Pol-InSAR Exercises with PolSARpro – Biomass Edition v1.0.0

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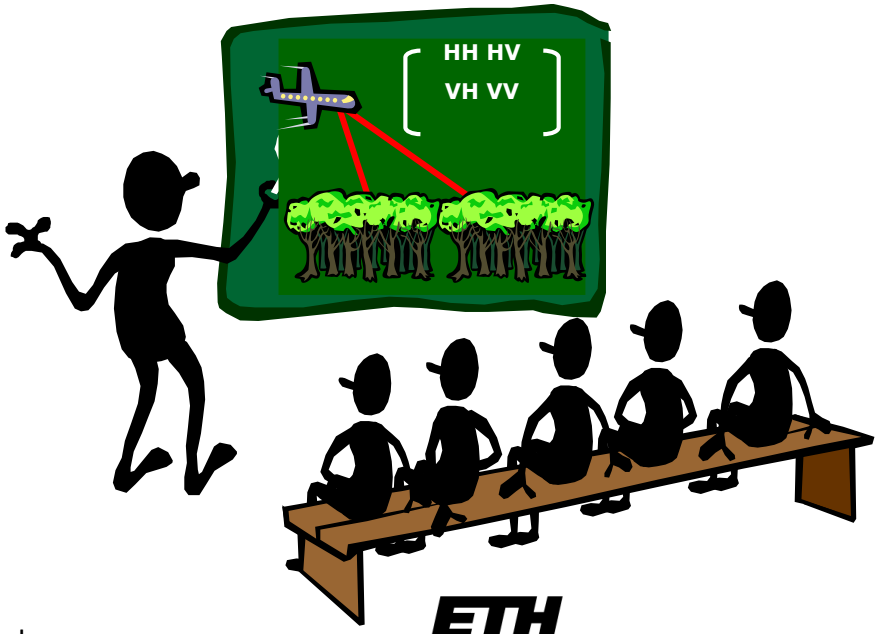
Outline – Polarimetric SAR Interferometry

- 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



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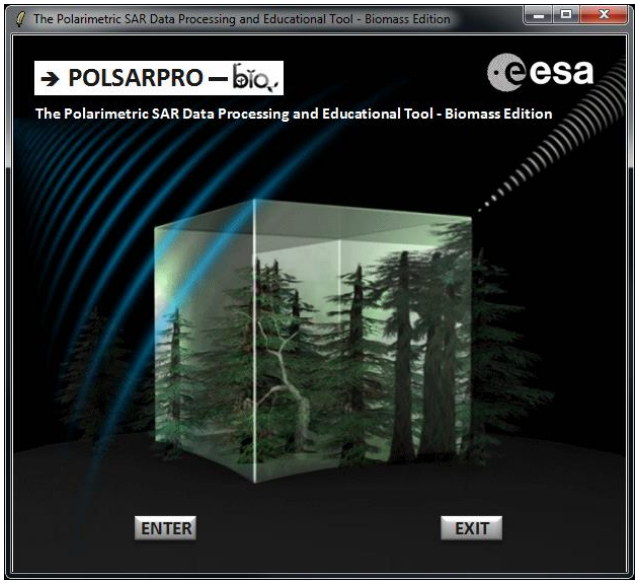
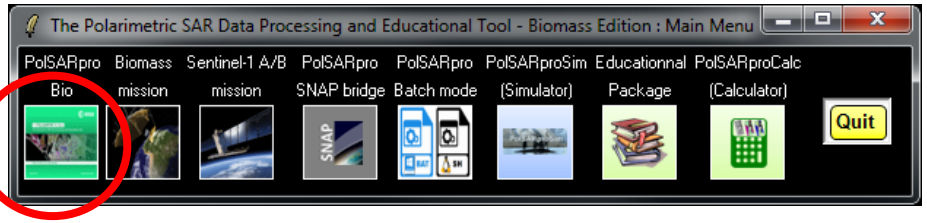
PolSARpro-Biomass Edition V1.0.0 (January 2019)





PolSARpro - Bio SOFTWARE

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

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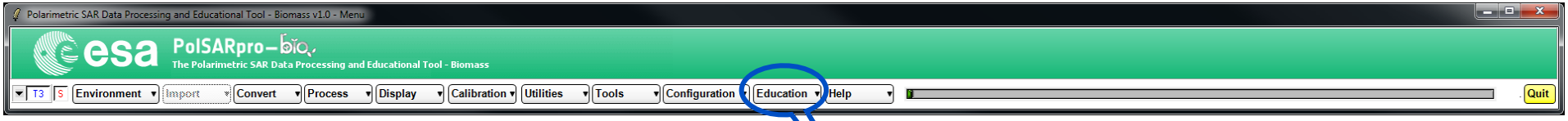

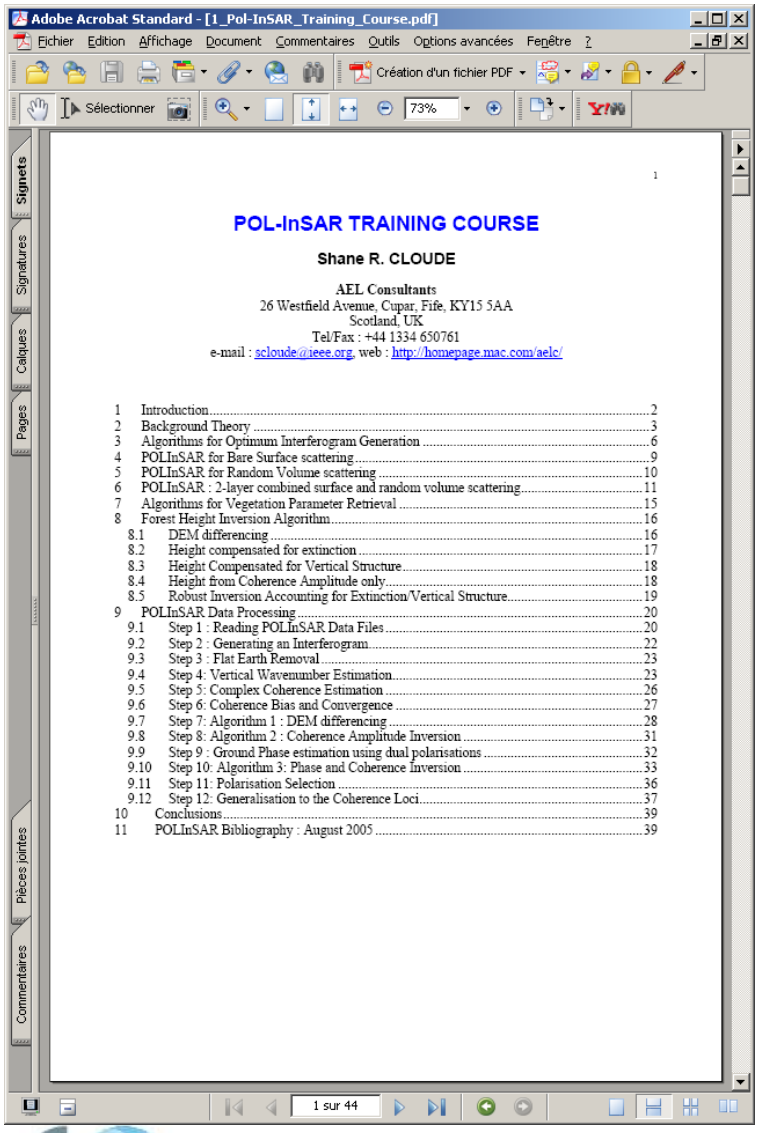

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POL-InSAR TRAINING COURSE

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AEL Consultants
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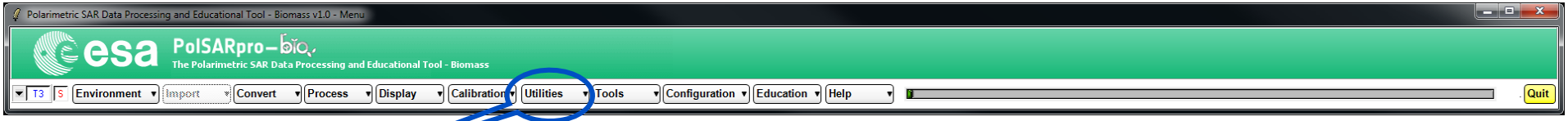
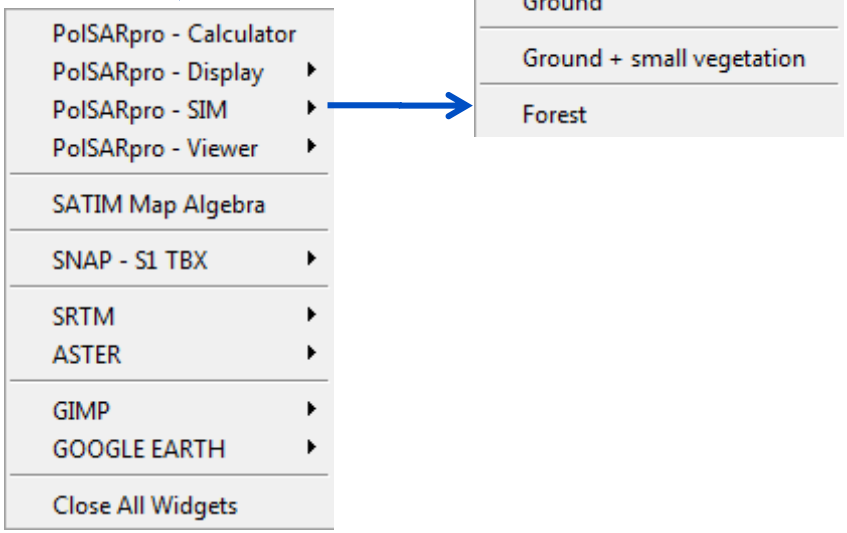
Scotland, UK
Tel/Fax : +44 1334 650761
e-mail : scloude@ieee.org, web : http://homepage.mac.com/aelc/

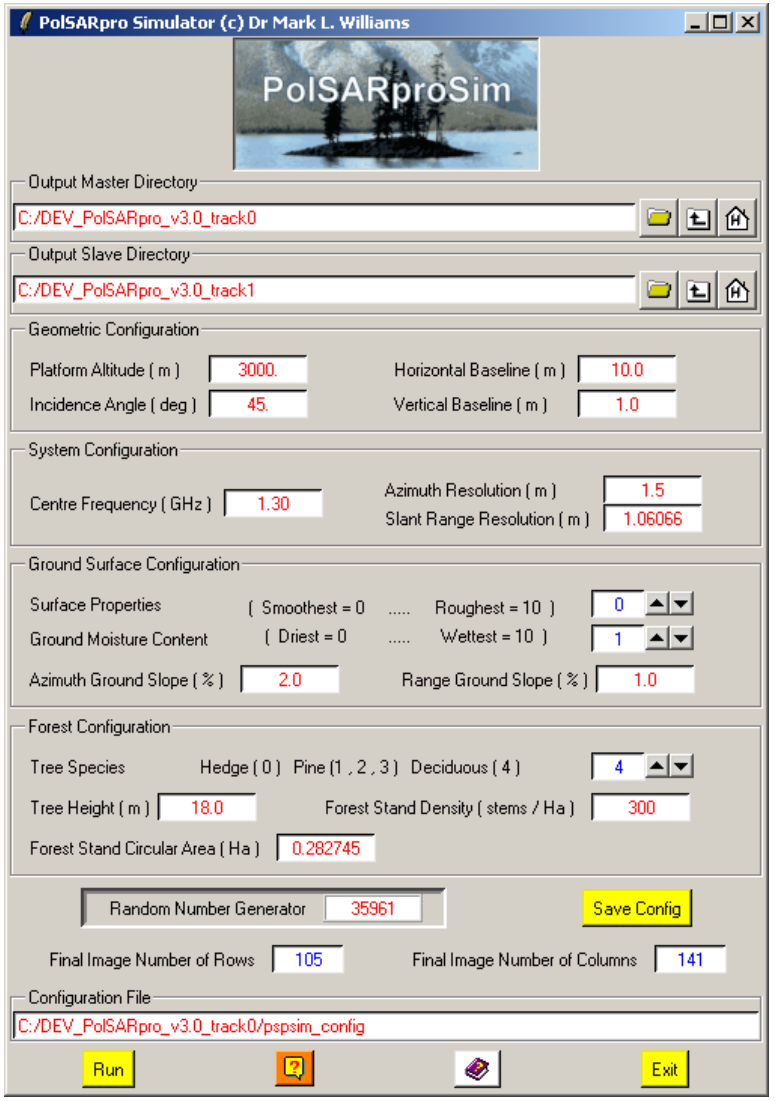
PolSARap Tutorial (C. Lopez - E. Pottier) ▸
PolSARap Showcases
Lectures Notes ▸

Recent Advances (W.M. Boerner)
Basic Concepts (W.M. Boerner)
Advanced Concepts (E. Pottier, J.S. Lee, L. Ferro-Famil)
Polarimetric SAR Interferometry (S.R. Cloude, K. Papathanassiou) ▸
Surface Parameter Retrieval (I. Hajnsek, K. Papathanassiou) ▸

Single vs multi polarization interferometry
Pol-InSAR (Training Course)
Polarization Coherence Tomography (Training Course)







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

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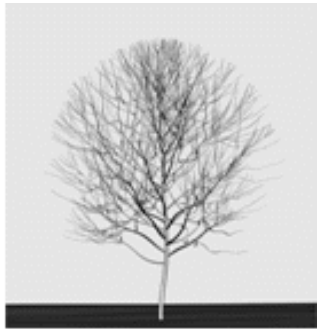
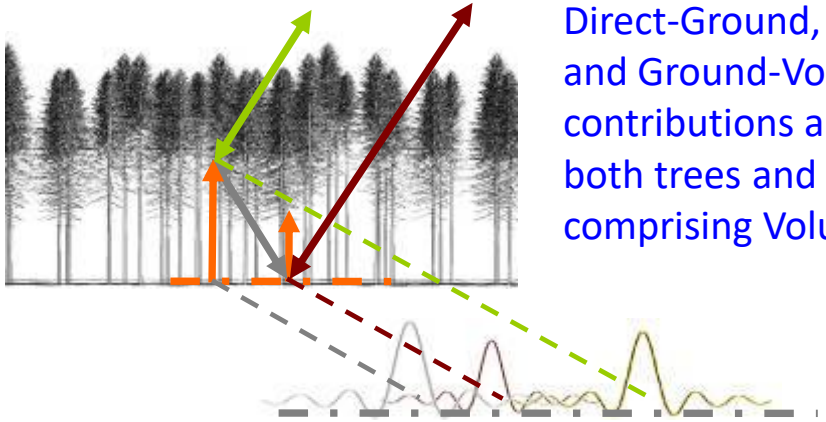
PolSARpro – SIM

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

PINE

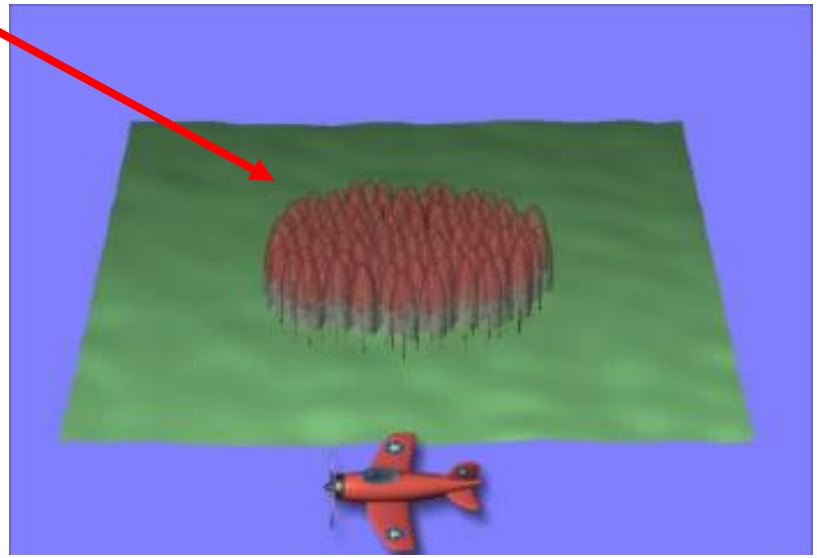


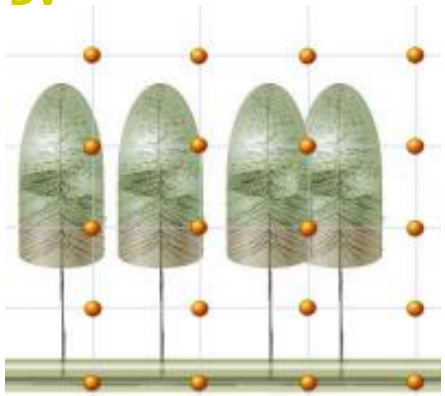
DECIDUOUS



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

RANDOM HEDGE





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

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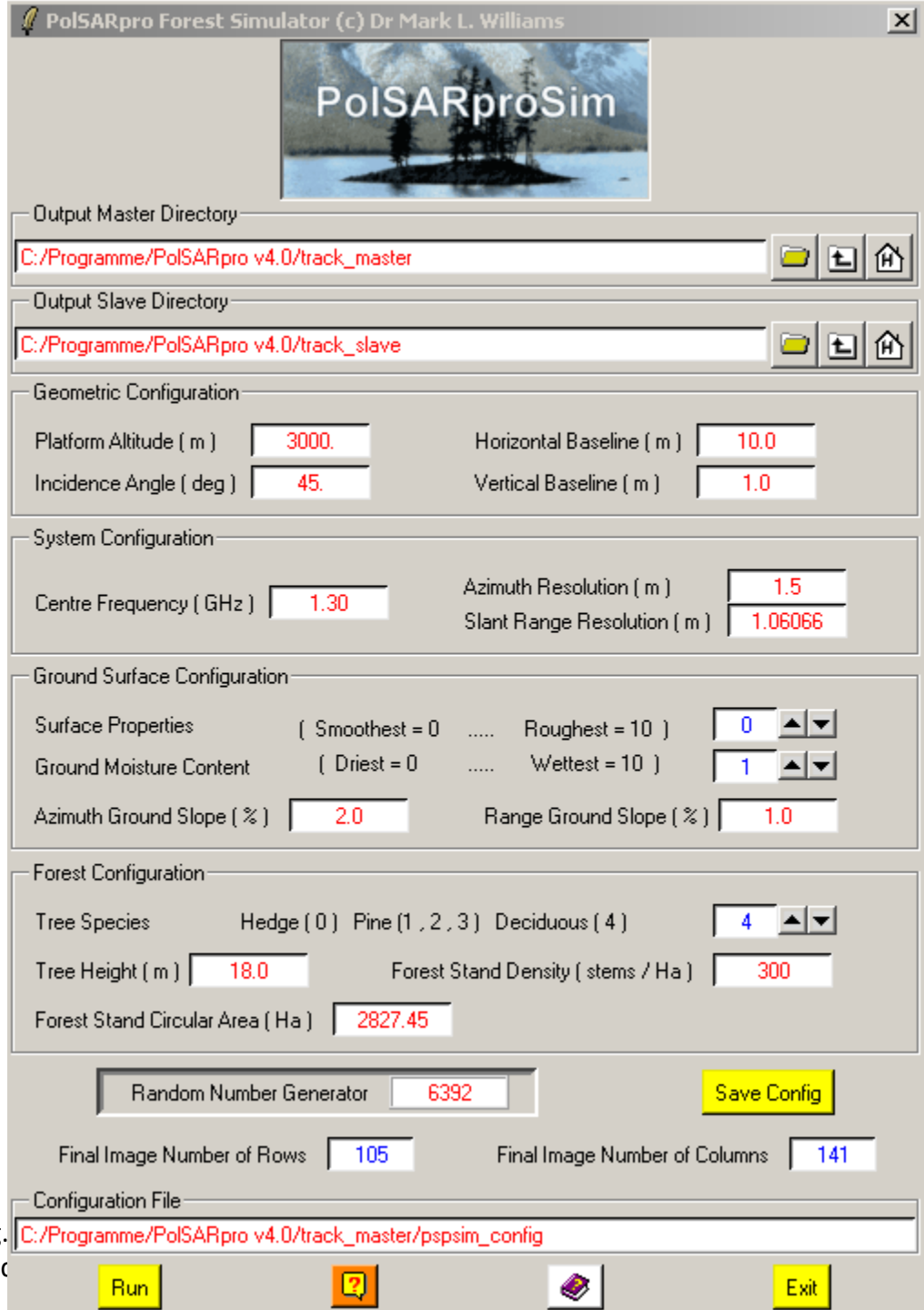
Simulation of a Deciduous Forest Stand

