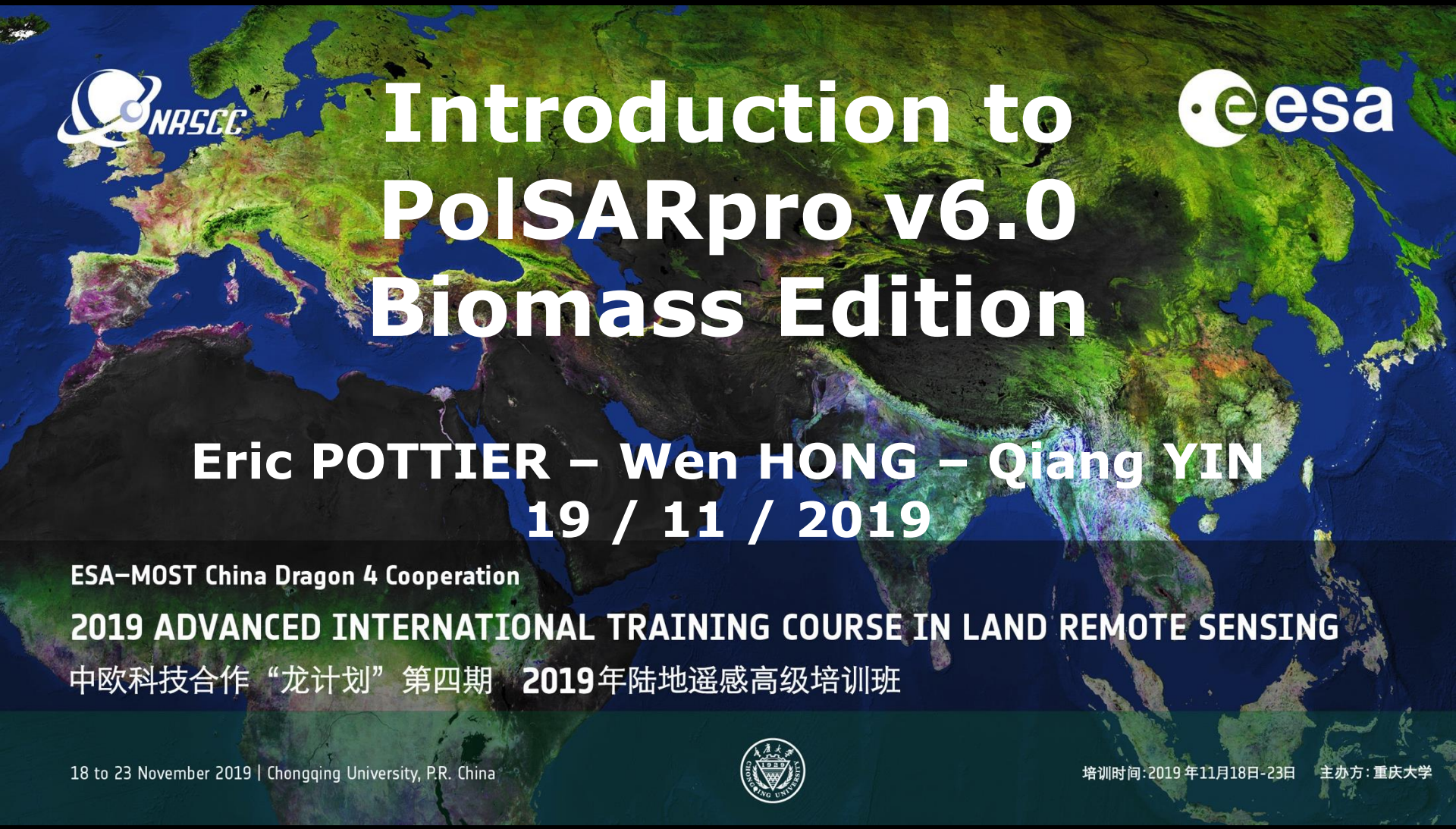


Introduction to PolSARpro v6.0 Biomass Edition

Eric POTTIER – Wen HONG – Qiang YIN

19 / 11 / 2019

ESA–MOST China Dragon 4 Cooperation

2019 ADVANCED INTERNATIONAL TRAINING COURSE IN LAND REMOTE SENSING

中欧科技合作“龙计划”第四期 2019年陆地遥感高级培训班

18 to 23 November 2019 | Chongqing University, P.R. China

培训时间:2019 年11月18日-23日 主办方:重庆大学

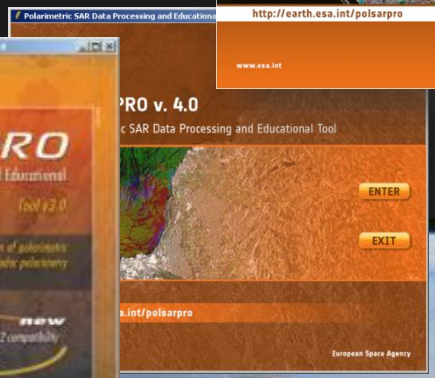
HISTORY

2003

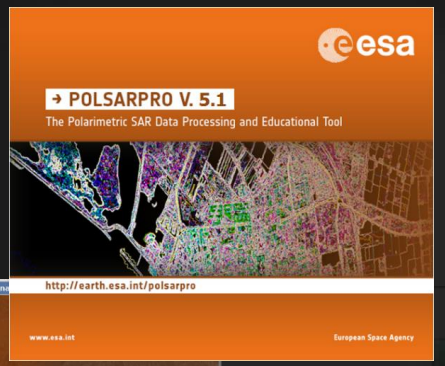
2004

2005

2007



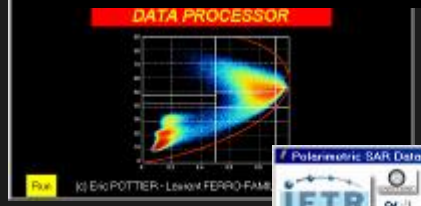
2009



2013 (5.0)
to
2018 (5.2)

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.

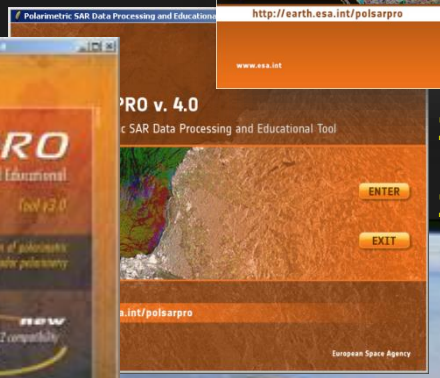


2003

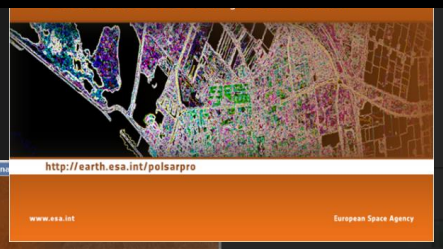
2004

2005

2007



2009

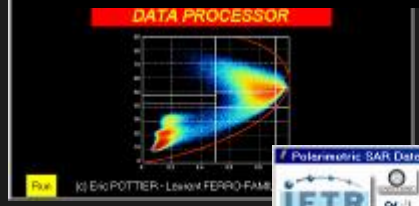


2013 (5.0) to 2018 (5.2)

HISTORY

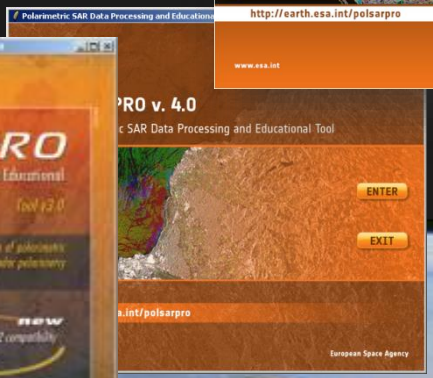
The initiative development of ...pro Software is a direct result of recommendation...aring the POLinSAR 2003 Workshop held at ESA-E...anuary 2003.

16 YEARS OF DEVELOPMENT



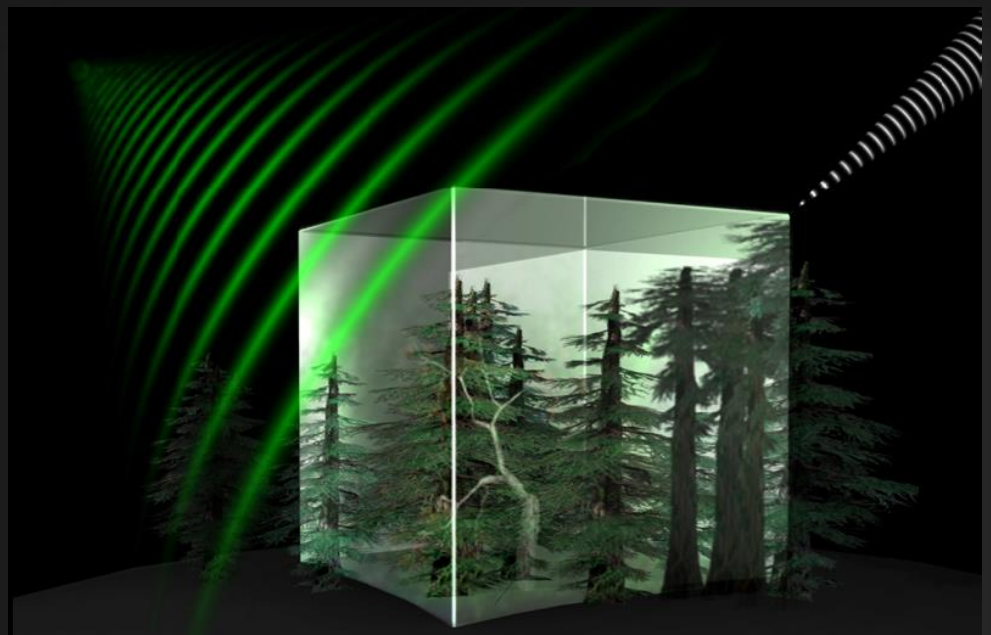
2003

2004 2005



2007 2009 2013 (5.0) to 2018 (5.2)

BIOMASS mission : 7th ESA Earth Explorer (2022)

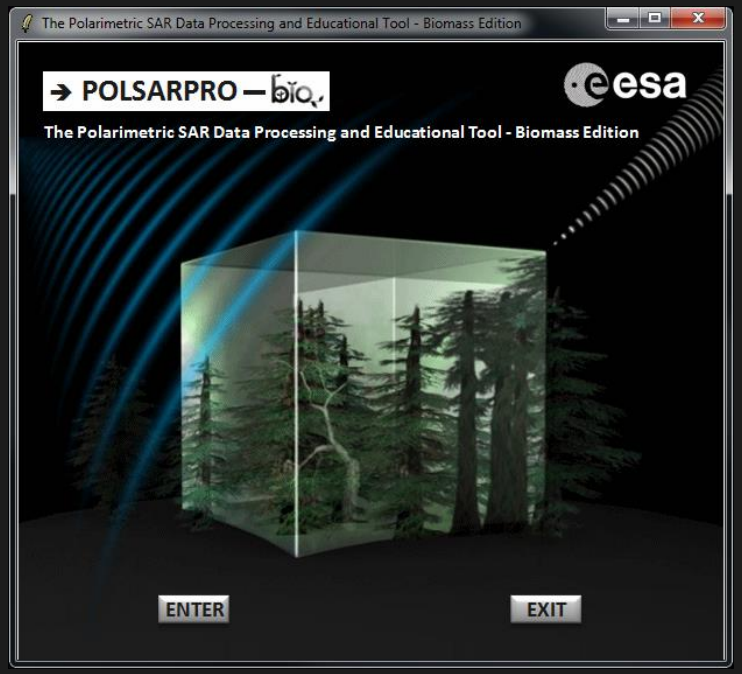


Biomass will provide global maps of the amount of carbon stored in the world's forests and how this changes over time.

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

P-Band Pol-TomoSAR spaceborne mission

PolSARpro - Biomass Edition

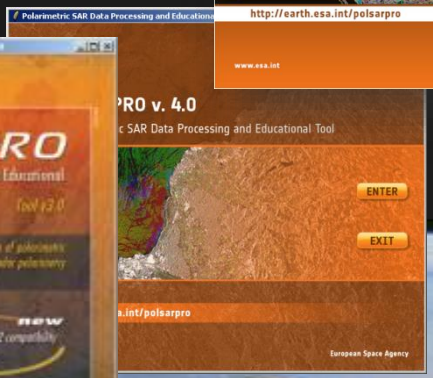


2003

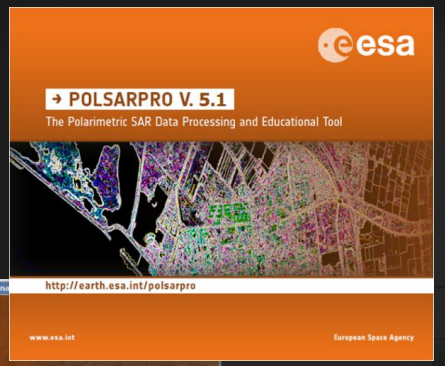
2004

2005

2007

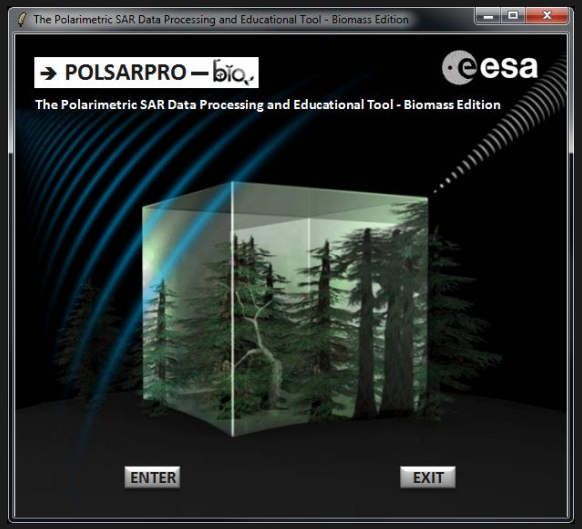


2009



2013 (5.0)
to
2018 (5.2)

PolSARpro - Biomass Edition

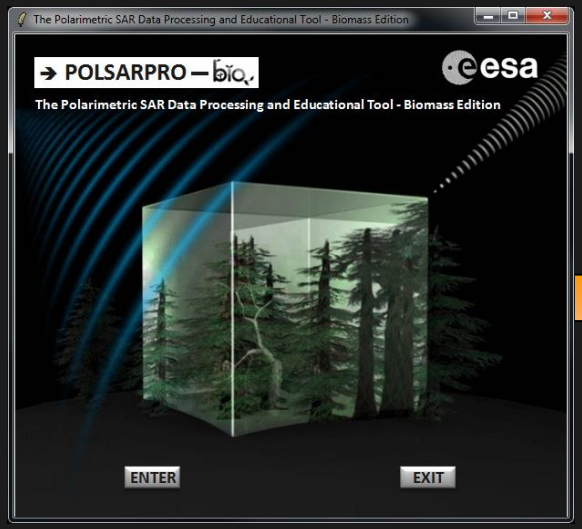


Toolbox specifically designed to handle : **Pol-SAR**, **Pol-InSAR**, **Pol-TimeSAR** and now **Pol-TomoSAR** data.

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**....

PolSARpro - Biomass Edition



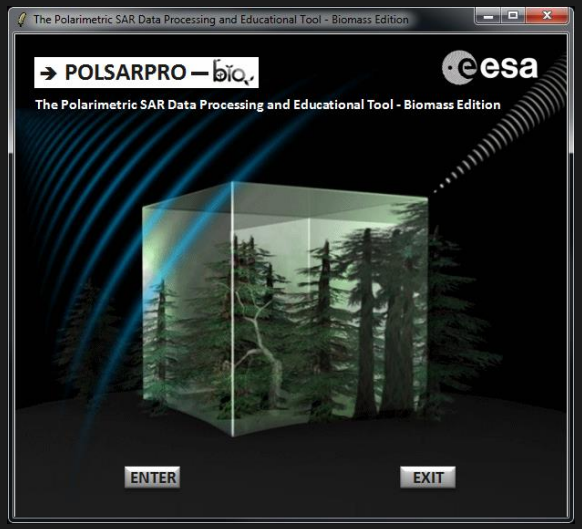
Around **1800** different Pol-SAR, Pol-InSAR, Pol-TimeSAR and now Pol-TomoSAR **functionalities**.

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

Windows 10 Compatible

PolSARpro v6.0 (Biomass Edition) Software is made available following the: **Open Source Software Development** (**OSSD**) approach, and follows the: **GNU General Public License v2** – June 1991.

PolSARpro - Biomass Edition



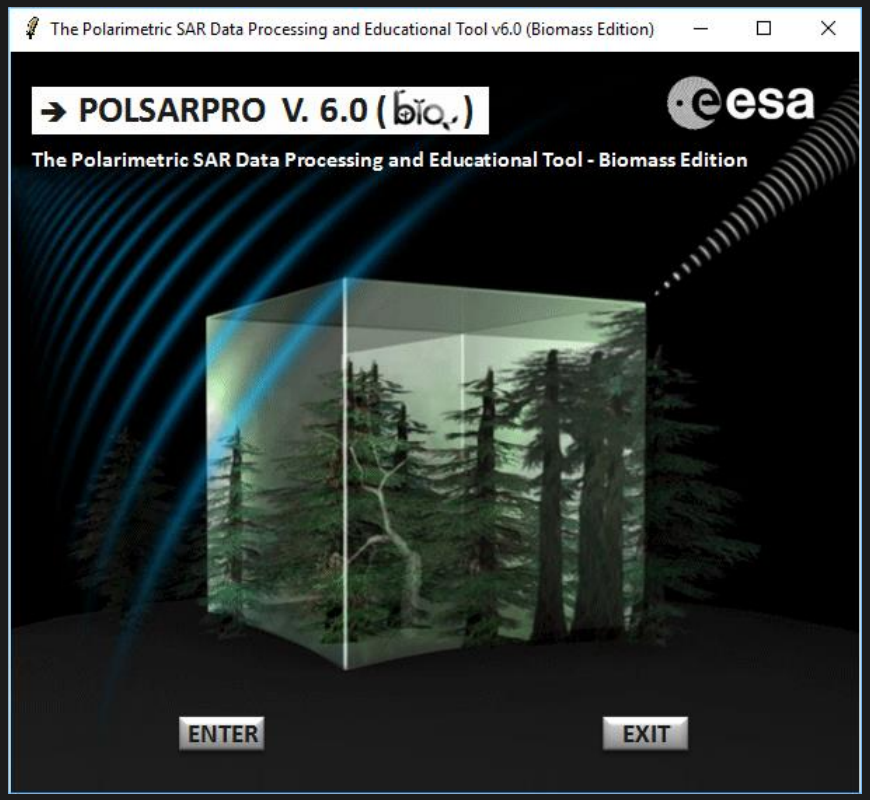
esa since 2003

- +3000 registered users
- +70 foreign countries

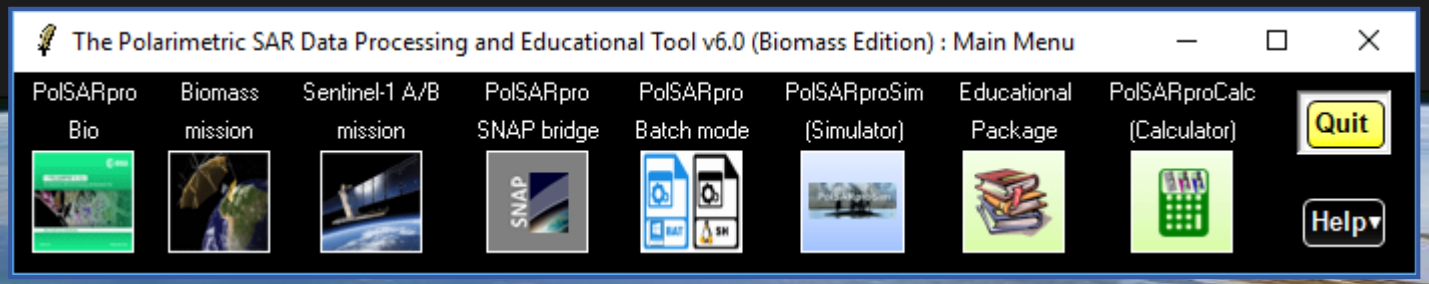
International Collaborative Project

(4 Agencies, 19 Research Centres, 21 Universities)

