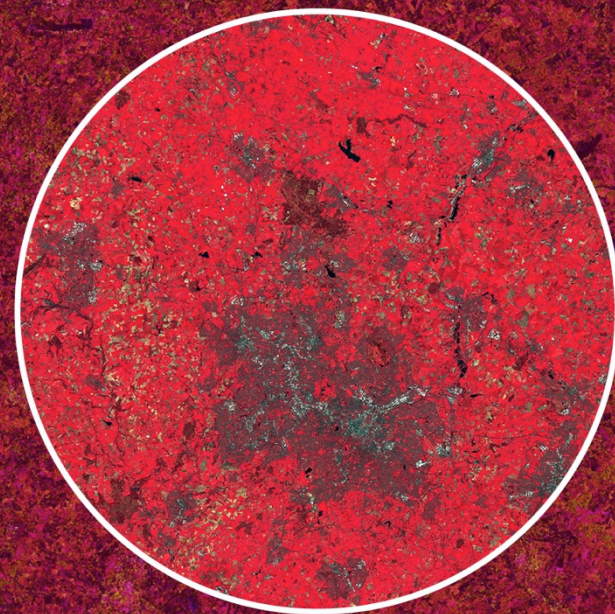


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University of Leicester | United Kingdom



Forestry applications with Polarimetry and Interferometry (Practical)

Laurent FERRO-FAMIL, Eric POTTIER

IETR / University of Rennes 1, France

HISTORY



2003



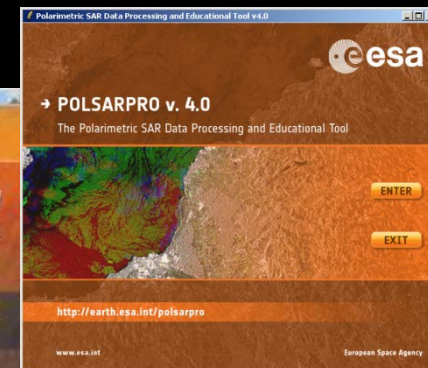
2004



2005



2007



2009

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HISTORY



The initiative development of **PolSARpro Software** is a direct result of recommendations made during the **POLinSAR 2003 Workshop** held at ESA-ESRIN in January 2003.



2003



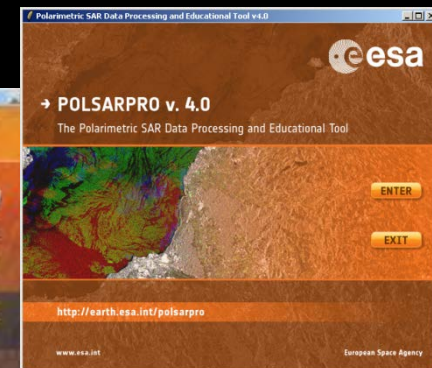
2004



2005



2007



2009

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HISTORY



The initiative development of **POLSARPRO Software** is a direct result of recommendations following the **POLinSAR 2003 Workshop** held at ESA-ESRIN in January 2003.

15 YEARS OF DEVELOPMENT



2003



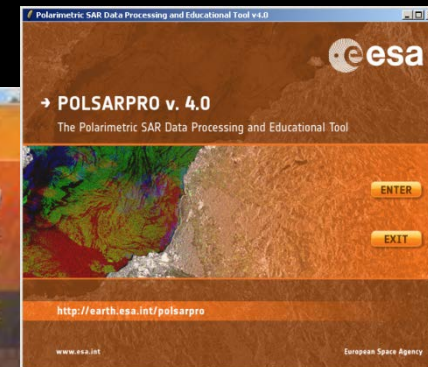
2004



2005



2007



2009

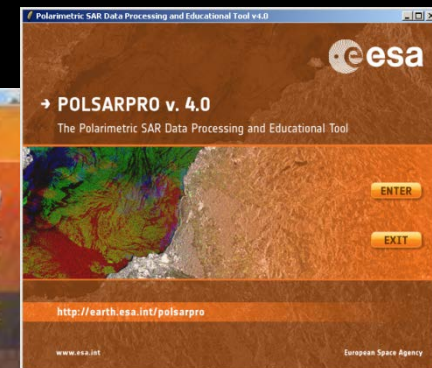
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HISTORY



2013 (5.0) - 2018 (5.2)



2009



2007



2005



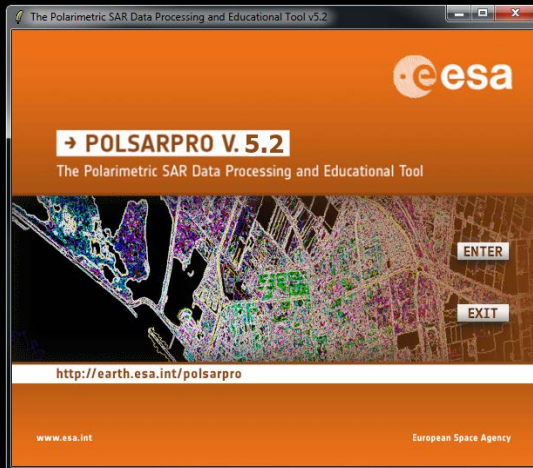
2004



2003

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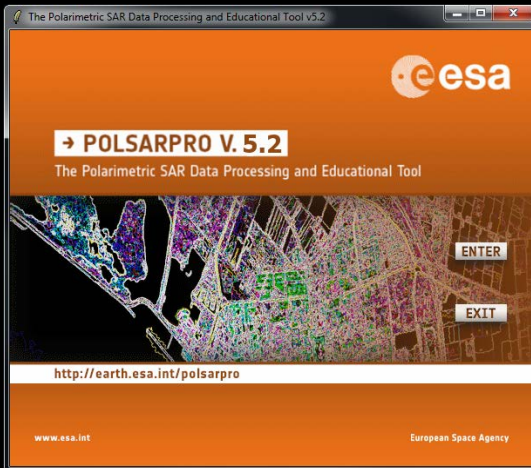


Toolbox specifically designed to handle : **Pol-SAR, Pol-InSAR, Pol-TomoSAR** and **Pol-TimeSAR** data.

Educational Software offering a tool for **self-education** in the field of **Polarimetric SAR** data processing and analysis.

Developed to be **accessible** to : a wide range of users from **novices** to **experts** in the field of **Pol-SAR, Pol-InSAR, Pol-TomoSAR, Pol-TimeSAR**.

More than **1740** different
Pol-SAR, Pol-InSAR, Pol-TomSAR
and Pol-TimeSAR **functionalities**.



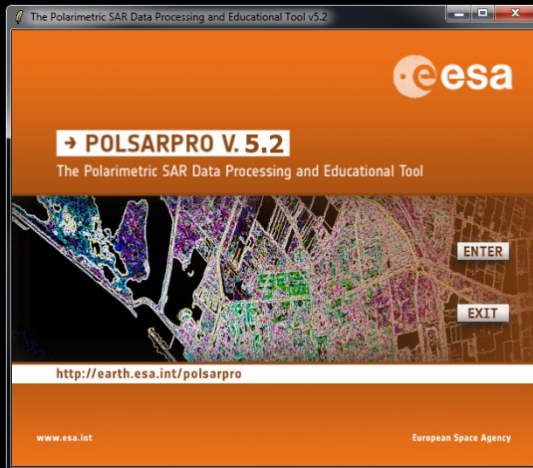
Each element of the
Software (**a function**) can
be **extracted** and
incorporated individually
into **users'** own processing
software.

PolSARpro v5.2 Software is made available
following the: **Open Source Software Development**
(**OSSD**) approach, and follows the: **GNU General**
Public License v2 – June 1991.



since **2003**

- **+3000** registered users
- **+70** foreign countries

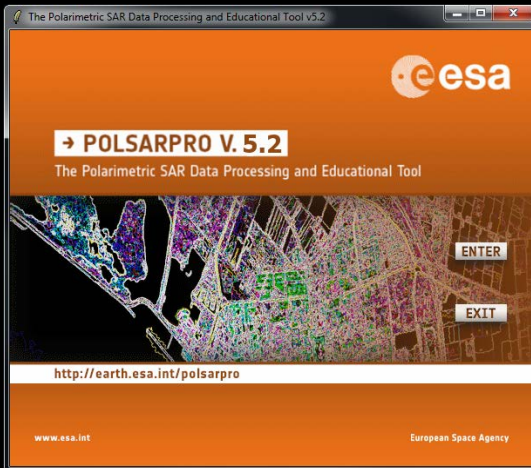


International Collaborative Project (4 Agencies, 15 Research Centres, 14 Universities)



→ 8th .

Contributors 2017



Tsinghua University, China



University of Mining and Technology, China



National Space Science Center, CAS, China



Wuhan University, China



**Satellite Surveying and Mapping
Application Center, China**



Xidian University, China



**Harbin Institute of Technology
China**



Fudan University, China



**Studies in Resources Engineering Indian
Institute of Technology**



Universidade Federal de Alagoas, Brazil



**University of Science and Technology,
Poland**



**University of Tehran, School of Surveying
and Geospatial Engineering, Iran**



**ADVANCED TRAINING COURSE ON LAND REMOTE SENSING
Key Lab of Microwave Remote Sensing, CAS, China**



**Khajeh Nasir Toosi University of
Technology, Iran**

PolSARpro v5.2 SOFTWARE



SETHI



PISAR

NASDA
CRL



ESAR - FSAR



UAV-SAR

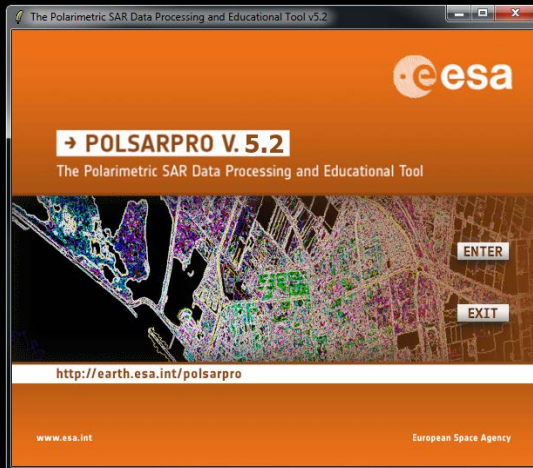
CURRENT

PolSARpro v5.2 Software offers the possibility to handle and convert polarimetric data from a range of well established **CURRENT polarimetric airborne platforms.**

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PolSARpro v5.2 SOFTWARE



ALOS - PALSAR



PAST

PolSARpro v5.2 Software offers the possibility to handle and convert polarimetric data from a range of well established **PAST** polarimetric spaceborne platforms.

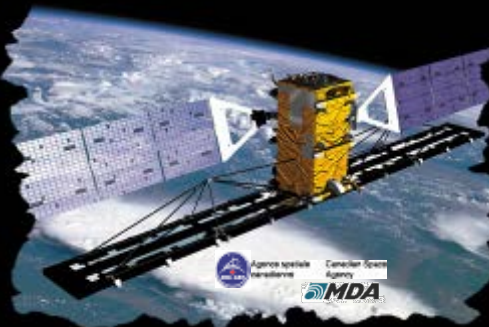
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PolSARpro v5.2 SOFTWARE



RADARSAT 2



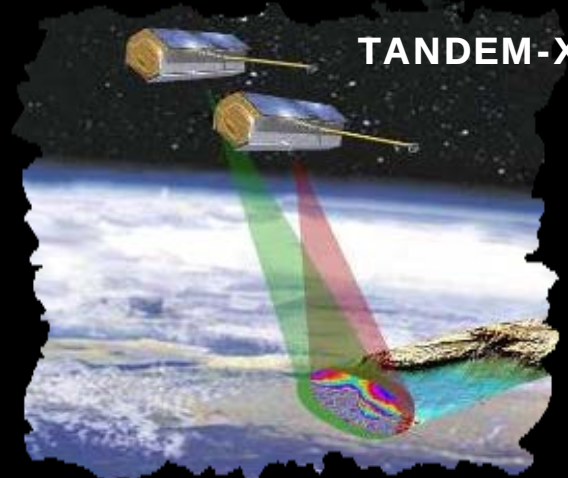
TerraSAR - X



COSMO - SKYMED



TANDEM-X



CURRENT

PolSARpro v5.2 Software offers the possibility to handle and convert polarimetric data from a range of well established **CURRENT polarimetric spaceborne platforms**.

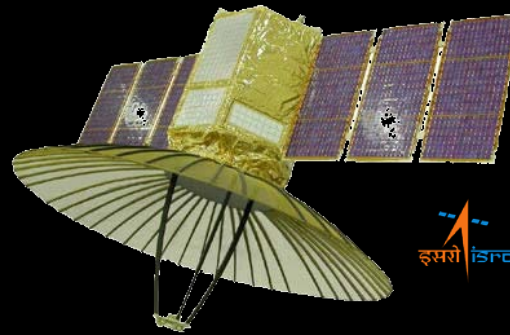
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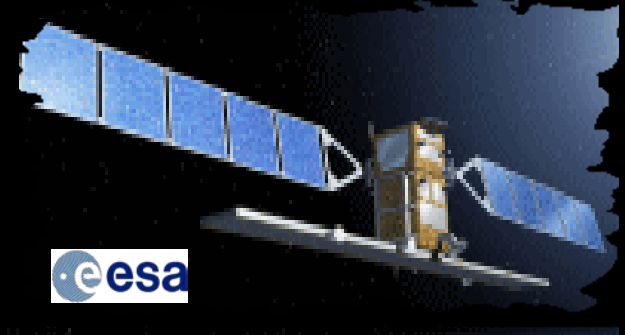
PolSARpro v5.2 SOFTWARE



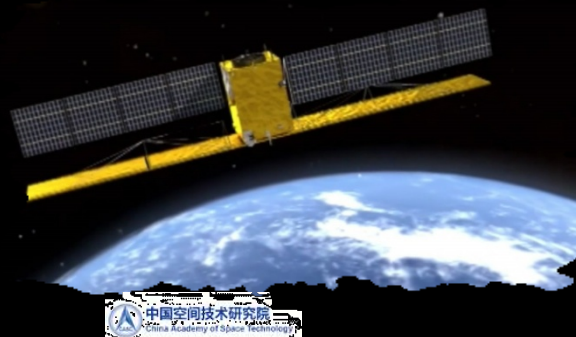
RISAT



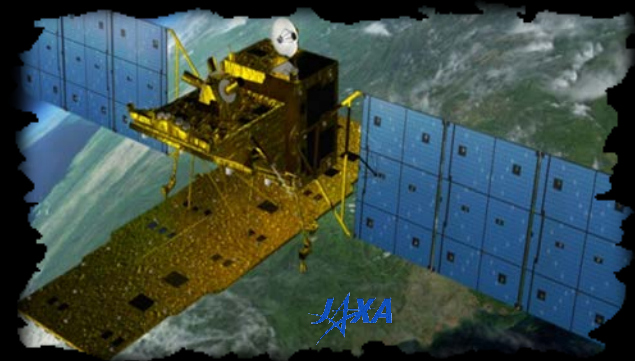
SENTINEL 1A / 1B



GaoFen 3 (GF3)



ALOS-2 – PALSAR-2



CURRENT

PolSARpro v5.2 Software offers the possibility to handle and convert polarimetric data from a range of well established **CURRENT** polarimetric spaceborne platforms.

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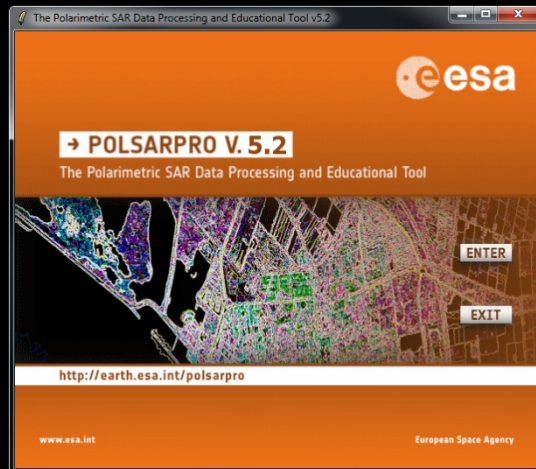
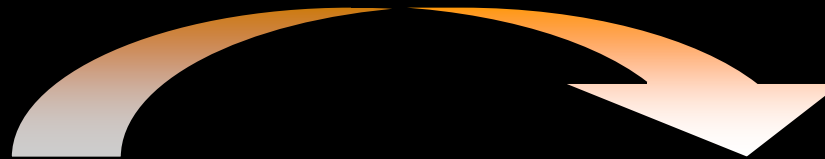
External Softwares



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ESA SNAP toolbox bridge



Polarimetric SAR Data Processing

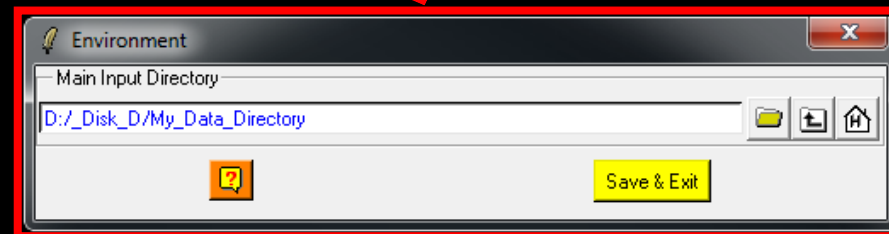
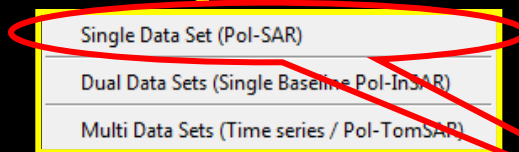
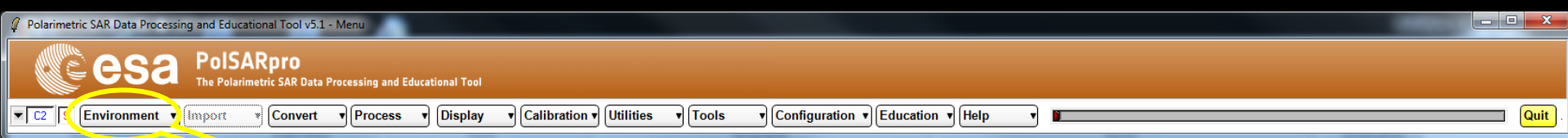


- S1 toolbox
(split, deburst, merge ...)
- Geocoding toolbox
- Terrain correction
- Interferometric toolbox
(co-registration, flat Earth estimation ...)

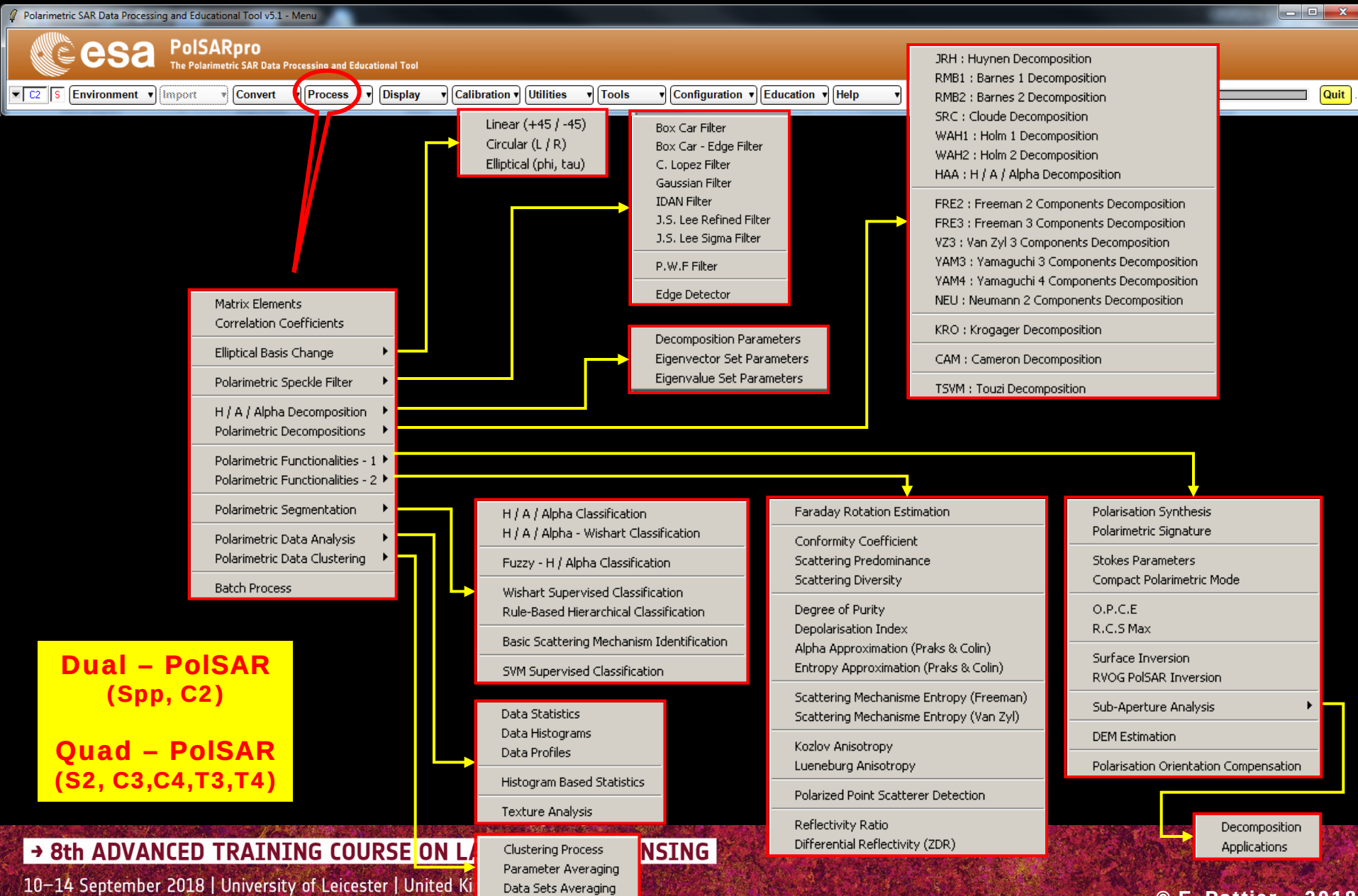


Software – General Presentation

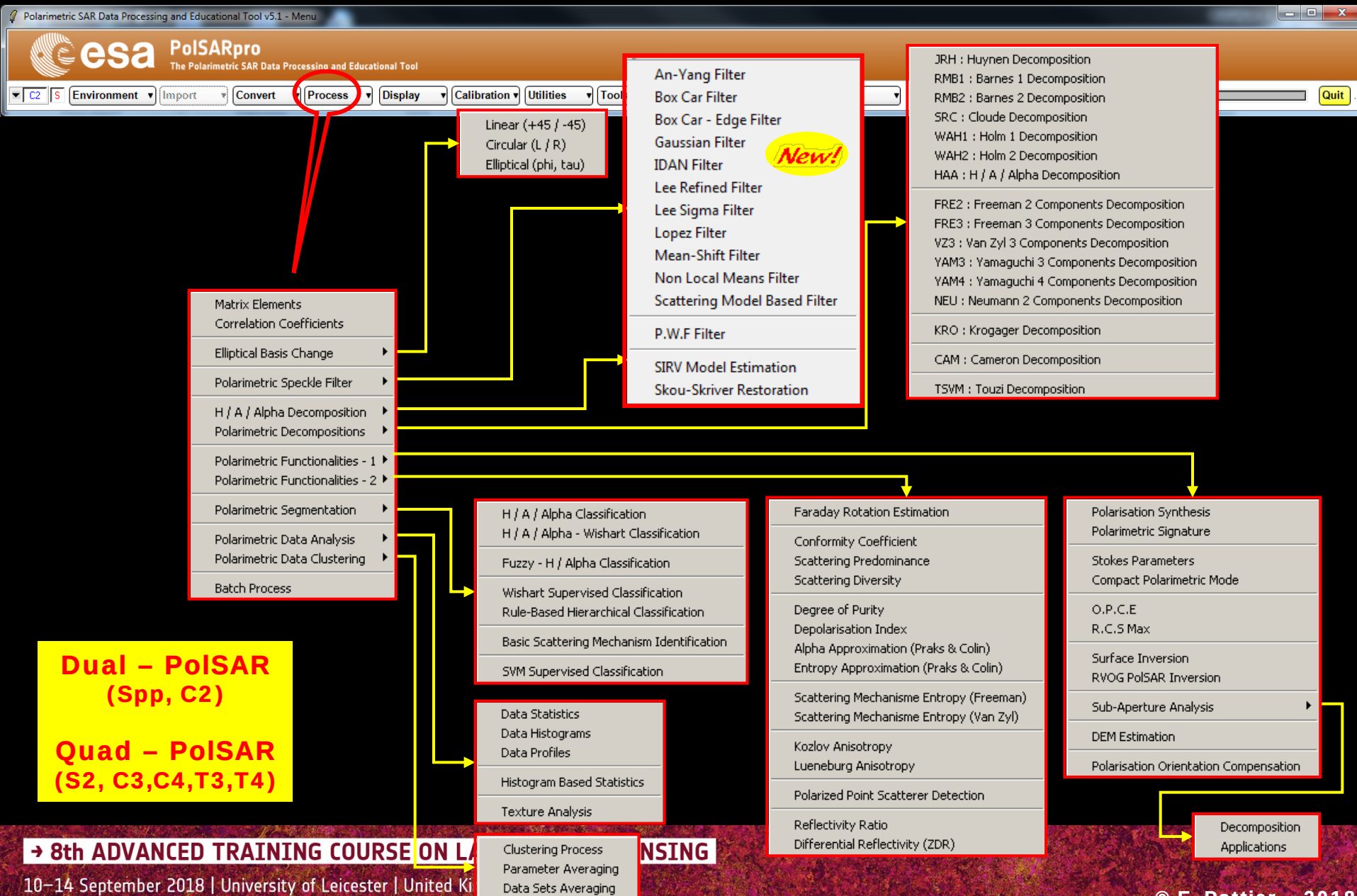
PolSARpro v5.2 SOFTWARE



PolSARpro v5.2 SOFTWARE



PolSARpro v5.2 SOFTWARE



PolSARpro v5.2 SOFTWARE



Polarimetric SAR Data Processing and Educational Tool v5.1 - Menu

esa PolSARpro
The Polarimetric SAR Data Processing and Educational Tool

Environment Import Convert **Process** Display Calibration Utilities Tools

Matrix Elements
Correlation Coefficients
Elliptical Basis Change
Polarimetric Speckle Filter
H / A / Alpha Decomposition
Polarimetric Decompositions
Polarimetric Functionalities - 1
Polarimetric Functionalities - 2
Polarimetric Segmentation
Polarimetric Data Analysis
Polarimetric Data Clustering
Batch Process

Linear (+45 / -45)
Circular (L / R)
Elliptical (phi, tau)

An-Yang Filter
Box Car Filter
Box Car - Edge Filter
Gaussian Filter **New!**
IDAN Filter
Lee Refined Filter
Lee Sigma Filter
Lopez Filter
Mean-Shift Filter
Non Local Means Filter
Scattering Model Based Filter
P.W.F Filter
SIRV Model Estimation
Skou-Skriver Restoration

JRH : Huynen Decomposition
RMB1 : Barnes 1 Decomposition
RMB2 : Barnes 2 Decomposition
SRC : Cloude Decomposition
WAH1 : Holm 1 Decomposition
WAH2 : Holm 2 Decomposition
HAA : H / A / Alpha Decomposition
FRE2 : Freeman 2 Components Decomposition
FRE3 : Freeman 3 Components Decomposition
VZ3 : Van Zyl 3 Components Decomposition
YAM3 : Yamaguchi 3 Components Decomposition
YAM4 : Yamaguchi 4 Components Decomposition
NEU : Neumann 2 Components Decomposition
KRO : Krogager Decomposition
CAM : Cameron Decomposition
TSVM : Touzi Decomposition

H / A / Alpha Classification
H / u / v Classification (Xu & Jin)
H / A / Alpha - Wishart Classification
Scattering Model Based - Wishart Classification
Unified Huynen Classification
Fuzzy - H / Alpha Classification **New!**
Wishart Supervised Classification
G.P.F. Supervised Classification
Rule-Based Hierarchical Classification
Basic Scattering Mechanism Identification
SVM Supervised Classification

Polarisation Synthesis
Polarimetric Signature
Stokes Parameters
Compact Polarimetric Mode
Compact Decomposition
Compact Classification
O.P.C.E **New!**
R.C.S Max
Surface Inversion
Roughness - Soil Inversion
RVOG PolSAR Inversion
Sub-Aperture Analysis
DEM Estimation
Polarisation Orientation Compensation

Dual - PolSAR
(Spp, C2)
Quad - PolSAR
(S2, C3, C4, T3, T4)

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Clustering Process
Parameter Averaging
Data Sets Averaging

Renewability Ratio
Differential Reflectivity (ZDR)

Decomposition Applications

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PolSARpro v5.2 SOFTWARE



Polarimetric SAR Data Processing and Educational Tool v5.1 - Menu

esa PolSARpro
The Polarimetric SAR Data Processing and Educational Tool

Environment Import Convert **Process** Display Calibration Utilities Tools

Linear (+45 / -45)
Circular (L / R)
Elliptical (phi, tau)

Matrix Elements
Correlation Coefficients
Elliptical Basis Change
Polarimetric Speckle Filter
H / A / Alpha Decomposition
Polarimetric Decompositions
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Polarimetric Functionalities - 2
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Polarimetric Data Analysis
Polarimetric Data Clustering
Batch Process

An-Yang Filter
Box Car Filter
Box Car - Edge Filter
Gaussian Filter **New!**
IDAN Filter
Lee Refined Filter
Lee Sigma Filter
Lopez Filter
Mean-Shift Filter
Non Local Means Filter
Scattering Model Based Filter
P.W.F Filter
SIRV Model Estimation
Skou-Skriver Restoration

H / A / Alpha Classification
H / u / v Classification (Xu & Jin)
H / A / Alpha - Wishart Classification
Scattering Model Based - Wishart Classification
Unified Huynen Classification
Fuzzy - H / Alpha Classification **New!**
Wishart Supervised Classification
G.P.F. Supervised Classification
Rule-Based Hierarchical Classification
Basic Scattering Mechanism Identification
SVM Supervised Classification

KRO : Krogager Decomposition
CAM : Cameron Decomposition
HAA : H / A / Alpha Decomposition
JRH : Huynen Decomposition
RMB1 : Barnes 1 Decomposition **New!**
RMB2 : Barnes 2 Decomposition
SRC : Cloude Decomposition
UHDx : Unified Huynen Decomposition
WAH1 : Holm 1 Decomposition
WAH2 : Holm 2 Decomposition
AN3 : An & Yang 3 Component Decomposition
AN4 : An & Yang 4 Component Decomposition
BF4 : Bhattacharya & Frey 4 Component Decomposition
FRE2 : Freeman 2 Component Decomposition
FRE3 : Freeman 3 Component Decomposition
NEU : Neumann 2 Component Decomposition
NNED : Arie 3 Component NNED Decomposition
ANNED : Arie 3 Component ANNED Decomposition
VZ3 : Van Zyl (1992) 3 Component Decomposition
SIN4 : Singh 4 Component Decomposition
YAM3 : Yamaguchi 3 Component Decomposition
YAM4 : Yamaguchi 4 Component Decomposition
MCSM5 : L. Zhang 5 Component Decomposition
TSVM : Touzi Decomposition
Aghababaei Decomposition
2KR : Raney Decomposition
CPD : Compact-Pol Decomposition
Sub-Aperture Analysis
DEM Estimation
Polarisation Orientation Compensation
Decomposition Applications

Dual - PolSAR
(Spp, C2)

Quad - PolSAR
(S2, C3, C4, T3, T4)

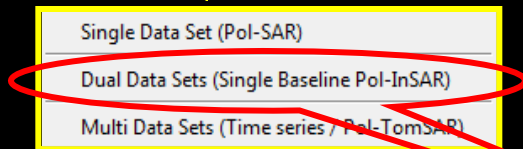
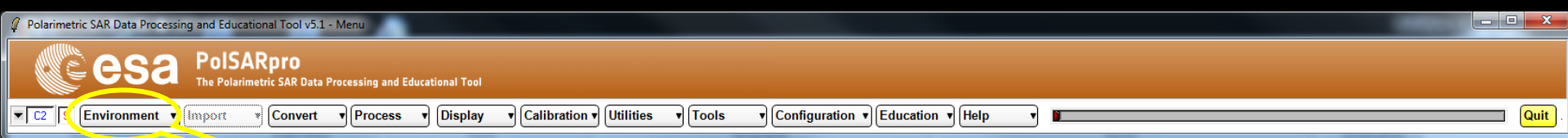
8th ADVANCED TRAINING COURSE ON POLSAR DATA PROCESSING
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Clustering Process
Parameter Averaging
Data Sets Averaging

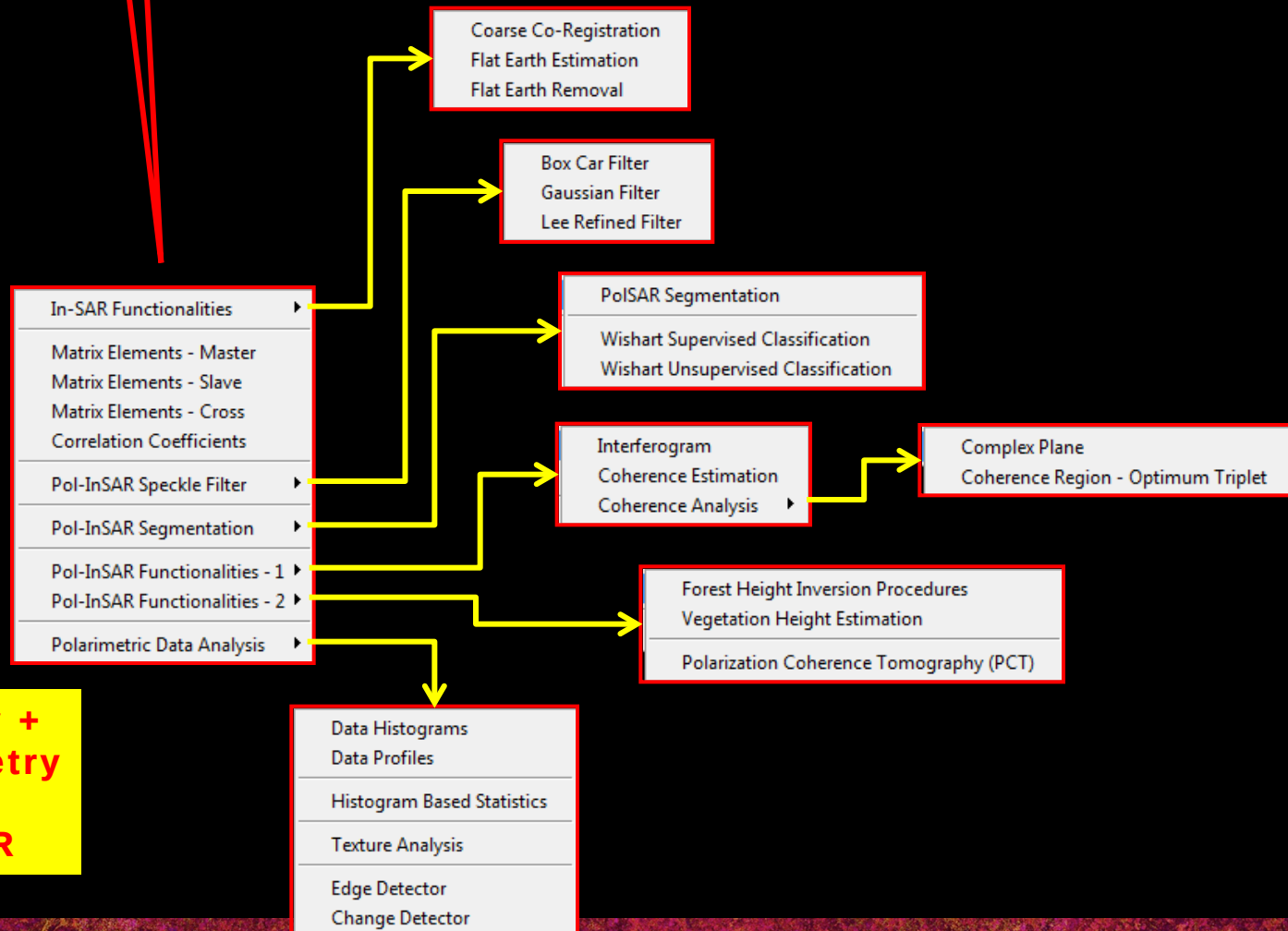
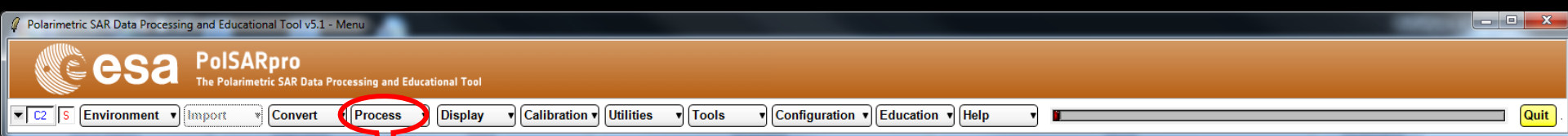
Renewability Ratio
Differential Reflectivity (ZDR)

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PolSARpro v5.2 SOFTWARE



PolSARpro v5.2 SOFTWARE



**Polarimetry +
Interferometry**

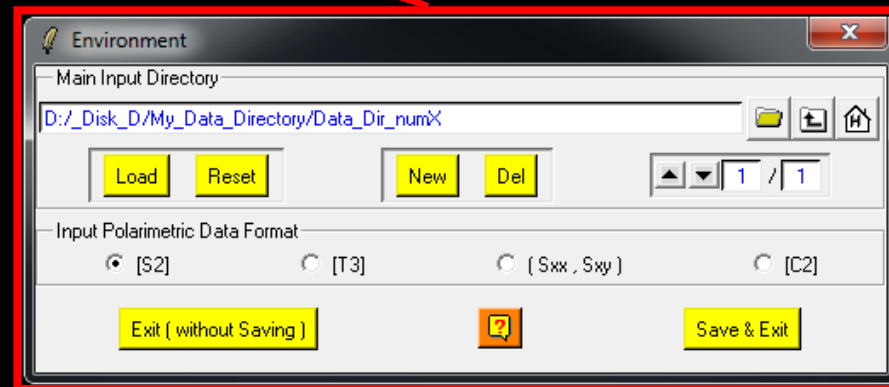
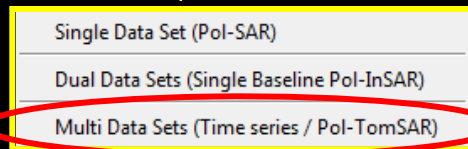
Pol-InSAR

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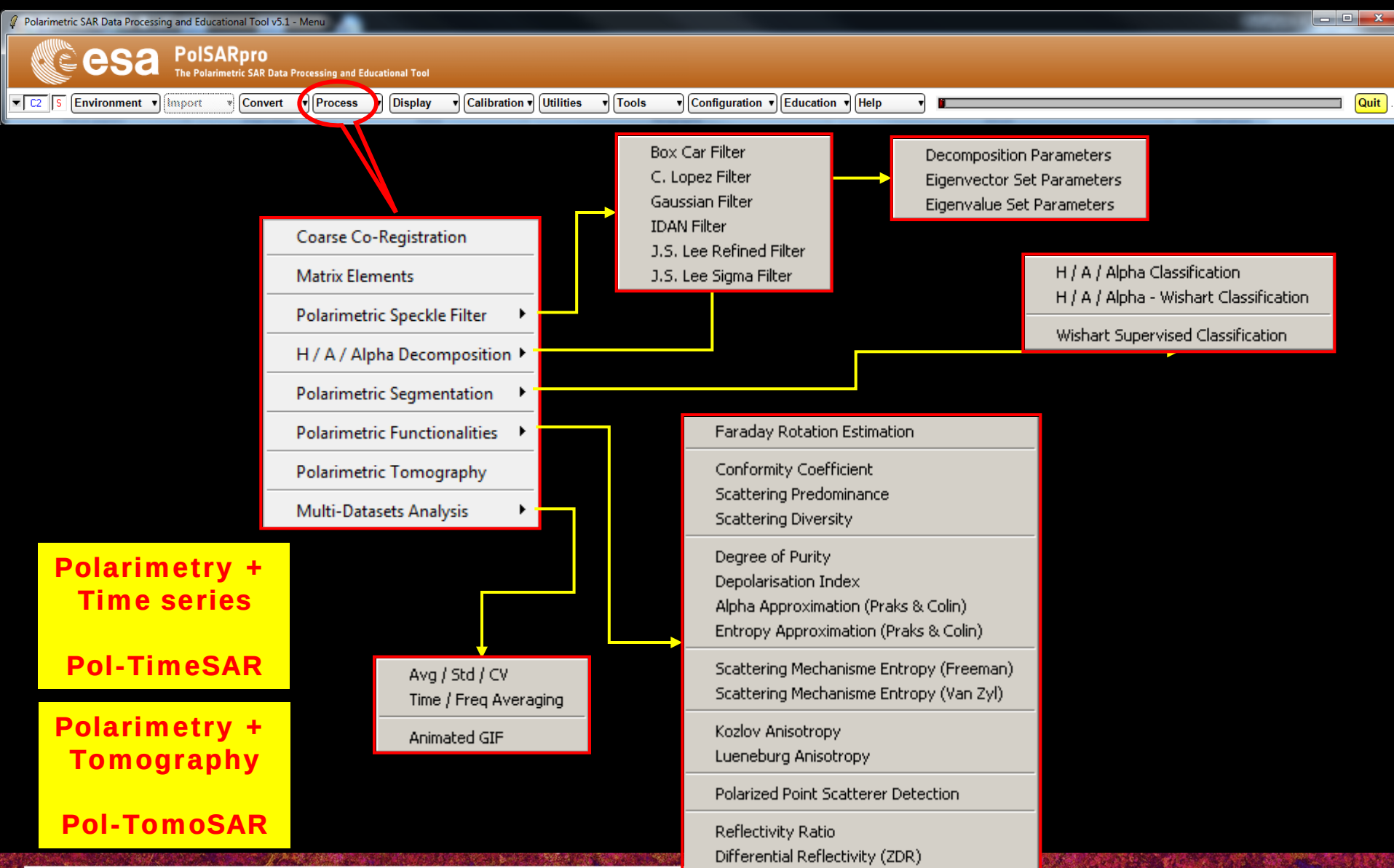
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PolSARpro v5.2 SOFTWARE



PolSARpro v5.2 SOFTWARE



**Polarimetry +
Time series**

Pol-TimeSAR

**Polarimetry +
Tomography**

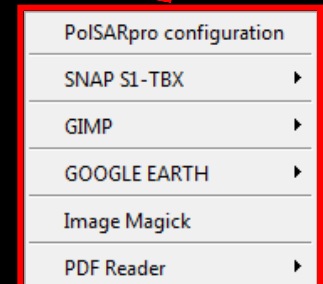
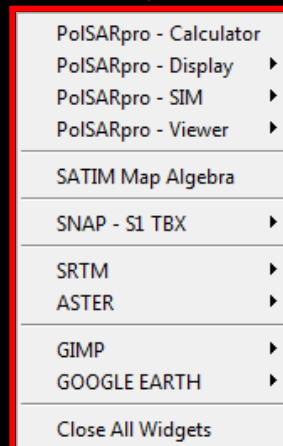
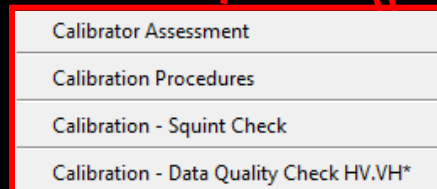
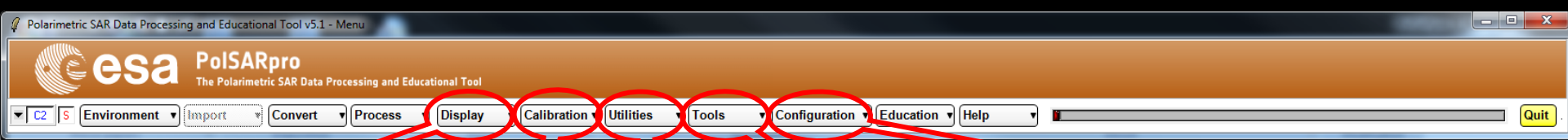
Pol-TomoSAR

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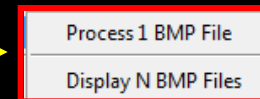
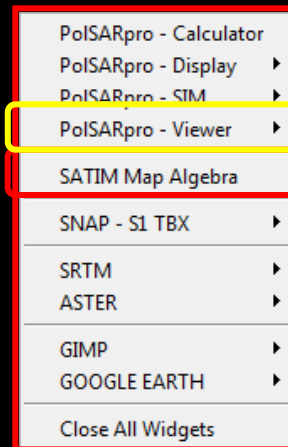
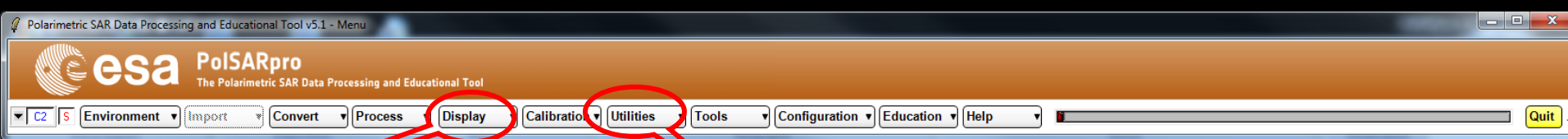
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PolSARpro v5.2 SOFTWARE



PolSARpro v5.2 SOFTWARE



A new tool (**Map Algebra**) for visualization and simple processing of the PolSARpro results

Based on the OpenGL technology : open and process large image (20000 x 20000)

SATIM Map Algebra



Polarimetric SAR Data Processing and Educational Tool v5.1 - Menu



PoISARpro
The Polarimetric SAR Data Process

C2 S Environment Import Convert P

Display



Create BMP File

Create RGB File

Create HSL File

Create KML File

Create Anim GIF File

Create Gray &
Color BMP File

Create Scatter Plot

Create Tomogram Display

Convert BMP File

Process 1 BMP File

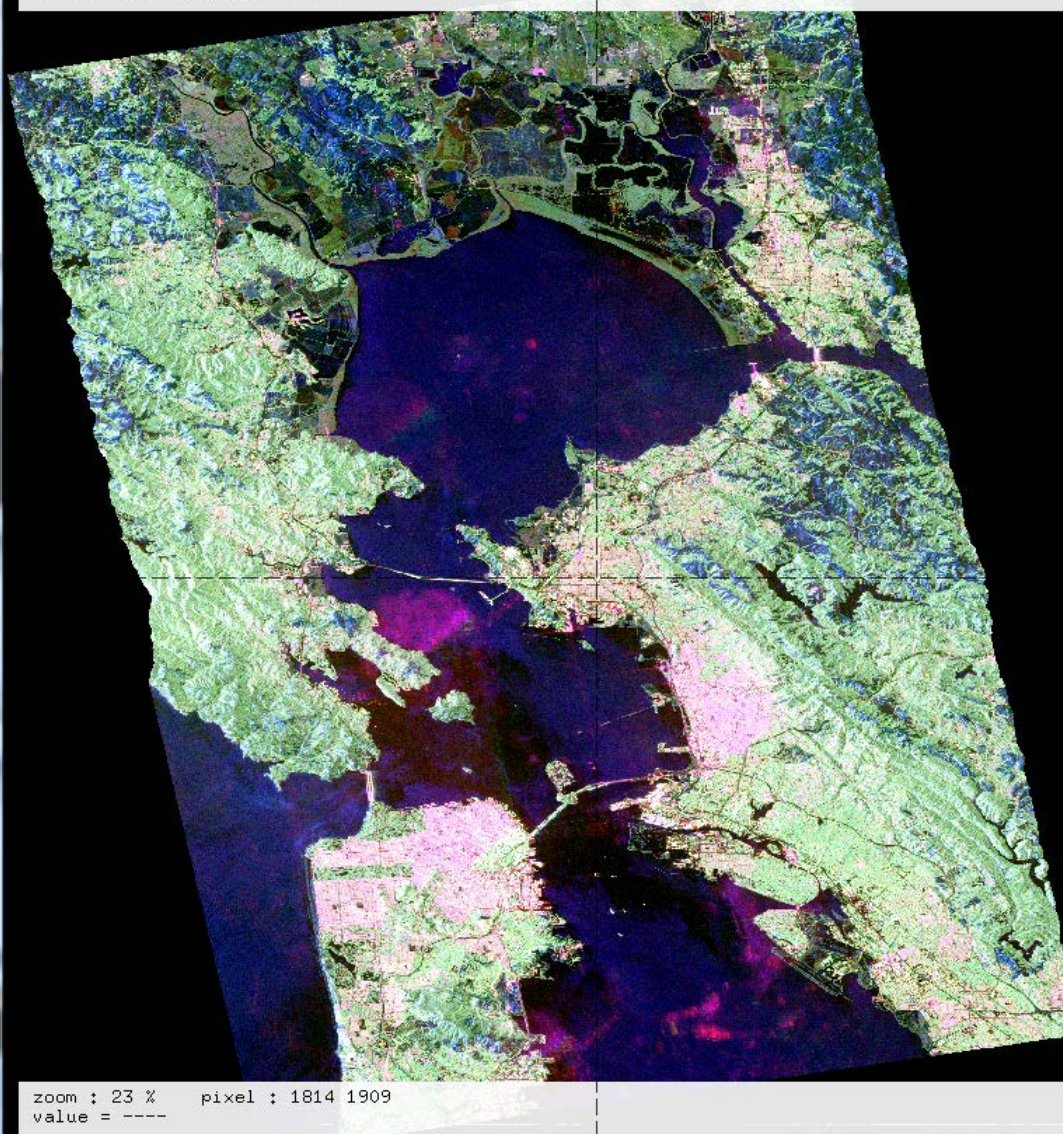
Display N BMP Files

SATIM Map Algebra

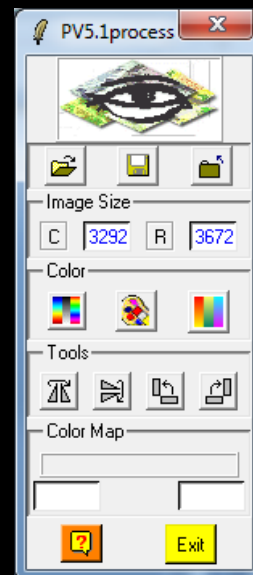
Exit

MapAlgebra v1.1

-1- PauliRGB.bmp (3292x3672)