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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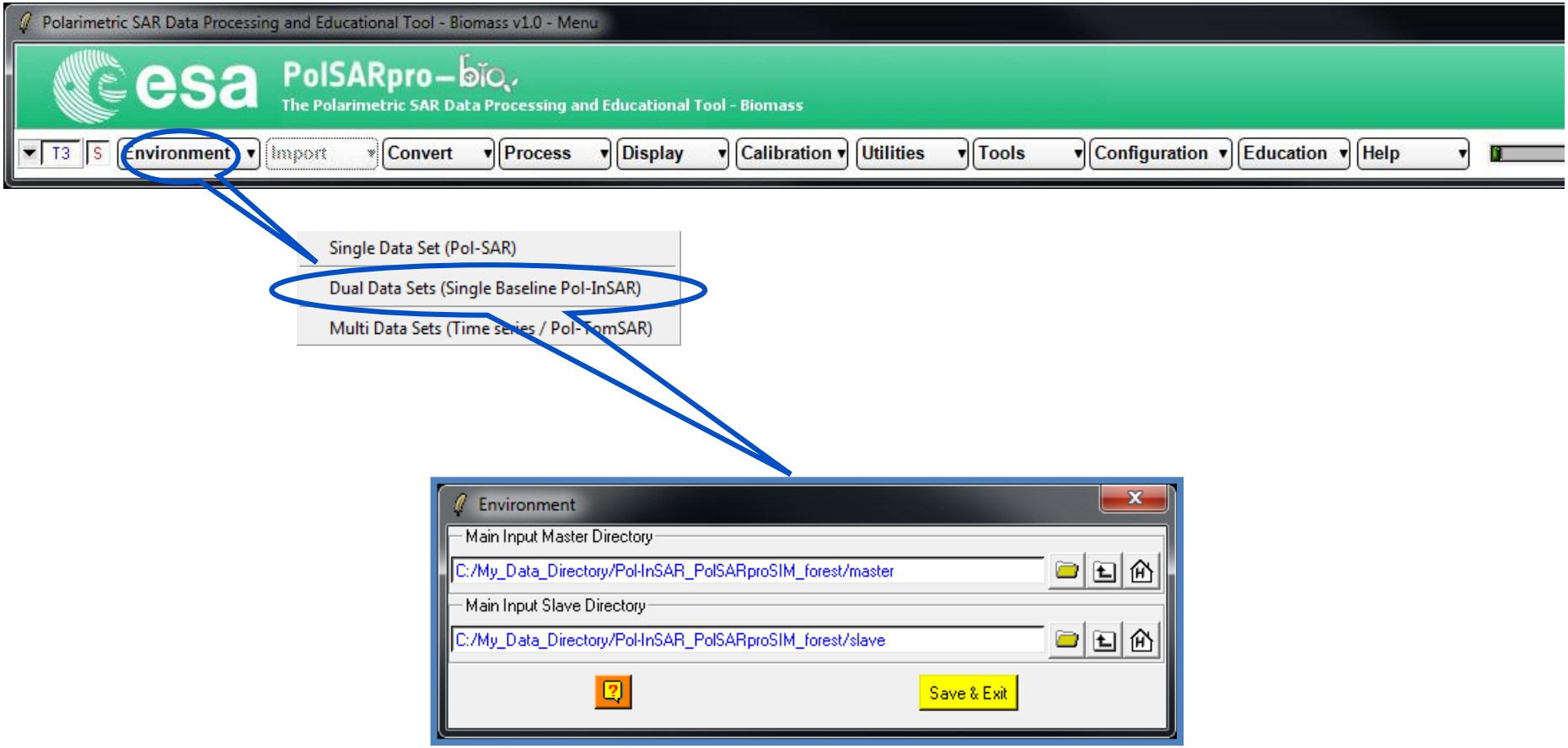
Process the Data Interferometricaly



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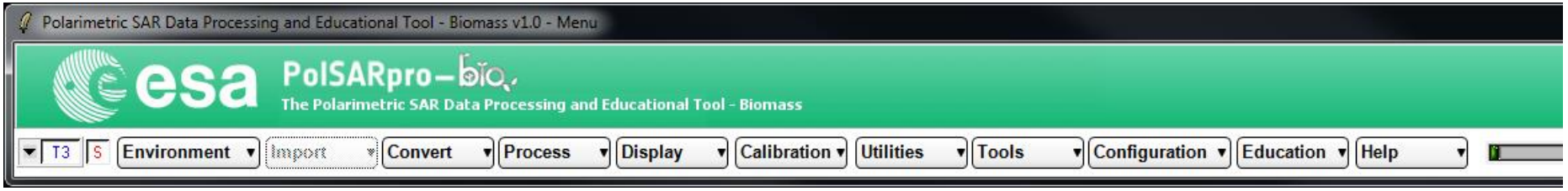
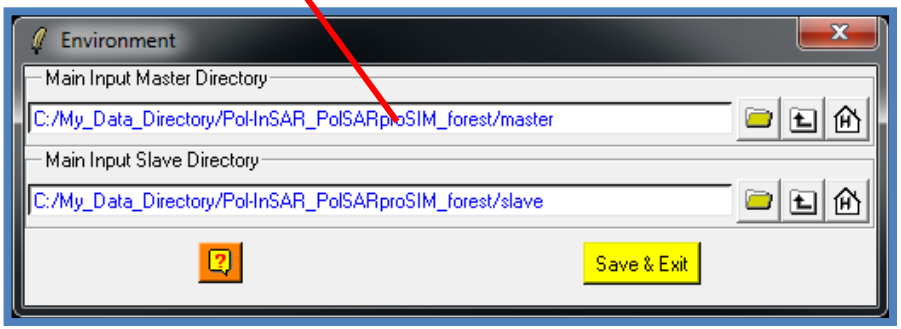


Configure Data Main Directories location



Input Master Directory: C:/… /Pol-InSAR_datasets/master

Input Slave Directory: C:/… /Pol-InSAR_datasets/slave

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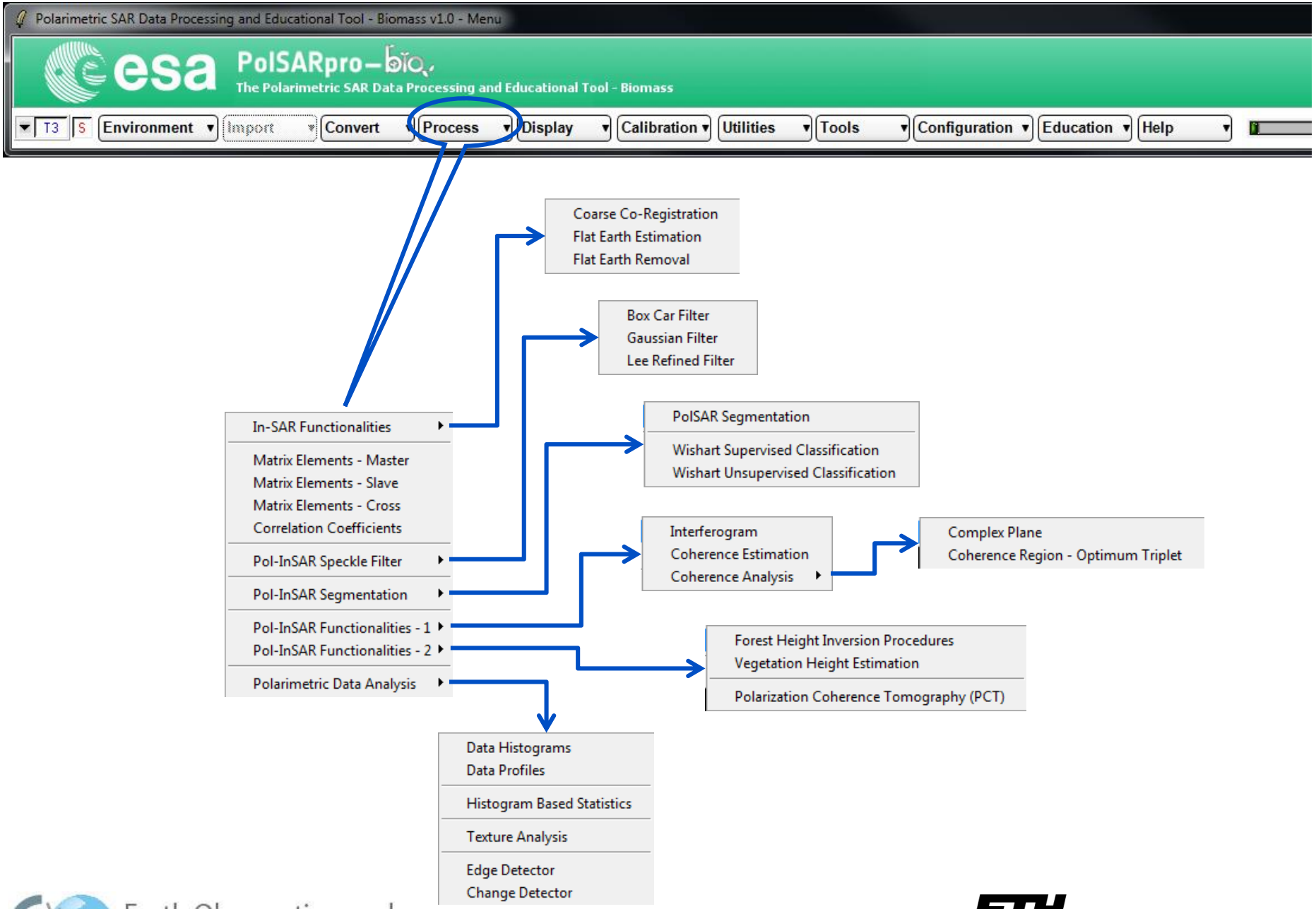

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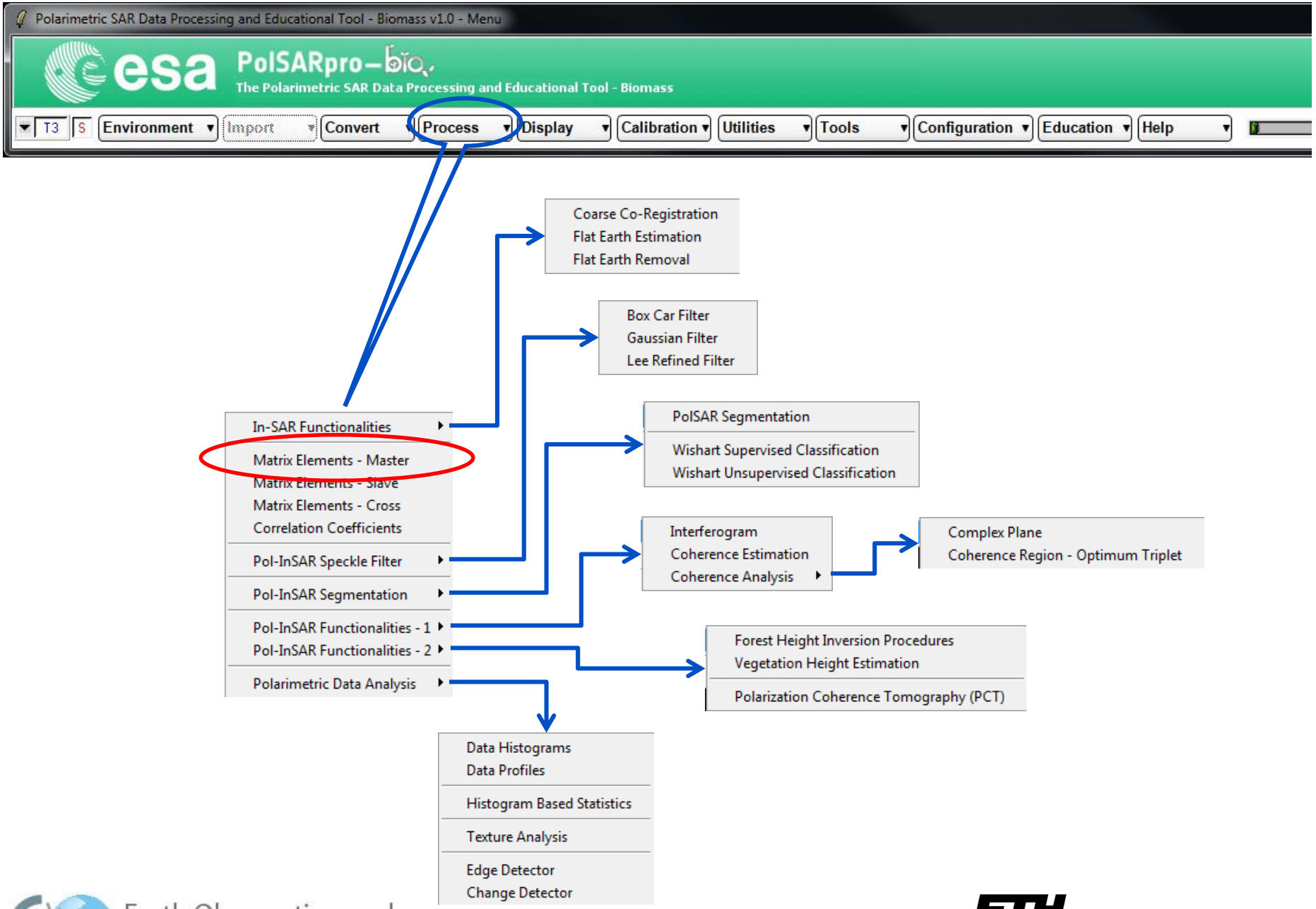

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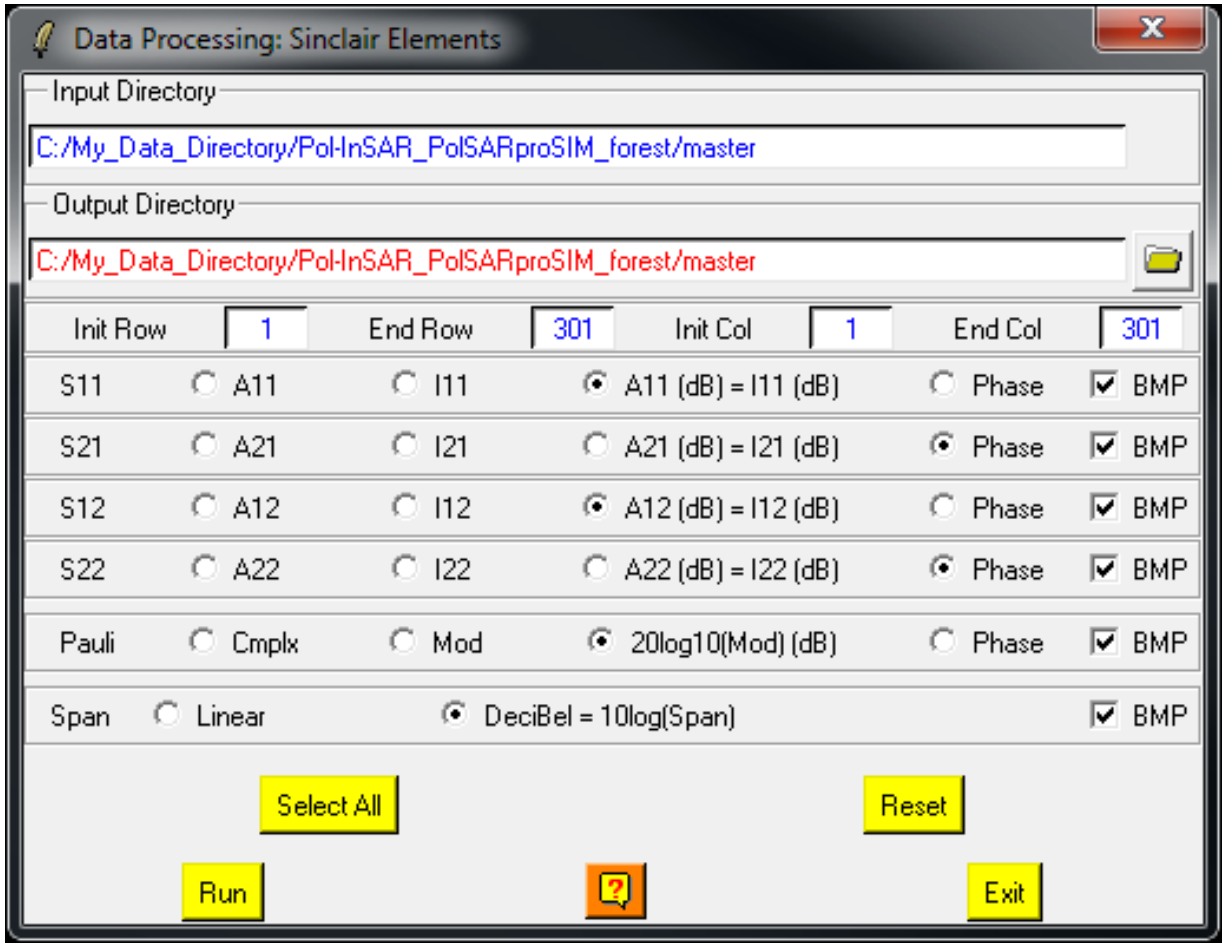
Generate the Scattering Matrix of the Master

- Processes to BMP File



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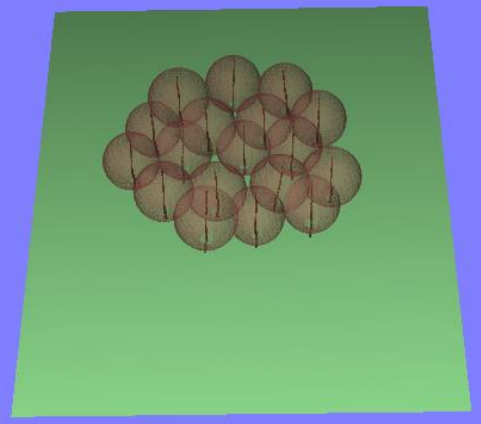
Display Master Files with GIMP

Forest Simulation



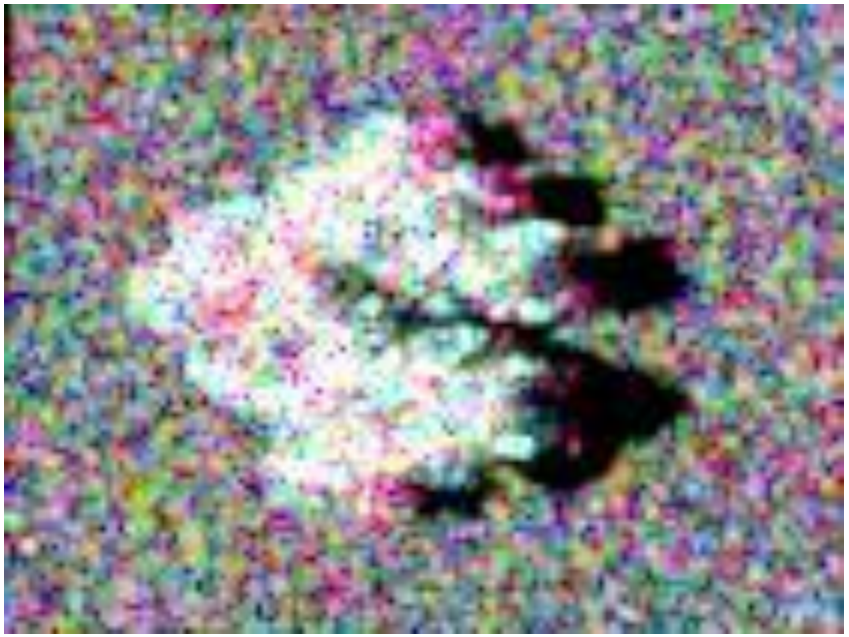
[S11] **[S12]** **Span**





[S21] **[S22]**

RGB



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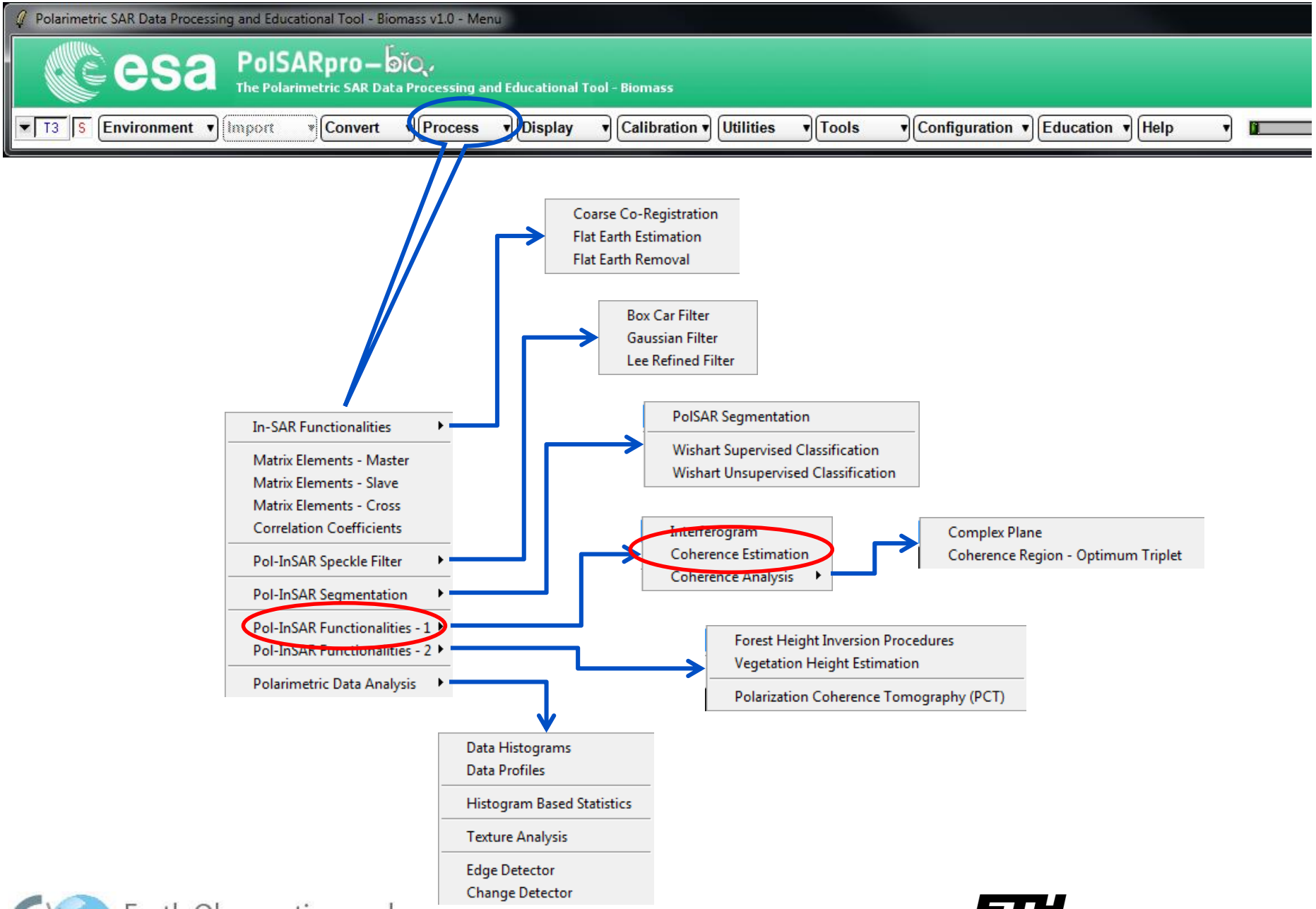