PolSARpro - Biomass Edition

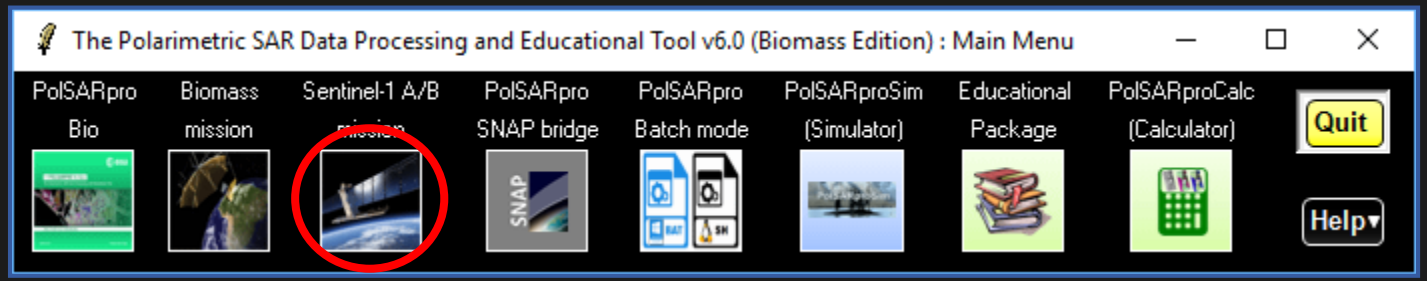


ENTRY SCREEN

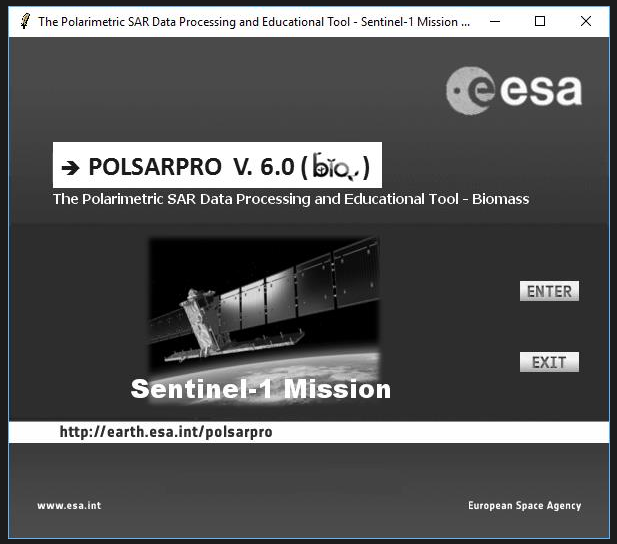


MAIN WINDOW

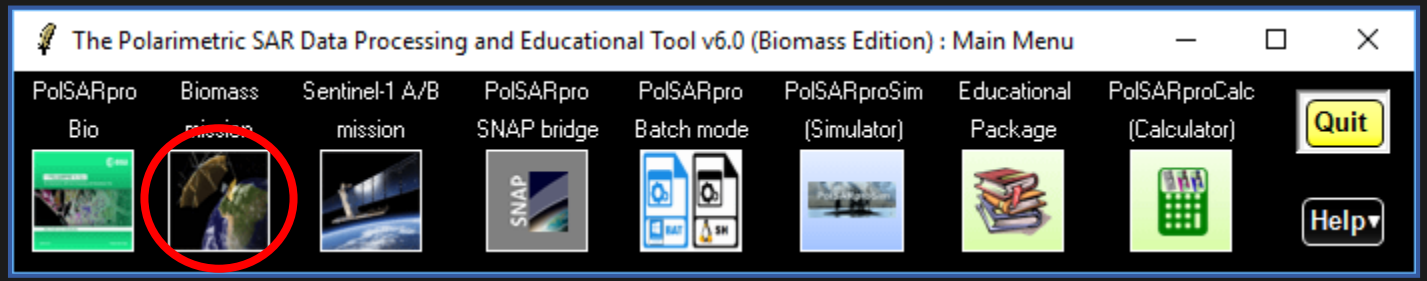
PolSARpro - Biomass Edition



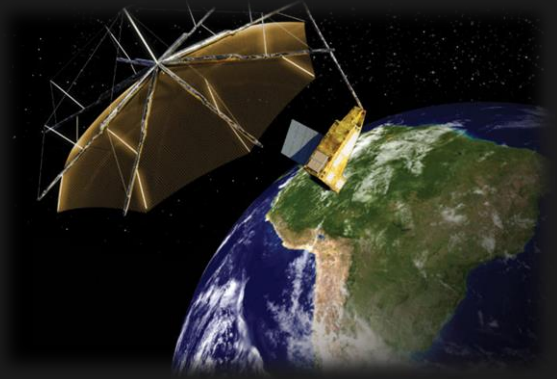
SENTINEL 1A / 1B

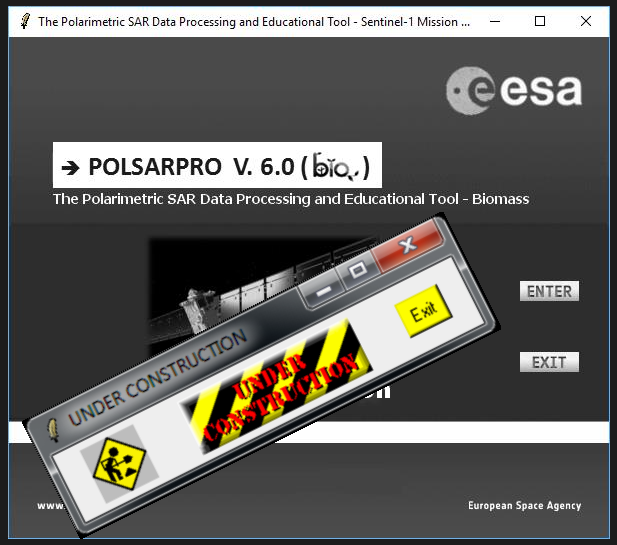


PolSARpro - Biomass Edition

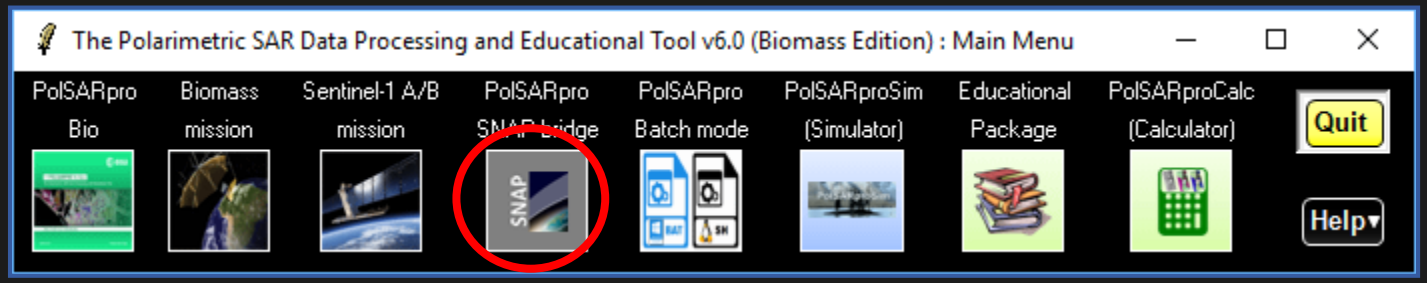


BIOMASS



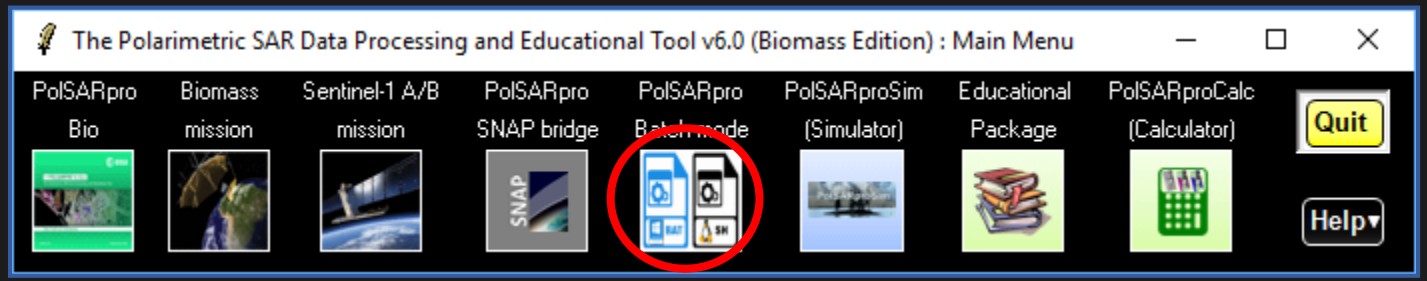


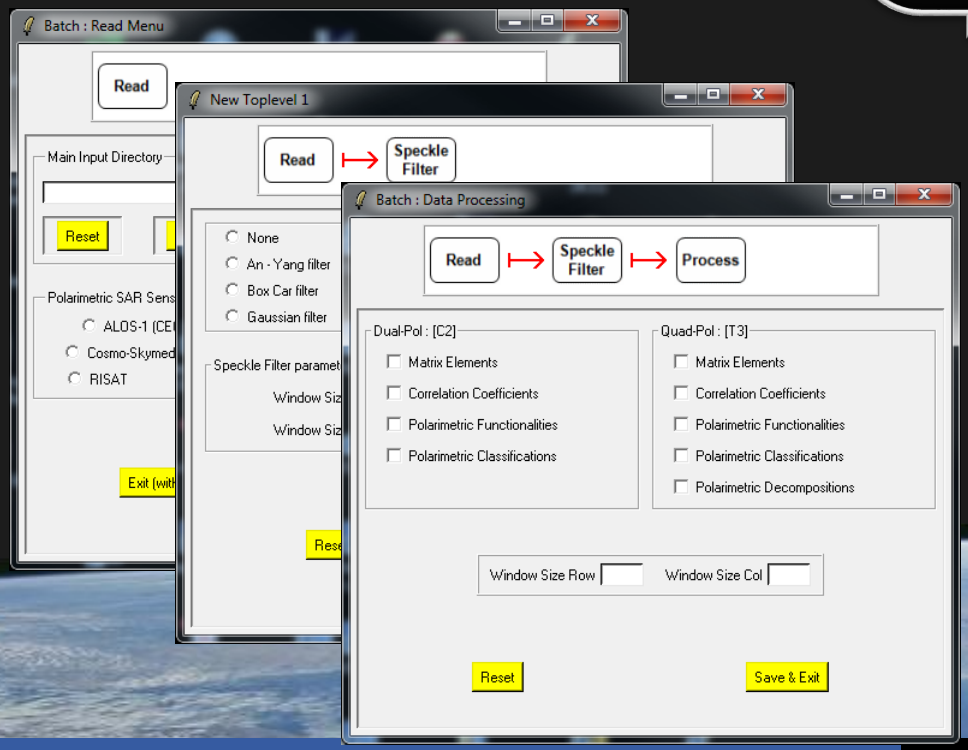
PolSARpro - Biomass Edition



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

PolSARpro - Biomass Edition

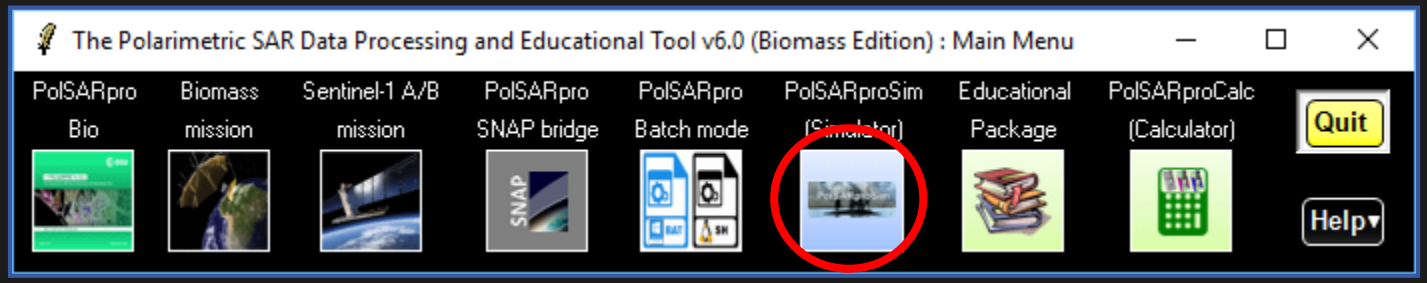


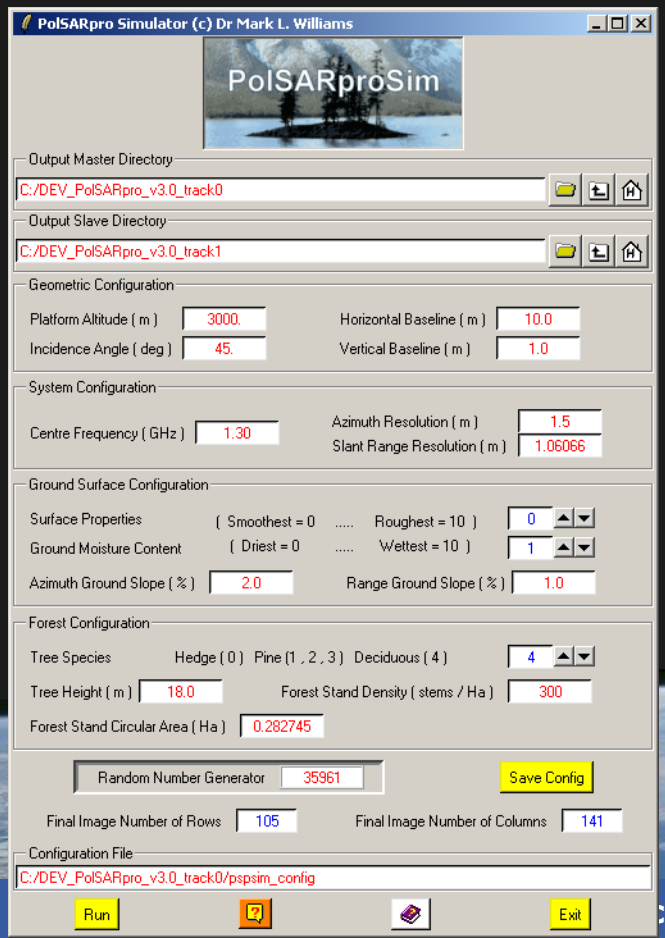


PolSARpro Batch Mode

Create a bat (windows) or a sh (linux) file to run different polarimetric data processes in a batch processing mode.

PolSARpro - Biomass Edition



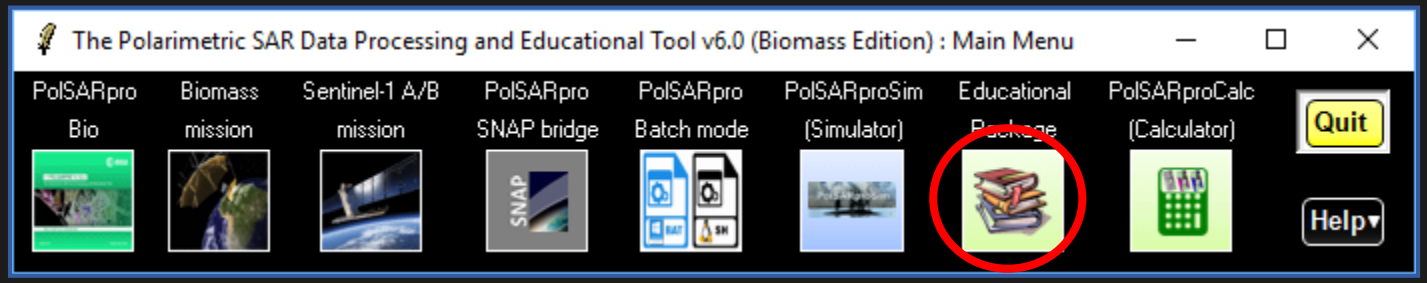


PolSARpro - Sim

This educational tool creates and provides simulated test data of sufficient fidelity to be used to illustrate the concepts of Pol-InSAR when applied on ground surface, ground surface covered with low vegetation or forest stands.

This simulator is developed by Mark Williams ©

PolSARpro - Biomass Edition



PolSARpro – Biomass Edition web site

- *On-line tutorials*
- *On-line self training packages*

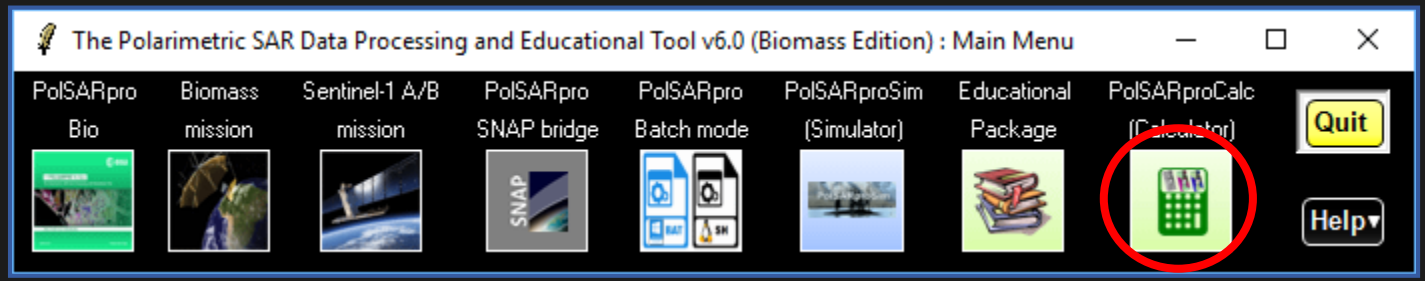
New lecture course

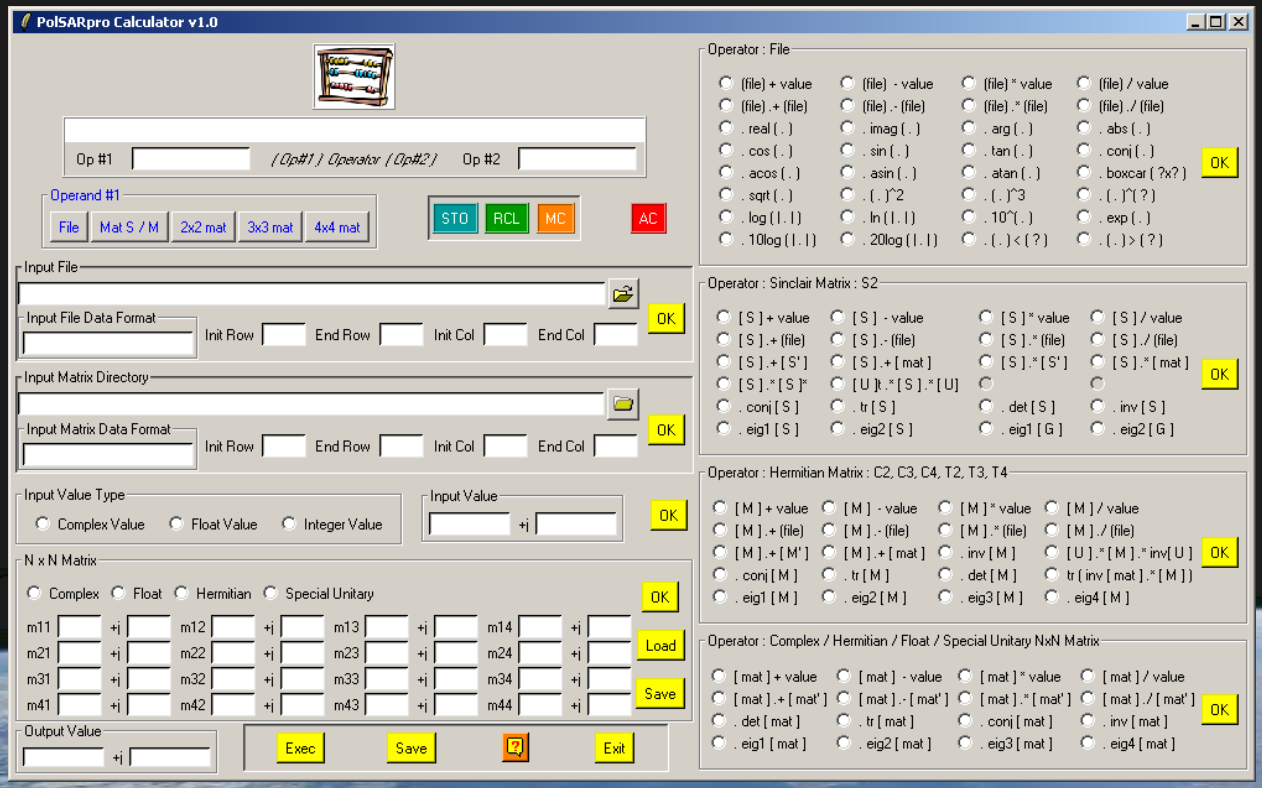
New topics

Re-design of the *Do It Yourself*

- *Video / Quizz*
- *Blog / Forum*

PolSARpro - Biomass Edition

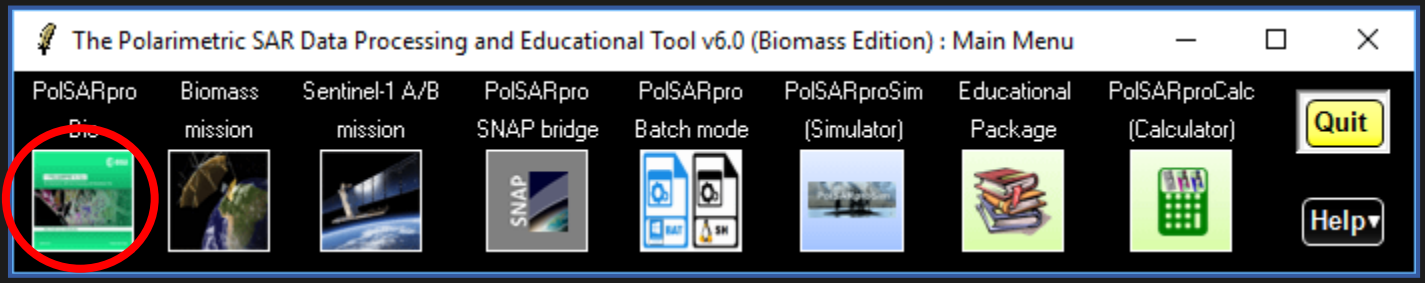


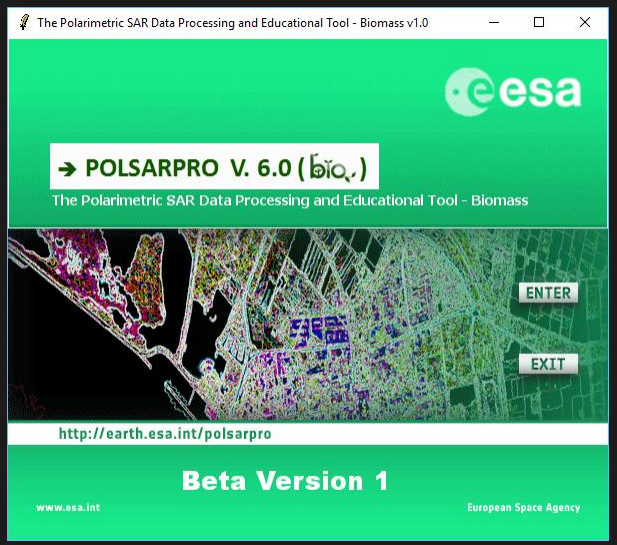


PolSARpro - Calc

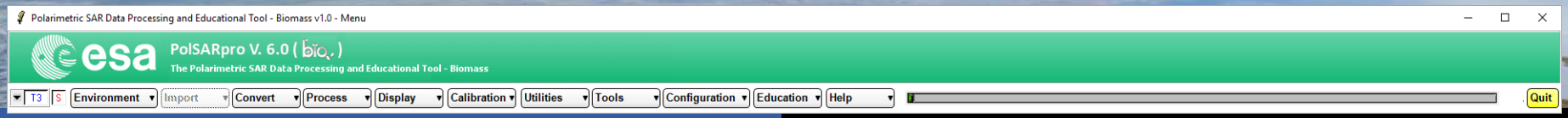
This tool proposes a Polarimetric Pocket Calculator offering basic processing functionalities which are applied on a set of SAR Polarimetric datasets.

PolSARpro - Biomass Edition

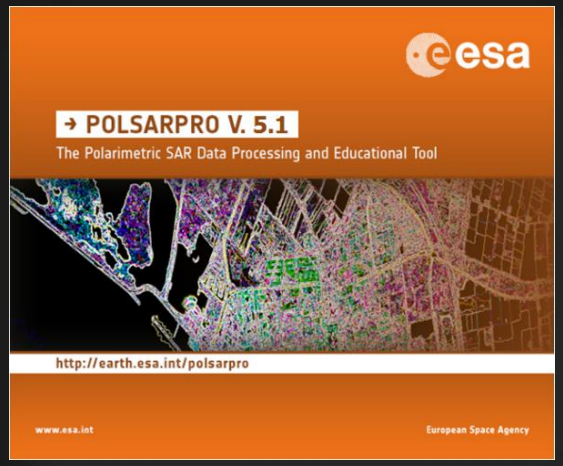




PolSARpro v6.0 (Biomass Edition) SOFTWARE

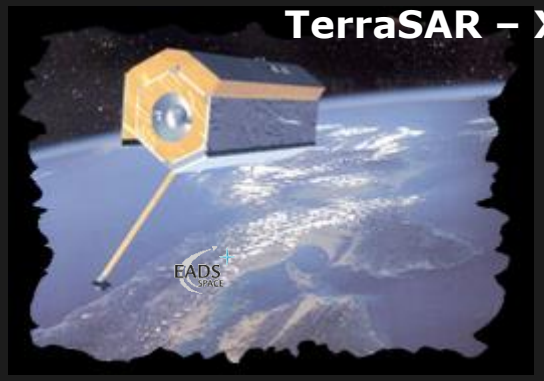


PolSARpro v5.2 SOFTWARE



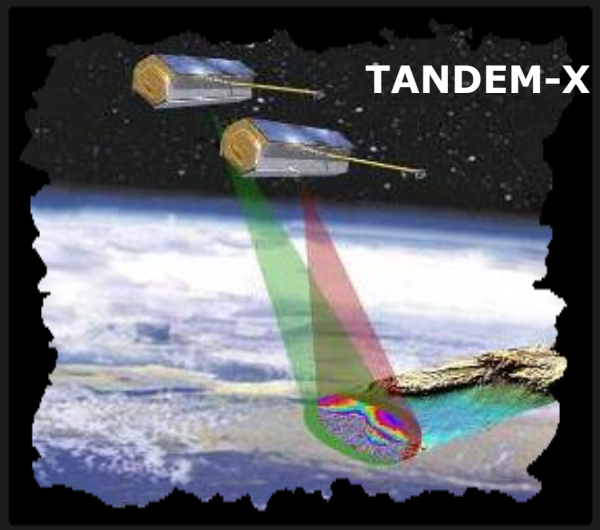
RADARSAT 2

TerraSAR – X



COSMO - SKYMED

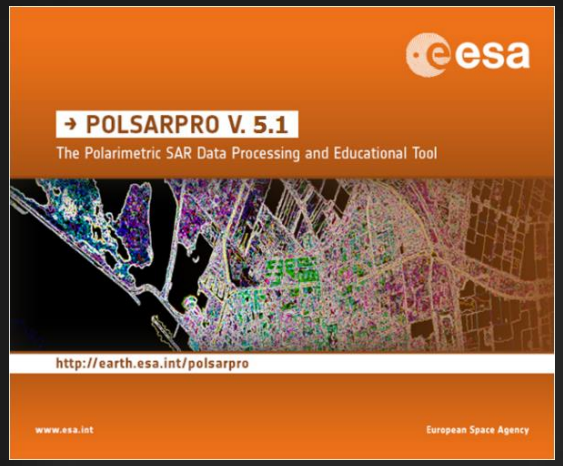
TANDEM-X



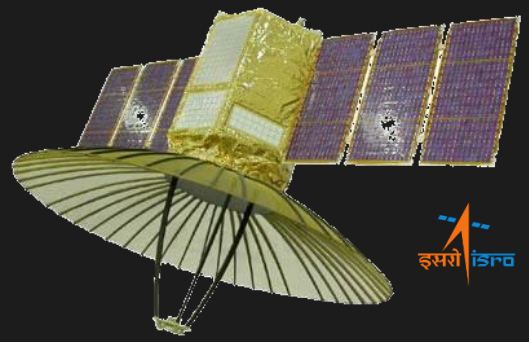
CURRENT

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

PolSARpro v5.2 SOFTWARE



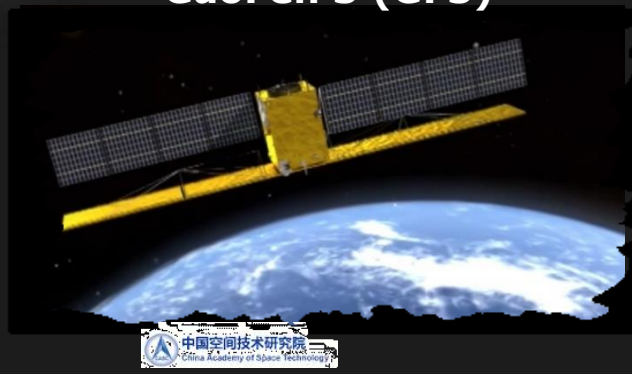
RISAT



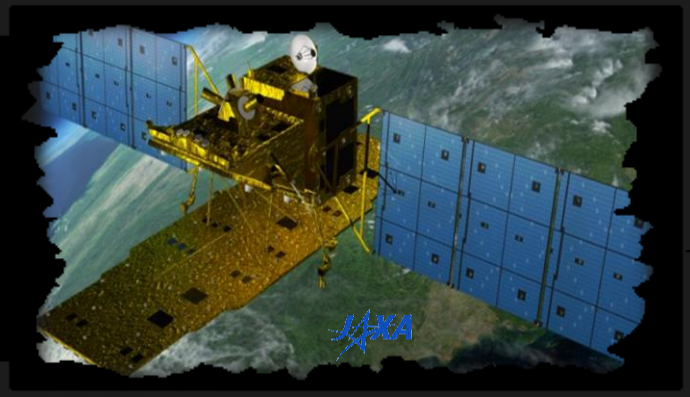
SENTINEL 1A / 1B

CURRENT

GaoFen 3 (GF3)

