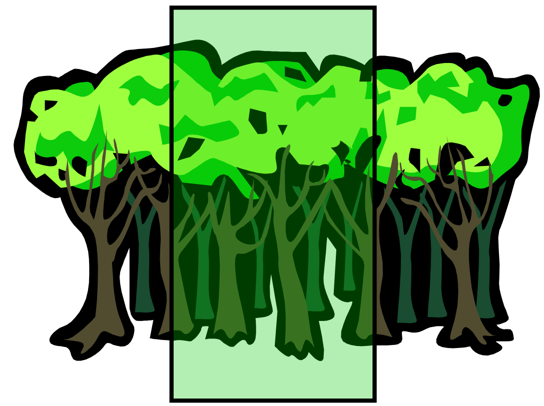
Interferometric Coherence

$$\tilde{\gamma}(S_1\, S_2) = \frac{< S_1\, S_2^* >}{\sqrt{< S_1\, S_1^* > < S_2\, S_2^* >}}$$

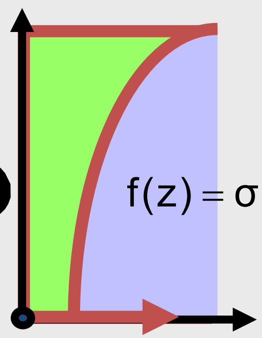
Volume Coherence

$$\tilde{\gamma}_{Vol}(f(z)) = e^{ik_z z_o} \frac{\int_o^{h_v} f(z)\, e^{ik_z z} dz}{\int_o^{h_v} f(z)\, dz}$$





2 Layer Scattering Model



$$f(z) = \sigma_{V0} \exp\left(\frac{2\ \sigma\ z}{\cos\theta_0}\right) + m'_G \delta(z - z_0)$$

$$\tilde{\gamma}(\vec{w}) = \exp(i\varphi_0) \frac{\tilde{\gamma}_V + m(\vec{w})}{1 + m(\vec{w})}$$

Volume Coherence

$$\tilde{\gamma}_V = \frac{I}{I_0} \left\{ \begin{array}{l} I = \int_0^{h_V} \exp(i\kappa_z z')\exp\left(\frac{2\ \sigma\ z'}{\cos\theta_0}\right)dz' \\ I_0 = \int_0^{h_V} \exp\left(\frac{2\ \sigma\ z'}{\cos\theta_0}\right)dz' \end{array} \right.$$