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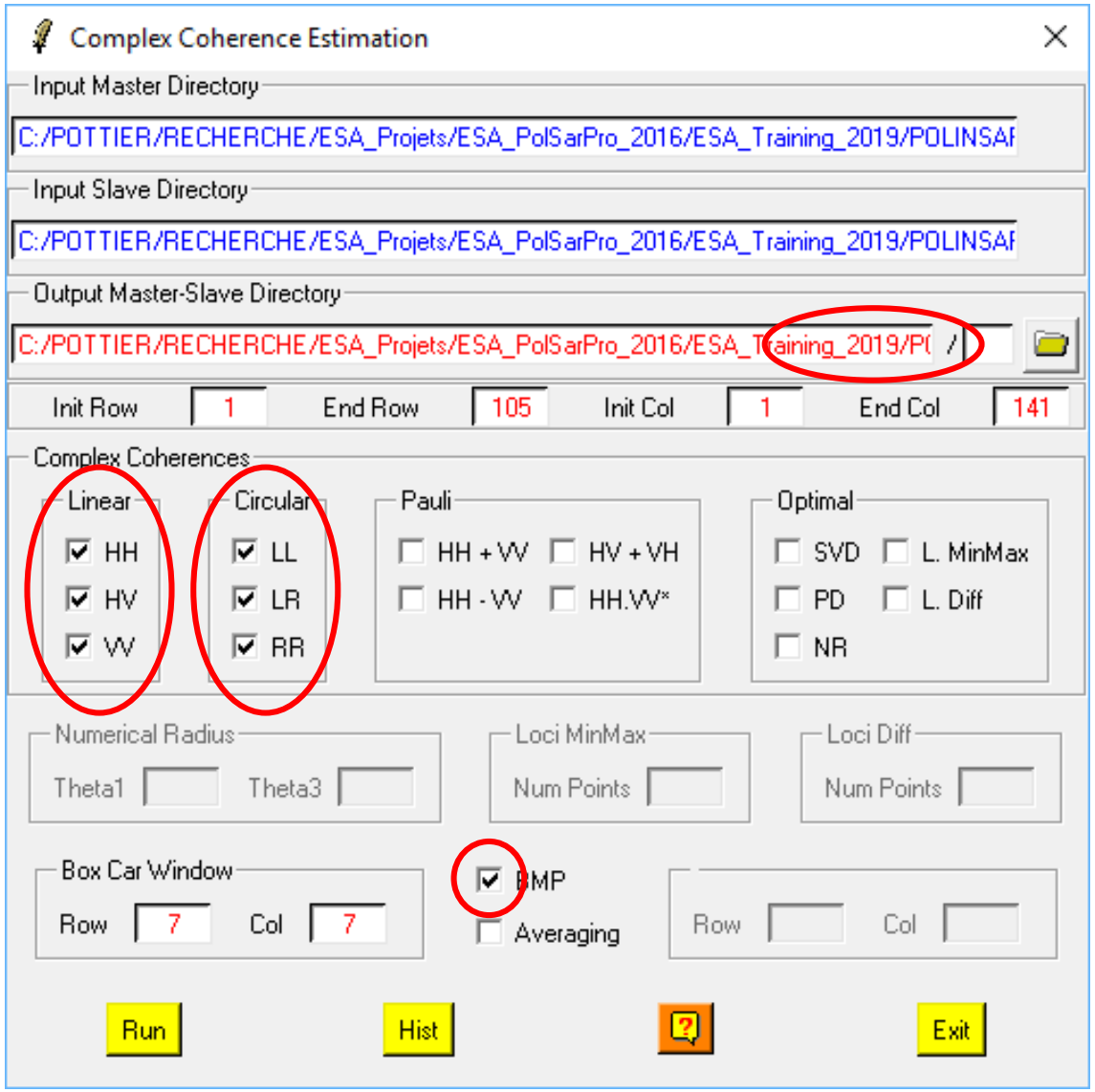
Generation of the Complex Coherence

- Go to Process
  - Coherence Estimation



Note:
The Output Directory is automatically set to:
master_slave

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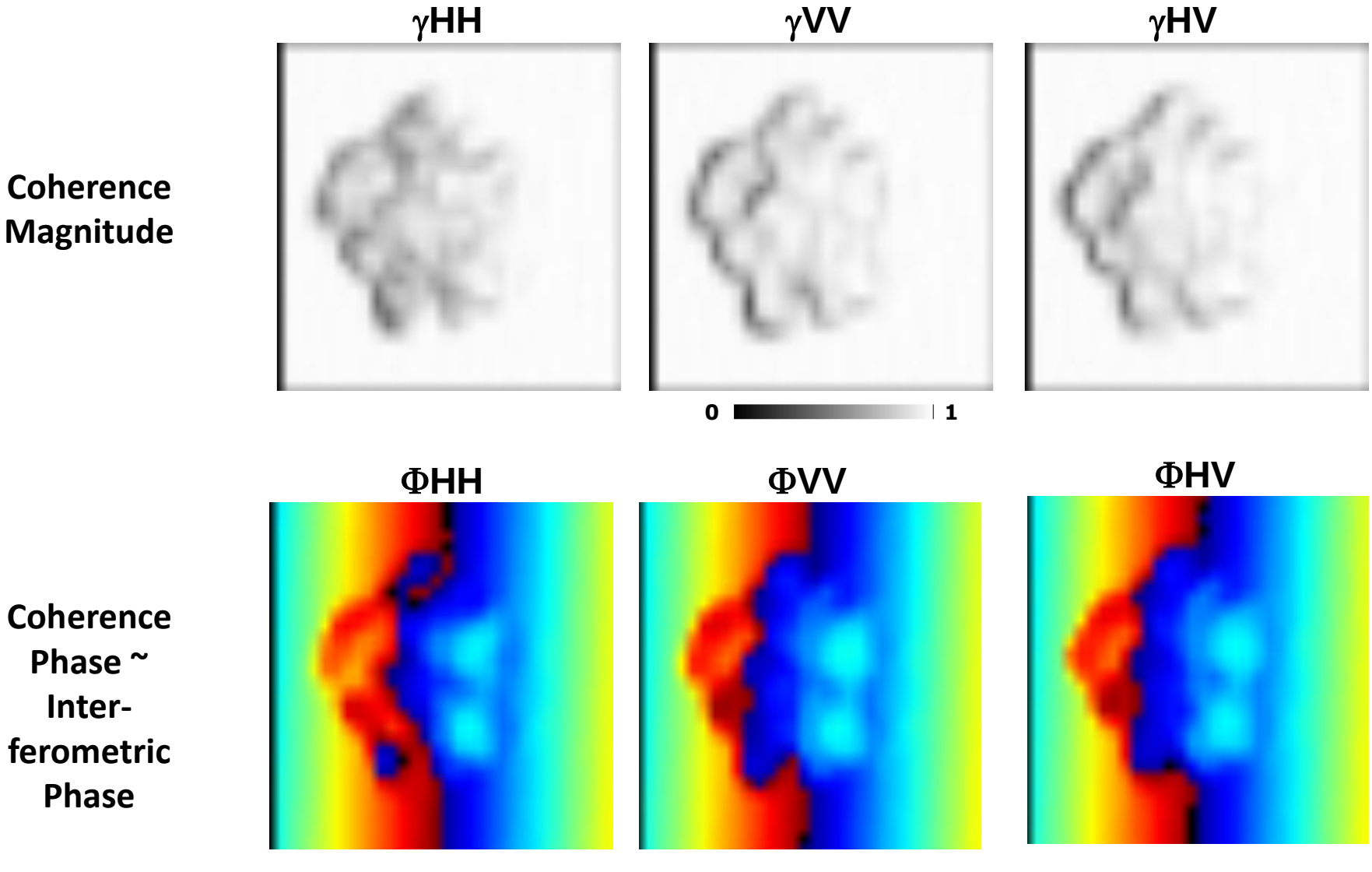
Display Complex Coherences with GIMP



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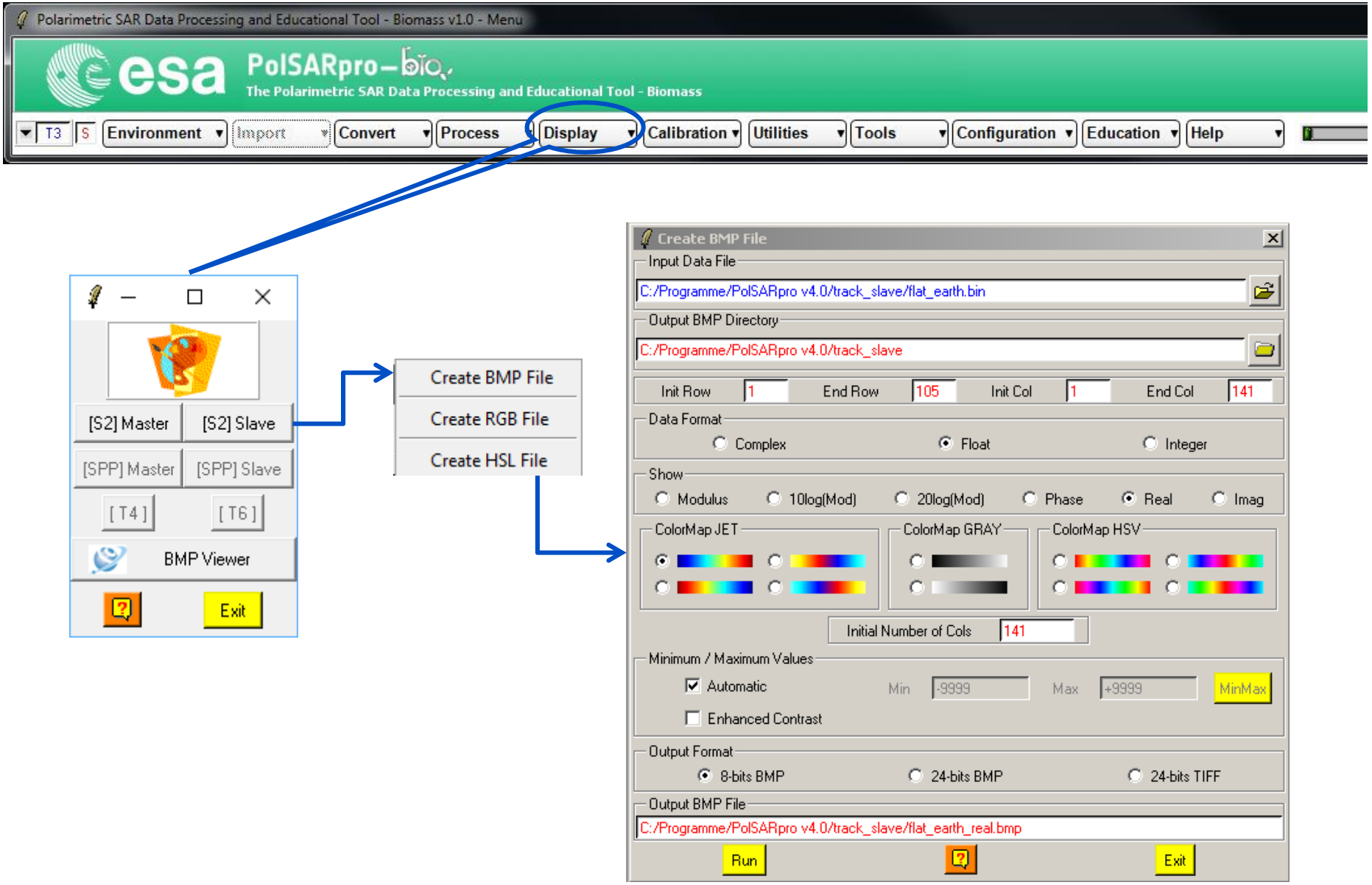

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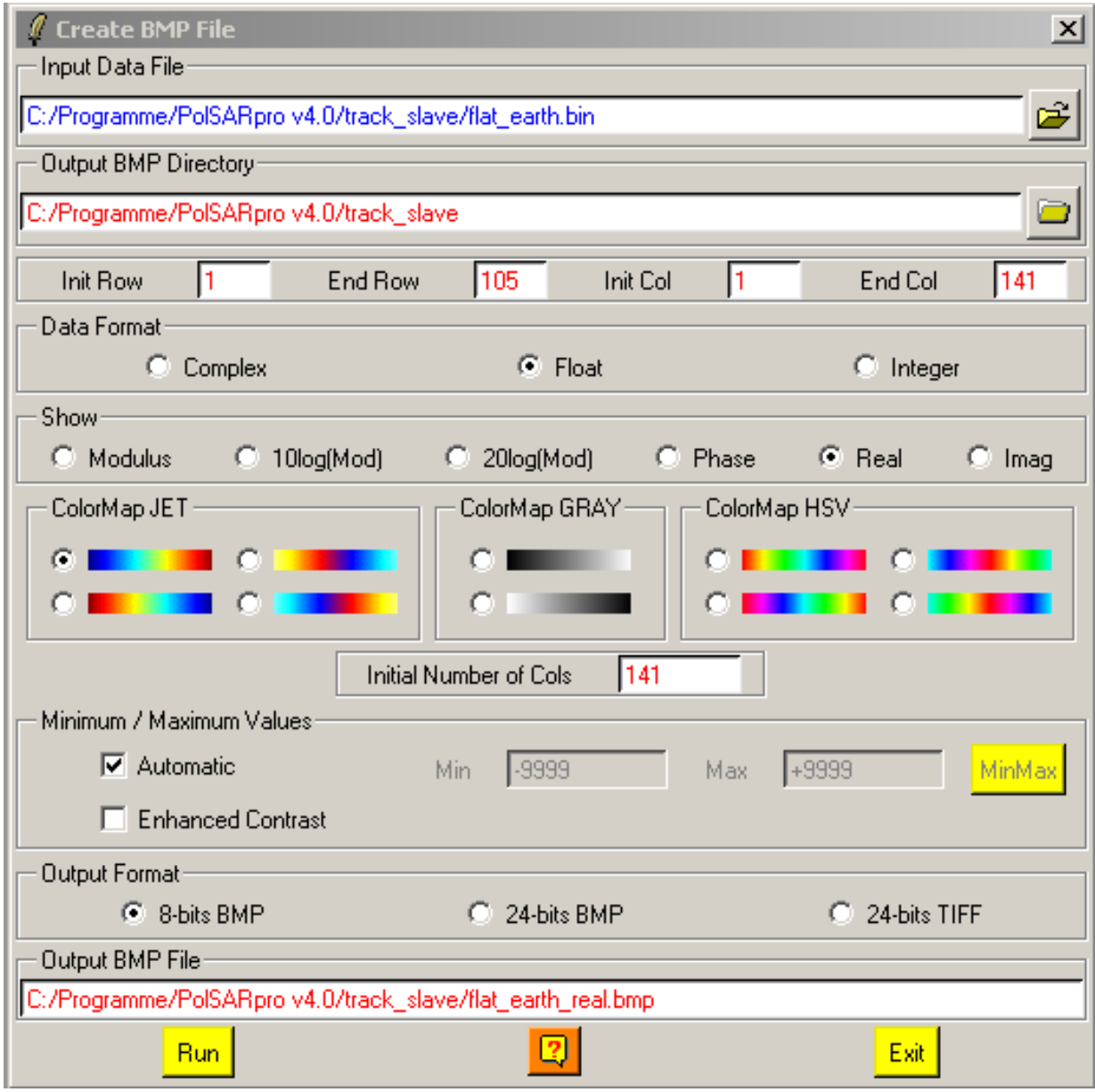
Display Flat Earth

- 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



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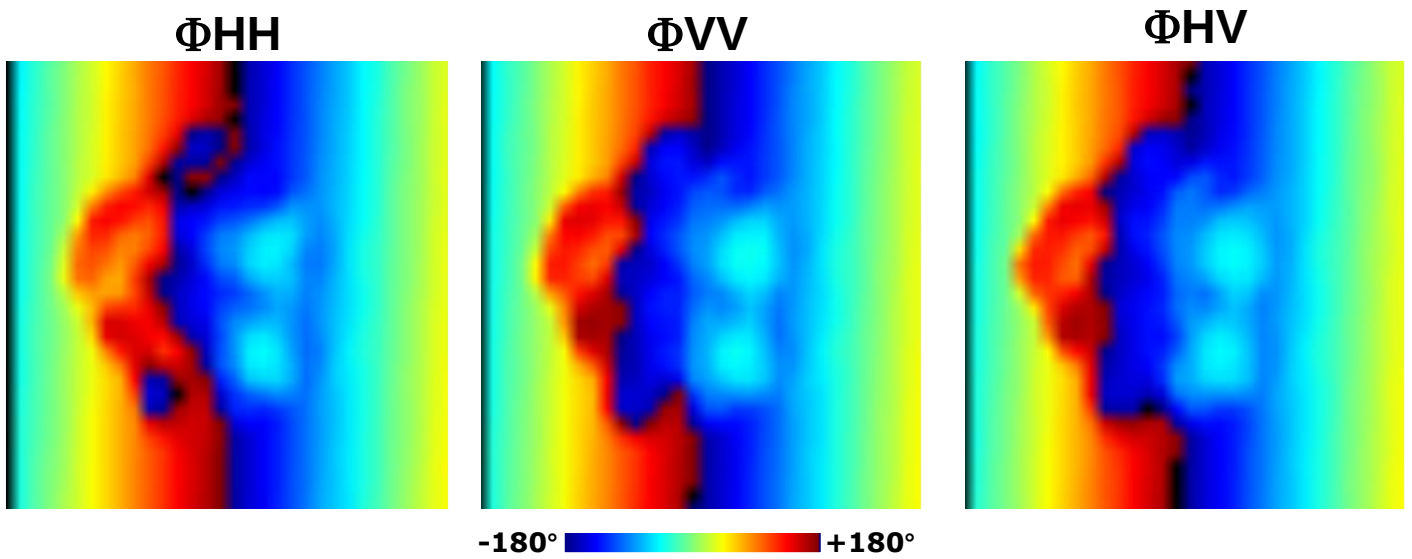
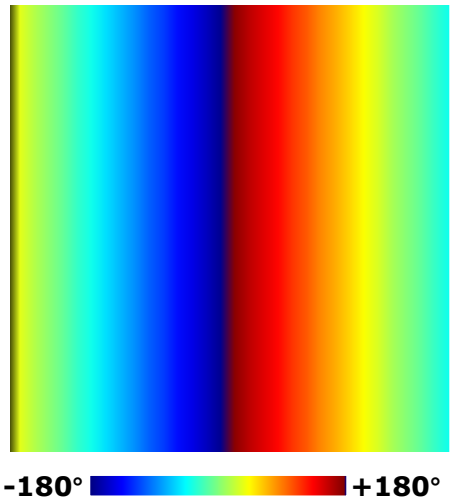
Display Flat Earth Earth & Store as .bmp