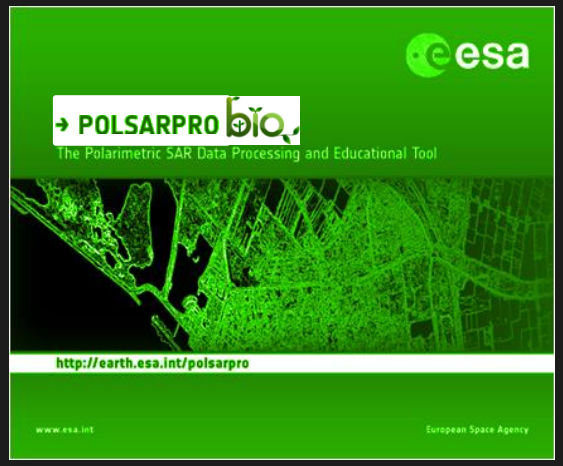


ALOS-2 – PALSAR-2



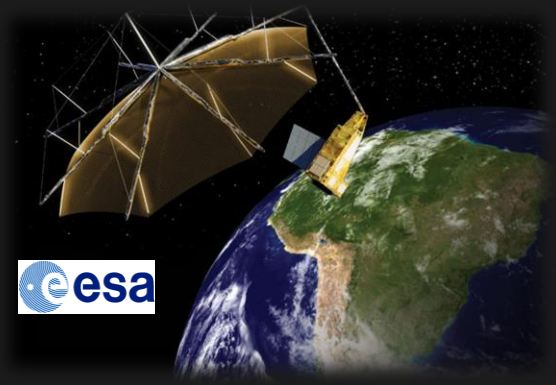
PolSARpro v5.2 Software offers the possibility to handle and convert polarimetric data from a range of well established CURRENT polarimetric spaceborne platforms.

PolSARpro - Bio SOFTWARE



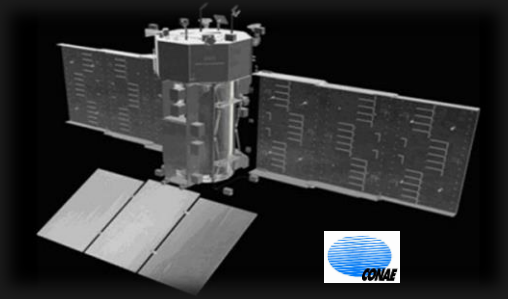
FUTURE

BIOMASS

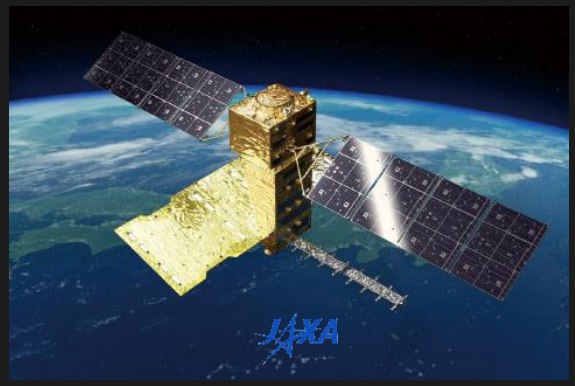


Radarsat Constellation Mission (RCM)

SAOCOM

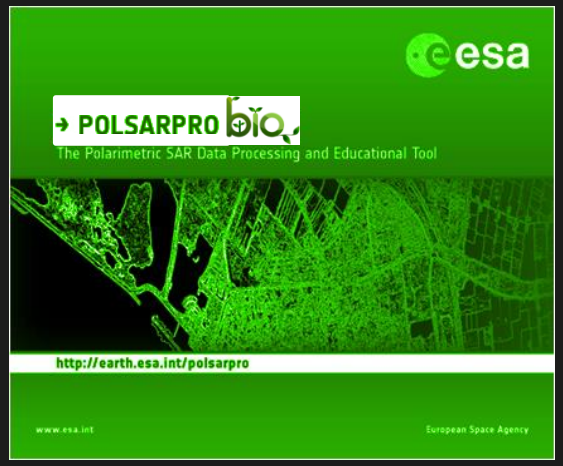


ALOS-4– PALSAR-3



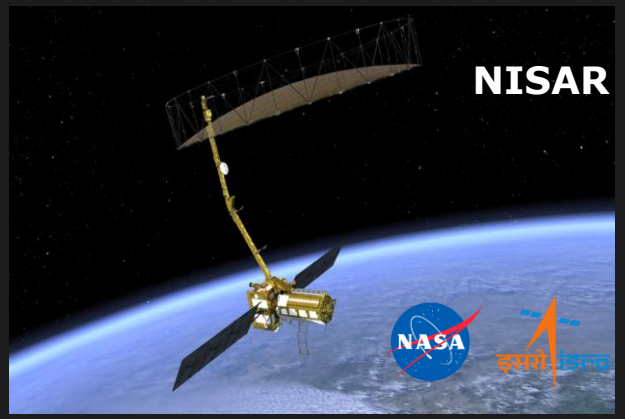
PolSARpro - Bio will offer the possibility to handle and convert polarimetric data of FUTURE polarimetric spaceborne platforms.

PolSARpro - Bio SOFTWARE



NovaSAR - S

NISAR

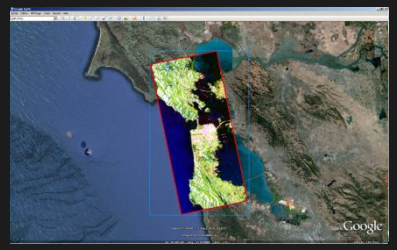


FUTURE

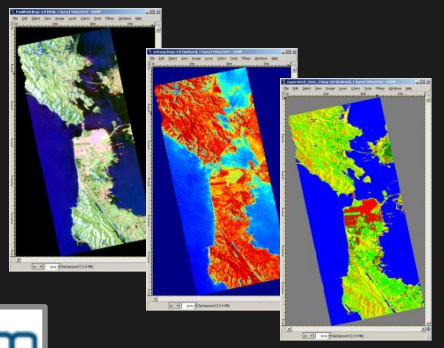
Tandem-L

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

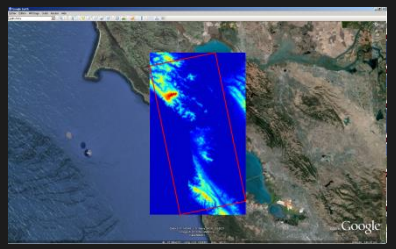
External Softwares

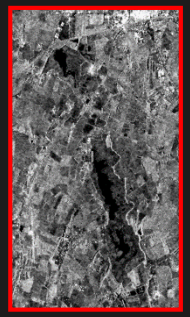


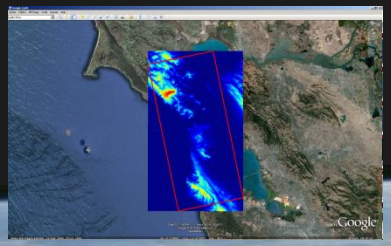
Google Earth



satim







ASTER

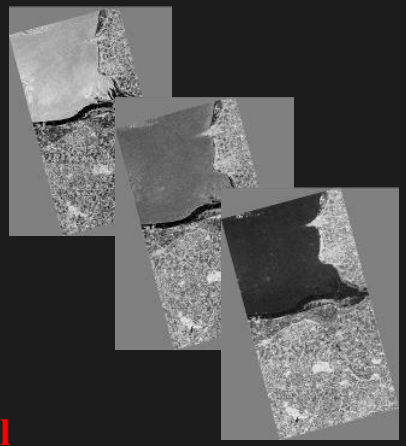
ESA - SNAP

Pre-Processing
Data Extract

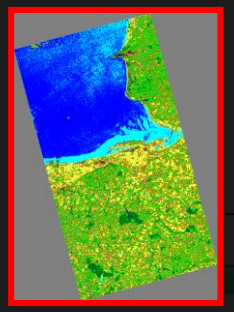
Geo-Coding
Terrain Correct - UTM Proj.

Post - Processing

POLARIMETRIC DATA SETS



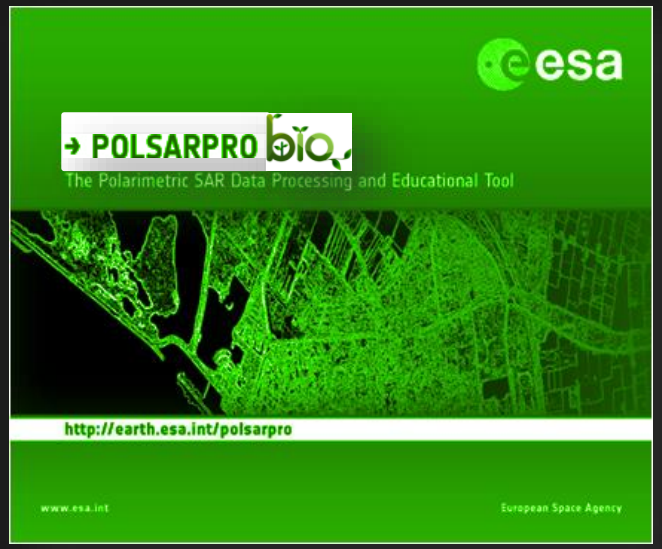
Only valid for:
[C2] matrix: Dual-Pol
[T3] matrix: Quad-Pol

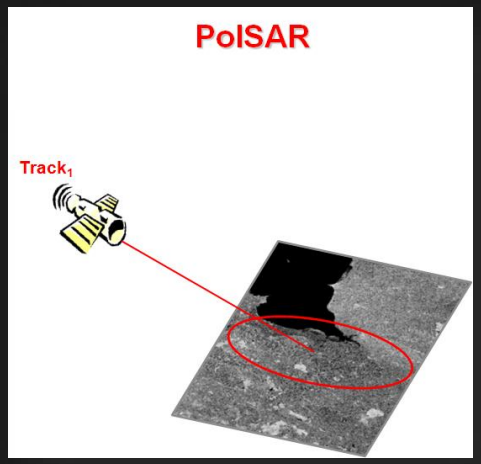


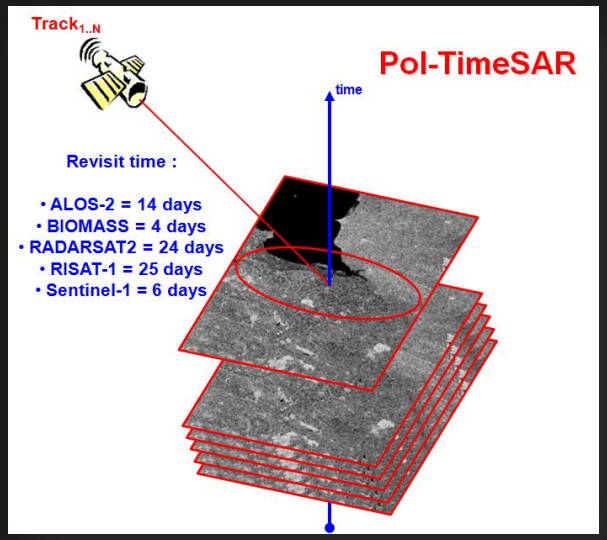
KML File generation

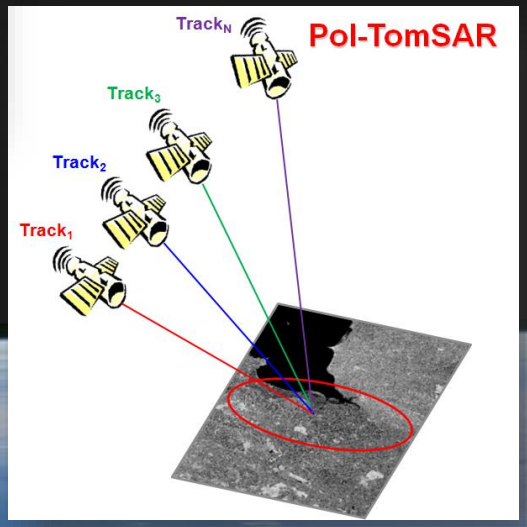
PolSARpro - Bio SOFTWARE

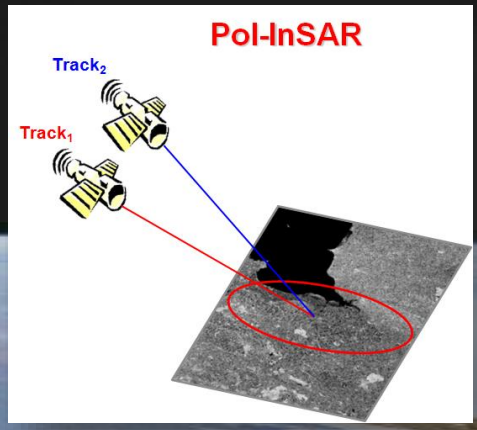
New functionalities



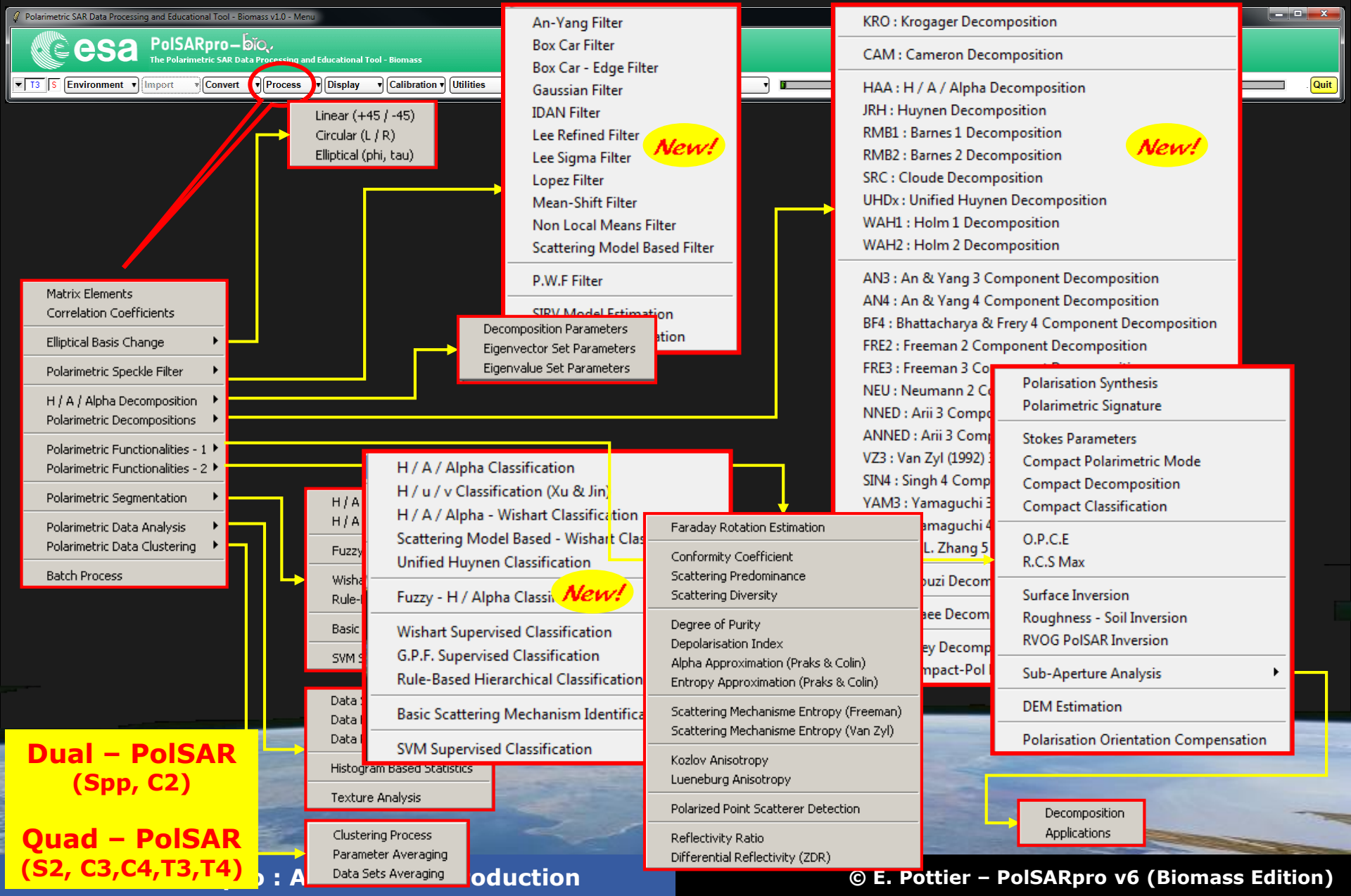






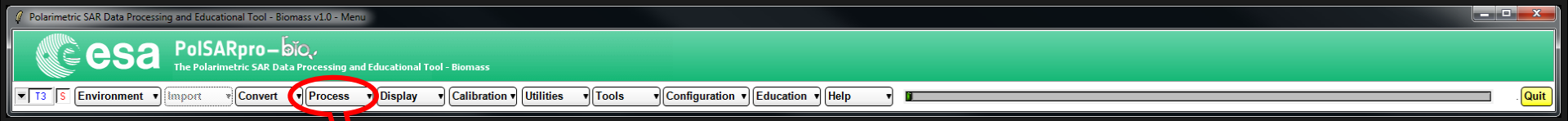


PolSARpro - Bio SOFTWARE



Dual – PolSAR (Spp, C2)

Quad – PolSAR (S2, C3,C4,T3,T4)

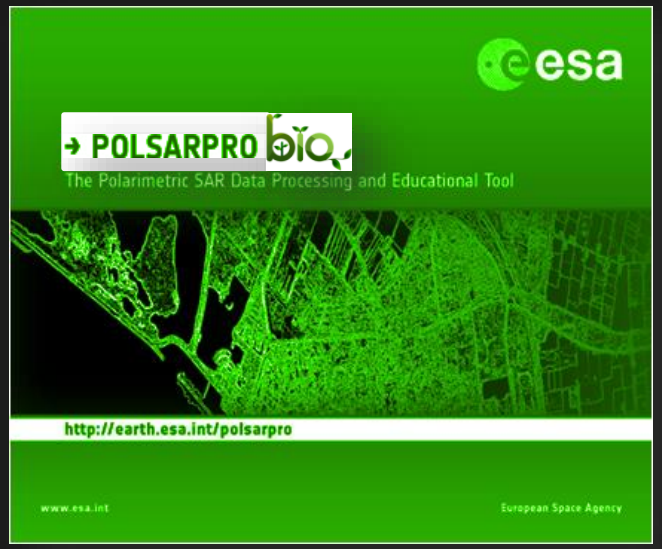


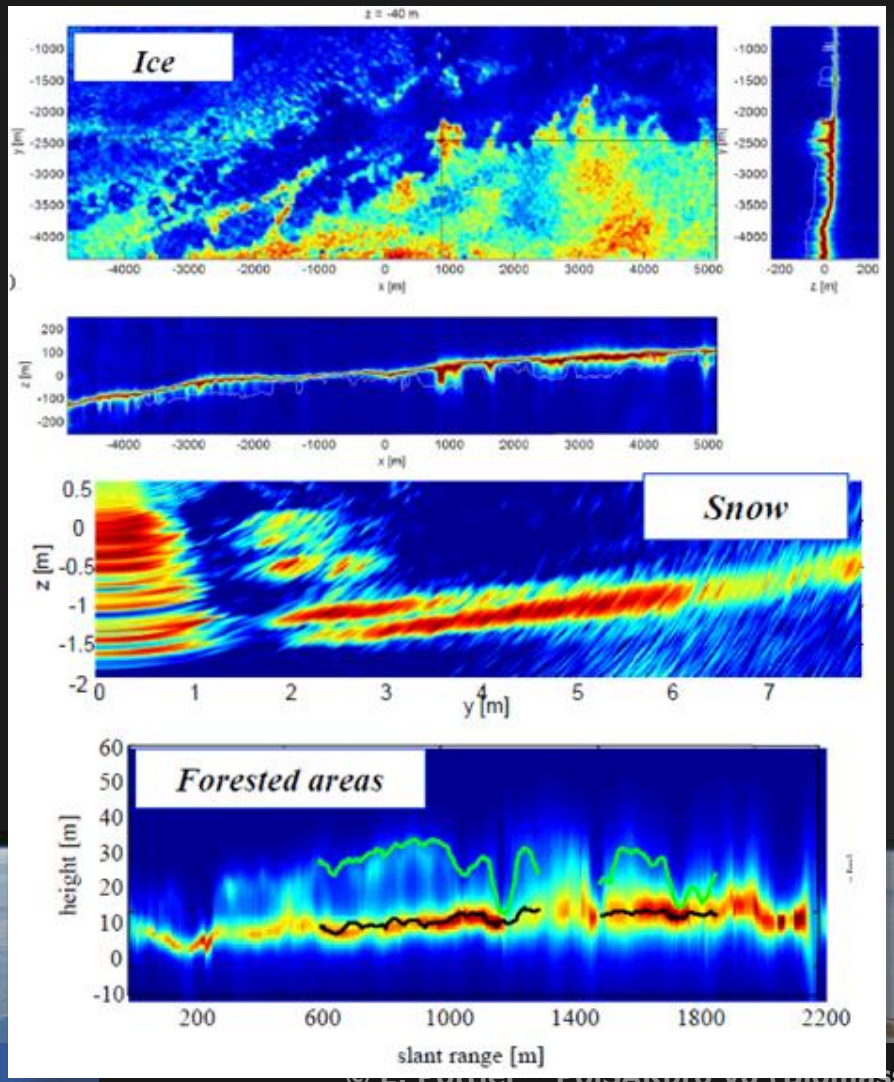
- In-SAR Functionalities
  - Coarse Co-Registration
  - Flat Earth Estimation
  - Flat Earth Removal
- Matrix Elements - Master
- Matrix Elements - Slave
- Matrix Elements - Cross
- Correlation Coefficients
- Pol-InSAR Speckle Filter
  - Box Car Filter
  - Gaussian Filter
  - Lee Refined Filter
- Pol-InSAR Segmentation
  - PolSAR Segmentation
  - Wishart Supervised Classification
  - Wishart Unsupervised Classification
- Pol-InSAR Functionalities - 1
  - Interferogram
  - Coherence Estimation
  - Coherence Analysis
    - Complex Plane
    - Coherence Region - Optimum Triplet
- Pol-InSAR Functionalities - 2
  - Forest Height Inversion Procedures
  - Vegetation Height Estimation
  - Polarization Coherence Tomography (PCT)
- Polarimetric Data Analysis
  - Data Histograms
  - Data Profiles
  - Histogram Based Statistics
  - Texture Analysis
  - Edge Detector
  - Change Detector

Polarimetry + Interferometry

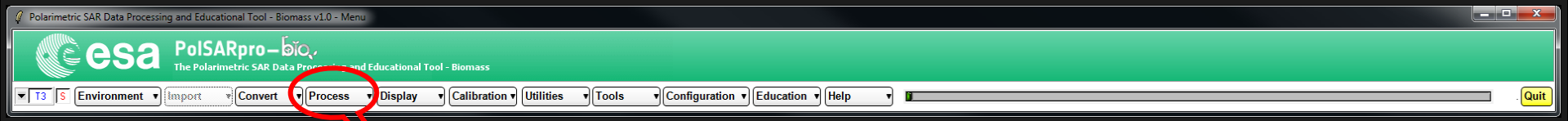
Pol-InSAR

Pol-TomoSAR processor





PolSARpro - Bio SOFTWARE



- Coarse Co-Registration
- Matrix Elements
- Polarimetric Speckle Filter
  - Box Car Filter
  - C. Lopez Filter
  - Gaussian Filter
  - IDAN Filter
  - J.S. Lee Refined Filter
  - J.S. Lee Sigma Filter
- H / A / Alpha Decomposition
  - Decomposition Parameters
  - Eigenvector Set Parameters
  - Eigenvalue Set Parameters
- Polarimetric Segmentation
  - H / A / Alpha Classification
  - H / A / Alpha - Wishart Classification
  - Wishart Supervised Classification
- Polarimetric Functionalities
  - Faraday Rotation Estimation
  - Conformity Coefficient
  - Scattering Predominance
  - Scattering Diversity
  - Degree of Purity
  - Depolarisation Index
  - Alpha Approximation (Praks & Colin)
  - Entropy Approximation (Praks & Colin)
  - Scattering Mechanisme Entropy (Freeman)
  - Scattering Mechanisme Entropy (Van Zyl)
  - Kozlov Anisotropy
  - Lueneburg Anisotropy
  - Polarized Point Scatterer Detection
  - Reflectivity Ratio
  - Differential Reflectivity (ZDR)
- Polarimetric Tomography
- Multi-Datasets Analysis
  - Avg / Std / CV
  - Time / Freq Averaging
  - Animated GIF

New!