G/V Ratio: $m(\vec{w}) = \frac{m_G(\vec{w})}{m_V(\vec{w}) I_0}$

Vertical Wavenumber: $\kappa_z = \frac{\kappa\Delta\theta}{\sin(\theta_0)}$

Volume Height h_V

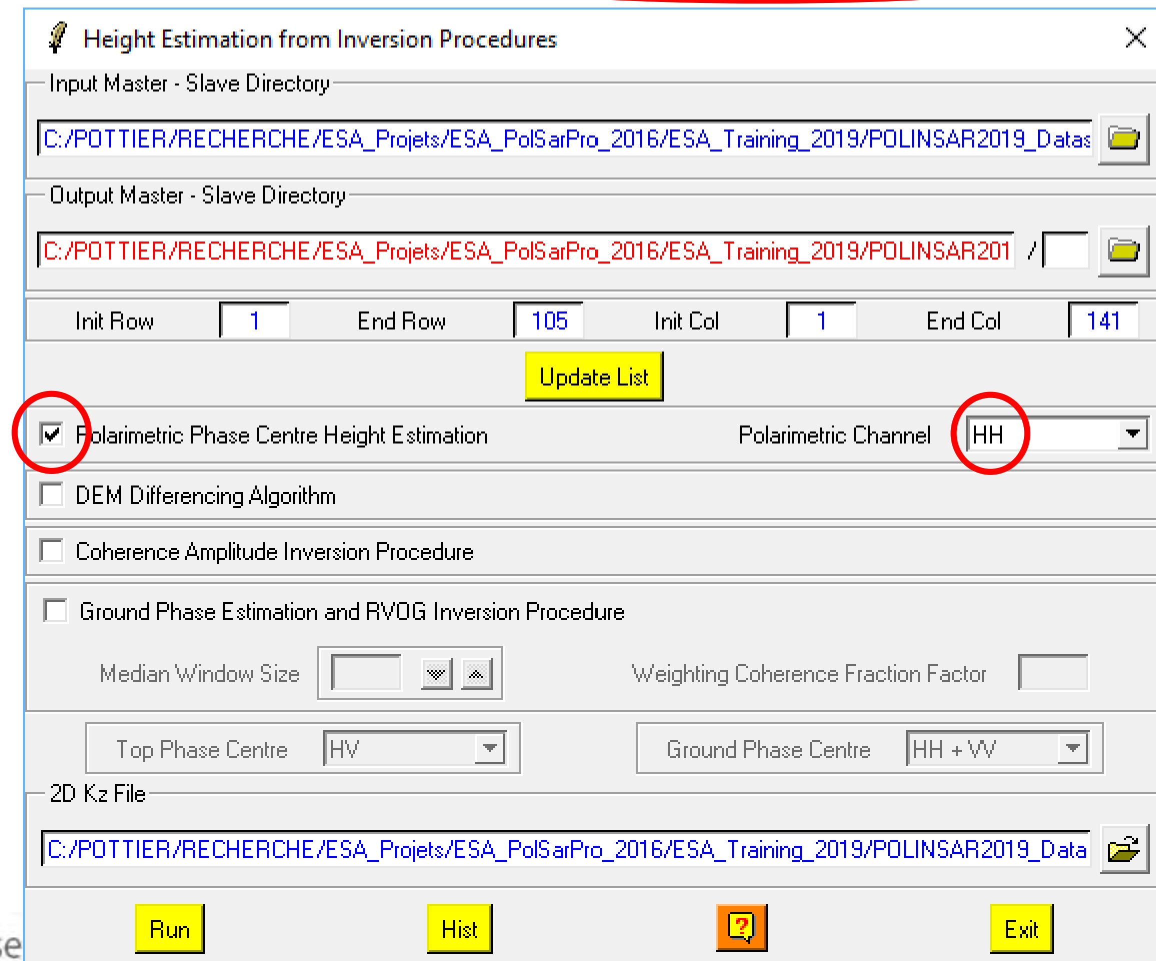
Extinction σ

Topography φ_0

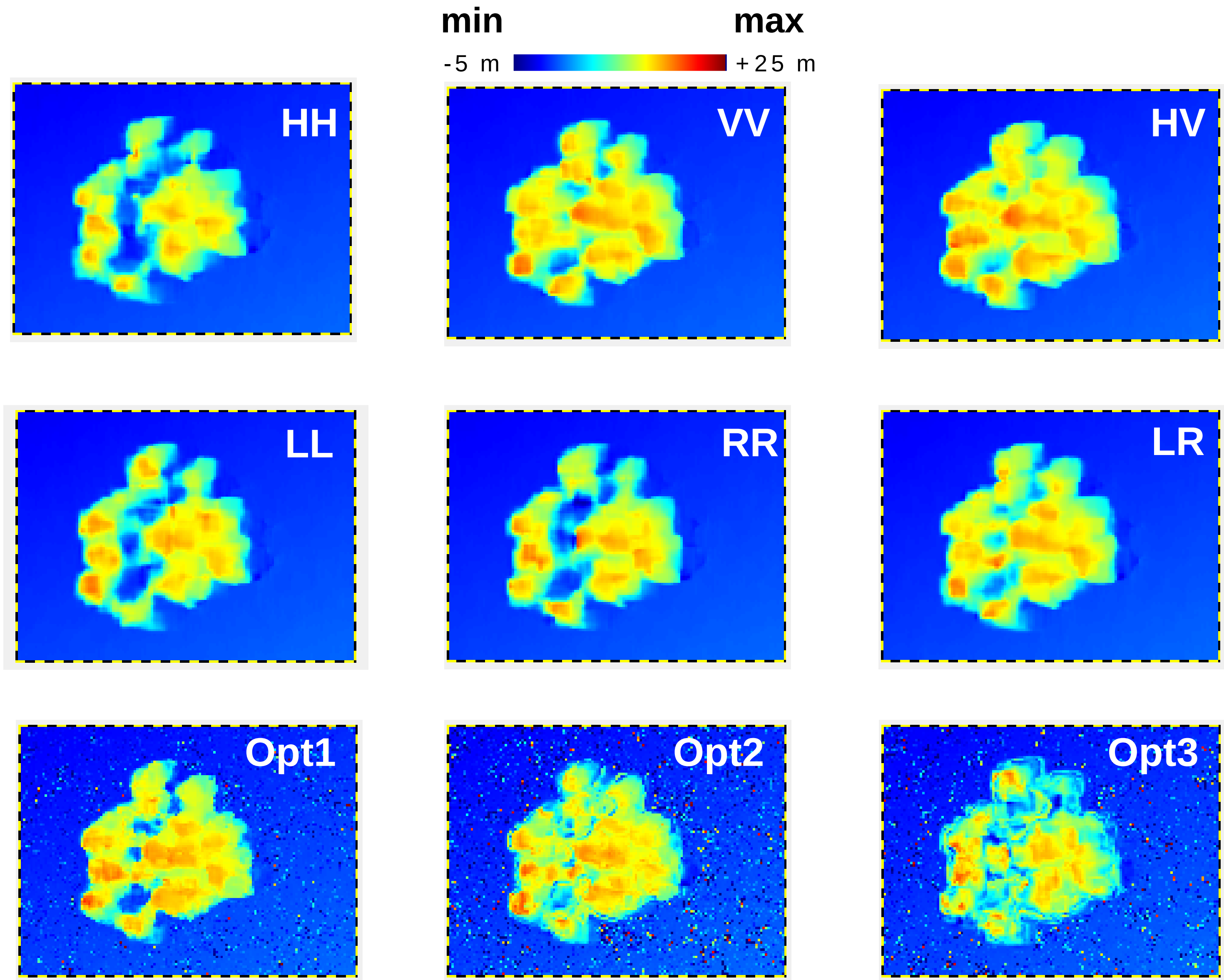
G/V Ratio $m(\vec{w})$

Do it yourself!

- Please generate the following products
  - Phase center heights in HH, VV, HV, LL, LR, RR, Opt1, Opt2, Opt3

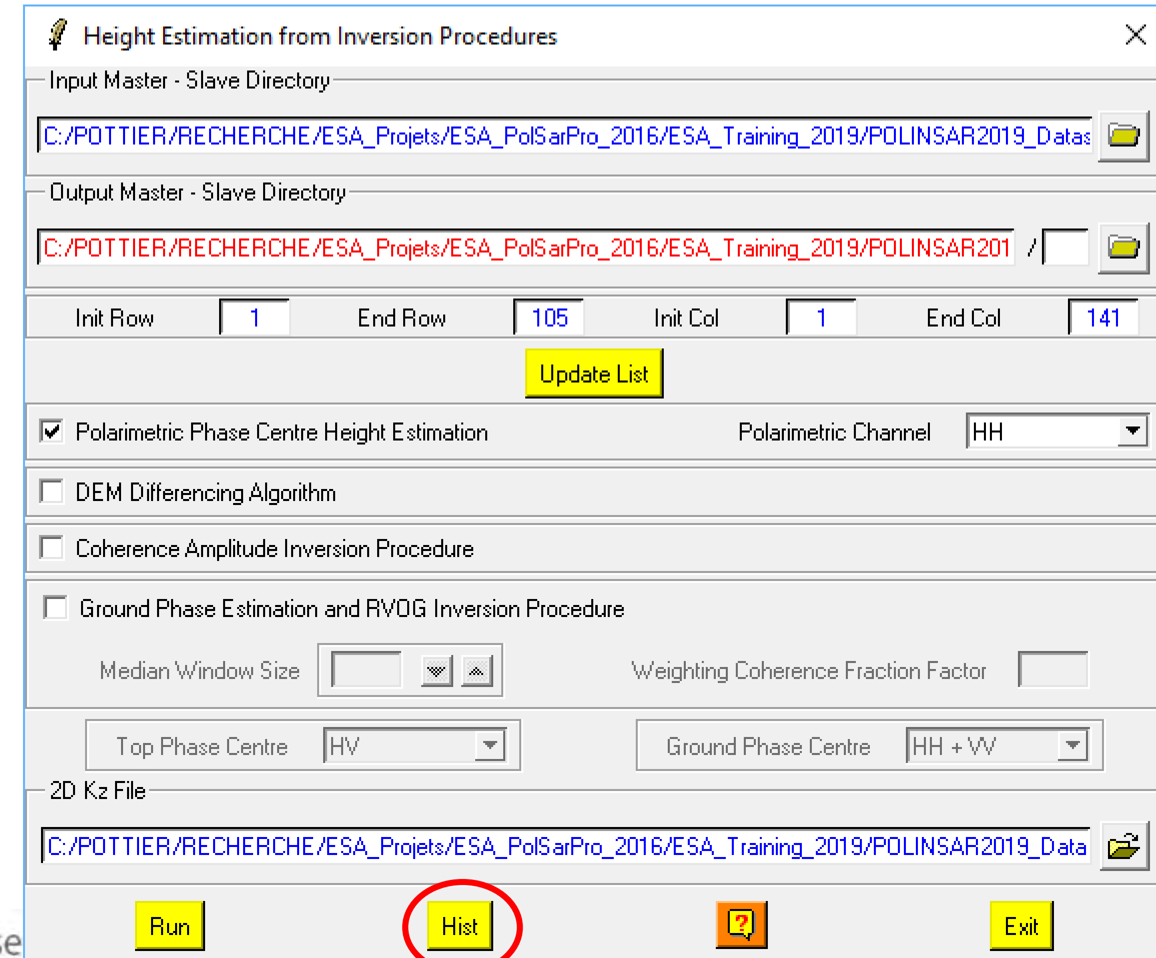


Phase Center Heights [m]