Coherence Phase ~ Inter-ferometric Phase



Flat Earth: regular fringe pattern in range



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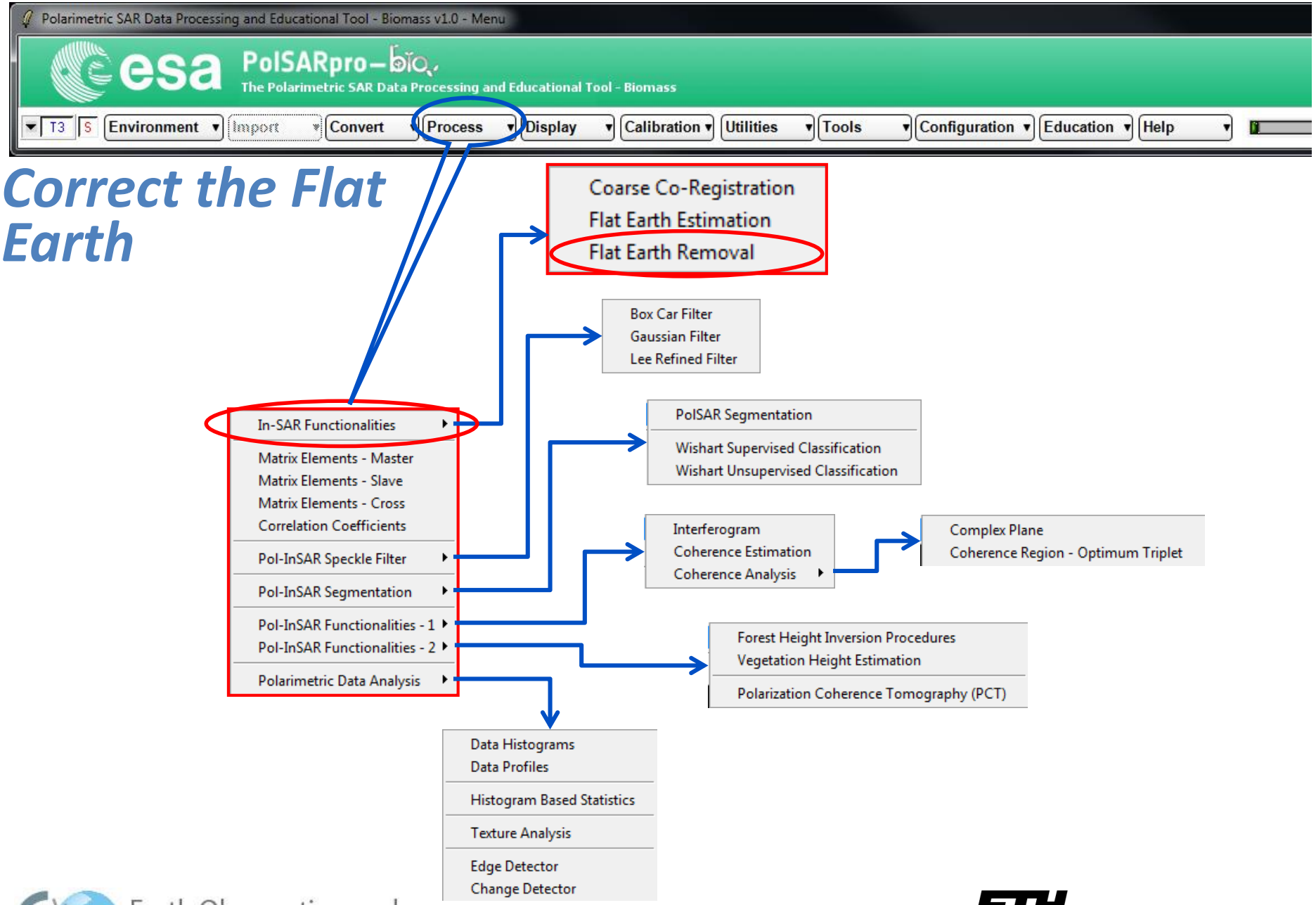
Correct the Flat Earth



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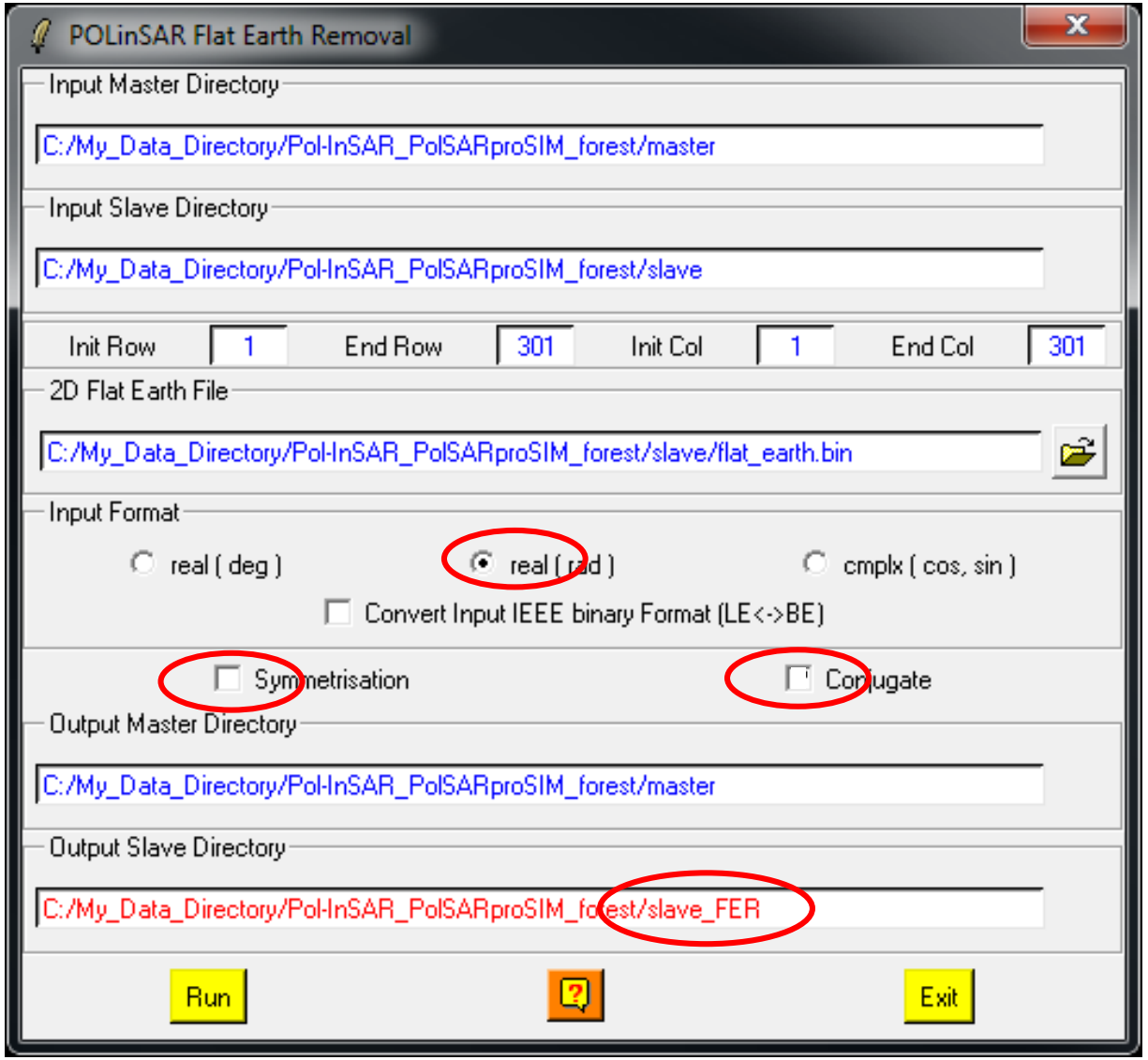
Correct the Flat Earth

- Go to Processes
  - Flat Earth Removal



Note:
The Output Directory is automatically set to:
slave_FER

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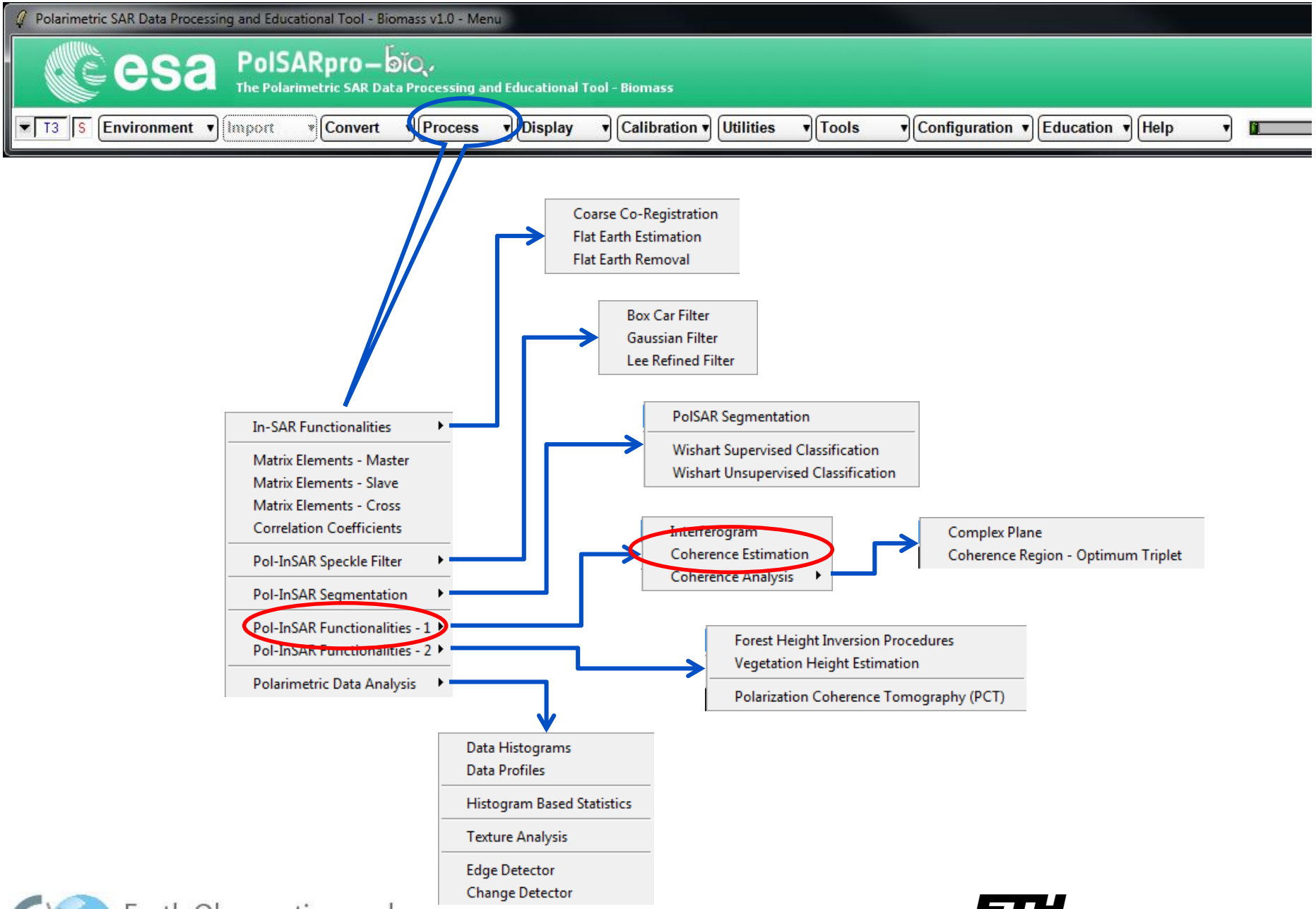

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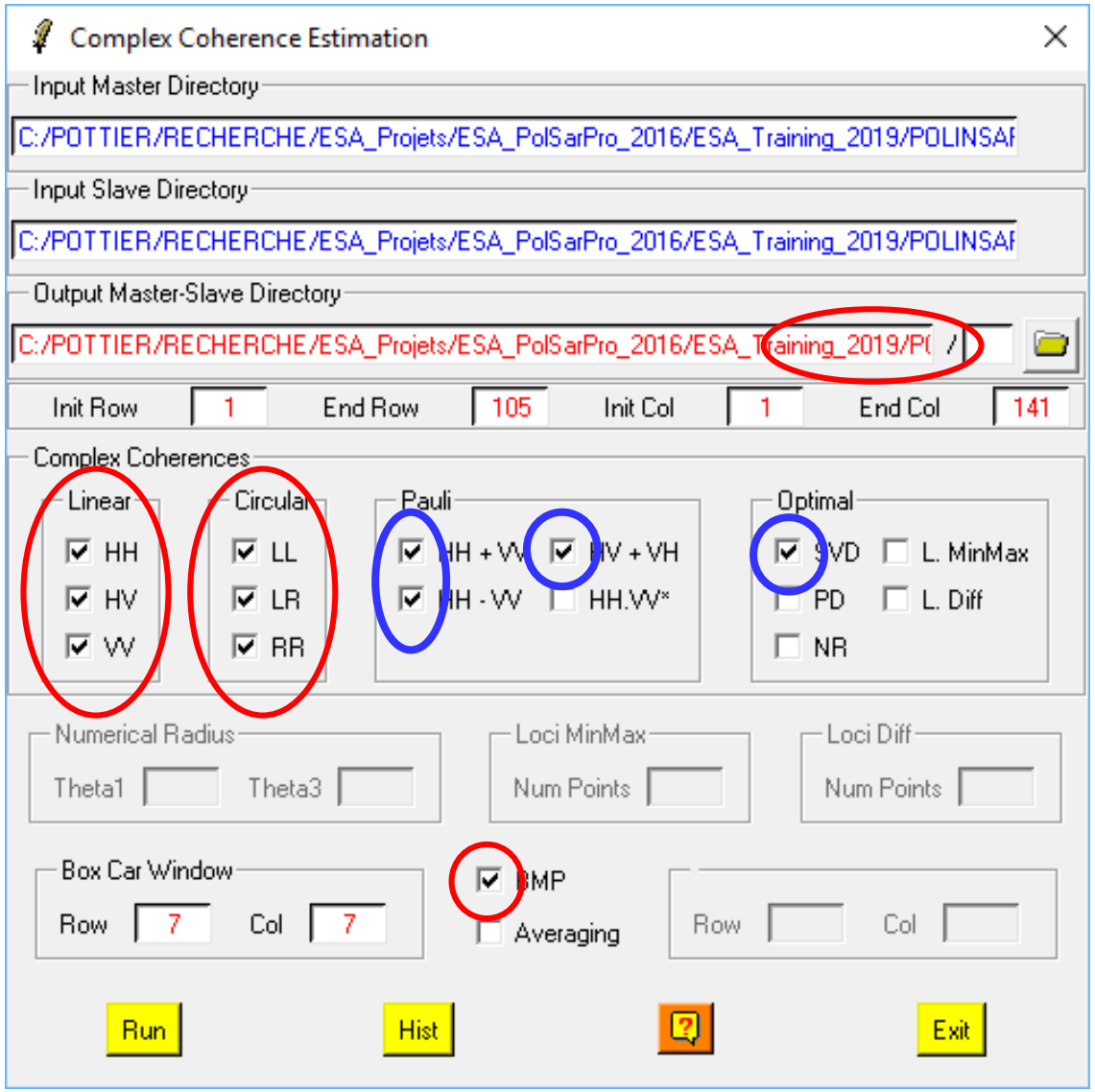
Run again the Coherence Estimation

- Go to Process
  - Coherence Estimation



Note:
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master_slave_FER

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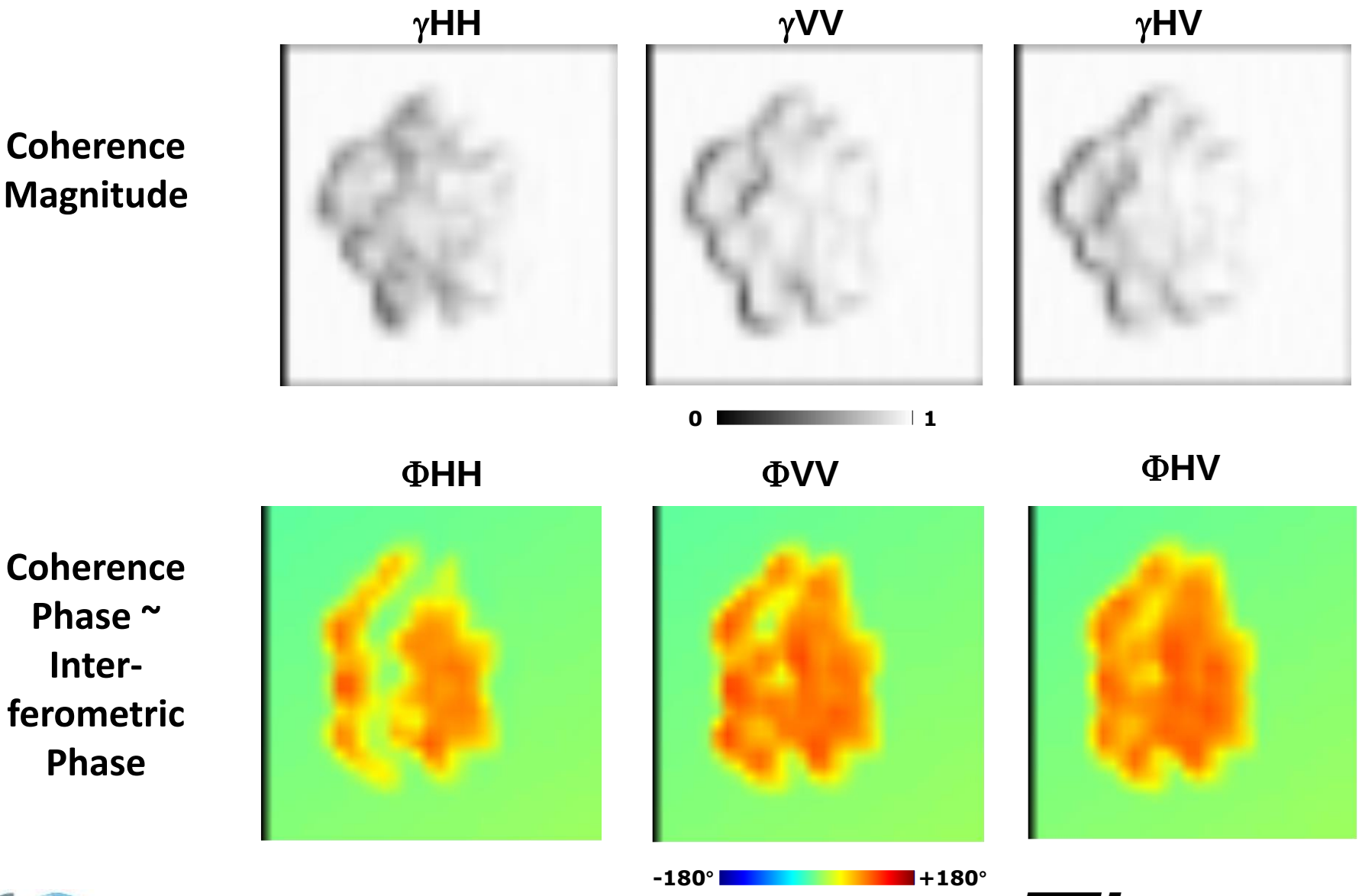
Display Complex Coherences with GIMP – After FE Correction