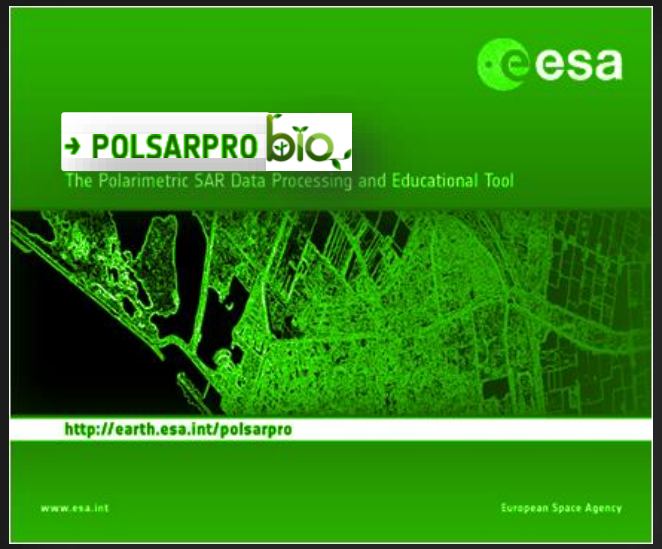
Polarimetry + Time series

Pol-TimeSAR

Polarimetry + Tomography

Pol-TomoSAR

SARSIM / SARSIM+ Data Bases

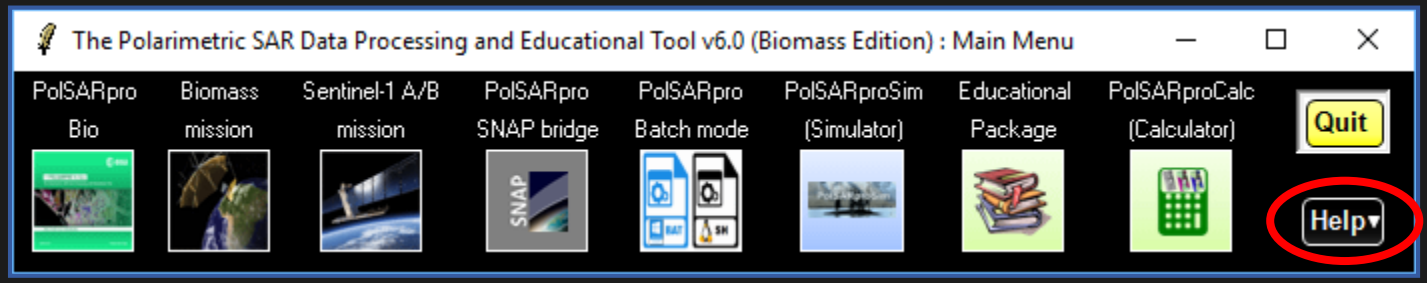


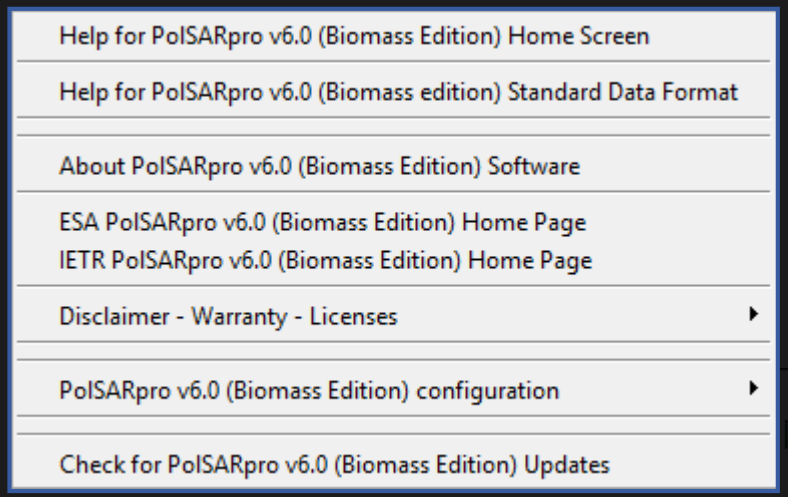
ESA study : L- and P-band SAR Tomography Synergies Consolidation Study

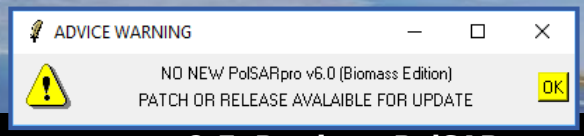
Goal : ***Build a reference dataset for current and future researches on the application of SAR Tomography for the RS of boreal, temperate and tropical forests at P- and L-Band.***

Includes : ***Stack of SLC SAR images (coregistered, phase calibrated and flattened) + ancillary data (kz maps, DTM …) – ESA campains (afrisar, biosar)***

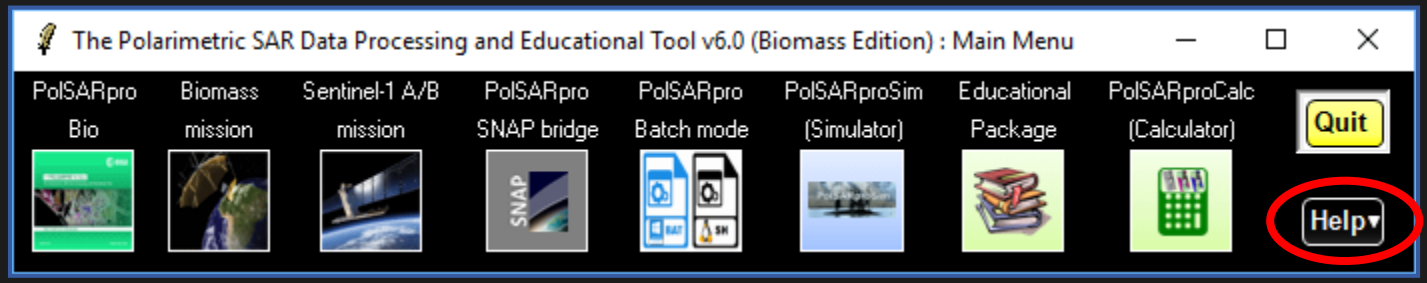
PolSARpro - Biomass Edition

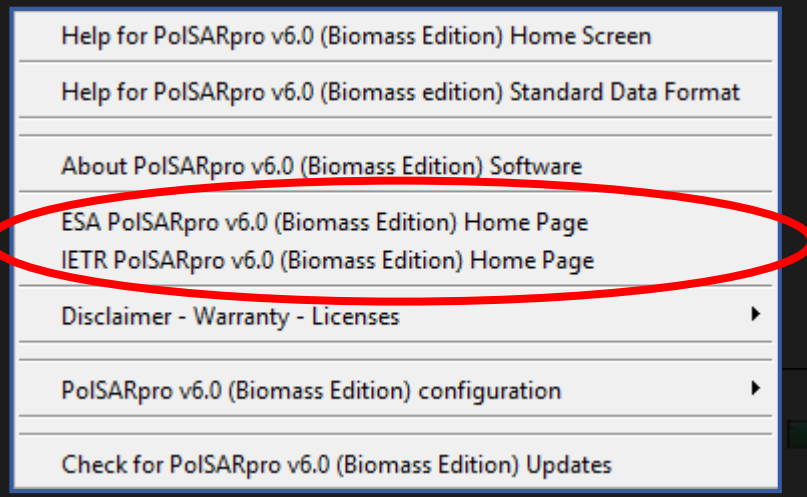


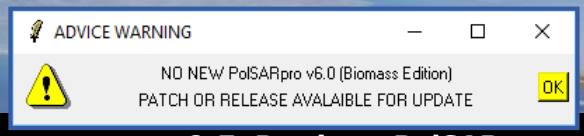


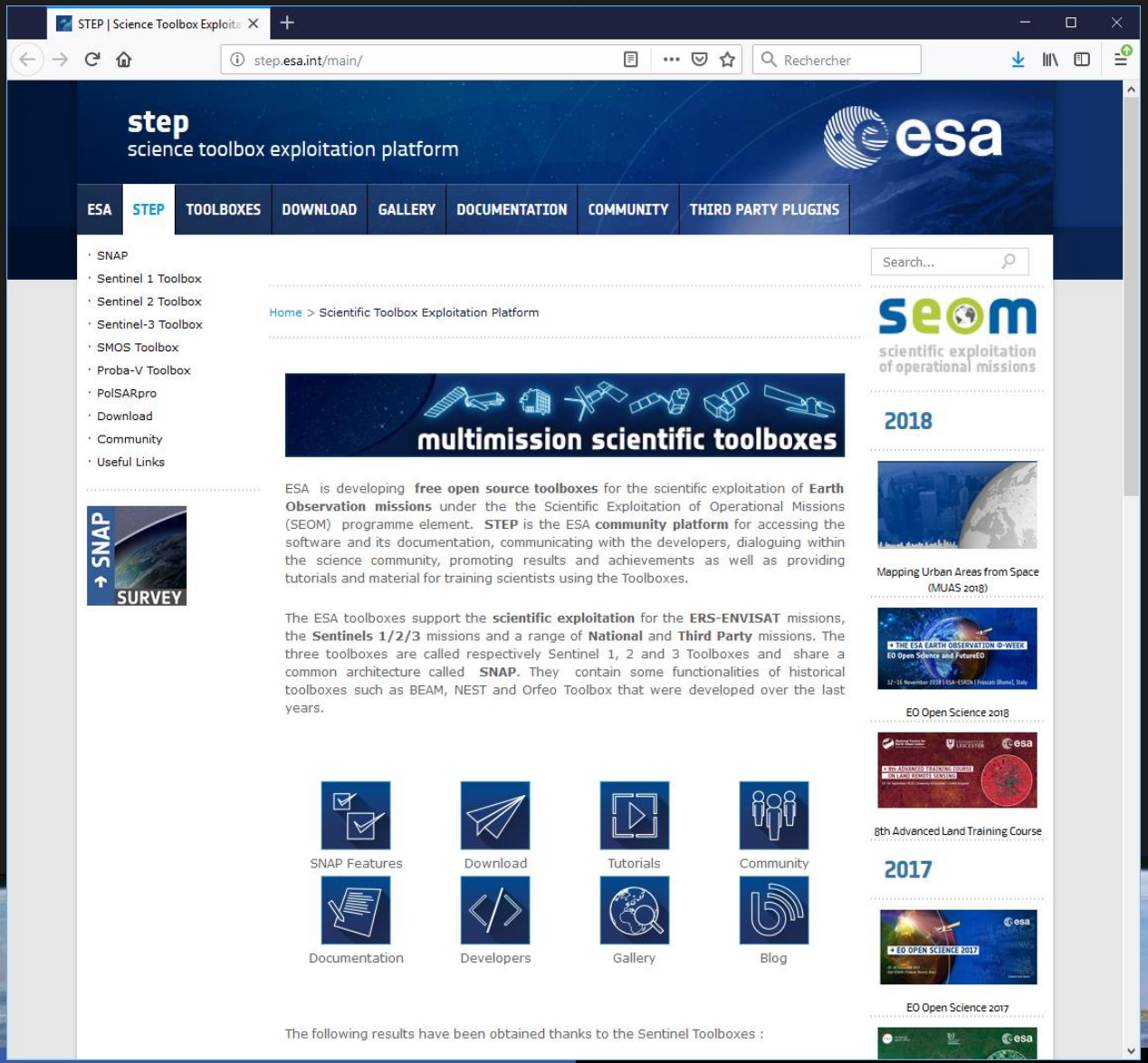


PolSARpro - Biomass Edition

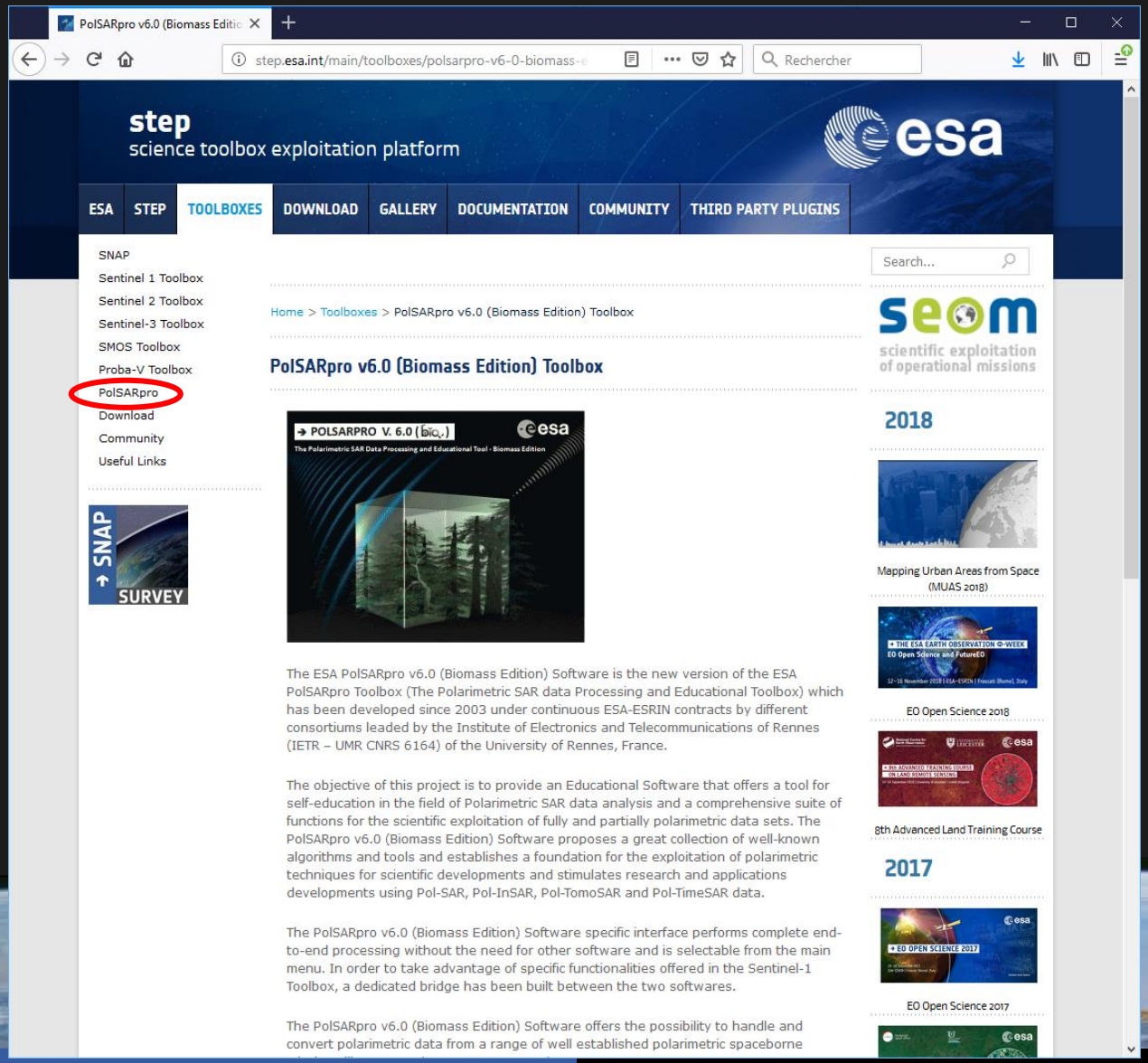




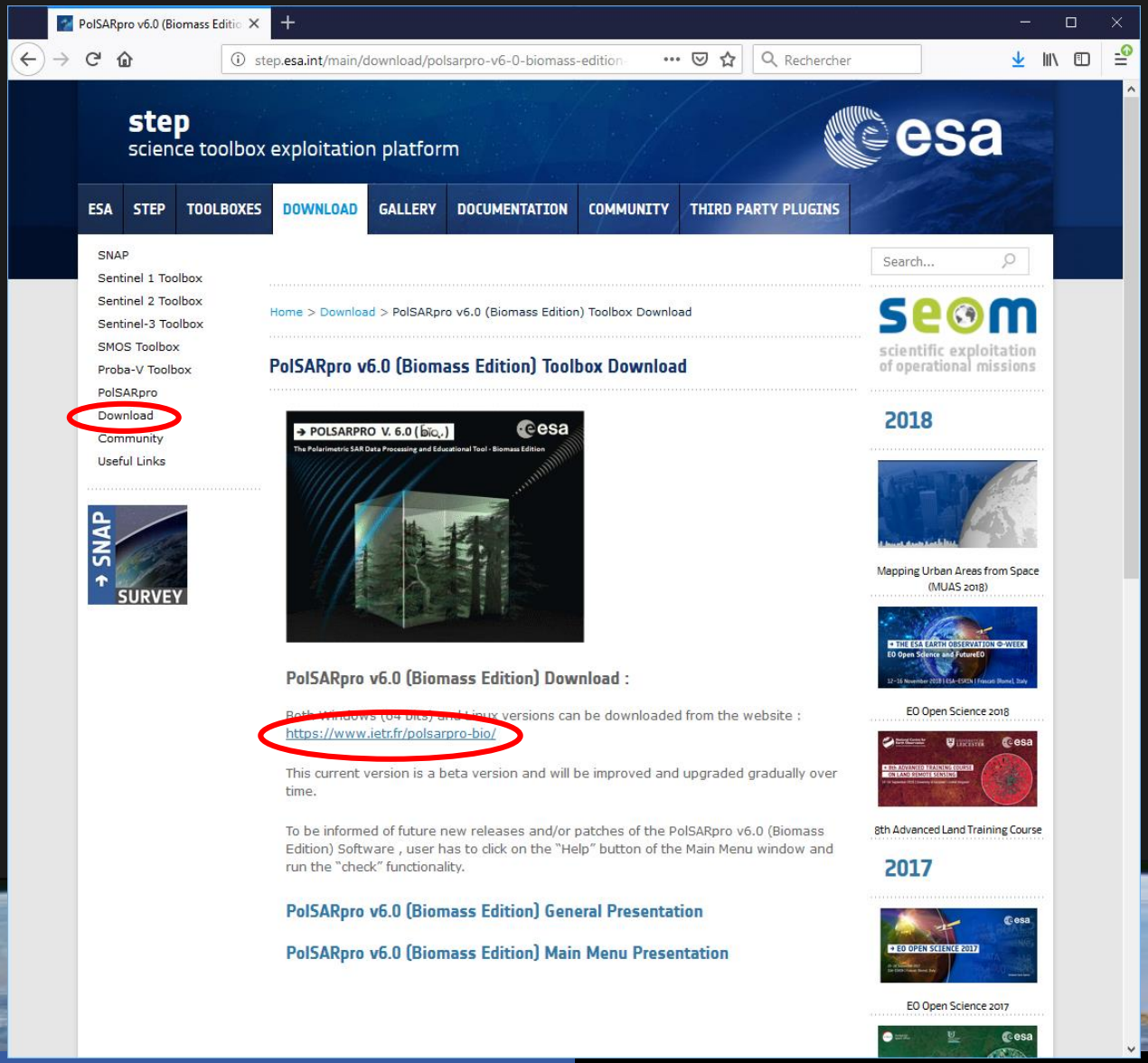



STEP | Science Toolbox Exploita
step.esa.int/main/
Rechercher
step
science toolbox exploitation platform
esa
ESA
STEP
TOOLBOXES
DOWNLOAD
GALLERY
DOCUMENTATION
COMMUNITY
THIRD PARTY PLUGINS
SNAP
Sentinel 1 Toolbox
Sentinel 2 Toolbox
Sentinel-3 Toolbox
SMOS Toolbox
Proba-V Toolbox
PolSARpro
Download
Community
Useful Links
SNAP SURVEY
Search...
Home > Scientific Toolbox Exploitation Platform
multimission scientific toolboxes
ESA is developing free open source toolboxes for the scientific exploitation of Earth Observation missions under the the Scientific Exploitation of Operational Missions (SEOM) programme element. STEP is the ESA community platform for accessing the software and its documentation, communicating with the developers, dialoguing within the science community, promoting results and achievements as well as providing tutorials and material for training scientists using the Toolboxes.
The ESA toolboxes support the scientific exploitation for the ERS-ENVISAT missions, the Sentinels 1/2/3 missions and a range of National and Third Party missions. The three toolboxes are called respectively Sentinel 1, 2 and 3 Toolboxes and share a common architecture called SNAP. They contain some functionalities of historical toolboxes such as BEAM, NEST and Orfeo Toolbox that were developed over the last years.
SNAP Features
Download
Tutorials
Community
Documentation
Developers
Gallery
Blog
The following results have been obtained thanks to the Sentinel Toolboxes :
seom
scientific exploitation of operational missions
2018
Mapping Urban Areas from Space (MUAS 2018)
EO Open Science 2018
8th Advanced Land Training Course
2017
EO Open Science 2017

PolSARpro - Bio SOFTWARE



PolSARpro - Bio SOFTWARE



PolSARpro v6.0 (Biomass Edition)

https://www.ietr.fr/polsarpro-bio/

ESA PolSARpro v6.0 (Biomass Edition) Software

Version 6.0.1 released (2019/04/01)

The **ESA PolSARpro v6.0 (Biomass Edition) Software** is the new version of the **ESA PolSARpro Toolbox** (*The Polarimetric SAR data Processing and Educational Toolbox*) which has been developed since 2003 under different ESA-ESRIN contracts.