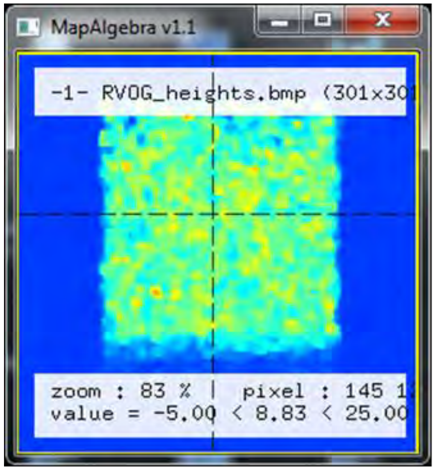


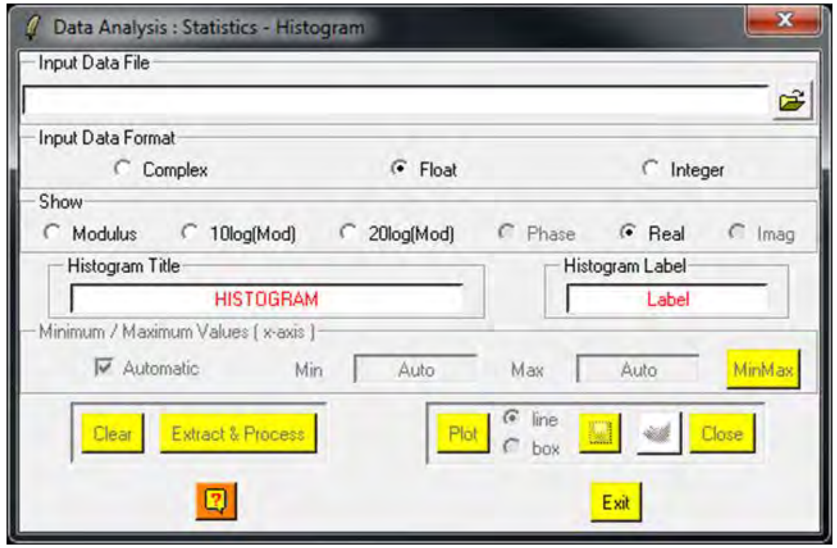
Do it yourself!

- Please generate the following products
  - Compare the phase center heights (statistics)



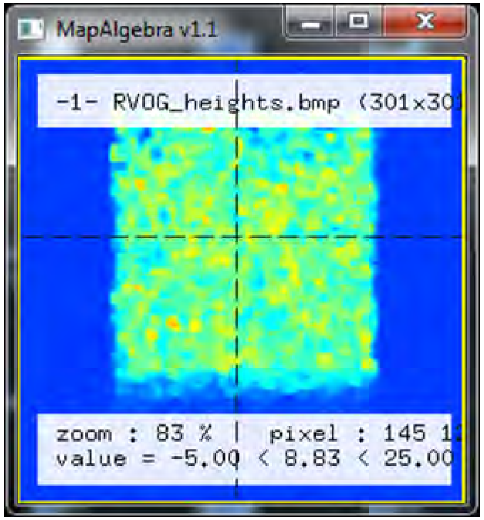
Statistics: Histogram for the Vegetation Height

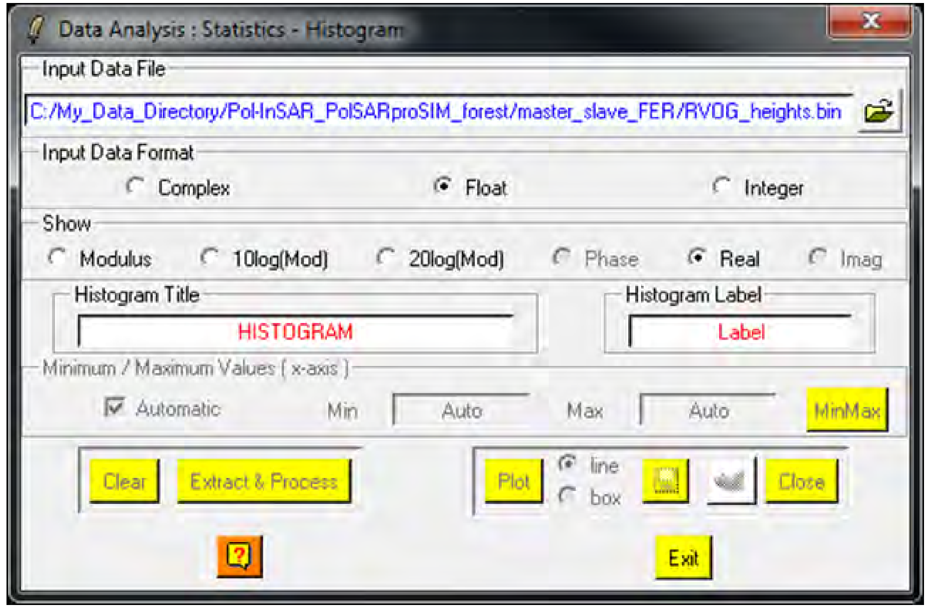




Do it Yourself:
Step 1 : Select a BMP File

Statistics: Histogram for the Vegetation Height





Do it Yourself:

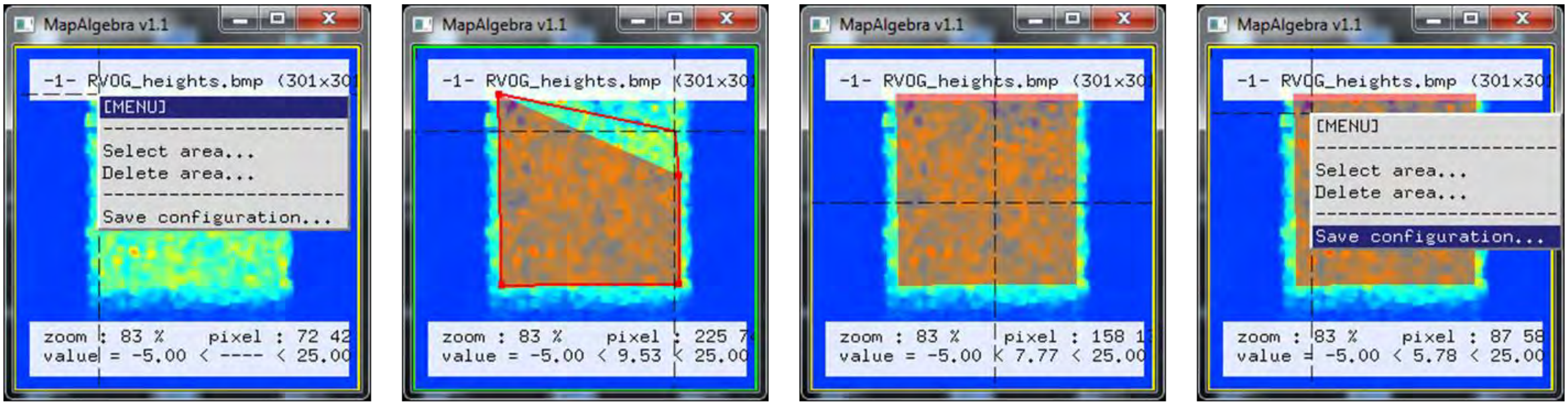
Step 2 : Select an Input Binary Data File