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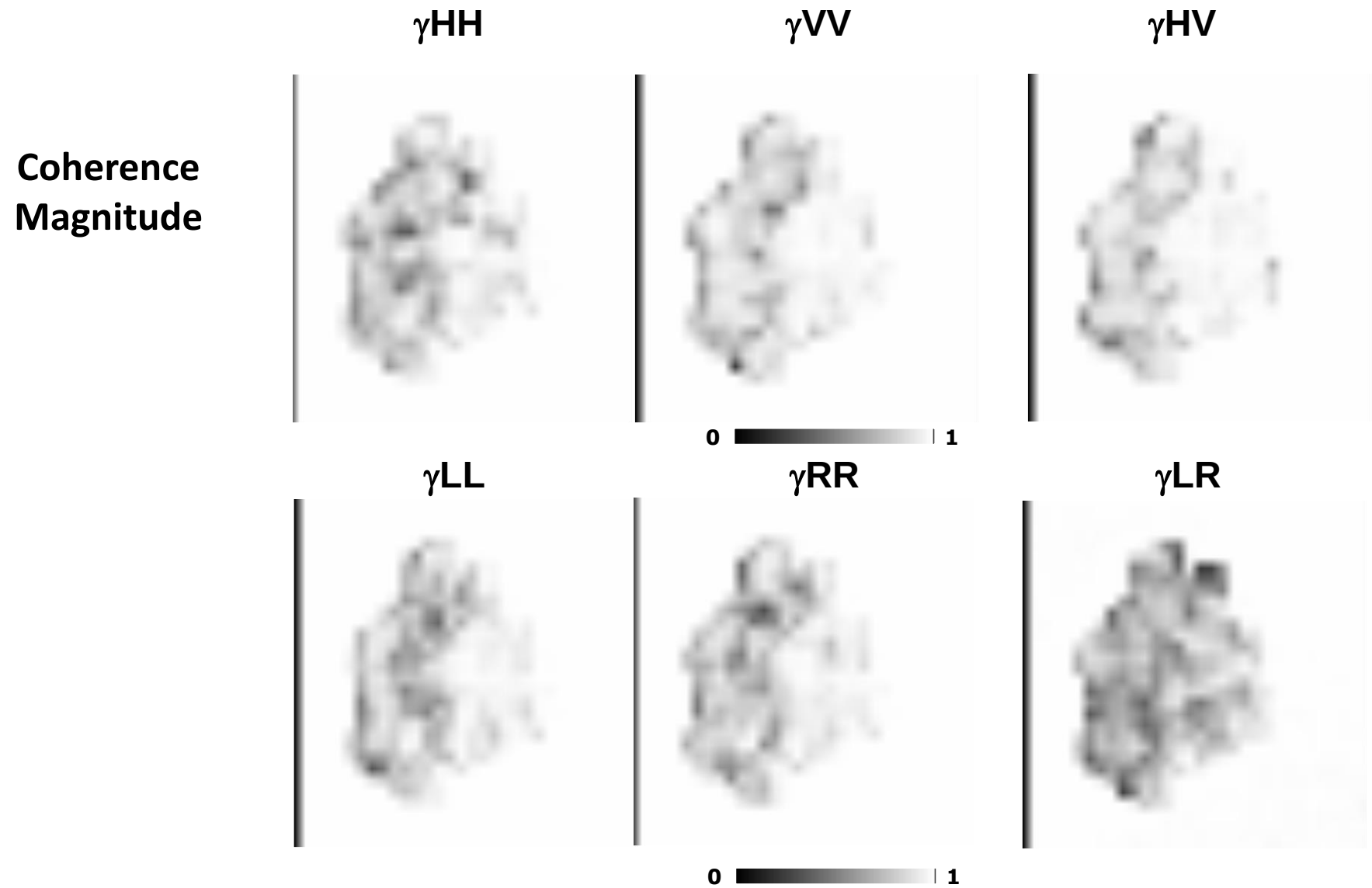

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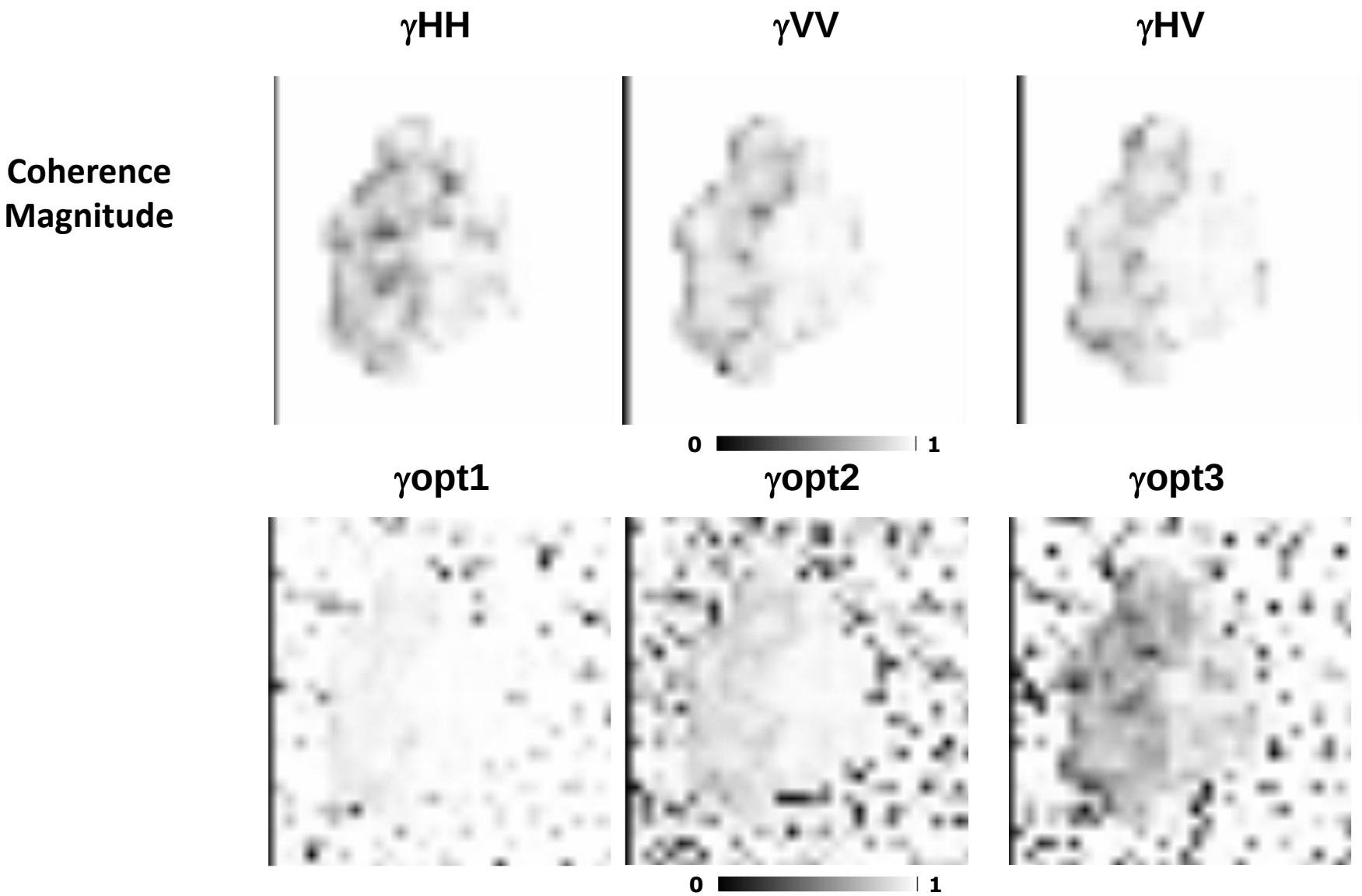

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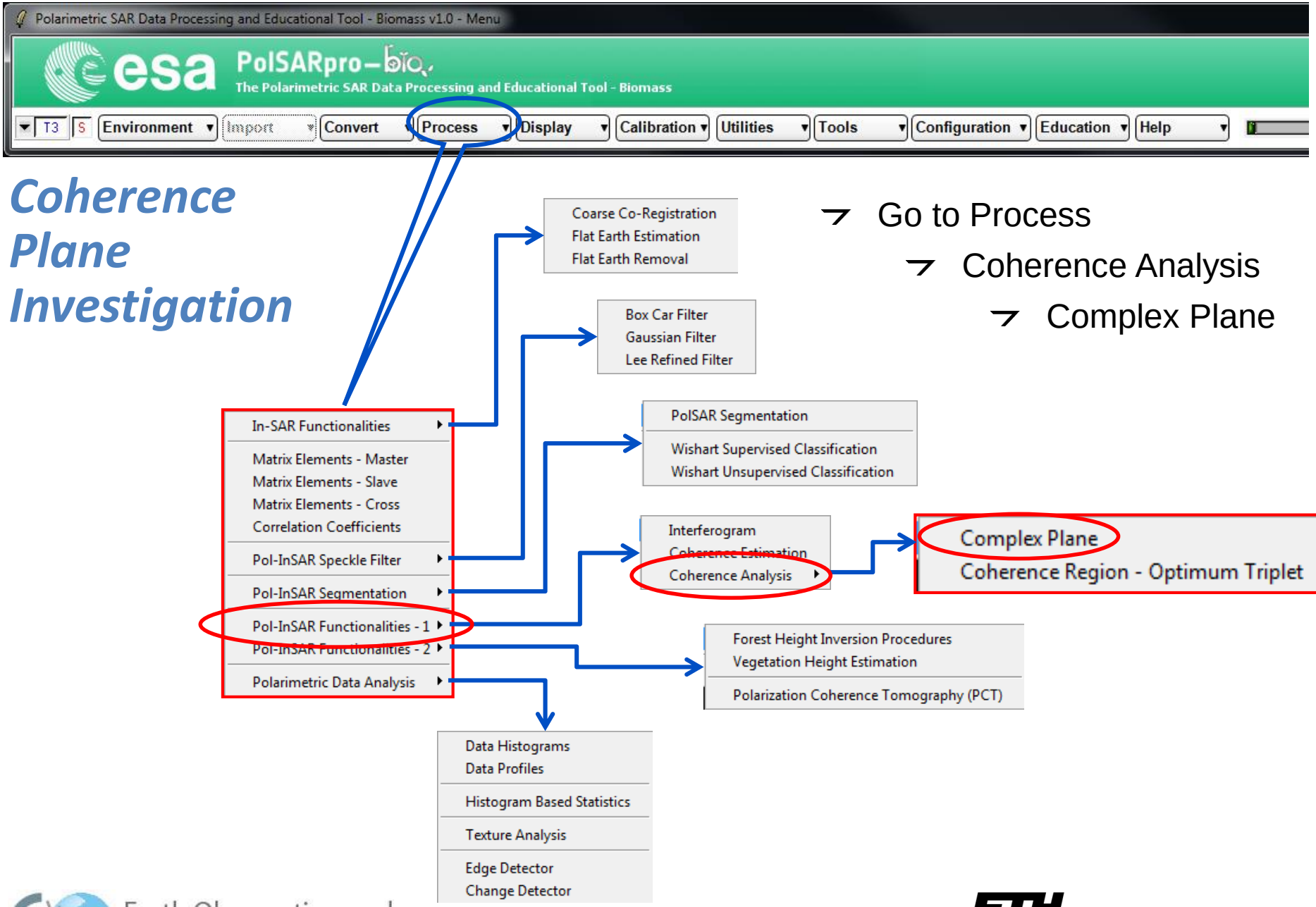
Coherence Plane Investigation



- Go to Process
  - Coherence Analysis
    - Complex Plane

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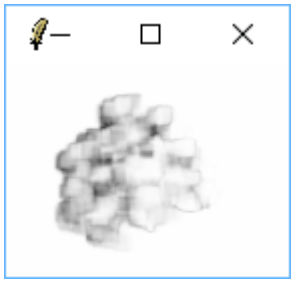
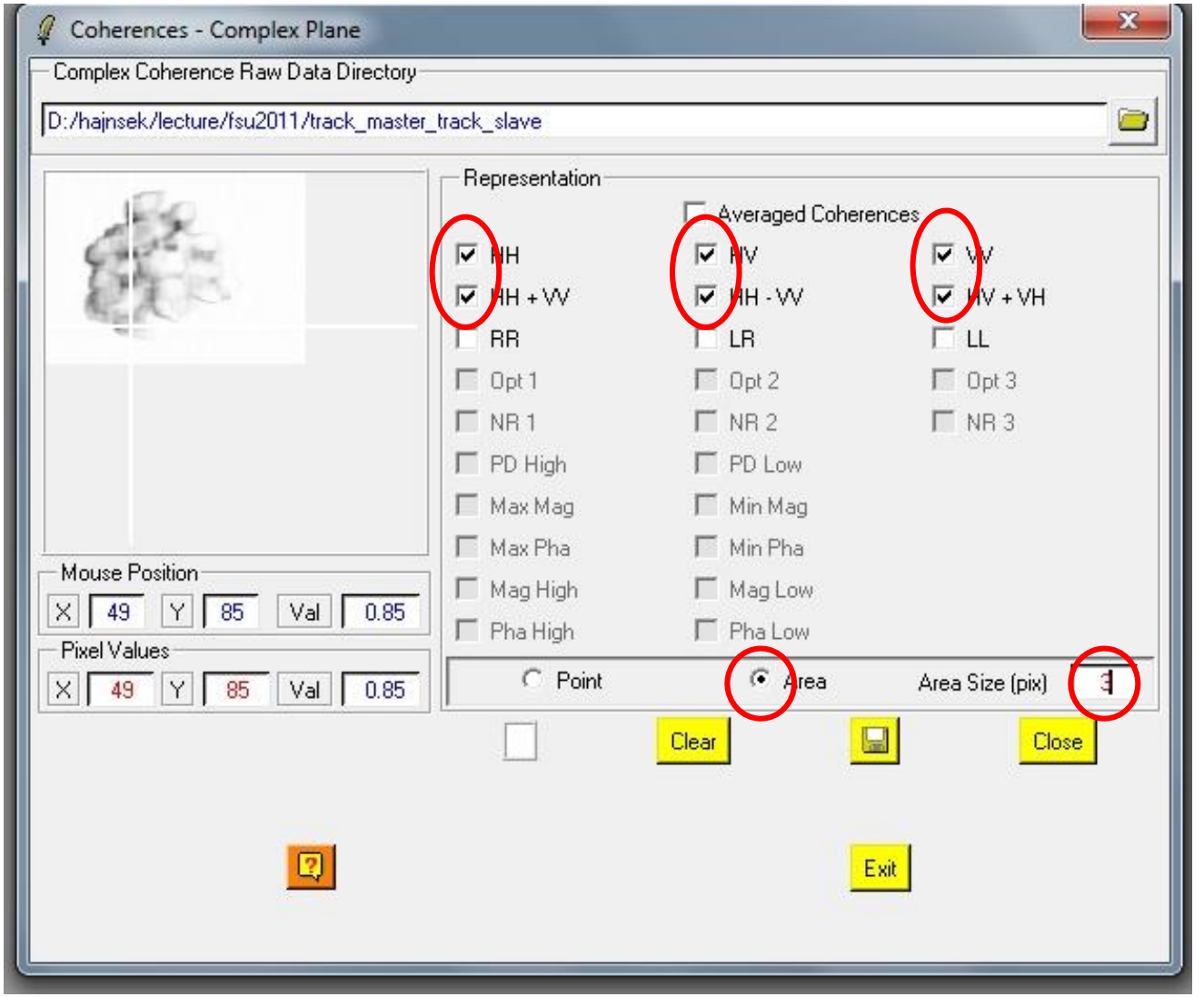
Coherence Plane Investigation

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





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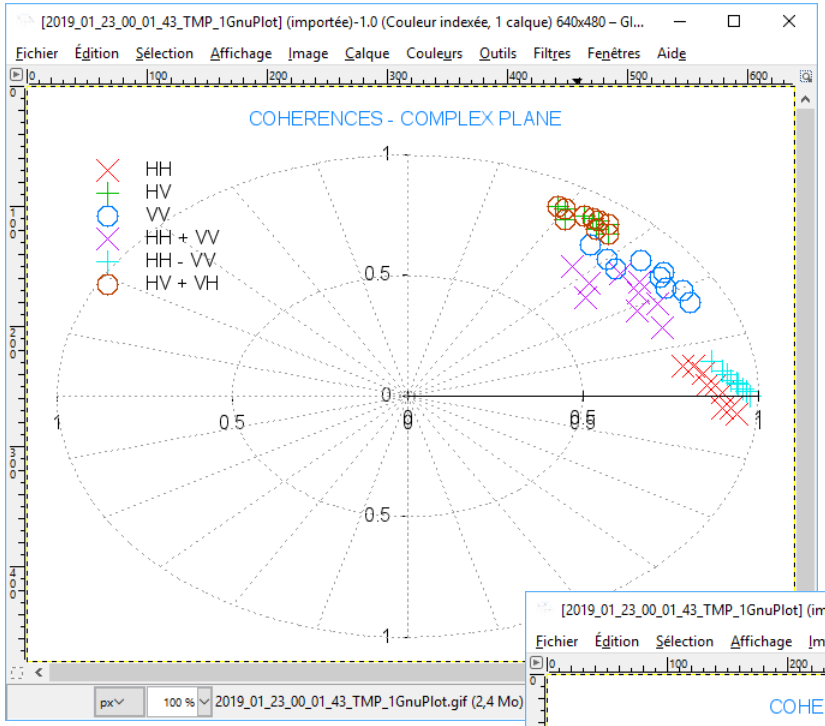
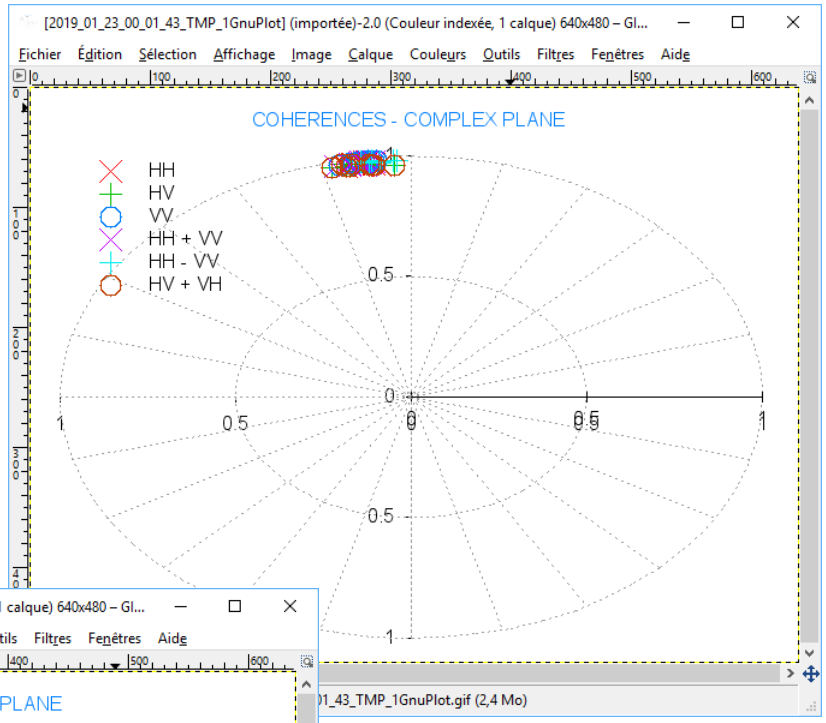
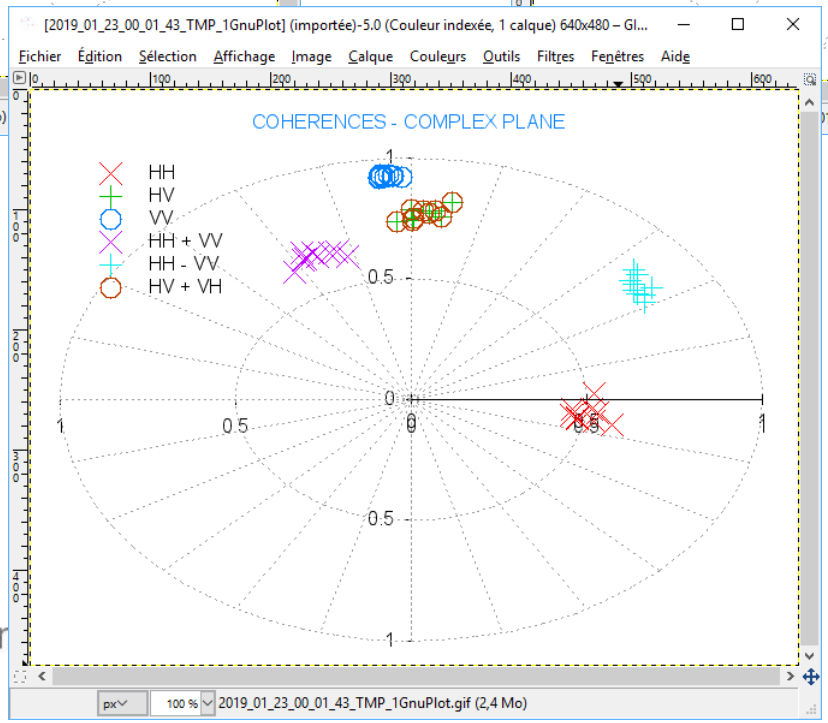
Complex Unit Circle