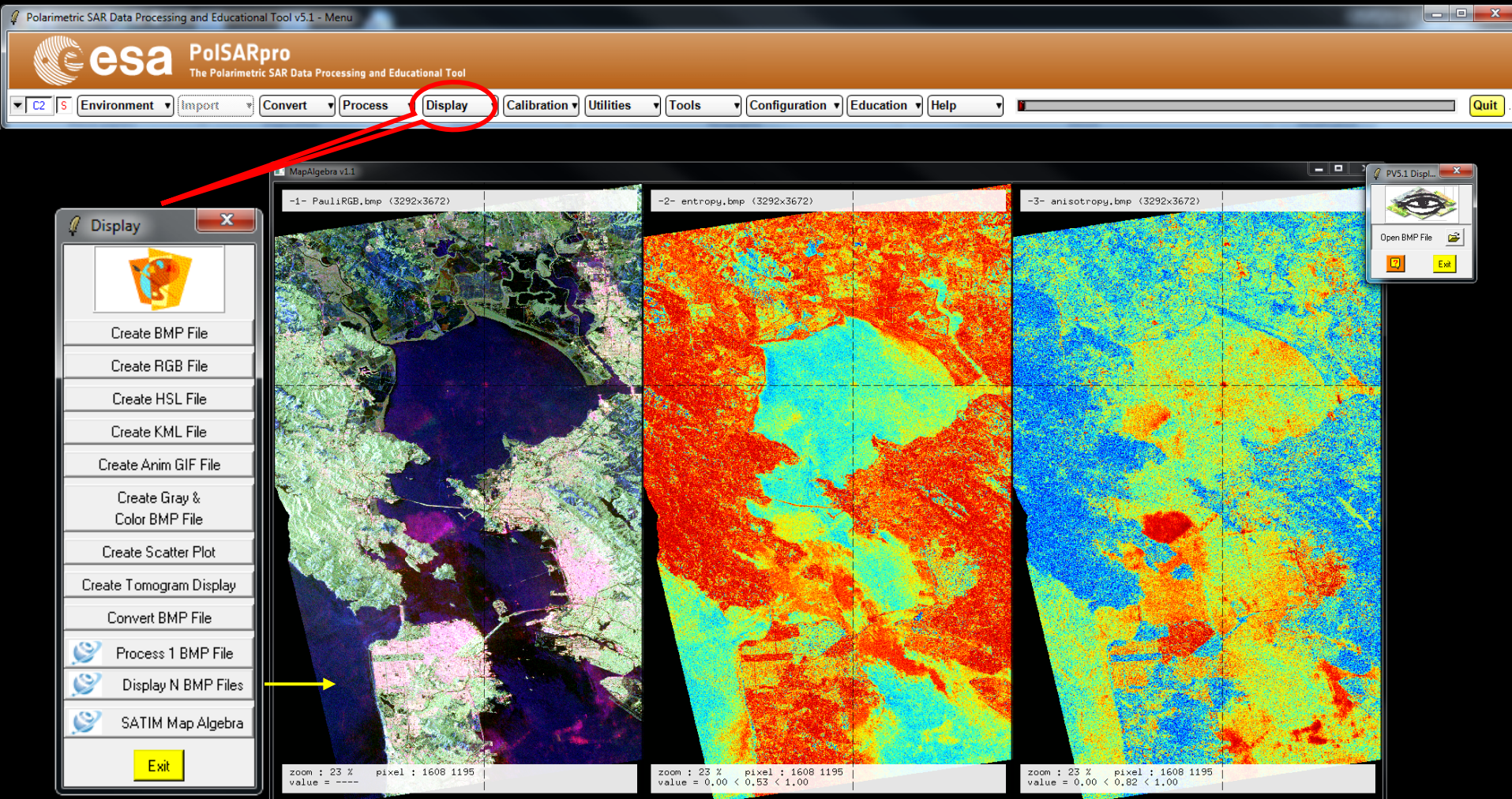
zoom : 23 % pixel : 1814 1909
value = ----



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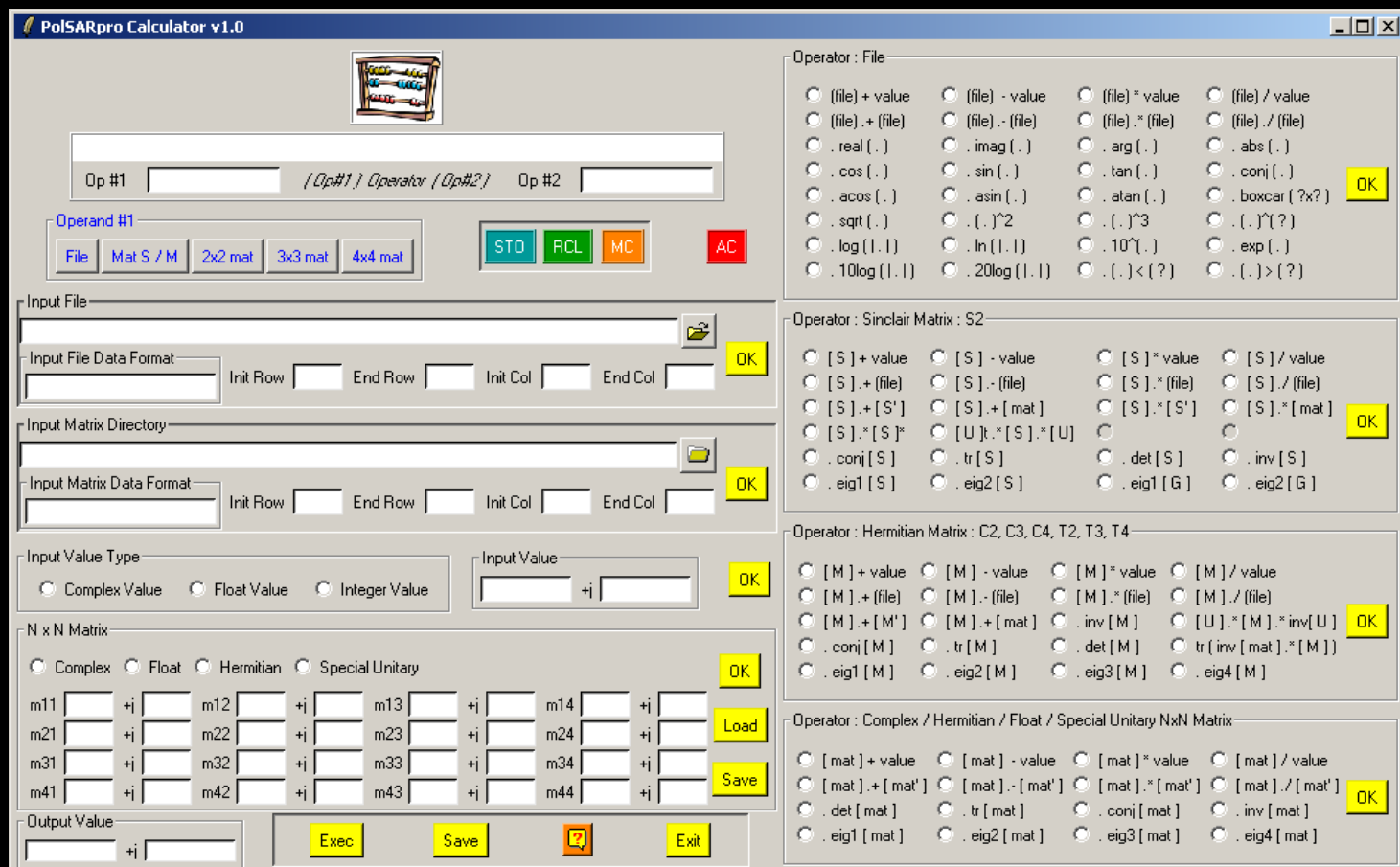
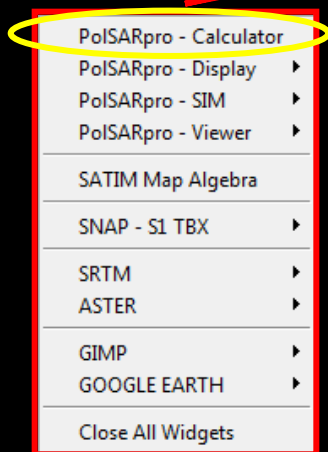
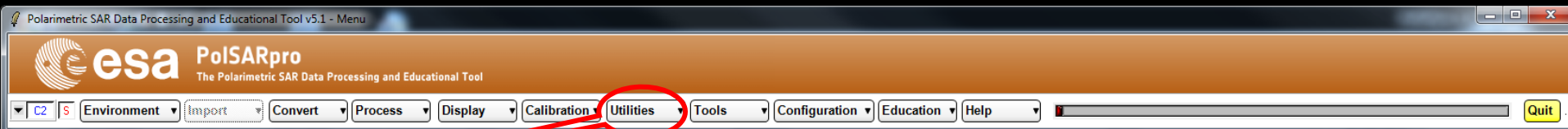
10-14 September 2018 | University of

SATIM Map Algebra



Display N BMP Images

PolSARpro v5.2 SOFTWARE

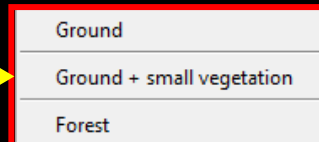
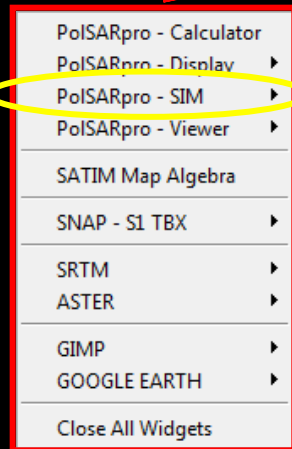
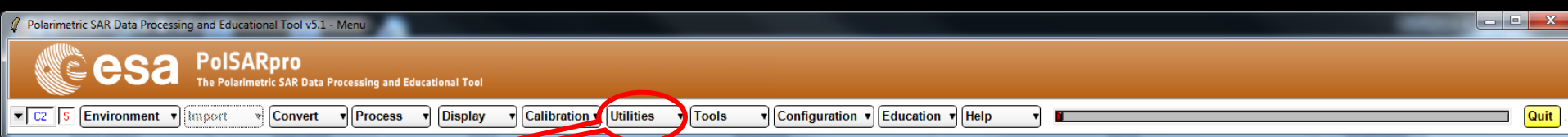


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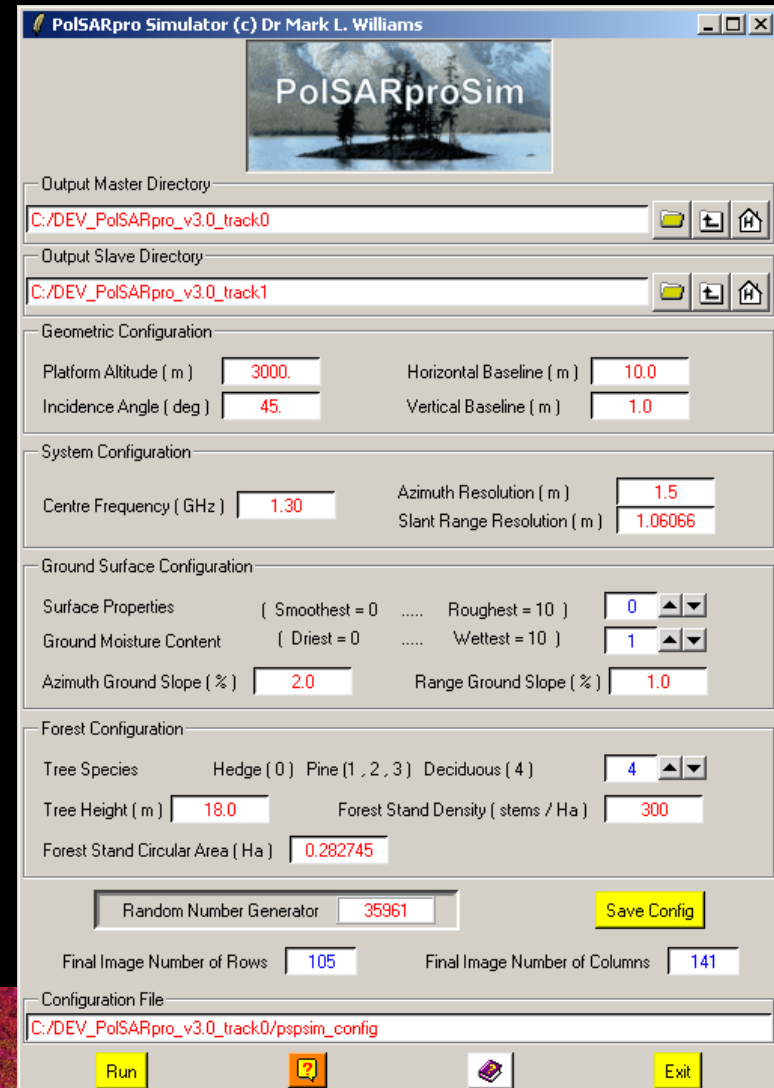
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PolSARpro v5.2 SOFTWARE



Mark Williams

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



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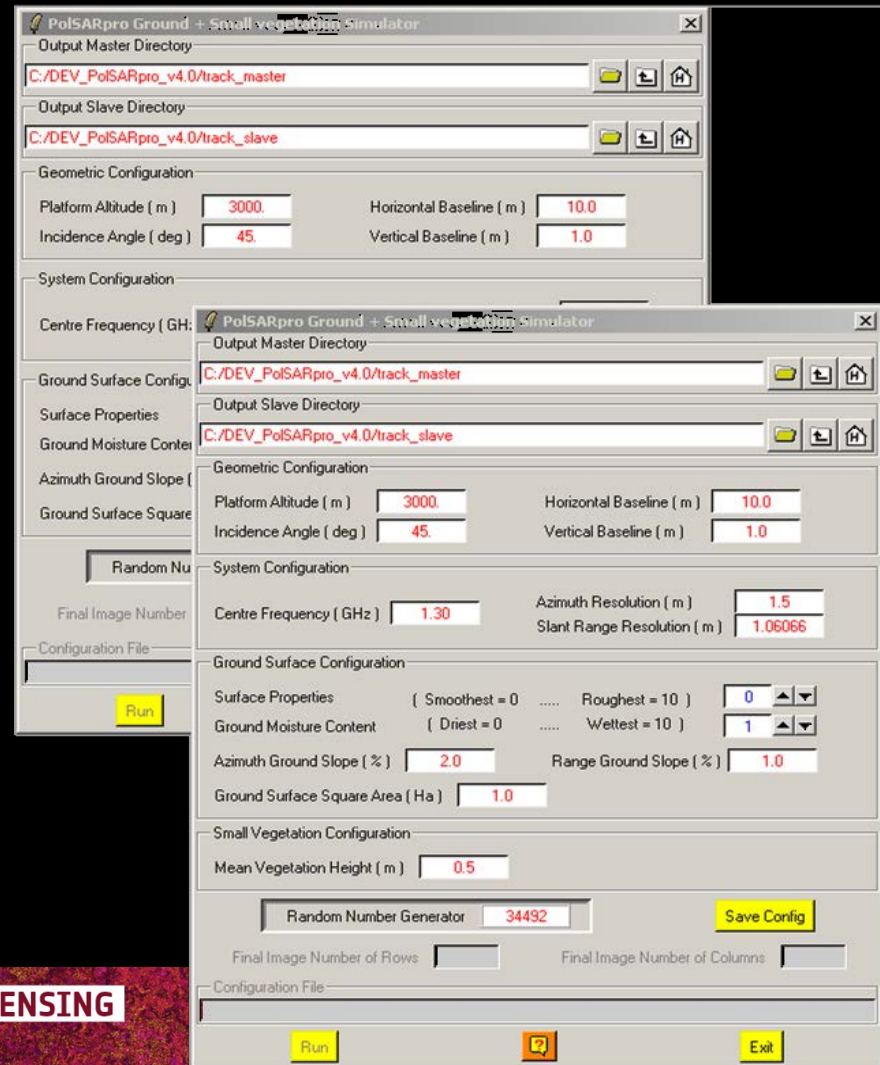
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PolSARpro v5.2 SOFTWARE



- PolSARpro - Calculator
- PolSARpro - Display
- PolSARpro - SIM**
- PolSARpro - Viewer
- SATIM Map Algebra
- SNAP - S1 TBX
- SRTM
- ASTER
- GIMP
- GOOGLE EARTH
- Close All Widgets

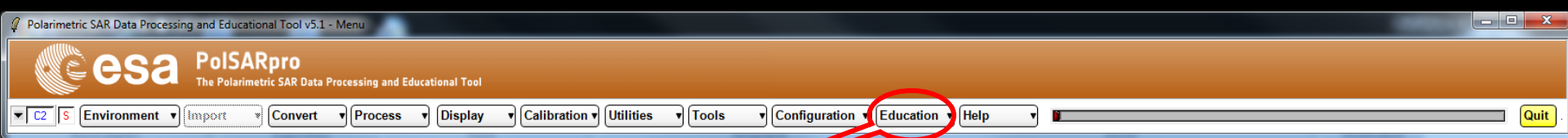
- Ground
- Ground + small vegetation
- Forest



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PolSARpro v5.2 SOFTWARE



PolSARap Tutorial (C. Lopez - E. Pottier) ▶

PolSARap Showcases

Lectures Notes ▶



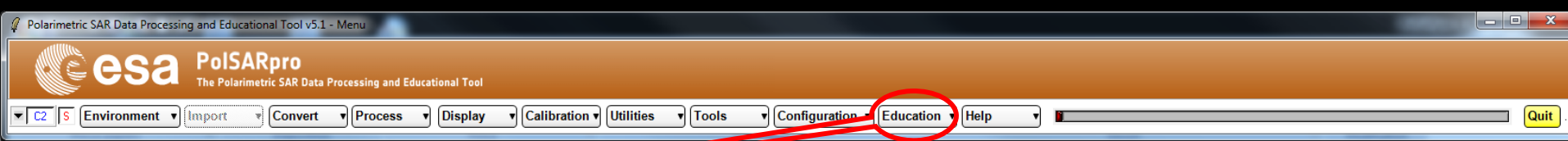
Learning / Training Next P.I Generations

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PolSARpro - Bio SOFTWARE



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

PolSAR-Ap Project



1 Basic Principles of SAR Polarimetry

C. Lopez Martinez¹, E. Pottier²

¹UPC Barcelona
²University of Kansas-1

1.1 Theory of radar polarimetry

1.1.1 Wave polarimetry

Polarimetry refers specifically to the vector nature of the electromagnetic waves, whereas radar polarimetry is the science of acquiring, processing and analyzing the polarization state of an electromagnetic wave in radar applications. This section summarizes the main theoretical aspects necessary for a correct processing and interpretation of the polarimetric information. As a result, the first part presents the so called wave polarimetry that deals with the representations and the understanding of the polarization state of an electromagnetic wave. The second part introduces the concept of scattering polarimetry. This concept extends the scope of analyzing the properties of a given target, from a polarimetric point of view, given the incident and the scattered polarized electromagnetic waves.

1.1.1.1 Electromagnetic waves and wave polarization descriptors

The generation, the propagation, as well as the interaction with matter of the electric and the magnetic waves are governed by the Maxwell's equations [1]. For an electromagnetic wave that is propagating in the z direction, the real electric wave can be decomposed into two orthogonal components: E_x and E_y , assuming the following vector formulation:

$$\mathbf{E}(x, y) = \begin{bmatrix} E_x \\ E_y \\ 0 \end{bmatrix} = \begin{bmatrix} E_0 \cos(\alpha - kx + \delta_x) \\ E_0 \cos(\alpha - ky + \delta_y) \\ 0 \end{bmatrix} \quad (1.1)$$

which may be also considered in a complex form

66

Inventory matrices must be address by considering a better exploitation of the Wishart distribution. As shown in [72] and [73], the Wishart distribution allows defining the multiplicative-additive speckle noise model for all the elements of the covariance or the coherency matrices. This model has been exploited for PolSAR data filtering in [76], where it is demonstrated that if the filtering process is adapted to the multiplicative or additive nature of speckle, depending on the correlation of a pair of SAR images, it may lead to an improved estimation of the different parametric parameters that characterize the covariance or coherency matrices.



Fig. 1.8. Radarim-2 polarimetric: RGB image view San Francisco (USA) when the colour code is: I_{hh} , I_{hv} , I_{vh} and I_{vv} , green. Filtered image with the LLMMSE speckle filter.



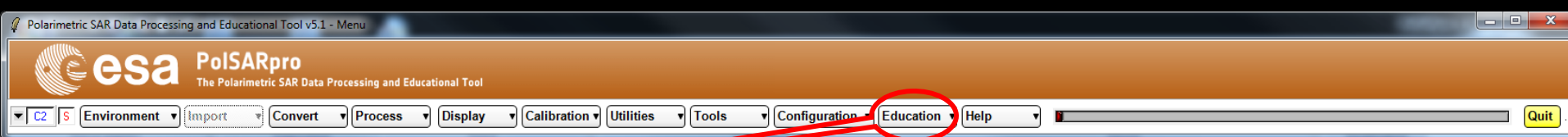
Fig. 1.9. Radarim-2 polarimetric: RGB image view San Francisco (USA) when the colour code is: I_{hh} , I_{hv} , I_{vh} and I_{vv} , green. Filtered image with the SPT speckle filter.

Beyond all the PolSAR data filtering techniques presented in this Section, there exist a wide variety of similar approaches in the related literature, where a com-

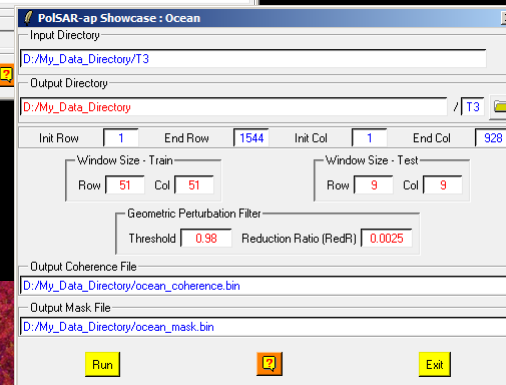
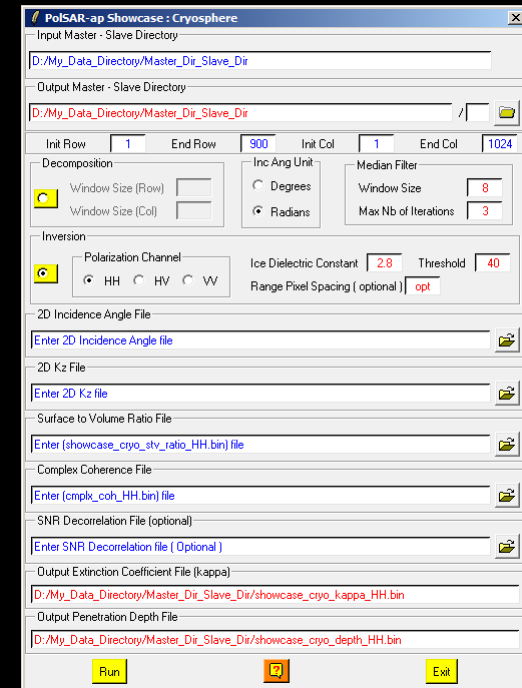
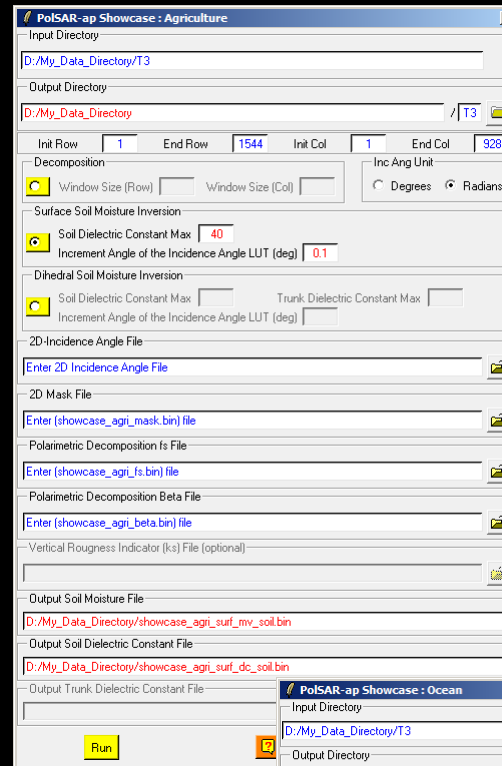
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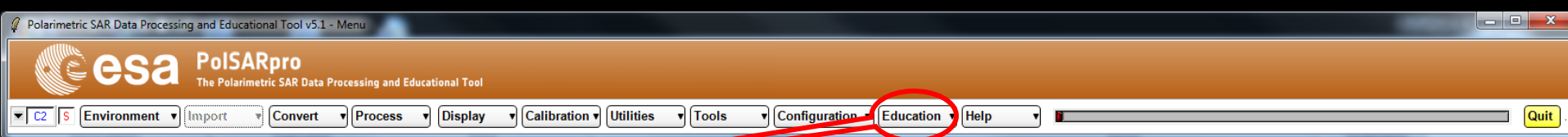
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Advanced Concepts (E. Pottier, J.S. Lee, L. Ferro-Famil)

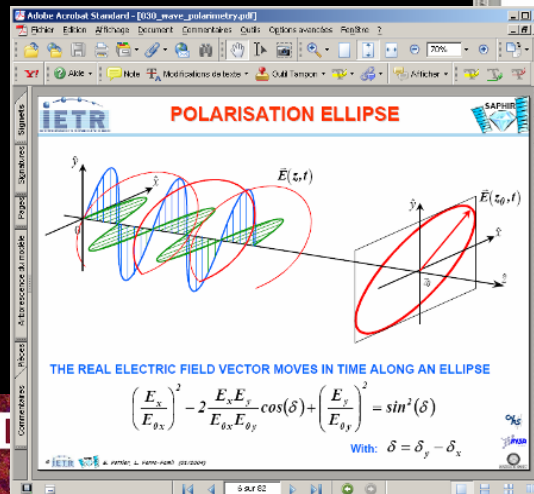
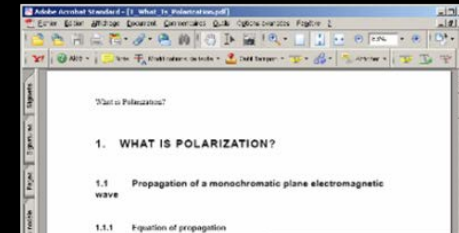
Polarimetric SAR Interferometry (S.R. Cloude, K. Papathanassiou) ▶

Surface Parameter Retrieval (I. Hajnsek, K. Papathanassiou) ▶

Single vs multi polarization interferometry

Pol-InSAR (Training Course)

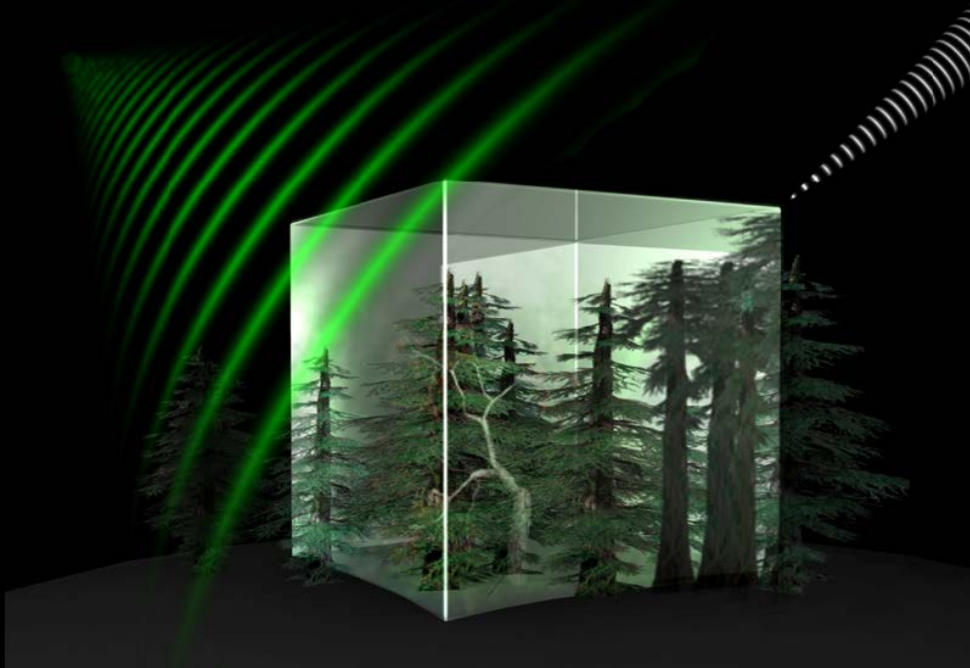
Polarization Coherence Tomography (Training Course)



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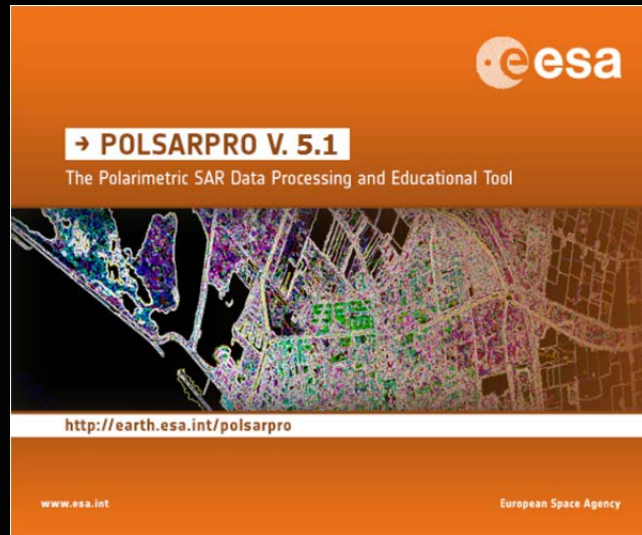
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BIOMASS mission : 7th ESA Earth Explorer (2021)



Biomass will provide **global maps** of the amount of **carbon stored** in the world's forests and how this **changes** over time.

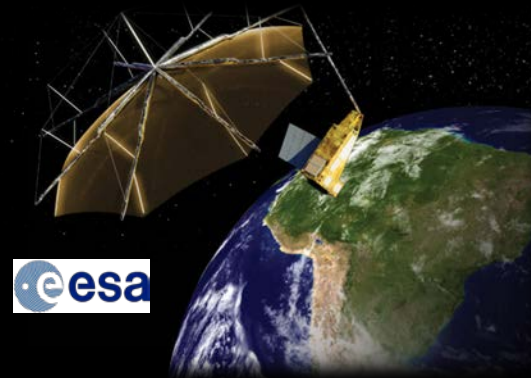
Further our **knowledge** of the role **forests** play in the **carbon cycle**.



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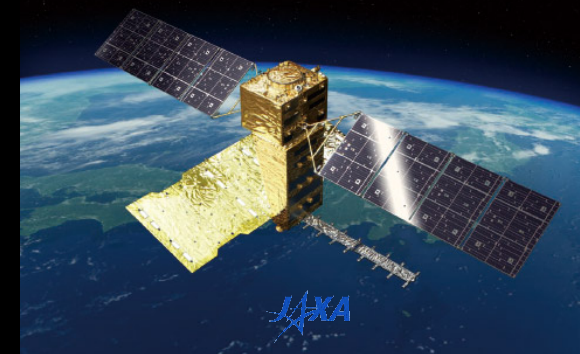
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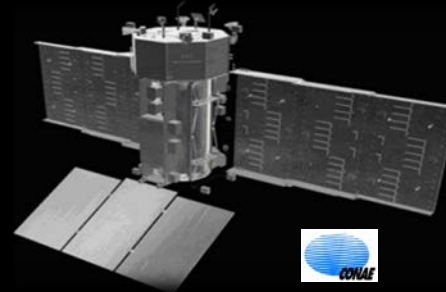
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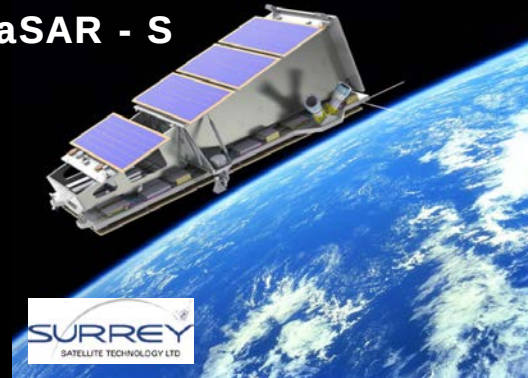


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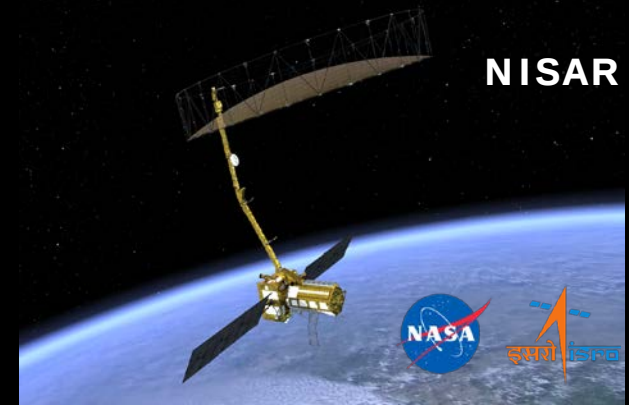
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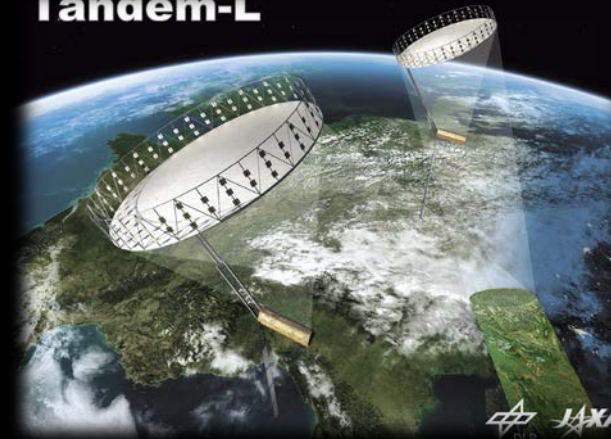
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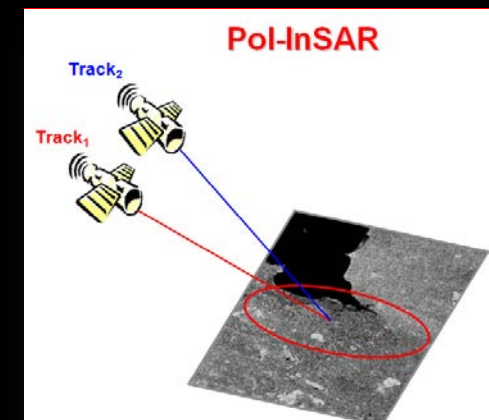
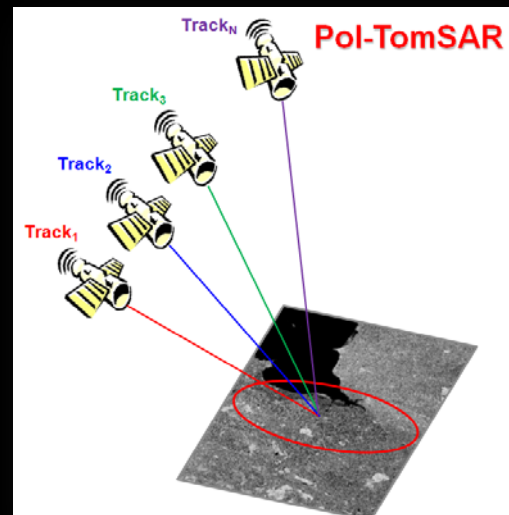
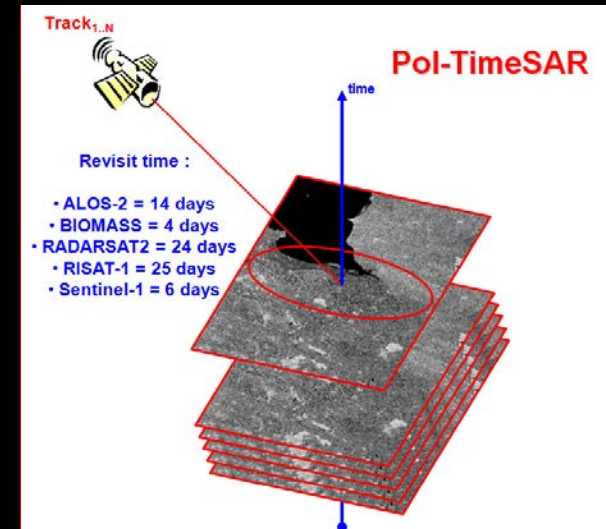
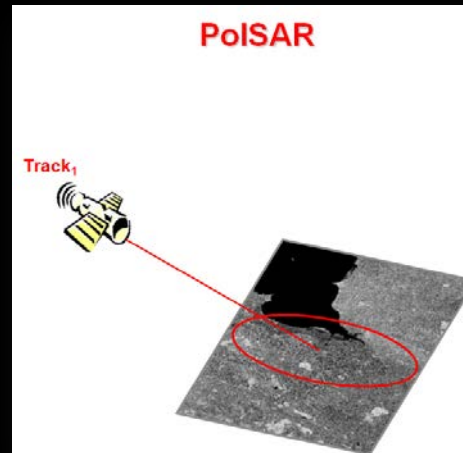
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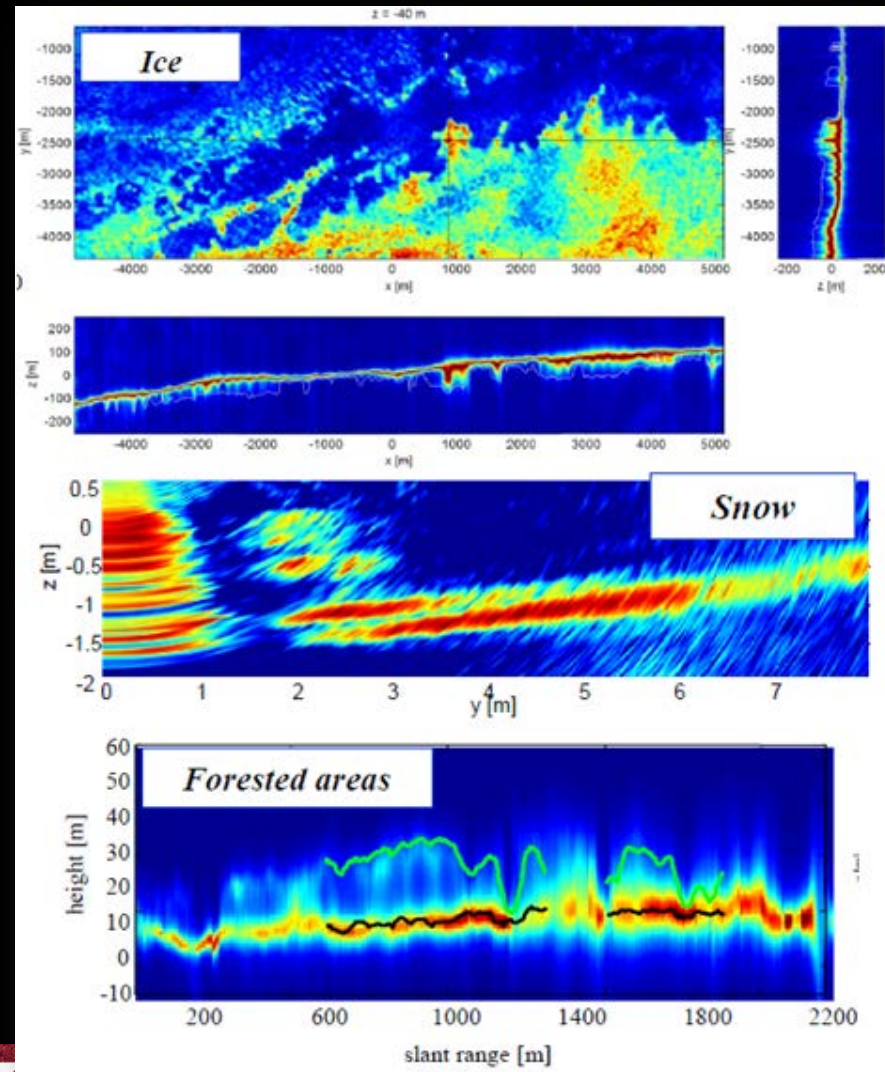
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PolSARpro - Bio will offer the possibility to handle and convert polarimetric data of **FUTURE polarimetric spaceborne platforms**.

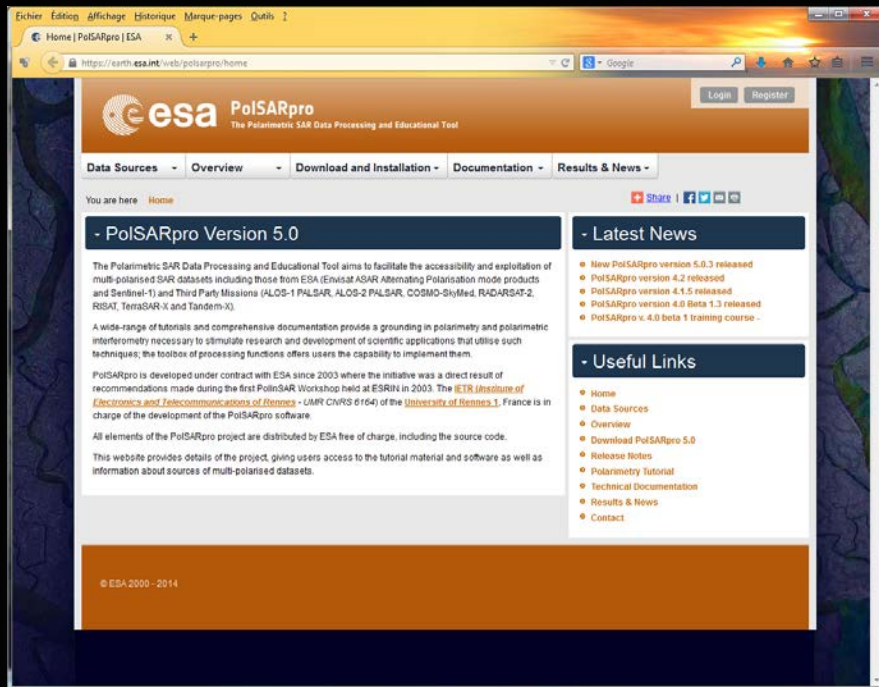
New functionalities



Pol-TomoSAR processor



<http://earth.esa.int/web/polsarpro>



The Web Site provides

- **Details of the project**
- **Access to the tutorial and software**
- **Information about status of the development**
- **Demonstration Sample Datasets**

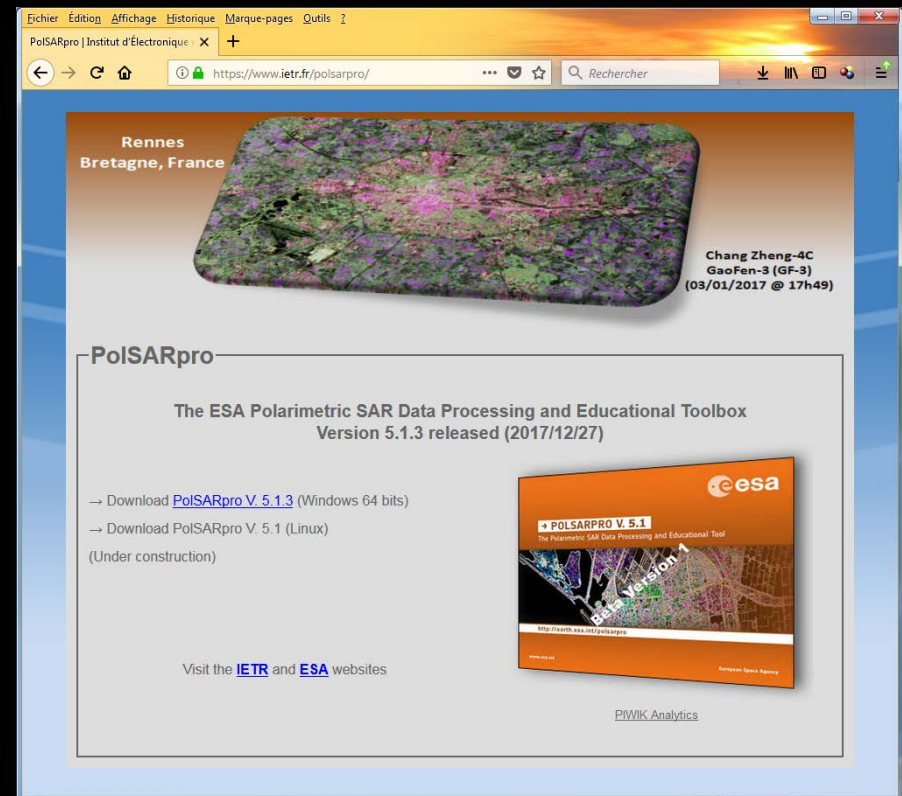
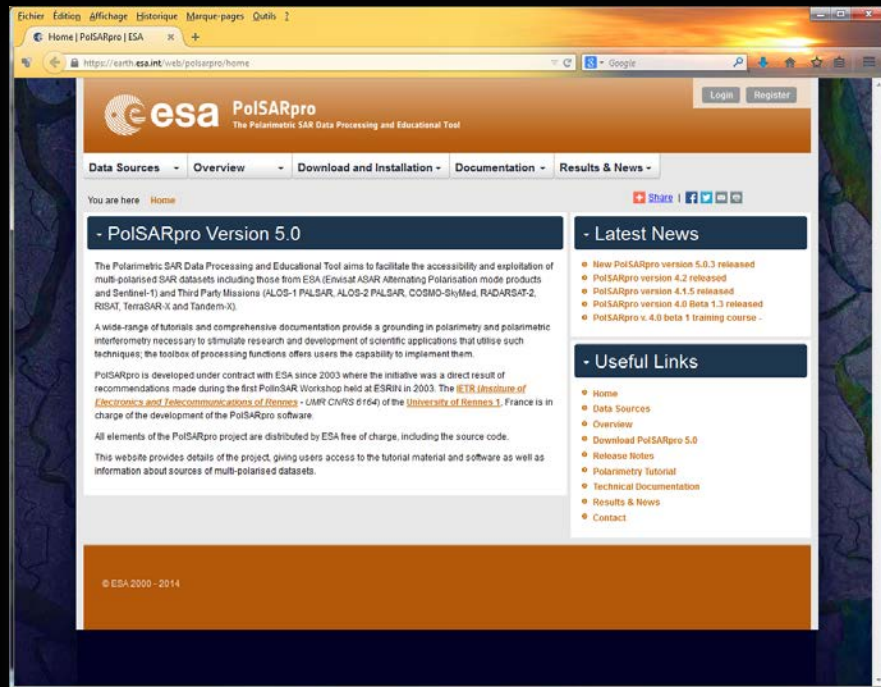
ESA validated, tested and vetted releases

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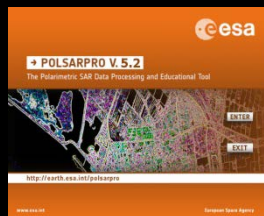


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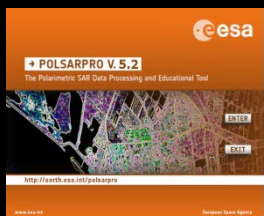
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- Permanent updates (bugg fixed, new functionalities ...)
- Beta version releases (not ESA validated)

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PolSARpro - v5.2 : Linux *light* version



PolSARpro - v5.2
complete version



December 2018



October 2018



PolSARpro - Bio : Distribution will start from January 2019

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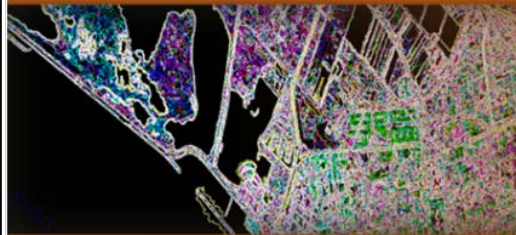
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The Polarimetric SAR Data Processing and Education



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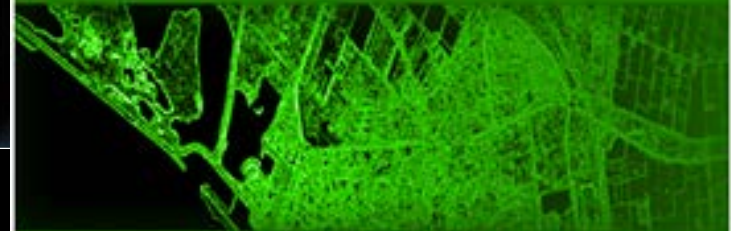
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Questions ?