Select what to *Show*

Enter the *Histogram Title*

Enter the *Histogram Label*

Statistics: Histogram for the Vegetation Height

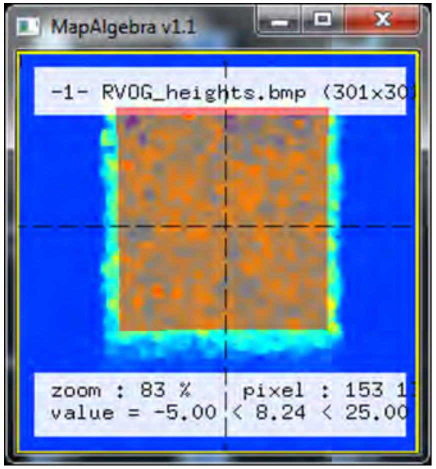


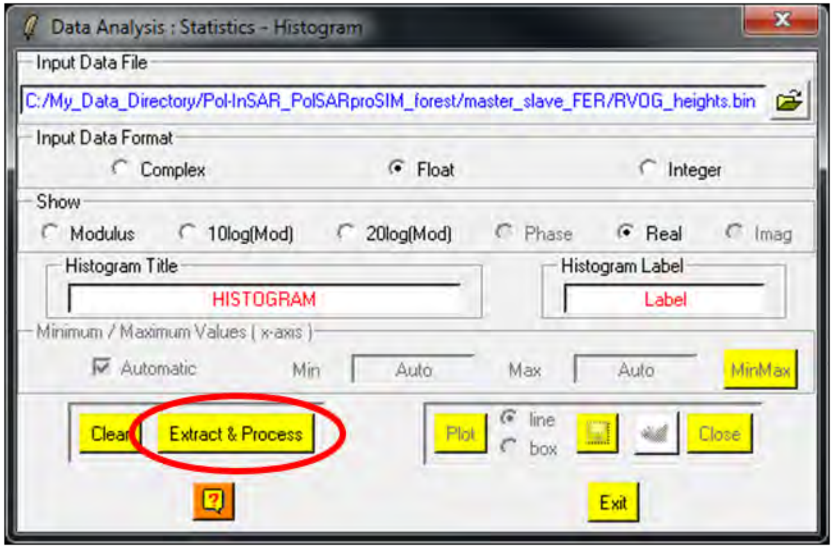
Do it Yourself:

Step 3 : Define the polygon area

1) ***Right button*** **: Select area**
2) ***Left button*** **: Draw the polygon**
3) ***Enter*** **: Close the polygon**
4) ***Right button*** **: Save configuration**

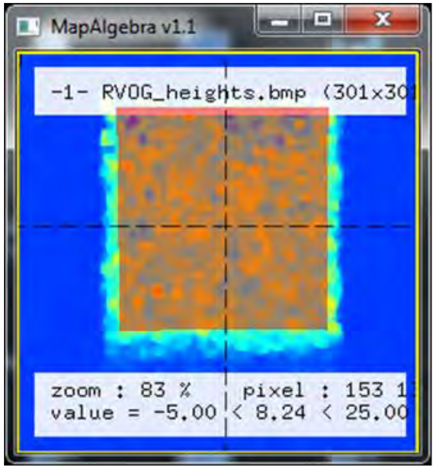
Statistics: Histogram for the Vegetation Height