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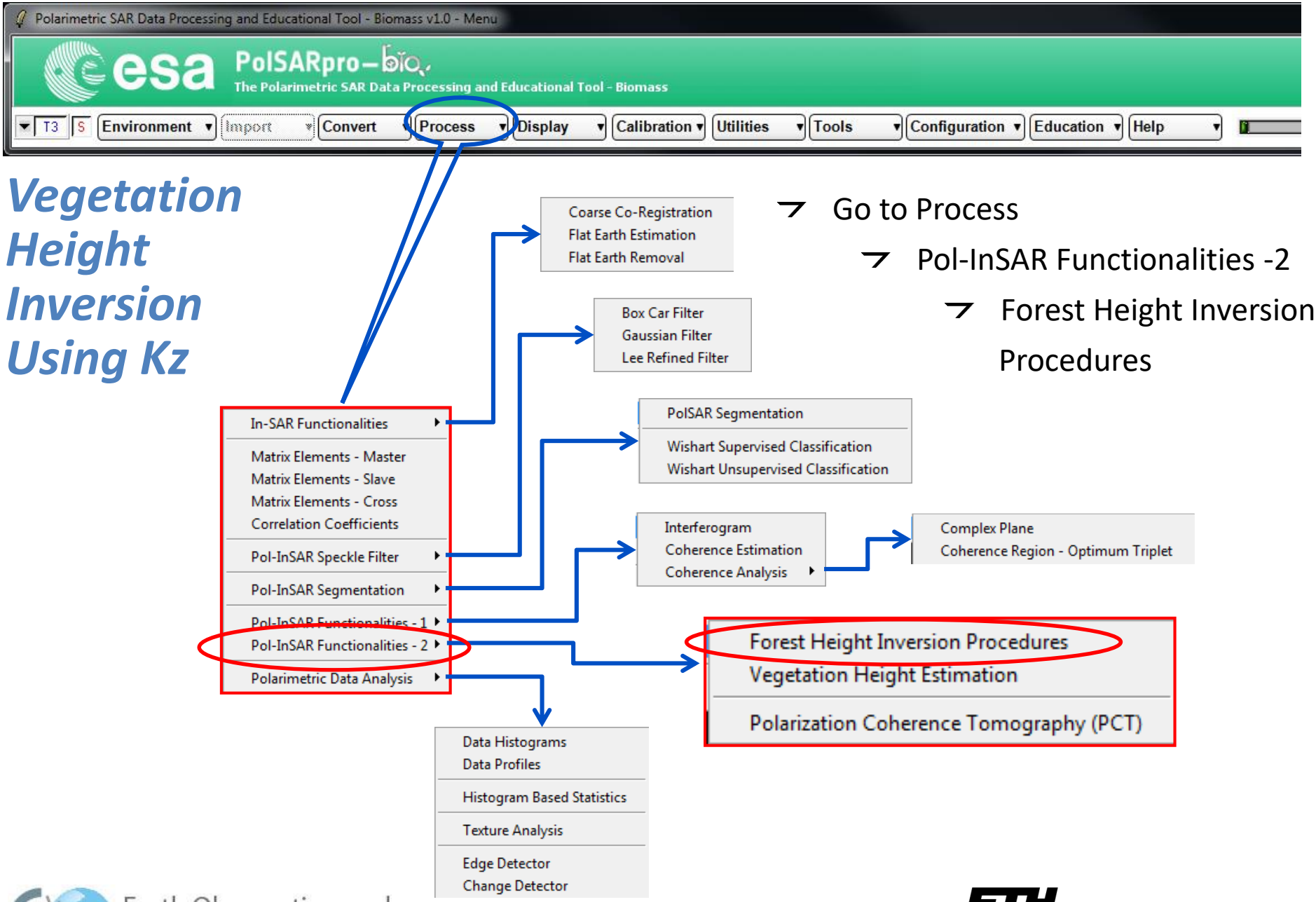
Swiss Federal Institute of Technology Zurich

Vegetation Height Inversion Using Kz



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

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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)

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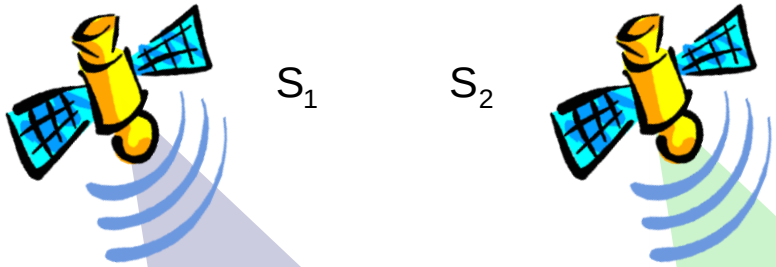
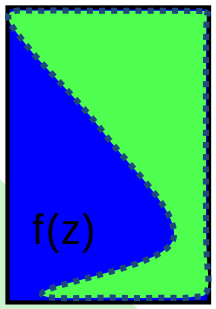


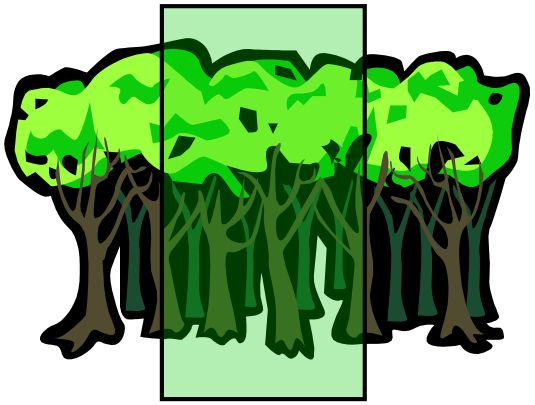
Interferometric Coherence

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

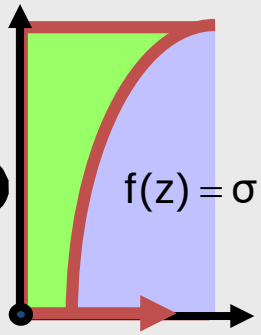
Volume Coherence

$$\tilde{\gamma}_{Vol}(f(z)) = e^{ik_z z_o}\,\frac{\int_0^{h_v} f(z)\,e^{ik_z z}dz}{\int_0^{h_v} f(z)\,dz}$$





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

$$\tilde{\gamma}_V = \frac{I}{I_0}$$

$$I = \int_0^{h_V} \exp(i\kappa_z z')\exp\left(\frac{2\,\sigma\,z'}{\cos\theta_0}\right)dz'$$

$$I_0 = \int_0^{h_V} \exp\left(\frac{2\,\sigma\,z'}{\cos\theta_0}\right)dz'$$

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

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

Volume Height h_V

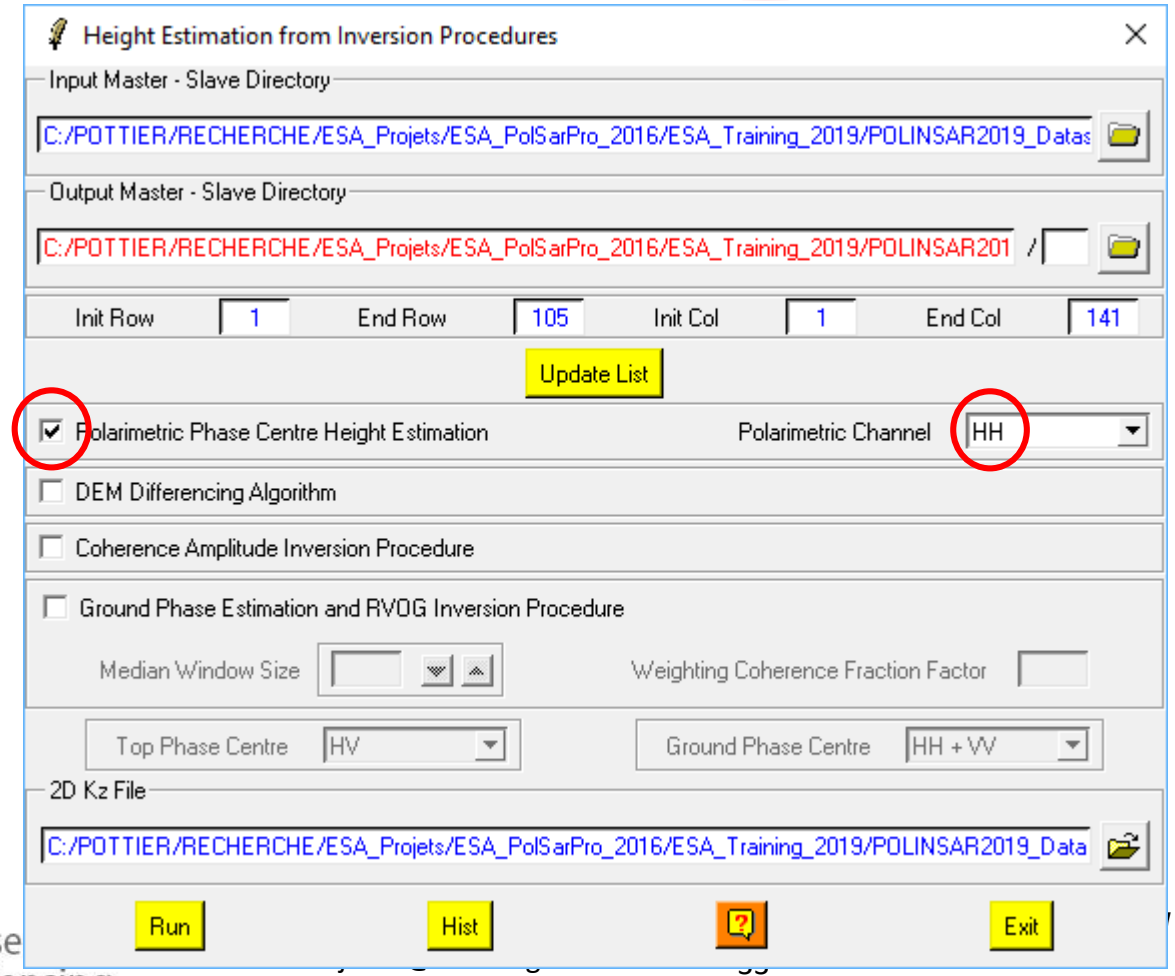
Extinction σ

Topography φ_0

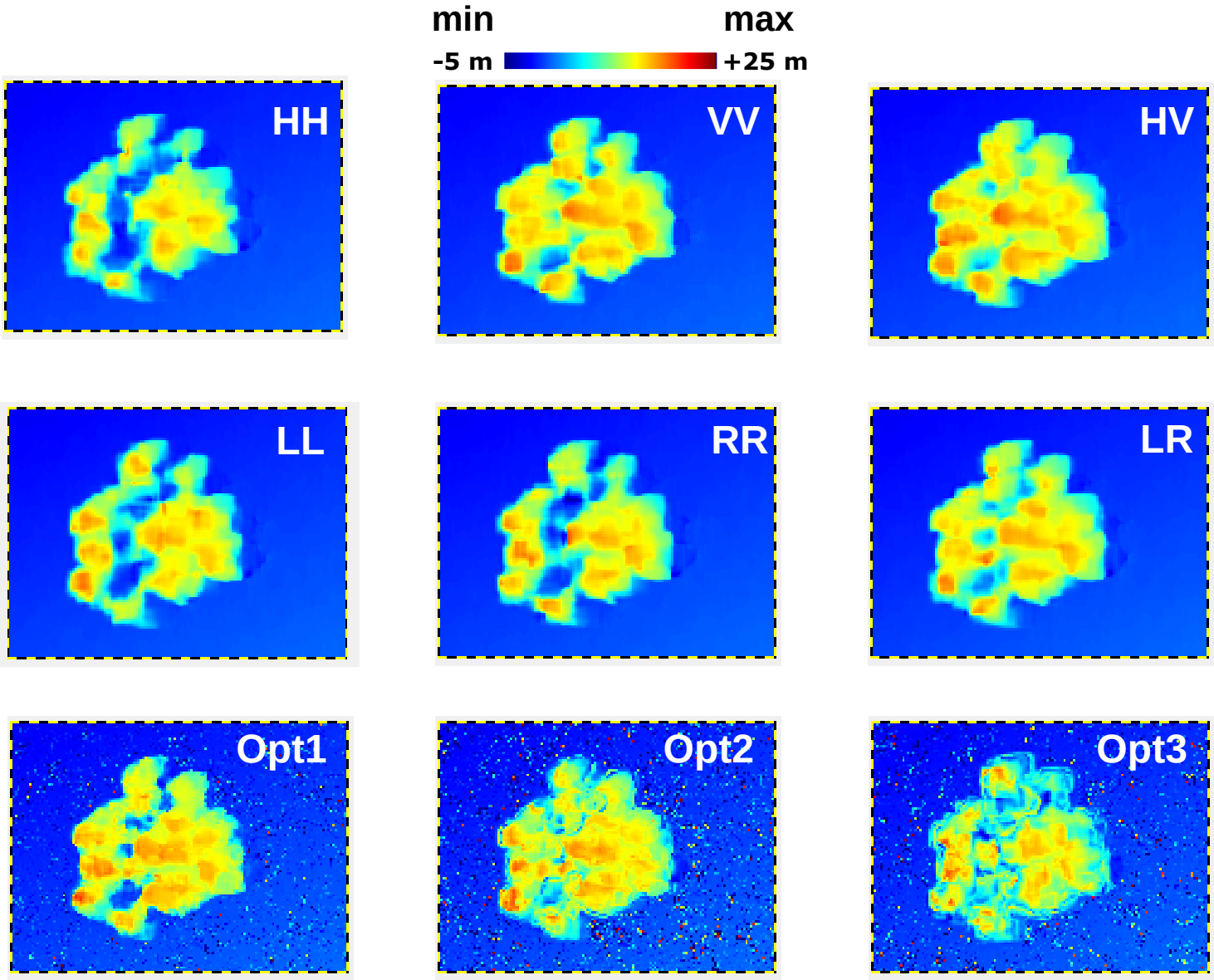
G/V Ratio $m(\vec{w})$

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]



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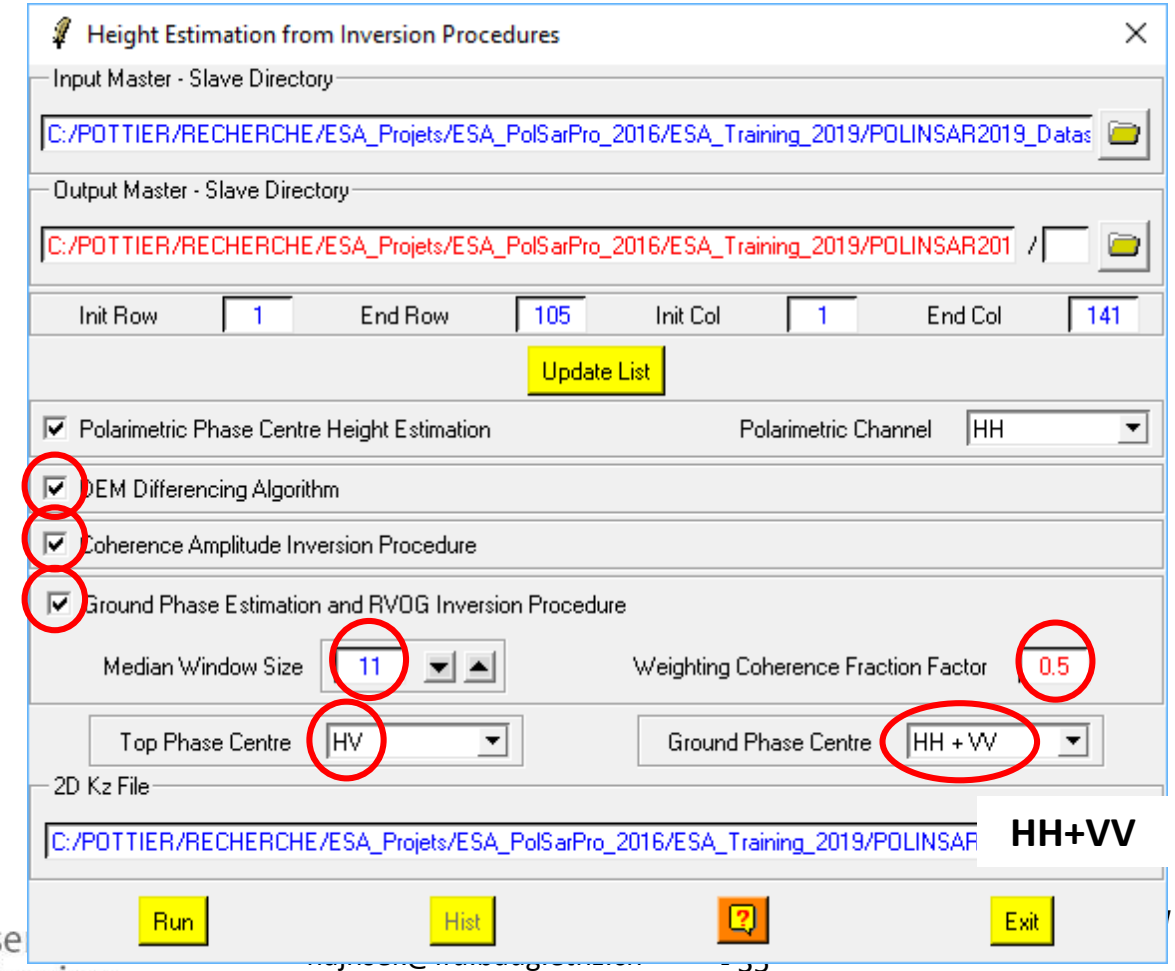
Do it yourself!

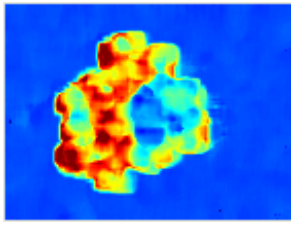
- Please generate the following products
  - Compare the different inversion models in terms of height inversion



Height Inversion using different Methods

- RVoG Inversion

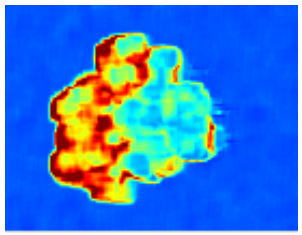
min -5 m — max +25 m



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

- Coherence Height

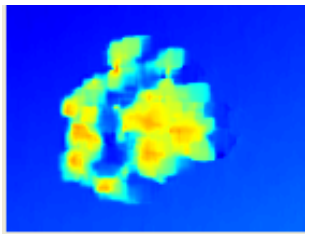
min -5 m — max +25 m



→ 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)

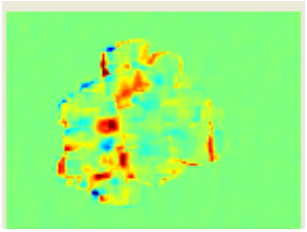
min -5 m — max +25 m



→ 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)