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The Polarimetric SAR Data Processing and Educational Tool



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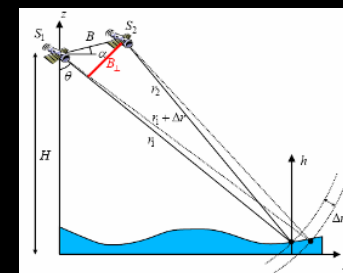
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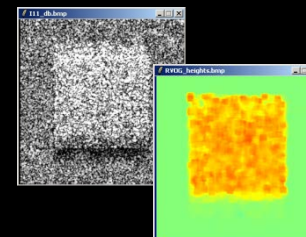
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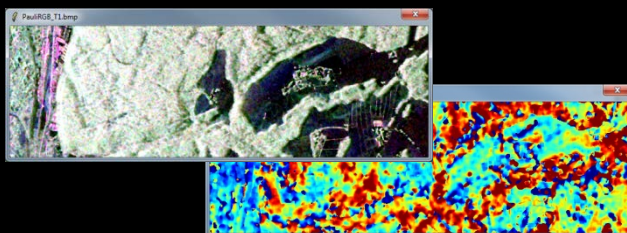
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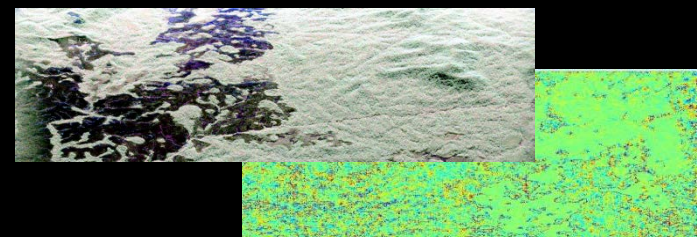
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2nd part : Airborne Pol-InSAR datasets (*ESAR - DLR*)



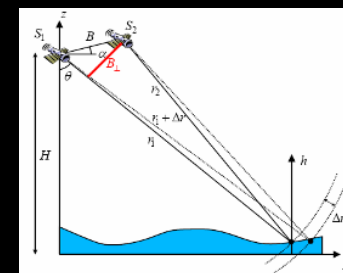
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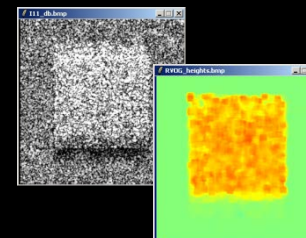
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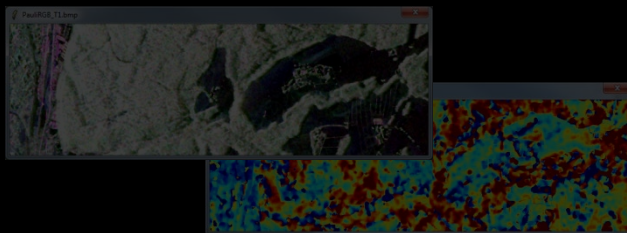
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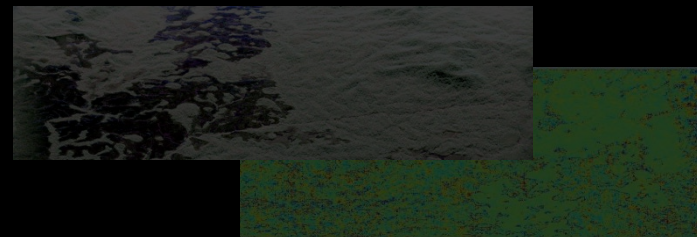
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Polarimetric SAR Data Processing and Educational Tool v5.1 - Menu

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The Polarimetric SAR Data Processing and Educational Tool

Environment Import Convert Process Display Calibration Utilities Tools Configuration **Education** Help Quit

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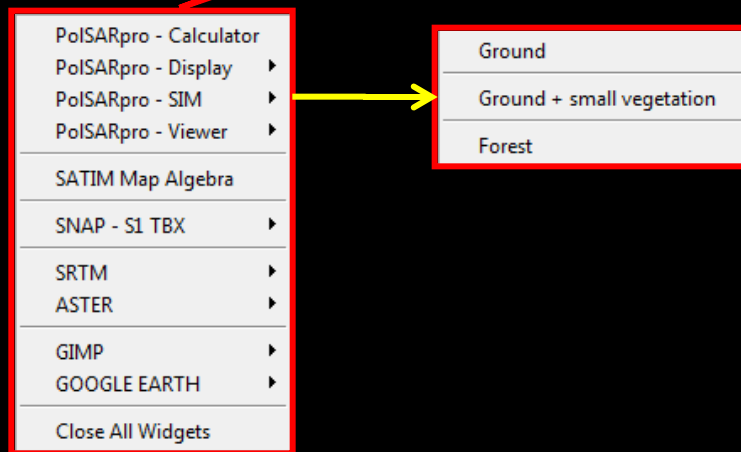
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- Advanced Concepts (E. Pottier, J.S. Lee, L. Ferro-Famil)
- Polarimetric SAR Interferometry (S.R. Cloude, K. Papathanassiou) ▶
- Surface Parameter Retrieval (I. Hajnsek, K. Papathanassiou) ▶

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

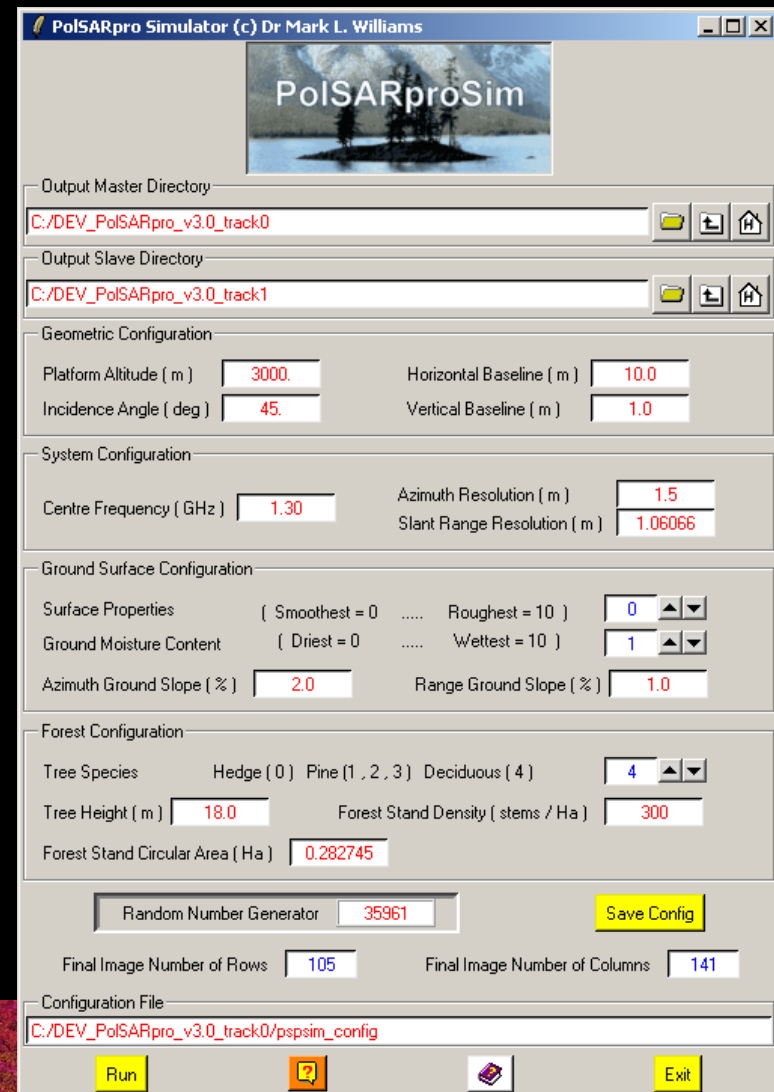
SENSING

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PolSARpro – SIM



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



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



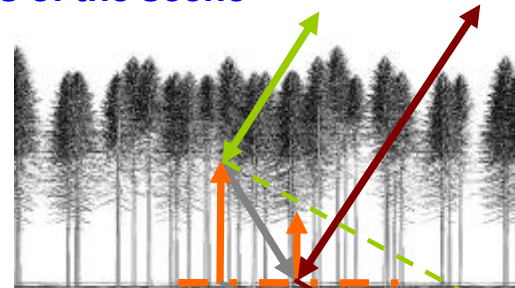
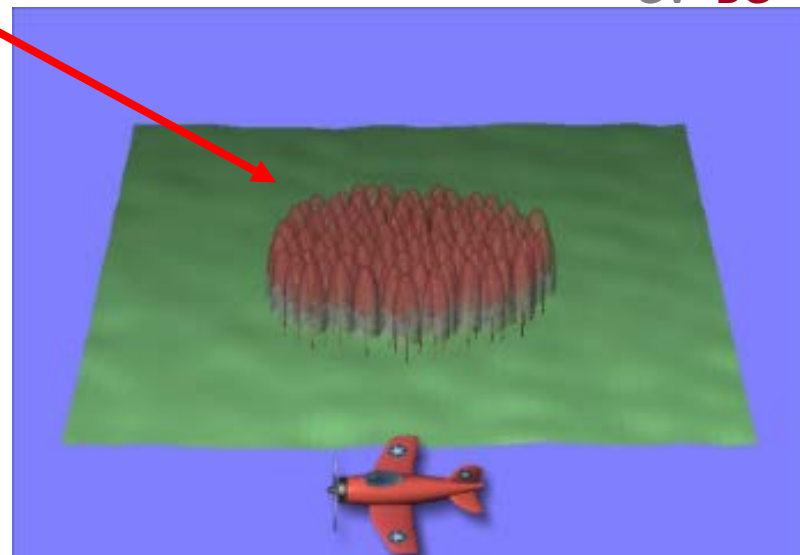
PINE



DECIDUOUS



RANDOM HEDGE

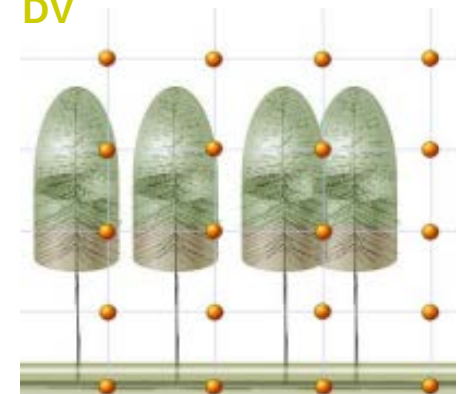


Direct-Ground, Direct-Volume and Ground-Volume contributions are included, with both trees and short vegetation comprising Volume terms.



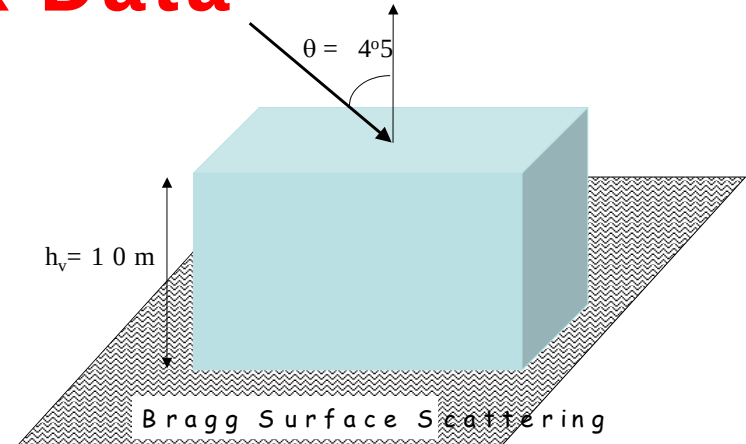
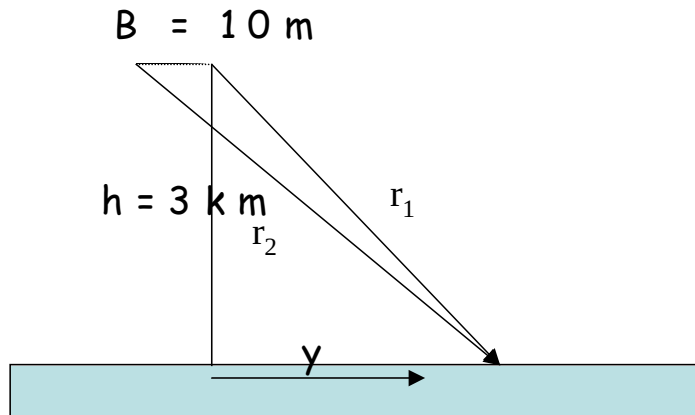
GV DG

DV



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

Pol-InSAR Data



Geometric configuration

Platform altitude :	3000m
Incidence angle:	45°
Horizontal Baseline :	10m
Vertical Baseline :	0m

System Configuration

Frequency :	1.5 GHz
Azimuth resolution :	1.3811 m
Range resolution :	0.6905 m

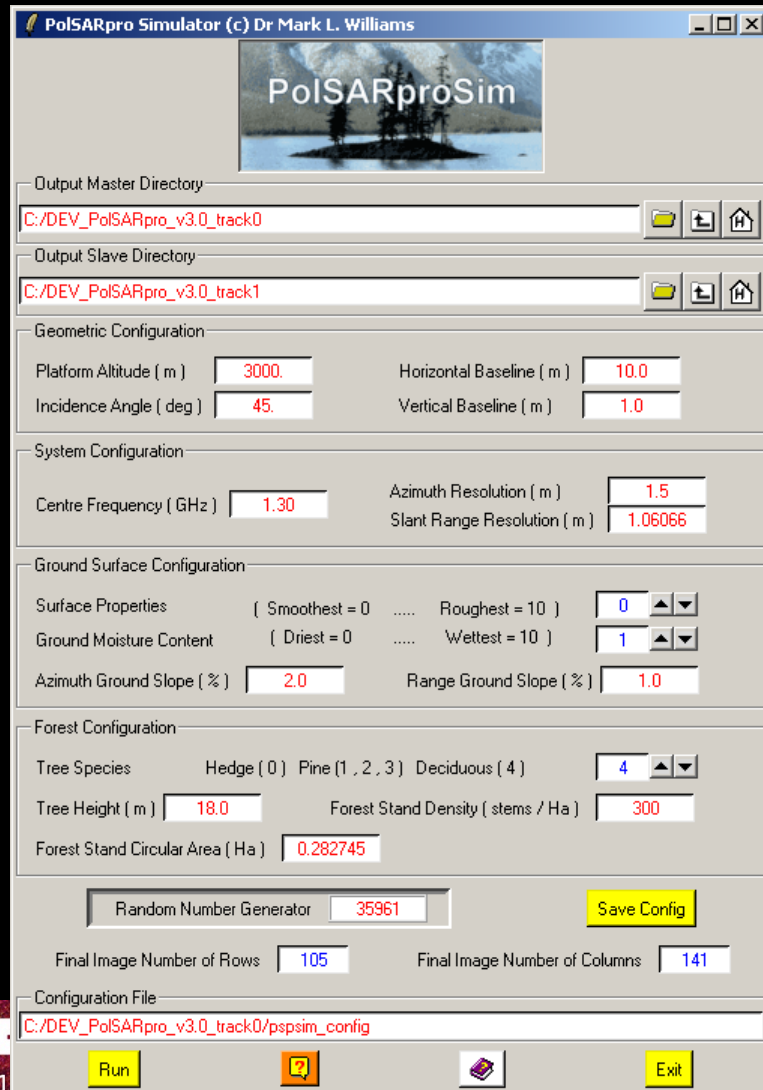
Ground Surface Configuration

Surface properties :	0 (smoothest)
Ground moisture Content :	0 (driest)
Azimuth / Range ground slope :	0 %

Forest configuration

Tree Species :	0 (hedge)
Tree Height:	10m
Forest stand density :	0.2
Forest Stand Circular Area :	1 Ha

PolSARpro – SIM



DATA_MASTERDIR

config.txt

s11.bin, s12.bin
s21.bin, s22.bin

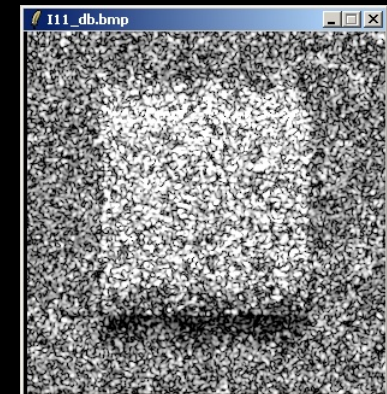
DATA_SLAVEDIR

config.txt

s11.bin, s12.bin
s21.bin, s22.bin

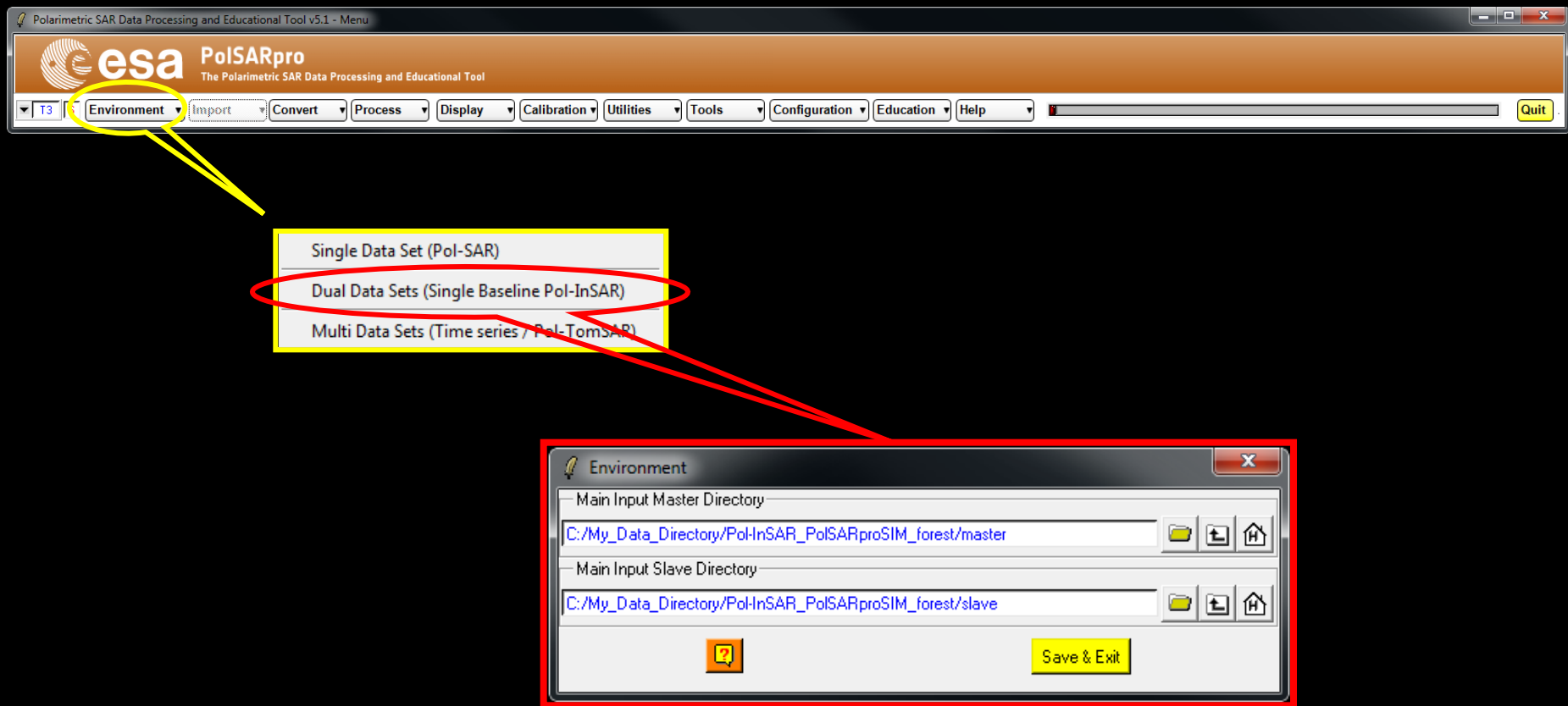
flat_earth.bin

kz.bin



OTE SENSING

MAIN MENU - ENVIRONMENT



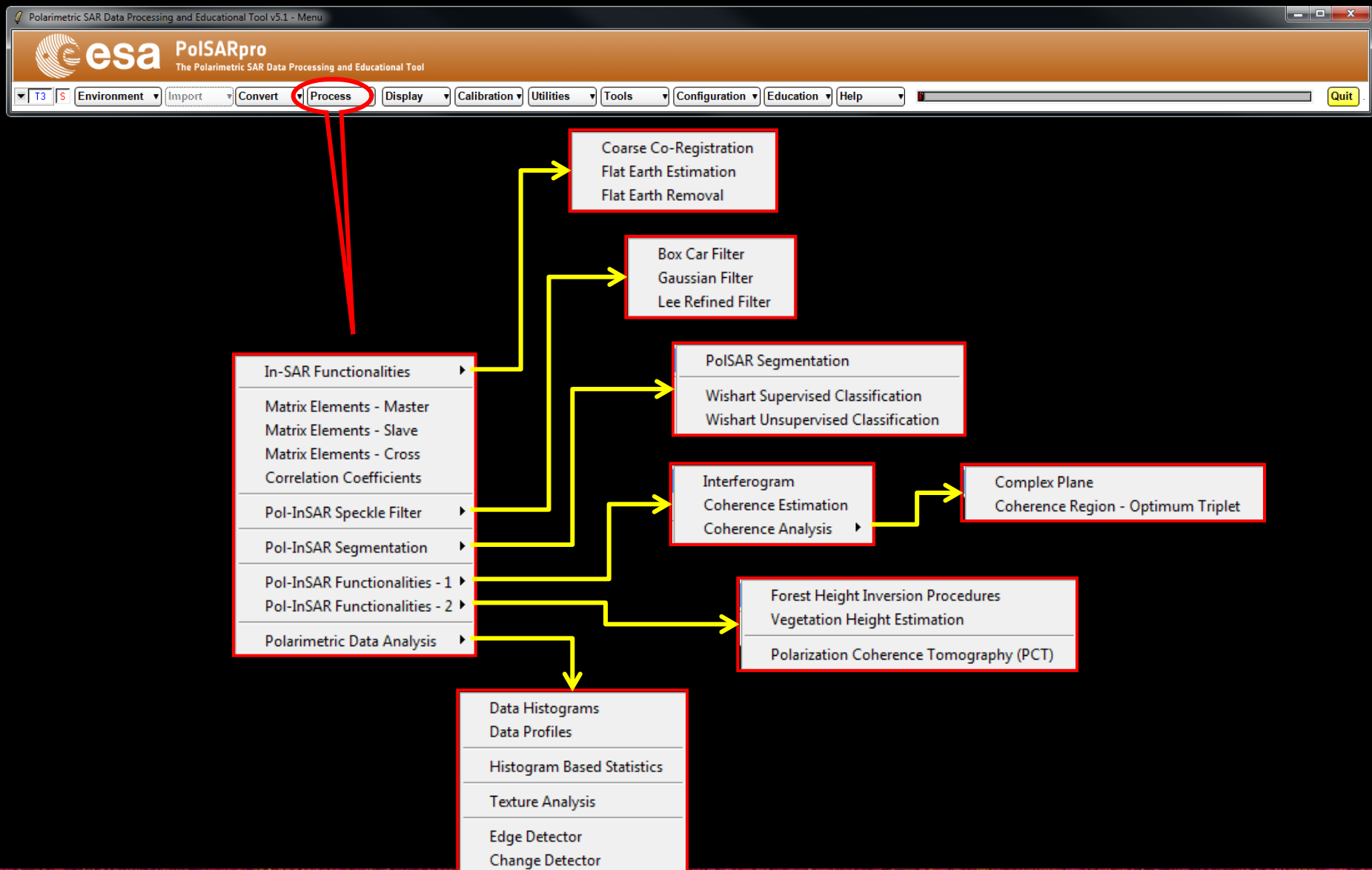
Input Master Directory:

My_Data_Directory / Pol-InSAR_PolSARproSIM_forest / master

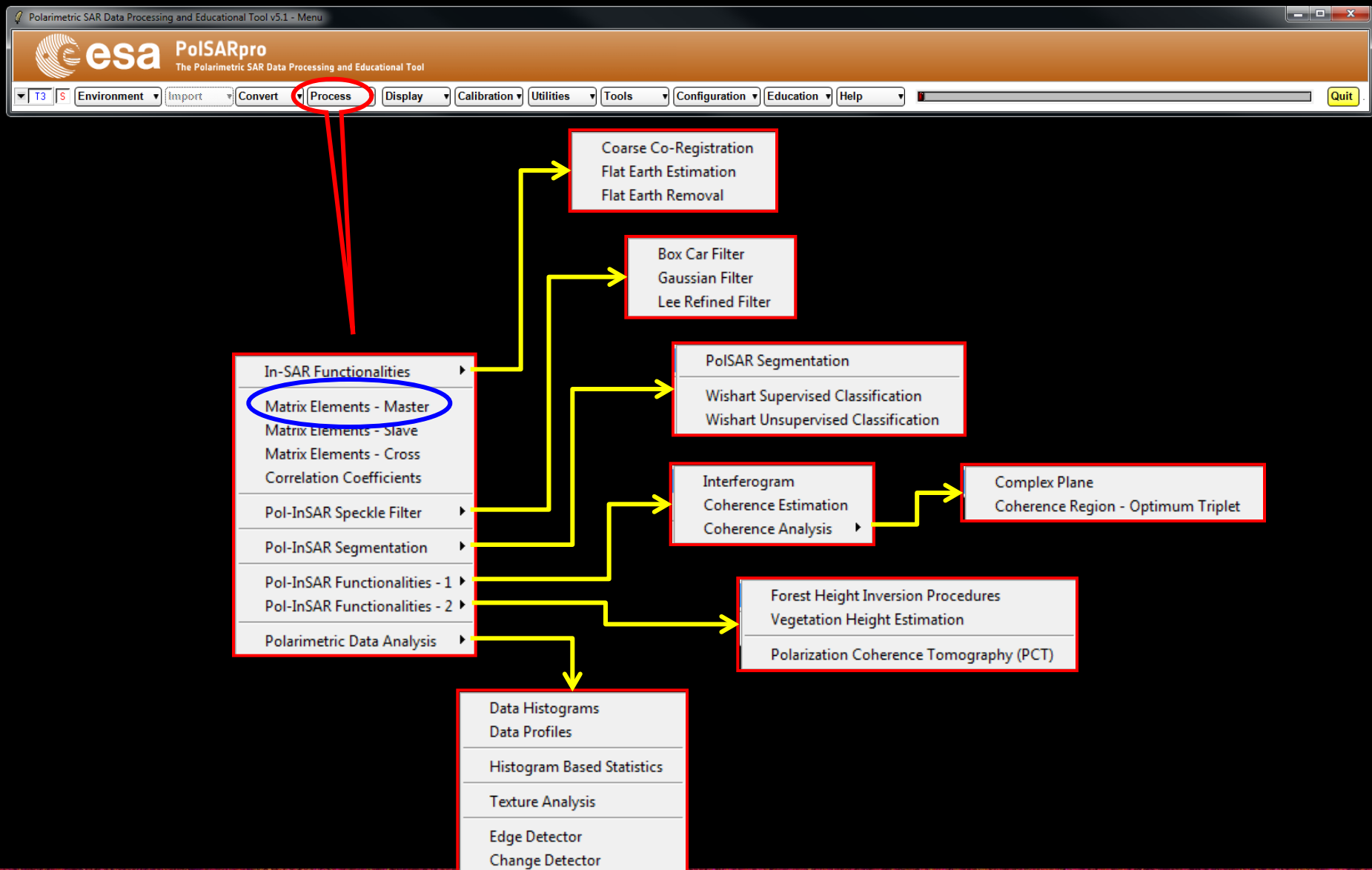
Input Slave Directory:

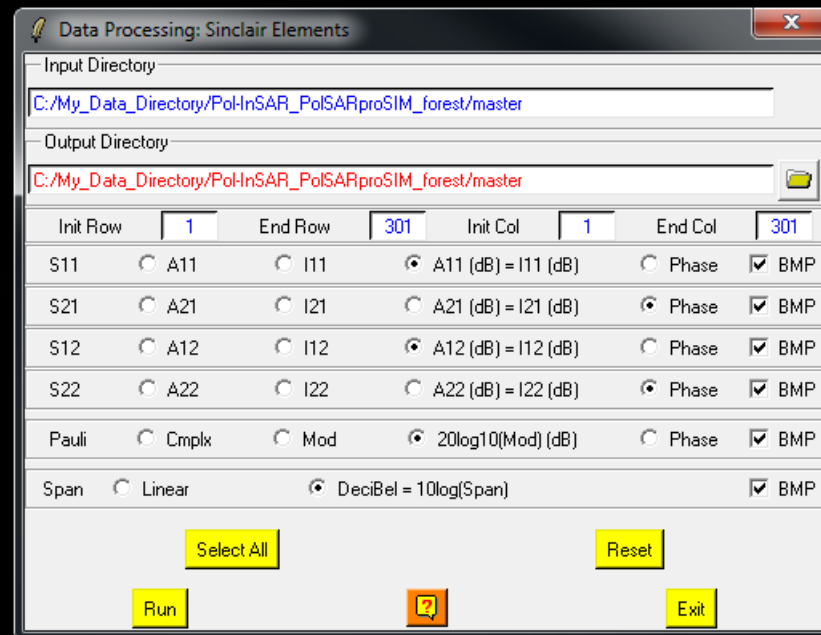
My_Data_Directory / Pol-InSAR_PolSARproSIM_forest / slave

PROCESS DATA



PROCESS DATA





Do it Yourself:

Select some elements, set the parameters and view the corresponding BMP files (*select BMP*).



DATA_MASTERDIR



config.txt



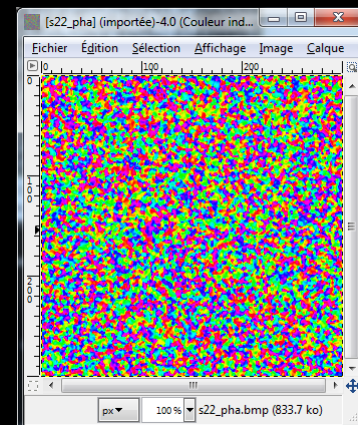
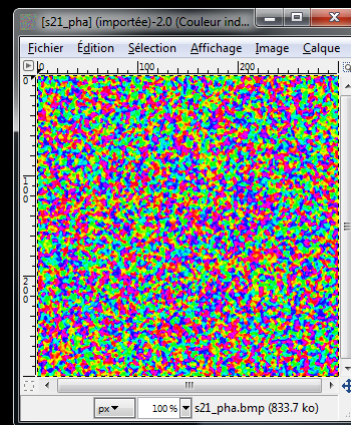
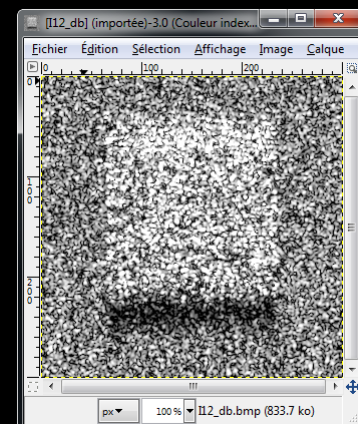
s11.bin, s12.bin
s21.bin, s22.bin



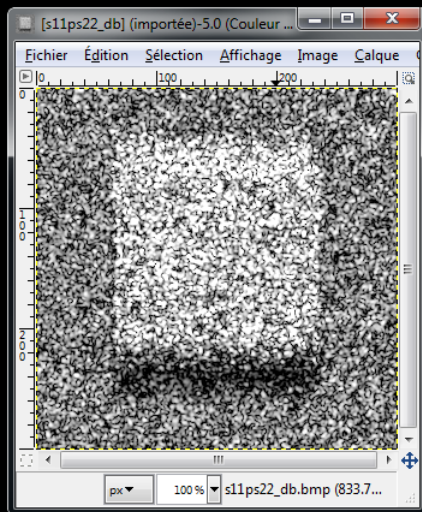
Axy.bin, Ixy.bin
Ixy_db.bin
sxy pha.bin



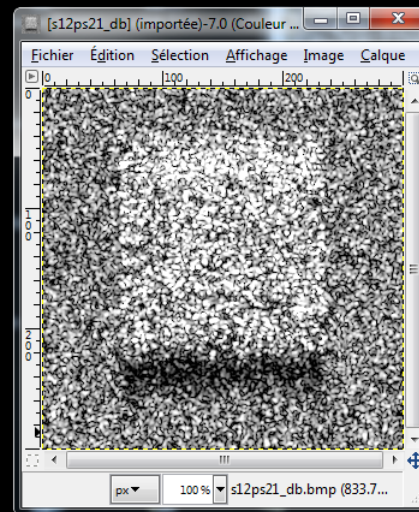
Axy.bmp, Ixy.bmp
Ixy_db.bmp
sxy pha.bmp



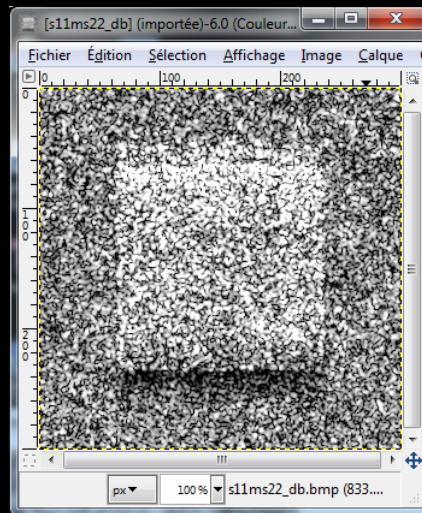
ELEMENTS



HH + VV



HV + VH

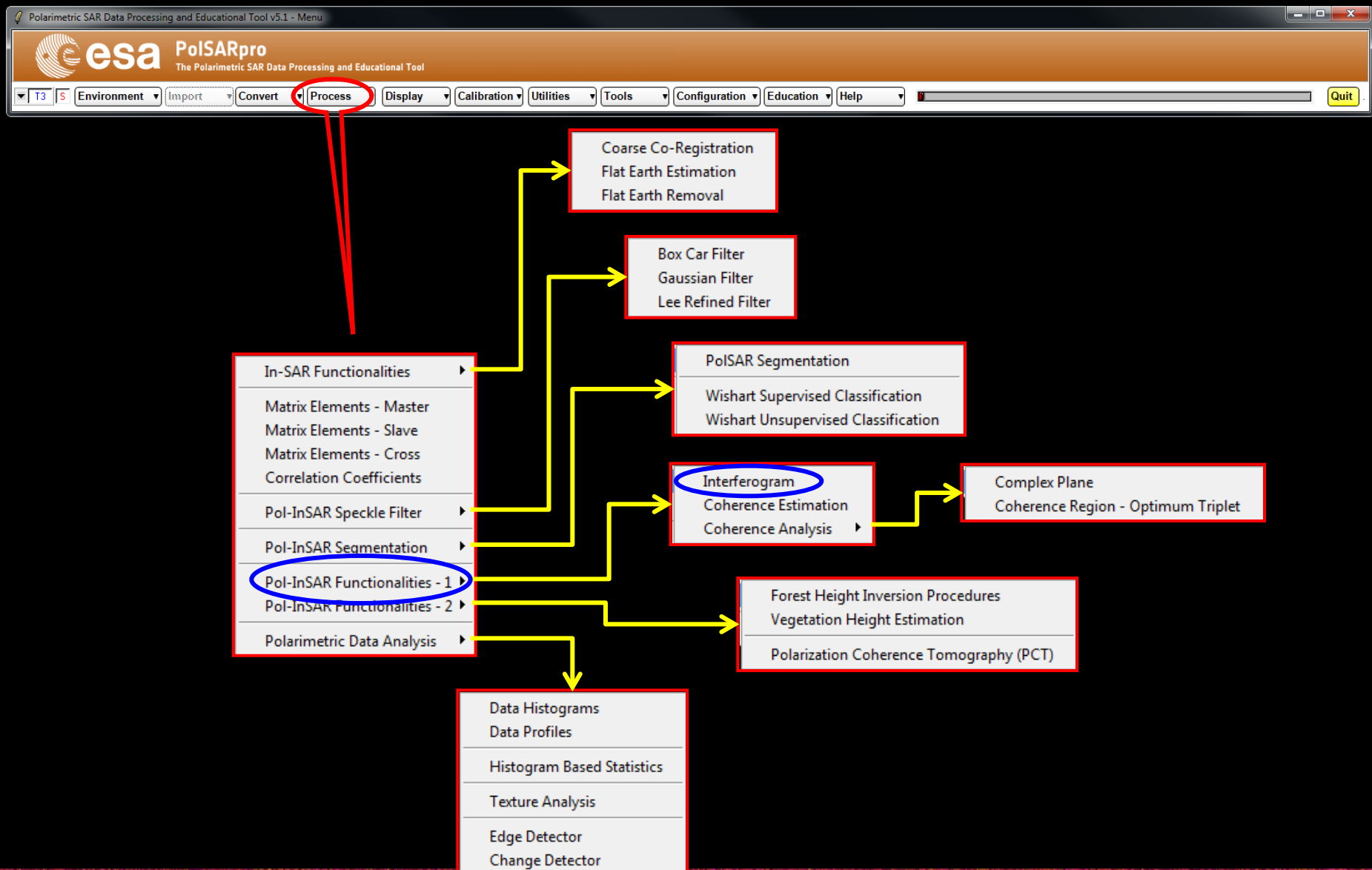


HH-VV

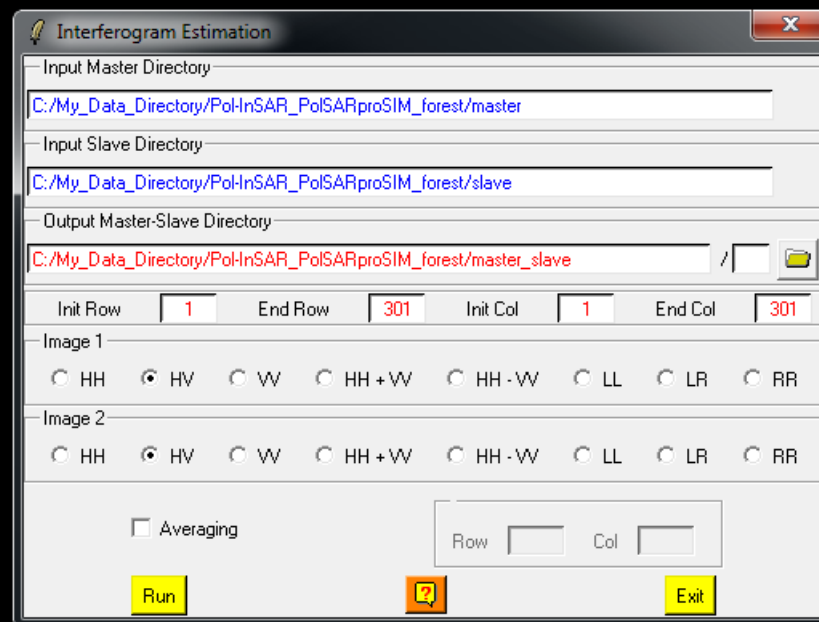


span

PROCESS DATA

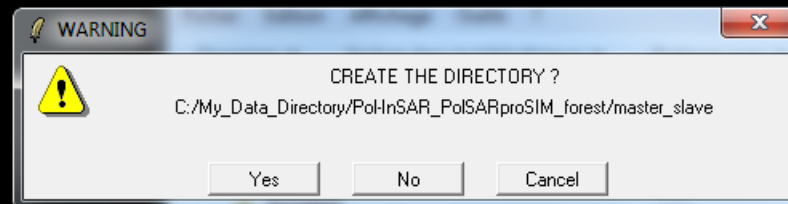
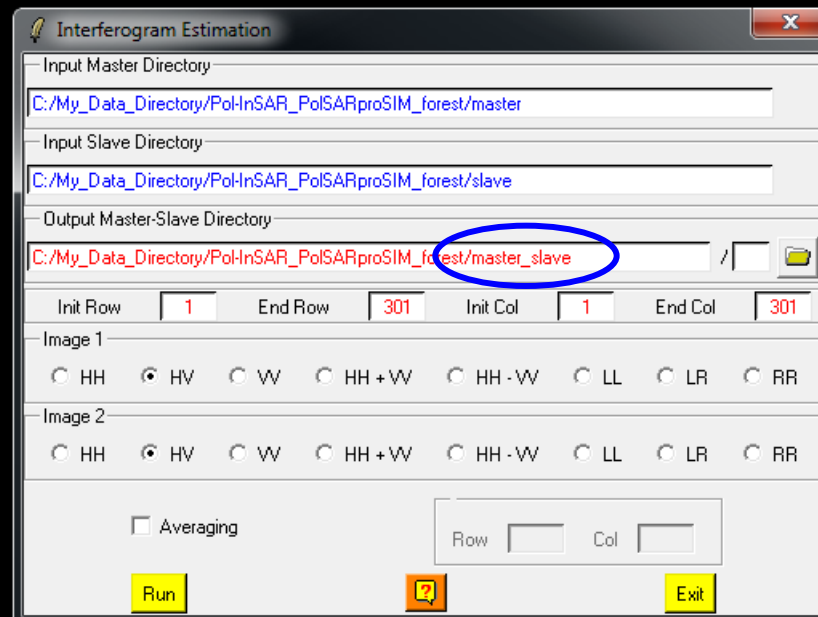


RAW INTERFEROGRAM



Do it Yourself:
Select polarization channels and view the corresponding BMP files.

RAW INTERFEROGRAM



Note:

The Output Directory is automatically set to: **MasterDir_SlaveDir**

RAW INTERFEROGRAM



DATA_MASTERDIR_SLAVEDIR



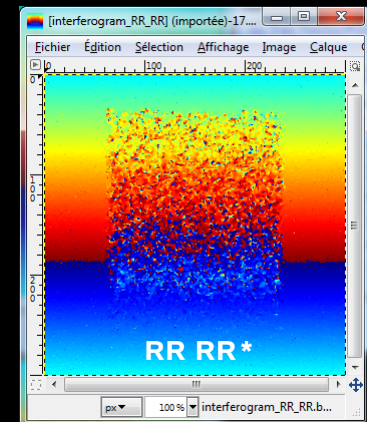
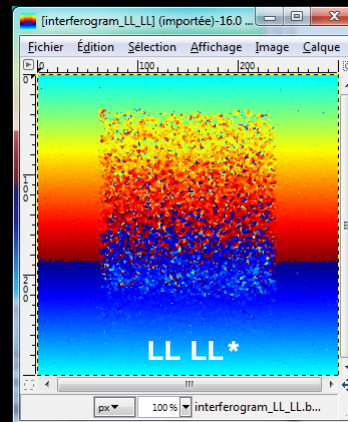
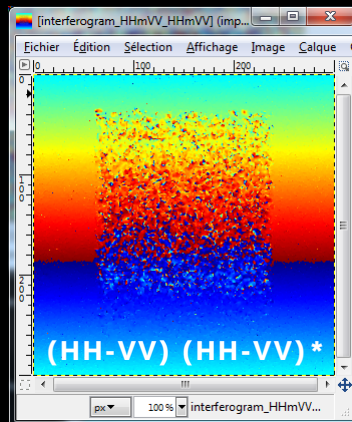
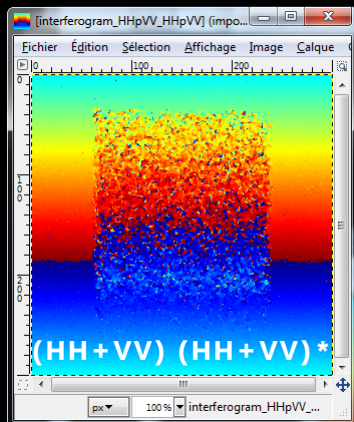
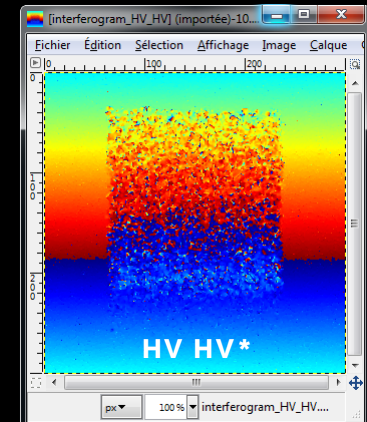
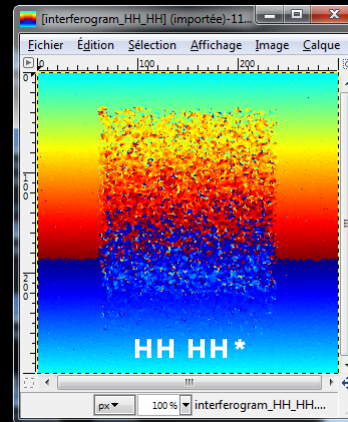
config.txt



interferogram_XX_XX.bin



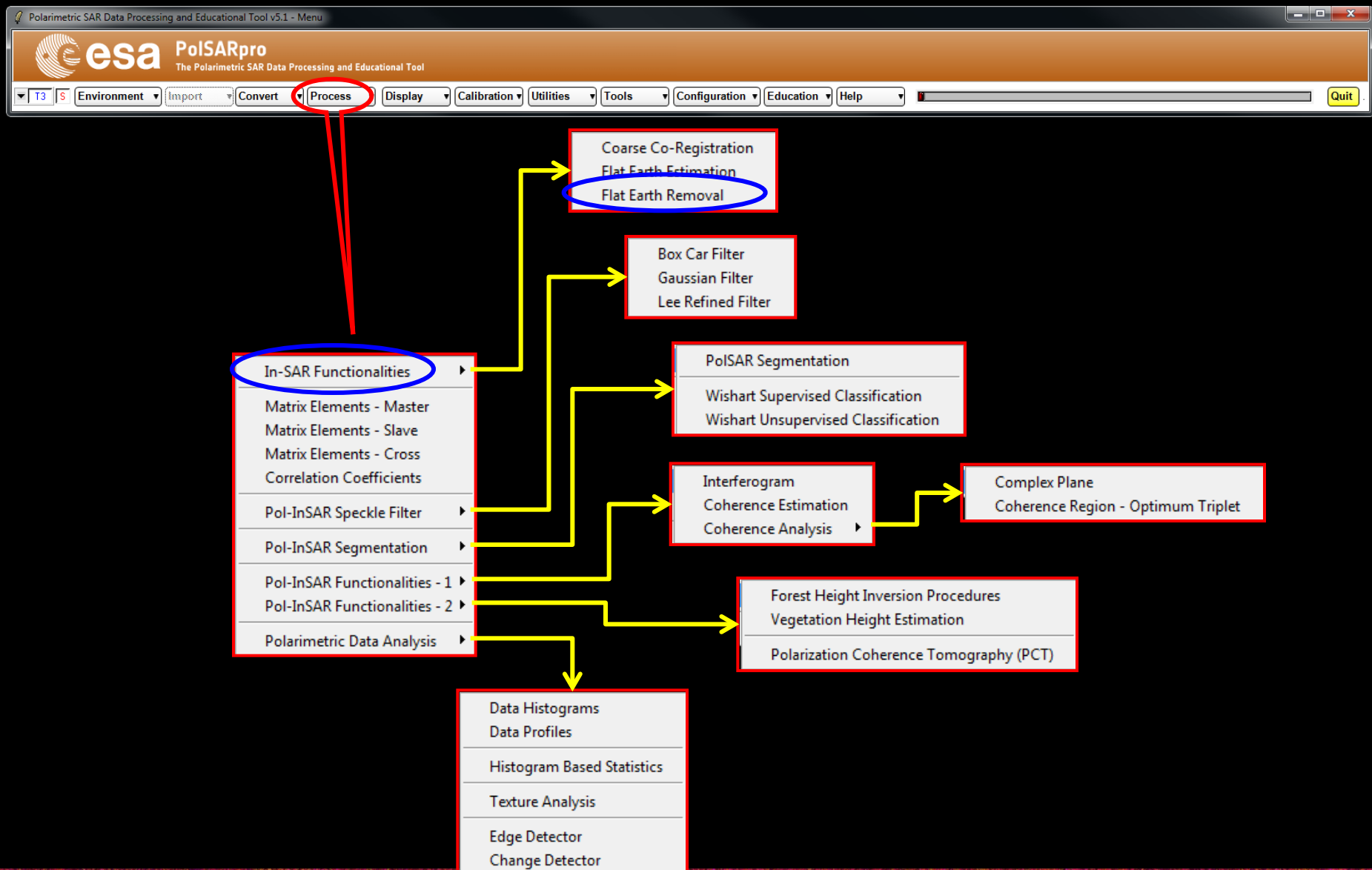
interferogram_XX_XX.bmp



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PROCESS DATA



FLAT EARTH REMOVAL



Polarimetric SAR Data Processing and Educational Tool v5.1 - Menu

esa PolSARpro
The Polarimetric SAR Data Processing and Educational Tool

Environment Import Convert Process Display Calibration Utilities Tools Configuration Education Help Quit

POLinSAR Flat Earth Removal

Input Master Directory
C:/My_Data_Directory/PolInSAR_PolSARproSIM_forest/master

Input Slave Directory
C:/My_Data_Directory/PolInSAR_PolSARproSIM_forest/slave

Init Row 1 End Row 301 Init Col 1 End Col 301

2D Flat Earth File
C:/My_Data_Directory/PolInSAR_PolSARproSIM_forest/slave/flat_earth.bin

Input Format
☐ real (deg) ☒ real (rad) ☐ cmplx (cos, sin)
☐ Convert Input IEEE binary Format (LE->BE)
☐ Symmetrisation ☒ Conjugate

Output Master Directory
C:/My_Data_Directory/PolInSAR_PolSARproSIM_forest/master

Output Slave Directory
C:/My_Data_Directory/PolInSAR_PolSARproSIM_forest/slave_FER

Run Exit

DATA_SLAVEDIR

config.txt
s11.bin, s12.bin
s21.bin, s22.bin

DATA_SLAVEDIR_FER

config.txt
s11.bin, s12.bin
s21.bin, s22.bin

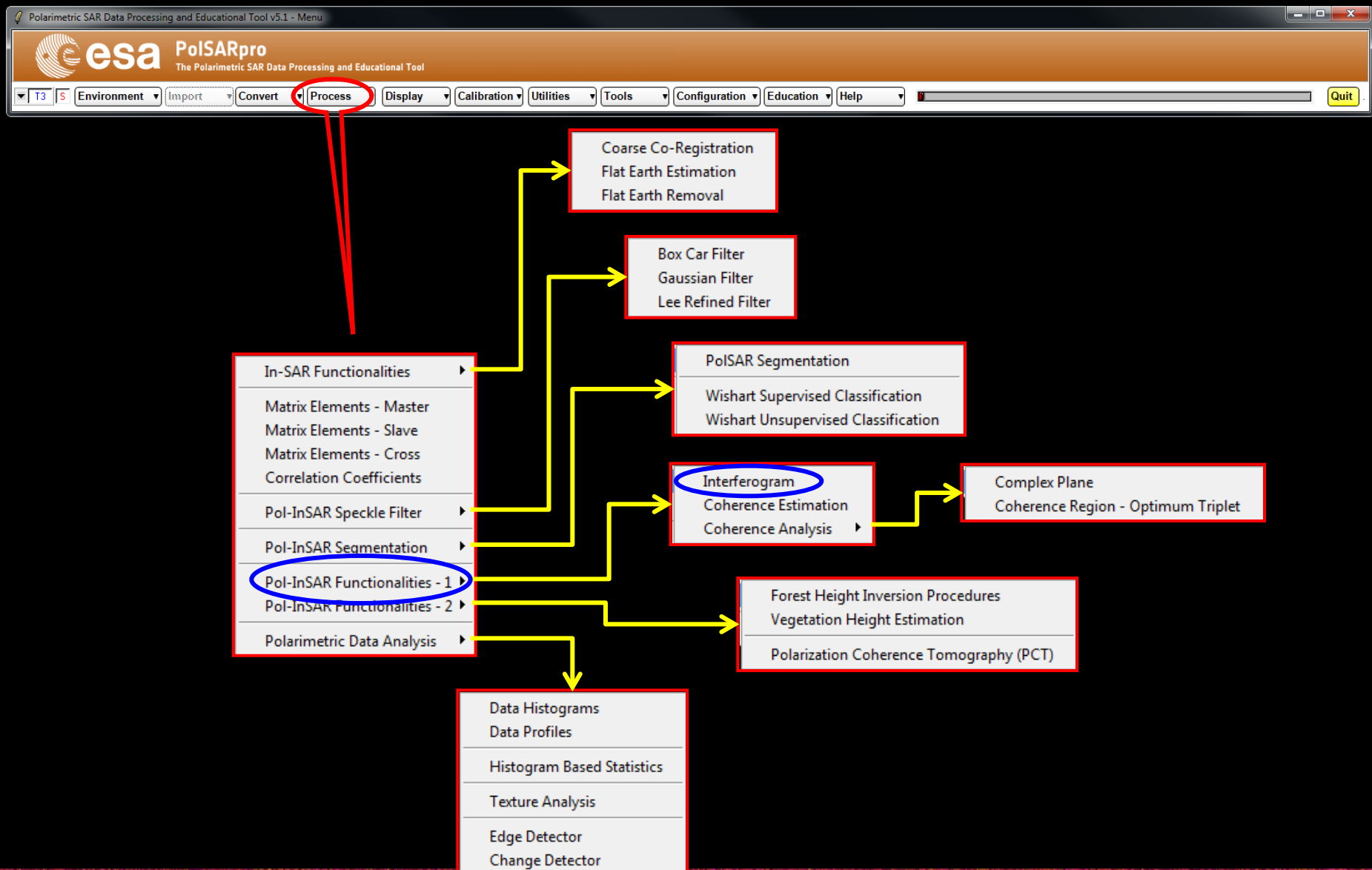
Do it Yourself:

Enter Flat Earth file name, set the parameters and run the function.