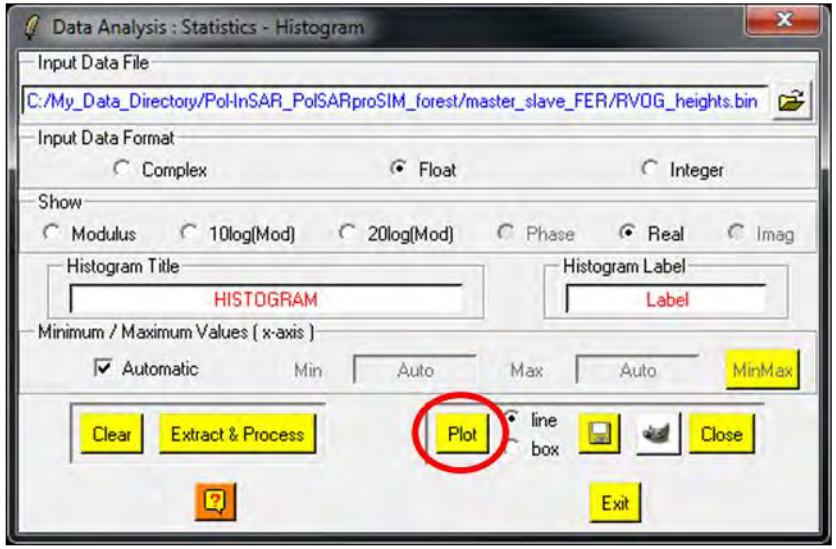


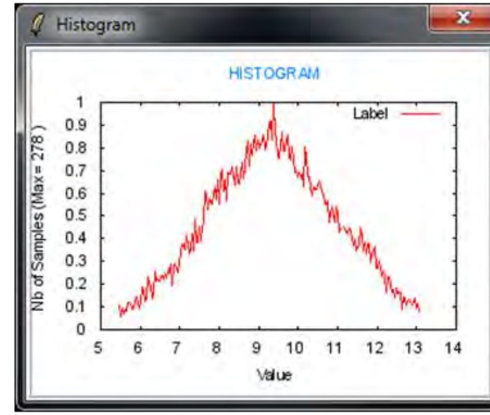


Do it Yourself:
Step 4 : Extract and Process

Statistics: Histogram for the Vegetation Height



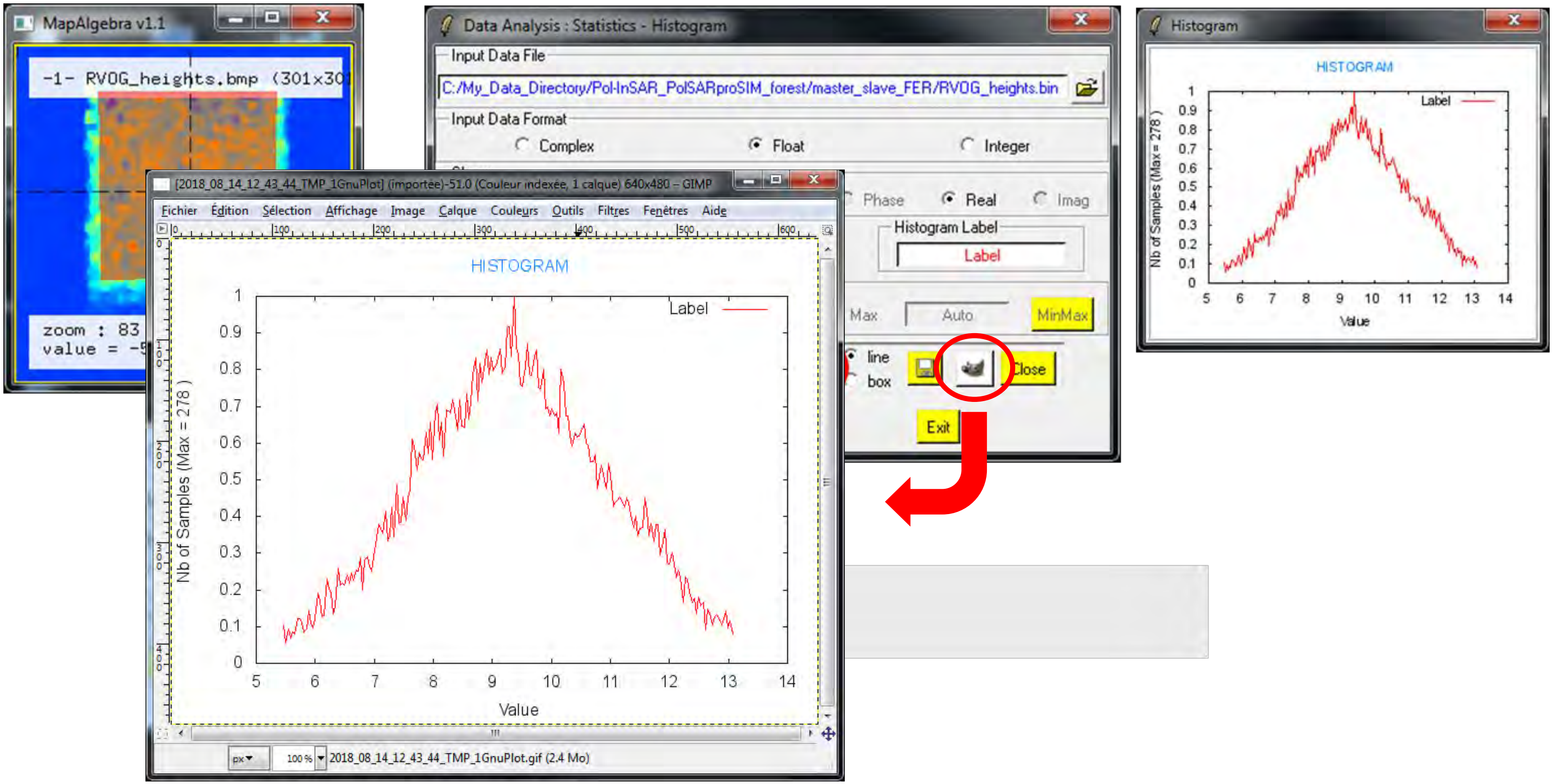




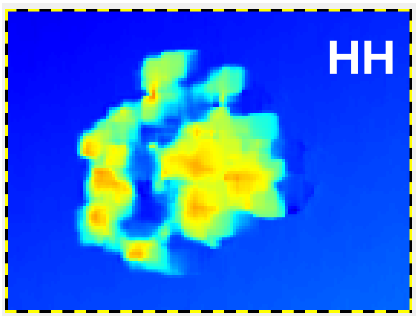
Do it Yourself:

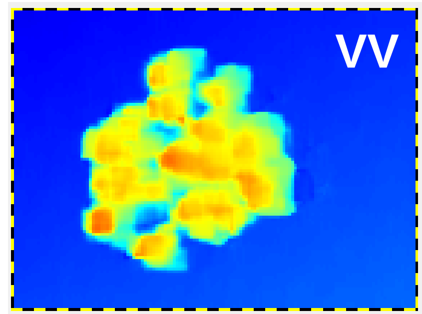
Step 5 : Plot the histogram

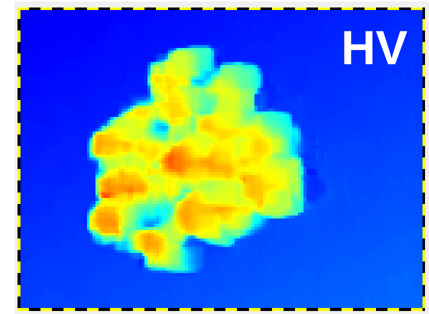
Statistics: Histogram for the Vegetation Height