Download Windows 64 bits Version (*Read-me first*)

Download Linux Version (*Read-me first*)

License | Legal | Credits

Visit the PolSARpro v6.0 (Biomass Edition) FORUM at the ESA STEP website

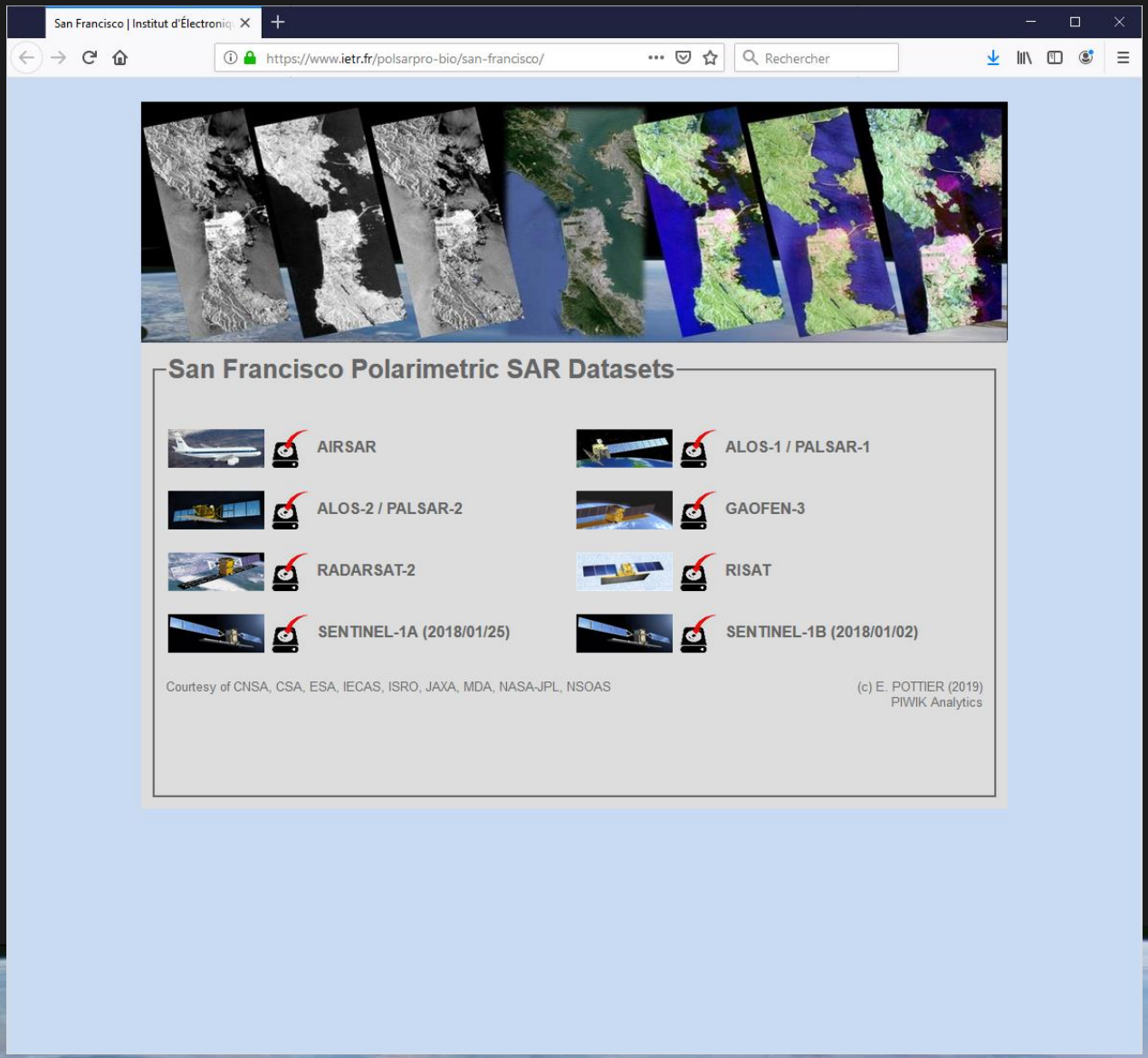
For any help / request / comment, please contact : *polsarpro.team@yahoo.com*

(c) E. Pottier (2019)
PIWIK Analytics

Do not to forget to visit the GaoFen-3 (GF-3) and the San Francisco webpages.

https://www.ietr.fr/polsarpro-bio/

polsarpro.team@yahoo.com



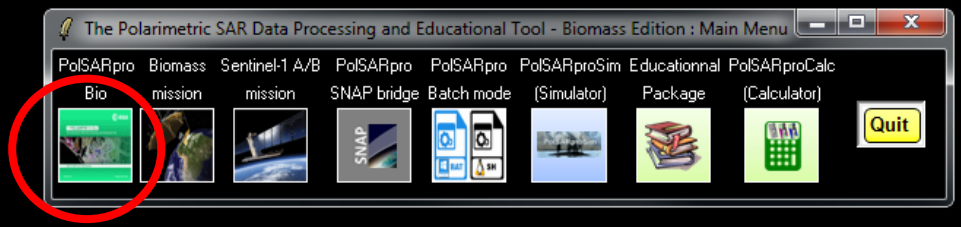
https://www.ietr.fr/polsarpro-bio/san-francisco

Questions ?

PolSARpro - Bio SOFTWARE

ENTRY SCREEN

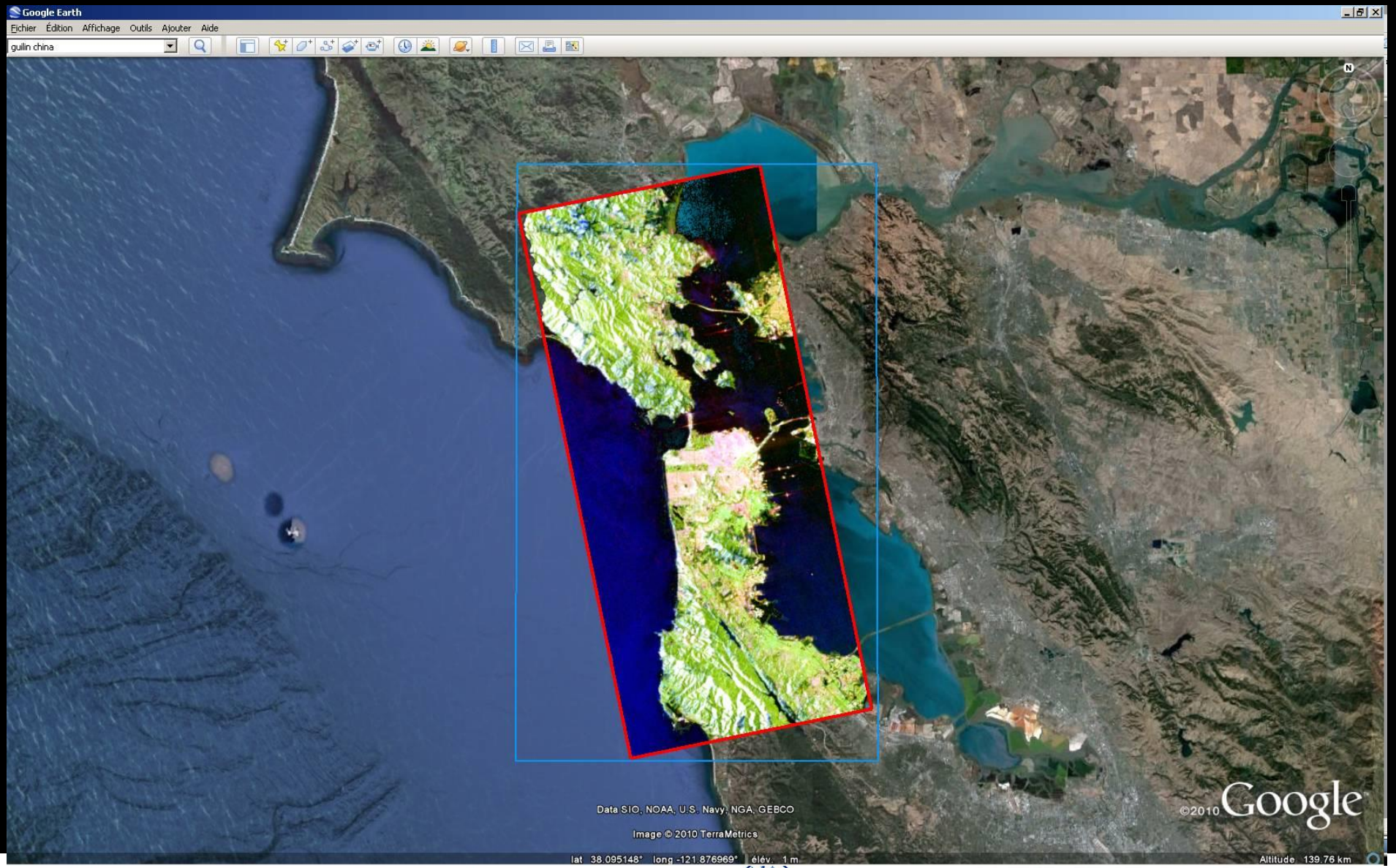
MAIN WINDOW



DATA SETS

ALOS : Advanced Land Observing Satellite
PALSAR : Phase Array L-Band SAR

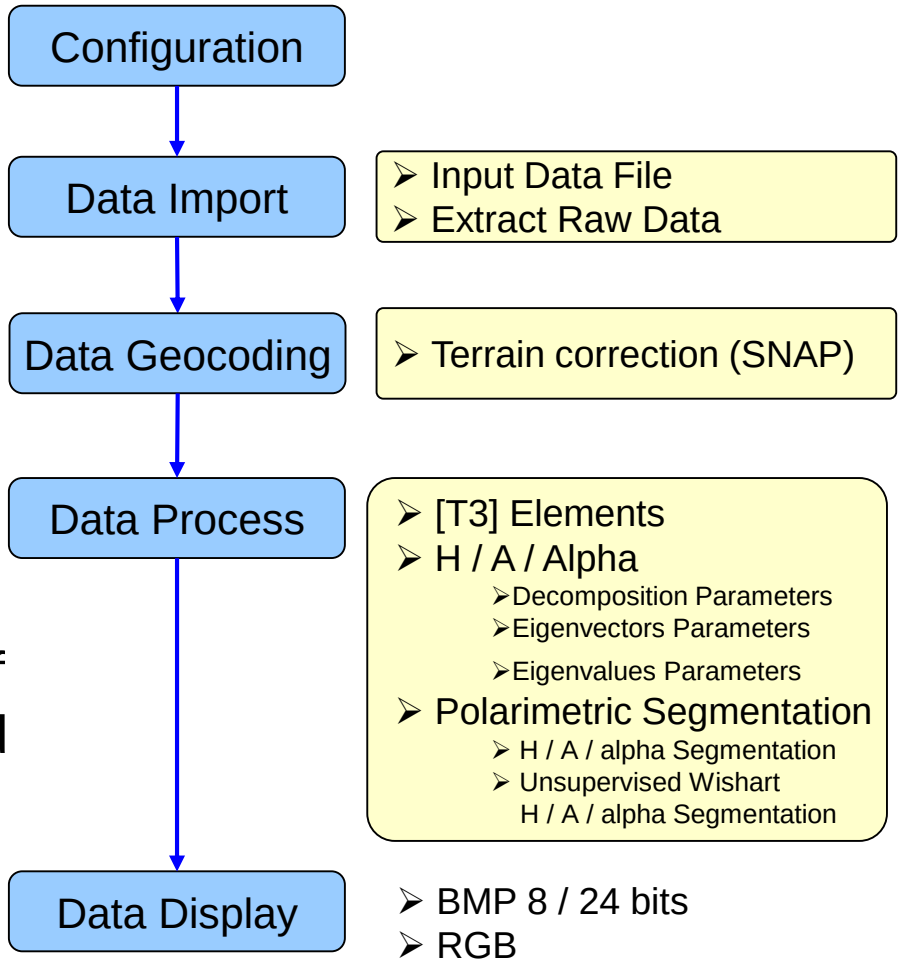
DATA SETS


Google Earth
Fichier Édition Affichage Outils Ajouter Aide
guilin china
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2010 TerraMetrics
©2010 Google
lat 38.095148° long -121.876969° élév. 1 m
Altitude 139.76 km

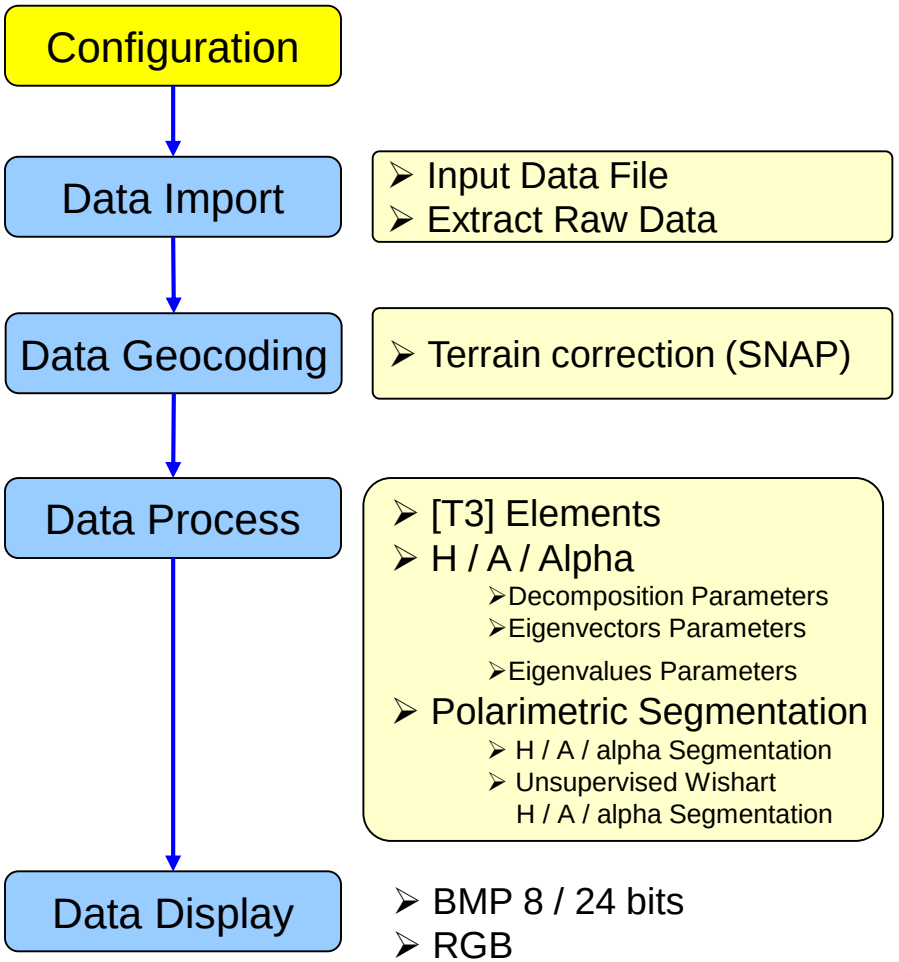
PolSARpro - Bio Software performs complete end-to-end processing without the need for any other software.

Data Processing Approach along a '**recommended**' and easy processing chain

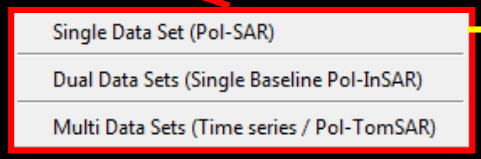
Provide a **First Qualitative Analysis** of the fully polarimetric data set processed



PROCESSING CHAIN



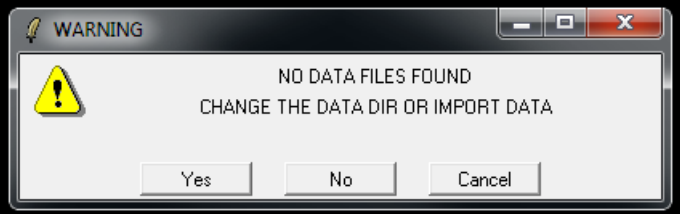
PolSARpro - Bio SOFTWARE



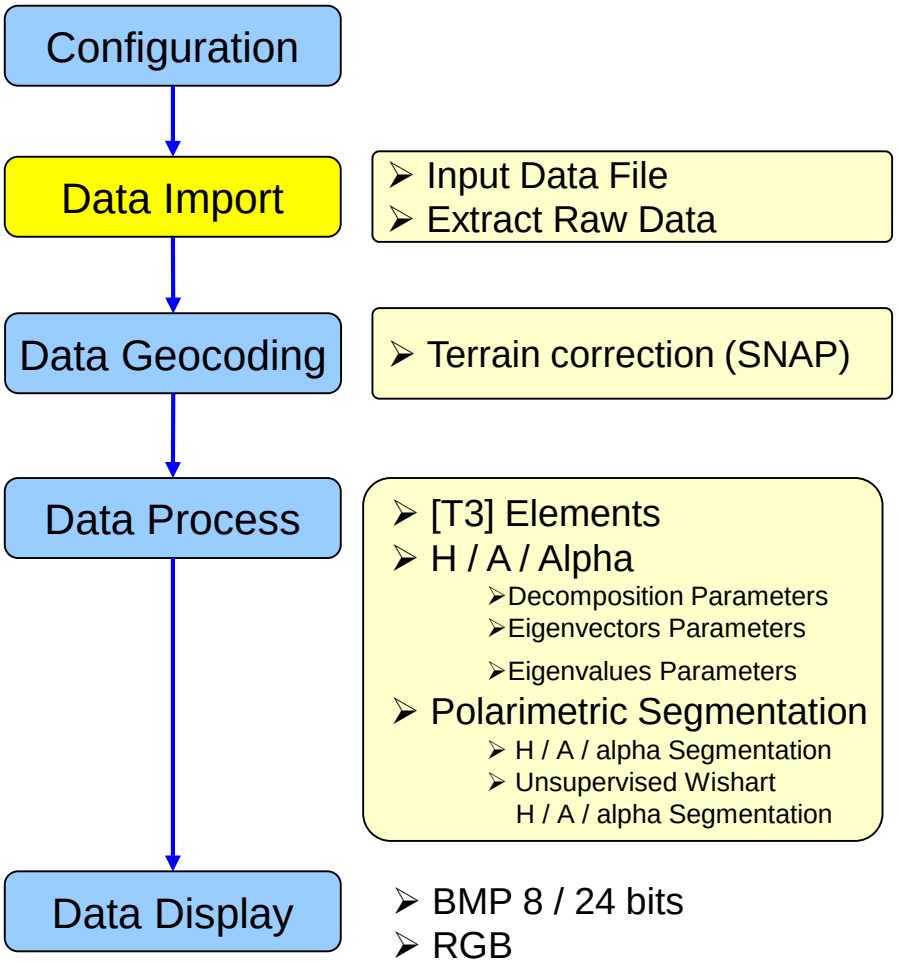
Configure Data Main Directory location

Input Data Directory :

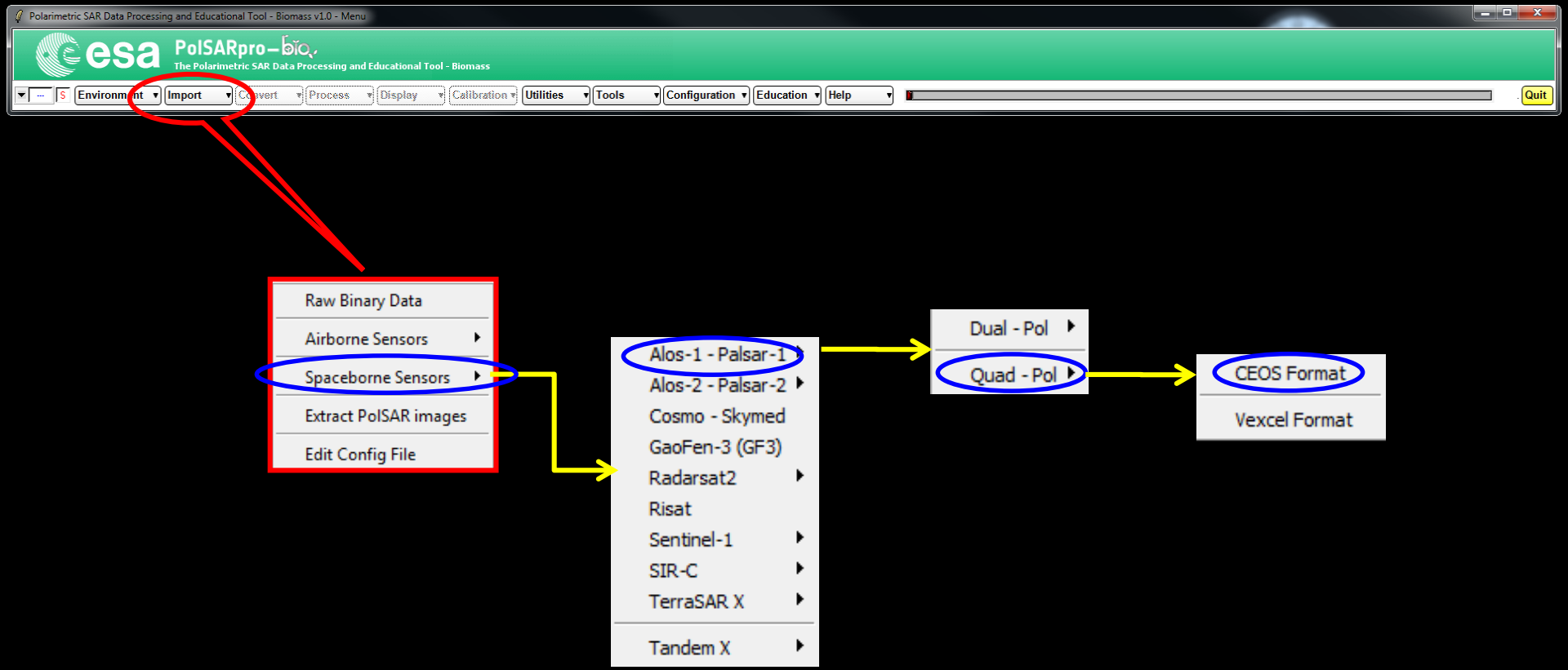
C:/ … / SAN_FRANCISCO_ALOS-1



PROCESSING CHAIN



PolSARpro - Bio SOFTWARE



Data IMPORT – Input Data Fi

Polarimetric SAR Data Processing and Educational Tool - Biomass v1.0 - Menu

PolSARpro–bio
The Polarimetric SAR Data Processing and Educational Tool - Biomass

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

ALOS Input Data File (JAXA - CEOS Format)

Input Directory
D:/SAN_FRANCISCO_ALOS

Output Directory
D:/SAN_FRANCISCO_ALOS

SAR Leader File (LED-xxxxxxxxxxxx-xx.x__x)
D:/SAN_FRANCISCO_ALOS/LED-ALPSRP202350750-P1.1__A

Check Files

Scene ID: ALPSRP202350750 Mode: Quad Pol Mode
Data Level: 1.1 Node: Ascending Projection Map:

SAR Trailer File
D:/SAN_FRANCISCO_ALOS/TRL-ALPSRP202350750-P1.1__A

SAR Image Files
s11
s12
s21
s22

Read Header | Edit Header | Extract Uncalibrated Raw Binary Data

Initial Number of Rows | Initial Number of Cols

OK | Cancel

ADVICE

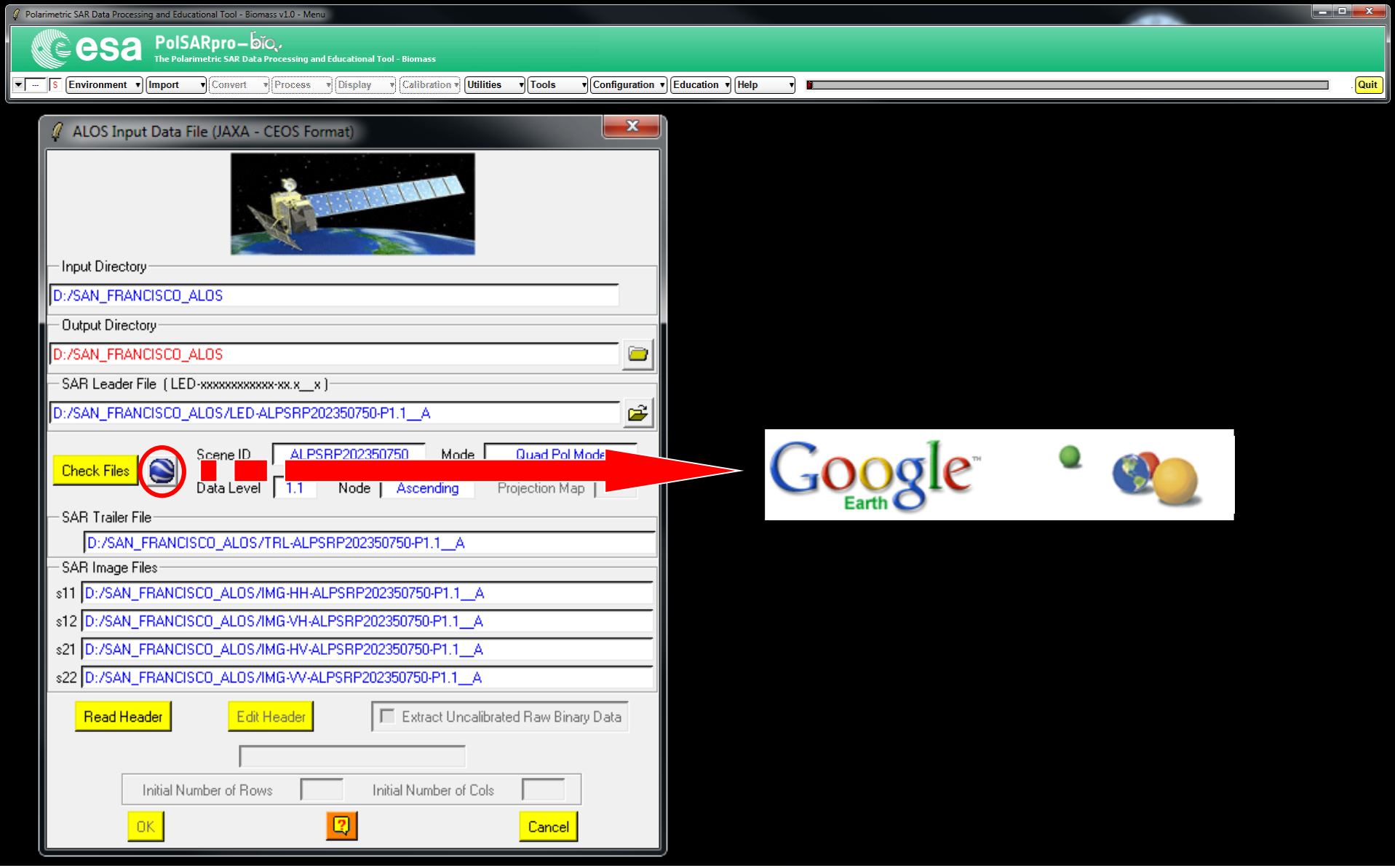
PolSARpro WILL TAKE INTO ACCOUNT THE
ALOS-PALSAR ENGINEER CONVENTION FOR THE
DEFINITION OF THE POLARIMETRIC CHANNELS
WITH : s12 = VH and s21 = HV