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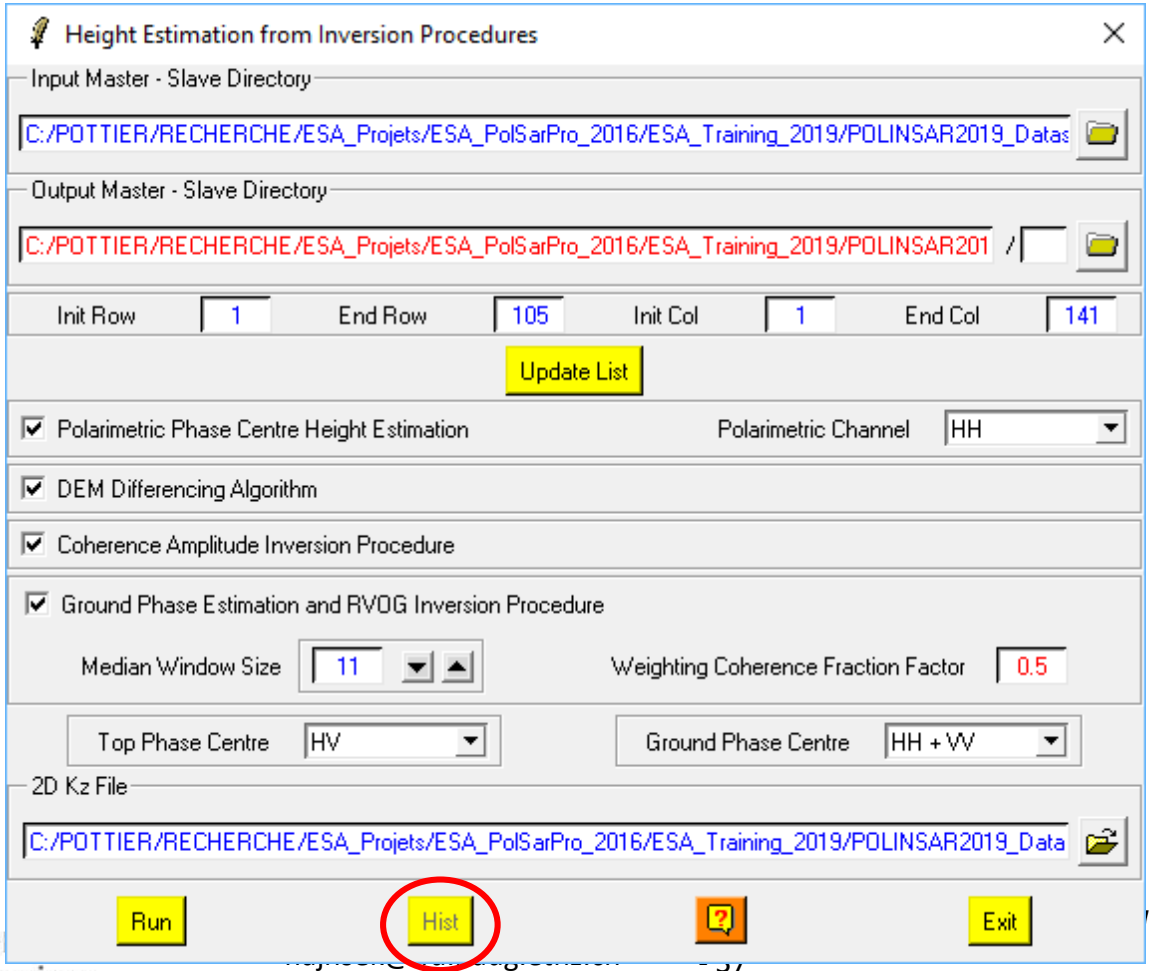
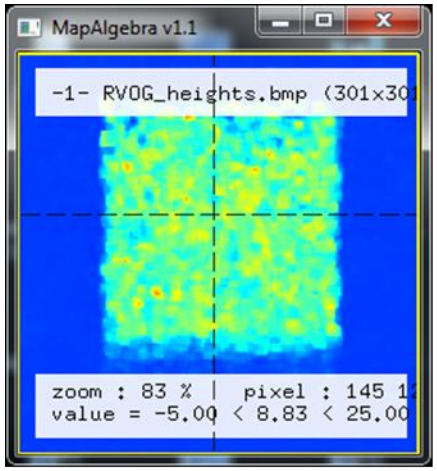
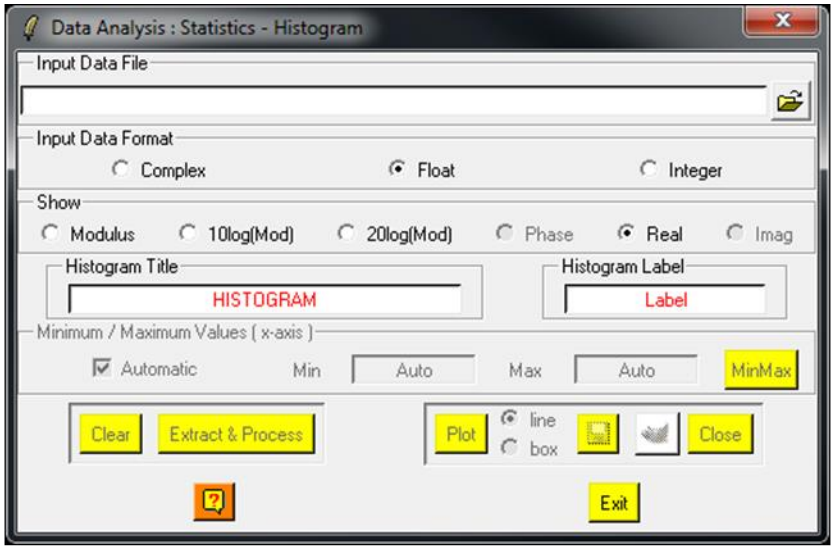
Do it yourself!

- 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

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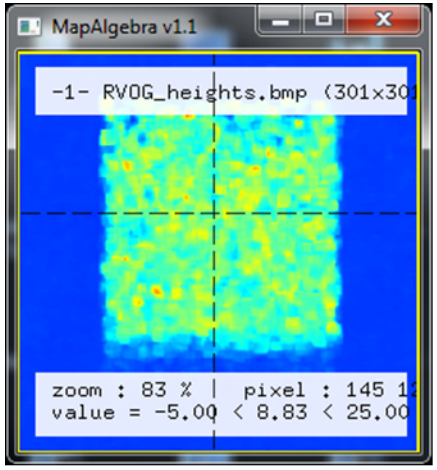

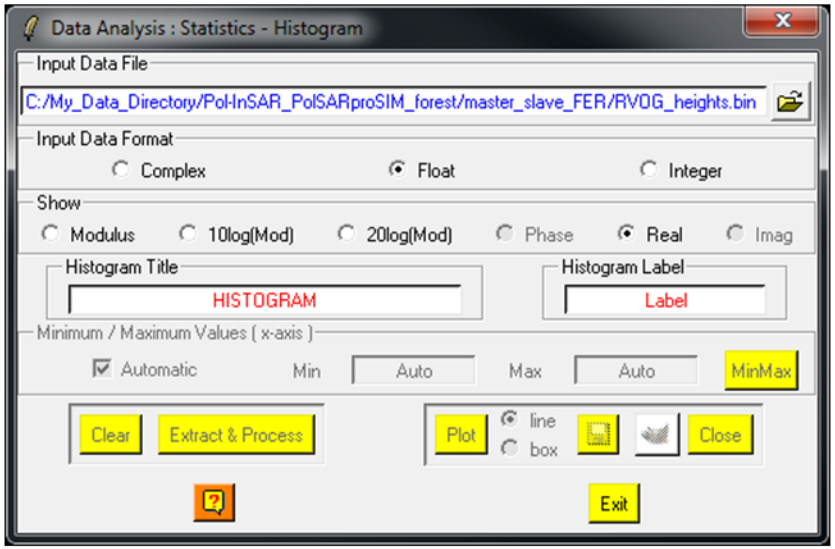

Do it Yourself:

Step 2 : Select an Input Binary Data File
Select what to *Show*
Enter the *Histogram Title*
Enter the *Histogram Label*

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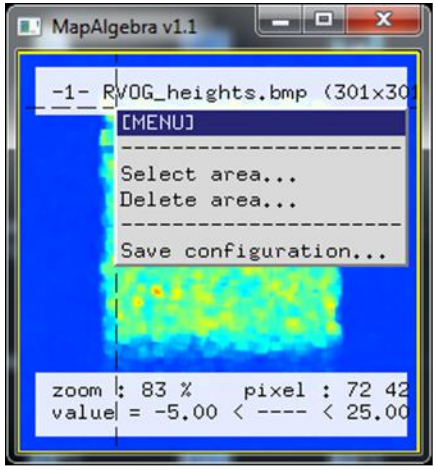

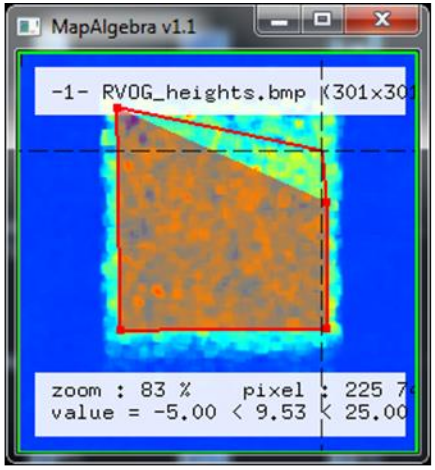

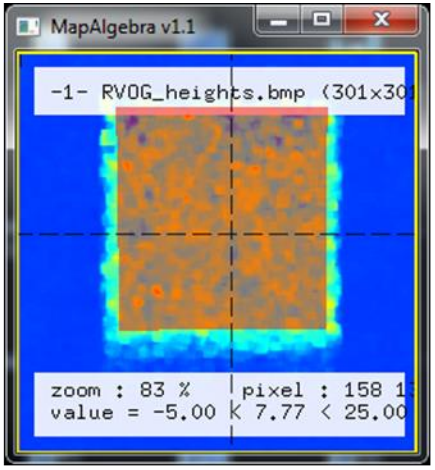

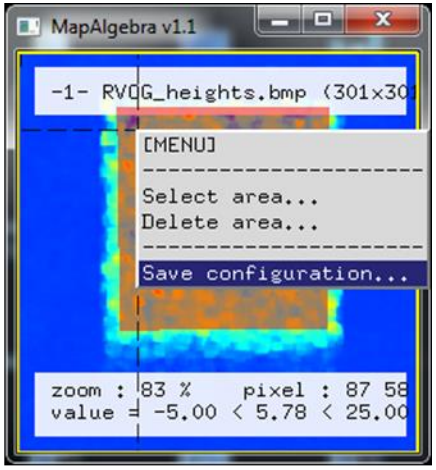

Do it Yourself:

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**

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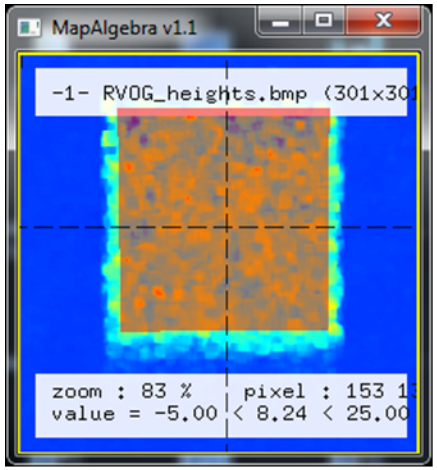

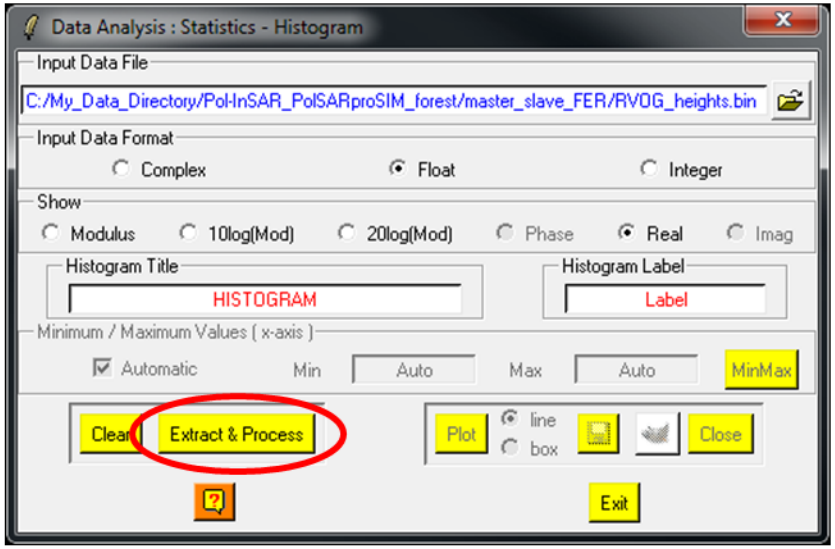

Do it Yourself:
Step 4 : Extract and Process

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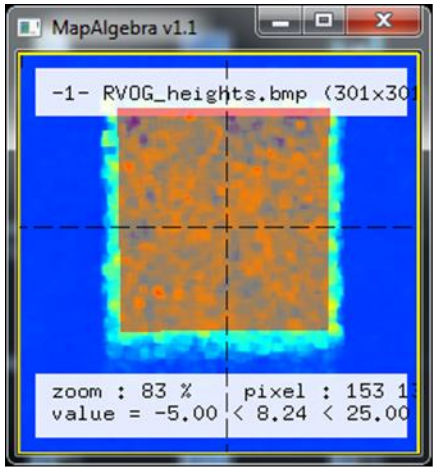

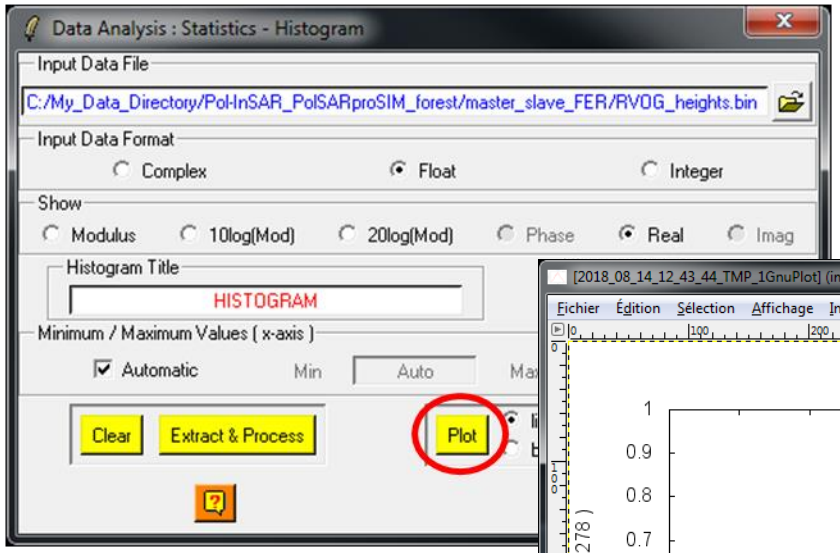

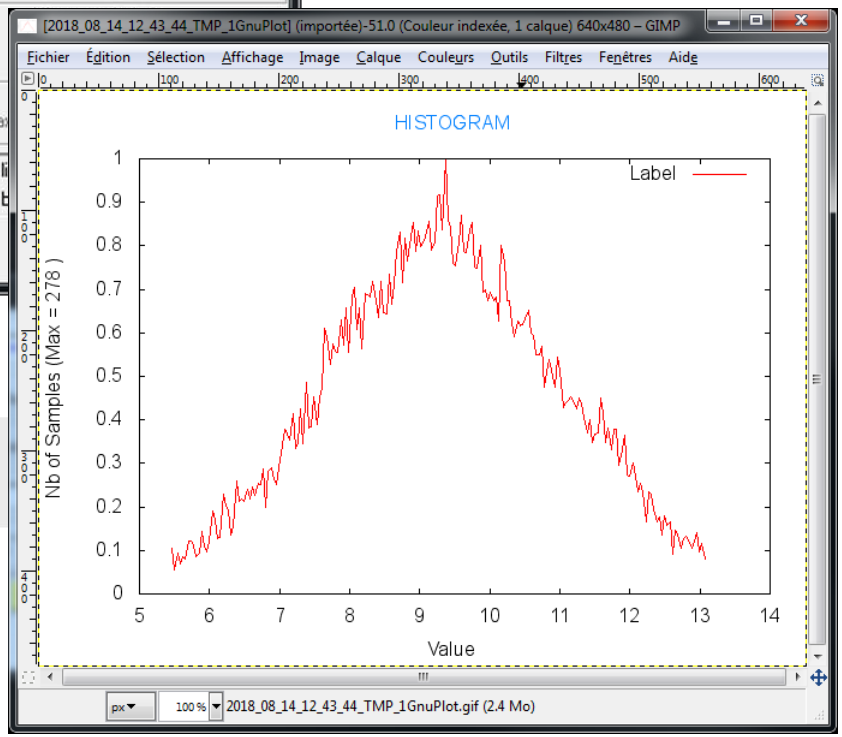

Do it Yourself:
Step 5 : Plot the histogram

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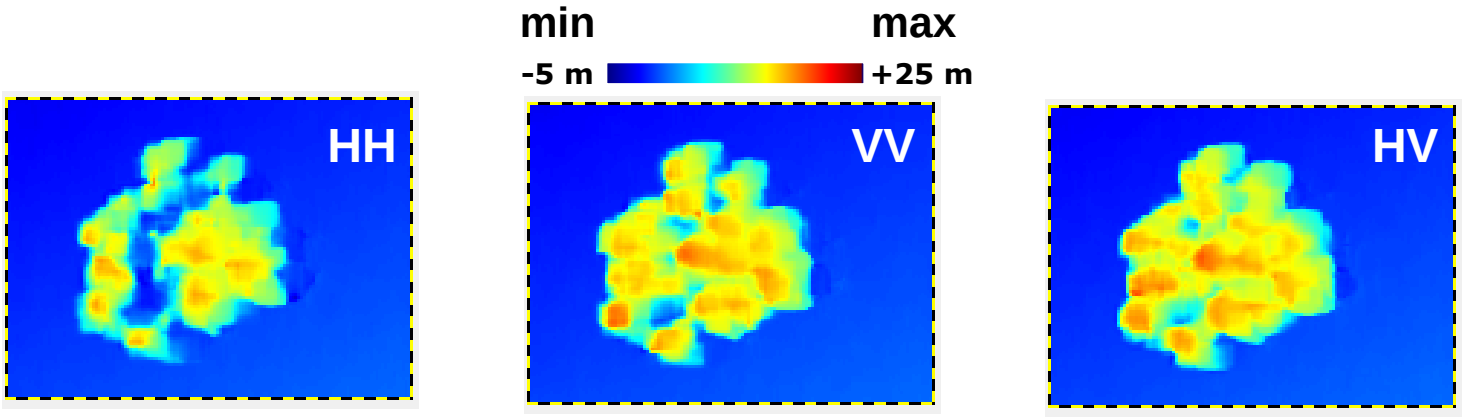
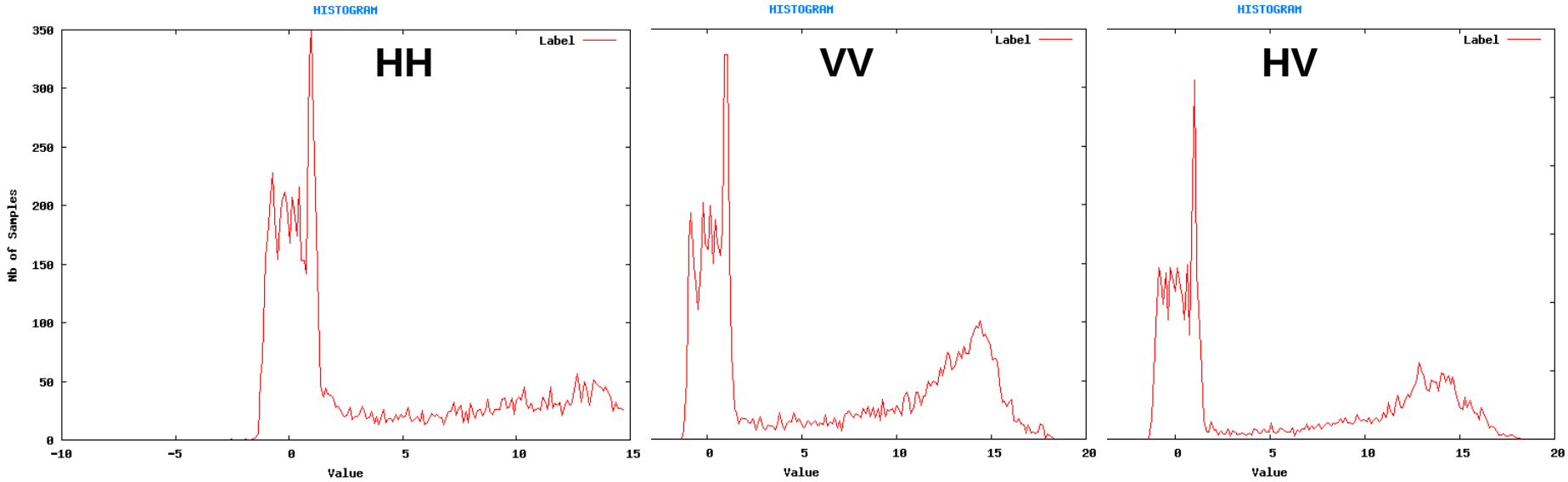
Phase Center Heights





primarily ground contribution

primarily volume contribution

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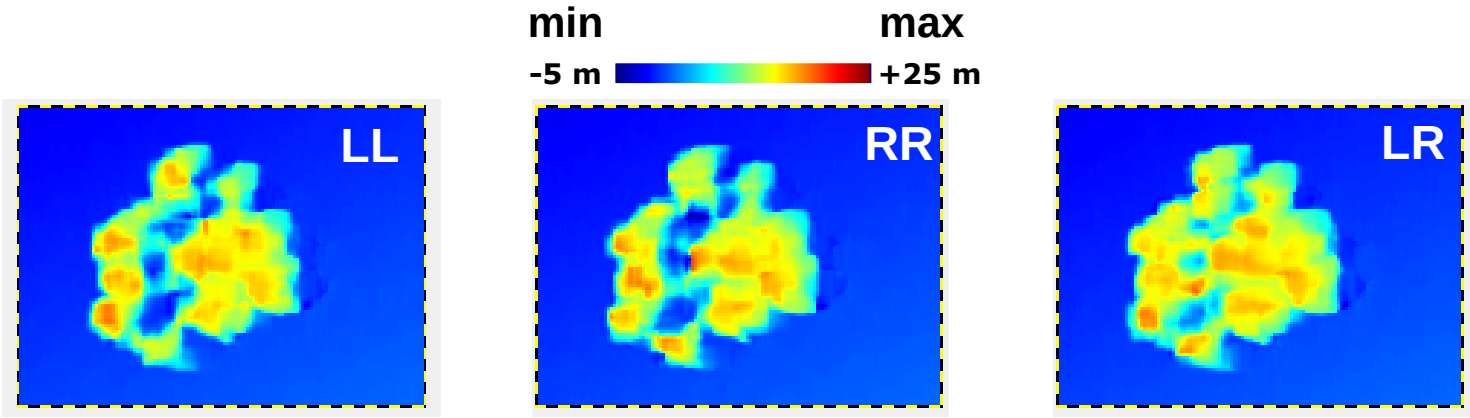

