

# → 4th ADVANCED COURSE ON RADAR POLARIMETRY

30 January – 2 February 2017 | ESA-ESRIN | Frascati (Rome), Italy

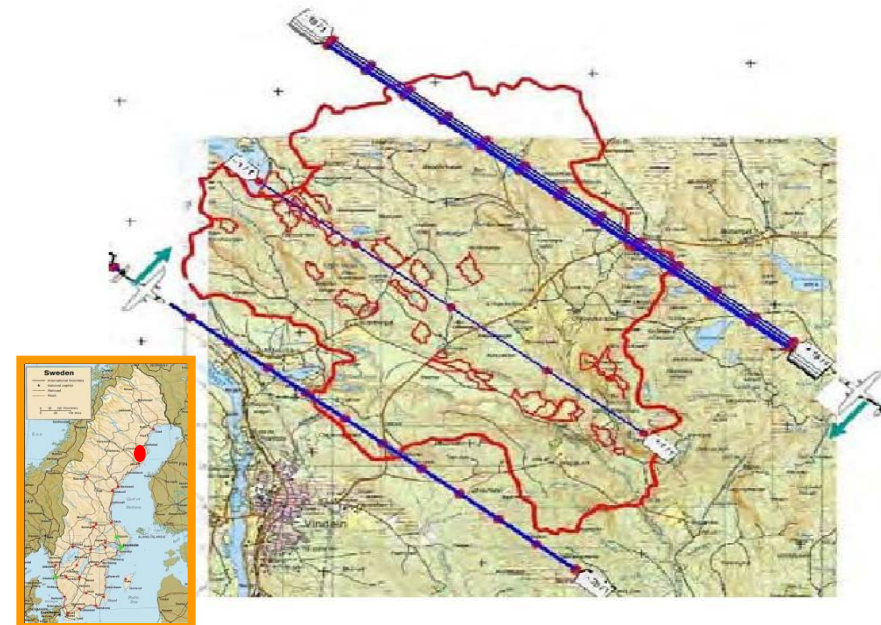
## Polarimetric SAR Tomography (Pol-TomSAR) Practical session

Laurent Ferro-Famil   Stefano Tebaldini

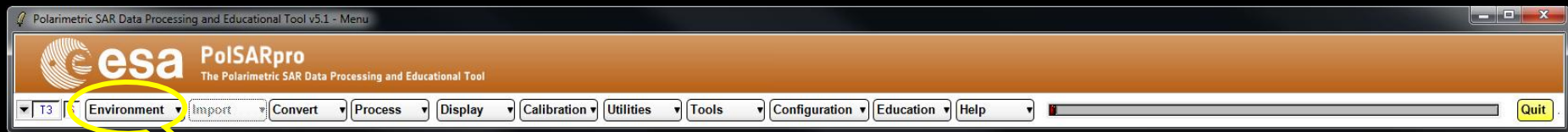


# DATASETS

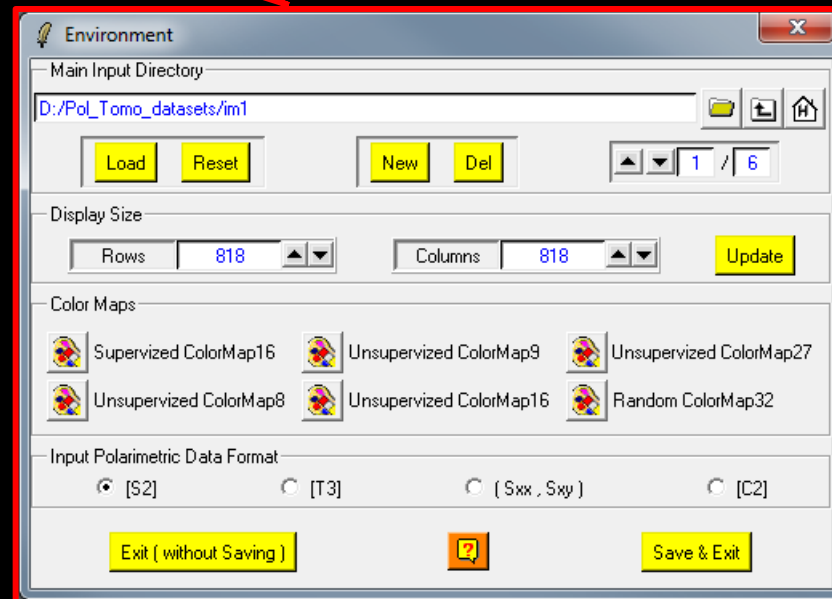
<u>Campaign</u>	<u>BioSAR 2008 - ESA</u>
<b>System</b>	<b>E-SAR - DLR</b>
<b>Site</b>	<b>Krycklan river catchment, Northern Sweden</b>
<b>Scene</b>	<b>Boreal forest Pine, Spruce, Birch, Mixed stand</b>
<b>Topography</b>	<b>Hilly</b>
<b>Tomographic Tracks</b>	<b>6 + 6 – Fully Polarimetric (South-West and North-East)</b>
<b>Carrier Frequency</b>	<b>P-Band and L-Band</b>
<b>Slant range resolution</b>	<b>1.5 m</b>
<b>Azimuth resolution</b>	<b>1.6 m</b>
<b>Vertical resolution (P-Band)</b>	<b>20 m (near range) to &gt;80 m (far range)</b>
<b>Vertical resolution (L-Band)</b>	<b>6 m (near range) to 25 m (far range)</b>



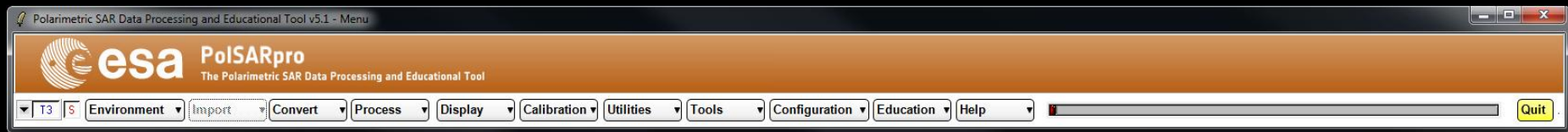
# MAIN MENU



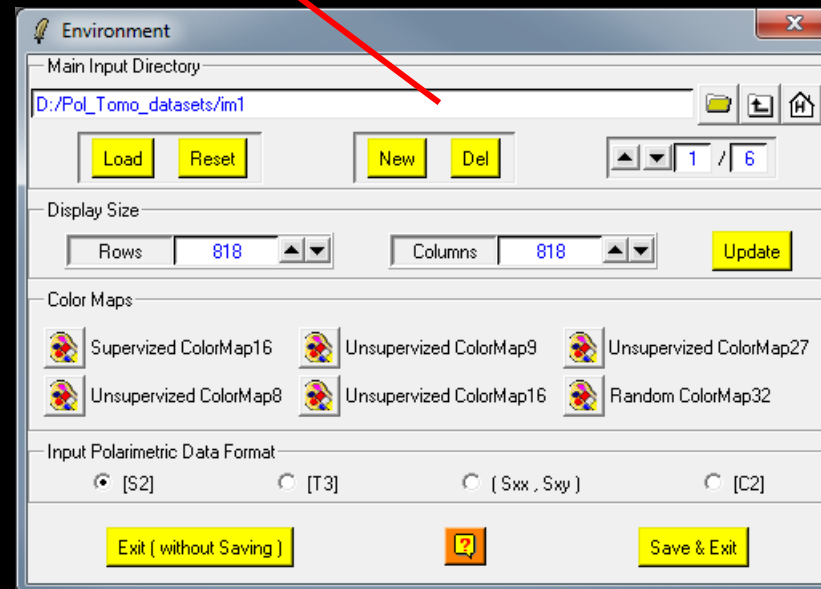
- Single Data Set (Pol-SAR)
- Dual Data Sets (Single Baseline Pol-InSAR)
- Multi Data Sets (Time series / Pol-TomSAR)



# ENVIRONMENT



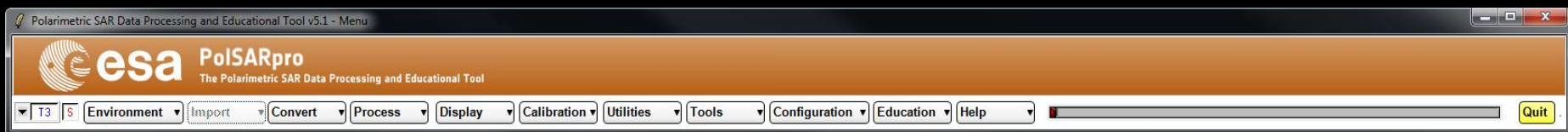
## Configure Data Main Directory location