OK

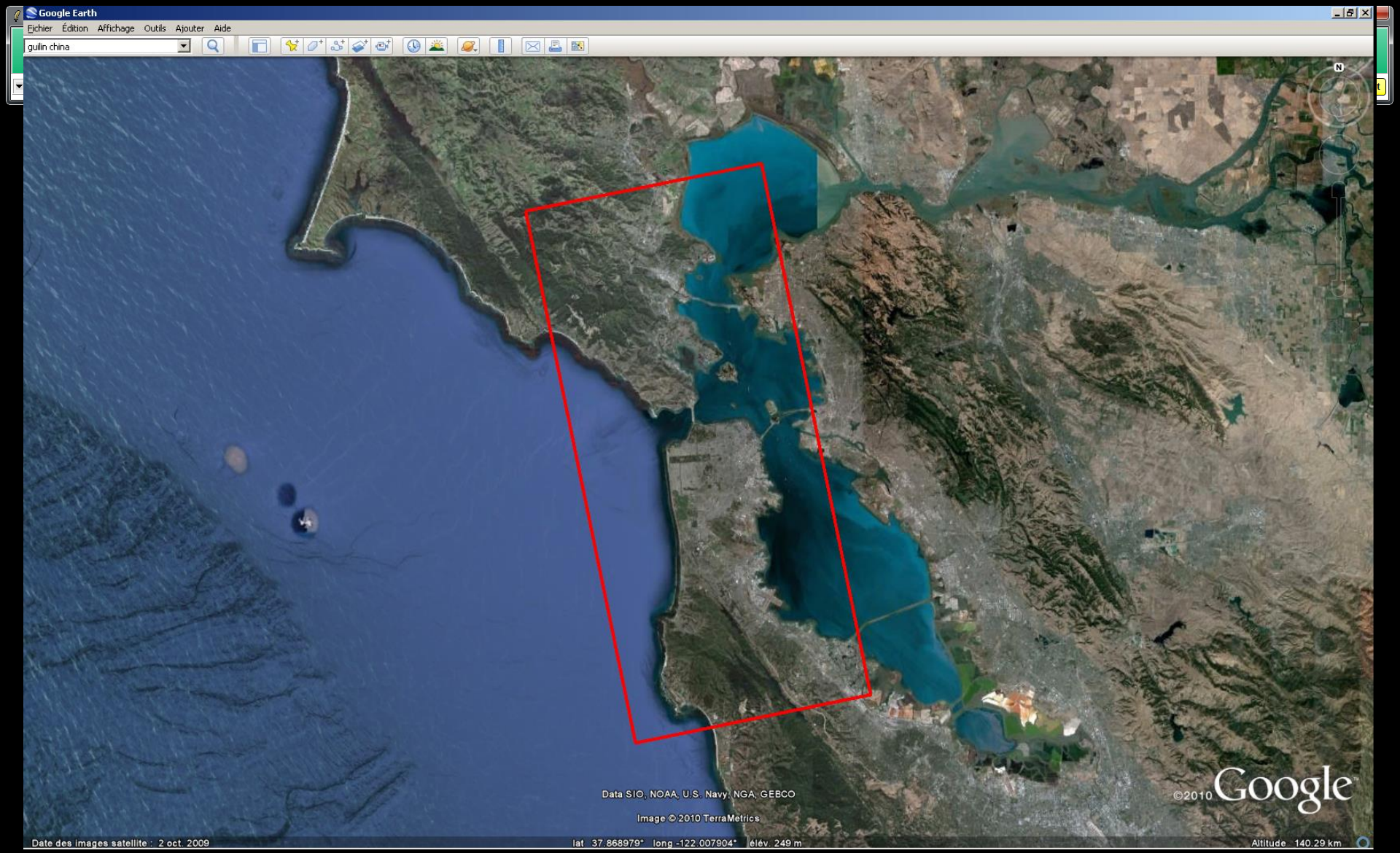
Do it Yourself:

Enter SAR Leader File
Check File

Data IMPORT – Input Data Fi



Data IMPORT – Input Data Fi

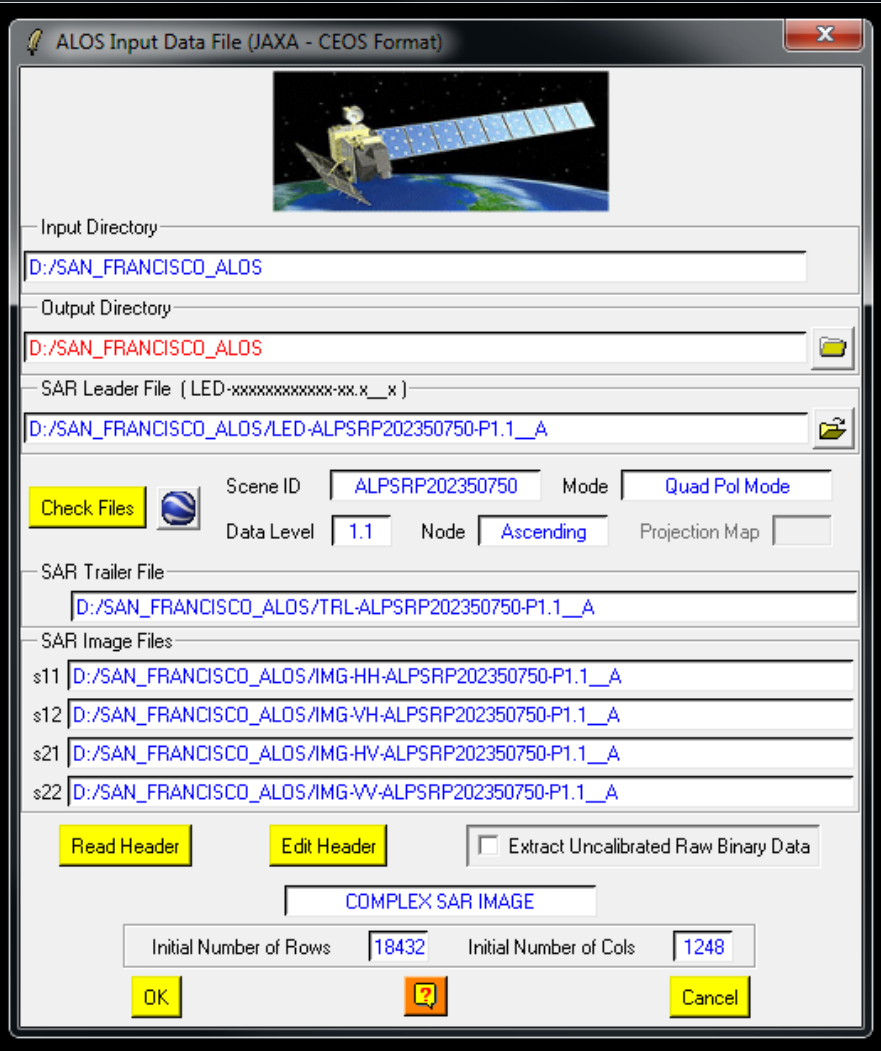


Data IMPORT – Input Data Fi

Polarimetric SAR Data Processing and Educational Tool - Biomass v1.0 - Menu

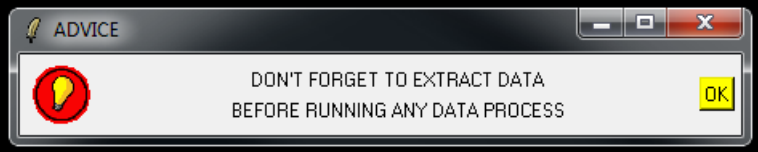
PolSARpro–bio
The Polarimetric SAR Data Processing and Educational Tool - Biomass

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

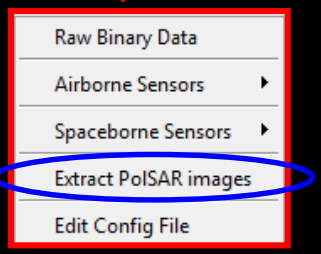


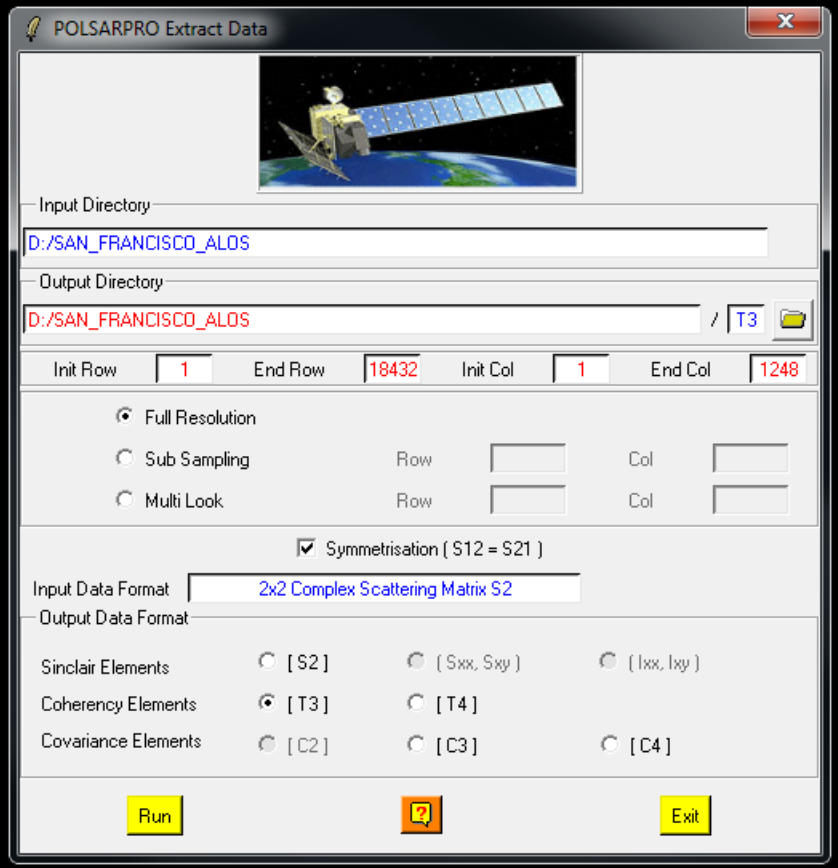
Do it Yourself:

Enter SAR Leader File
Read Header
OK



ENVIRONNEMENT

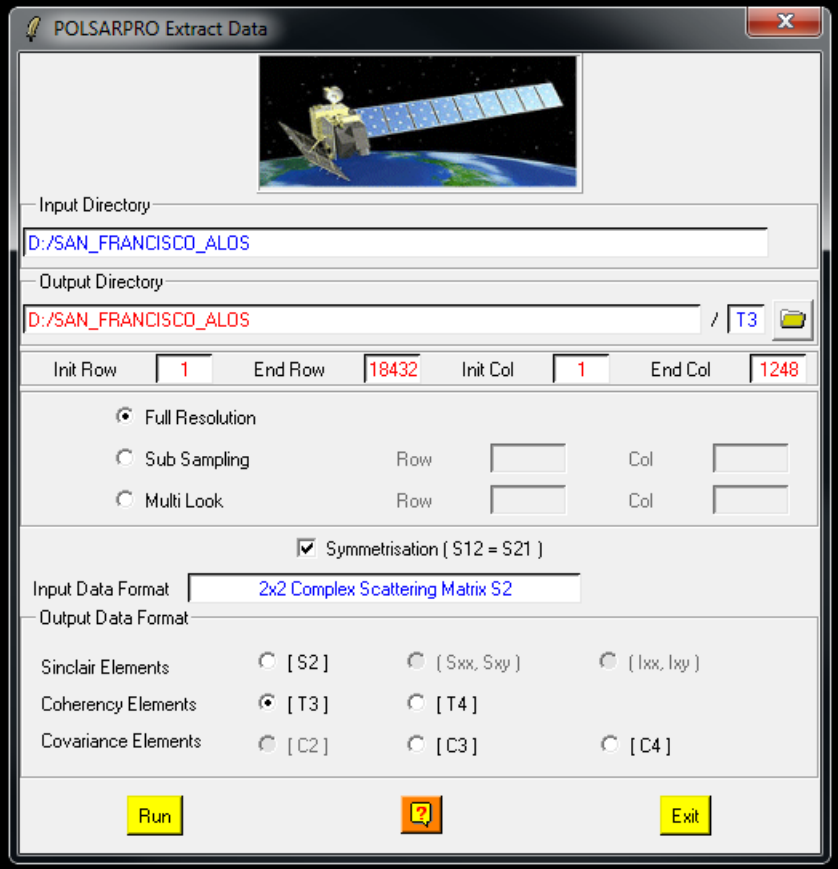




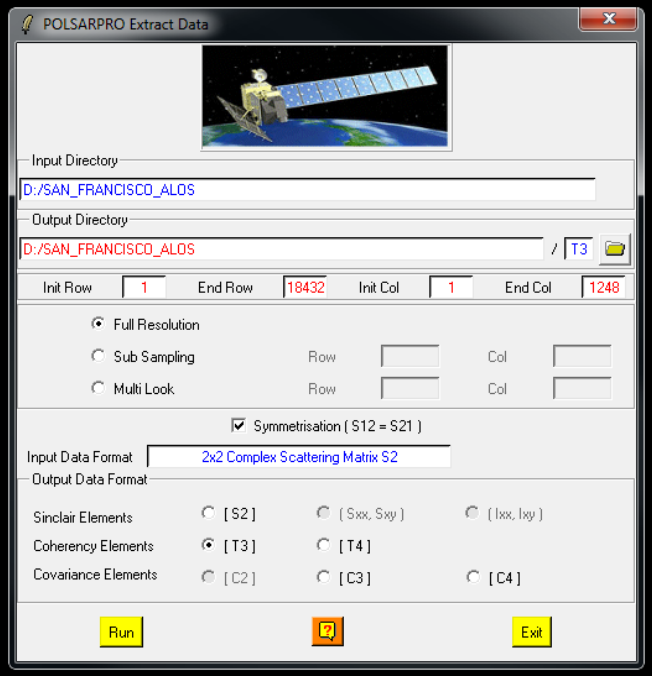
Data IMPORT – Extract Binary Data

Do it Yourself:

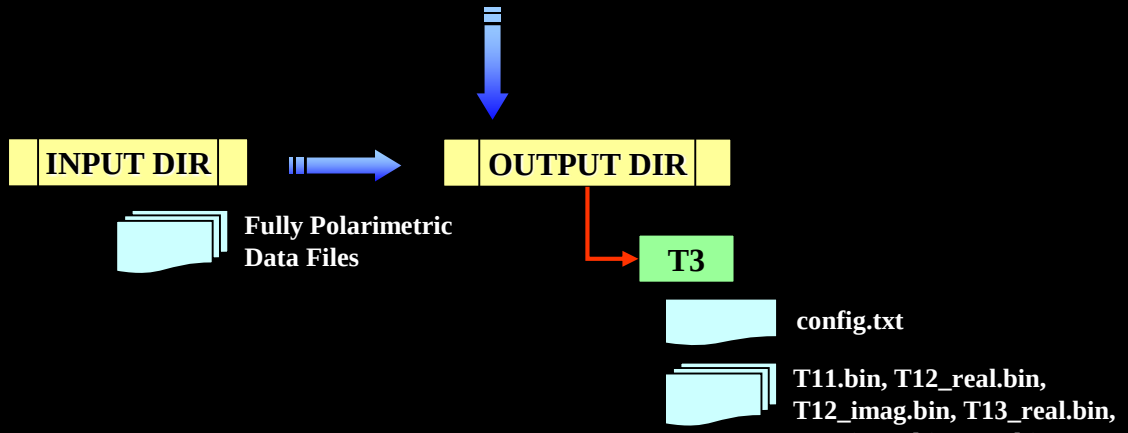
Full Resolution
Output Data Format = [T3]
Run



Data IMPORT – Extract Binary Data



Convert ALOS Fully Polarimetric Data Files to Complex (3x3) Coherency Matrix [T3]



$$\underline{k}_{3P} = \frac{1}{\sqrt{2}} \begin{bmatrix} S_{11} + S_{22} & S_{11} - S_{22} & S_{12} + S_{21} \end{bmatrix}$$

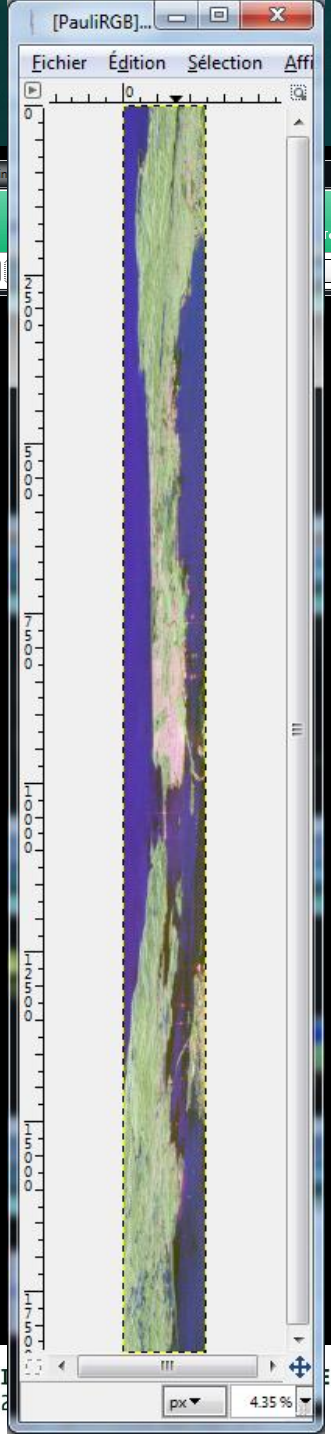
$$\Longrightarrow \quad [T_3] = \langle \underline{k}_{3P} . \underline{k}_{3P}^{\dagger} \rangle$$

$$[T_3] = \begin{bmatrix} T_{11} & T_{12} & T_{13} \\ T_{12}^{*} & T_{22} & T_{23} \\ T_{13}^{*} & T_{23}^{*} & T_{33} \end{bmatrix}$$

Do it Yourself:

Full Resolution
Output Data Format = [T3]
Run

Display Pauli-RGB Image



After multi-looking 7 x 1

ESA - SNAP

Polarimetric Data Processing

- **S1 toolbox (split, deburst, merge …)**
- **Geocoding toolbox**
- **Interferometric toolbox**
  (co-registration, flat Earth estimation …

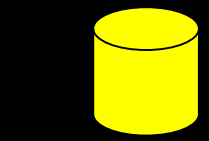
PolSARpro - Bio SOFTWARE

ESA - SNAP

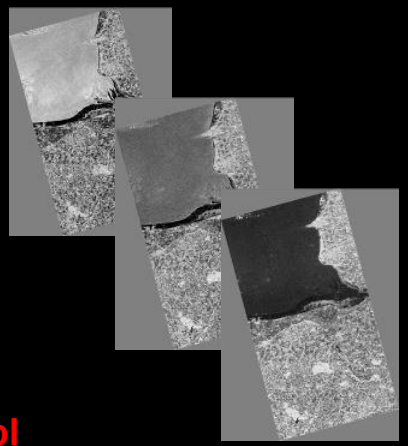
Pre-Processing
Data Extract

Geo-Coding
Terrain Correct - UTM Proj.