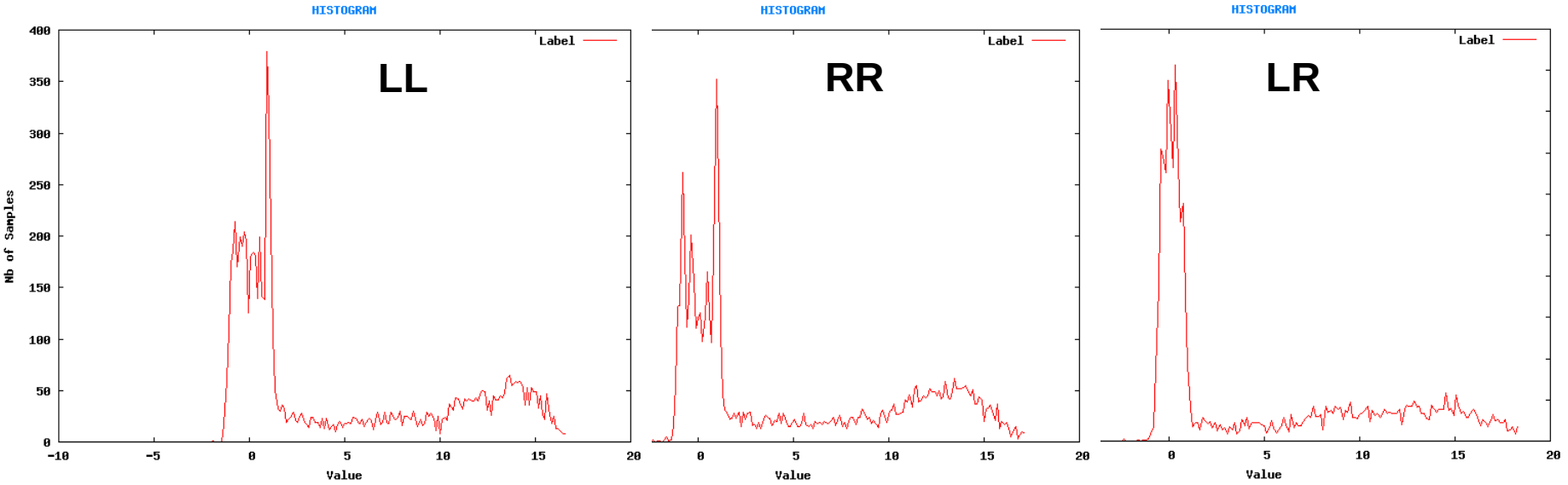

Earth Observation and Remote Sensing

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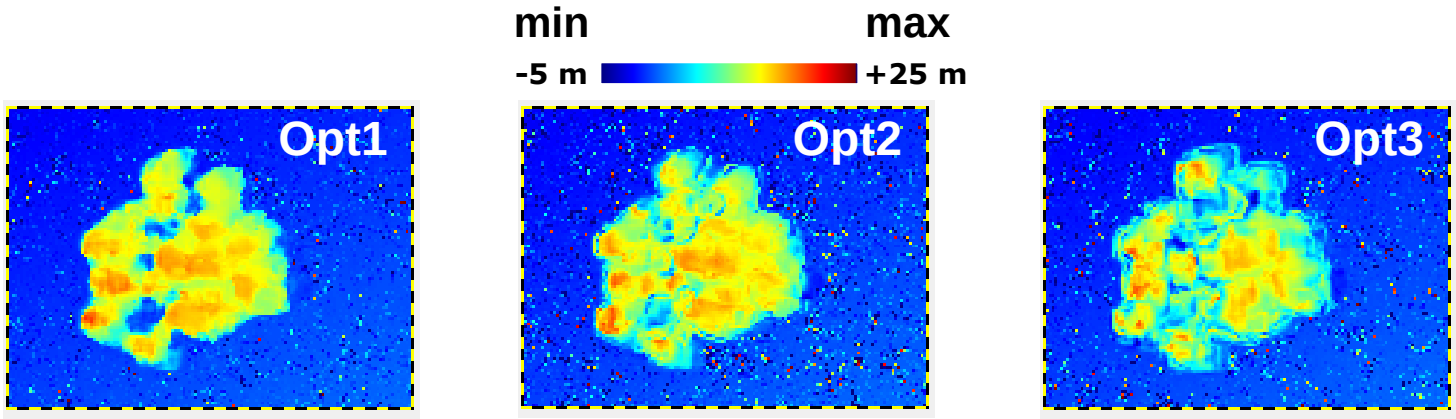
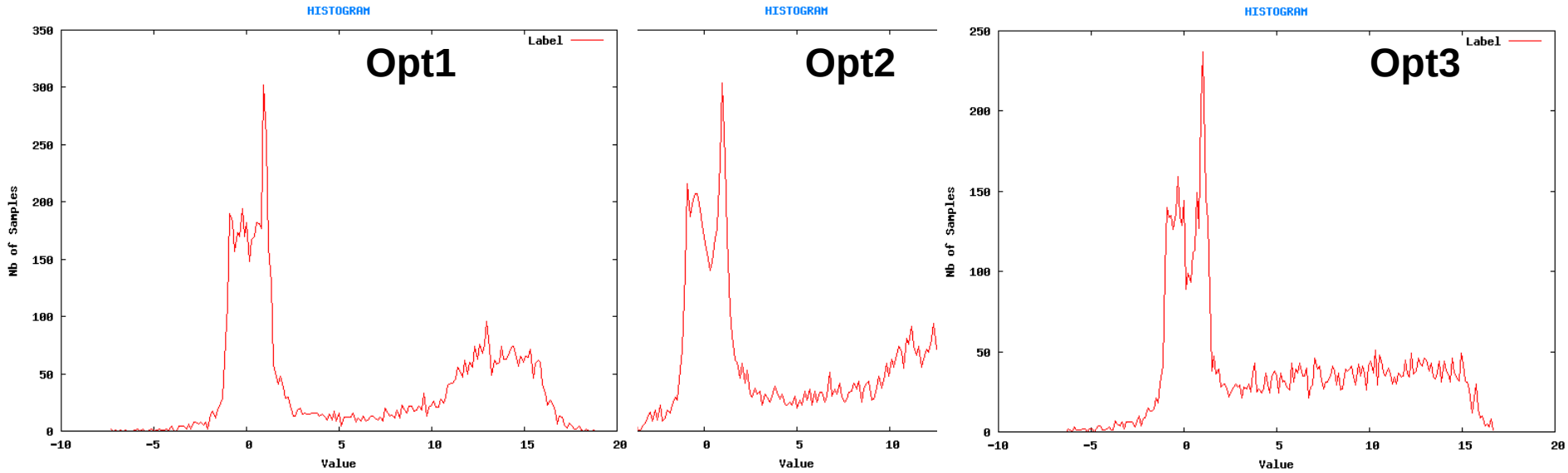
Phase Center Heights





primarily ground contribution

primarily volume contribution

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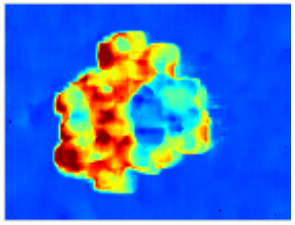
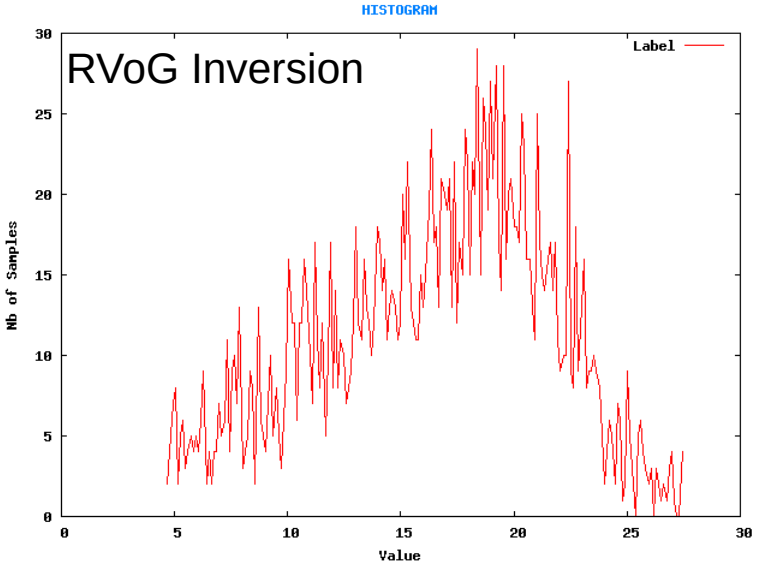
Height Inversion using different Methods

- RVoG Inversion

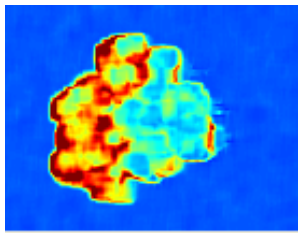
min max
-5 m +25 m





- Coherence Height

min max
-5 m +25 m



- Phase Center Heights (HH)

min max
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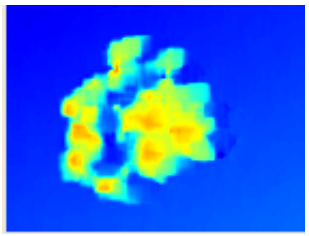
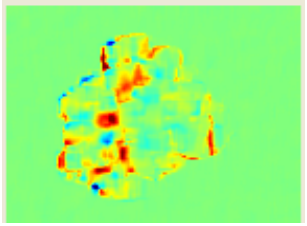


- DEM Difference Heights

min max
-10 m +10 m



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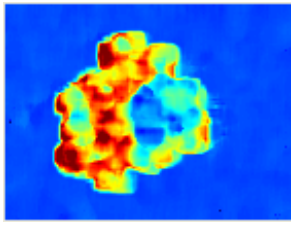

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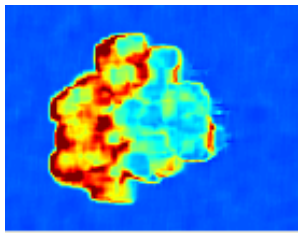

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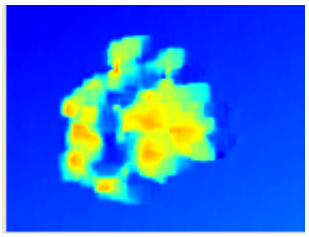
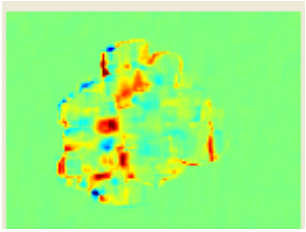
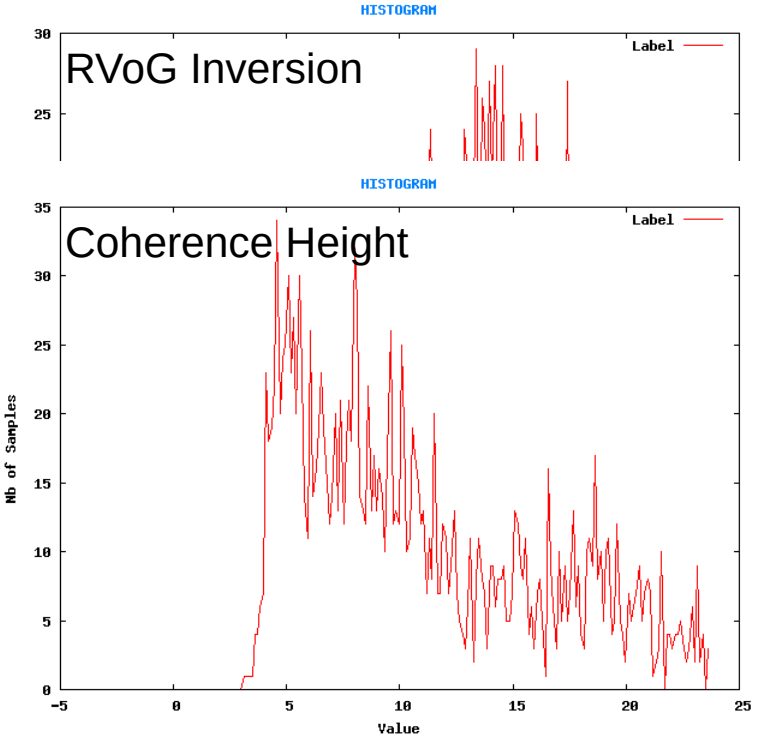


- DEM Difference Heights

min max
-10 m +10 m





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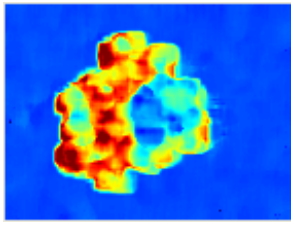
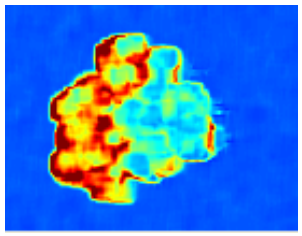


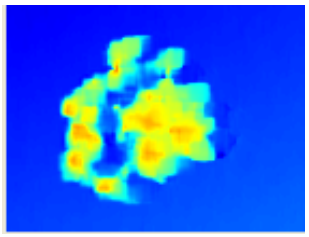
- Coherence Height

min -5 m — max +25 m



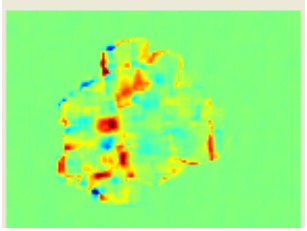
- Phase Center Heights (HH)

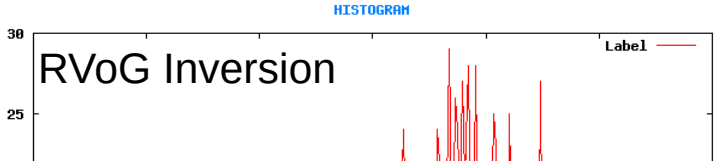
min -5 m — max +25 m

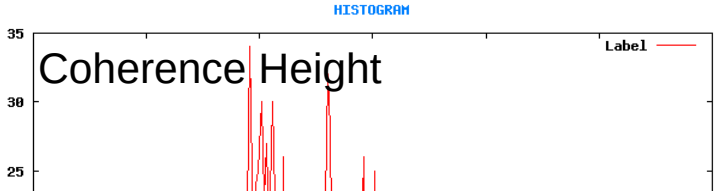


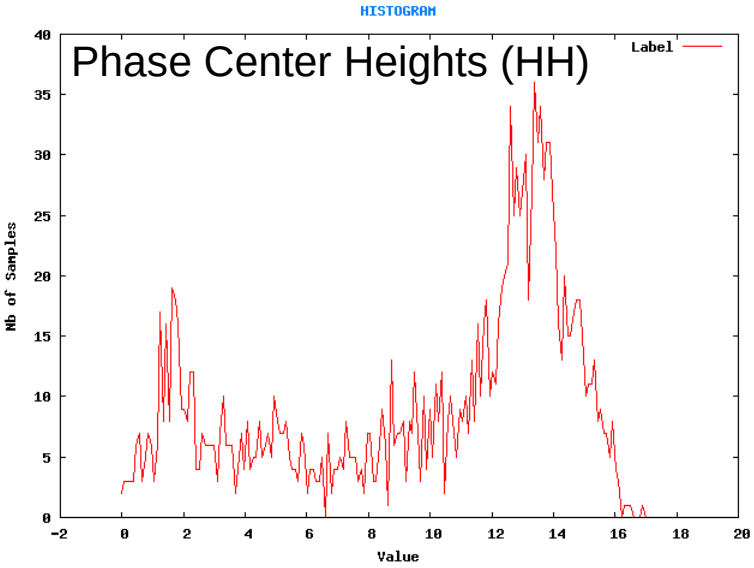
- DEM Difference Heights

min -10 m — max +10 m









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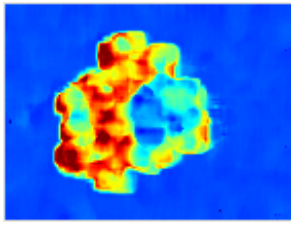
Height Inversion using different Methods

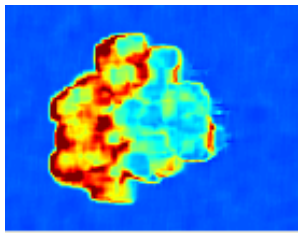
- RVoG Inversion

min max
-5 m +25 m



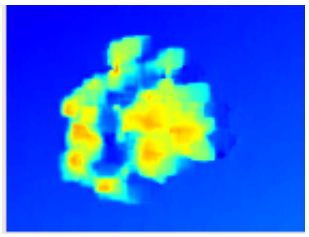
- Coherence Height

min max
-5 m +25 m



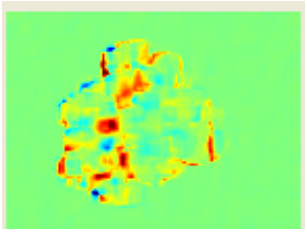
- Phase Center Heights (HH)

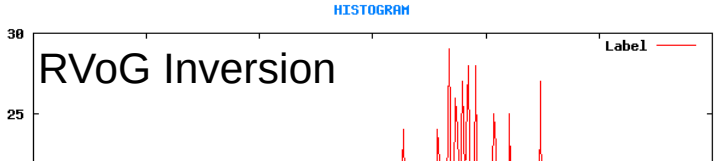
min max
-5 m +25 m

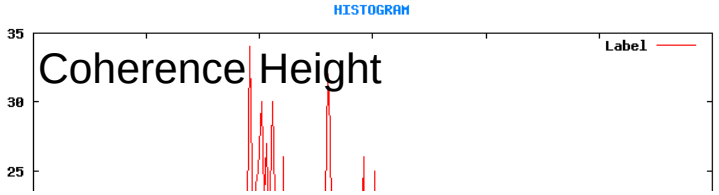


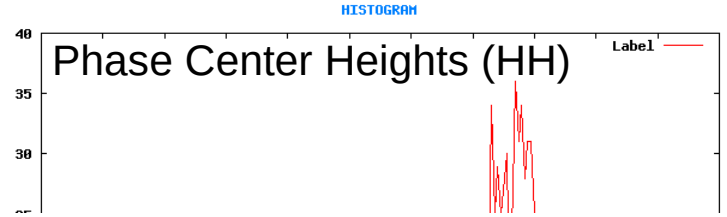
- DEM Difference Heights

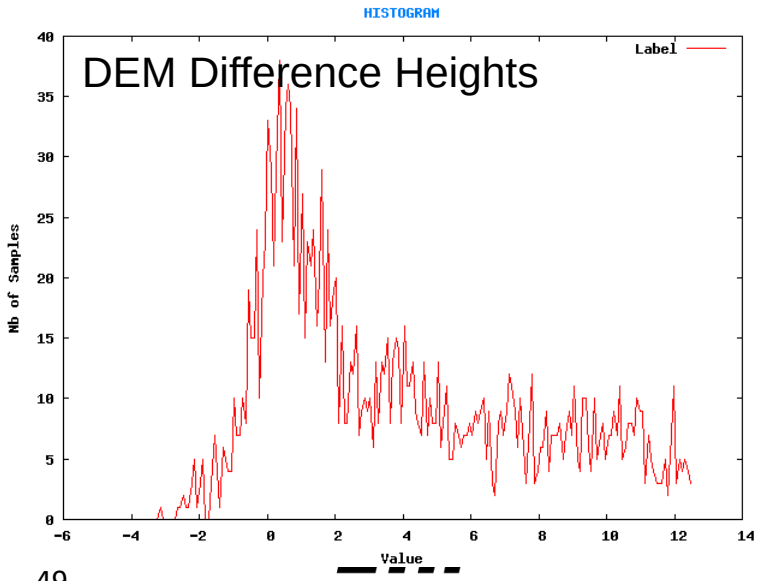
min max
-10 m +10 m











Earth Observation and Remote Sensing

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