**Input Directory: C:/ .../Pol\_Tomo\_datasets/im1**



# ENVIRONMENT

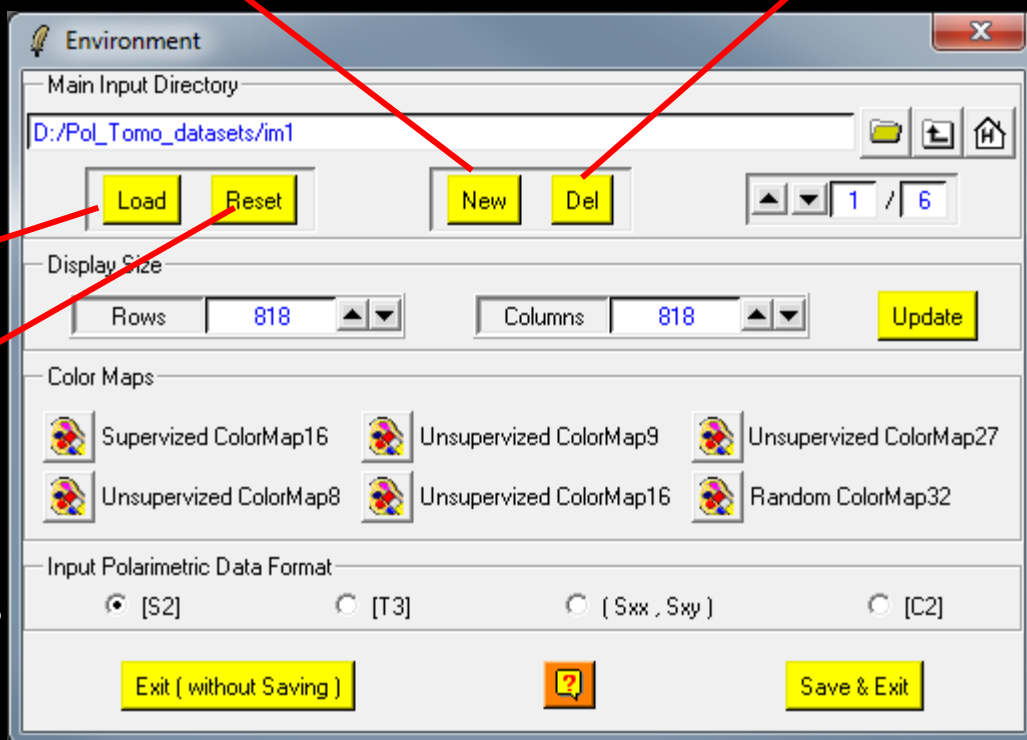


**Add a new Data Directory**

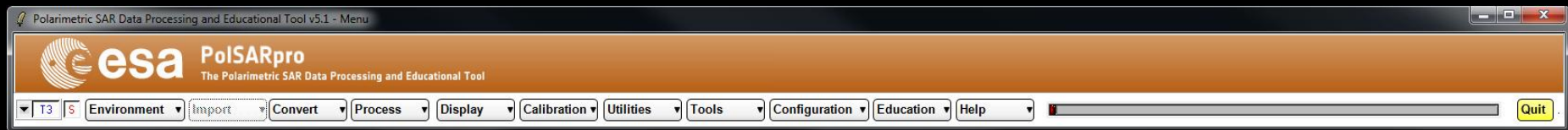
**Delete a Data Directory**

**Load a predefined list of Data Directories**

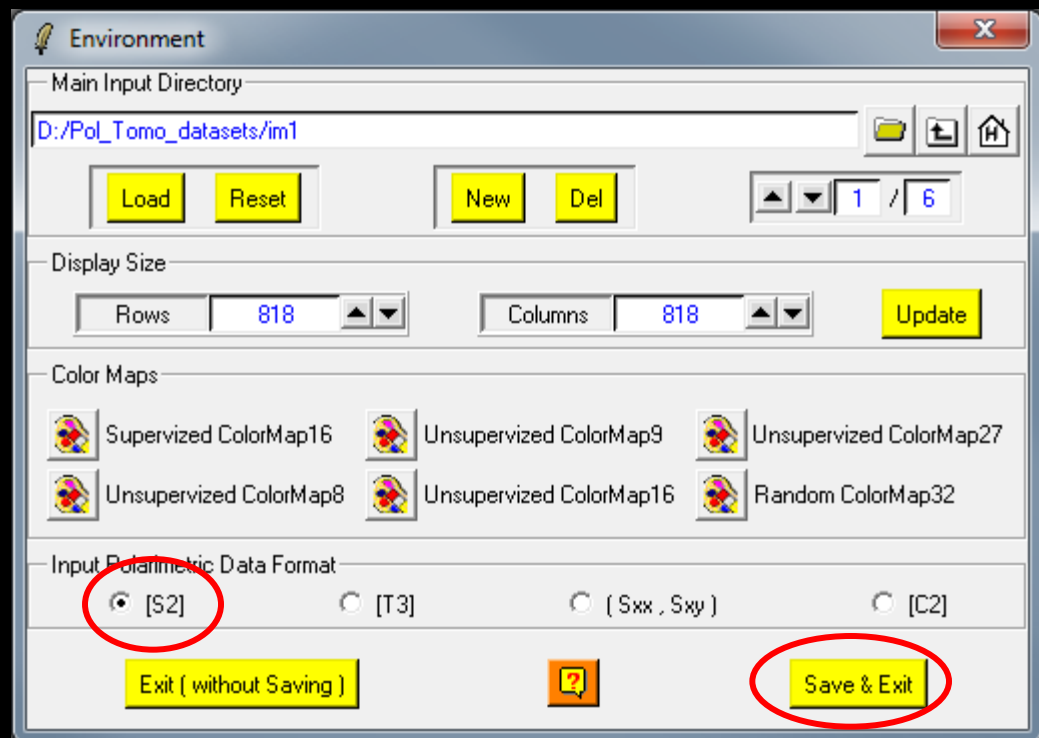
**Reset the list of the Data Directories**



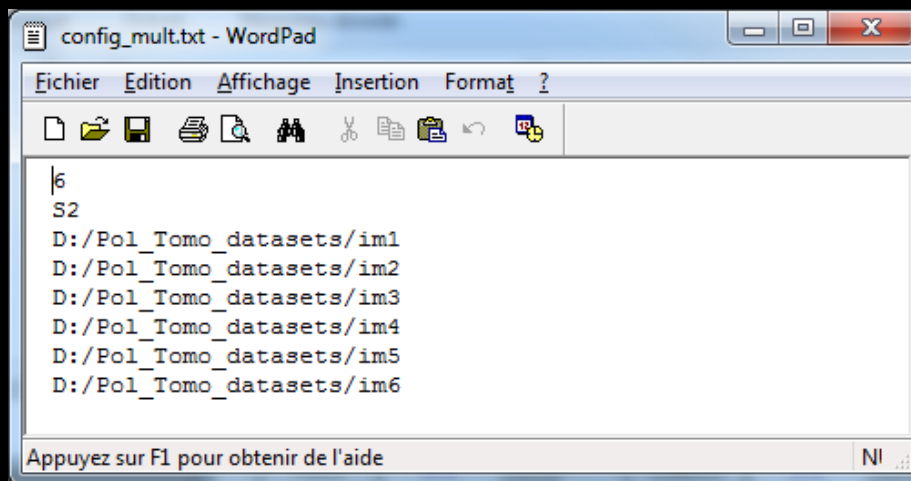
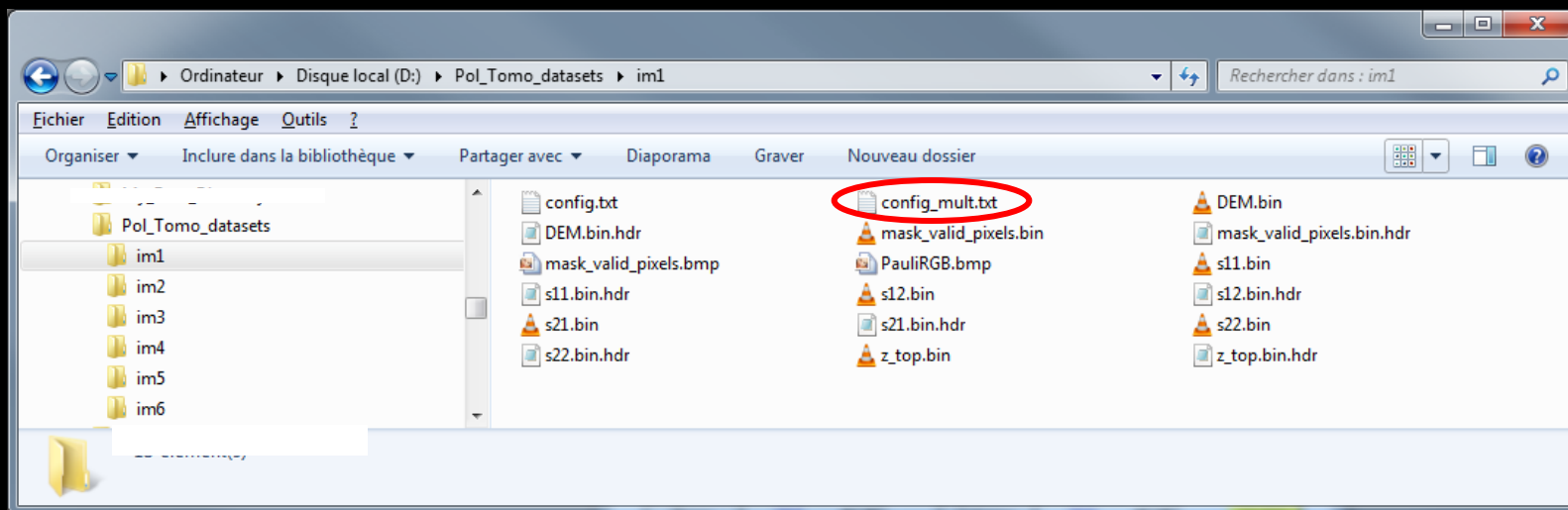
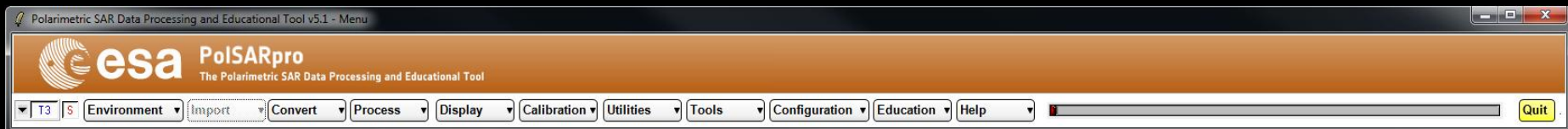
# ENVIRONMENT



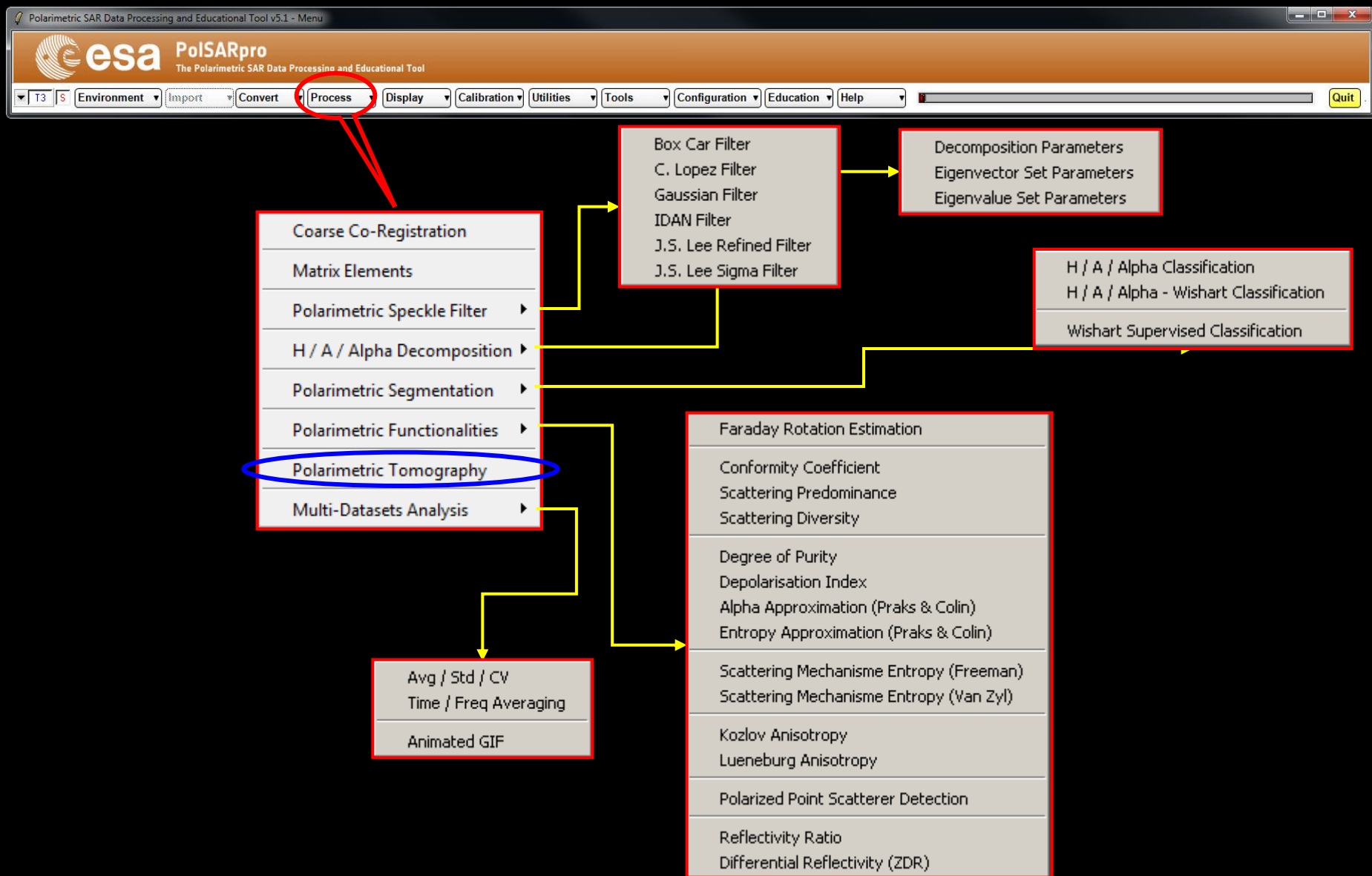
Pol\_Tomo\_datasets/im1  
Pol\_Tomo\_datasets/im2  
Pol\_Tomo\_datasets/im3  
Pol\_Tomo\_datasets/im4  
Pol\_Tomo\_datasets/im5  
Pol\_Tomo\_datasets/im6