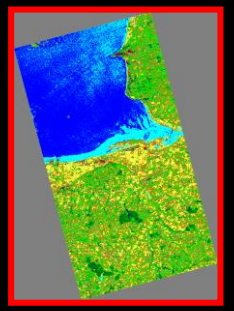
Post - Processing



POLARIMETRIC DATA SETS

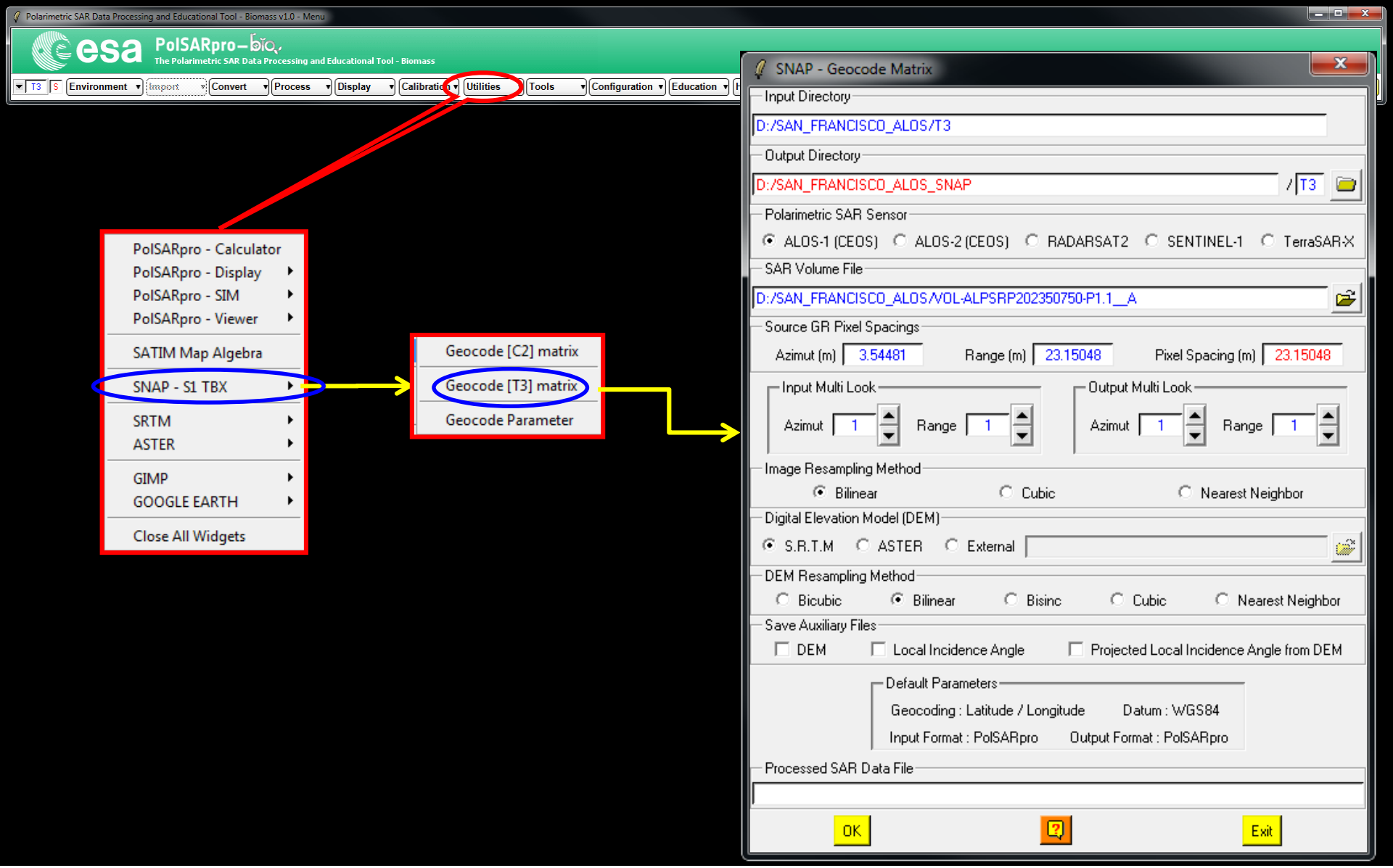


Only valid for:
[C2] matrix: Dual-Pol
[T3] matrix: Quad-Pol

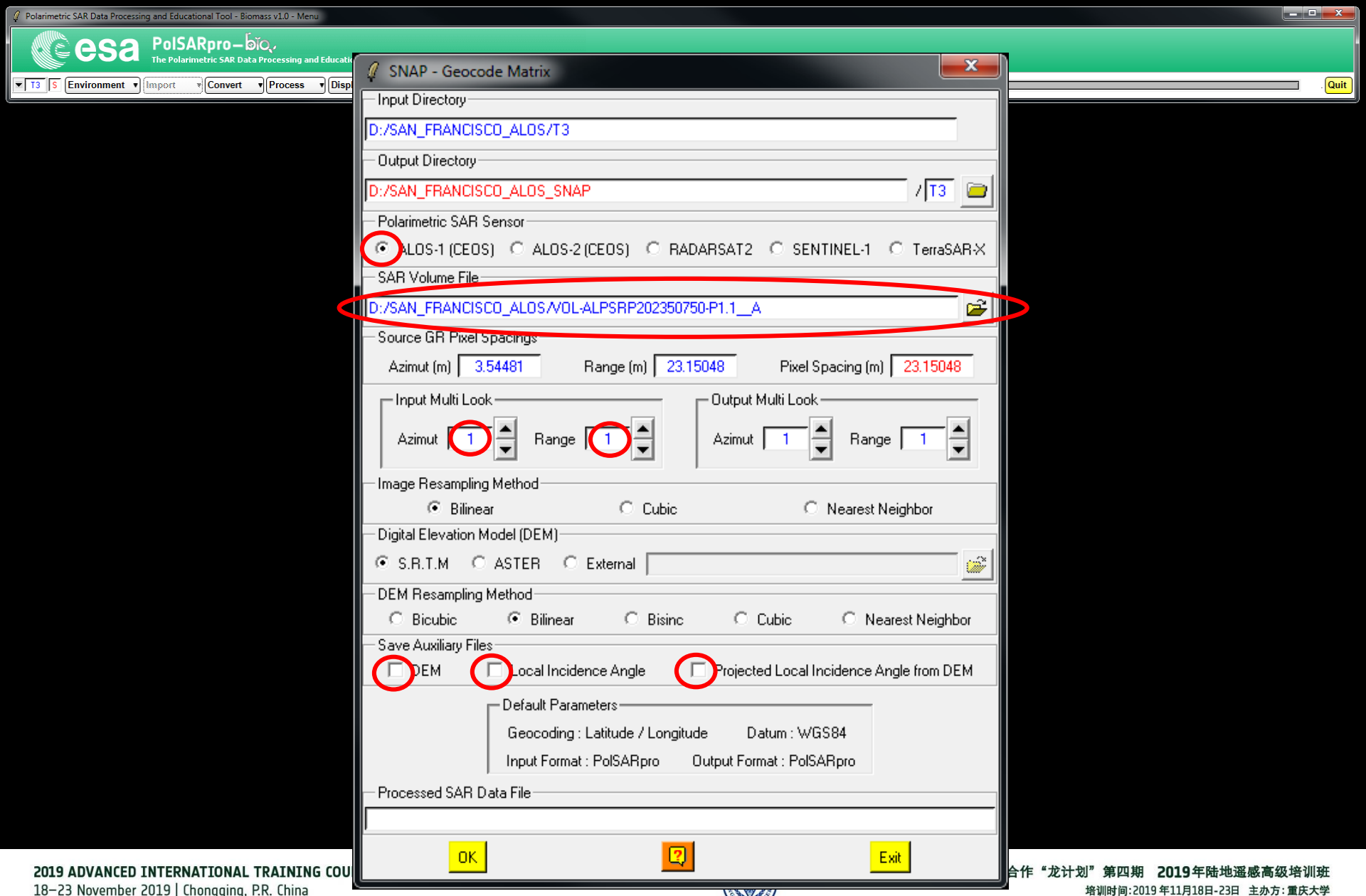


KML File generation

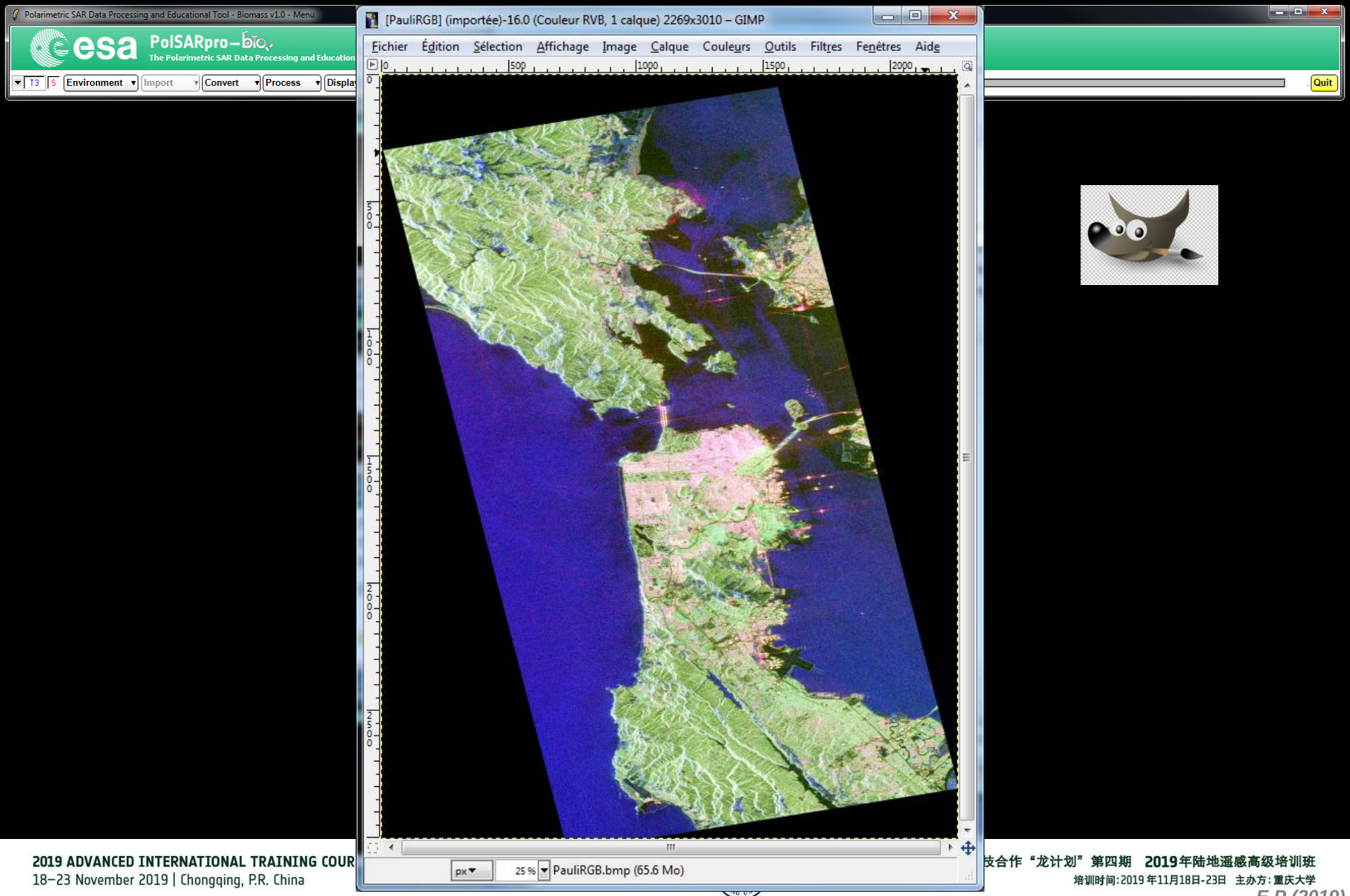
PolSARpro - Bio SOFTWARE



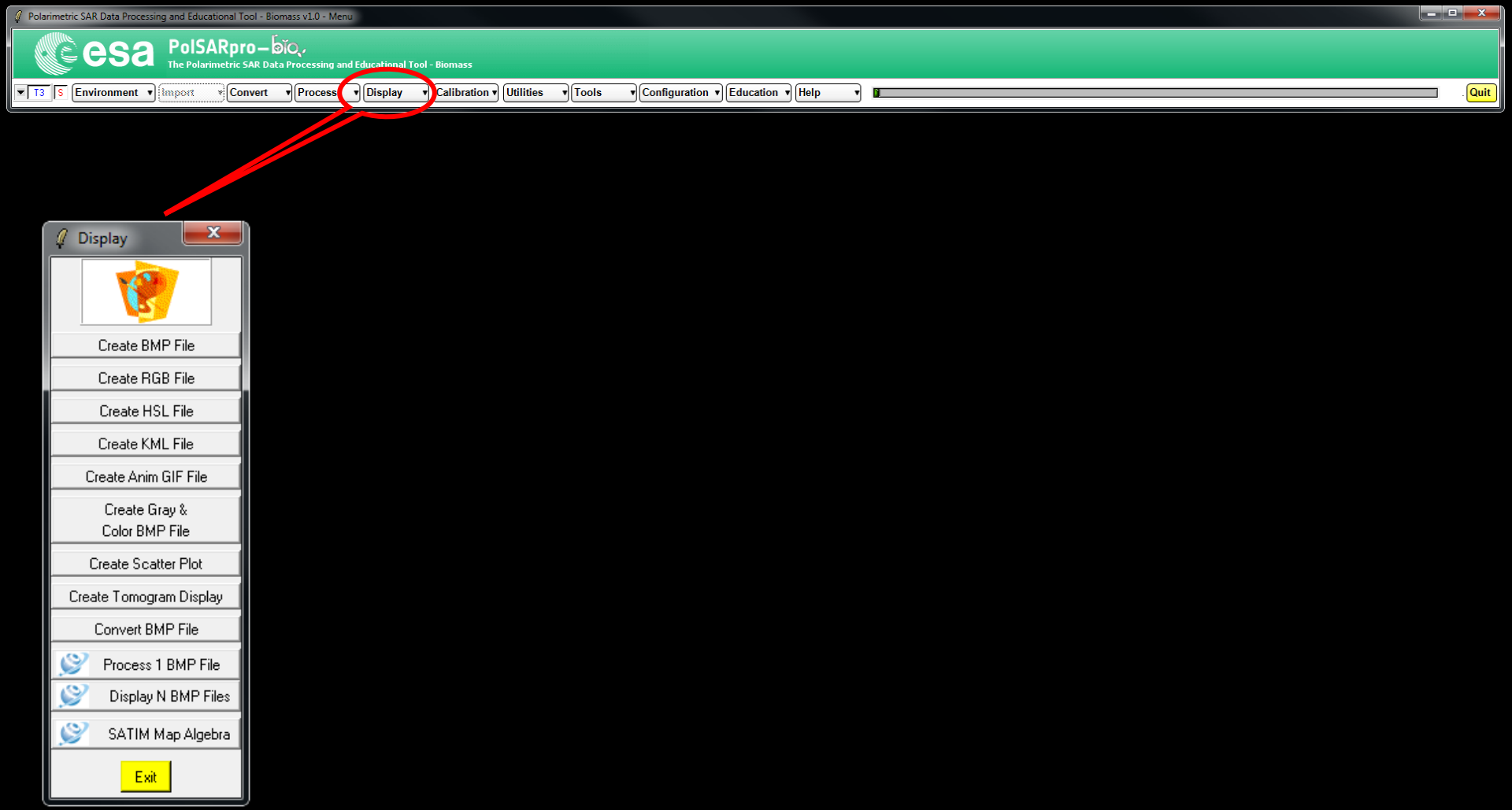
PolSARpro - Bio SOFTWARE



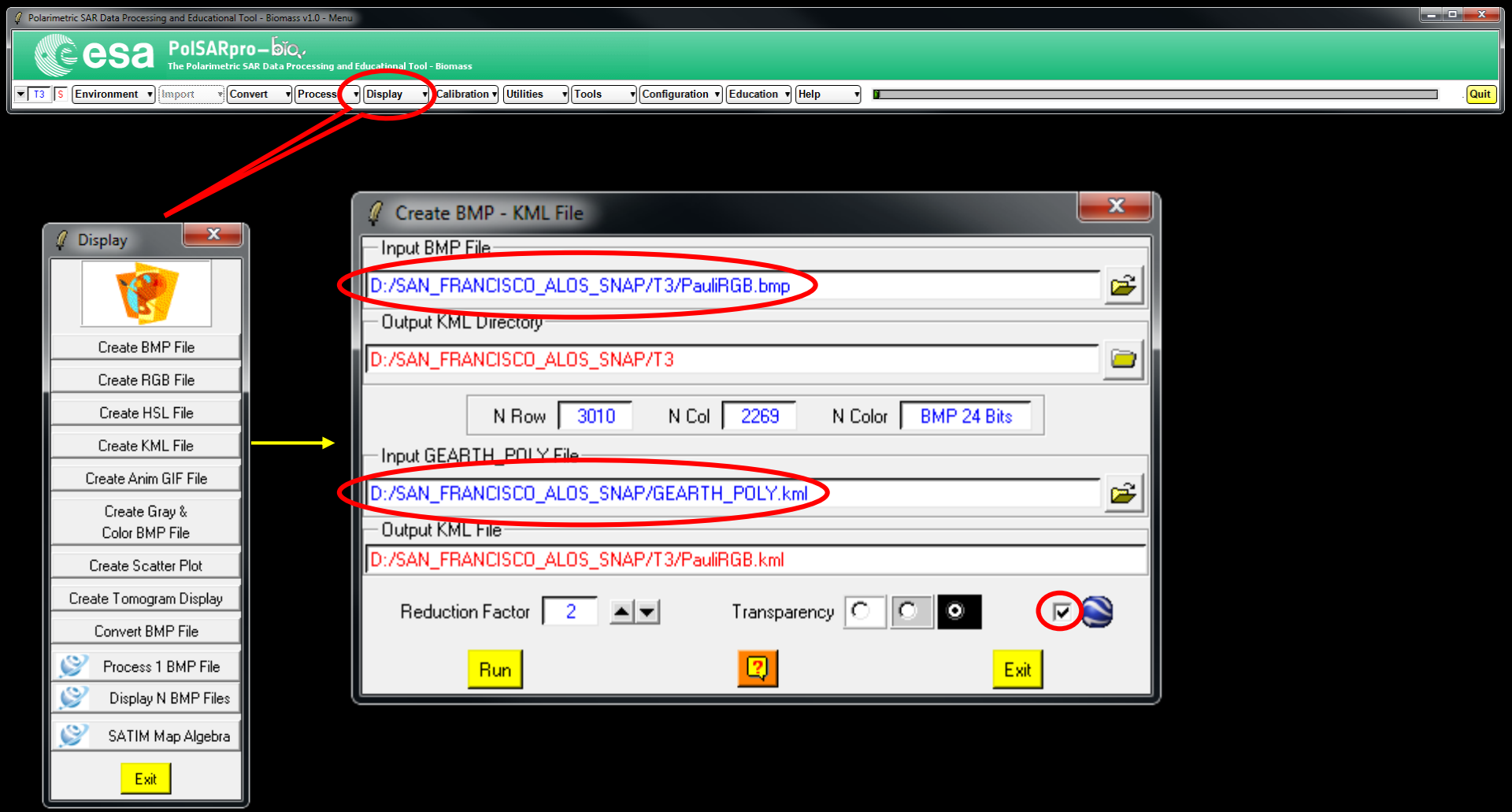
Display Pauli-RGB Image



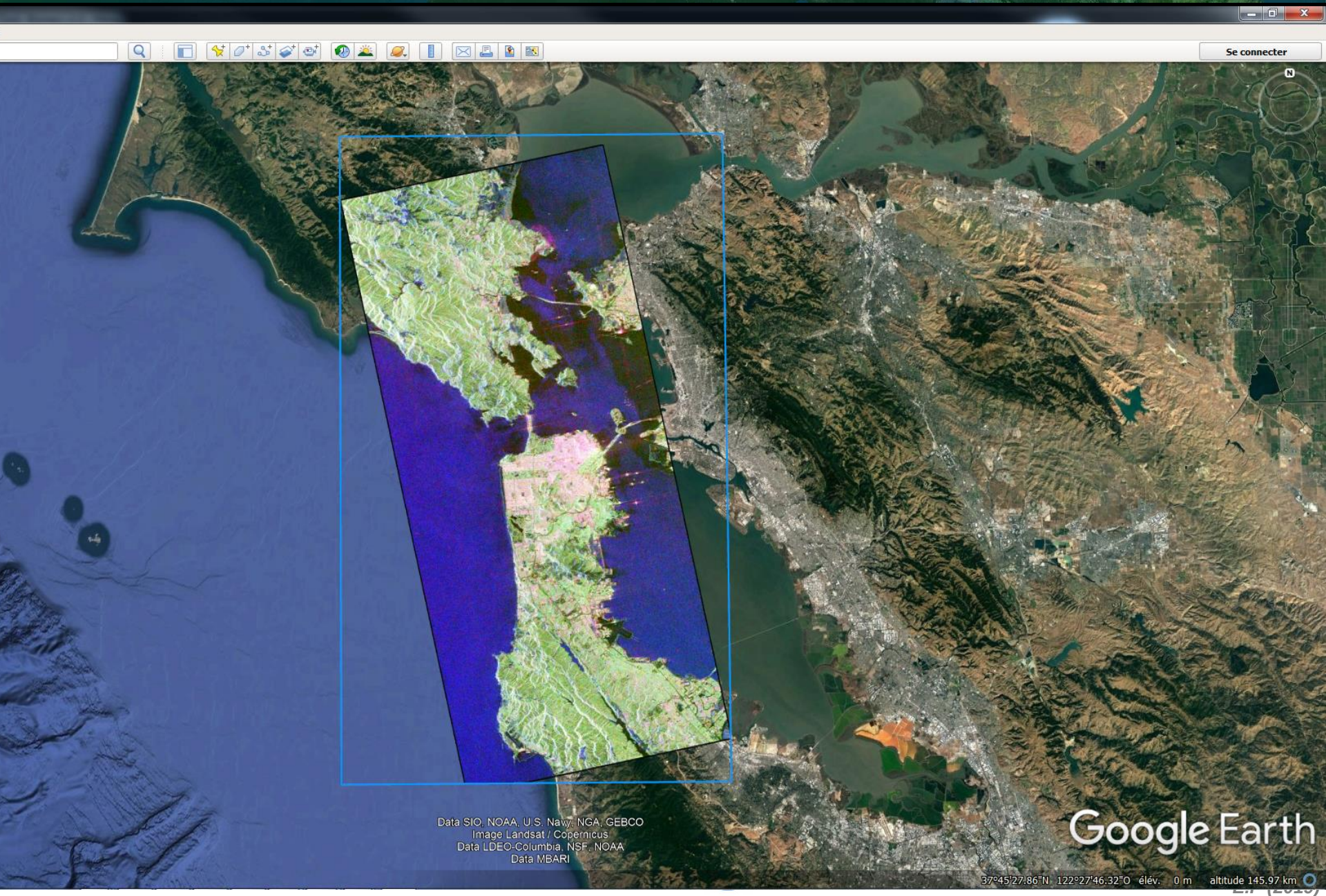
Display Main Menu



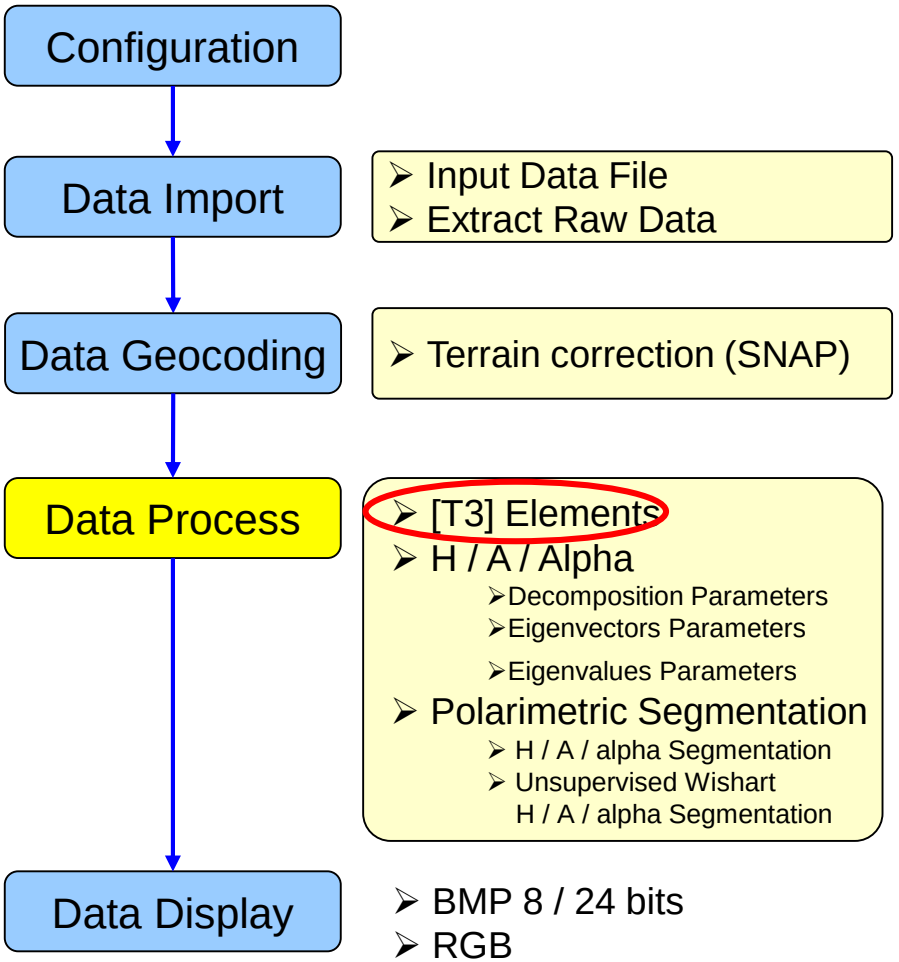
Create Pauli-RGB to KML Ima



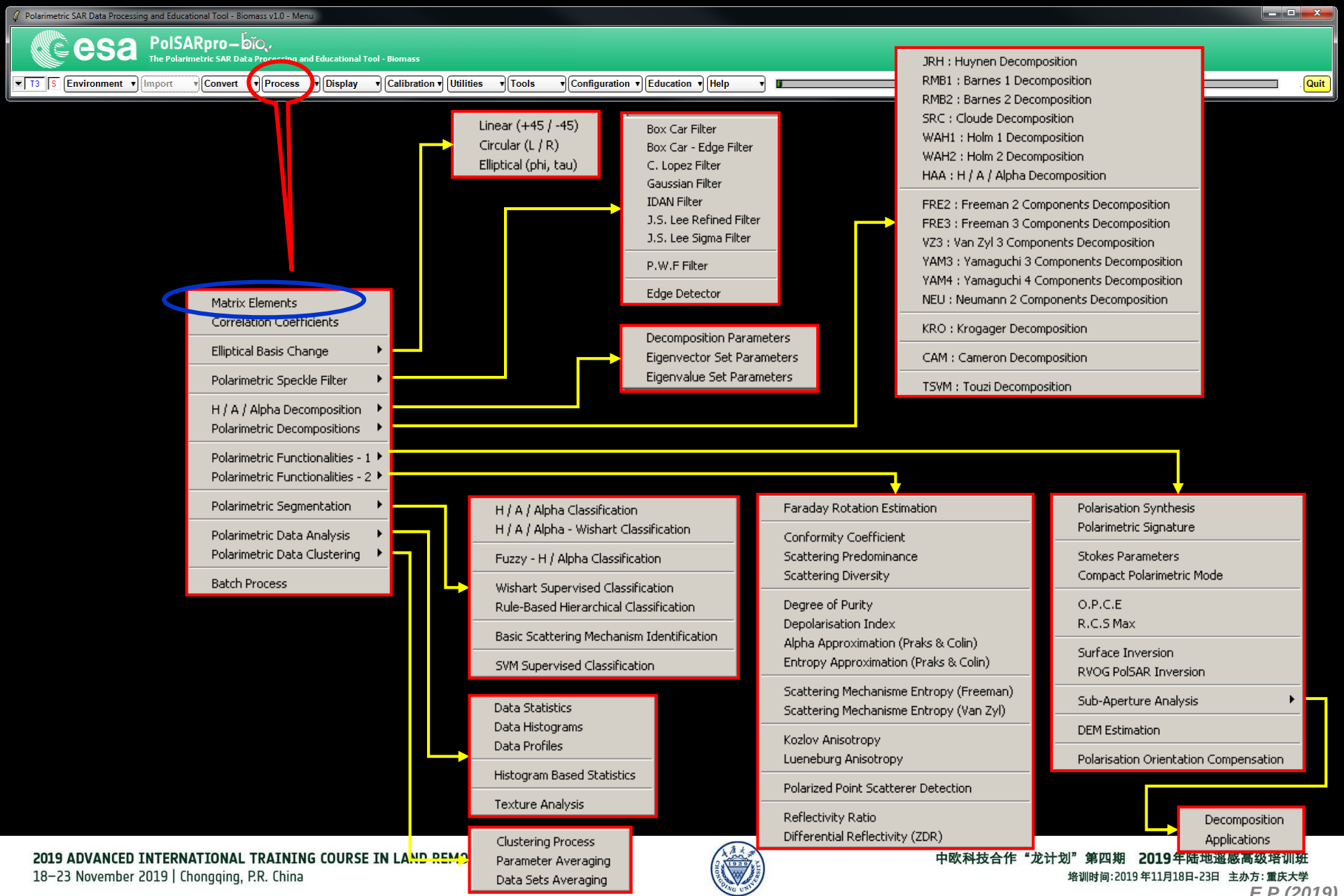
PolSARpro - Bio SOFTWARE



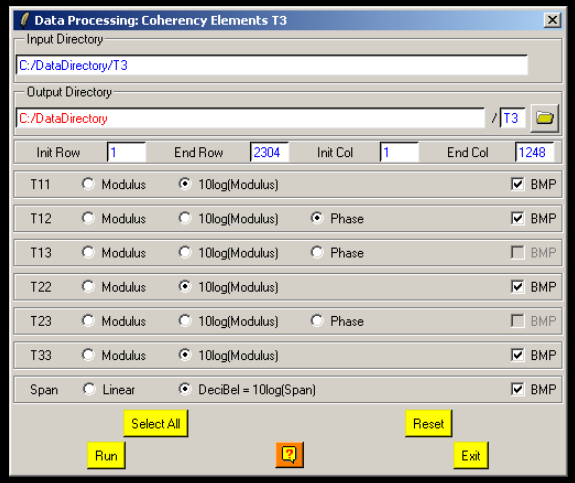
PROCESSING CHAIN