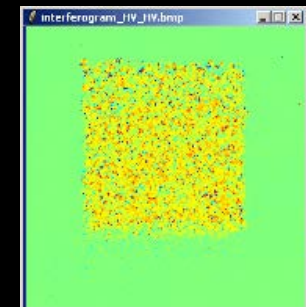
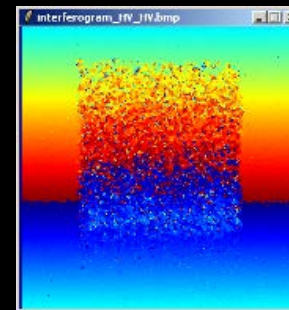
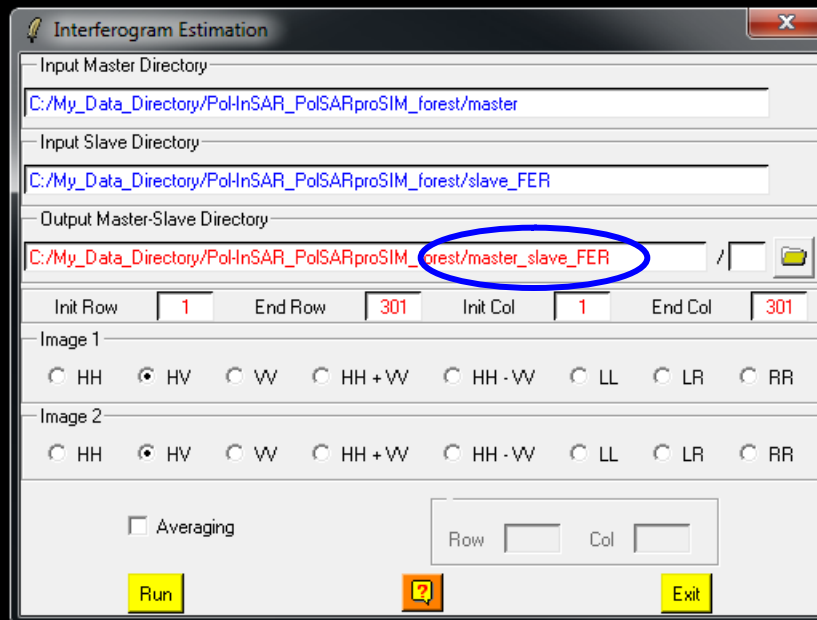
Note:

The Input Slave Directory is automatically set to: **SlaveDir_FER**

PROCESS DATA



RAW INTERFEROGRAM



Do it Yourself:

Select polarization channels view the corresponding BMP files.

Note:

The Output Directory is automatically set to: **MasterDir_SlaveDir_FER**

RAW INTERFEROGRAM



DATA_MASTERDIR_SLAVEDIR_FER



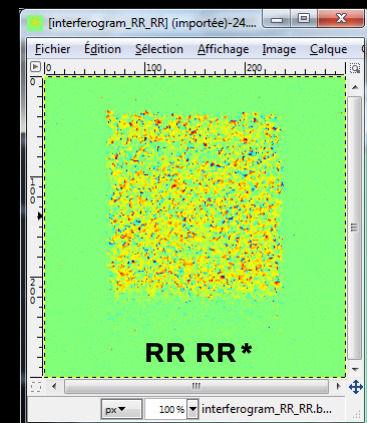
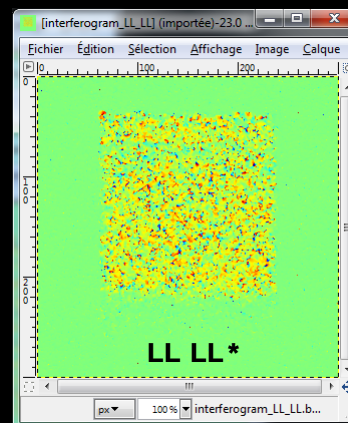
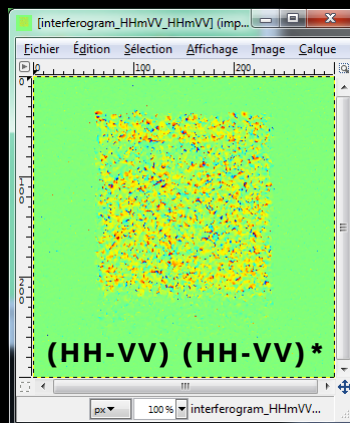
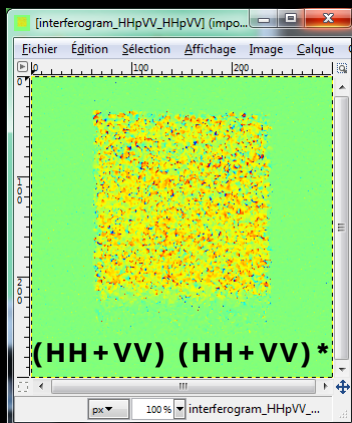
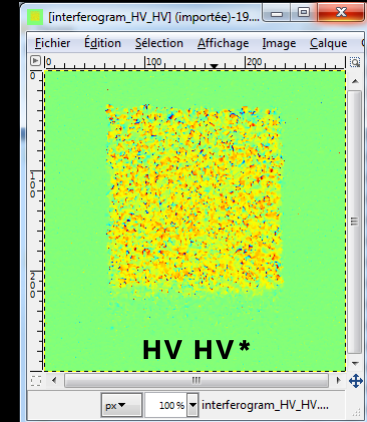
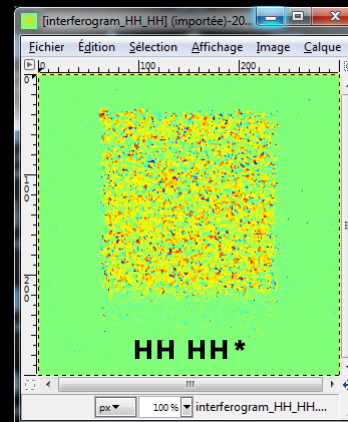
config.txt



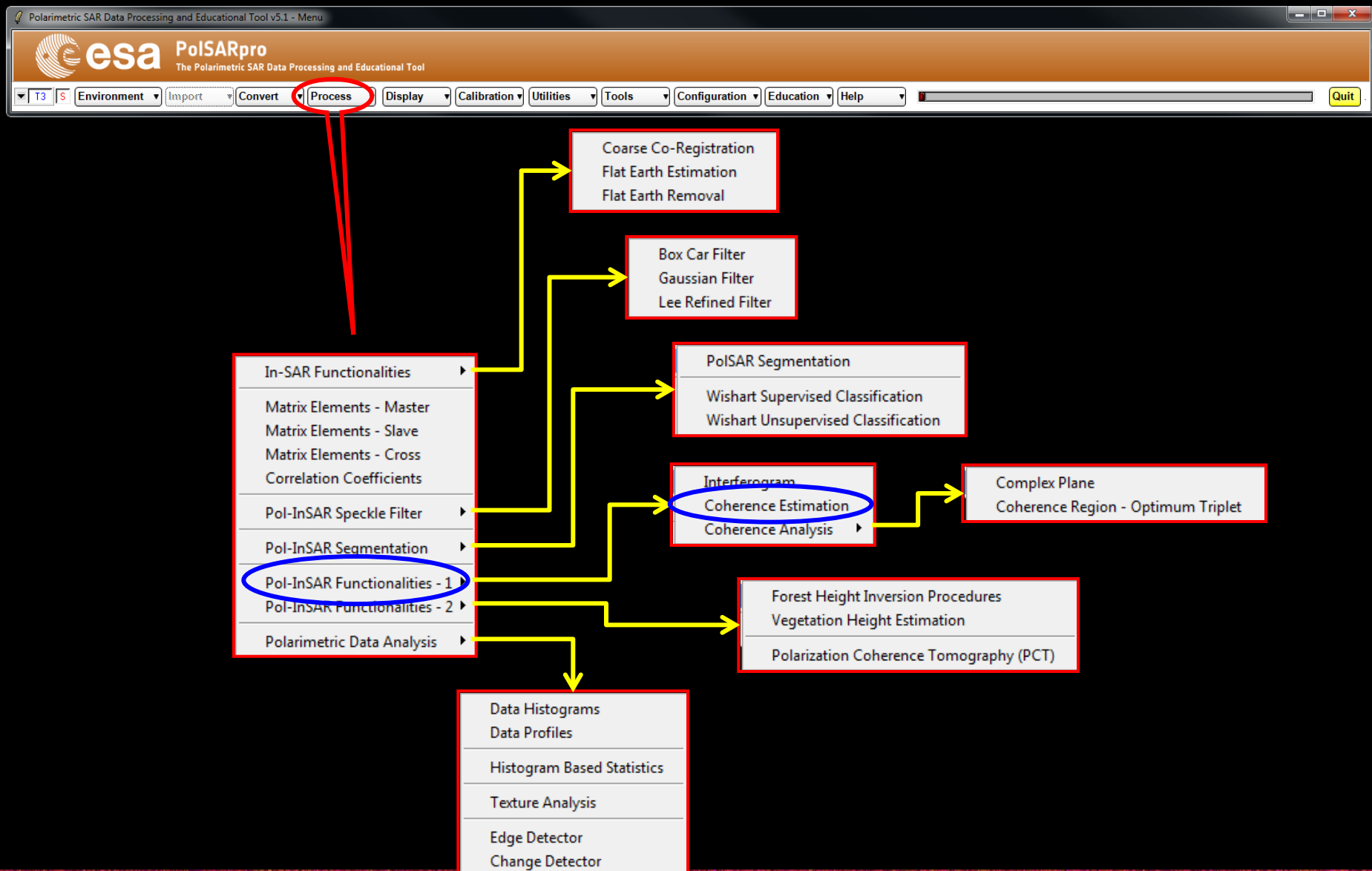
interferogram_XX_XX.bin



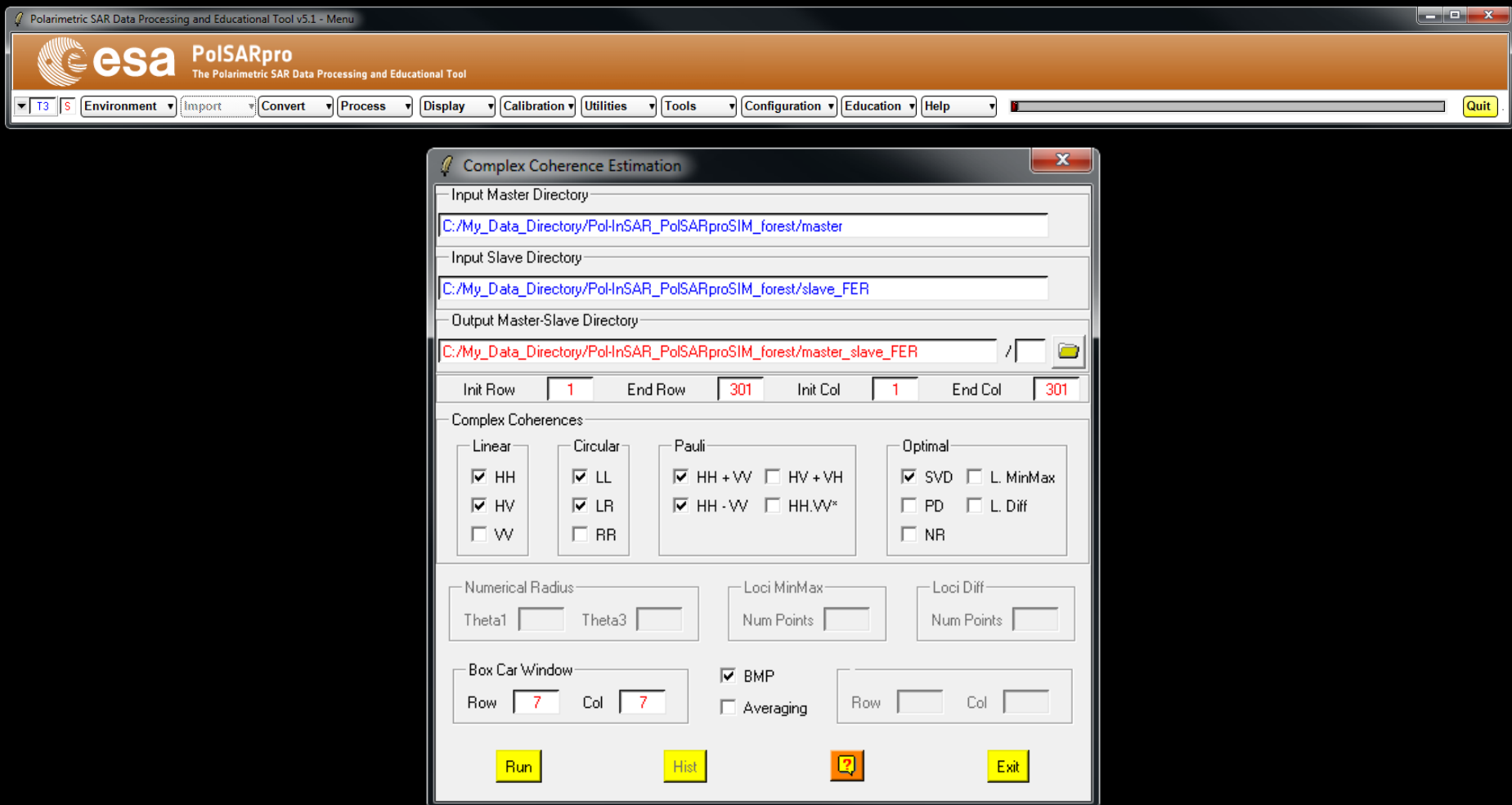
interferogram_XX_XX.bmp



PROCESS DATA



COHERENCE ESTIMATION



Do it Yourself:

Select polarization channels (*linear, circular, pauli, SVD*), set the parameters (*Box Car = 7x7*) and view the corresponding BMP files (*select BMP*).

COHERENCE ESTIMATION



DATA_MASTERDIR_SLAVEDIR_FER



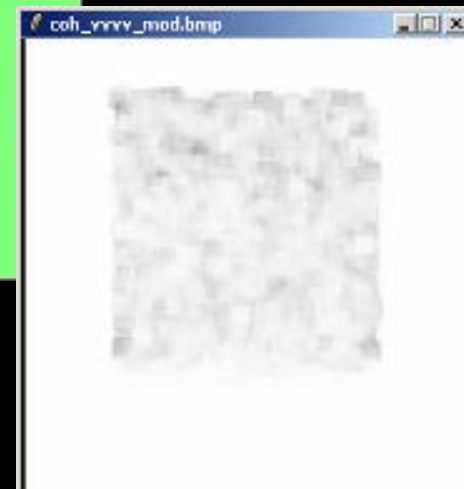
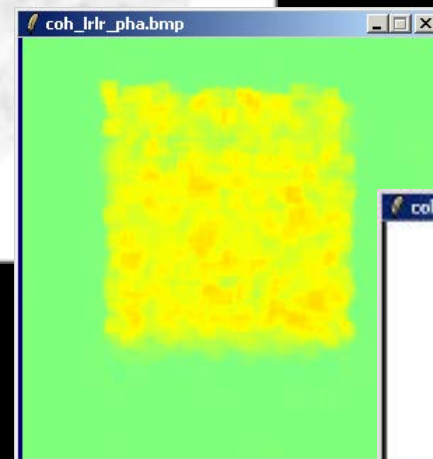
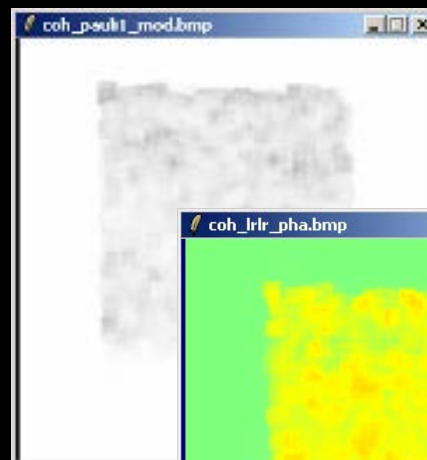
config.txt



cmplx_coh_XX.bin



cmplx_coh_XX_mod.bmp
cmplx_coh_XX pha.bmp

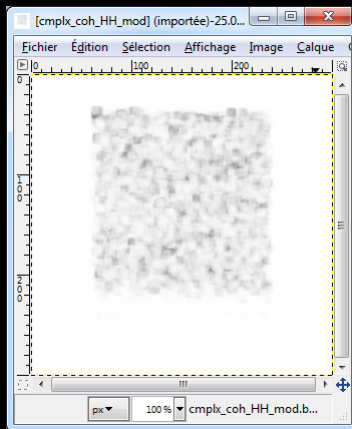
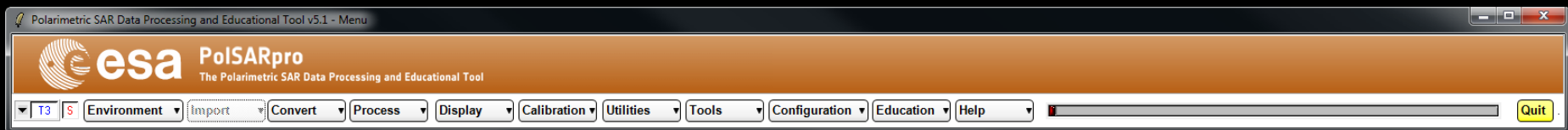


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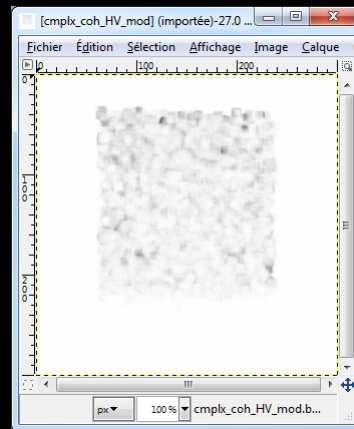
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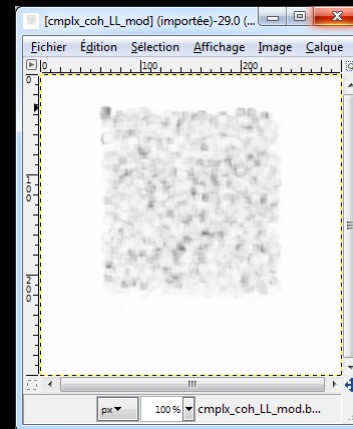
COHERENCE ESTIMATION



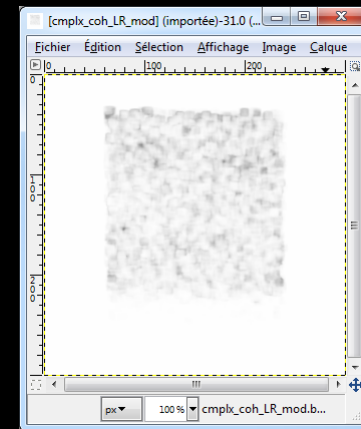
γ_{HH}



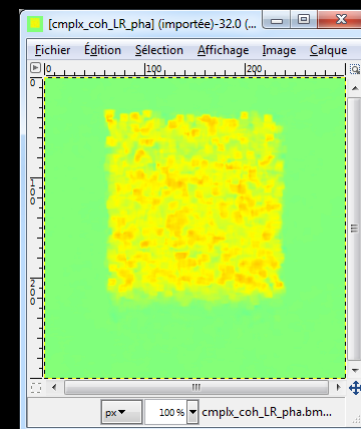
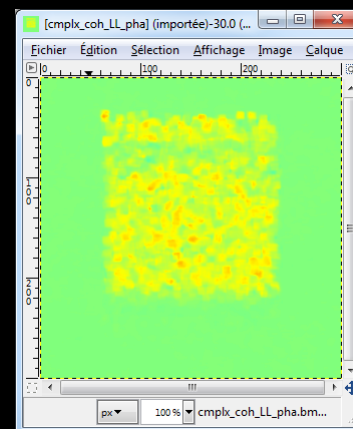
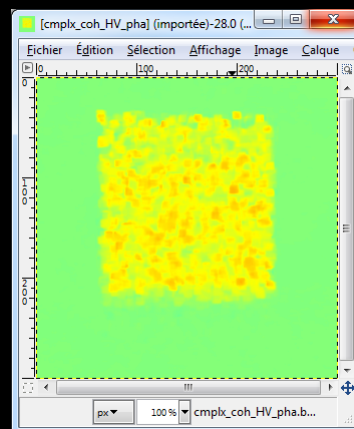
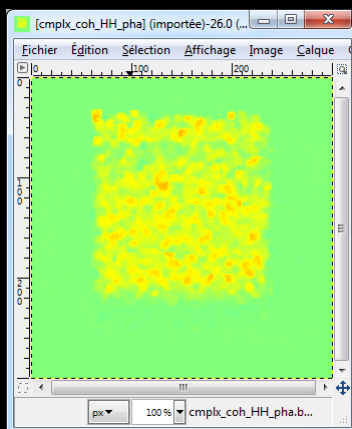
γ_{HV}



γ_{LL}



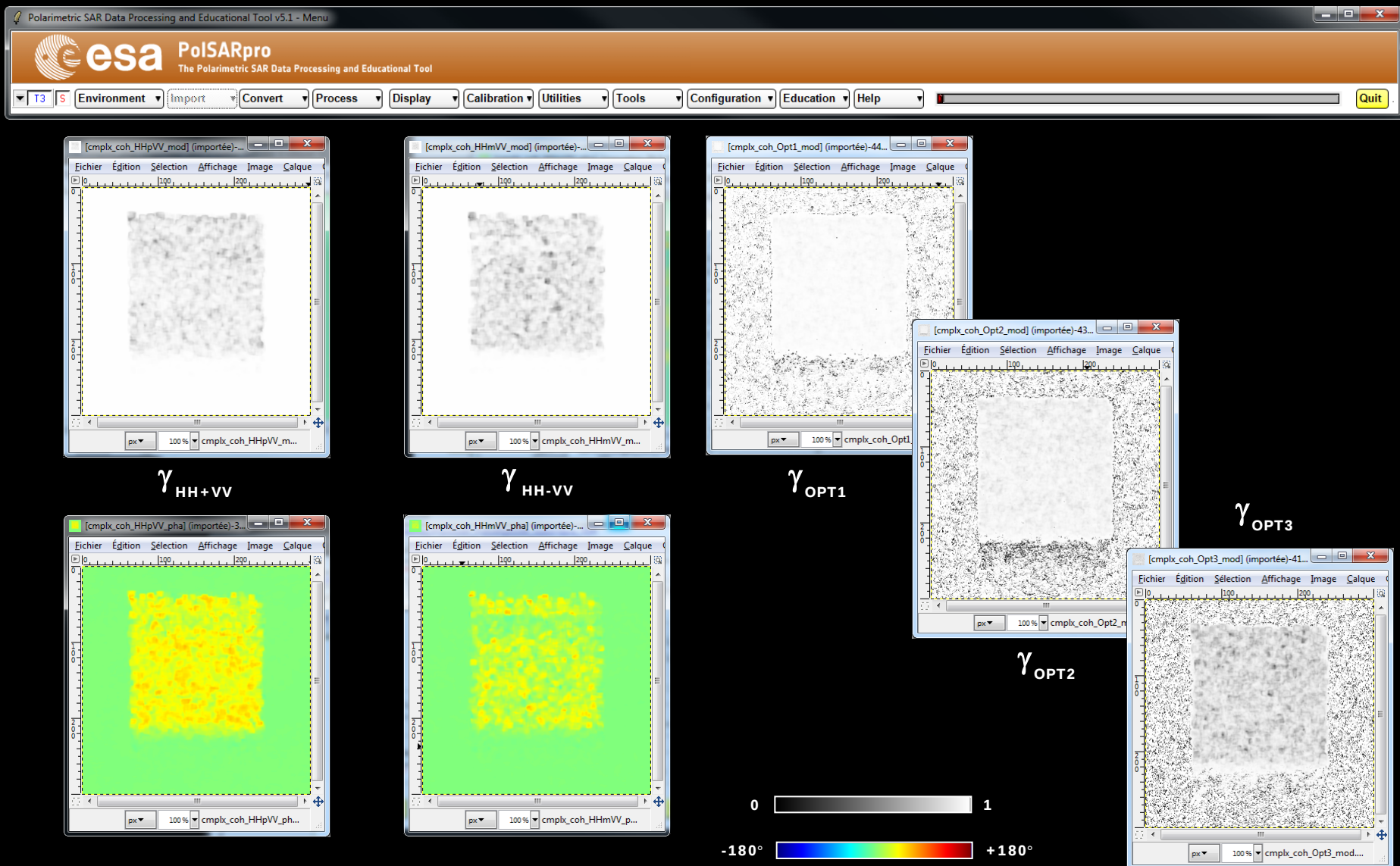
γ_{RR}



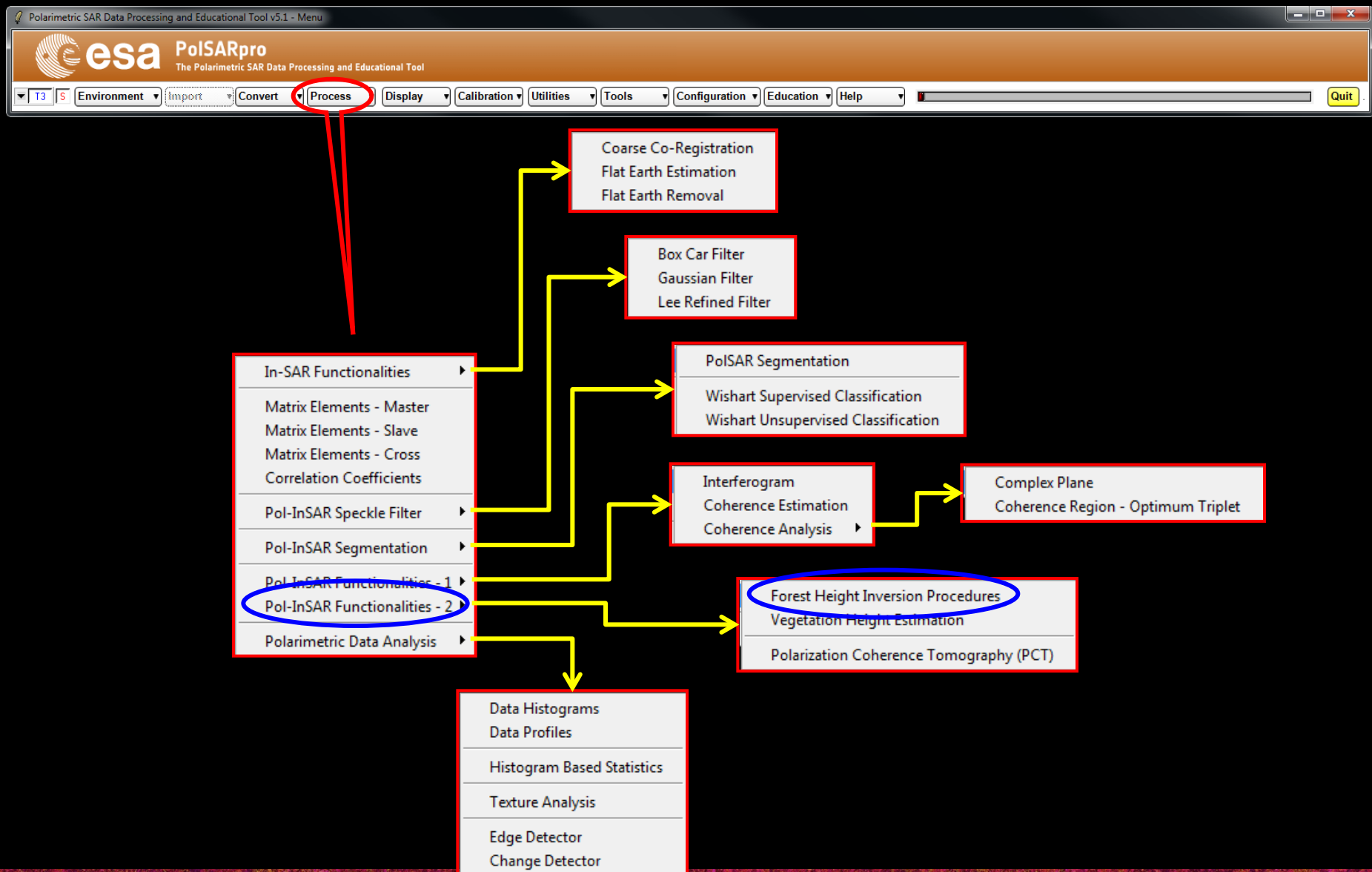
0  1

-180°  +180°

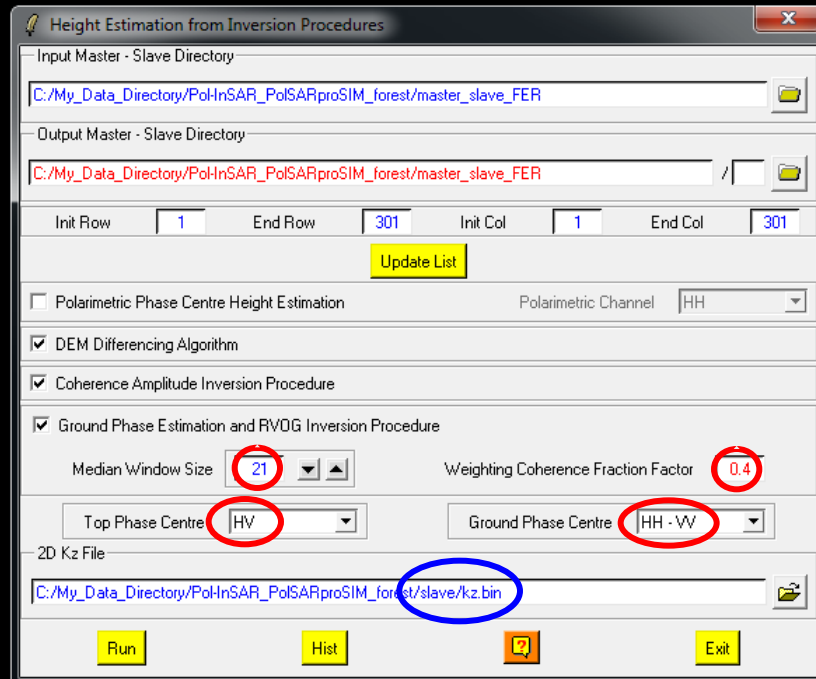
COHERENCE ESTIMATION



PROCESS DATA



HEIGHT ESTIMATION



INVERSION PROCEDURES

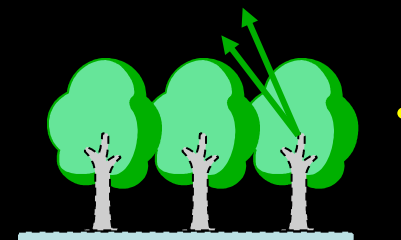
DEM Differencing Algorithm

Coherence Amplitude Inversion Procedure

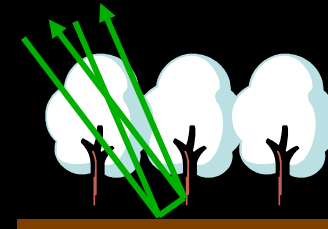
Ground Phase Estimation &

RVOG Inversion Procedure

2HV



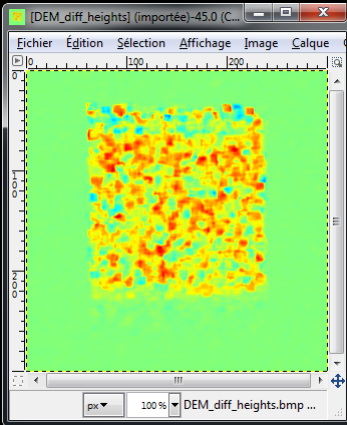
HH - VV



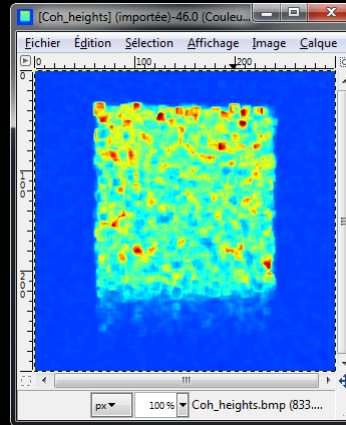
Do it Yourself:

Set the parameters (*Median Size = 21, Factor = 0.4*) and view the corresponding BMP files.

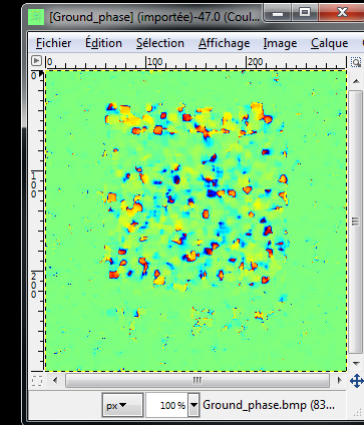
HEIGHT ESTIMATION



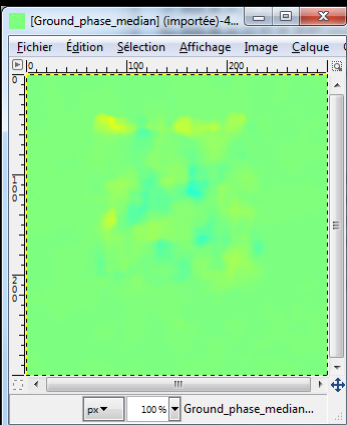
DEM_diff_heights



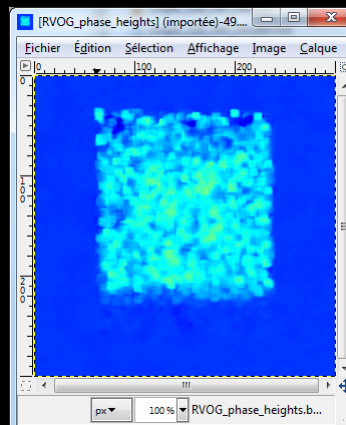
Coh_heights



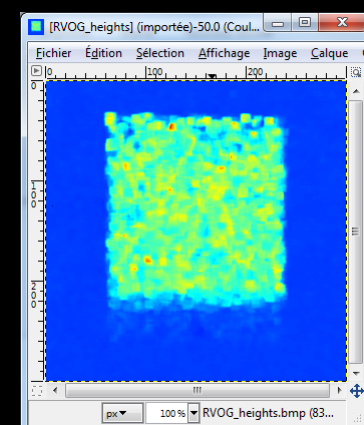
Ground_phase



Ground_phase_median

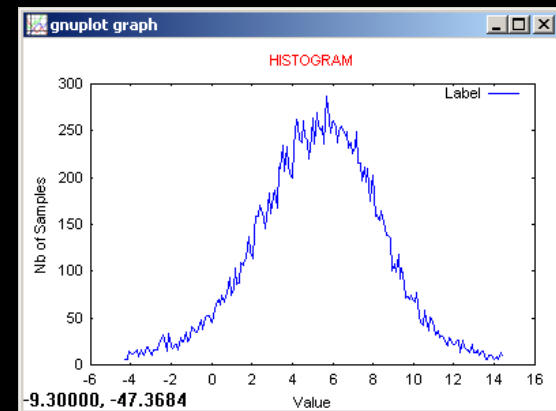
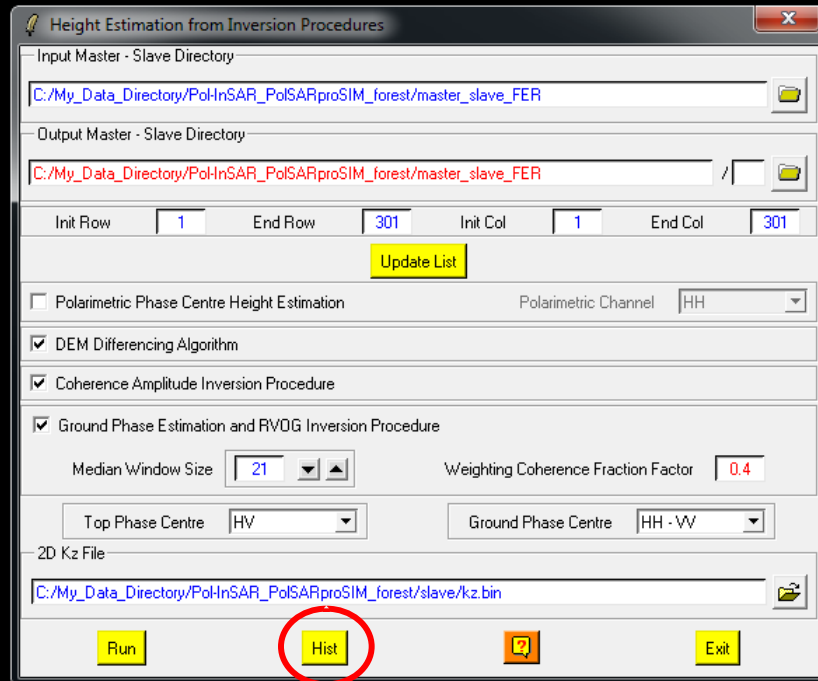


RVOG_phase_heights



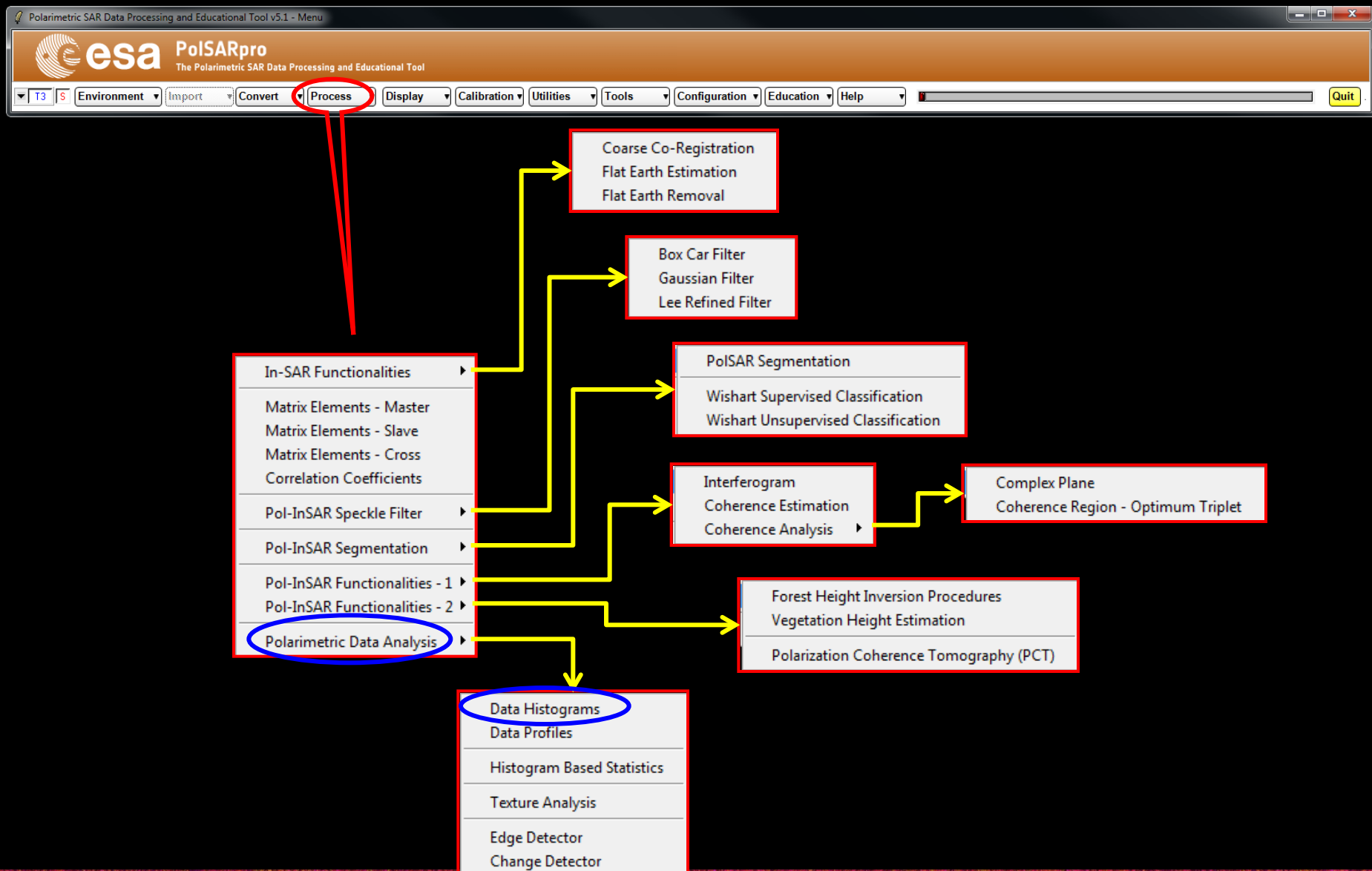
RVOG_heights

HEIGHT ESTIMATION

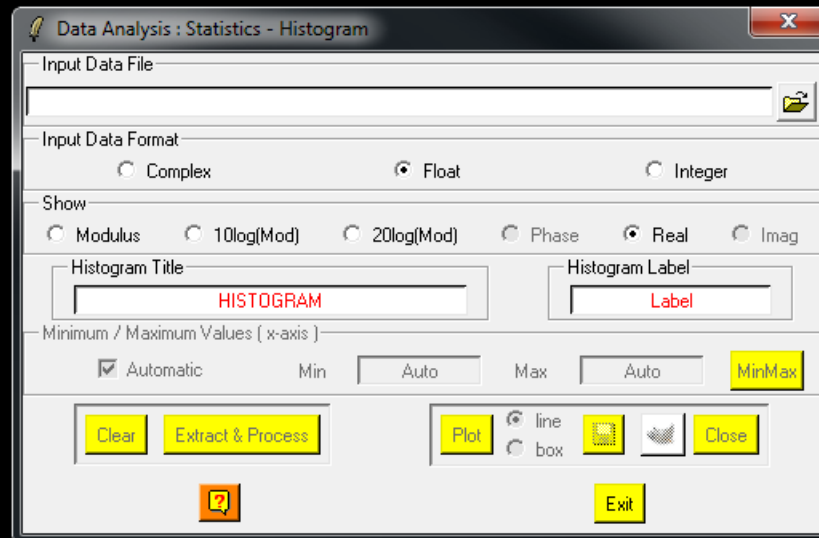
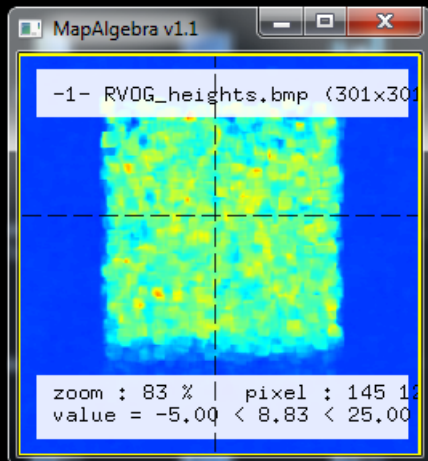


Data Analysis - Data histograms

PROCESS DATA

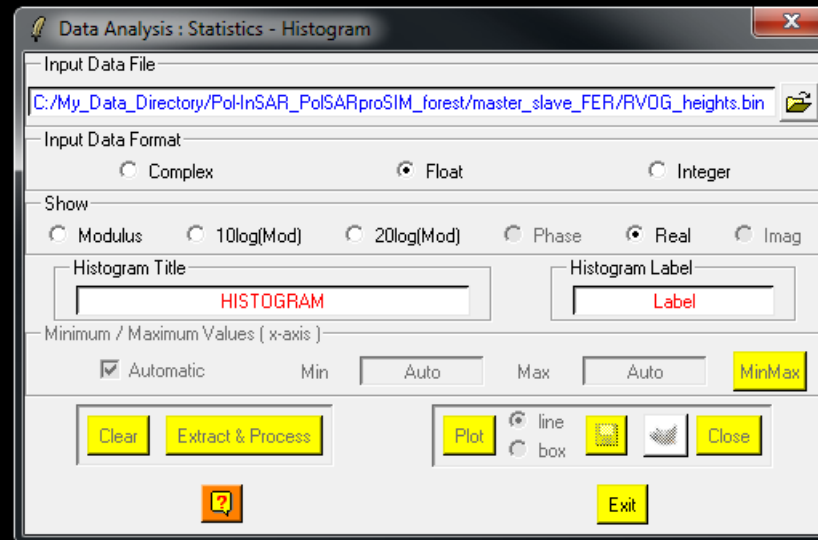
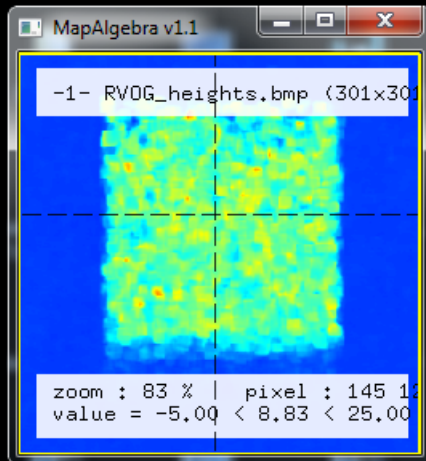