# ENVIRONMENT

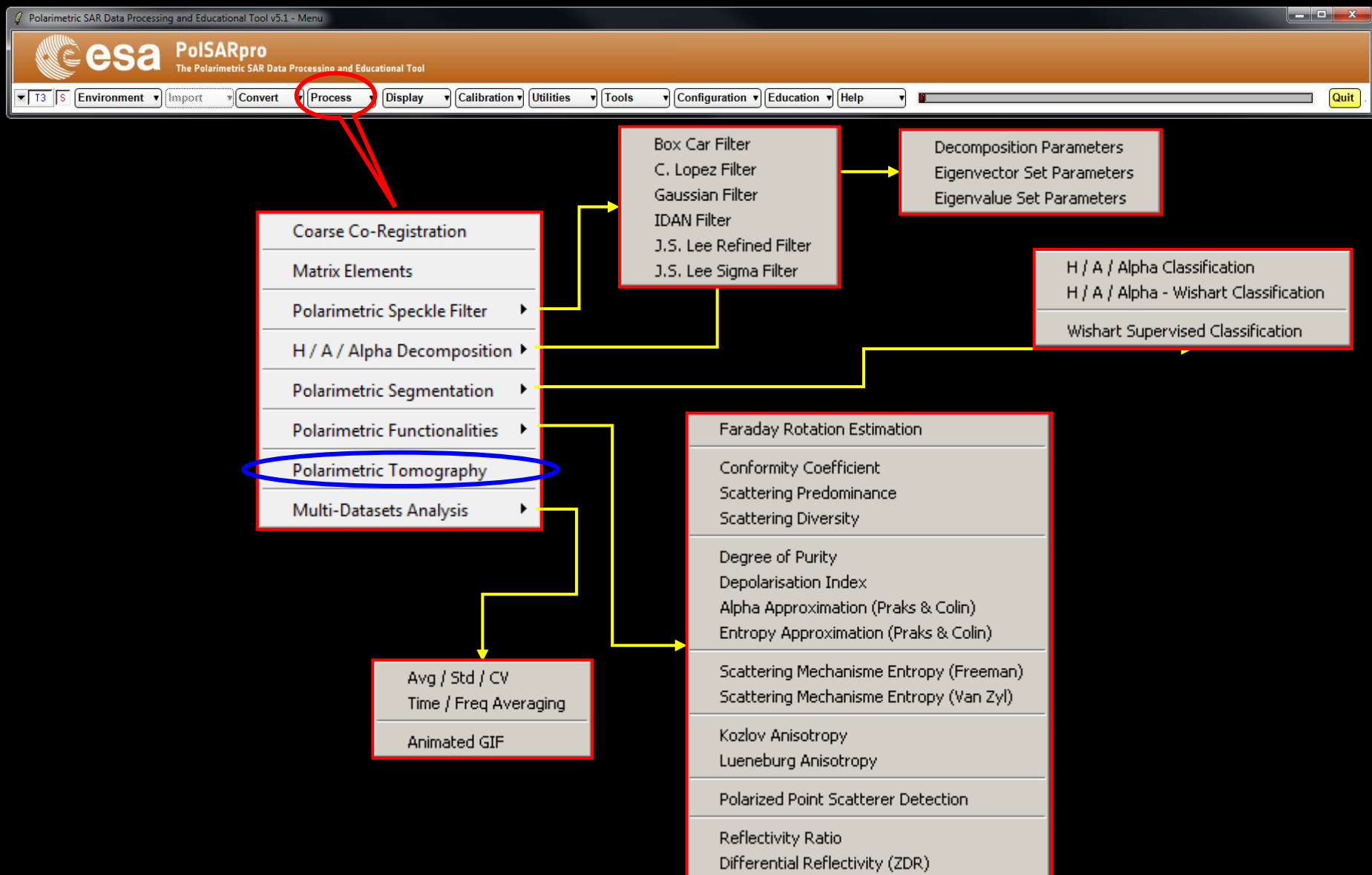


# PROCESS DATA

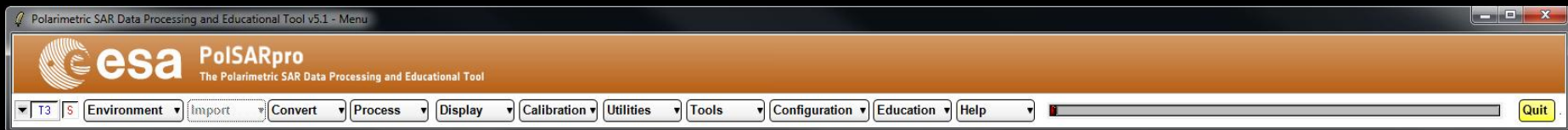




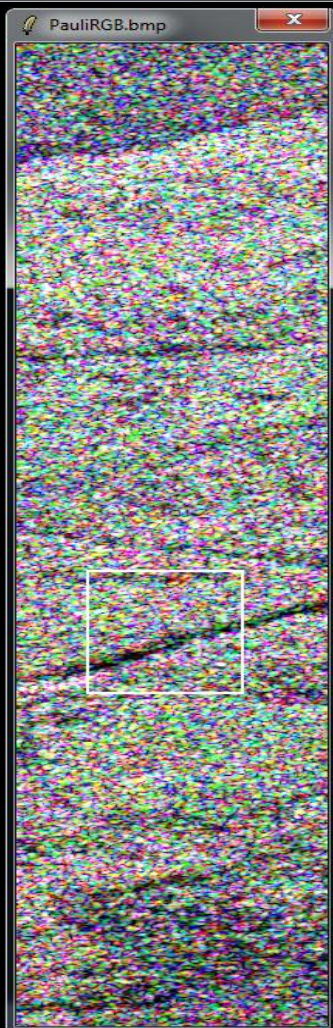
# PROCESS DATA



# PROCESS DATA



**Step 0 :  
Open a BMP file**



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# PROCESS DATA

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

**esa PolSARpro**  
The Polarimetric SAR Data Processing and Educational Tool

T3 | Environment | Import | Convert | Process | Display | Calibration | Utilities | Tools | Configuration | Education | Help | Quit

PauliRGB.bmp

Polarimetric Tomography ( Pol-TomSAR )

Output Directory: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/profile\_beamformer\_col\_1 / T3

Input 2D Slant-Range DEM File: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/DEM.bin

Input 2D Slant-Range Top Height File: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/z\_top.bin

Slant-Range Row values: min 4365.986 max 5570.814 [m] [bin]

Slant-Range Col values: min 203.0713 max 297.0711 [m] [bin]

Pol-TomSAR coherence maps analysis

Window Size : Row 7 Col 7 Sub-sampling : Row 5 Col 1 **Run**

Mouse Position: X 115 Y 1 Selected Pixel: X Y

Window Size: Row 7 Col 7 Tomogram Along: Col (X) Row (Y)

Height (z) values: z min ? z max ? delta z ?

Pol-TomSAR analysis: **DEM compensation** Run

Algorithm: B.F Capon

Input - Output Process Directory:

Polarization Channels: HH HV VV HH + VV HH - VV LL LR RR

Matrix Elements: Span Corr Coeffs - [T3] Corr Coeffs - [C3] C.C.C Normalized C.C.C

Eigenvalues parameters: Entropy / Anisotropy / Alpha / Lambda Shannon Entropy Probabilities (p1,p2,p3) / eigenvalues (L1,L2,L3) Eigenvalue Relative Difference (E.R.D) Polarisation asymetry / polarisation fraction

Polarimetric Decompositions: Anis NED 3 components Van Zyl 3 components Freeman 3 components Singh 4 components Yamaguchi 4 components