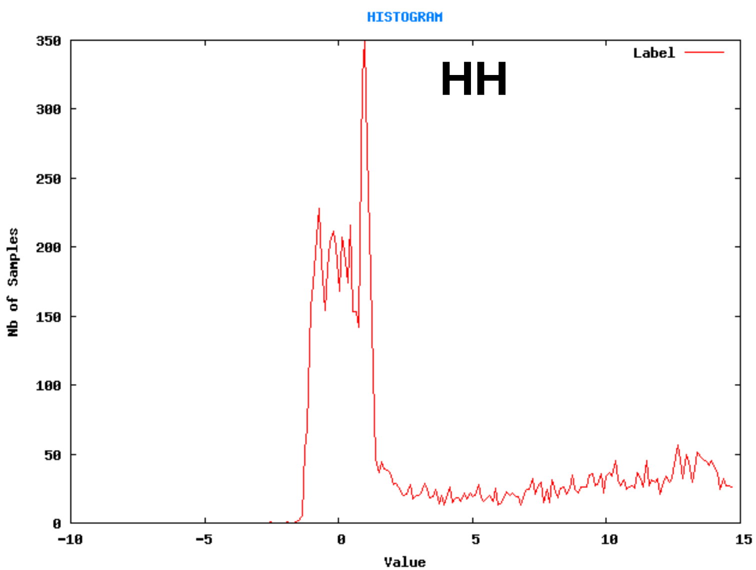


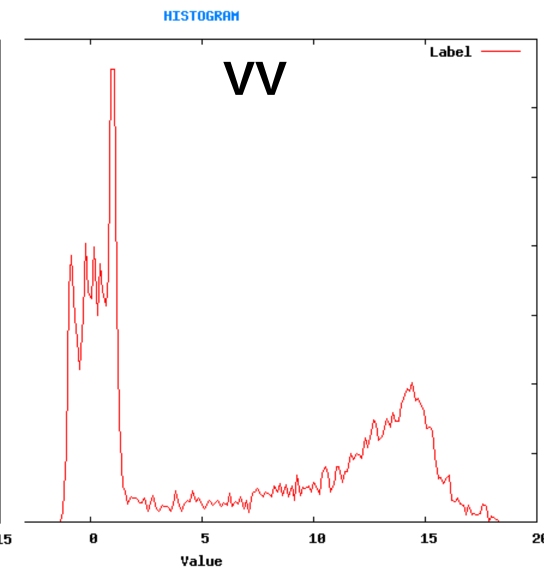
Phase Center Heights

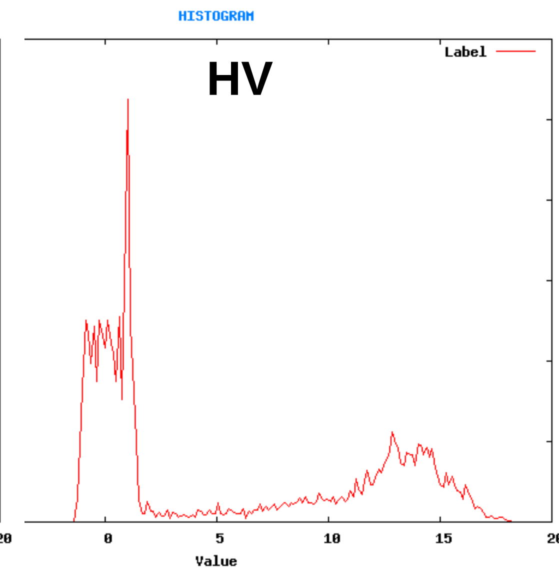












primarily ground contribution **primarily volume contribution**

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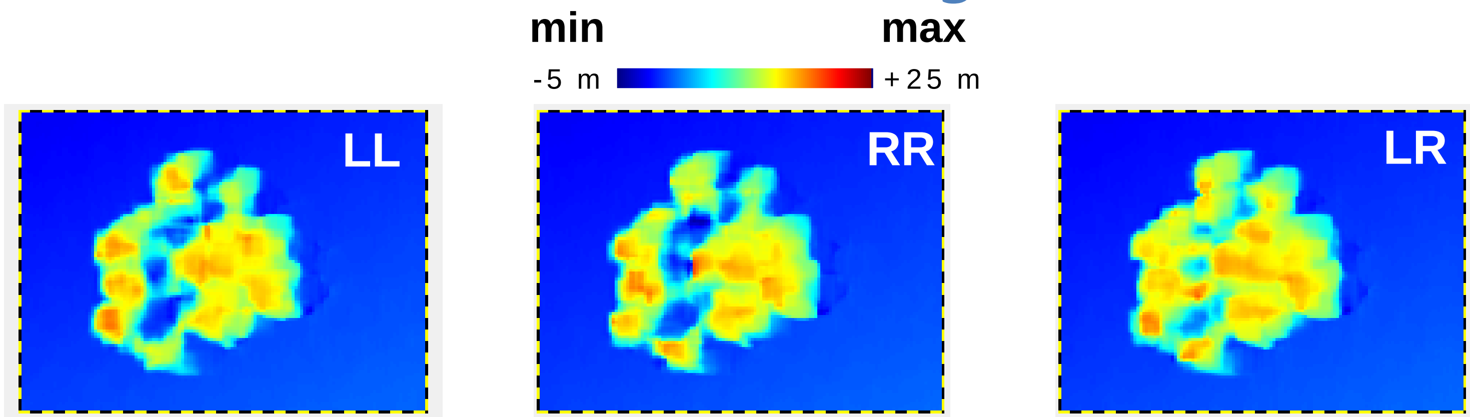
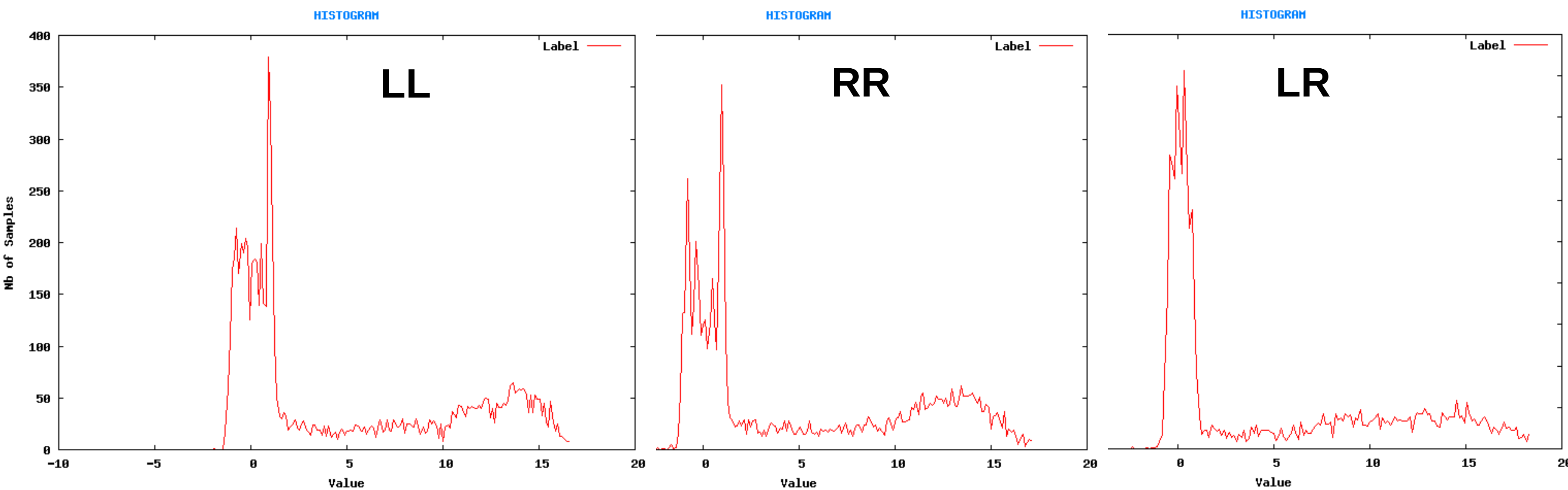
irena.hajnsek@dlr.de