HEIGHT ESTIMATION - HISTOGRAM



Do it Yourself:
Step 1 : Select a BMP File

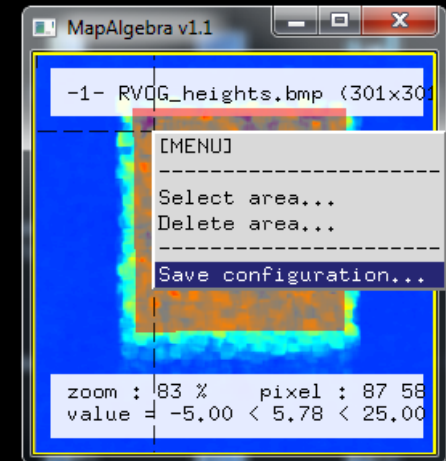
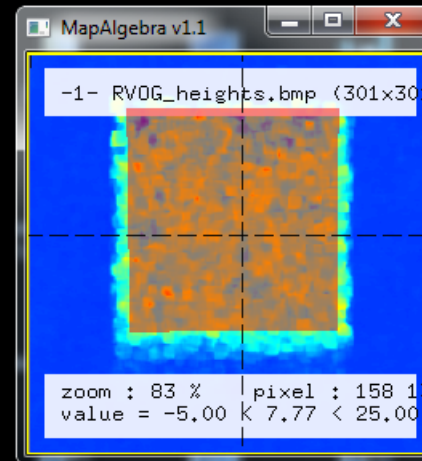
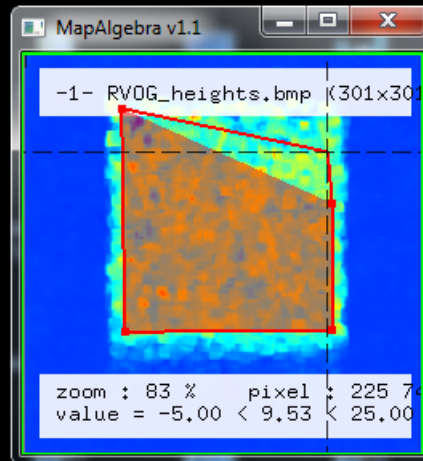
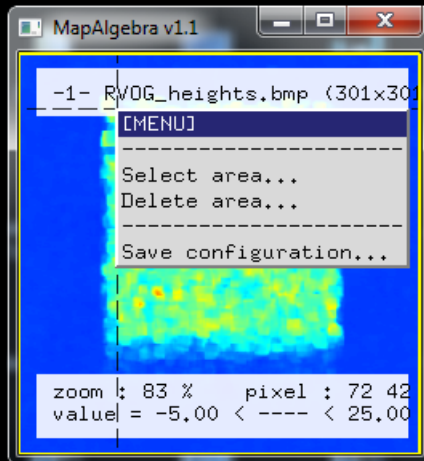
HEIGHT ESTIMATION - HISTOGRAM



Do it Yourself:

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

HEIGHT ESTIMATION - HISTOGRAM

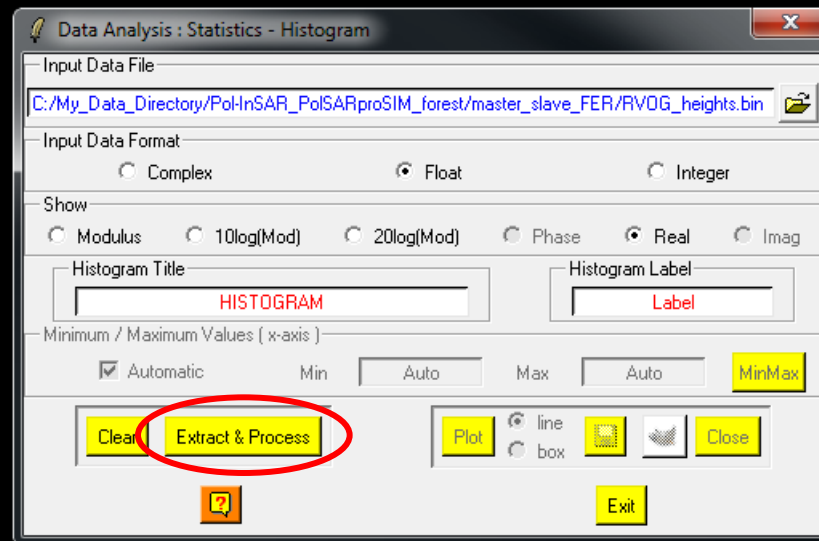
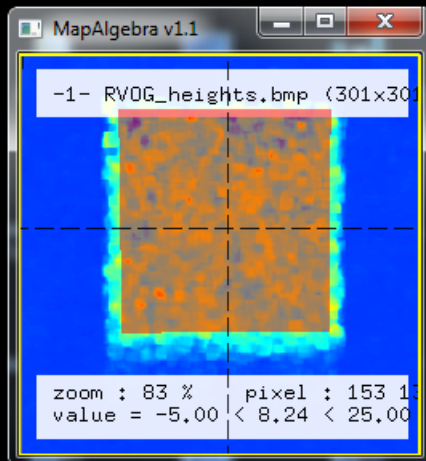


Do it Yourself:

Step 3 : Define the polygon area

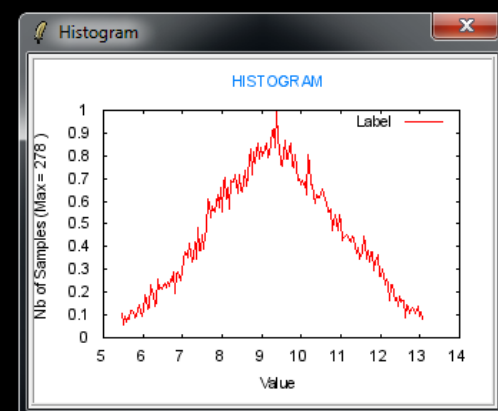
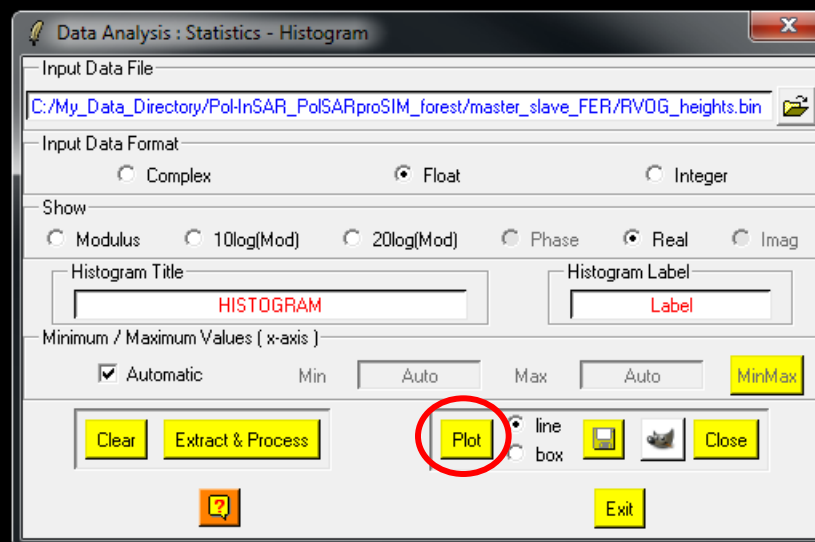
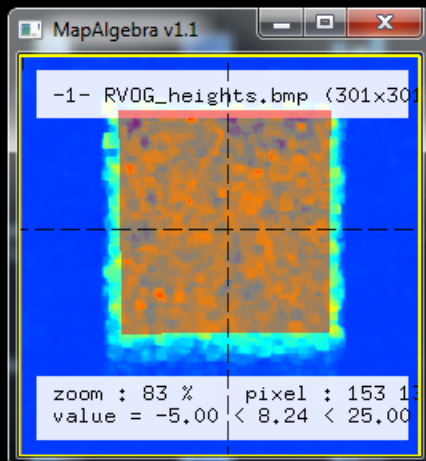
- 1) *Right button* : Select area
- 2) *Left button* : Draw the polygon
- 3) *Enter* : Close the polygon
- 4) *Right button* : Save configuration

HEIGHT ESTIMATION - HISTOGRAM



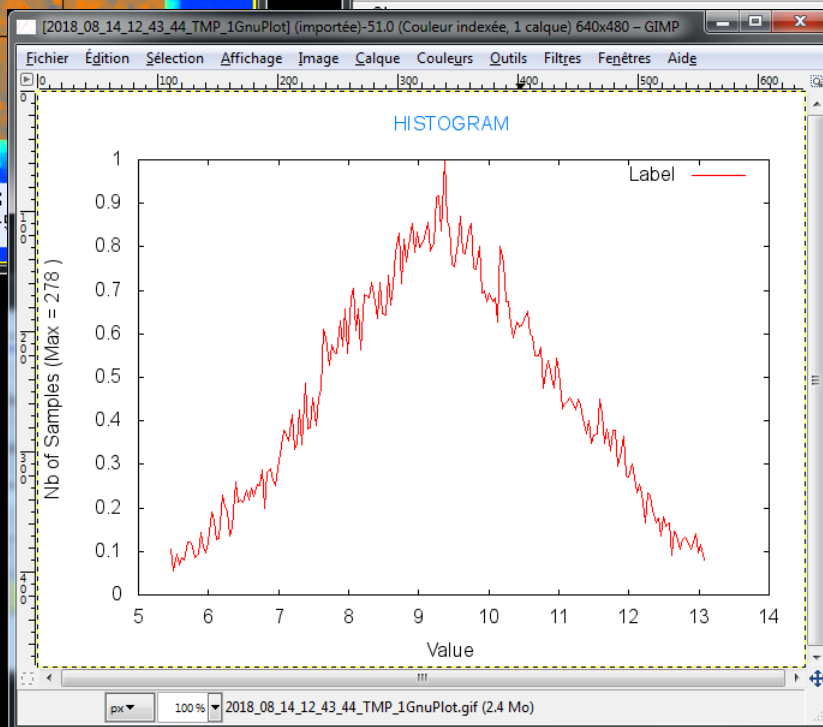
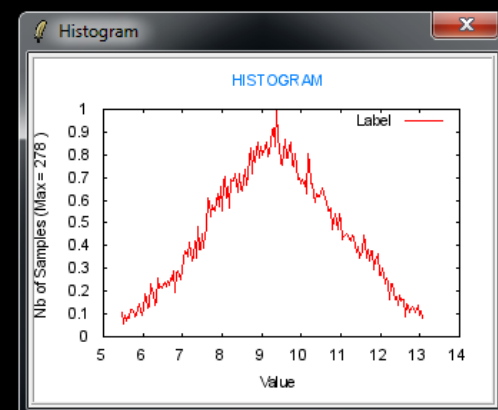
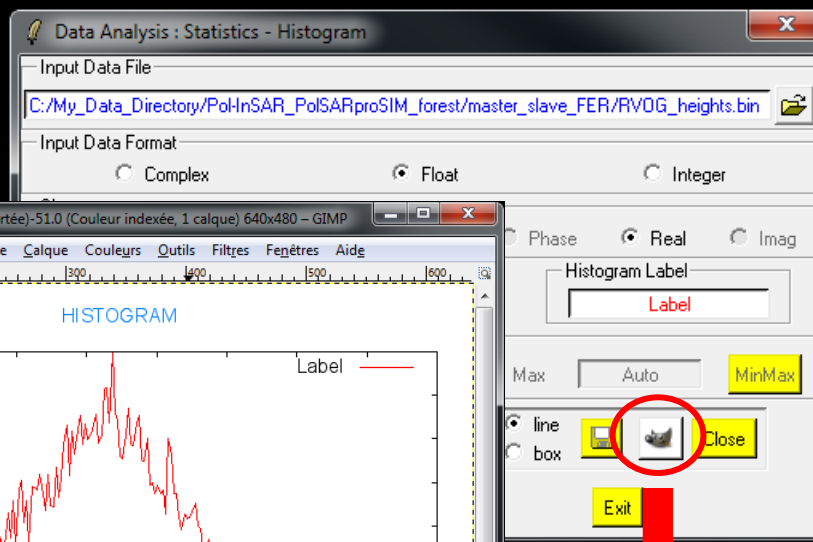
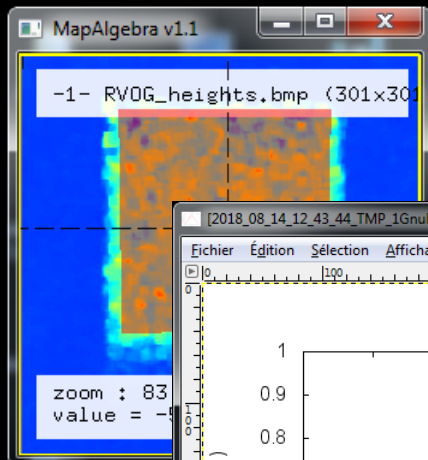
Do it Yourself:
Step 3 : Extract and Process

HEIGHT ESTIMATION - HISTOGRAM



Do it Yourself:
Step 4 : Plot the histogram

HEIGHT ESTIMATION - HISTOGRAM

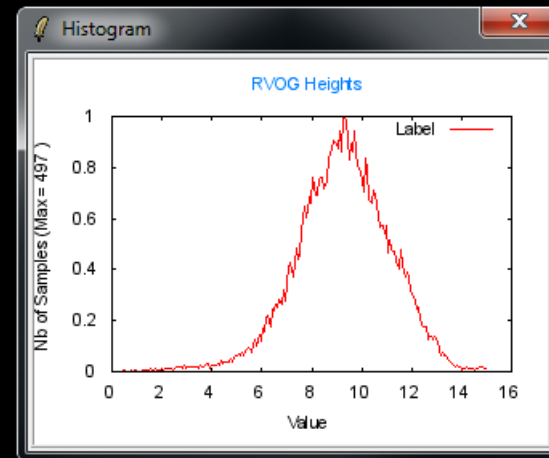
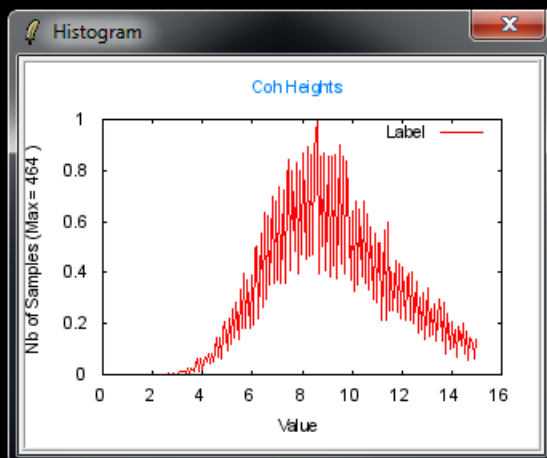
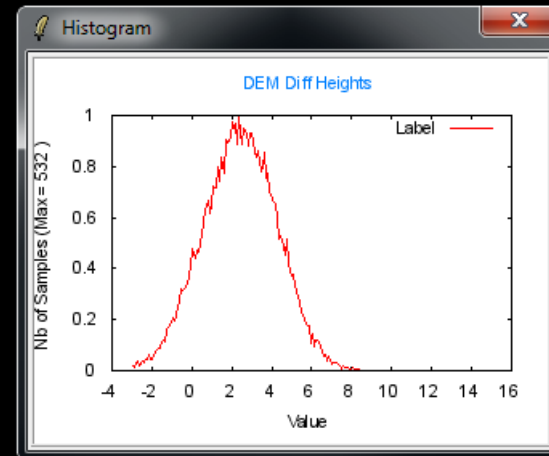
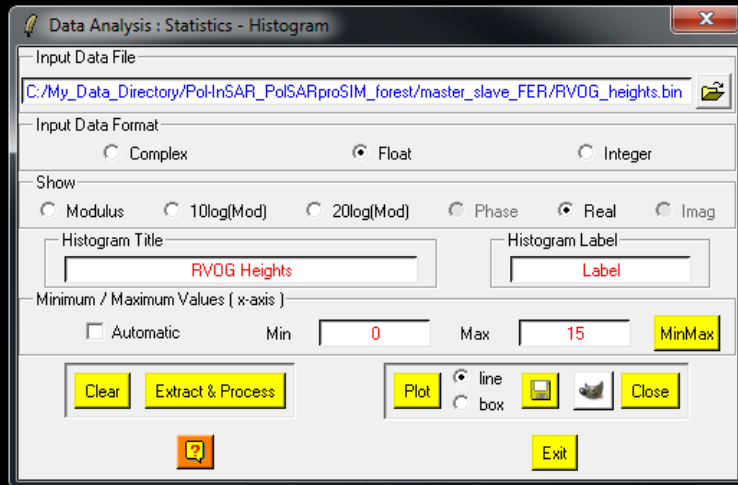


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HEIGHT ESTIMATION

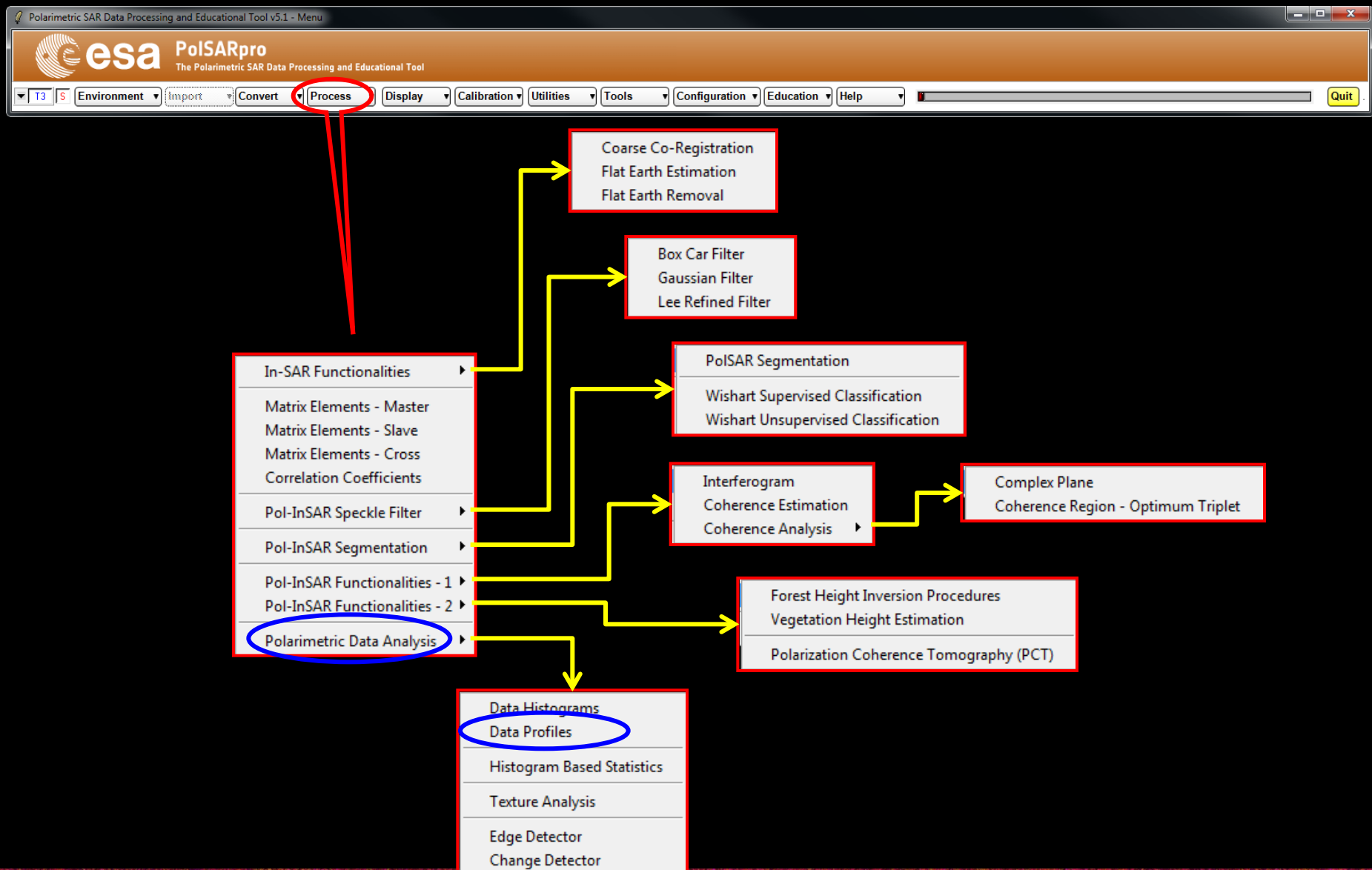


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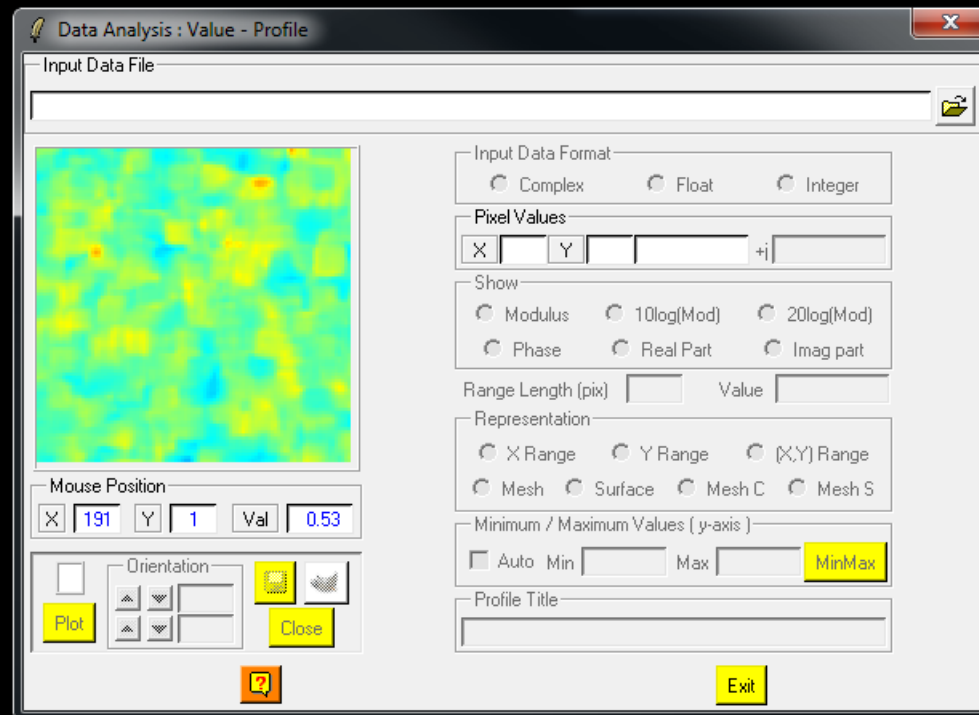
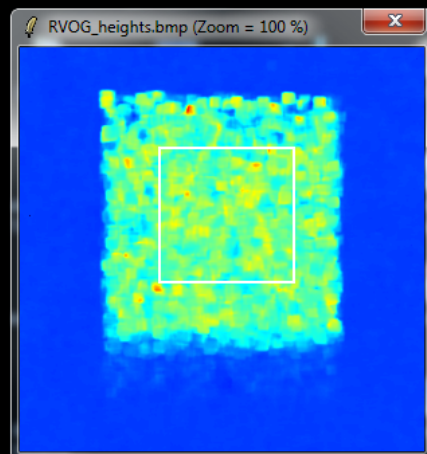
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PROCESS DATA

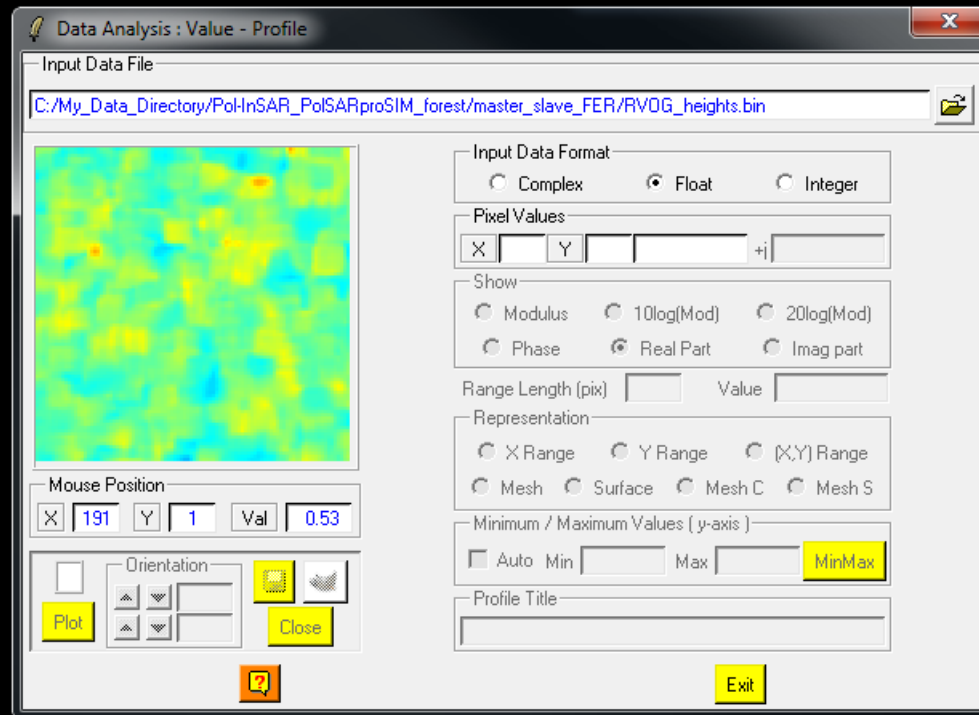
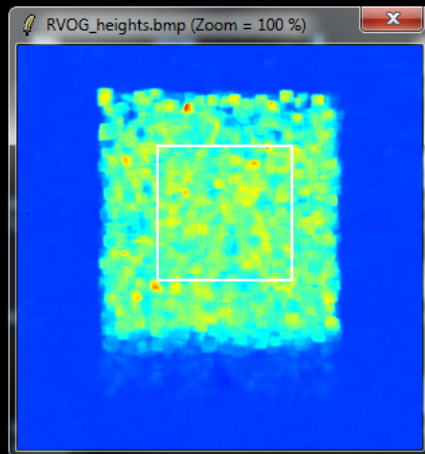


HEIGHT ESTIMATION - PROFILE



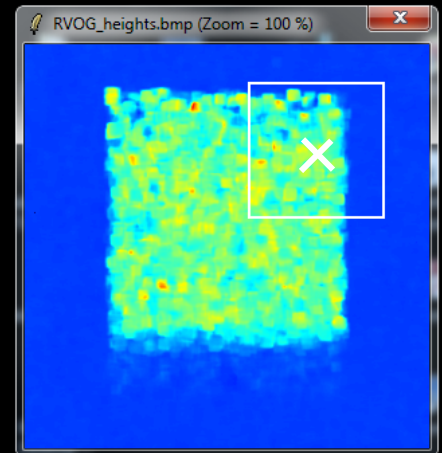
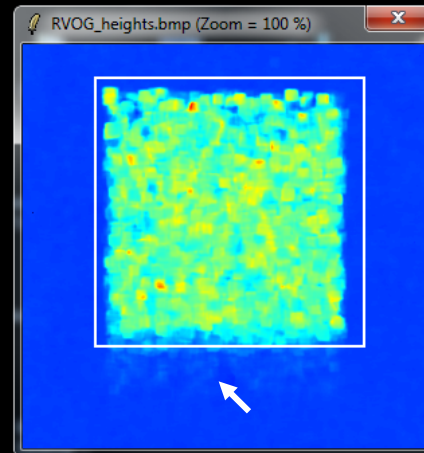
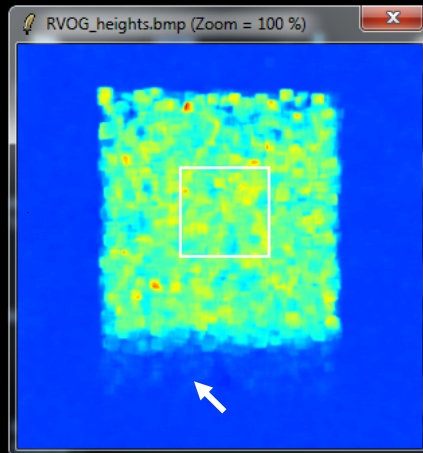
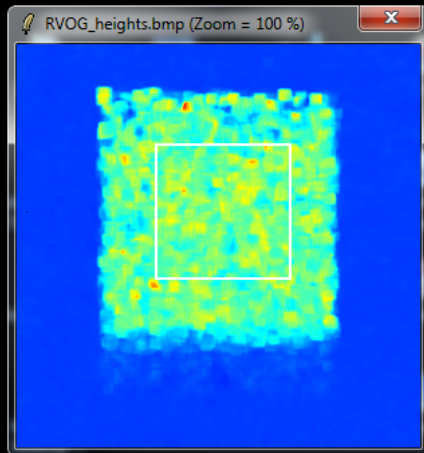
Do it Yourself:
Step 1 : Select a BMP File

HEIGHT ESTIMATION - PROFILE



Do it Yourself:
Step 2 : Select a Input Binary Data File

HEIGHT ESTIMATION - PROFILE



Do it Yourself:

Step 2 : Select the row / col to define the profile

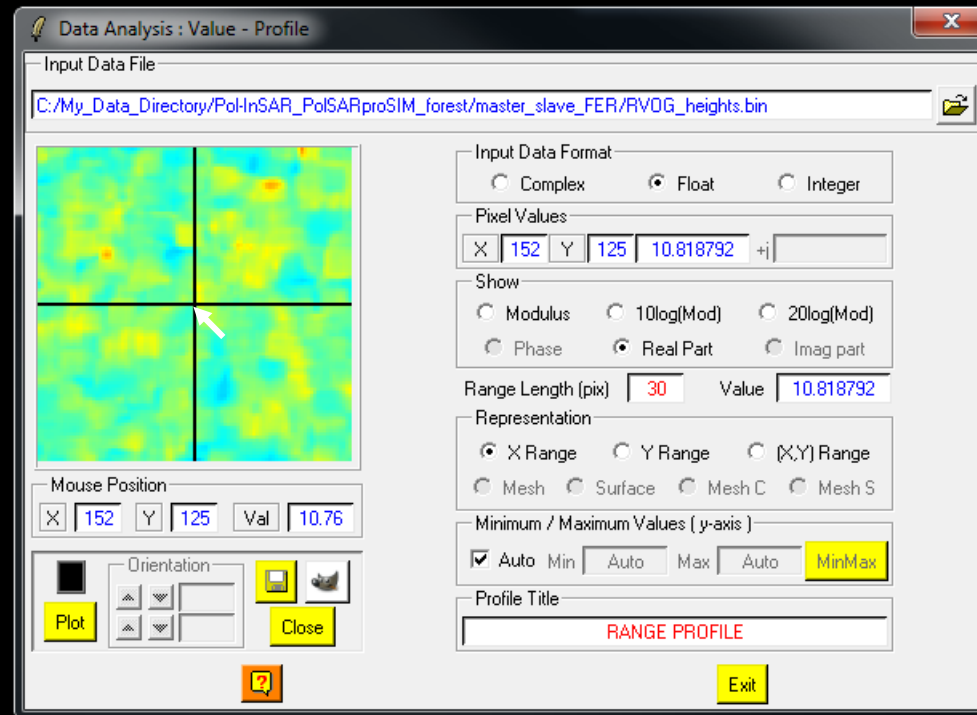
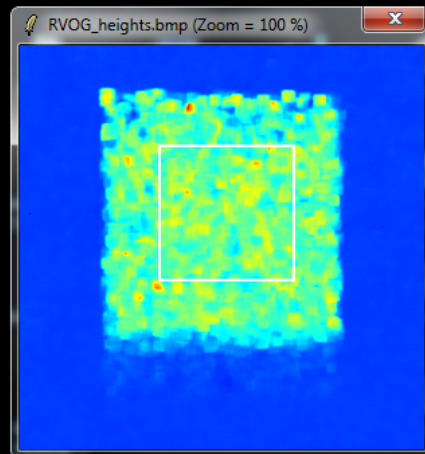
1) *Zoom* : mouse *outside* the rect

Left button : Zoom in

Right button : Zoom out

2) *Move* : mouse *inside* the rect

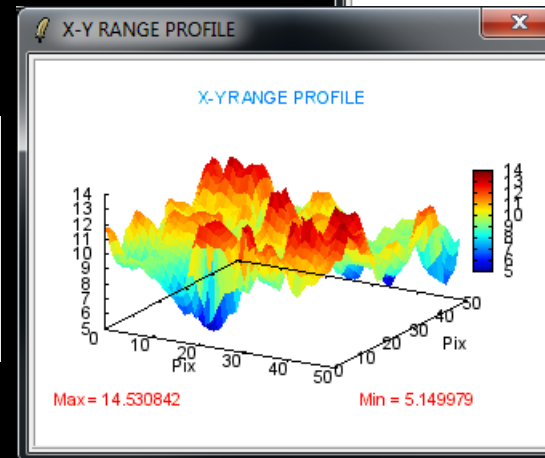
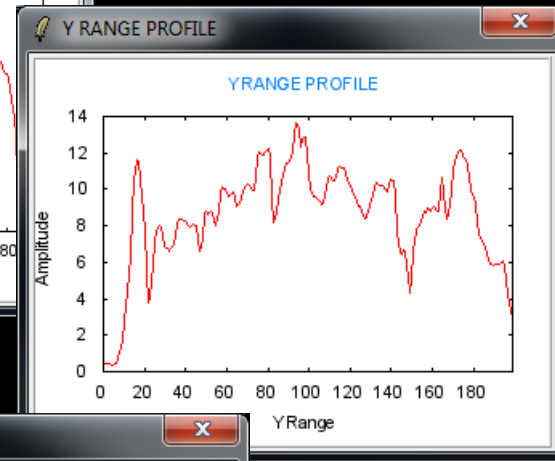
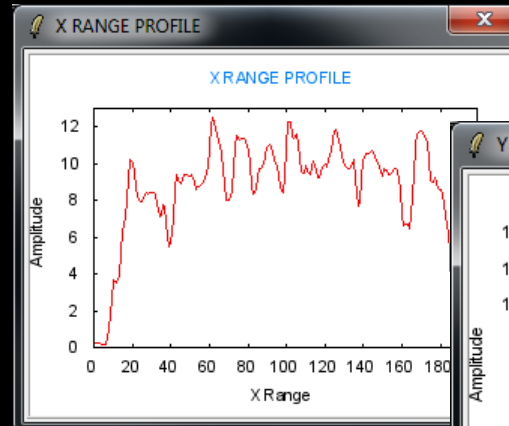
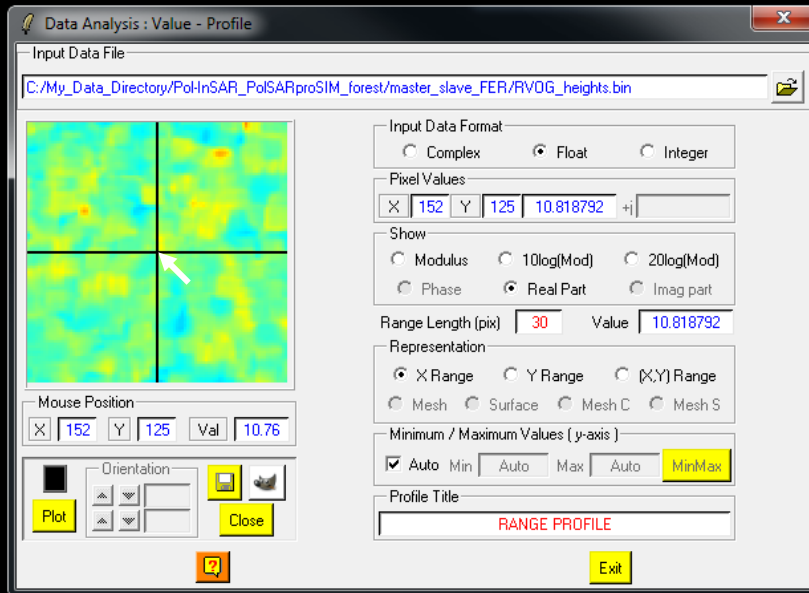
HEIGHT ESTIMATION - PROFILE



Do it Yourself:

Step 4 : Select the pixel (row / col) center of the profile

HEIGHT ESTIMATION - PROFILE



Do it Yourself:

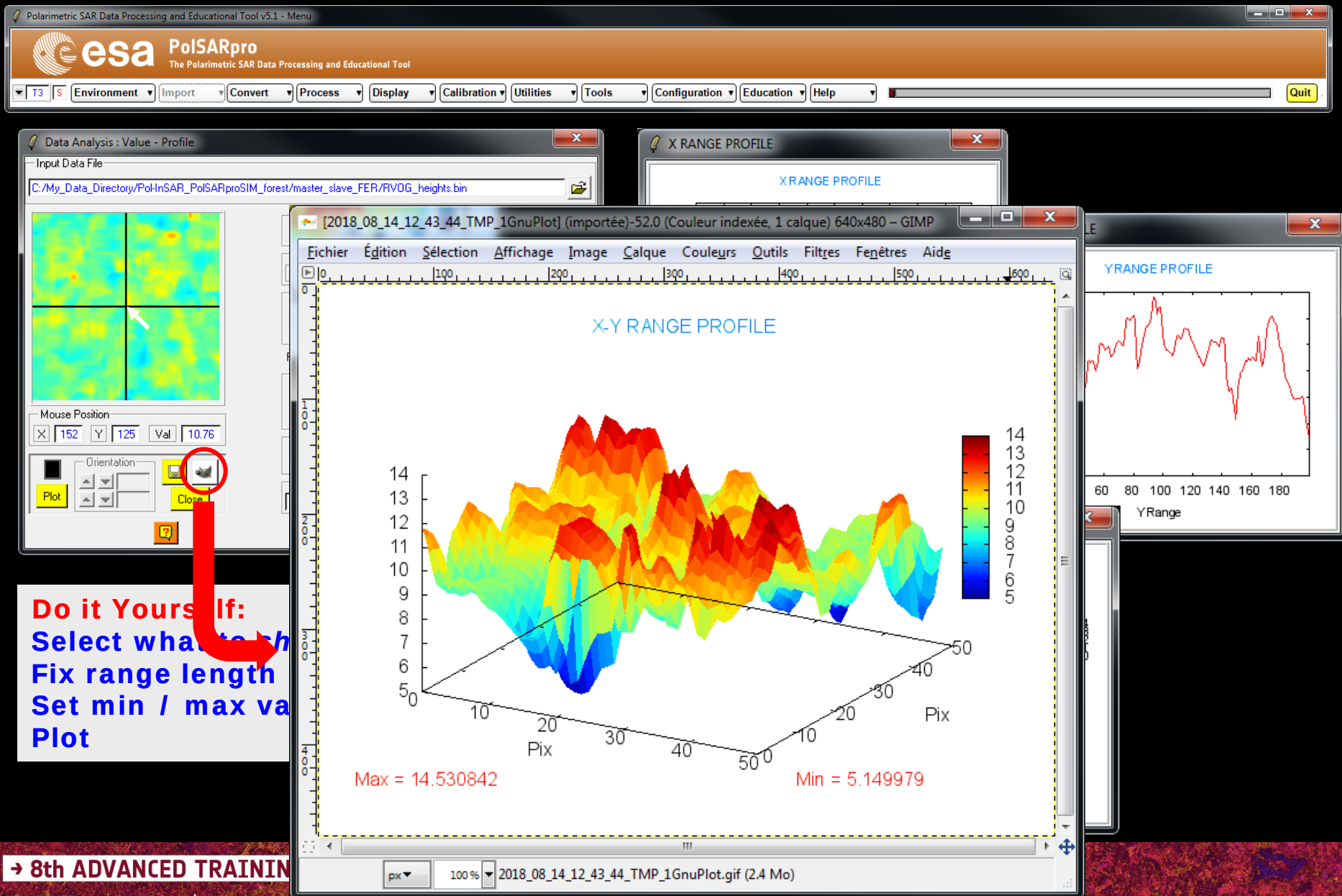
Select what to show in 1D or 3D

Fix range length (**100pix in 1D, 30pix in 3D**)

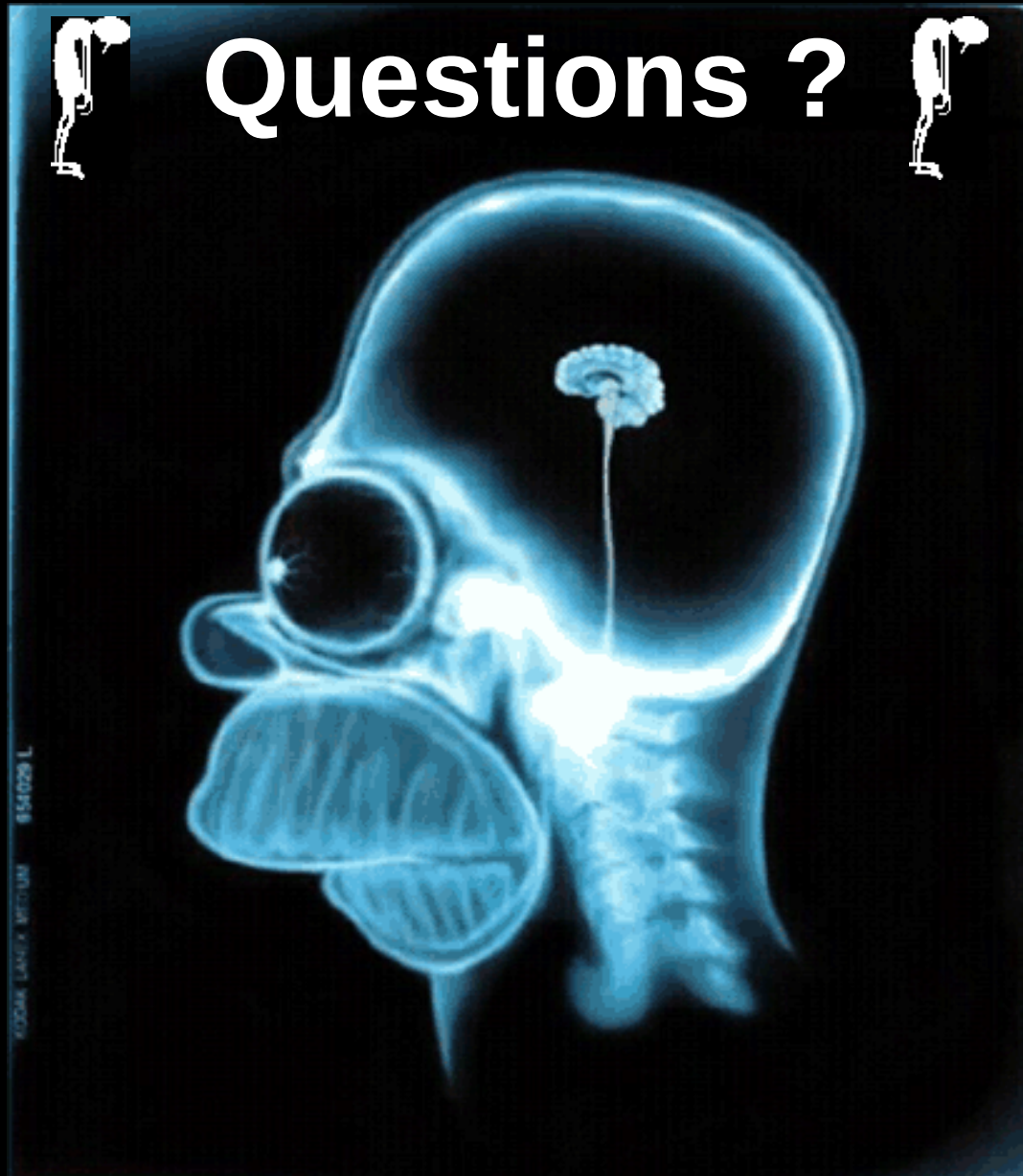
Set min / max values

Plot

HEIGHT ESTIMATION - PROFILE



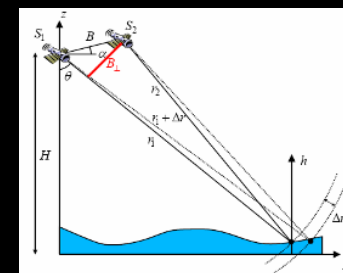
Questions ?



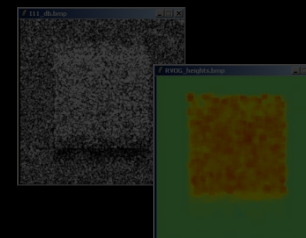
KODAK LAKSA MEDICAL 854028 L



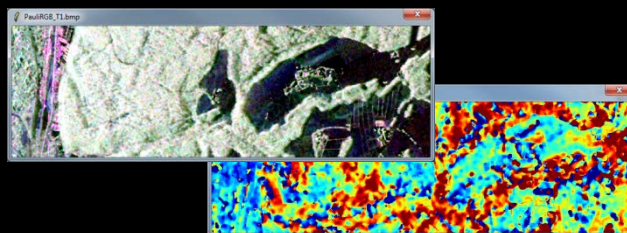
Forestry Applications with Pol-InSAR *Practical*



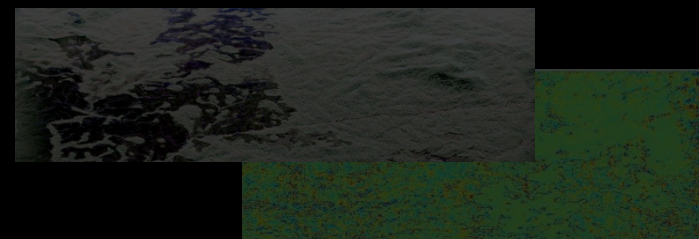
1st part : Simulated Pol-InSAR datasets



2nd part : Airborne Pol-InSAR datasets (**ESAR - DLR**)

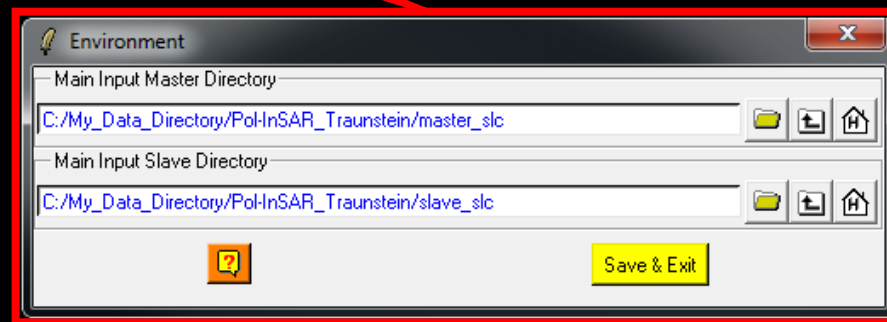
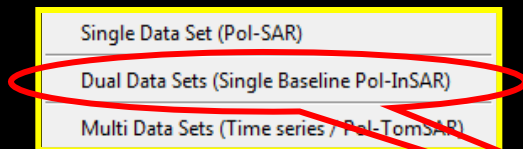


Traunstein / Germany



AfriSAR campaign / Gabon

MAIN MENU - ENVIRONMENT



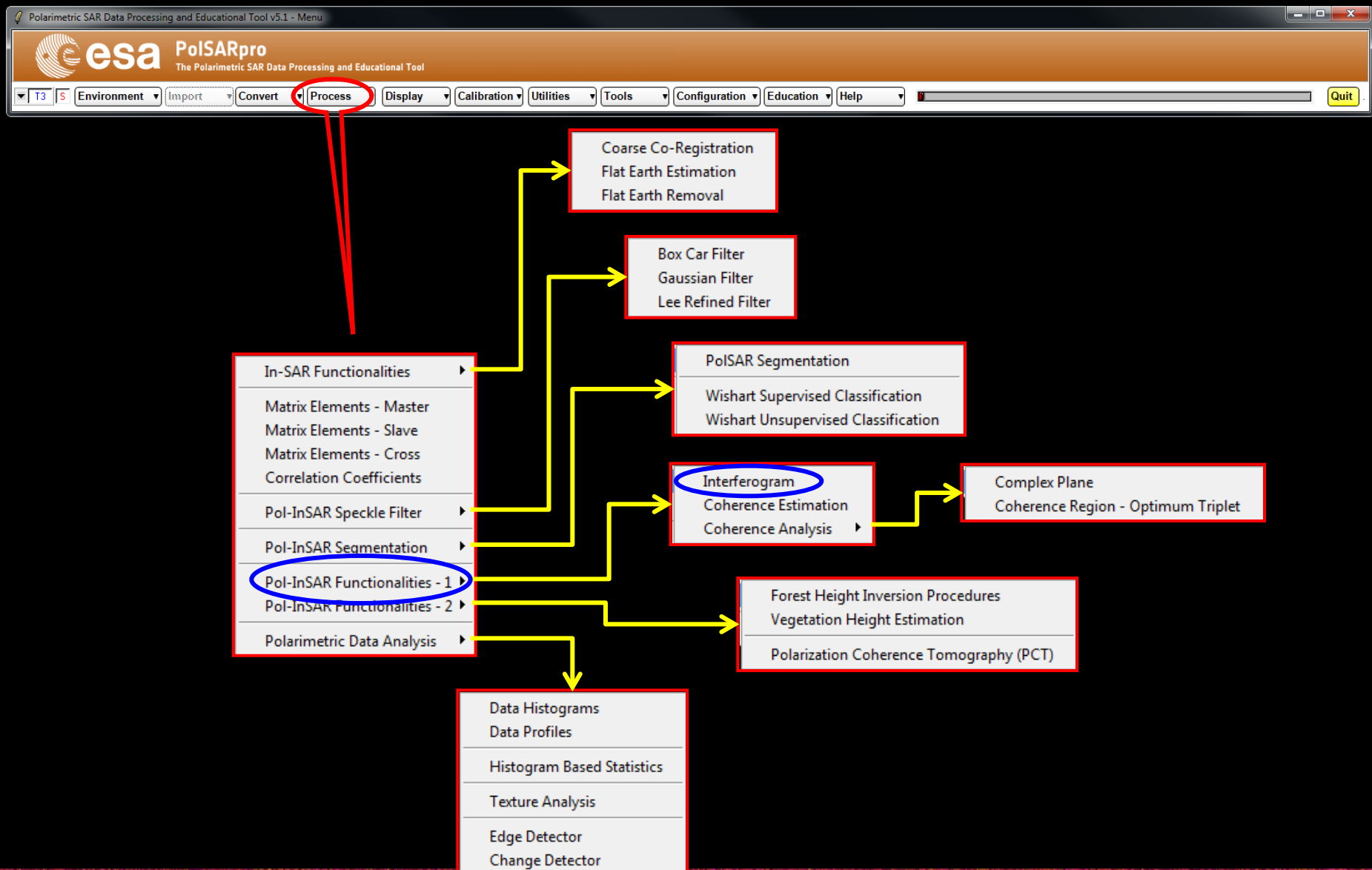
Input Master Directory:

My_Data_Directory / Pol-InSAR_Traunstein / master_slc

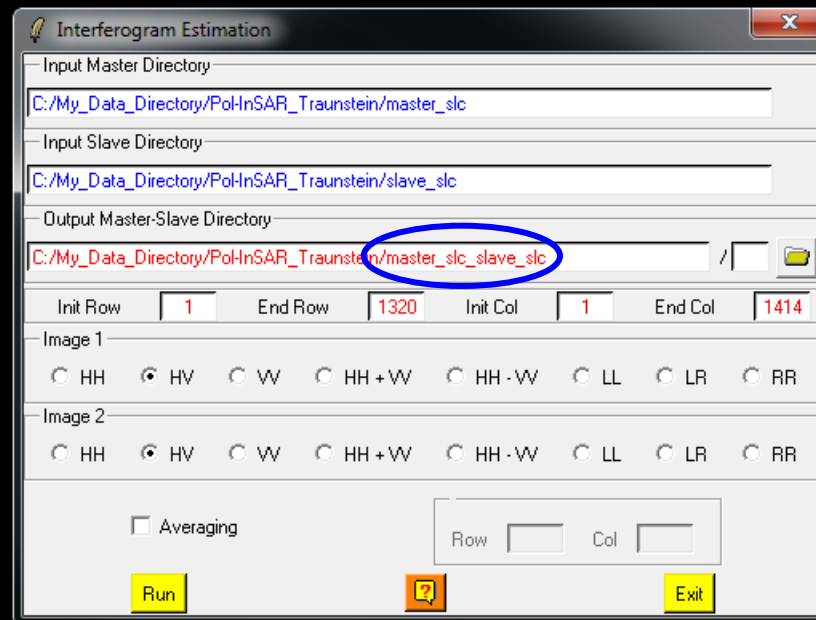
Input Slave Directory:

My_Data_Directory / Pol-InSAR_Traunstein / slave_slc

PROCESS DATA



RAW INTERFEROGRAM



Do it Yourself:

Select polarization channels and view the corresponding BMP files.