Run Select All Reset Display Exit

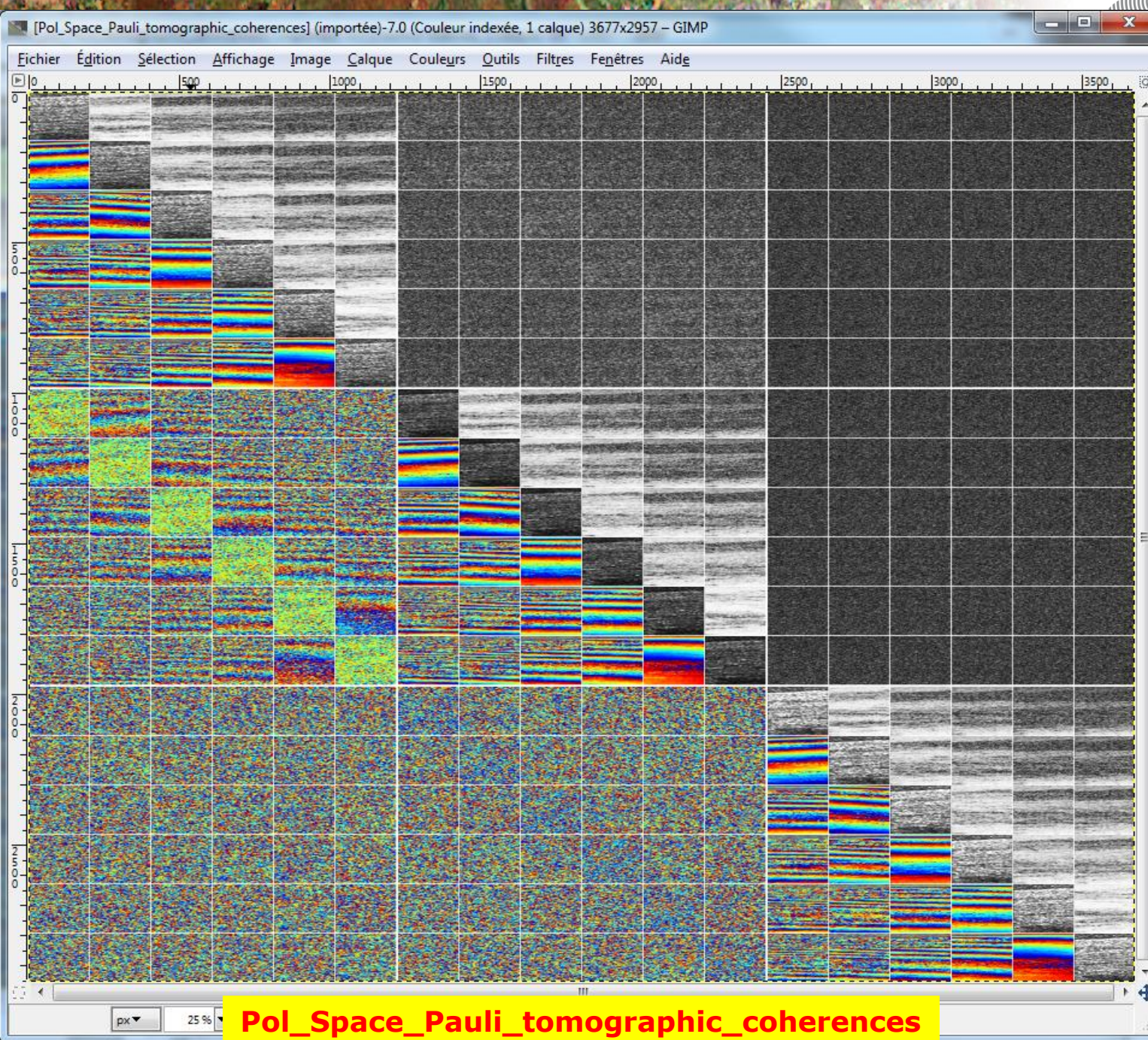
**Step 1 : Display Coherence Maps**

**Without DEM compensation**

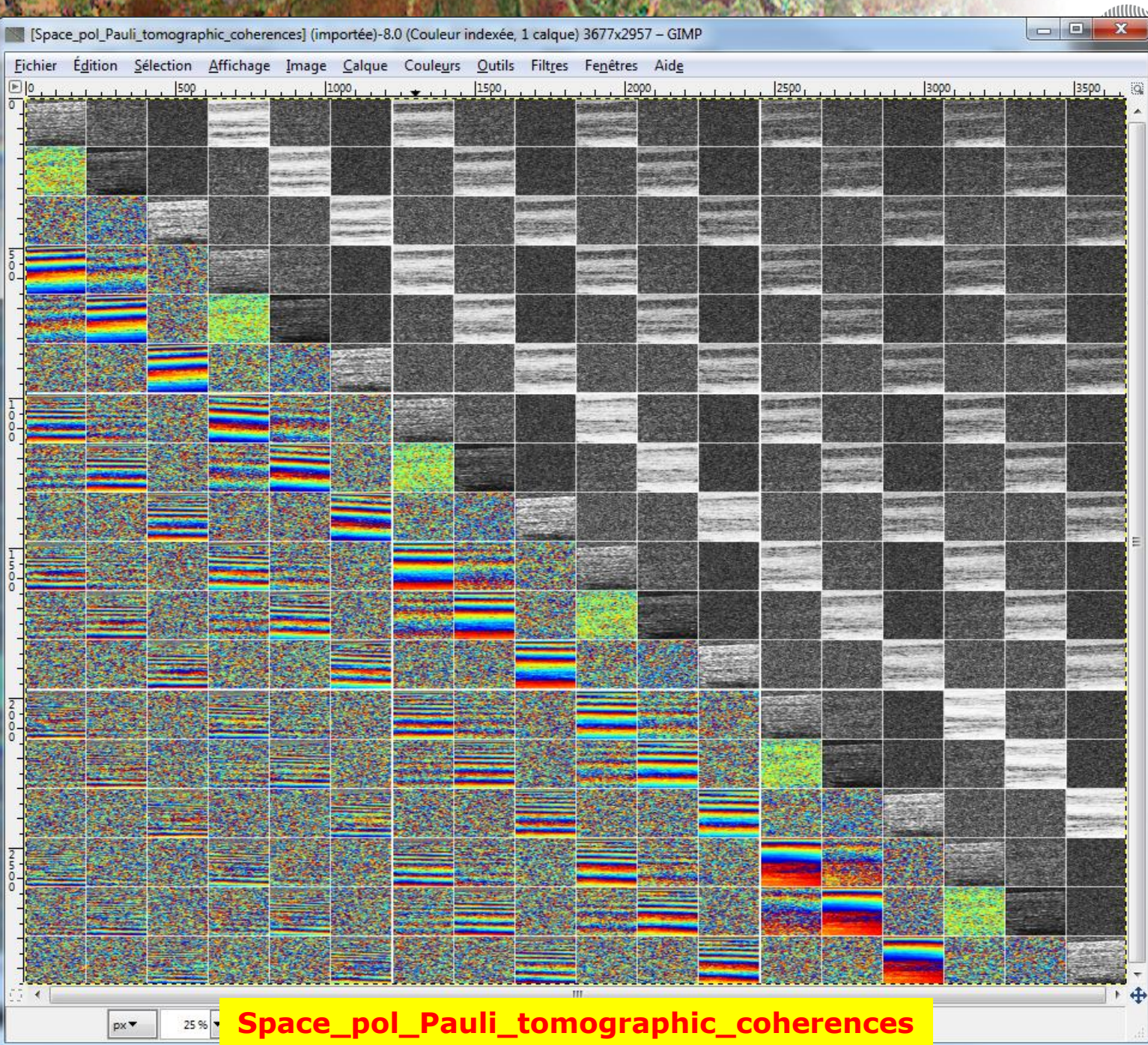
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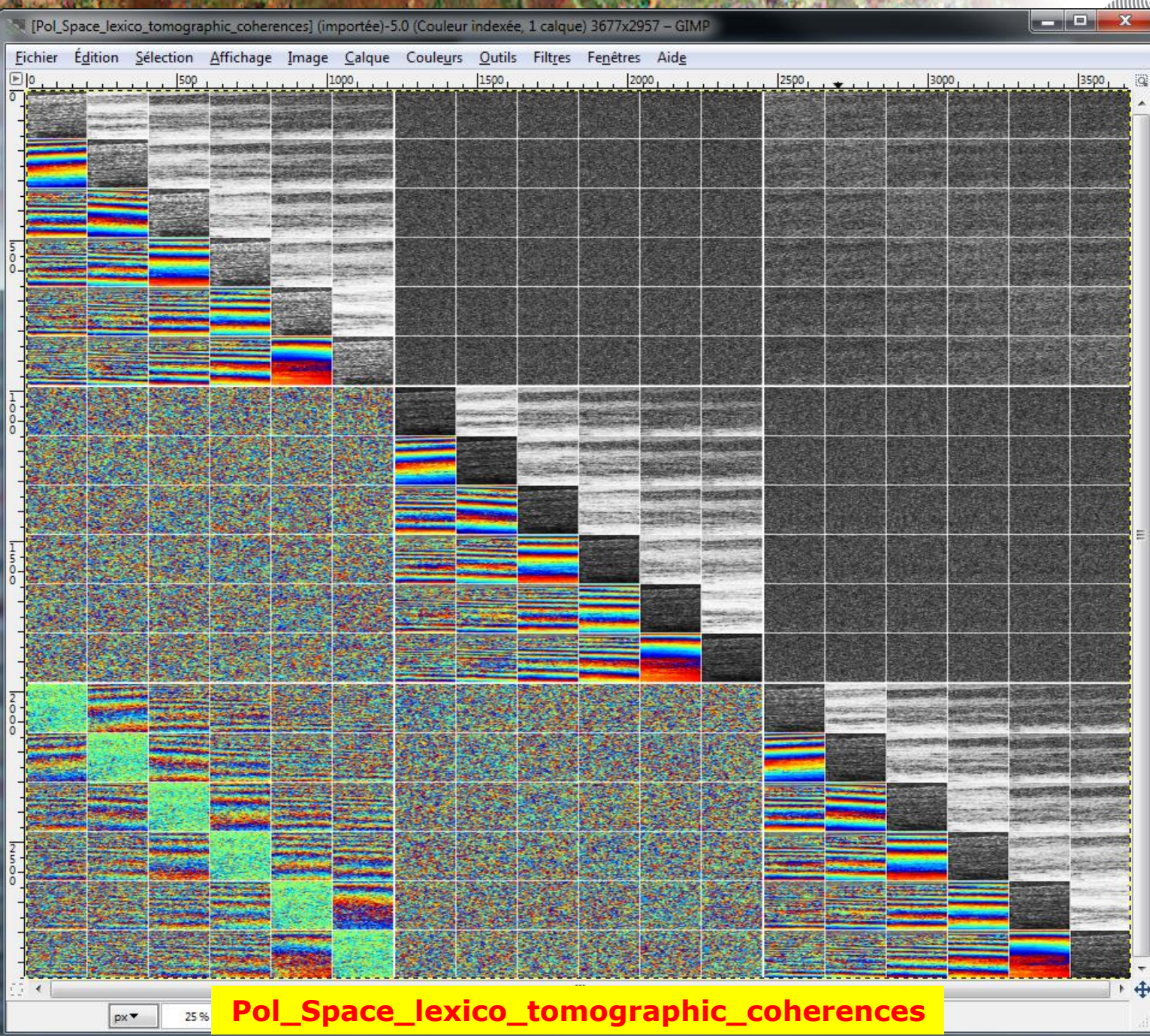