Phase Center Heights





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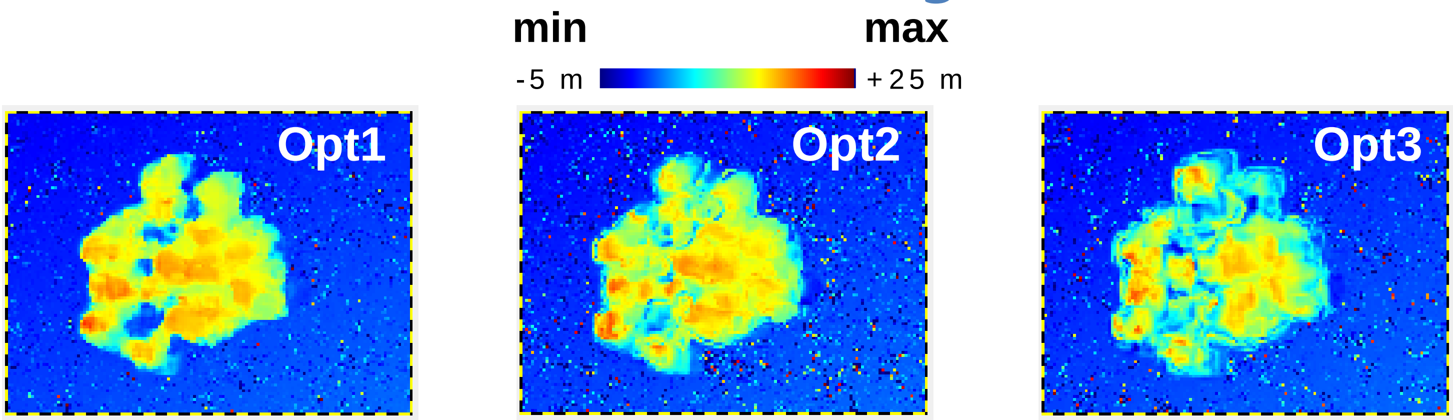
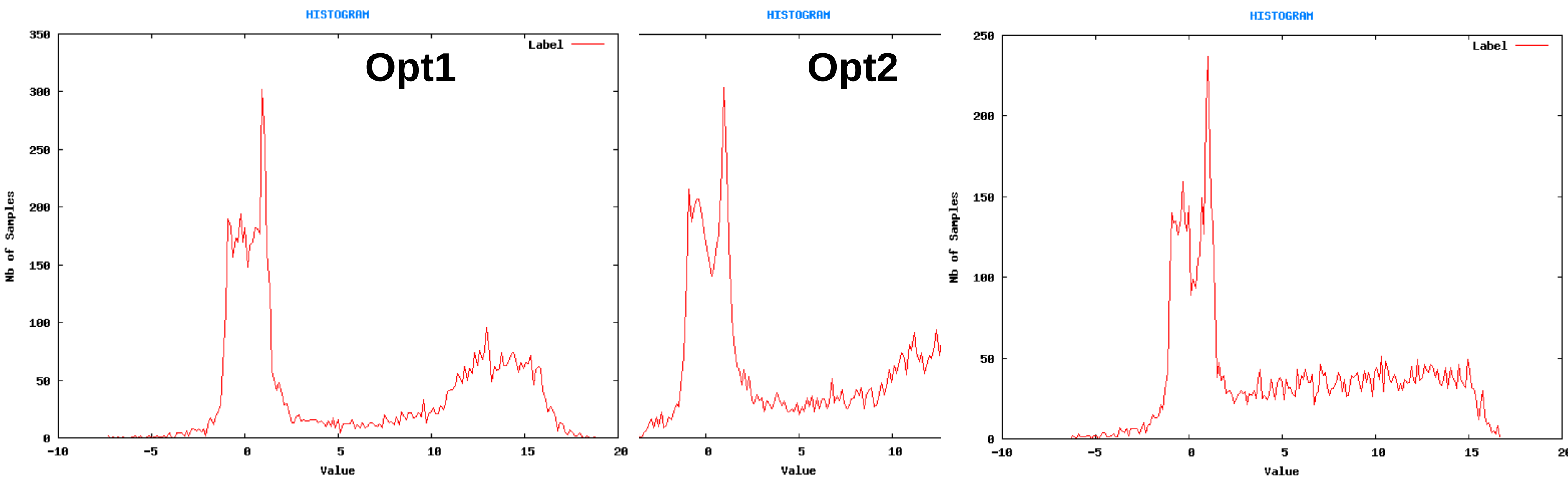
Phase Center Heights