Note:

The Output Directory is automatically set to: **MasterDir_SlaveDir**

RAW INTERFEROGRAM



DATA_MASTERDIR_SLAVEDIR



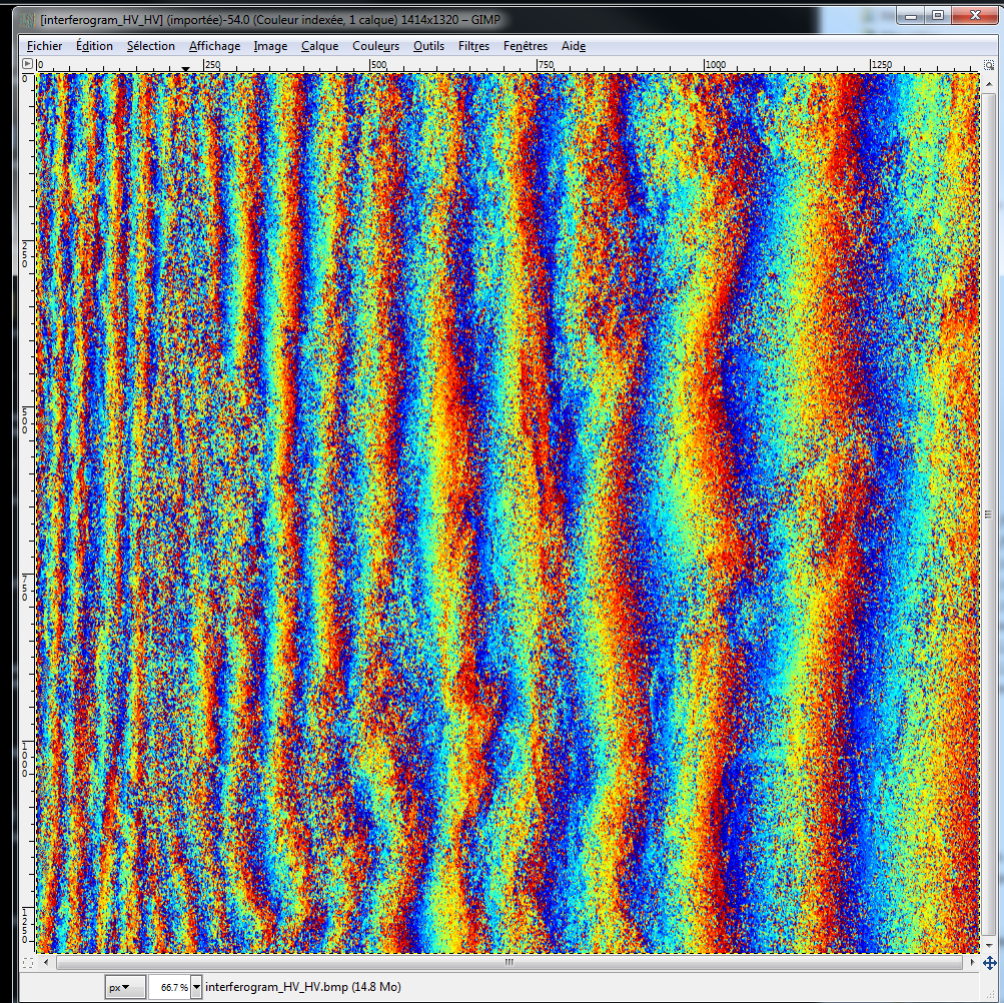
config.txt



interferogram_XX_XX.bin



interferogram_XX_XX.bmp

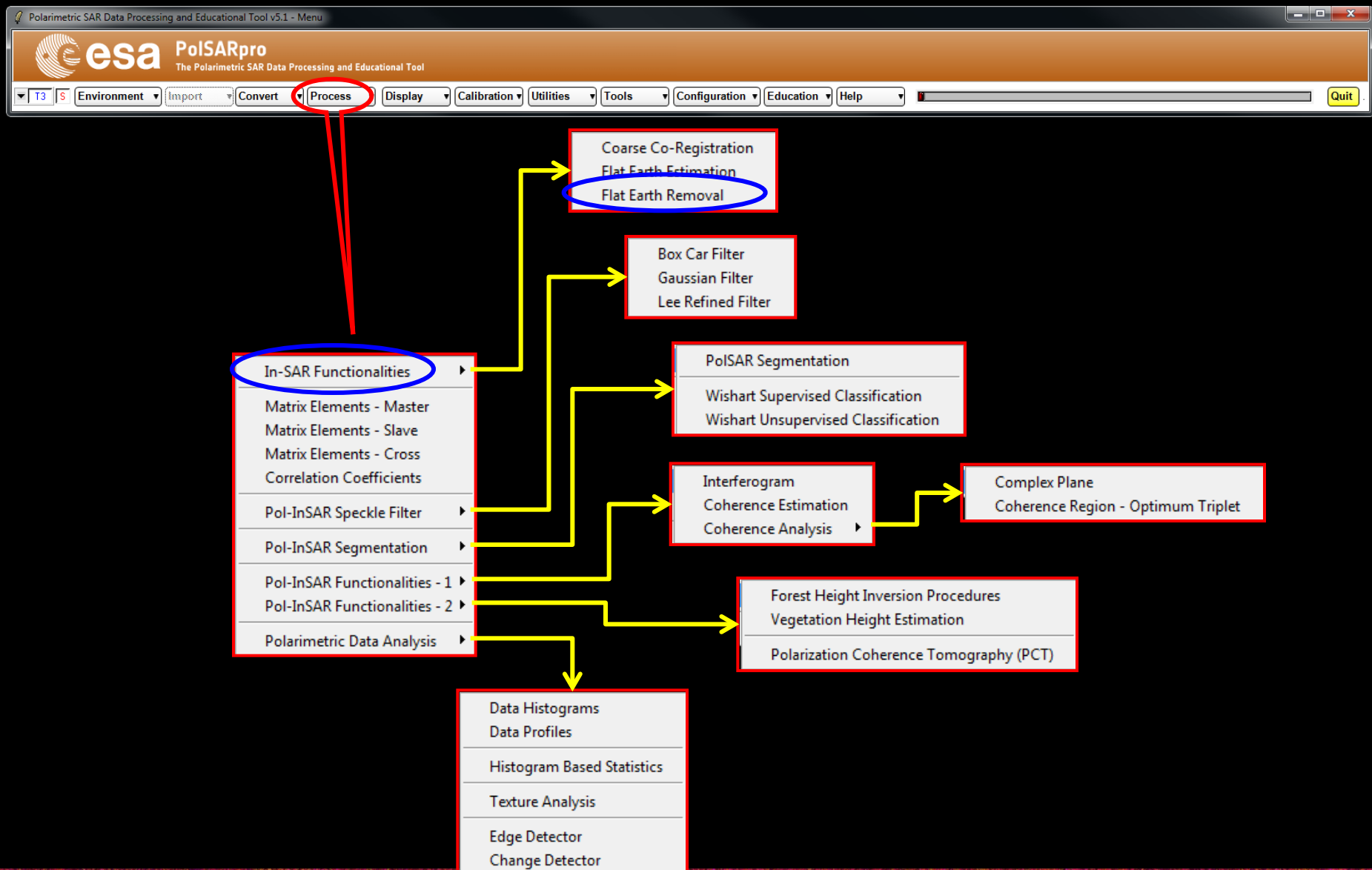


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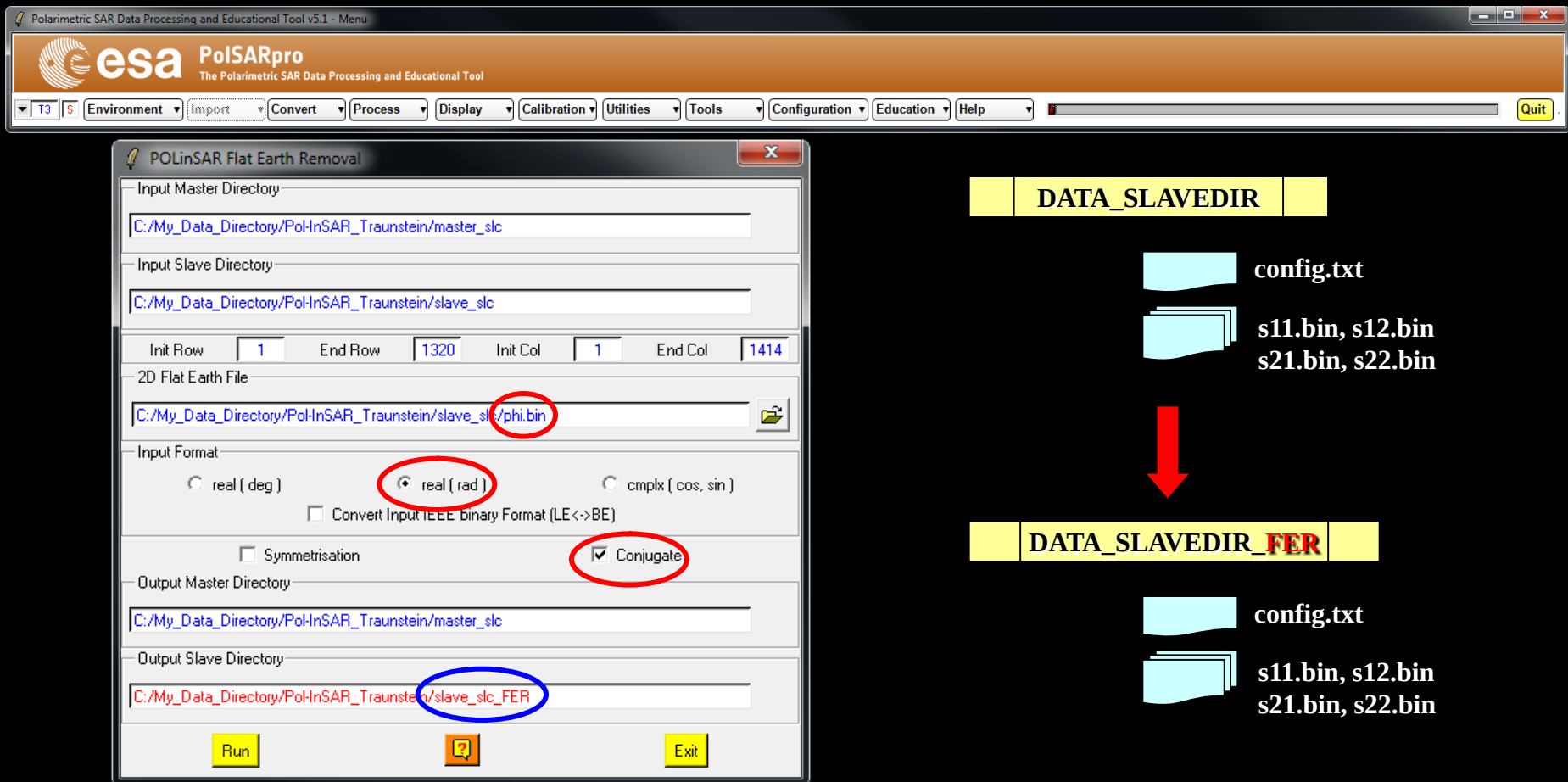
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PROCESS DATA



FLAT EARTH REMOVAL



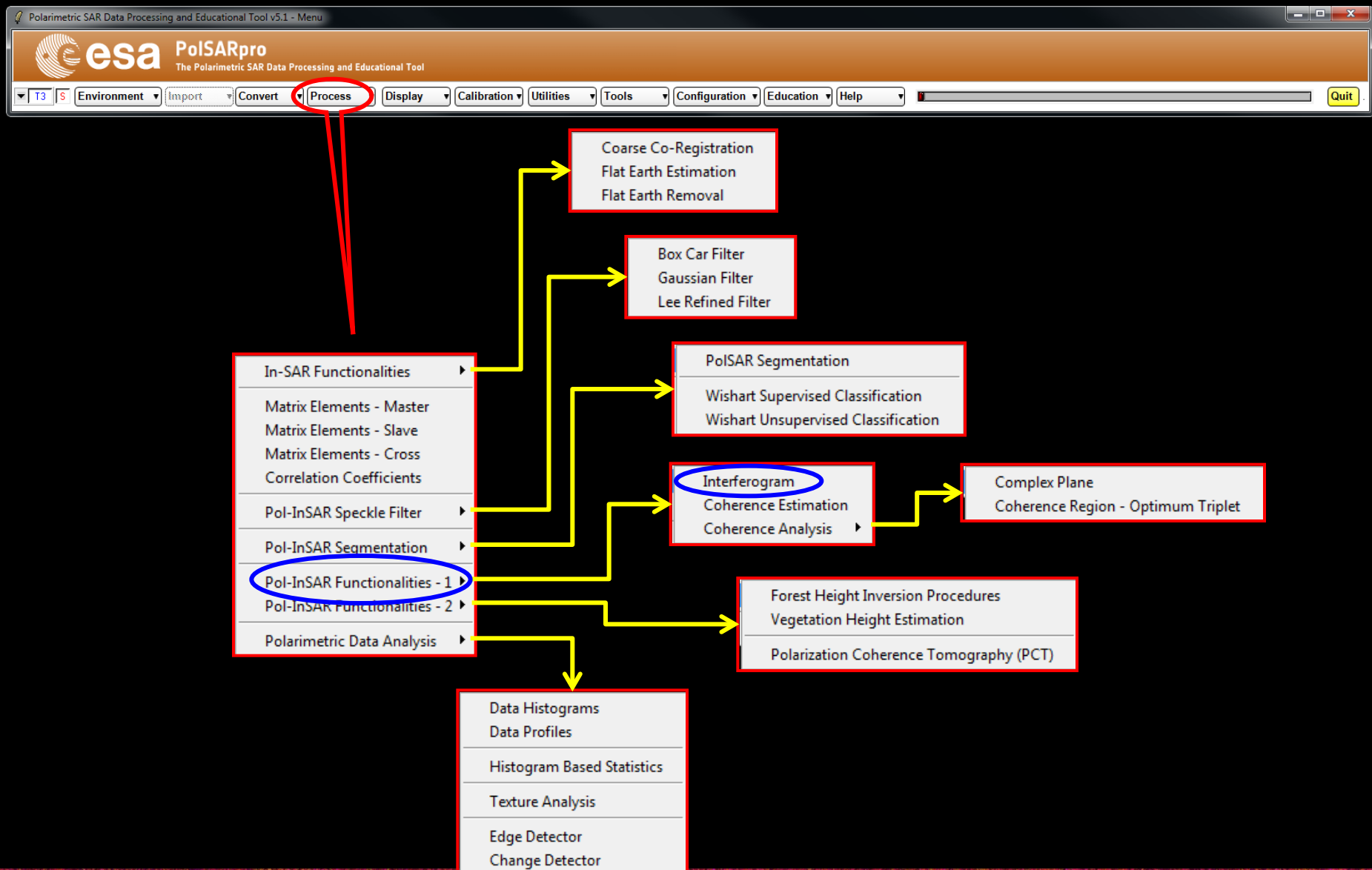
Do it Yourself:

Enter Flat Earth file name, set the parameters and run the function.

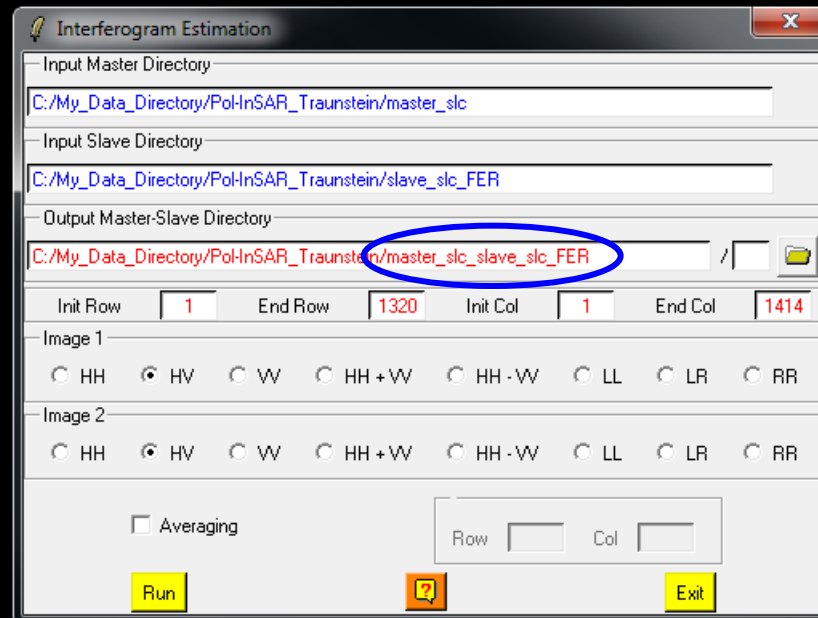
Note:

The Input Slave Directory is automatically set to: **SlaveDir_FER**

PROCESS DATA



RAW INTERFEROGRAM



Do it Yourself:

Select polarization channels and view the corresponding BMP files.

Note:

The Output Directory is automatically set to: **MasterDir_SlaveDir**

RAW INTERFEROGRAM

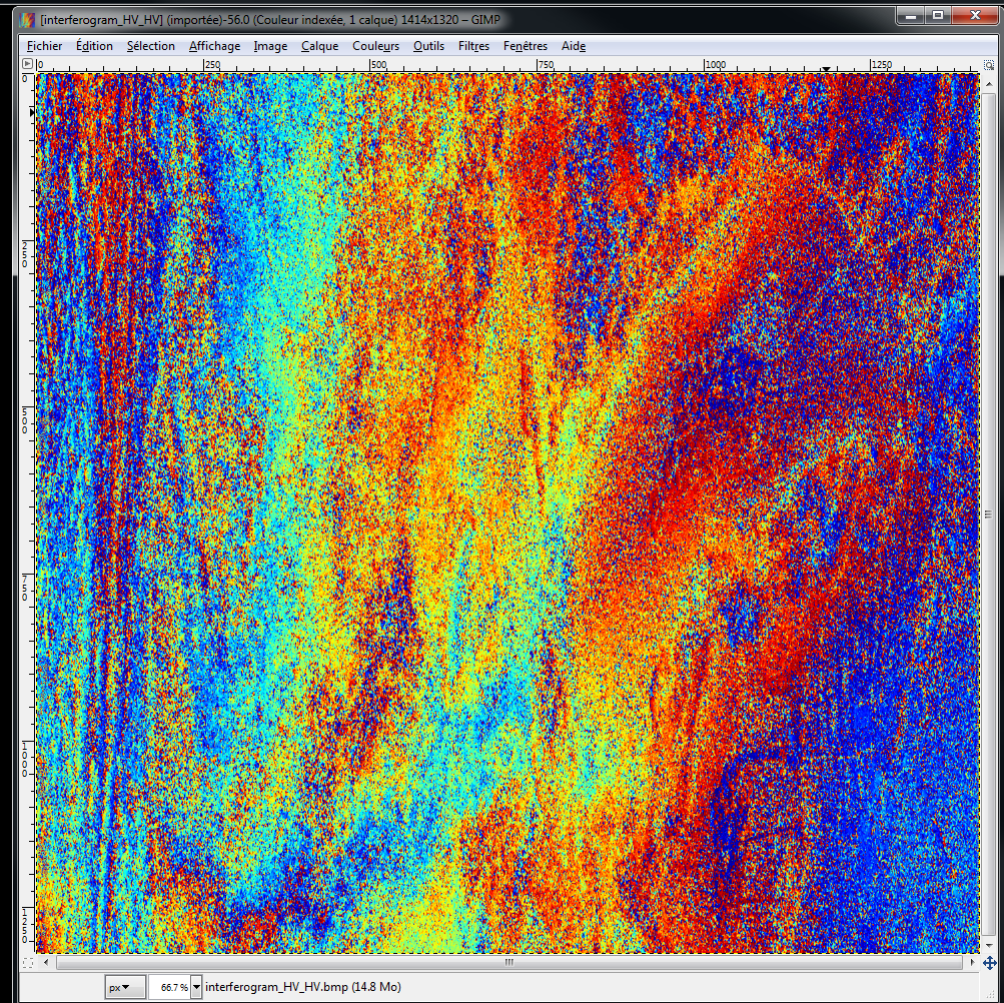


DATA_MASTERDIR_SLAVEDIR_FER

config.txt

interferogram_XX_XX.bin

interferogram_XX_XX.bmp

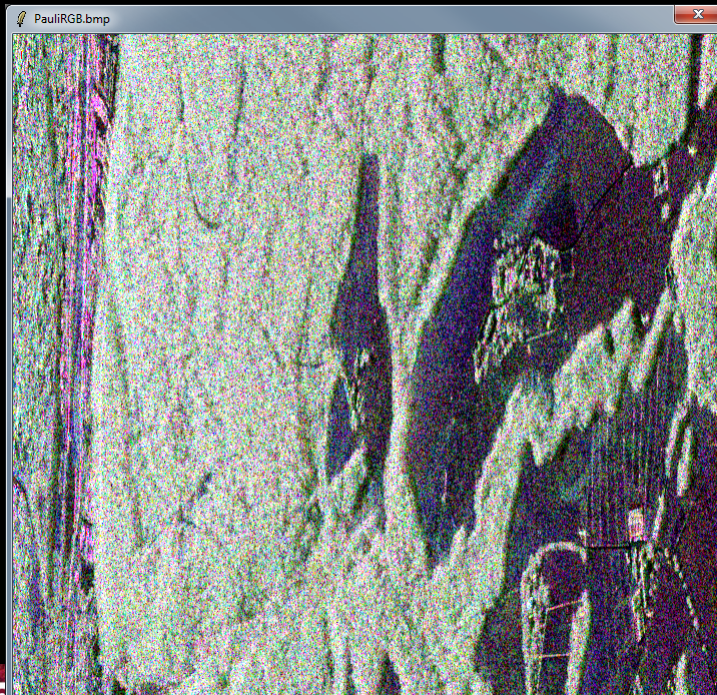


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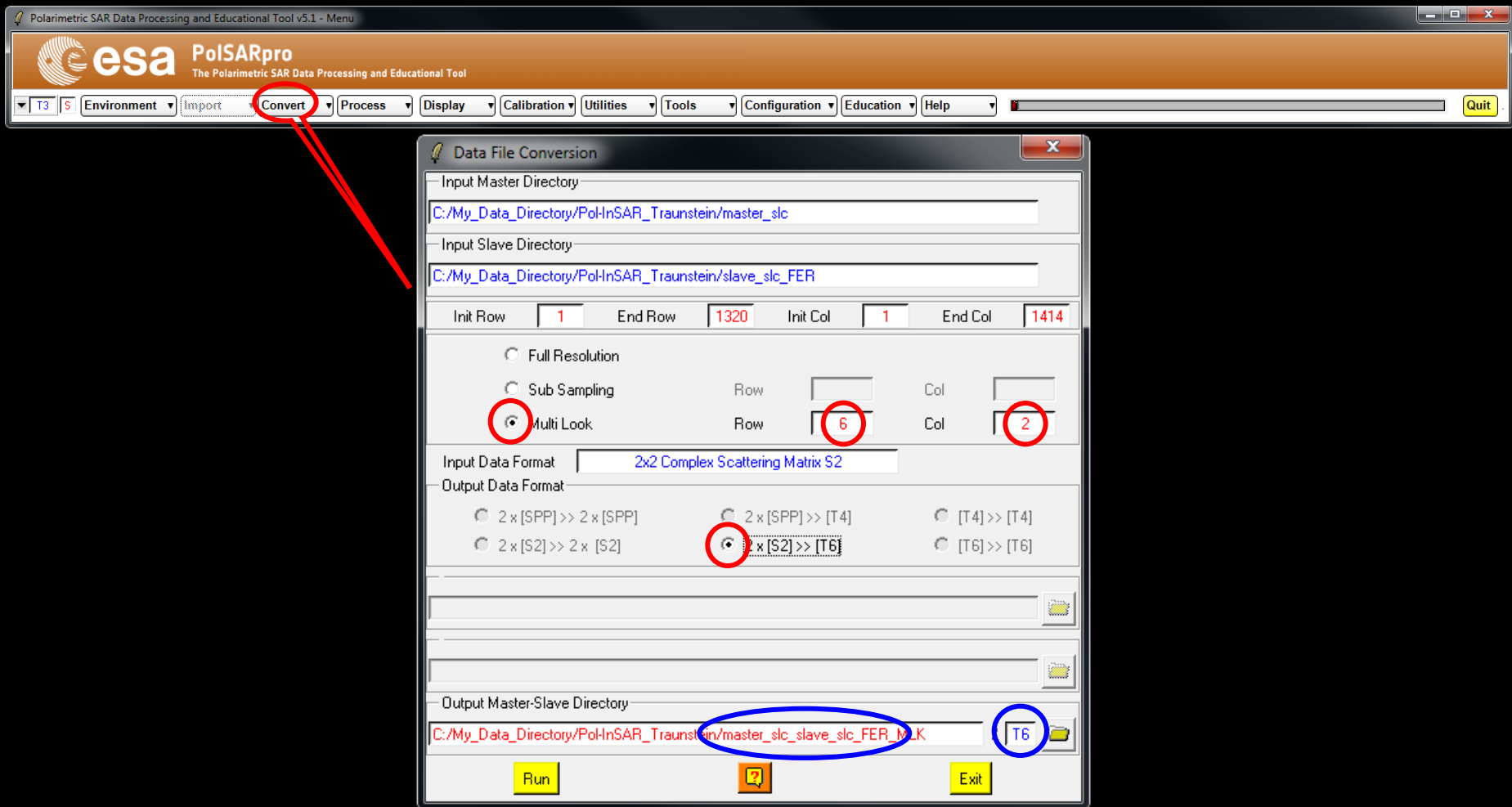
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CONVERT (S2 >> T6) + MULTILOOK esa



CONVERT (S2 >> T6) + MULTILOOK



Do it Yourself:

Select Multi Look : Row = 6 and Col = 2

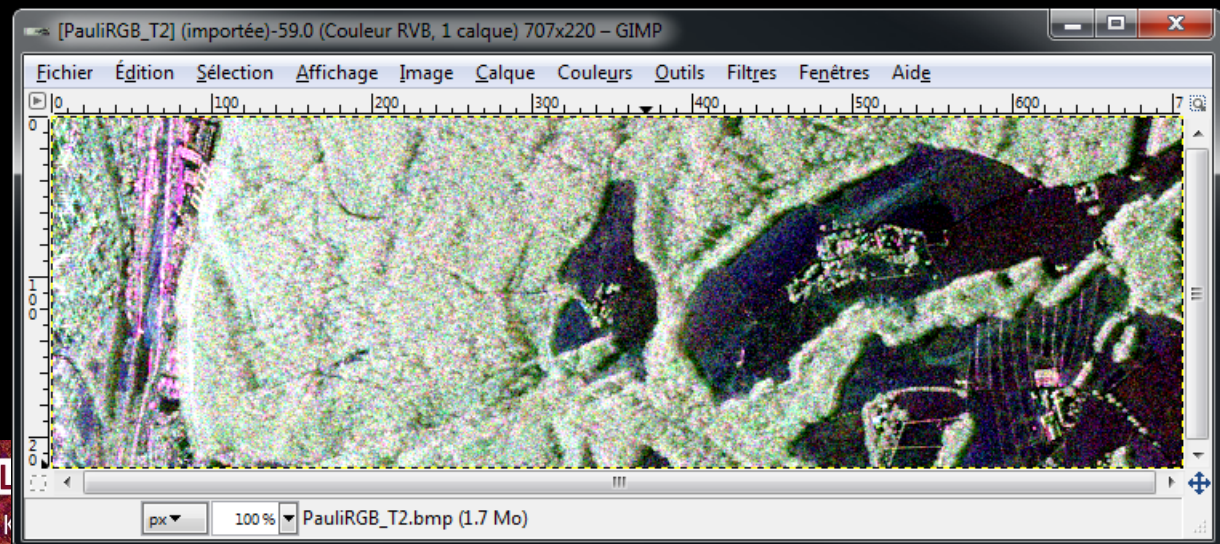
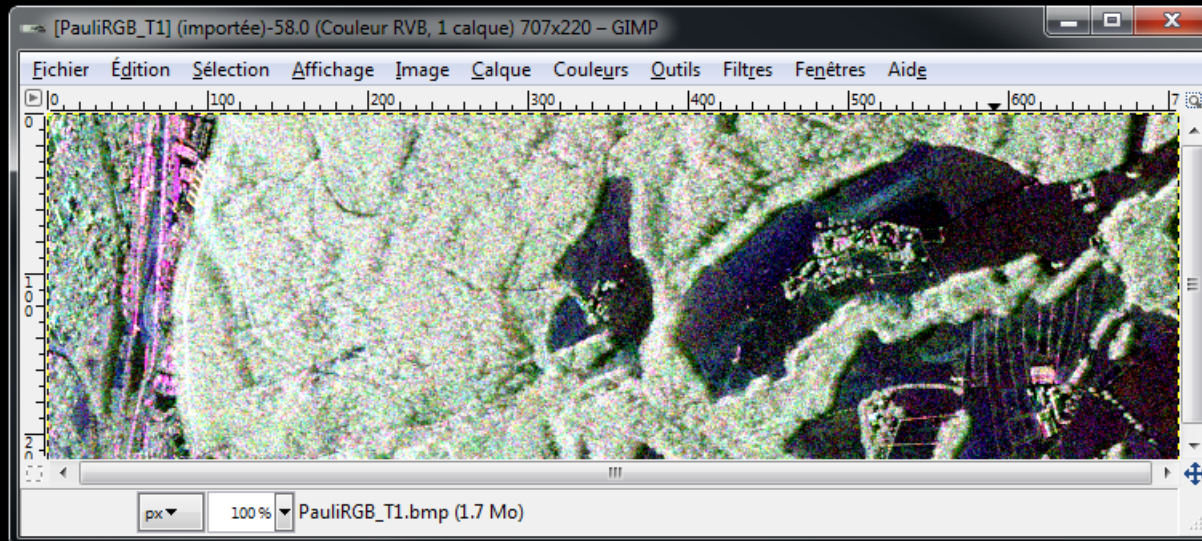
Select Output Data Format : 2 x [S2] >> [T6]

→ 8th

10-14

The Output Directory is automatically set to: MasterDir_SlaveDir_FER_MLK / T6

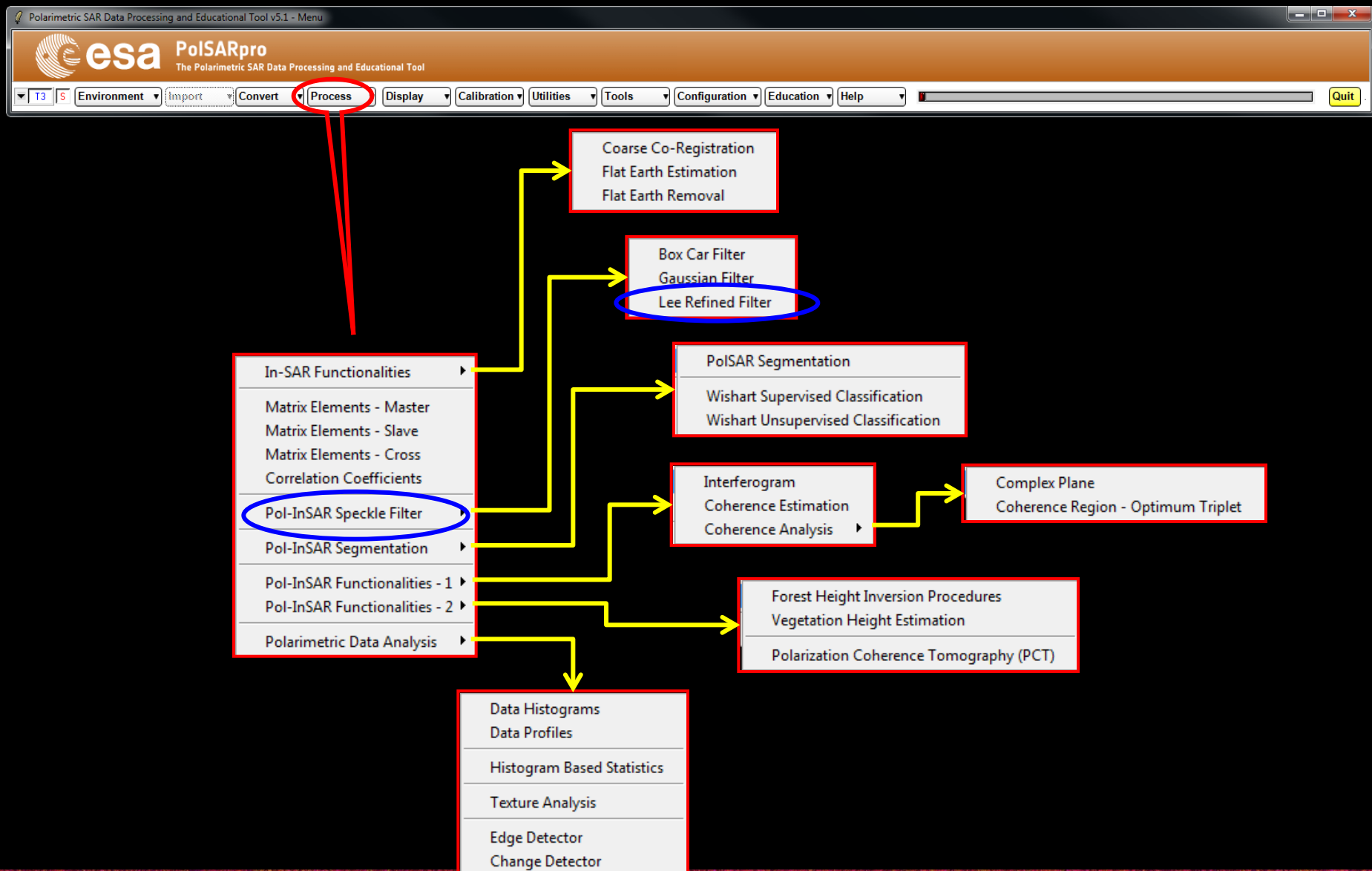
CONVERT (S2 >> T6) + MULTILOOK esa



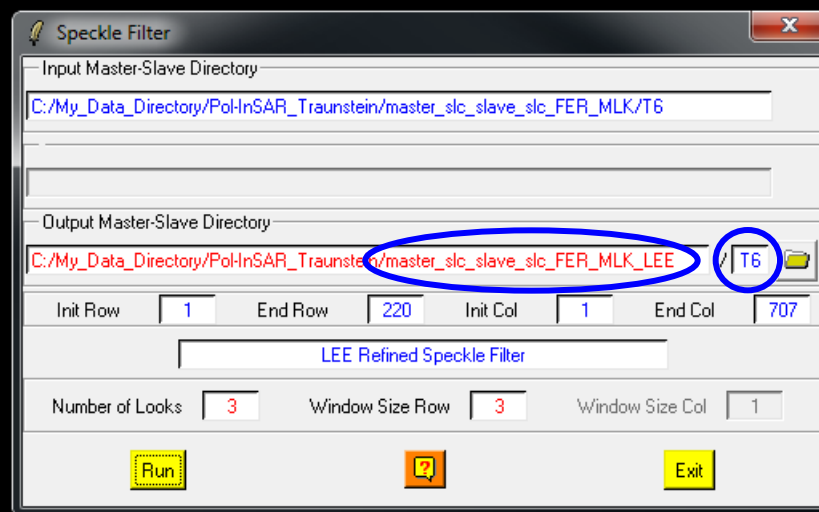
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PROCESS DATA



PROCESS DATA



Do it Yourself:

Set the parameters : Num Looks = 3 ; Window Size = 3.

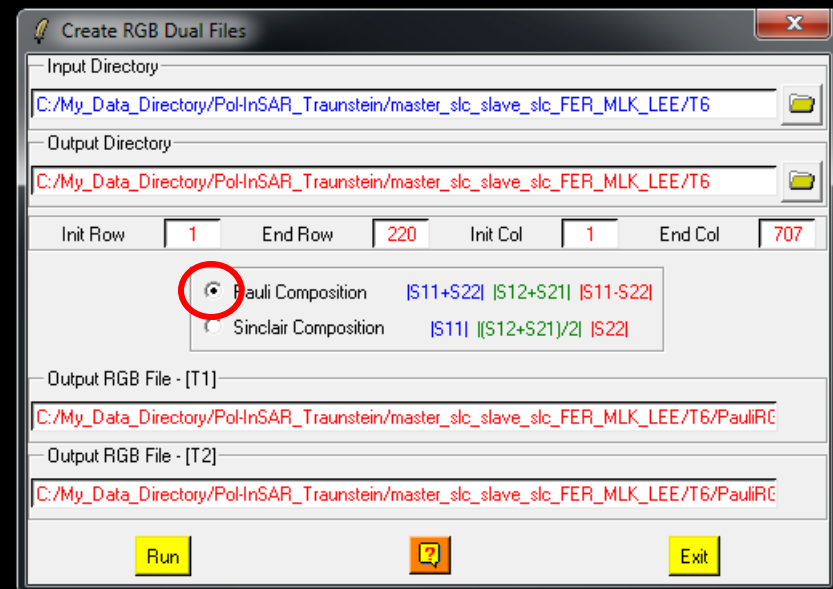
Note:

The Output Directory is automatically set to: MasterDir_SlaveDir_FER_MLK_LEE

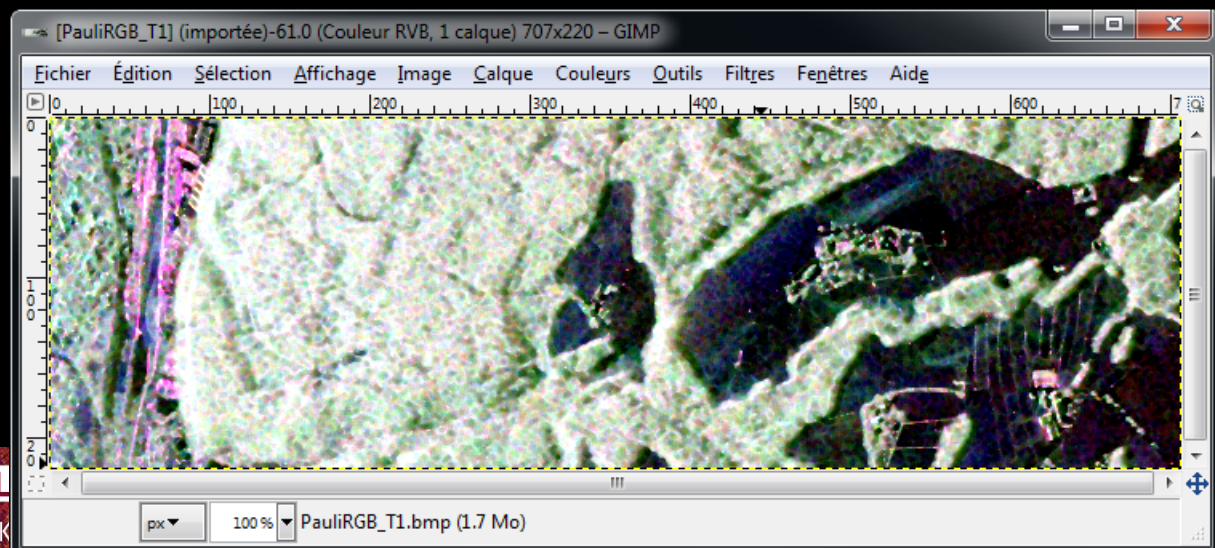
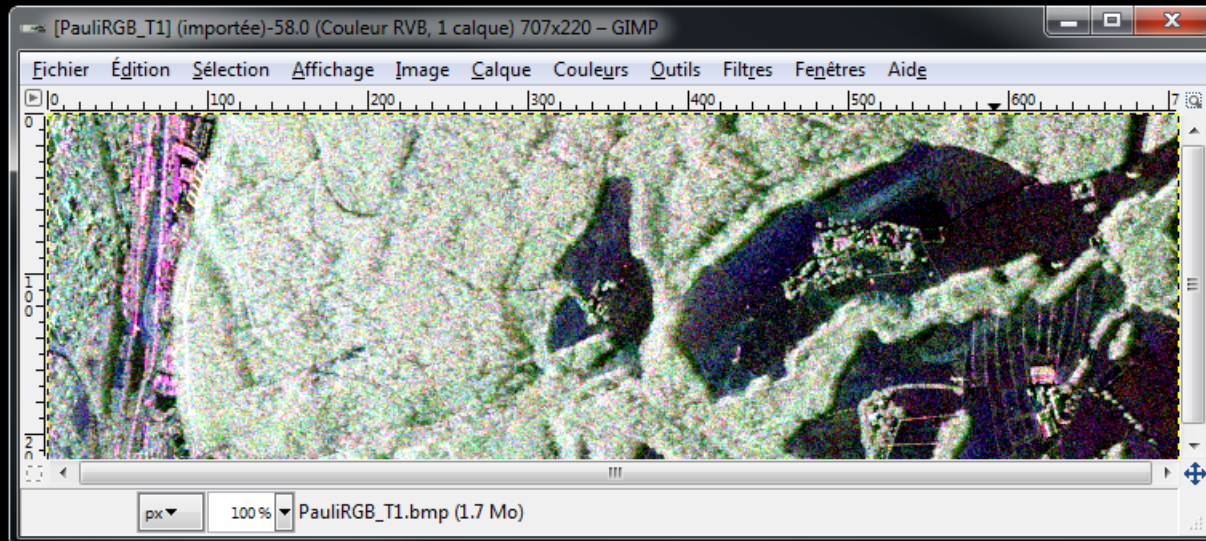
DISPLAY DATA



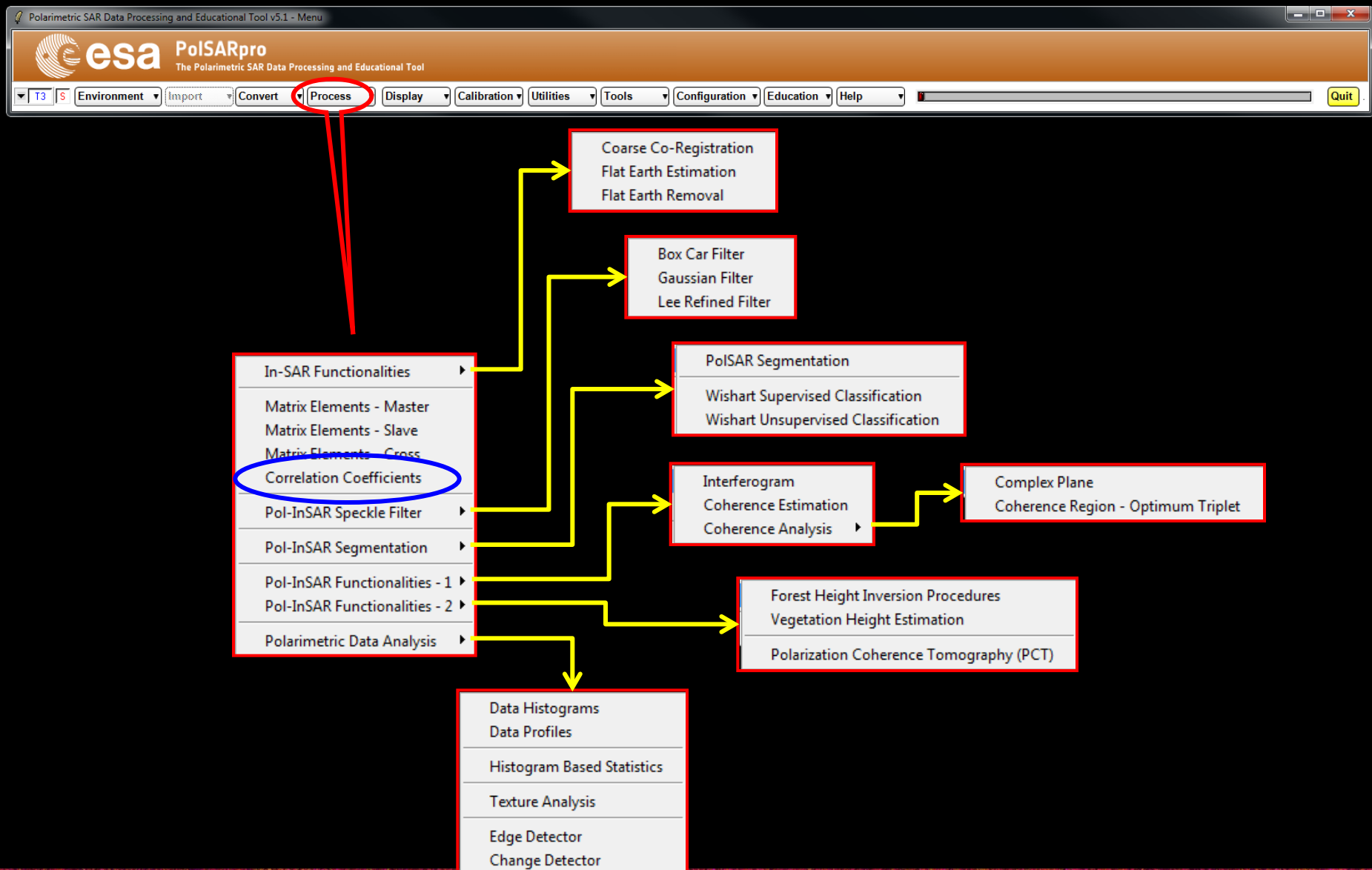
Create RGB file



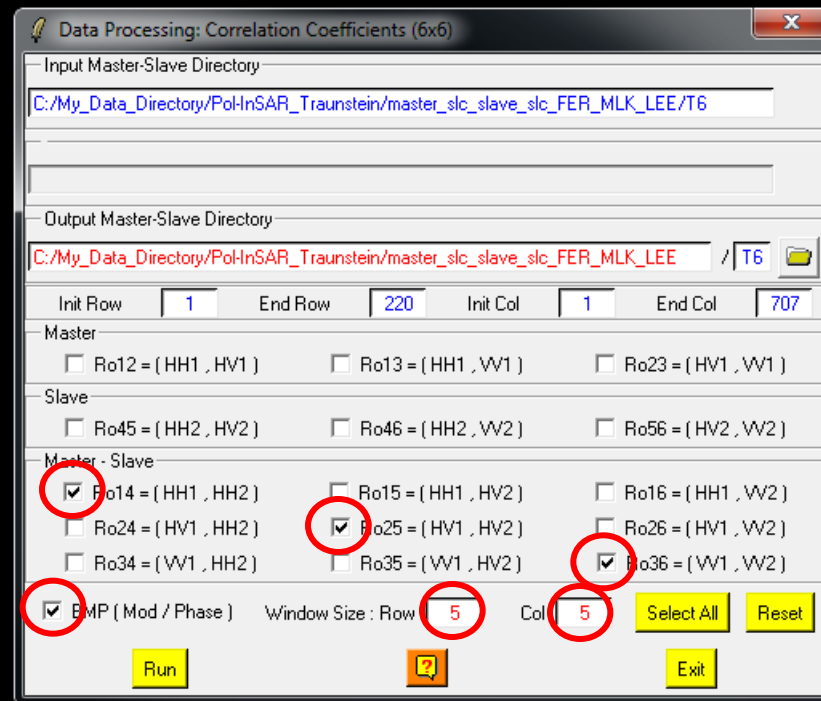
PROCESS DATA



PROCESS DATA

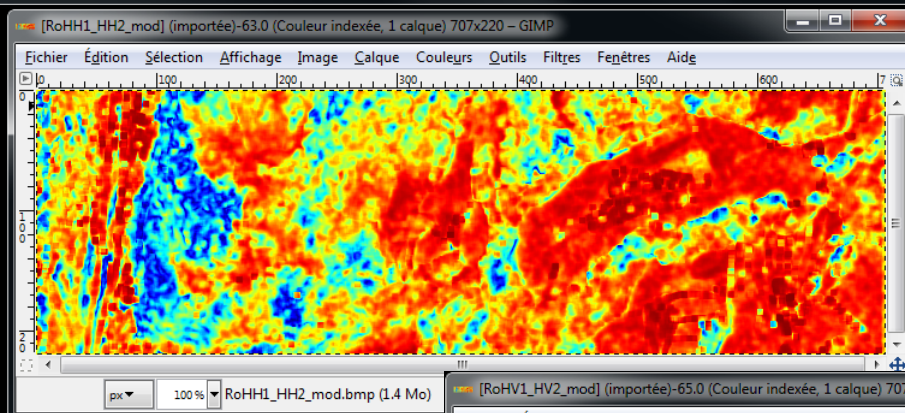


PROCESS DATA

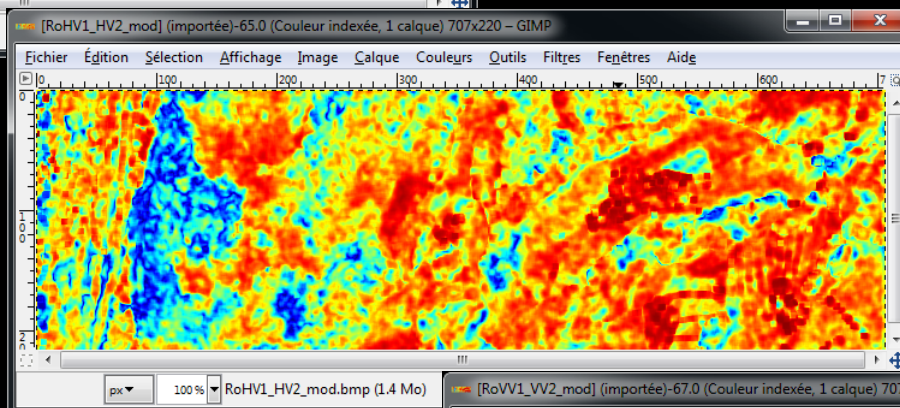


Do it Yourself:

Select the correlation coefficients, set the parameters (**Box Car = 5x5**) and view the corresponding BMP files.