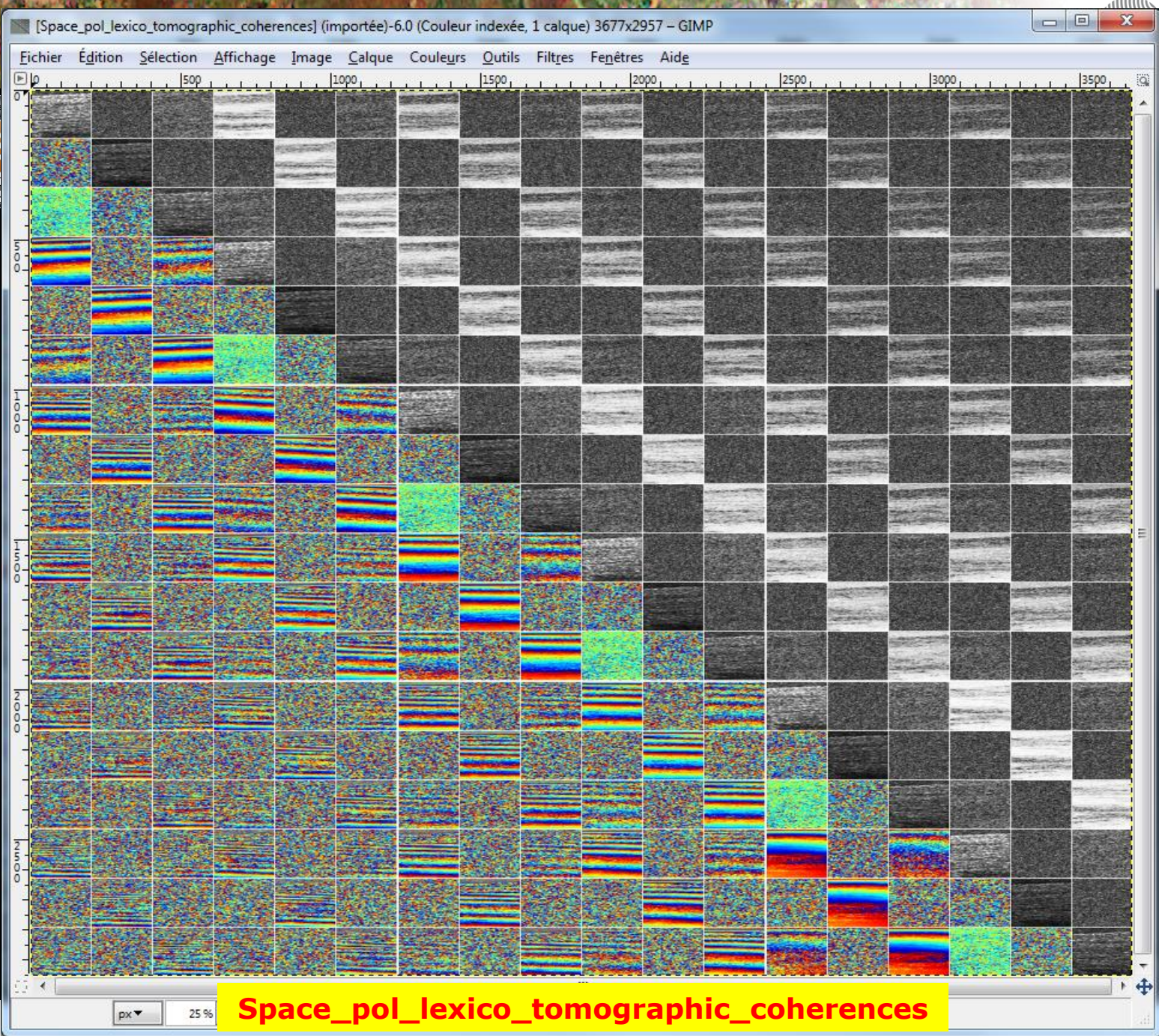












Space\_pol\_lexico\_tomographic\_coherences



# PROCESS DATA

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

**esa PolSARpro**  
The Polarimetric SAR Data Processing and Educational Tool

T3 S Environment Import Convert Process Display Calibration Utilities Tools Configuration Education Help Quit

PauliRGB.bmp

Polarimetric Tomography ( Pol-TomSAR )

Output Directory: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/profile\_beamformer\_col\_1 / T3

Input 2D Slant-Range DEM File: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/DEM.bin

Input 2D Slant-Range Top Height File: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/z\_top.bin

Slant-Range Row values: min 4365.986 max 5570.814 [m] [bin]  
Slant-Range Col values: min 203.0713 max 297.0711 [m] [bin]

Pol-TomSAR coherence maps analysis

Window Size : Row 7 Col 7 Sub-sampling : Row 5 Col 1 **Run**

Mouse Position: X 115 Y 1 Selected Pixel: X Y

Window Size: Row 7 Col 7 Tomogram Along: Col (X) Row (Y)

Height (z) values: z min ? z max ? delta z ?

Pol-TomSAR analysis: Gene **X** DEM compensation Run

Algorithm: B.F. Capon

Input - Output Process Directory:

Polarization Channels: HH HV VV HH + VV HH - VV LL LR RR

Matrix Elements: Span Corr Coeffs - [T3] Corr Coeffs - [C3] C.C.C Normalized C.C.C

Eigenvalues parameters: Entropy / Anisotropy / Alpha / Lambda Shannon Entropy Probabilities (p1,p2,p3) / eigenvalues (L1,L2,L3) Eigenvalue Relative Difference (E.R.D) Polarisation asymetry / polarisation fraction

Polarimetric Decompositions: Anis NED 3 components Van Zyl 3 components Freeman 3 components Singh 4 components Yamaguchi 4 components

Run Select All Reset Display Exit

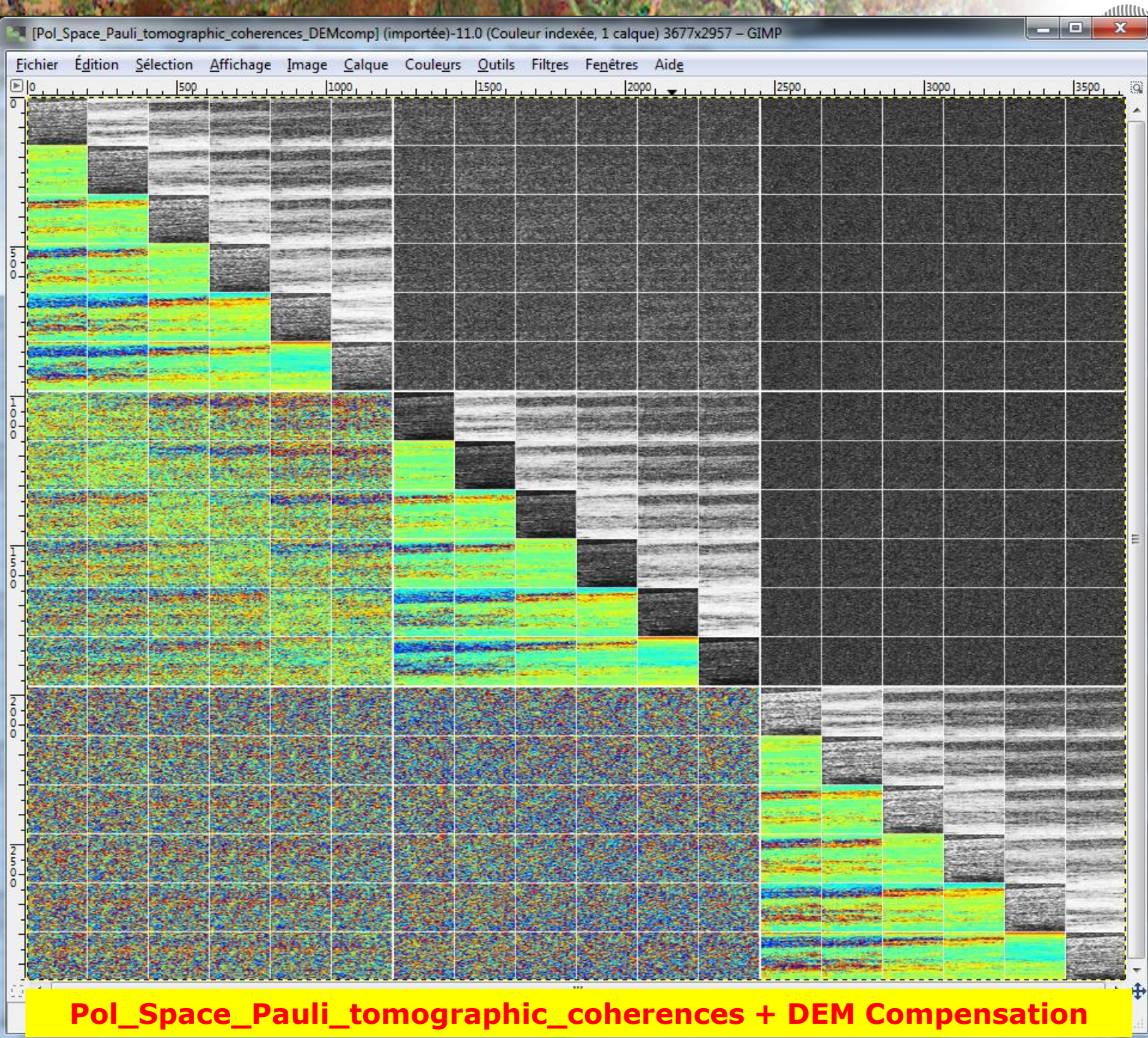
**Step 1-bis : Display Coherence Maps**

**With DEM compensation**

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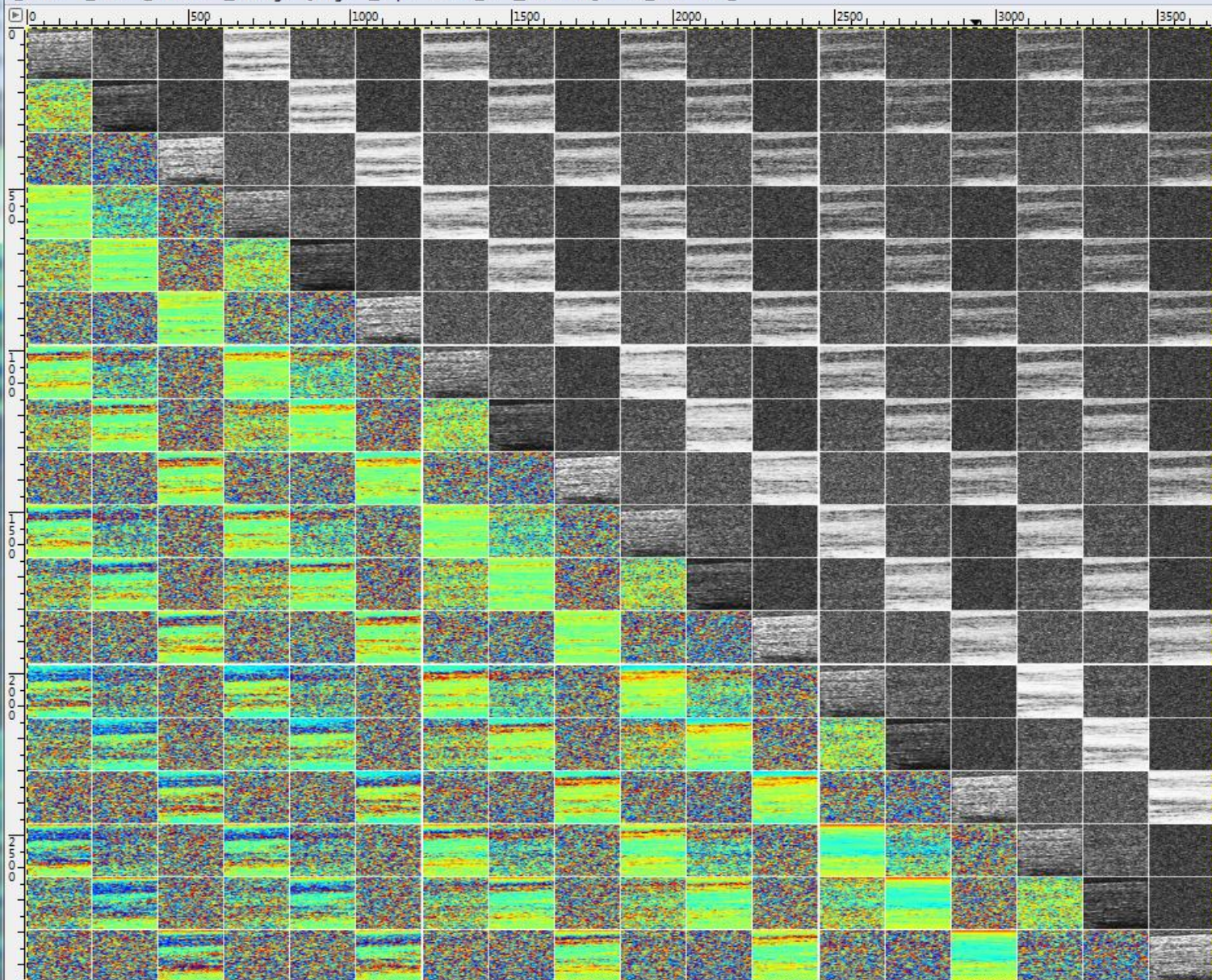