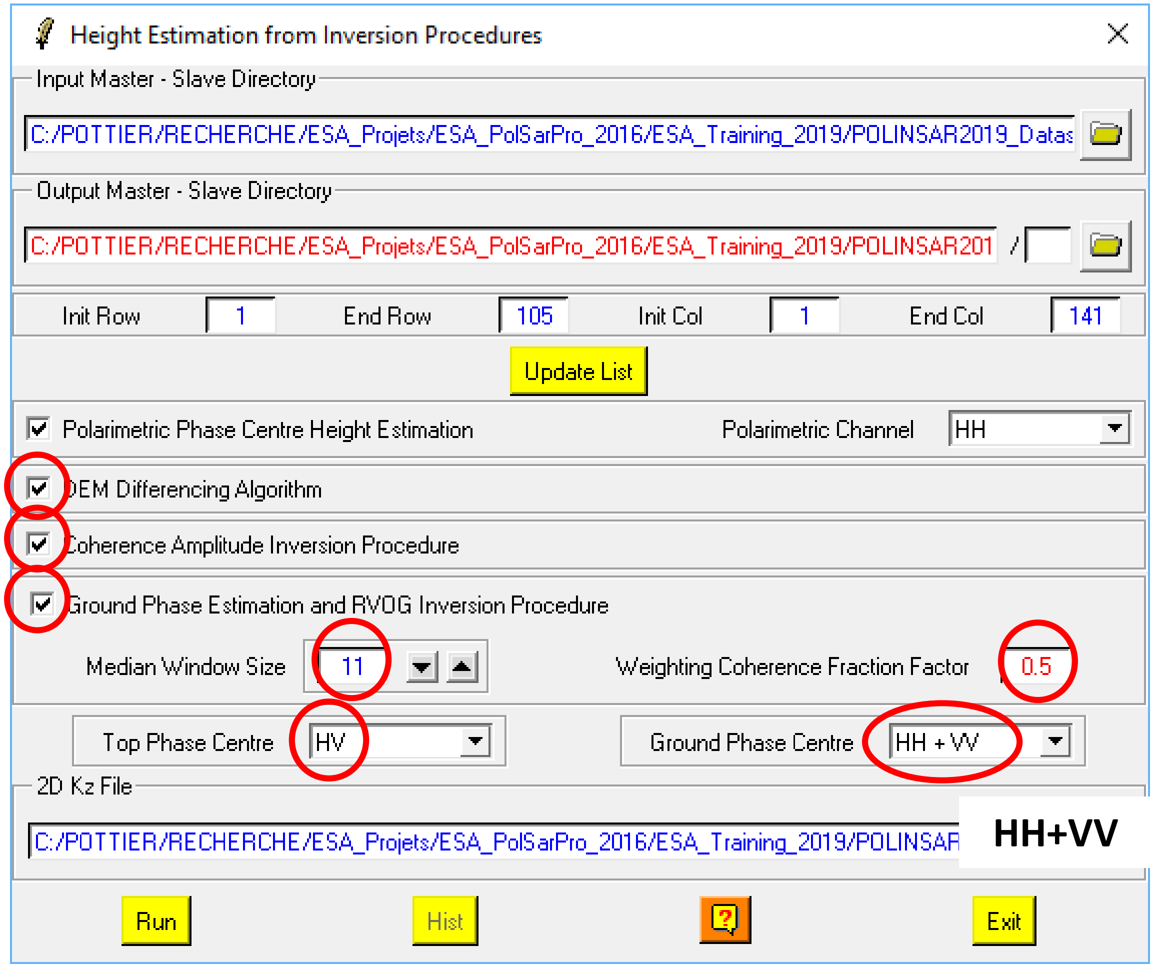




primarily ground contribution **primarily volume contribution**

Do it yourself!

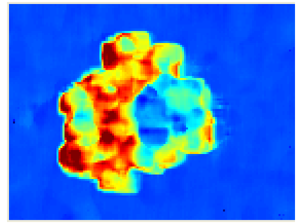
- Please generate the following products
  - Compare the different inversion models in terms of height inversion



Height Inversion using different Methods

- RVoG Inversion

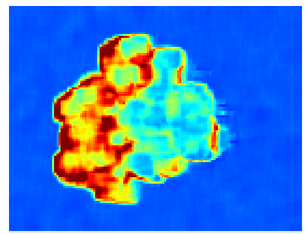
min -5 m — **max** +25 m



↗ 2-Layer inversion model (standard): Parameter space: groung/volume ratio, underlying topography, height, extinction

- Coherence Height

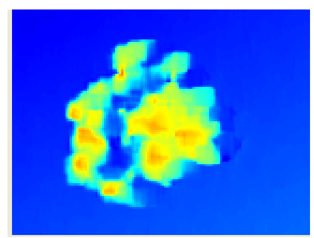
min -5 m — **max** +25 m



↗ Amplitude inversion, assumption only volume scattering is present, procedure uses coherence to RVoG model predictions (0 s) inversion according to a sinc funtion

- Phase Center Heights (HH)

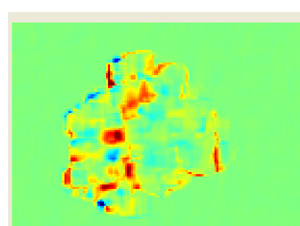
min -5 m — **max** +25 m



↗ Based on the inversion of the scattering phase centers – simple conversion into height

- DEM Difference Heights

min -10 m — **max** +10 m



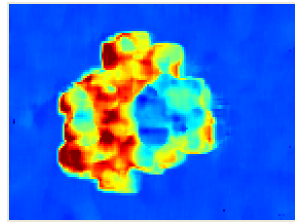
↗ Based on the difference of two polarisation channels (phase location between volume and ground)

Height Inversion using different Methods

- RVoG Inversion

min **max**

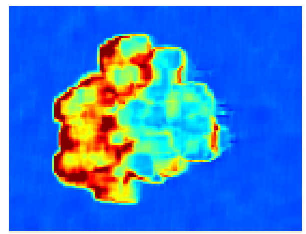
-5 m +25 m

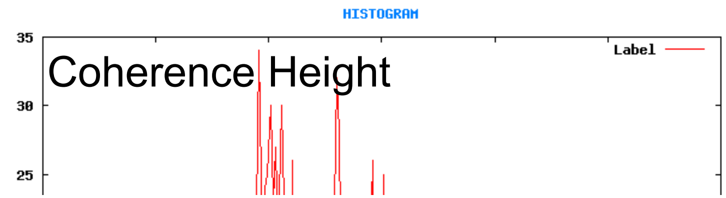


- Coherence Height

min **max**

-5 m +25 m

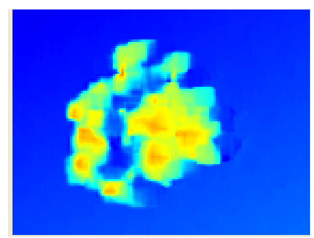


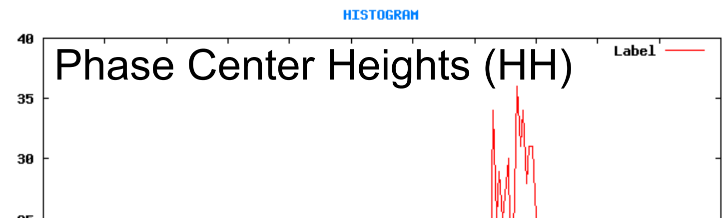


- Phase Center Heights (HH)

min **max**

-5 m +25 m

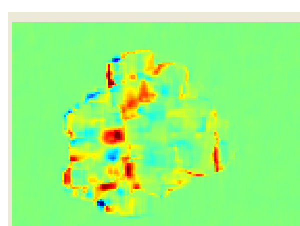


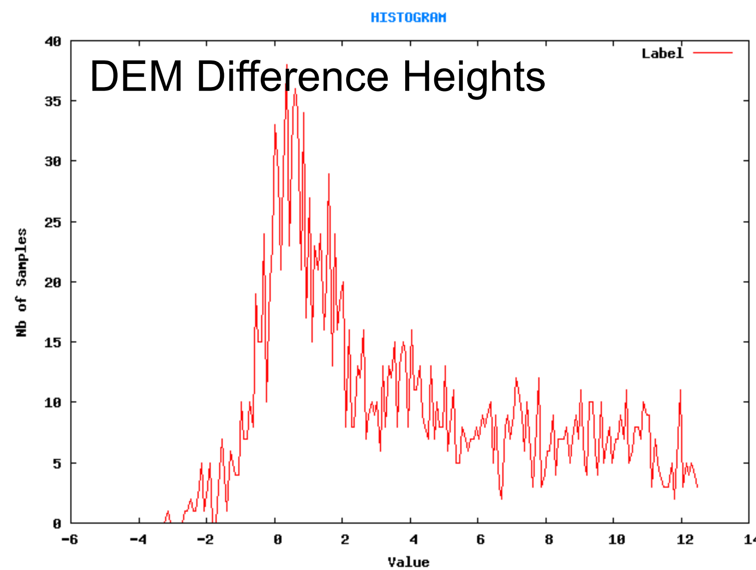


- DEM Difference Heights

min **max**

-10 m +10 m





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Thanks for your participation !

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irena.hajnsek@dlr.de