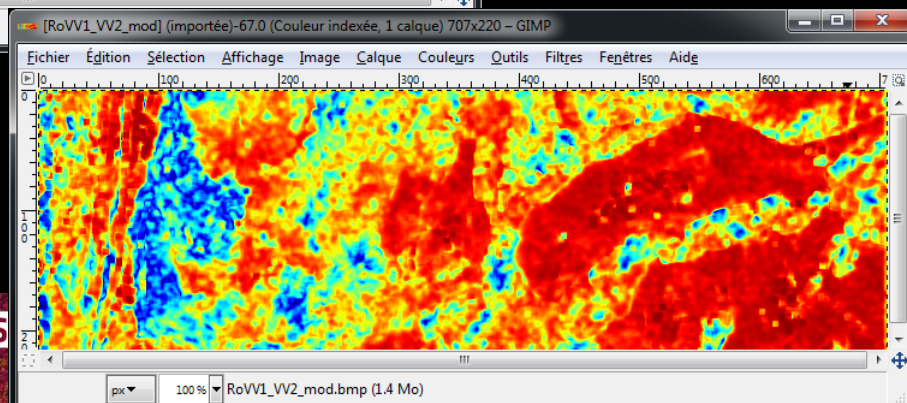


$$|\rho_{HH1 - HH2}|$$

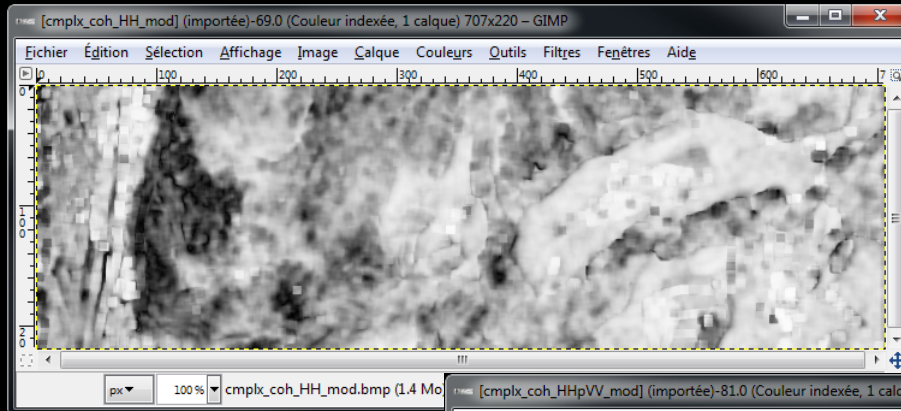


$$|\rho_{VV1 - VV2}|$$

$$|\rho_{HV1 - HV2}|$$



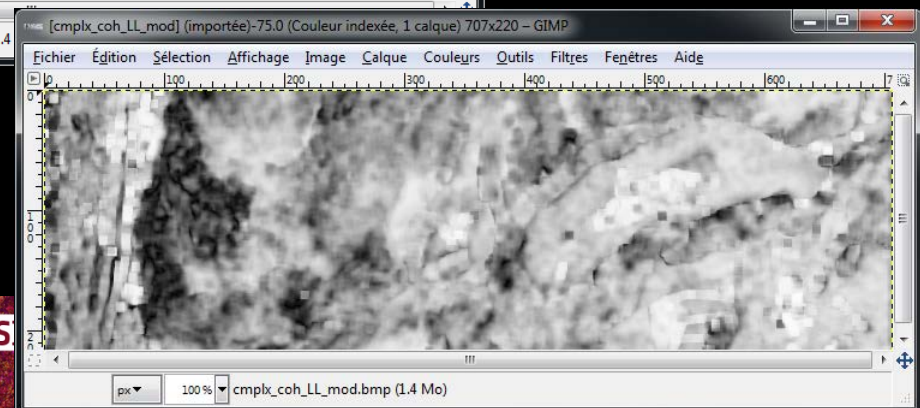
CORRELATION ESTIMATION



$$|\gamma_{HH}|$$

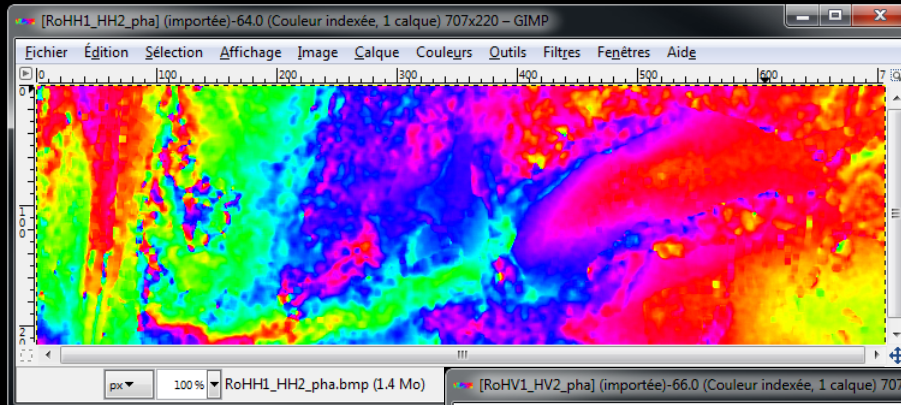


$$|\gamma_{HH + VV}|$$

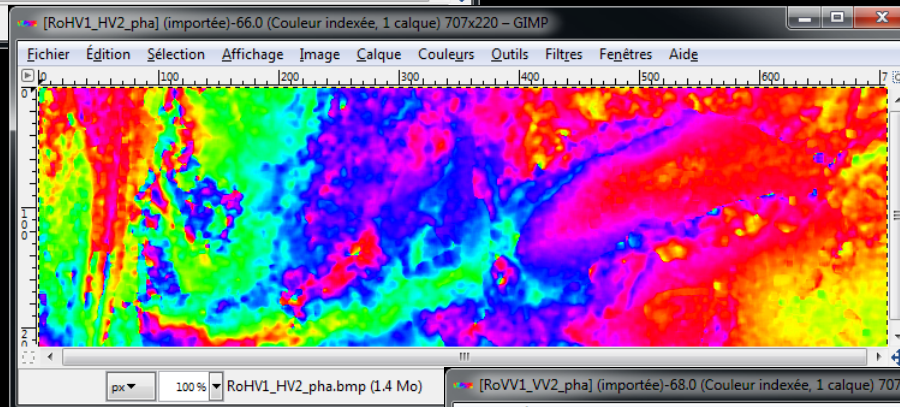


$$|\gamma_{LL}|$$

CORRELATION ESTIMATION

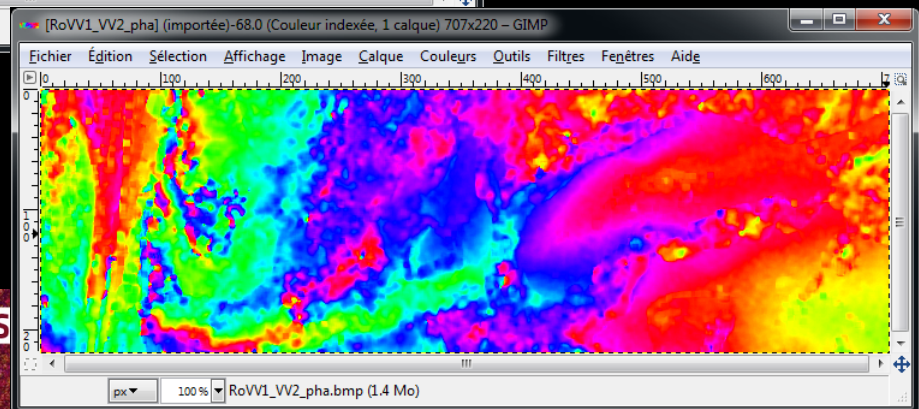


$$\rho_{HH1 - HH2}$$

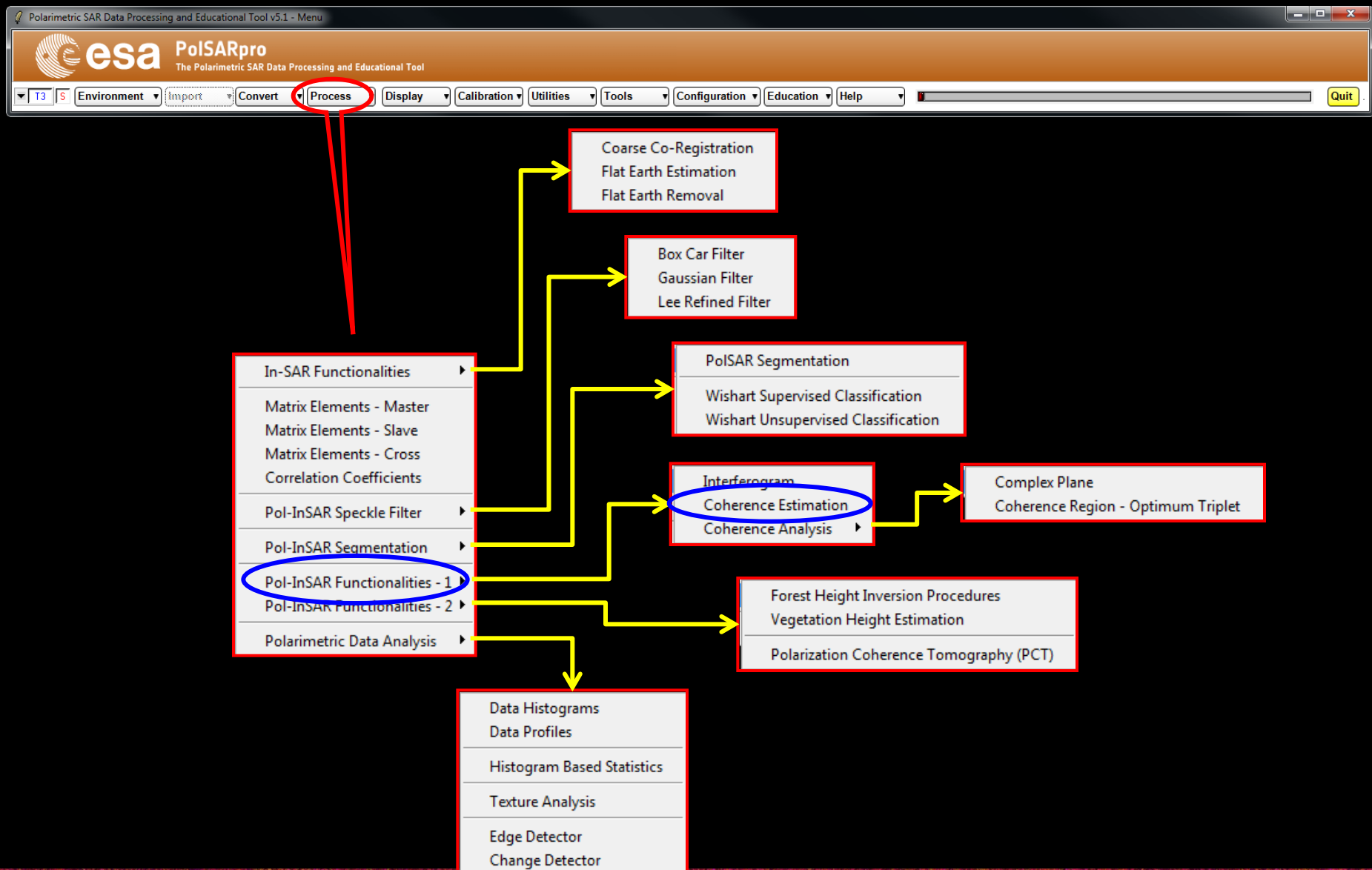


$$\rho_{VV1 - VV2}$$

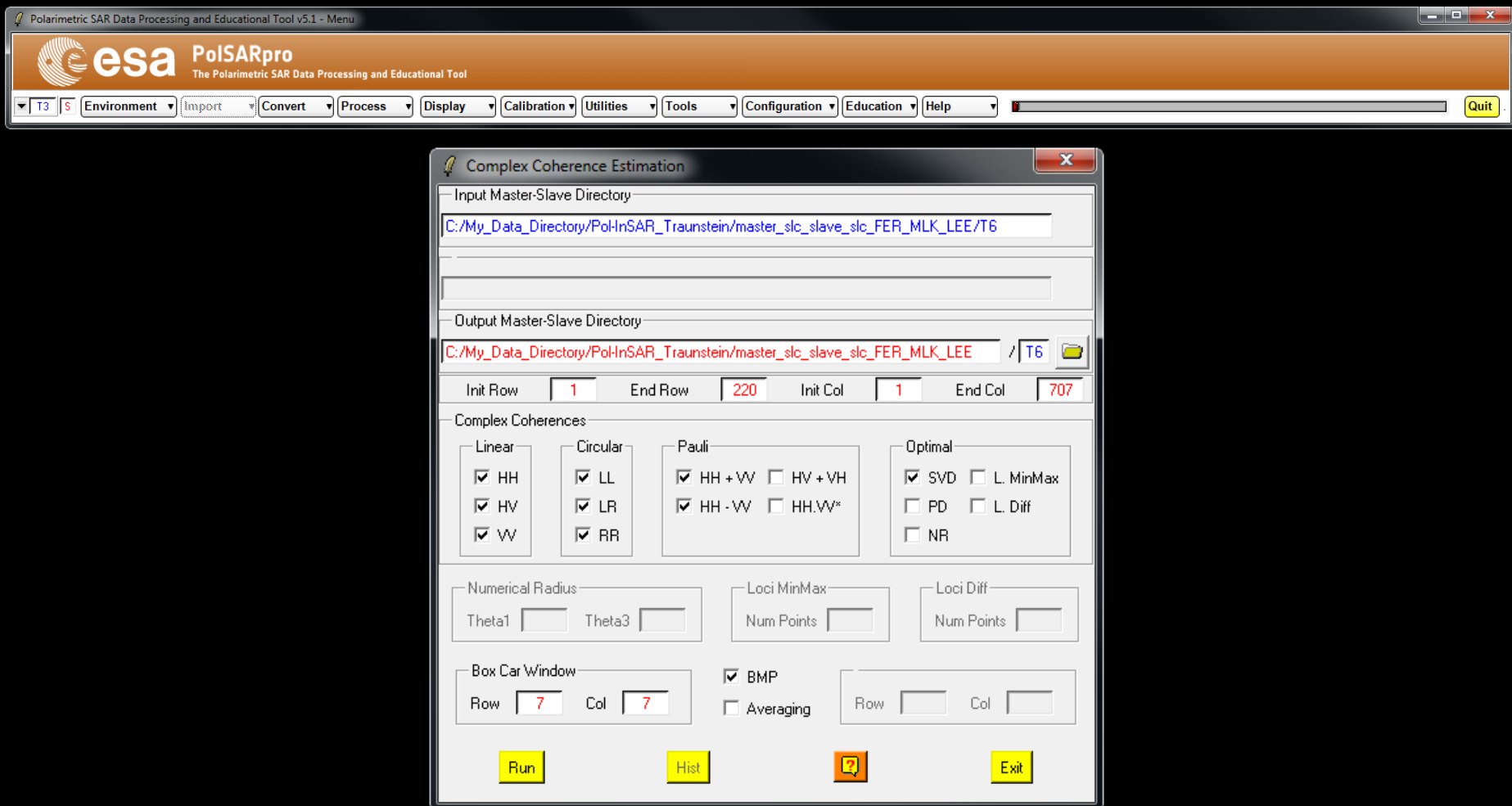
$$\rho_{HV1 - HV2}$$



PROCESS DATA



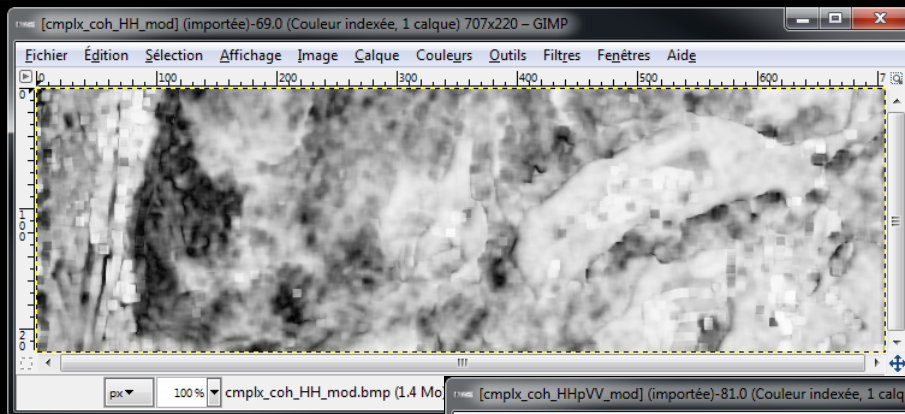
COHERENCE ESTIMATION



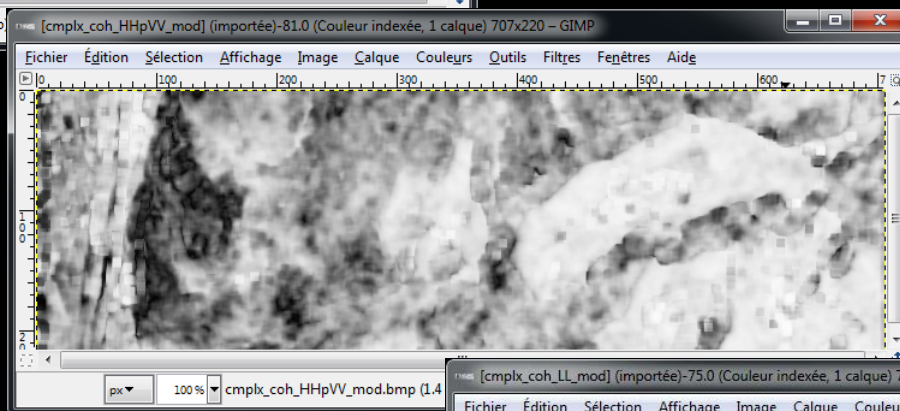
Do it Yourself:

Select polarization channels (*linear, circular, pauli, SVD*), set the parameters (*Box Car = 7x7*) and view the corresponding BMP files (*select BMP*).

COHERENCE ESTIMATION

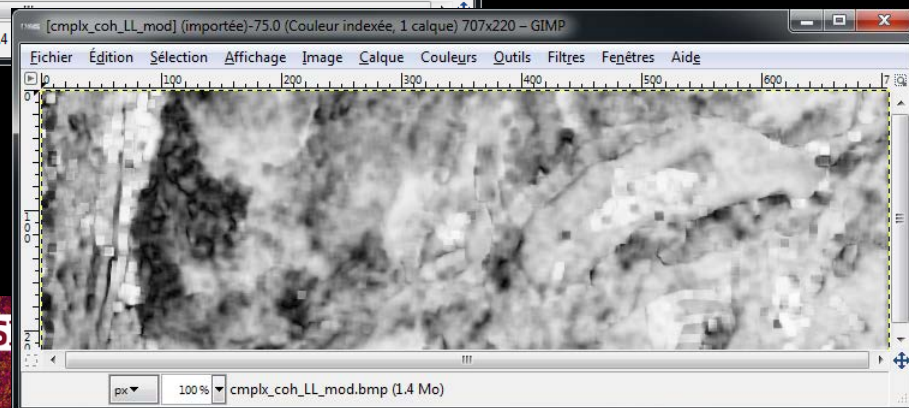


$$|\gamma_{HH}|$$

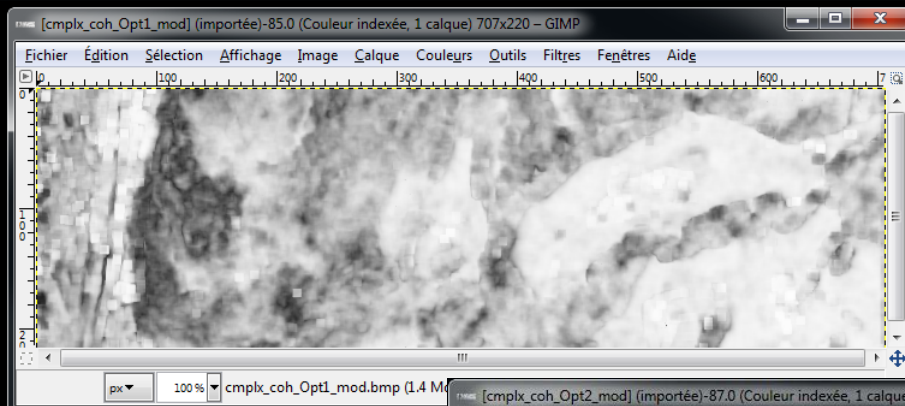


$$|\gamma_{LL}|$$

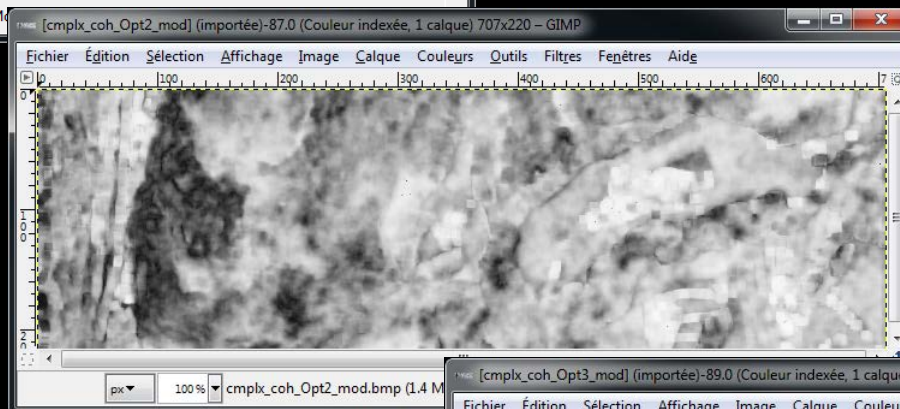
$$|\gamma_{HH + VV}|$$



COHERENCE ESTIMATION

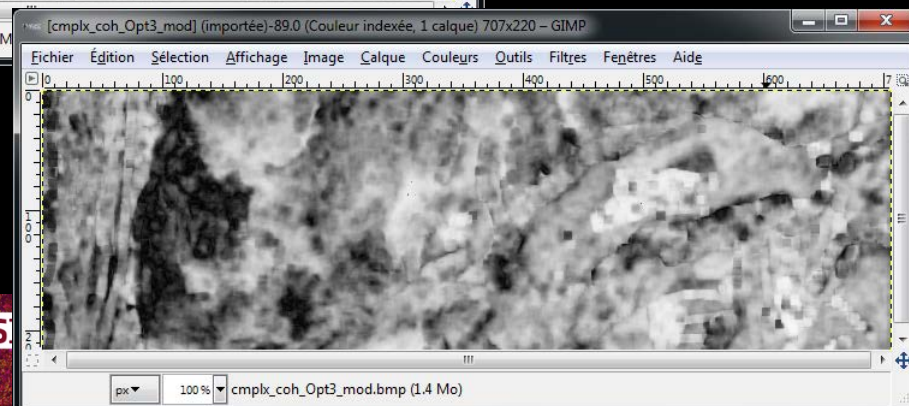


$\gamma_{\text{OPT-1}}$



$\gamma_{\text{OPT-2}}$

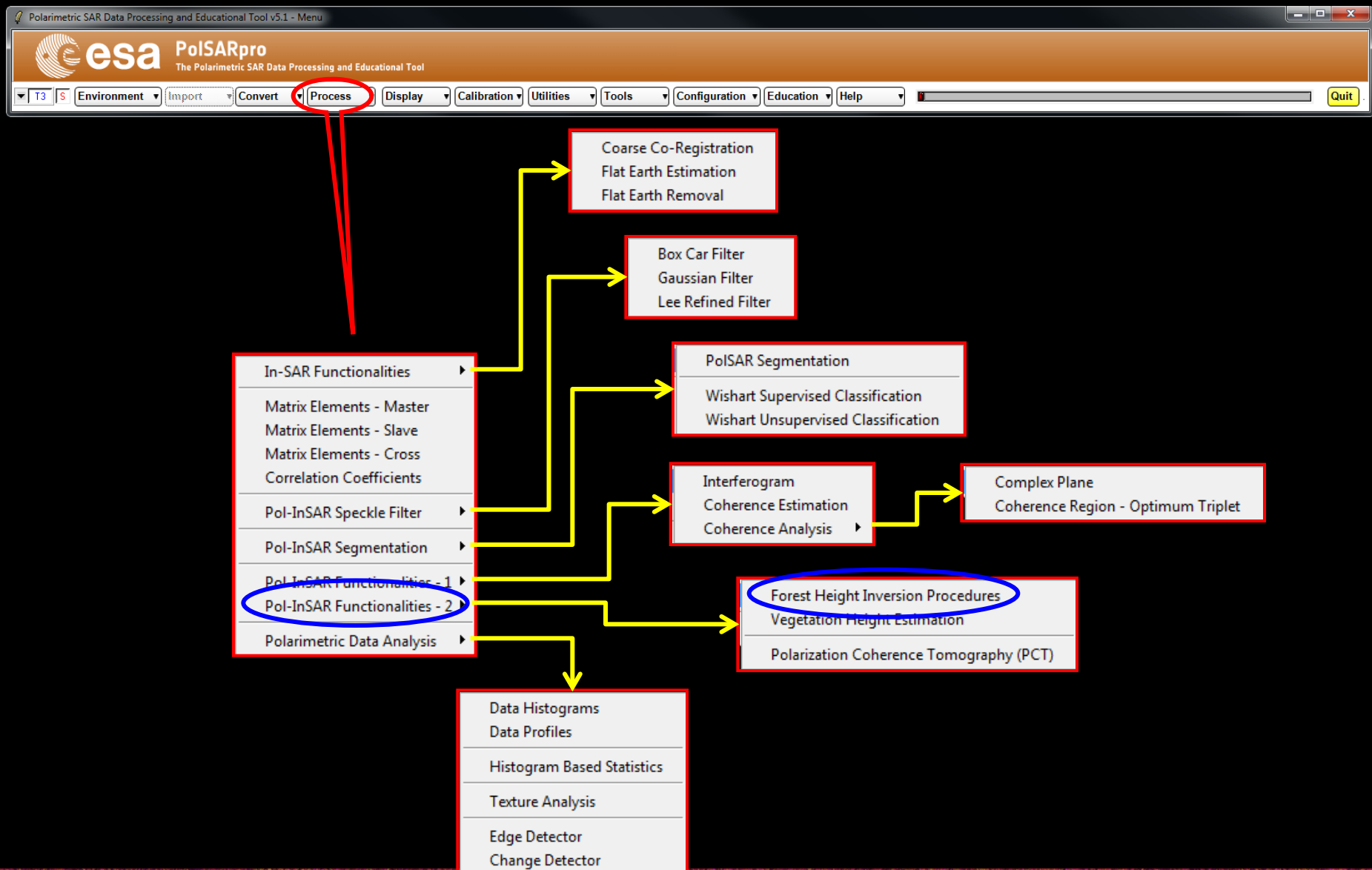
$\gamma_{\text{OPT-3}}$



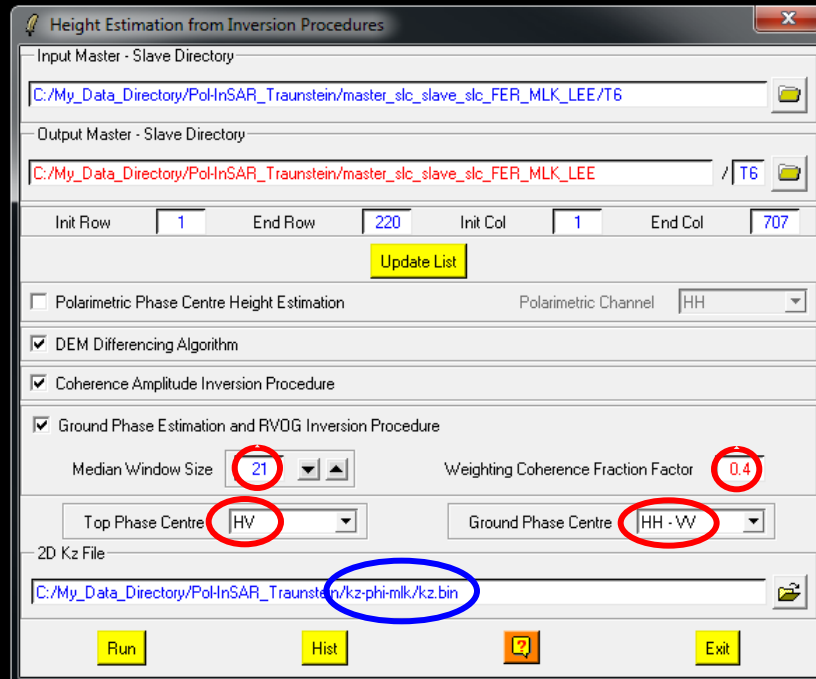
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PROCESS DATA



HEIGHT ESTIMATION



INVERSION PROCEDURES

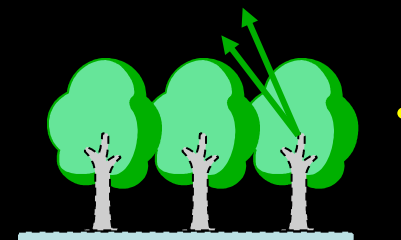
DEM Differencing Algorithm

Coherence Amplitude Inversion Procedure

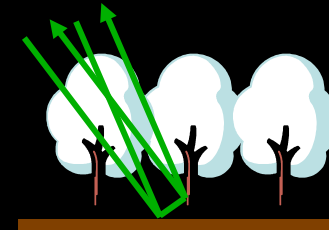
Ground Phase Estimation &

RVOG Inversion Procedure

2HV



HH - VV



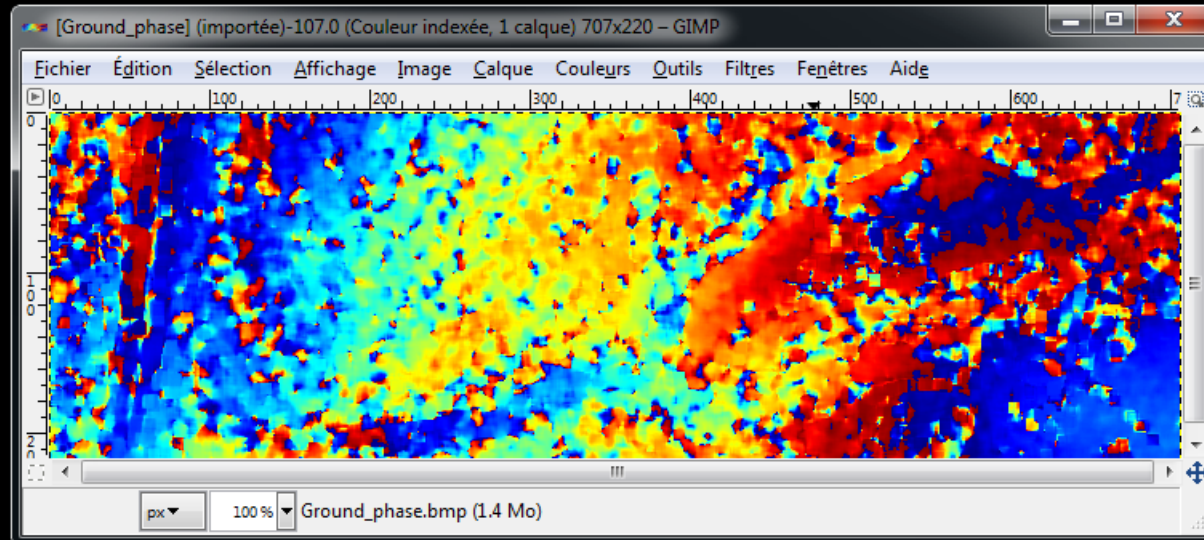
Do it Yourself:

Set the parameters (**Median Size = 21**, **Factor = 0.4**) and view the corresponding BMP files.

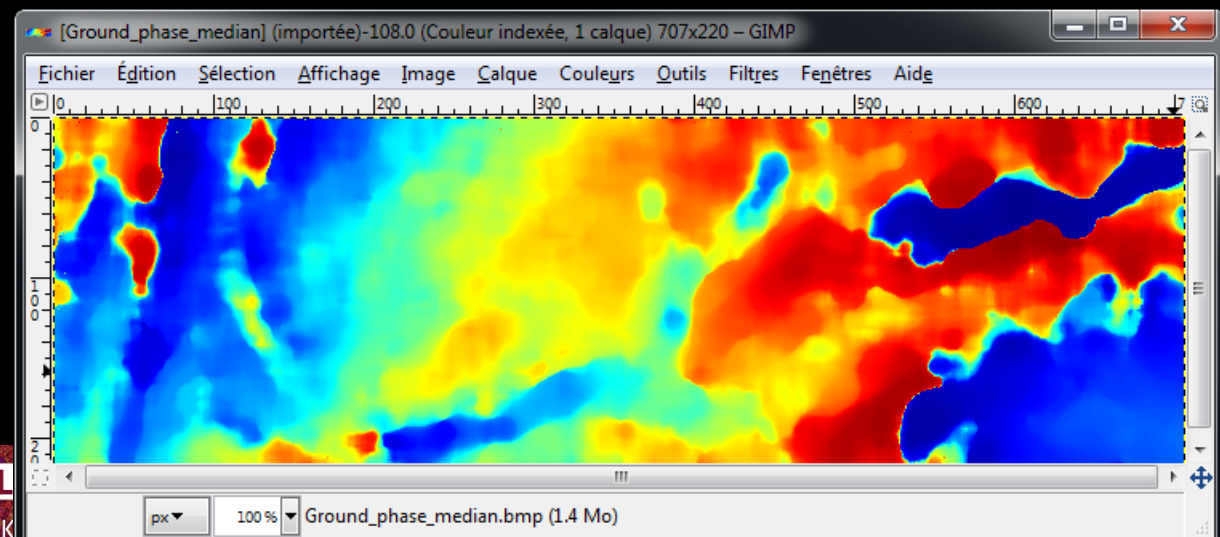
2D Kz File : DataDirectory / kz-phi-mlk / kz.bin

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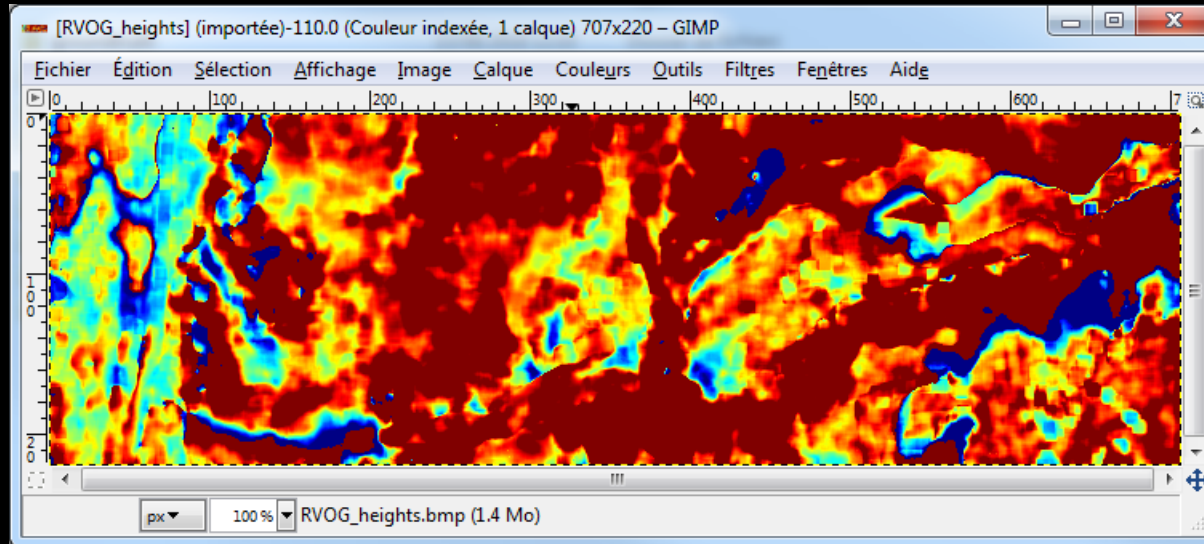
HEIGHT ESTIMATION



-180°  +180°

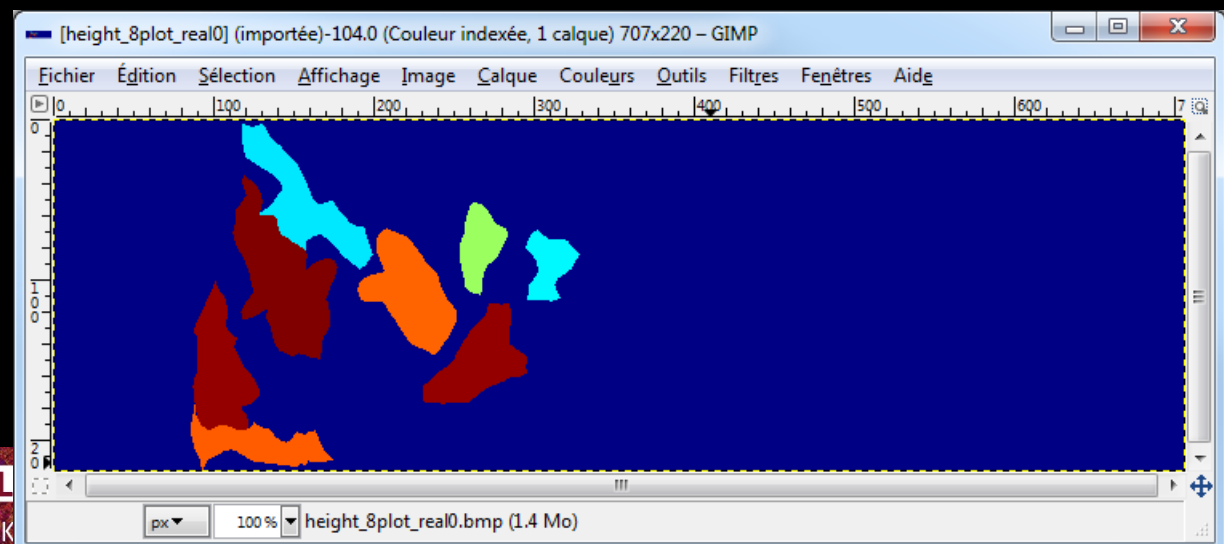


HEIGHT ESTIMATION



-5m  +25m

0m  +36m



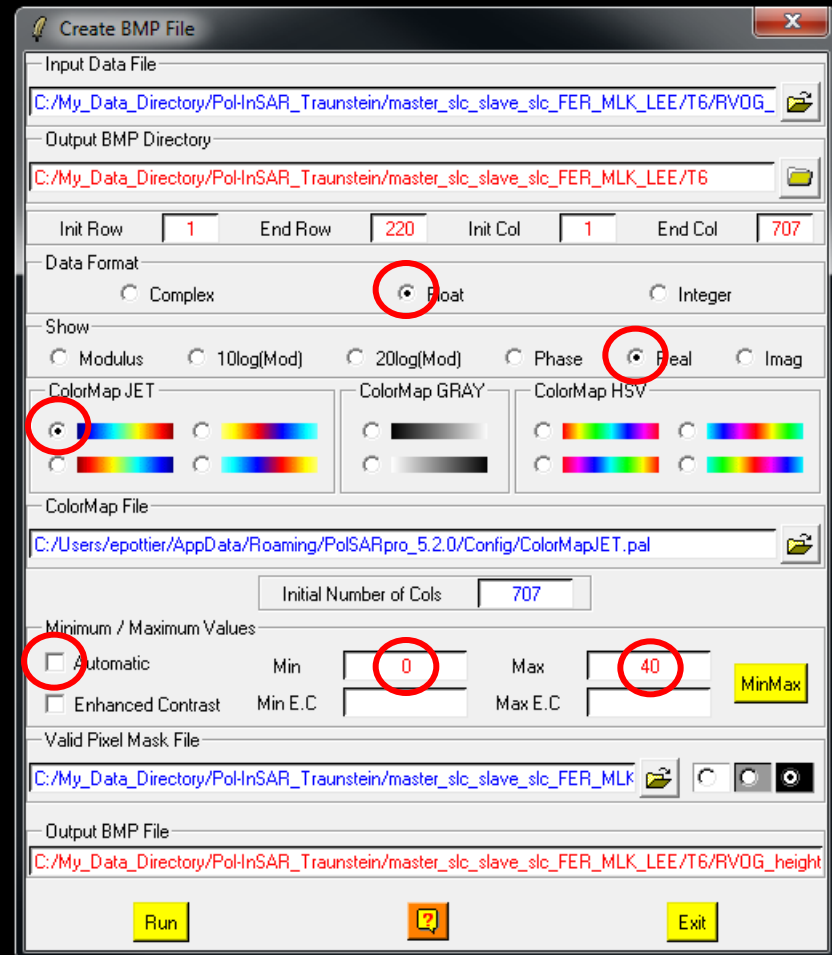
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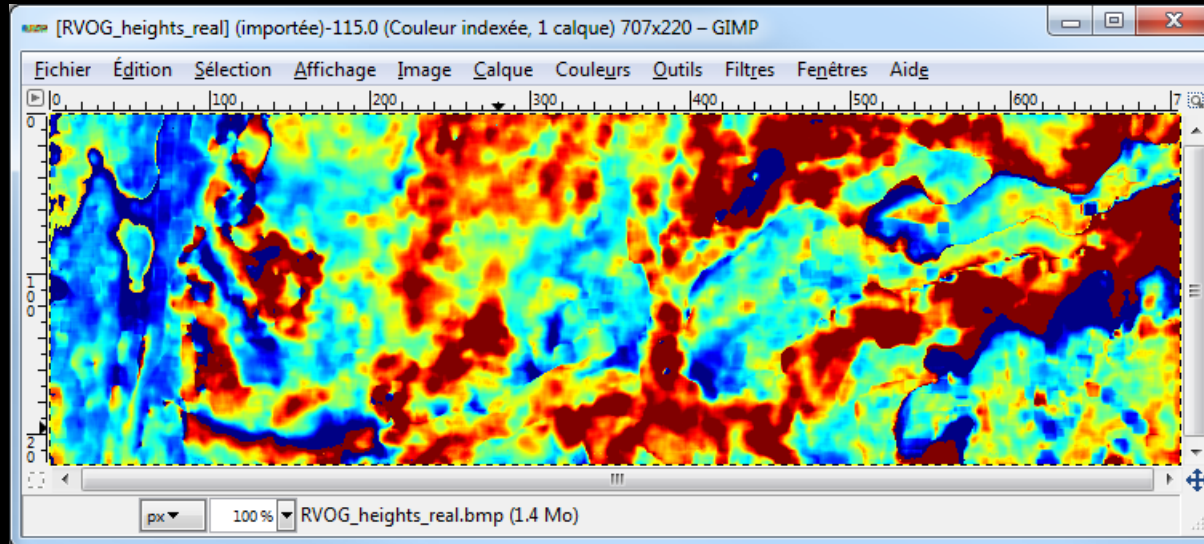
DISPLAY DATA