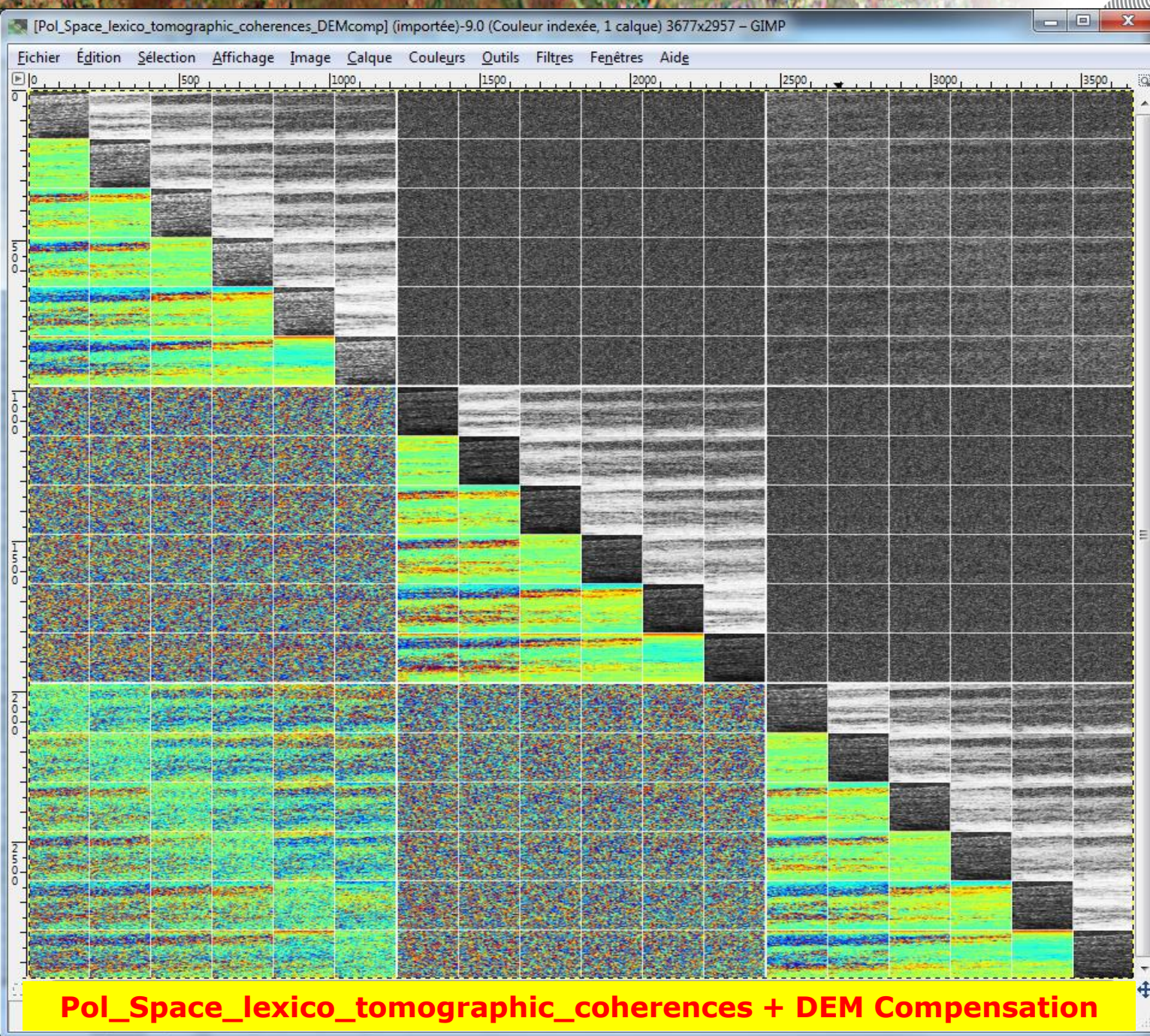


[Space\_pol\_Pauli\_tomographic\_coherences\_DEMcomp] (importée)-12.0 (Couleur indexée, 1 calque) 3677x2957 - GIMP

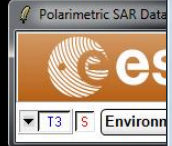
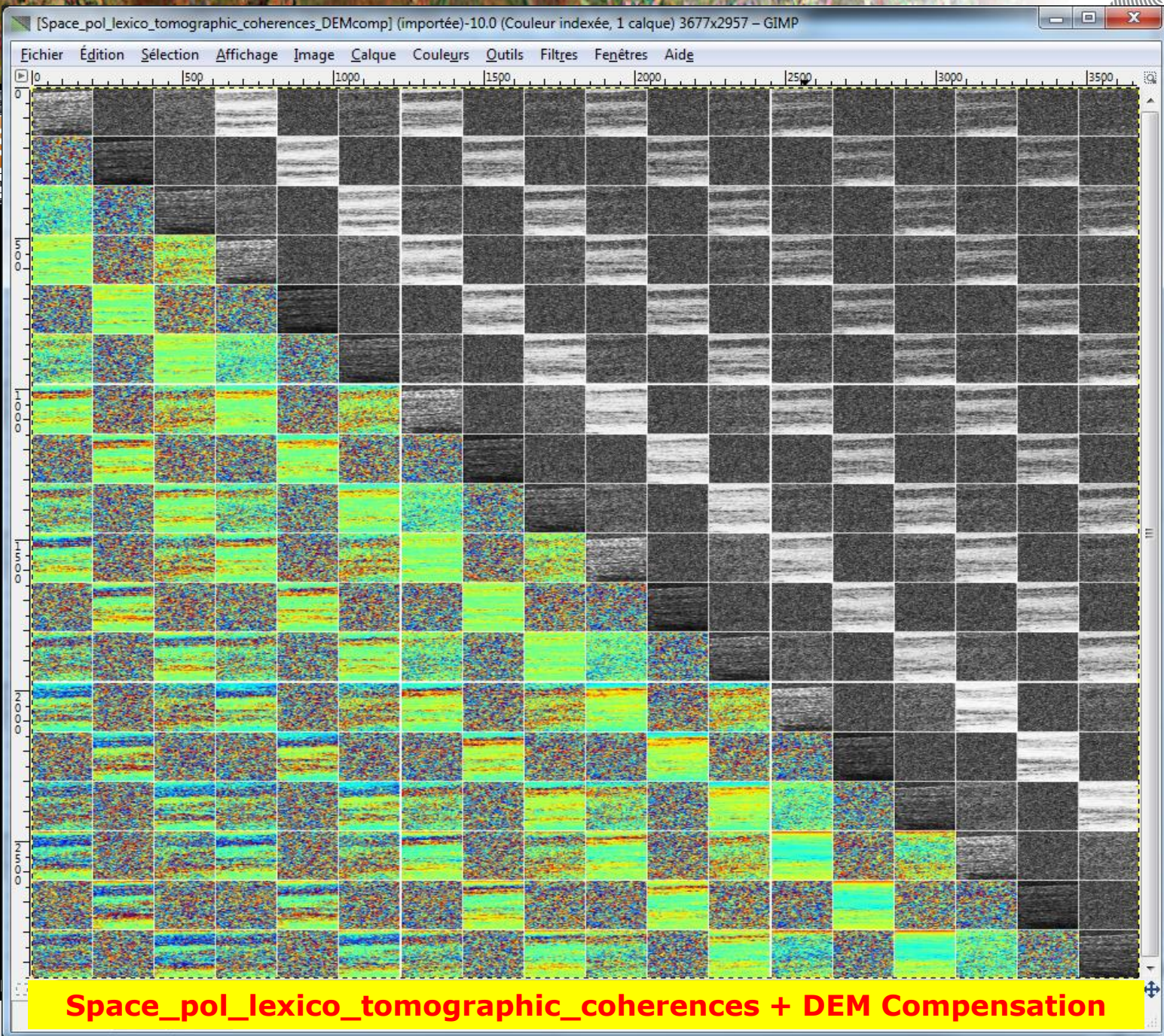
Fichier Édition Sélection Affichage Image Calque Couleurs Outils Filtres Fenêtres Aide

**Space\_pol\_Pauli\_tomographic\_coherences + DEM Compensation**











# PROCESS DATA

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

**esa PolSARpro**  
The Polarimetric SAR Data Processing and Educational Tool

T3 S Environment Import Convert Process Display Calibration Utilities Tools Configuration Education Help Quit

PauliRGB.bmp

**Polarimetric Tomography ( Pol-TomSAR )**

Output Directory  
C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/profile\_beamformer\_col\_100 / T3

Input 2D Slant-Range DEM File  
C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/DEM.bin

Input 2D Slant-Range Top Height File  
C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/z\_top.bin

Slant-Range Row values  
min 4365.986 max 5570.814 [m] [bin]

Slant-Range Col values  
min 203.0713 max 297.0711 [m] [bin]

Pol-TomSAR coherence maps analysis

Window Size : Row 7 Col 7 Sub-sampling : Row 5 Col 1 Run

Mouse Position  
X 149 Y 459

Selected Pixel  
X 100 Y 474

Window Size  
Row 15 Col 35

Tomogram Along :  
Col (X) Row (Y)

Height (z) values  
z min 180 z max 300 delta 0.5

Pol-TomSAR analysis  
Gene DEM compensation Run

Algorithm  
B.F Capon

Input - Output Process Directory

Polarization Channels  
HH HV VW HH + WV HH - WV LL LR RR

Matrix Elements  
Span Corr Coeffs - [T3] Corr Coeffs - [C3] C.C.C Normalized C.C.C

Eigenvalues parameters  
Entropy / Anisotropy / Alpha / Lambda  
Shannon Entropy  
Probabilities (p1,p2,p3) / eigenvalues (L1,L2,L3)  
Eigenvalue Relative Difference (E.R.D)  
Polarisation asymetry / polarisation fraction

Polarimetric Decompositions  
Arii NNED 3 components  
Van Zyl 3 components  
Freeman 3 components  
Singh 4 components  
Yamaguchi 4 components

Run Select All Reset Display Exit

**Step 2 :  
Run Pol-TomSAR  
analysis**

**Window size : 15 x 35**

**Height (z) values :  
Min = 180m  
Max = 300m  
Delta = 0.5m**

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# PROCESS DATA

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

esa PolSARpro  
The Polarimetric SAR Data Processing and Educational Tool

T3 S Environment Import Convert Process Display Calibration Utilities Tools Configuration Education Help Quit

Polarimetric Tomography ( Pol-TomSAR )

Output Directory  
D:/Pol\_Tomo\_datasets/im1/profile\_beamformer\_col\_ / T3

Input 2D Slant-Range DEM File  
Generate Input Slant-Range DEM File

Input 2D Slant-Range Top Height File  
Generate Input Slant-Range Top Height File

Slant-Range Row values  
min 4365.986 max 5570.814 [m] [bin]

Slant-Range Col values  
min 203.071 max 297.071 [m] [bin]

Pol-TomSAR coherence maps analysis  
Window Size : Row 7 Col 7 Sub-sampling : Row 5 Col 1 Run

Mouse Position  
X Y

Selected Pixel  
X Y

Window Size  
Row 7 Col 7

Tomogram Along :  
Col (X) Row (Y)

Height (z) values  
z min ? z max ? delta z ?

Pol-TomSAR analysis  
Gene DEM compensation Run

Algorithm  
B.F Capon

Input - Output Process Directory

Polarization Channels  
HH HV VW HH + WV HH - WV LL LR RR

Matrix Elements  
Span Corr Coeffs - [T3] Corr Coeffs - [C3] C.C.C Normalized C.C.C

Eigenvalues parameters  
Entropy / Anisotropy / Alpha / Lambda  
Shannon Entropy  
Probabilities (p1,p2,p3) / eigenvalues (L1,L2,L3)  
Eigenvalue Relative Difference (E.R.D)  
Polarisation asymmetry / polarisation fraction

Polarimetric Decompositions  
Arii NNED 3 components  
Van Zyl 3 components  
Freeman 3 components  
Singh 4 components  
Yamaguchi 4 components

Run Select All Reset Display Exit

Note :  
DEM and Top height  
files generator

Polarimetric Tomography ( Pol-TomSAR ) - Generators

Input 2D Slant-Range DEM File  
D:/Pol\_Tomo\_datasets/im1/DEM.bin  
Slant-Range axis  
Row Col  
Slant-Range values  
Near Range 100 Far Range 150

Input 2D Slant-Range Top Height File  
D:/Pol\_Tomo\_datasets/im1/z\_top.bin  
Slant-Range axis  
Row Col  
Slant-Range values  
Near Range 100 Far Range 150

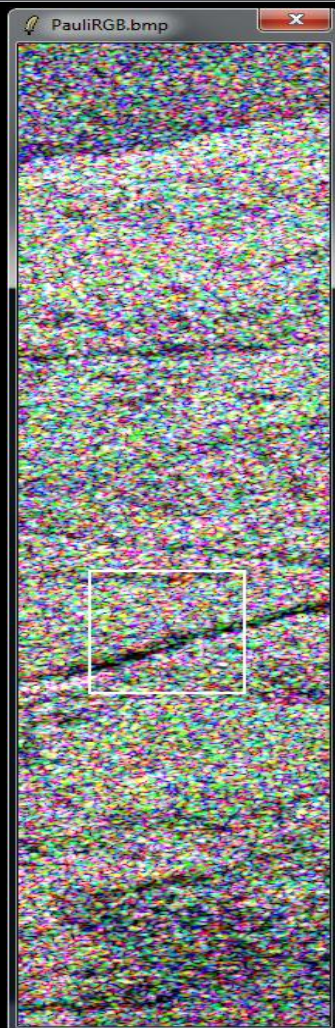
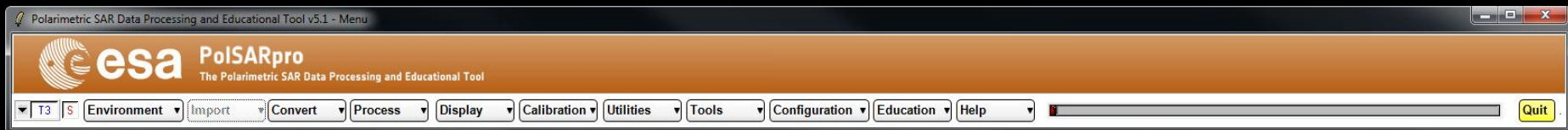
Run

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# PROCESS DATA



## Output Directories

**C:/Pol-Tomo\_datasets/im1/profile\_beamformer\_col\_100**

**C:/Pol-Tomo\_datasets/im1/profile\_capon\_col\_100**

**process**

**col / row**

**number**

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# PROCESS DATA

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

**esa PolSARpro**  
The Polarimetric SAR Data Processing and Educational Tool

T3 | Environment | Import | Convert | Process | Display | Calibration | Utilities | Tools | Configuration | Education | Help | Quit

### Polarimetric Tomography (Pol-TomSAR)

Output Directory: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/profile\_beamformer\_col\_100 / T3

Input 2D Slant-Range DEM File: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/DEM.bin

Input 2D Slant-Range Top Height File: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/z\_top.bin

Slant-Range Row values: min 4365.986 max 5570.814 [m] [bin] Slant-Range Col values: min 203.071 max 297.071 [m] [bin]

Pol-TomSAR coherence maps analysis

Window Size: Row 7 Col 7 Sub-sampling: Row 5 Col 1 Run

Mouse Position: X 149 Y 459 Selected Pixel: X 100 Y 474

Window Size: Row 15 Col 35 Tomogram Along: Col (X) Row (Y)

Height (z) values: z min 180 z max 300 delta z 0.5

Pol-TomSAR analysis: Gene DEM compensation Run

Algorithm: B.F Capon Input - Output Process Directory:


Polarization Channels: HH HV VW HH + WV HH - WV LL LR RR

Matrix Elements: Span Corr Coeffs - [T3] Corr Coeffs - [C3] C.C.C Normalized C.C.C

Eigenvalues parameters: Entropy / Anisotropy / Alpha / Lambda Shannon Entropy Probabilities (p1,p2,p3) / eigenvalues (L1,L2,L3) Eigenvalue Relative Difference (E.R.D) Polarisation asymetry / polarisation fraction

Polarimetric Decompositions: Arii NNED 3 components Van Zyl 3 components Freeman 3 components Singh 4 components Yamaguchi 4 components

Run Select All Reset Display ? Exit



### Polarimetric Tomography (Pol-TomSAR)

Output Directory: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/profile\_capon\_col\_100 / T3

Input 2D Slant-Range DEM File: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/DEM.bin

Input 2D Slant-Range Top Height File: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/z\_top.bin

Slant-Range Row values: min 4365.986 max 5570.814 [m] [bin] Slant-Range Col values: min 203.071 max 297.071 [m] [bin]

Pol-TomSAR coherence maps analysis

Window Size: Row 7 Col 7 Sub-sampling: Row 5 Col 1 Run

Mouse Position: X 50 Y 466 Selected Pixel: X 100 Y 474

Window Size: Row 15 Col 35 Tomogram Along: Col (X) Row (Y)

Height (z) values: z min 180.00000 z max 300.00000 delta z 0.5

Pol-TomSAR analysis: Gene DEM compensation Run

Algorithm: B.F Capon Input - Output Process Directory: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/profile\_beamformer\_col\_100/T3

Polarization Channels: HH HV VW HH + WV HH - WV LL LR RR

Matrix Elements: Span Corr Coeffs - [T3] Corr Coeffs - [C3] C.C.C Normalized C.C.C

Eigenvalues parameters: Entropy / Anisotropy / Alpha / Lambda Shannon Entropy Probabilities (p1,p2,p3) / eigenvalues (L1,L2,L3) Eigenvalue Relative Difference (E.R.D) Polarisation asymetry / polarisation fraction

Polarimetric Decompositions: Arii NNED 3 components Van Zyl 3 components Freeman 3 components Singh 4 components Yamaguchi 4 components

Run Select All Reset Display ? Exit



# PROCESS DATA

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

**esa PolSARpro**  
The Polarimetric SAR Data Processing and Educational Tool

T3 | Environment | Import | Convert | Process | Display | Calibration | Utilities | Tools | Configuration | Education | Help | Quit

PauliRGB.bmp

Polarimetric Tomography ( Pol-TomSAR )

Output Directory: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/profile\_capon\_col\_100 / T3

Input 2D Slant-Range DEM File: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/DEM.bin

Input 2D Slant-Range Top Height File: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/z\_top.bin

Slant-Range Row values: min 4365.986 max 5570.814 [m] [bin]

Slant-Range Col values: min 203.0713 max 297.0711 [m] [bin]

Pol-TomSAR coherence maps analysis

Window Size: Row 7 Col 7 Sub-sampling: Row 5 Col 1 Run

Mouse Position: X 140 Y 439 Selected Pixel: X 100 Y 474

Window Size: Row 15 Col 35 Tomogram Along: Col (X) Row (Y)

Height (z) values: z min 180.0000 z max 300.0000 delta z 0.5

Pol-TomSAR analysis: ☒ Generate ☐ DEM compensation Run

Algorithm: B.F. Capon Input - Output Process Directory: C:/My\_Data\_Directory/Pol\_Tomo\_datasets/im1/profile\_beamformer\_col\_100/T

Polarization Channels: ☒ HH ☒ HV ☒ VW ☒ HH + WV ☒ HH - WV ☒ LL ☒ LR ☒ RR

Matrix Elements: ☒ Span ☒ Corr Coeffs - [T3] ☒ Corr Coeffs - [C3] ☒ C.C.C ☒ Normalized C.C.C

Eigenvalues parameters: ☒ Entropy / Anisotropy / Alpha / Lambda ☒ Shannon Entropy ☒ Probabilities (p1,p2,p3) / eigenvalues (L1,L2,L3) ☒ Eigenvalue Relative Difference (E.R.D) ☒ Polarisation asymmetry / polarisation fraction

Polarimetric Decompositions: ☒ Arie NNED 3 components ☒ Van Zyl 3 components ☒ Freeman 3 components ☒ Singh 4 components ☒ Yamaguchi 4 components