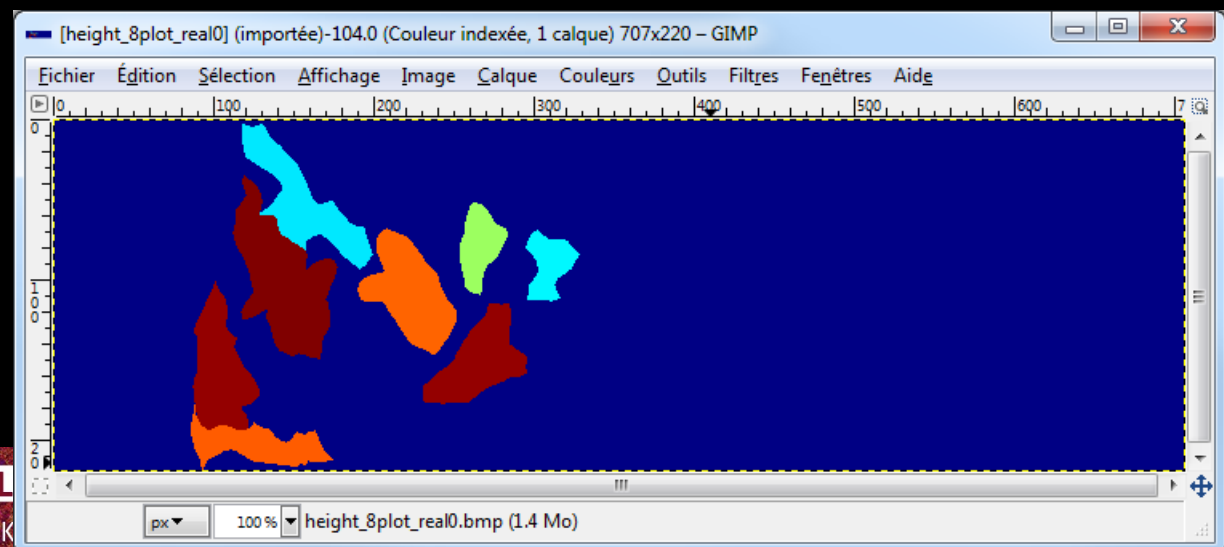
Create BMP file



HEIGHT ESTIMATION

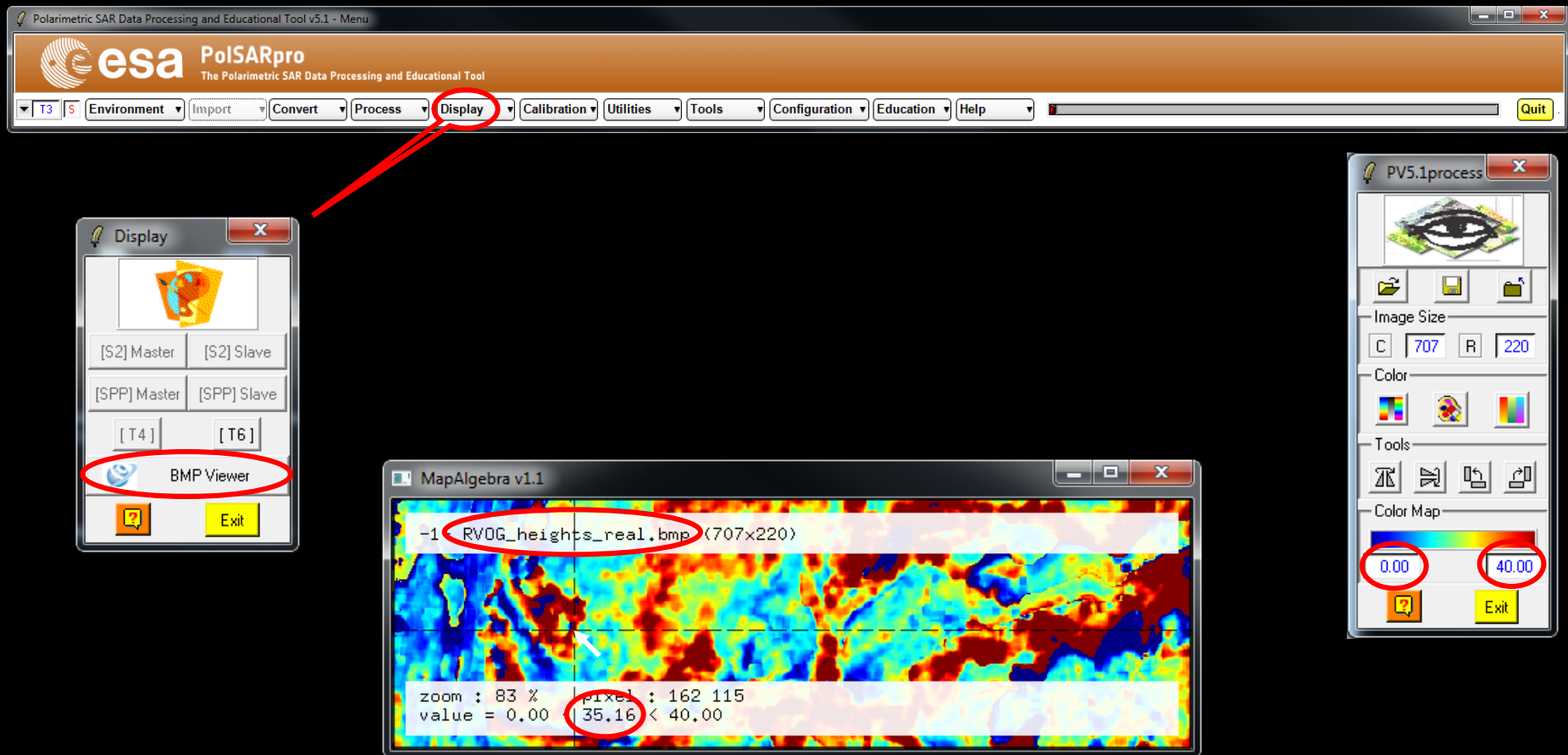


0m  +40m



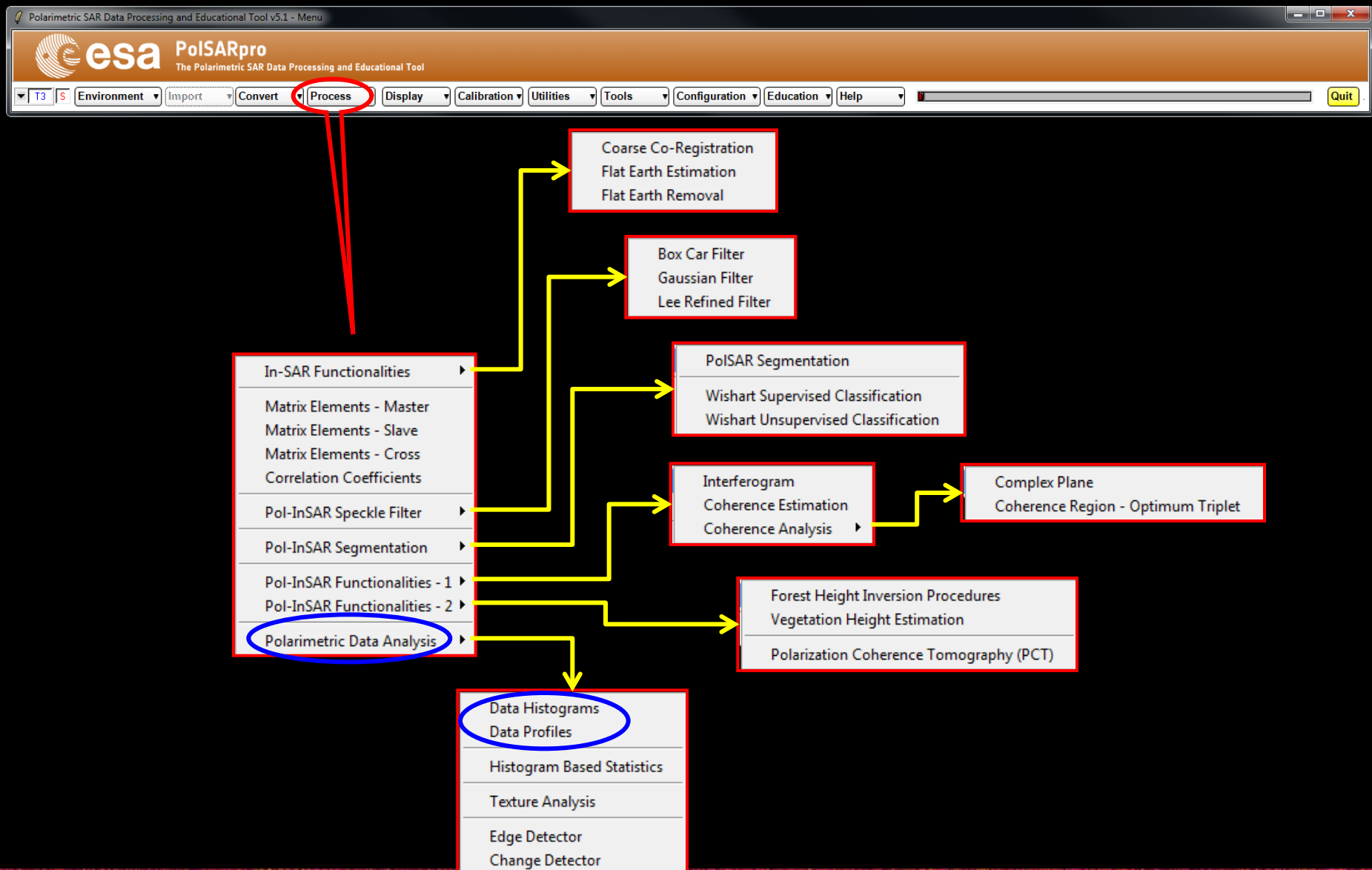
0m  +36m

DISPLAY DATA

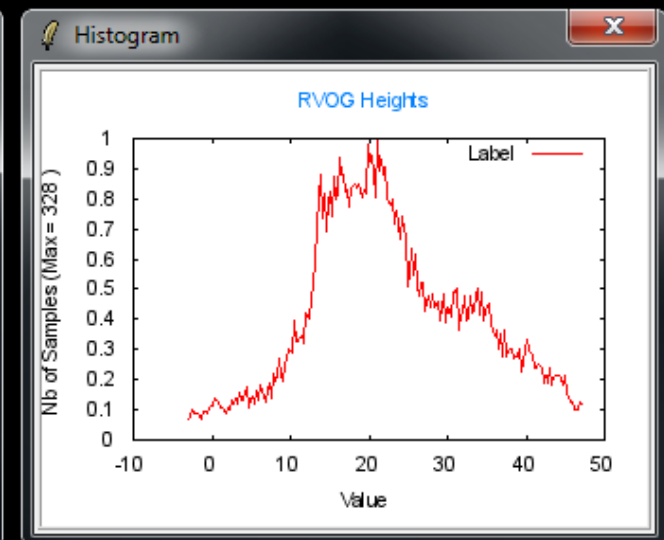
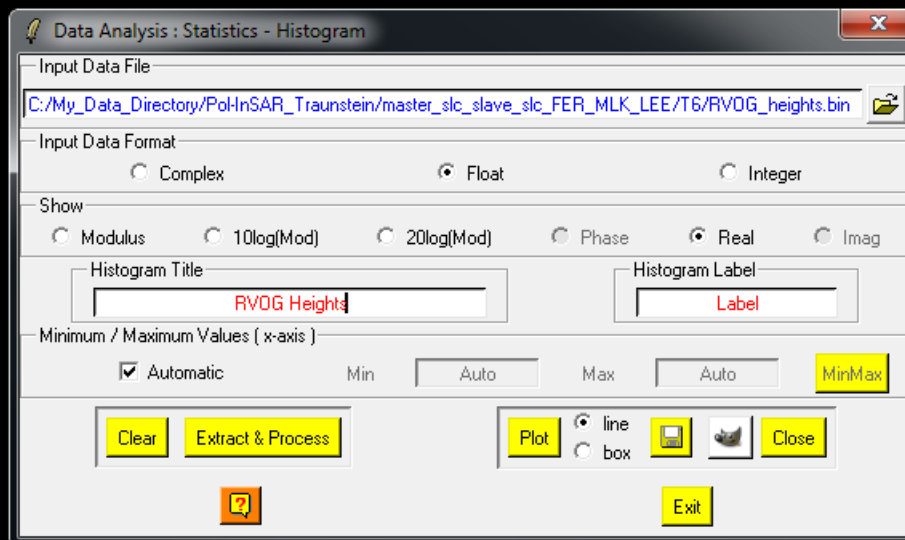
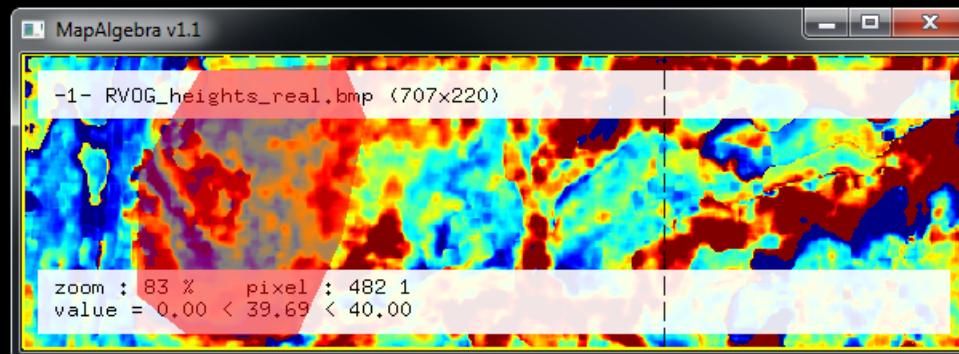


The screenshot displays the PolSARpro software interface. The main menu bar includes: File, Edit, Environment, Import, Convert, Process, **Display**, Calibration, Utilities, Tools, Configuration, Education, and Help. The **Display** menu is highlighted with a red circle, and a red arrow points to the **Display** sub-window. The **Display** sub-window contains buttons for [S2] Master, [S2] Slave, [SPP] Master, [SPP] Slave, [T4], [T6], **BMP Viewer** (circled in red), and Exit. The **MapAlgebra v1.1** window shows a color-coded map of a terrain. The title bar reads "MapAlgebra v1.1". The main area displays a color-coded map. The status bar at the bottom shows: zoom : 83 %, pixel : 162 115, value = 0.00, **35.16** (circled in red), < 40.00. The **PV5.1process** window is also visible on the right, showing a color map with a scale from 0.00 to 40.00 (both values circled in red).

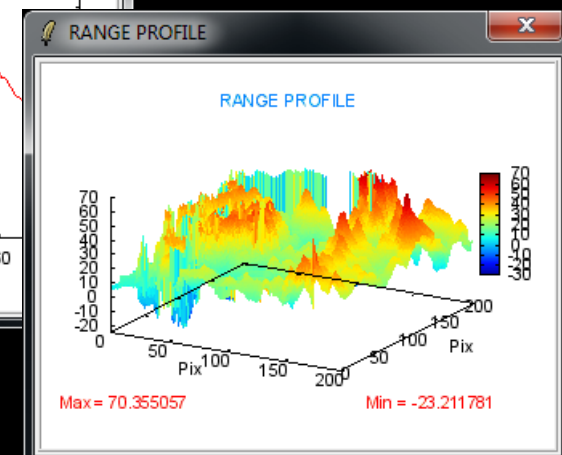
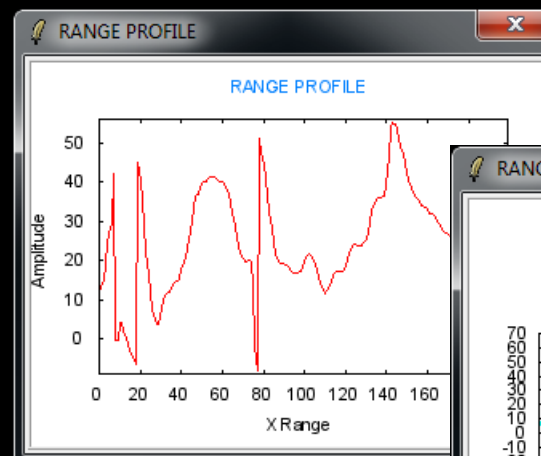
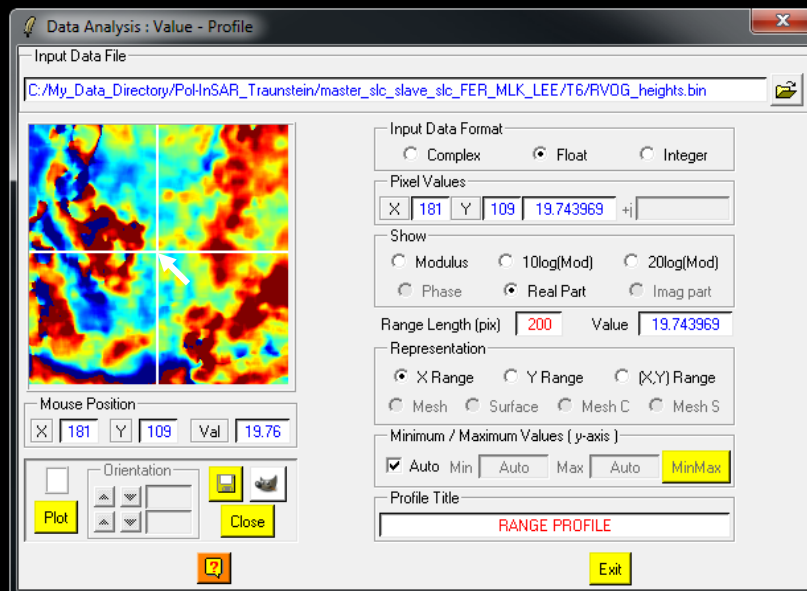
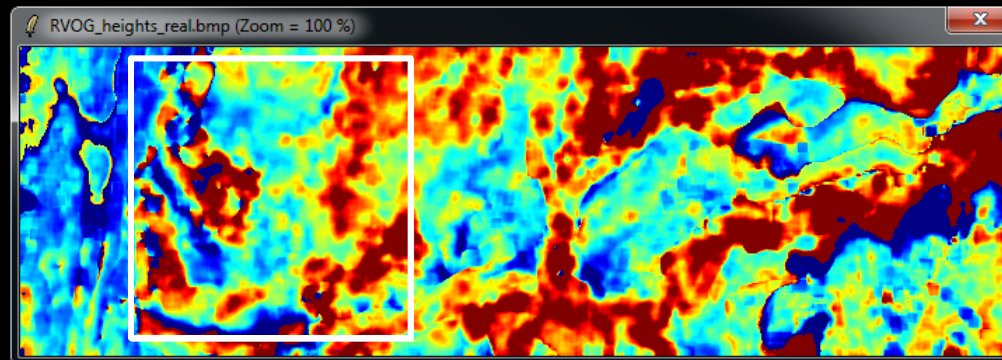
PROCESS DATA



HEIGHT ESTIMATION - HISTOGRAM



HEIGHT ESTIMATION - PROFILE

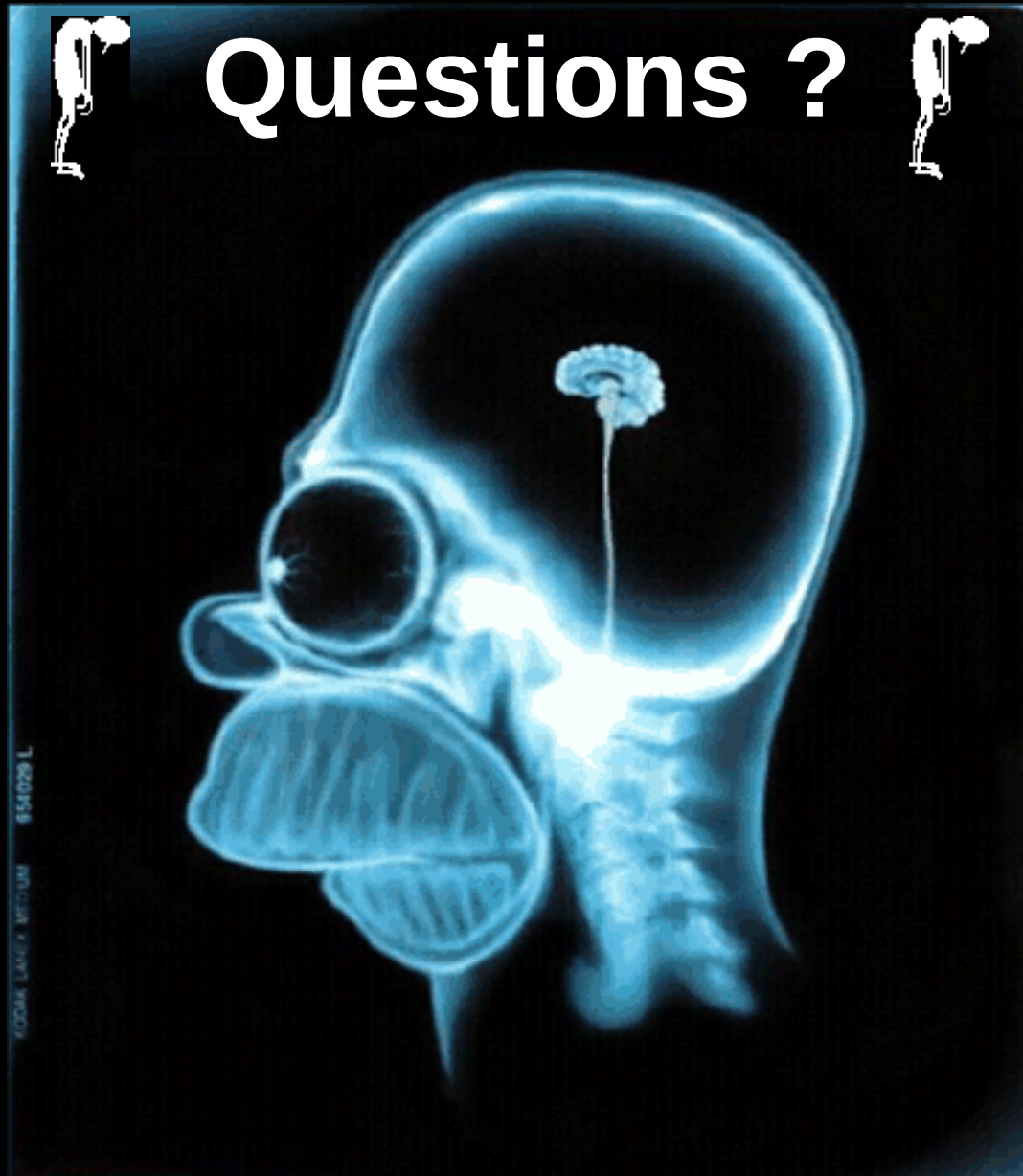


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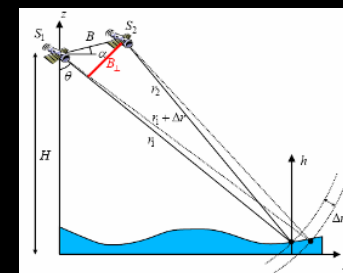
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Questions ?

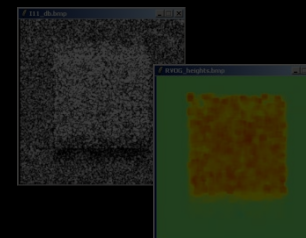




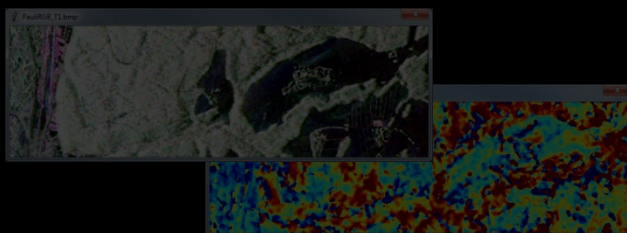
Forestry Applications with Pol-InSAR *Practical*



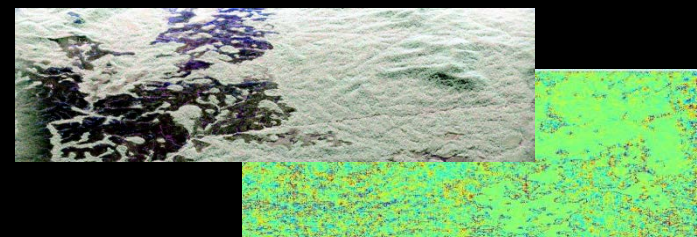
1st part : Simulated Pol-InSAR datasets



2nd part : Airborne Pol-InSAR datasets (**ESAR - DLR**)



Traunstein / Germany



AfriSAR campaign / Gabon

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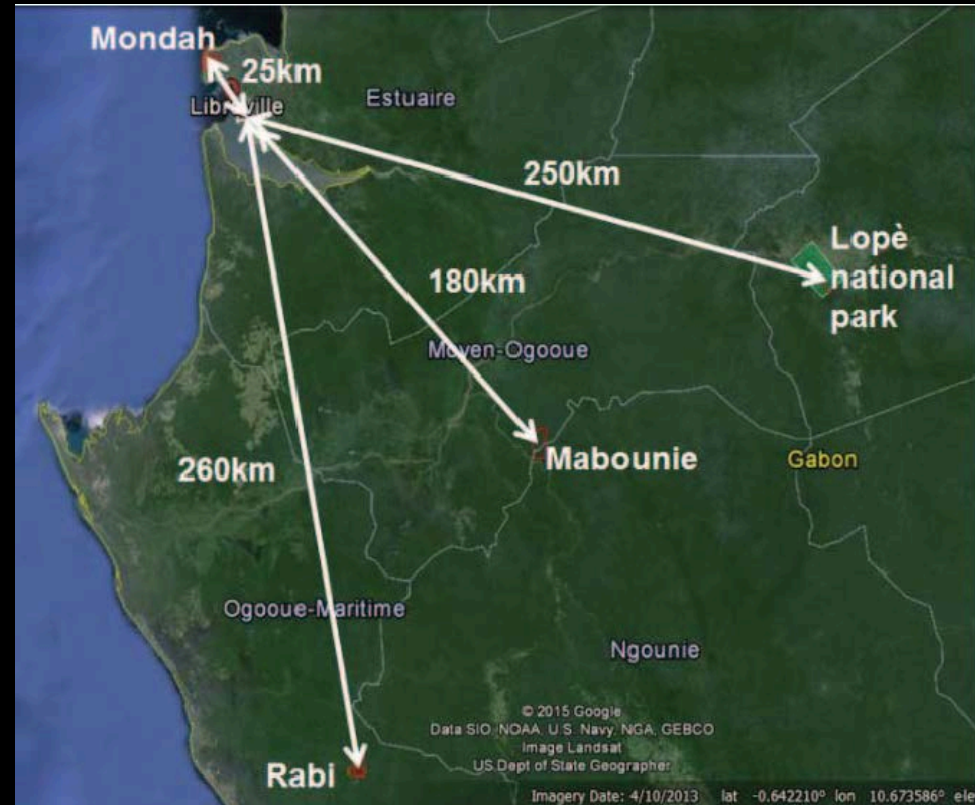
ESA AfriSAR Airborne Campaign Lopé National Park, Gabon

ONERA (2015) - DLR (2016)

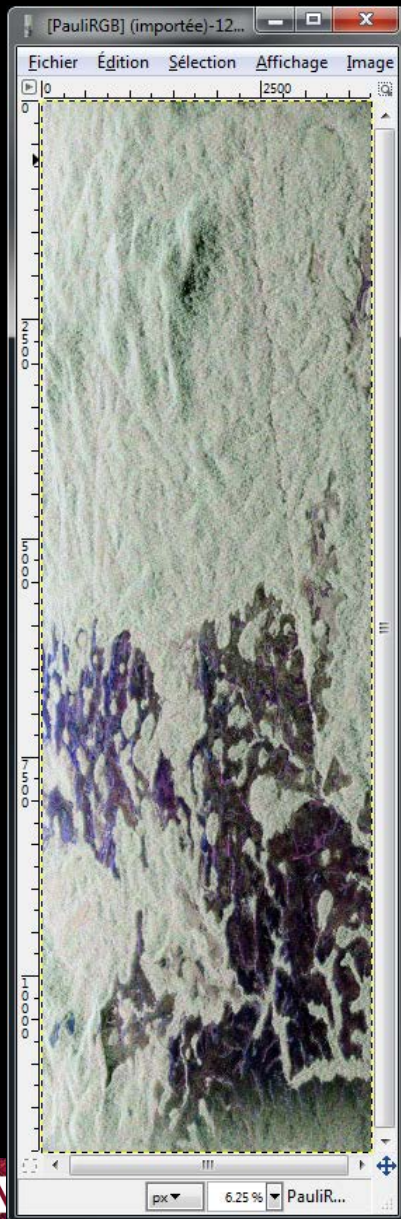
Tropical forests of Gabon

P-Band (*Biomass Mission*)
Single baseline = 80m

Courtesy of
Dr Maryam Pourshamsi



ESA AfriSAR CAMPAIGN



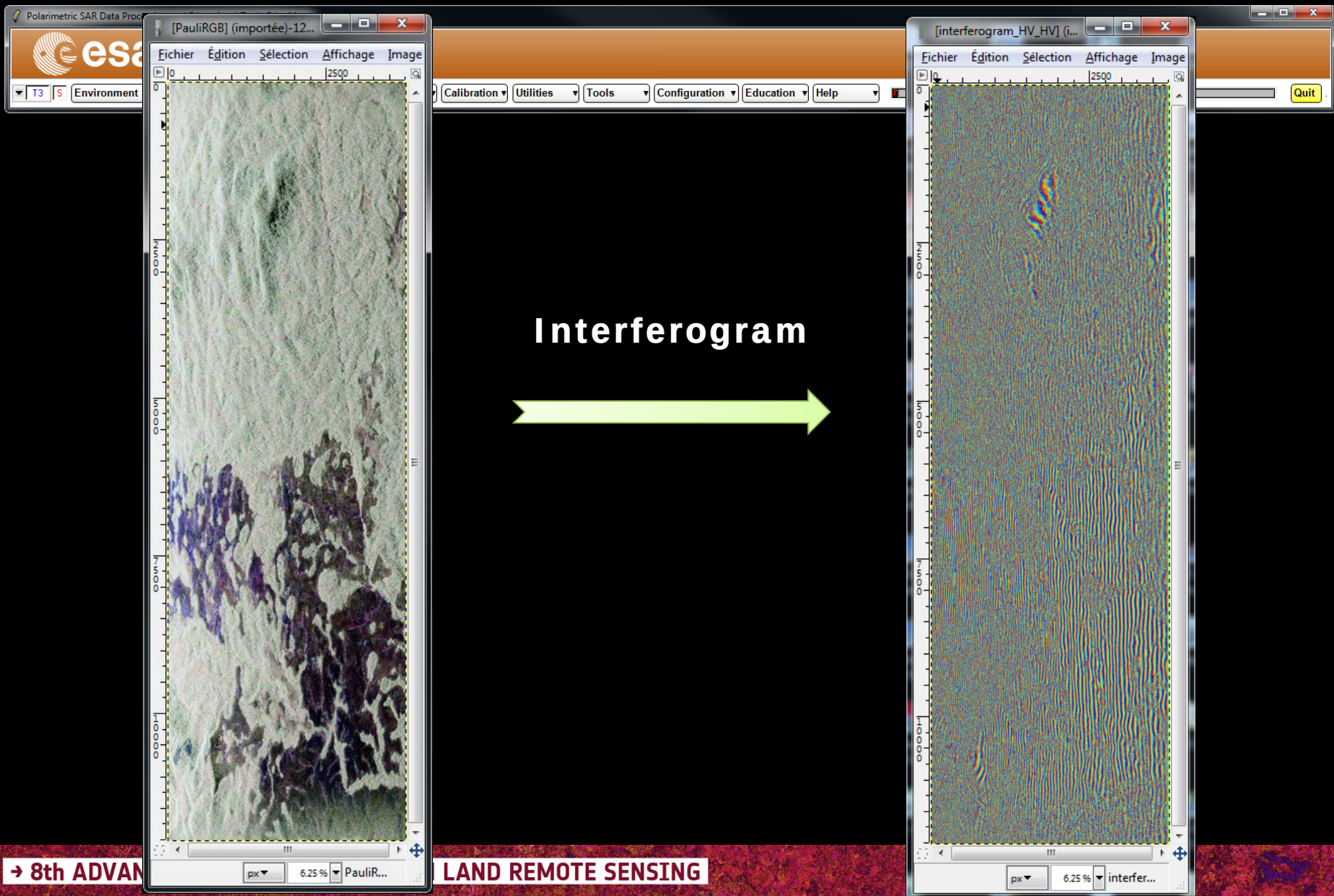
→ 8th ADVAN

LAND REMOTE SENSING

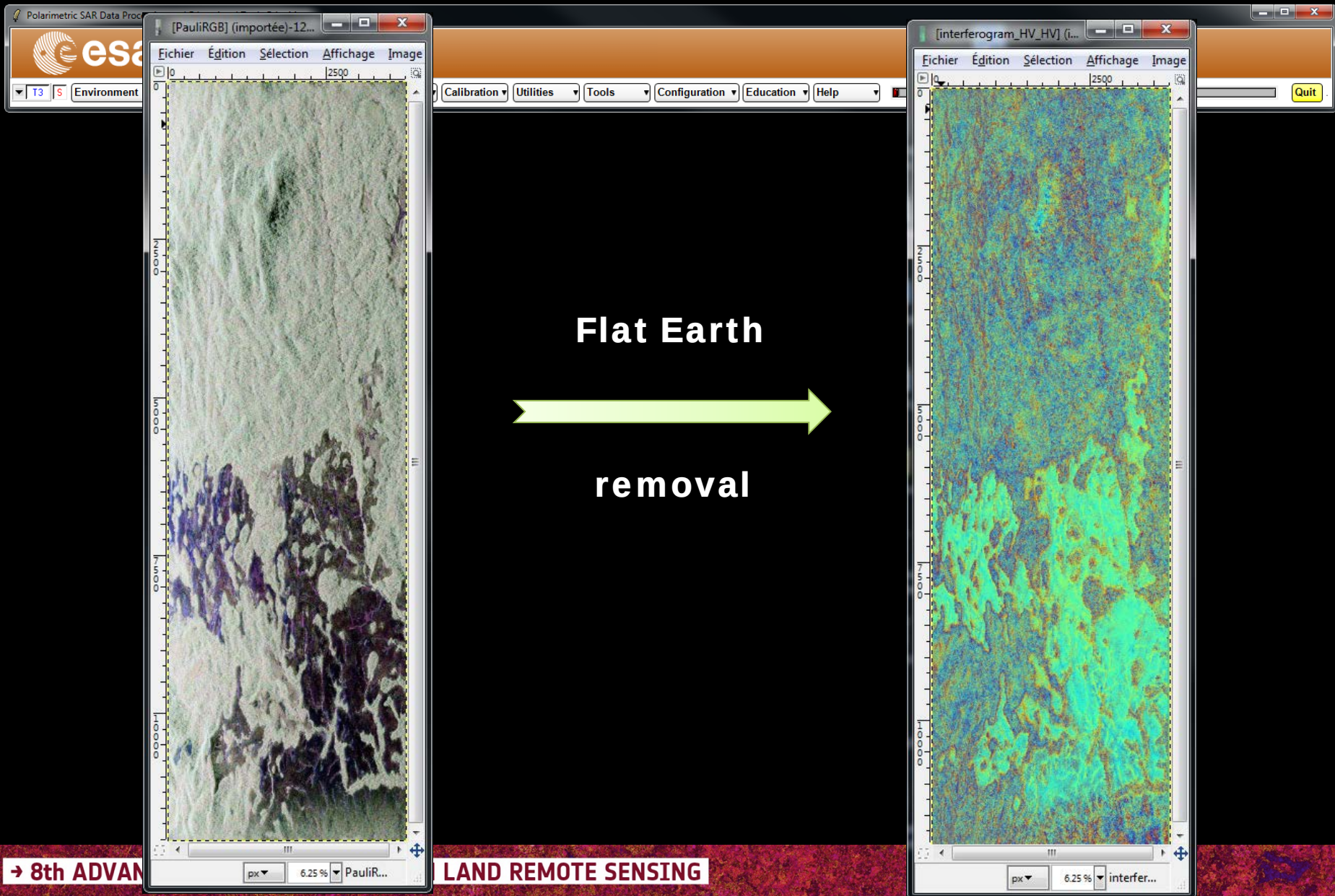
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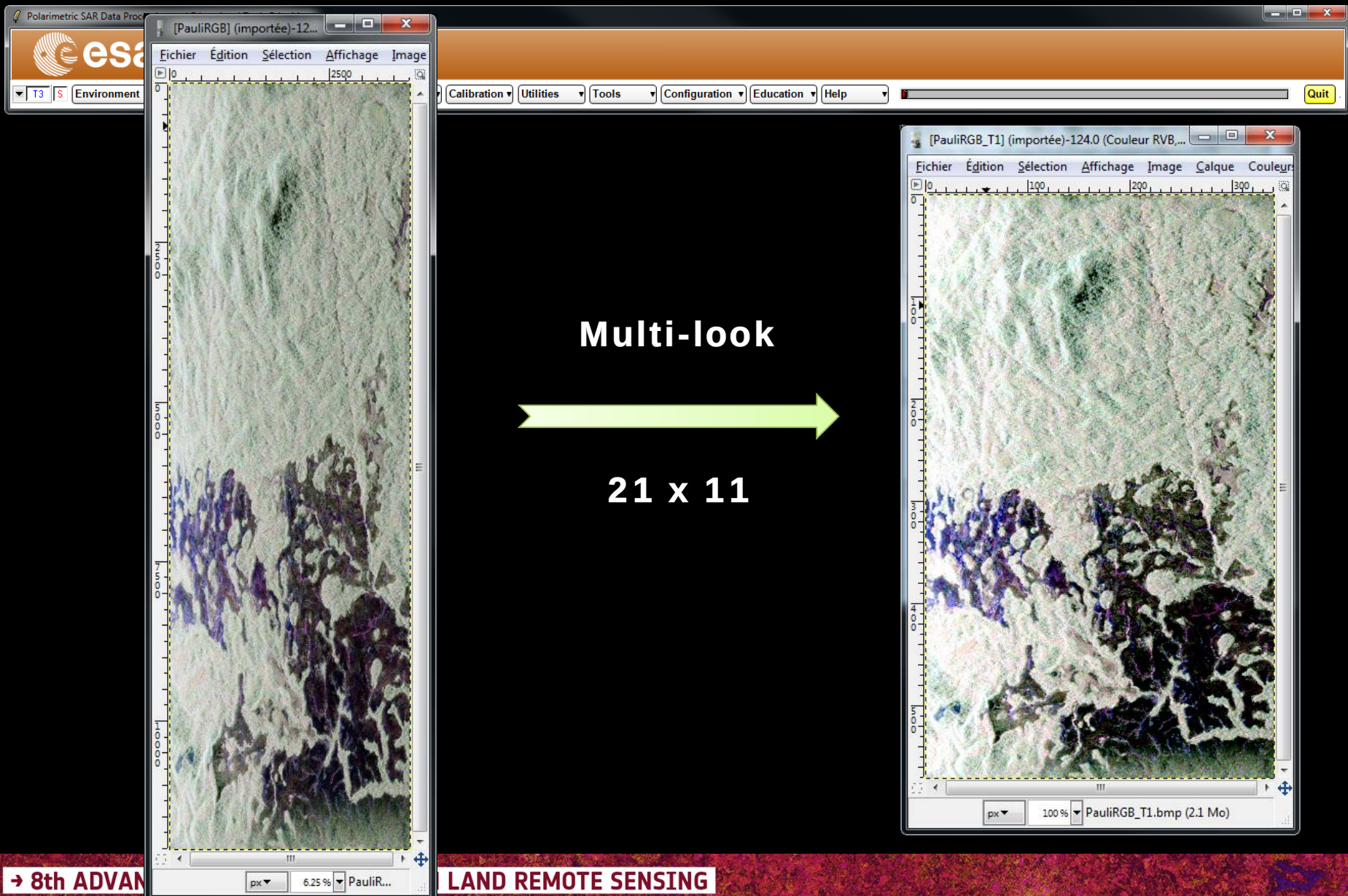
Pre - Processing



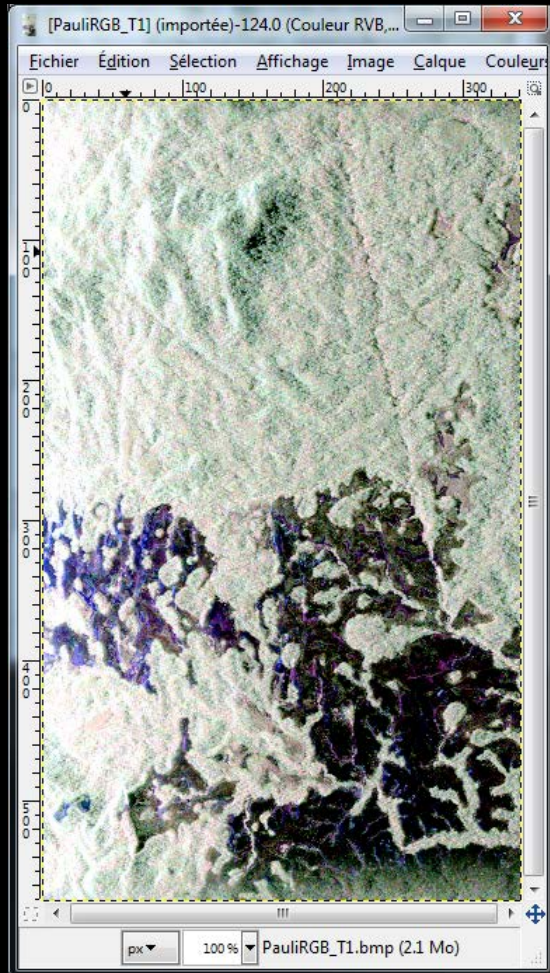
Pre - Processing



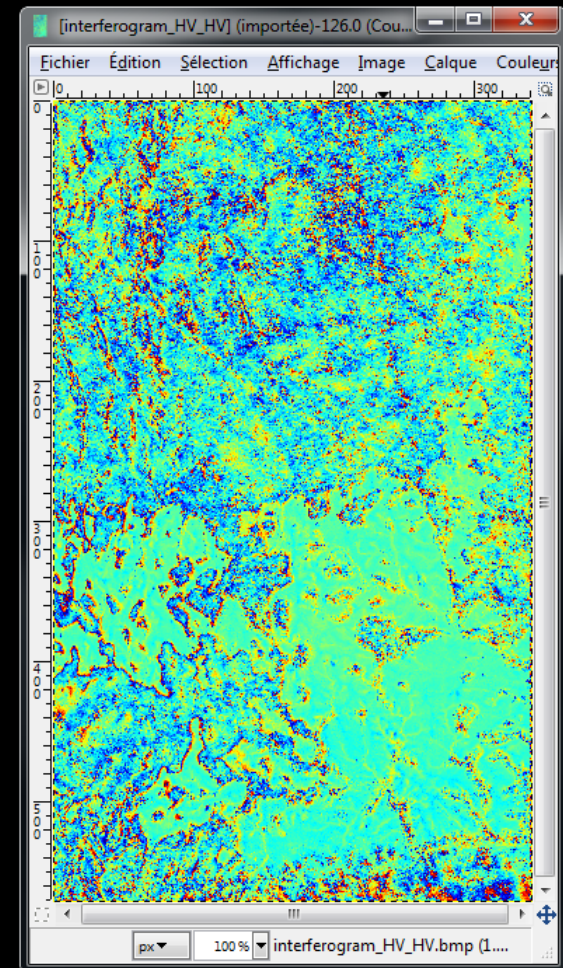
Pre - Processing



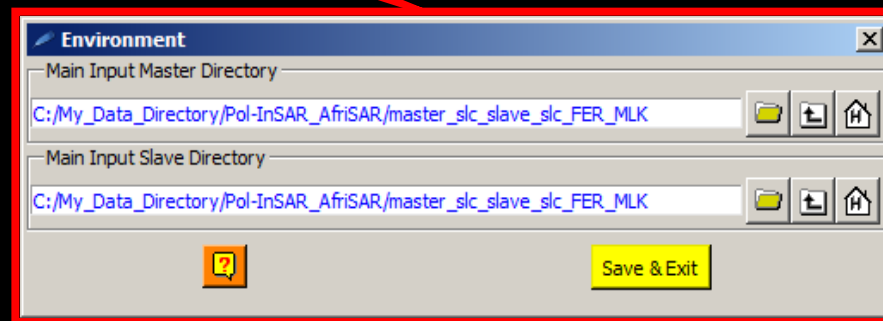
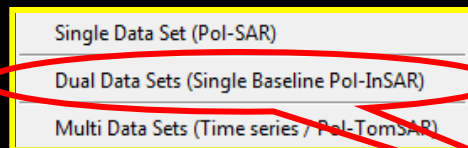
Pre - Processing



Interferogram



MAIN MENU - ENVIRONMENT



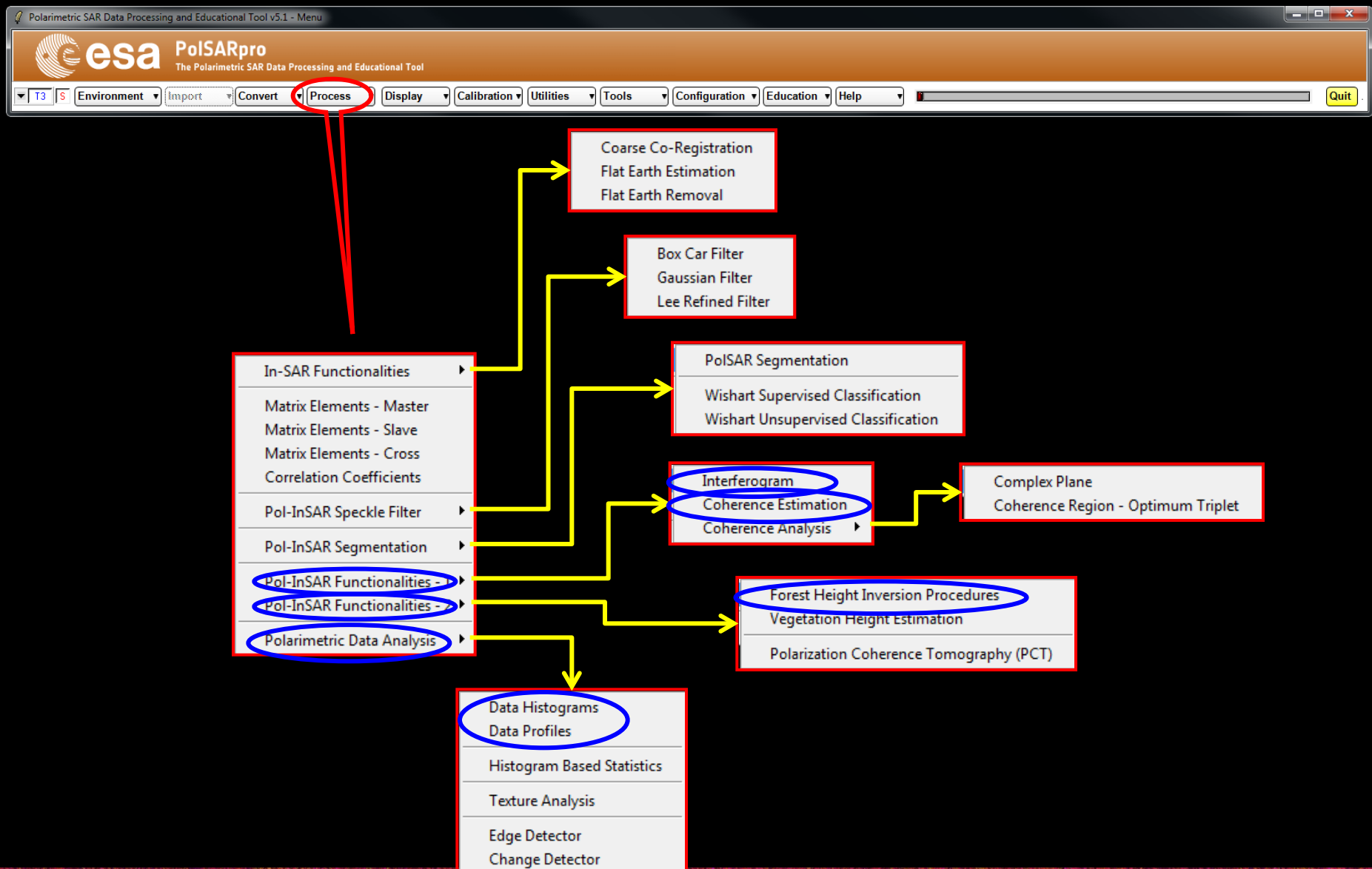
Input Master Directory:

My_Data_Directory / Pol-InSAR_AfriSAR / master_slc_slave_slc_FER_MLK

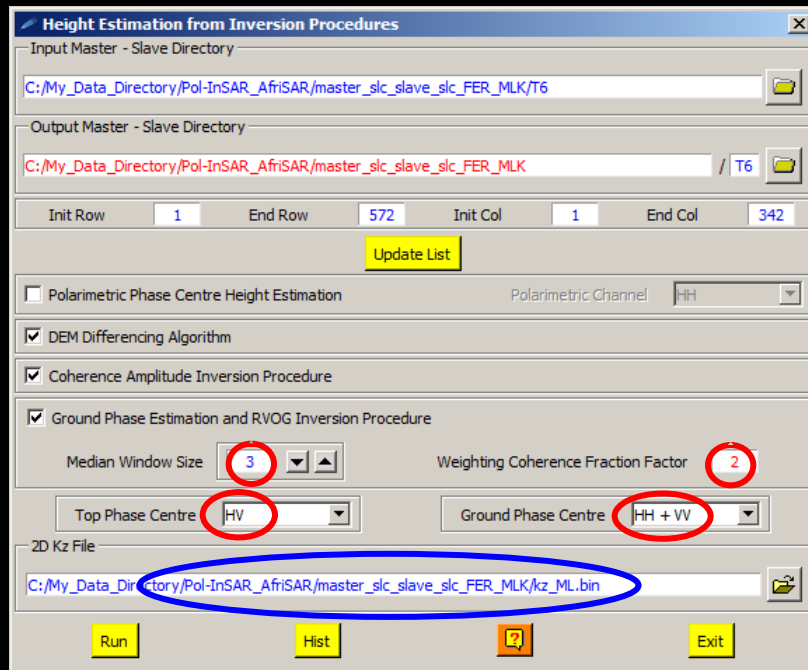
Input Slave Directory:

My_Data_Directory / Pol-InSAR_AfriSAR / master_slc_slave_slc_FER_MLK

DO IT YOURSELF



HEIGHT ESTIMATION



INVERSION PROCEDURES

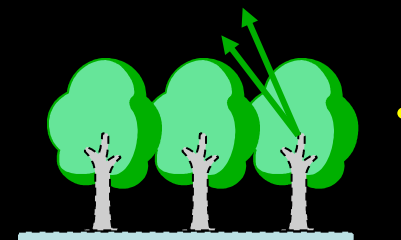
DEM Differencing Algorithm

Coherence Amplitude Inversion Procedure

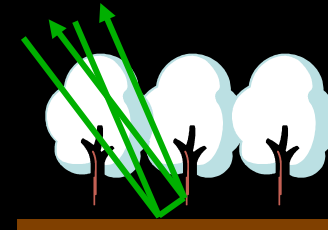
Ground Phase Estimation &

RVOG Inversion Procedure

$2HV$



$HH - VV$



Do it Yourself:

Set the parameters (**Median Size = 3**, **Factor = 2**) and view the corresponding BMP files.

2D Kz File :

DataDirectory / Pol-InSAR_AfriSAR / master_slc_slave_slc_FER_MLK / kz_ML.bin