Run Select All Reset Display Exit

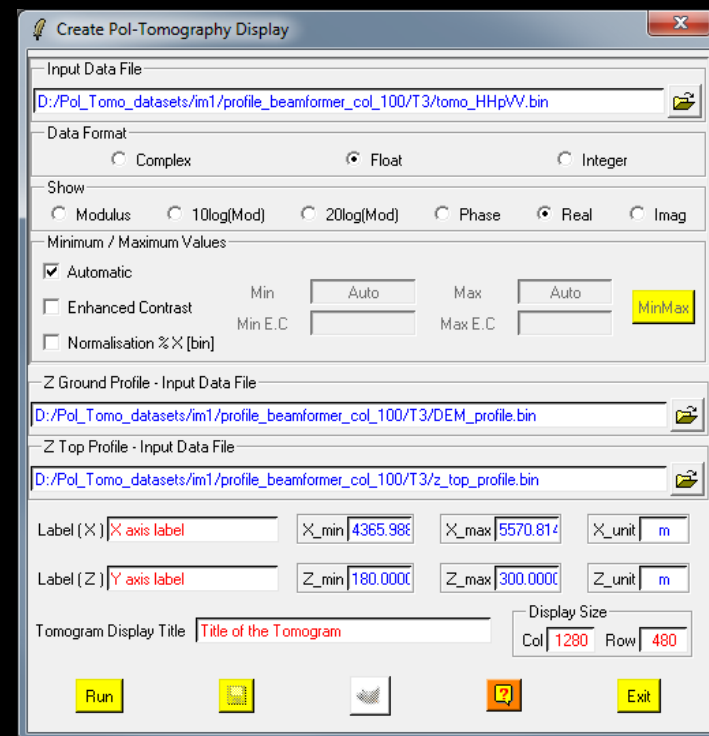
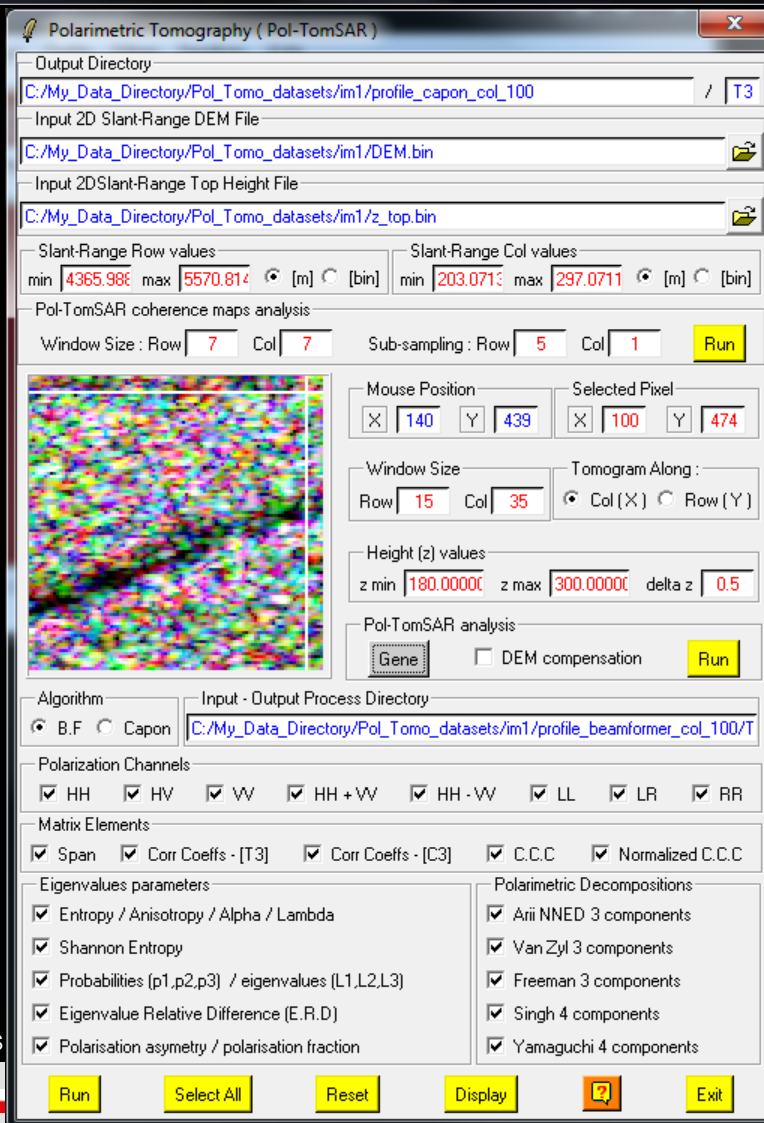
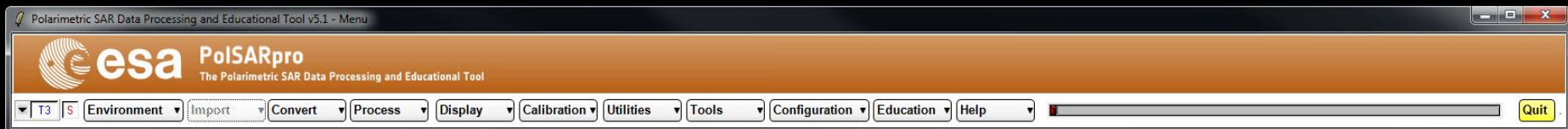
**Step 3 : Run additional polarimetric data processing**

**Step 4 : Display Results**

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# PROCESS DATA





# PROCESS DATA

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

**esa PolSARpro**  
The Polarimetric SAR Data Processing and Educational Tool

T3 | Environment | Import | Convert | Process | Display | Calibration | Utilities | Tools | Configuration | Education | Help | Quit

### Create Pol-Tomography Display

Input Data File  
D:/Pol\_Tomo\_datasets/im1/profile\_beamformer\_col\_100/T3/tomo\_HHpV.bin

Data Format  
☐ Complex ☒ Float ☐ Integer

Show  
☐ Modulus ☐ 10log(Mod) ☐ 20log(Mod) ☐ Phase ☒ Real ☐ Imag

Minimum / Maximum Values  
☒ Automatic  
☐ Enhanced Contrast  
☐ Normalisation % X [bin]

Min Auto Max Auto MinMax  
Min E.C. Max E.C.

Z Ground Profile - Input Data File  
D:/Pol\_Tomo\_datasets/im1/profile\_beamformer\_col\_100/T3/DEM\_profile.bin

Z Top Profile - Input Data File  
D:/Pol\_Tomo\_datasets/im1/profile\_beamformer\_col\_100/T3/z\_top\_profile.bin

Label (X) X axis label X\_min 4365.98 X\_max 5570.81 X\_unit m  
Label (Z) Y axis label Z\_min 180.000 Z\_max 300.000 Z\_unit m

Tomogram Display Title Title of the Tomogram  
Display Size Col 1280 Row 480

Run [ ] [ ] [ ] [ ] Exit

### Tomogram Display

Title of the Tomogram

Y axis label - [ m ]

X axis label - [ m ]

18 16 14 12 10 8 6 4 2

### Tomogram Display

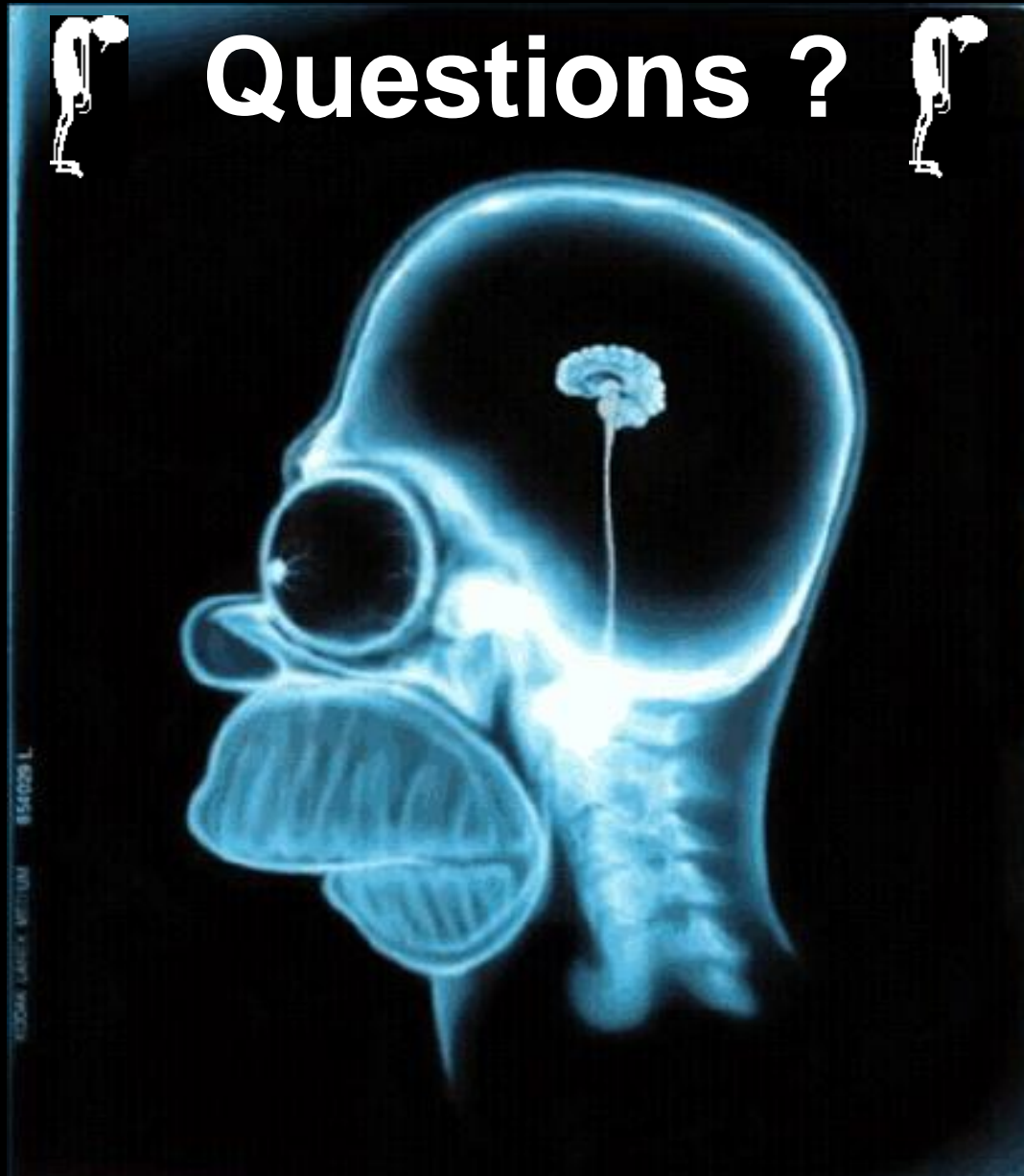
Title of the Tomogram

Y axis label - [ m ]

X axis label - [ m ]

1 0.8 0.6 0.4 0.2 0

# Questions ?



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