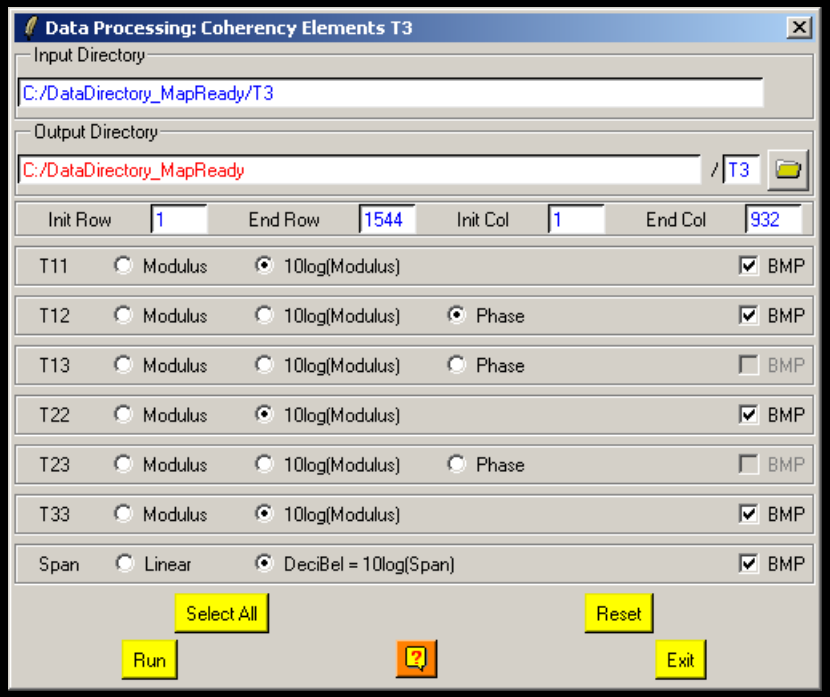


PolSARpro - Bio SOFTWARE



[T3] ELEMENTS





DATADIR

T3

config.txt

[T3x3] Elements

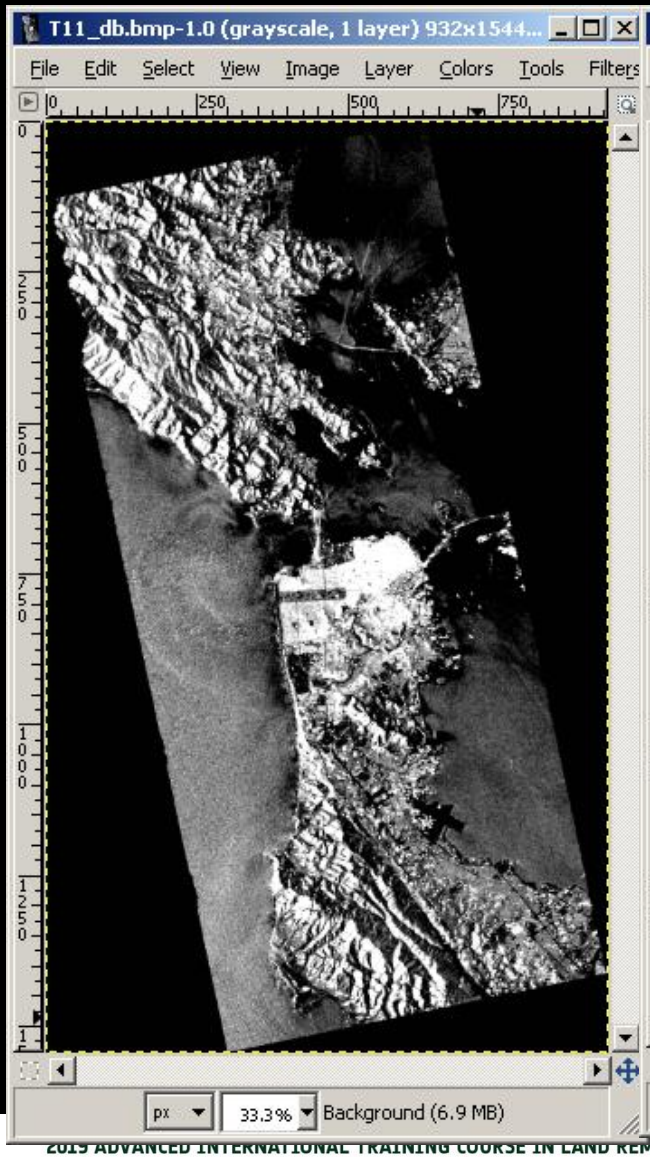
Txy_mod.bin
Txy_db.bin
Txy_pha.bin

Txy_mod.bmp
Txy_db.bmp
Txy_pha.bmp

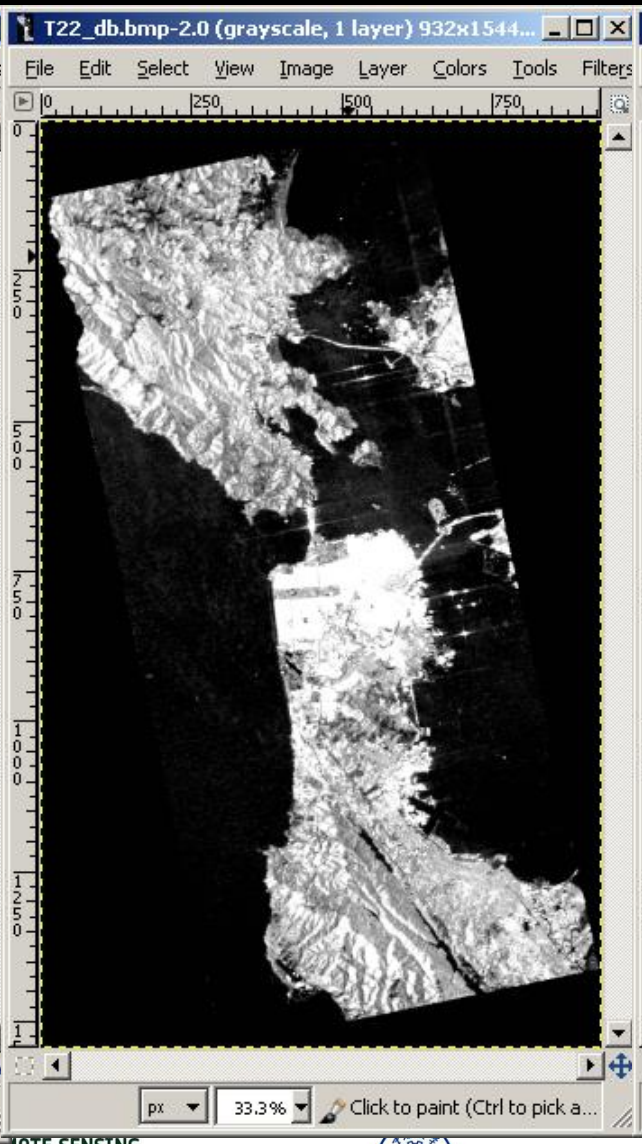
Do it Yourself:
Select some elements, set the parameters and view the corresponding BMP files (select BMP).

[T3] ELEMENTS

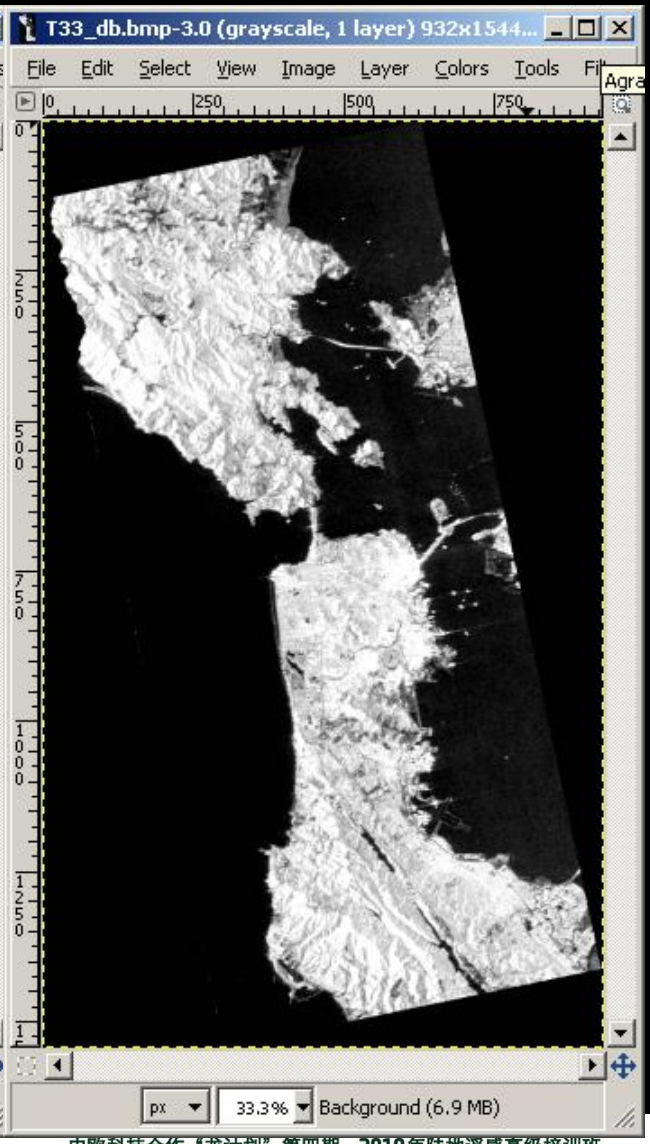
T11_dB



T22_dB

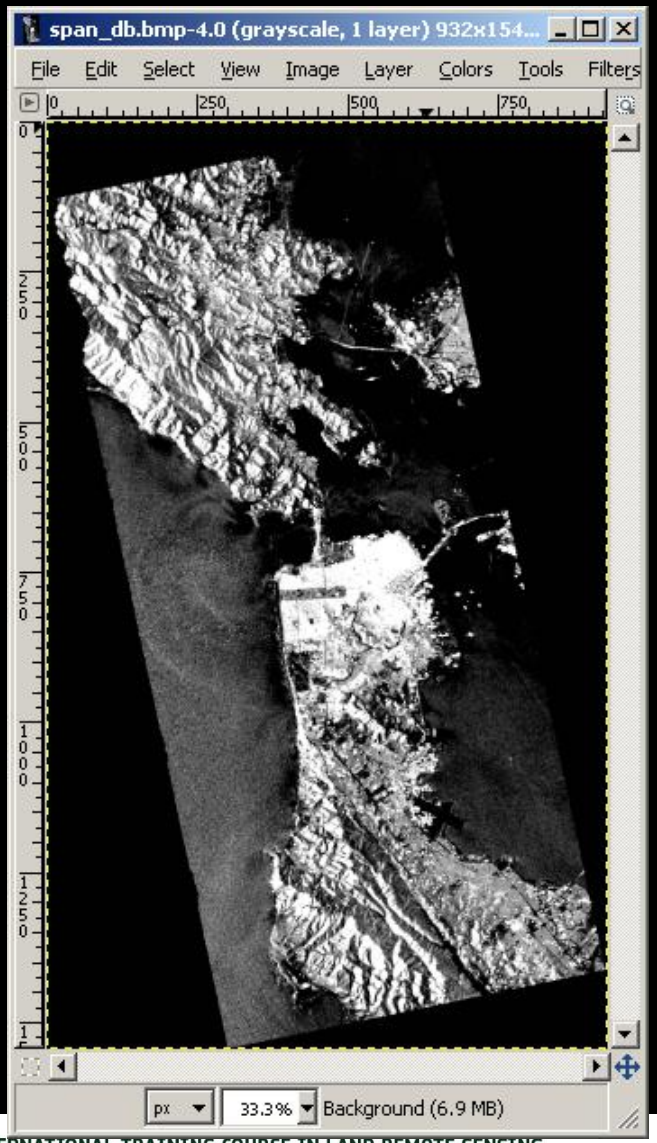


T33_dB

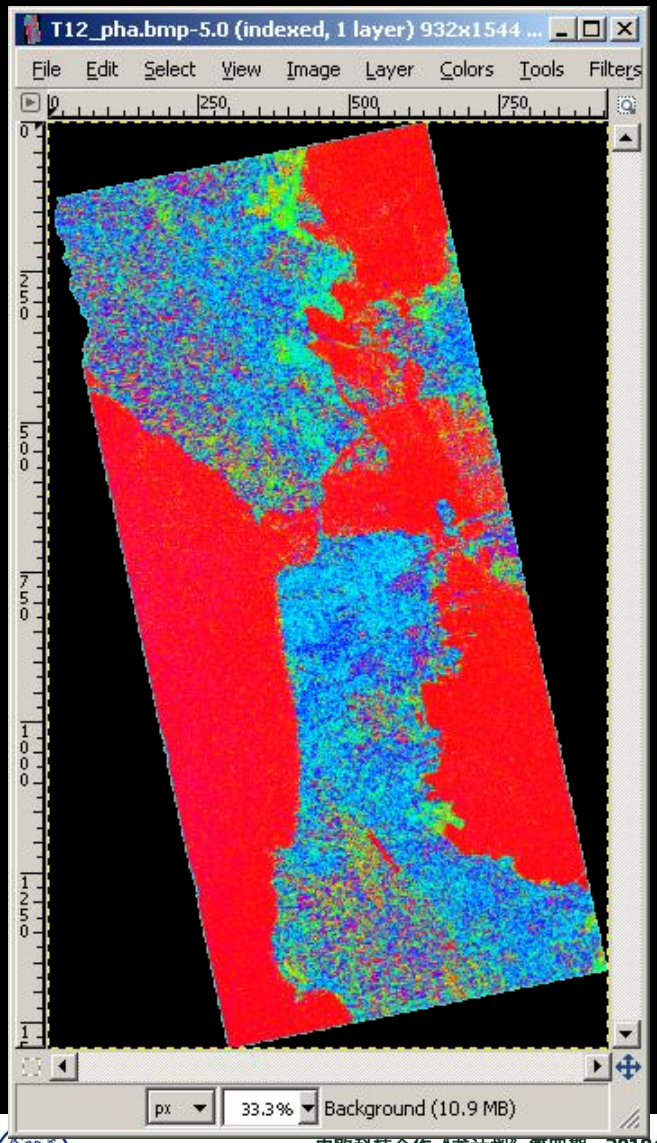


[T3] ELEMENTS

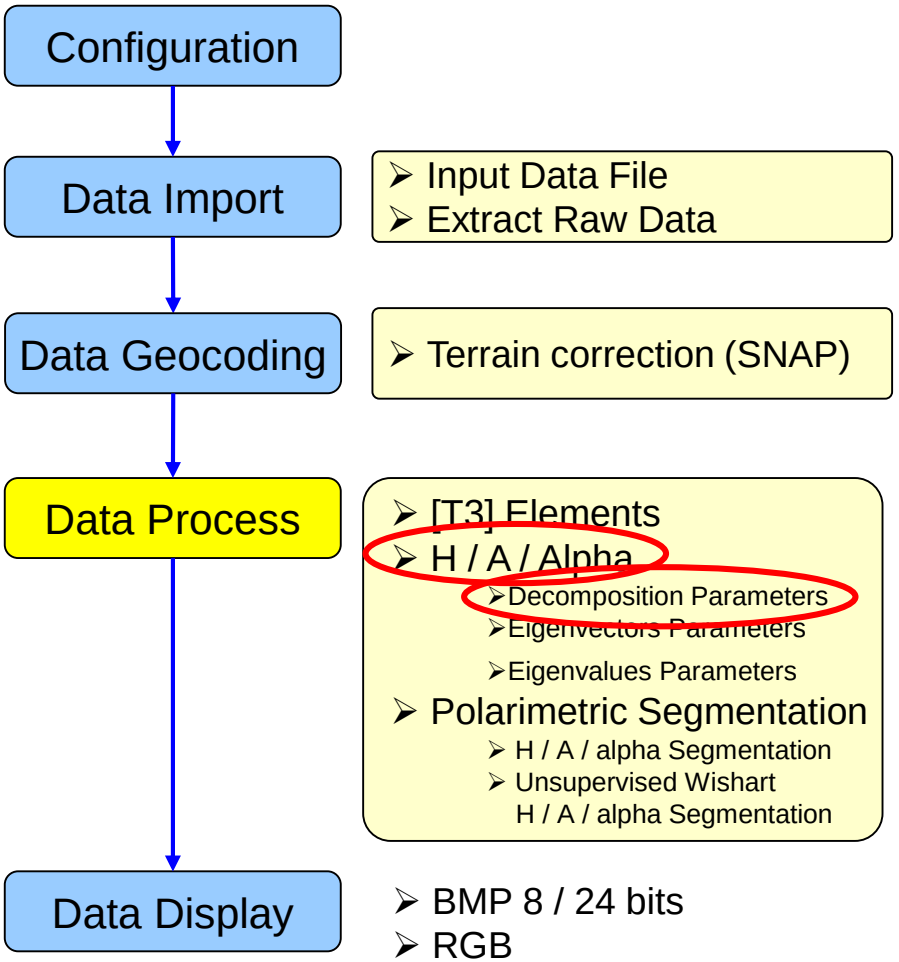
span_dB



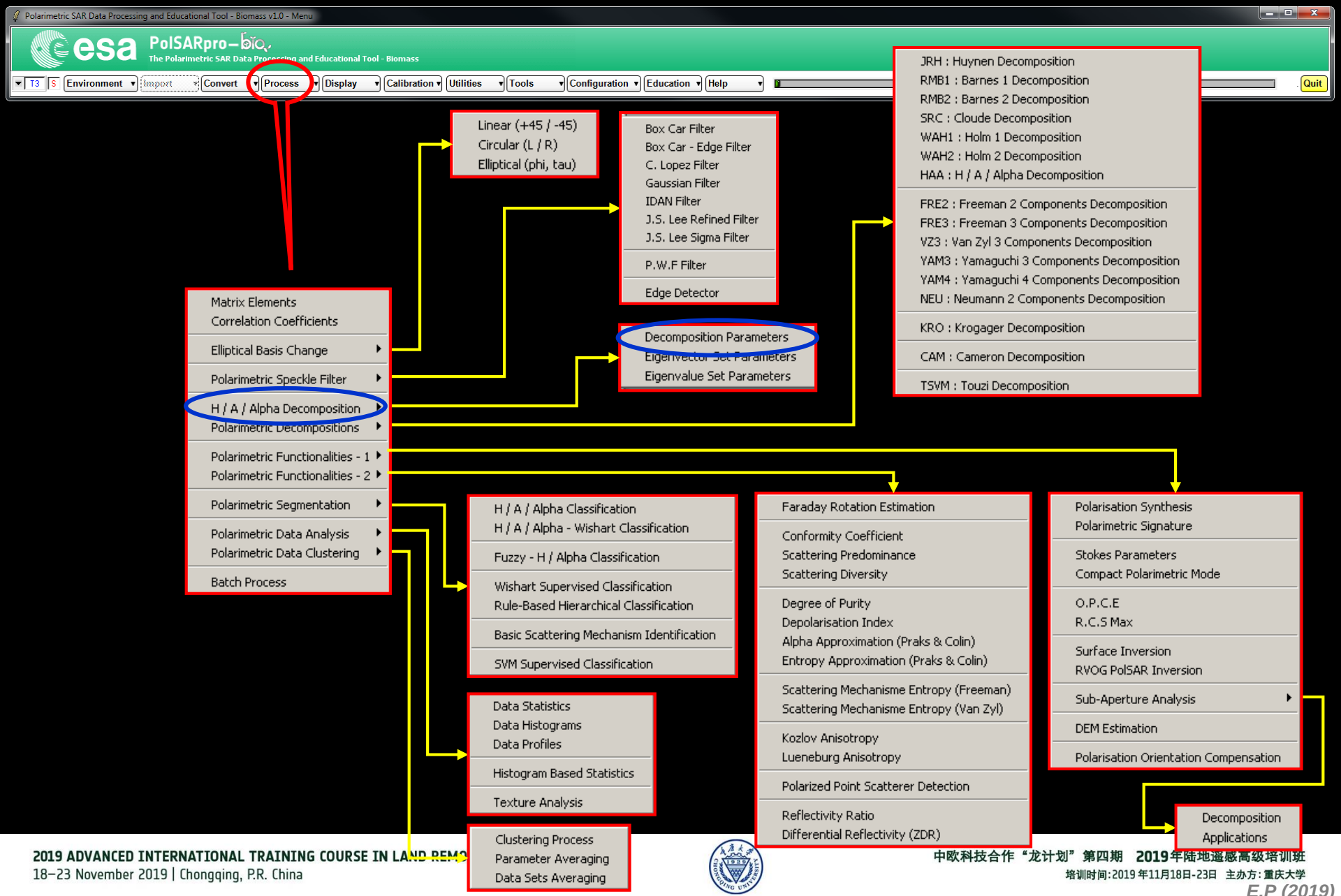
T12_pha



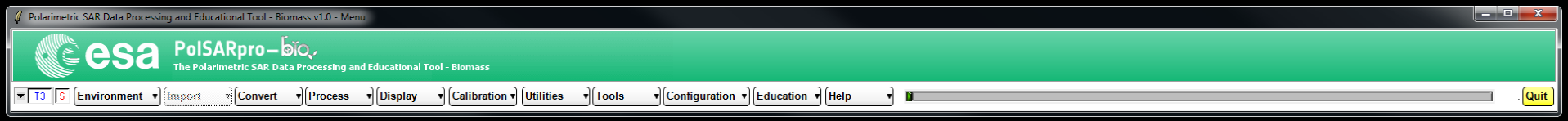
PROCESSING CHAIN



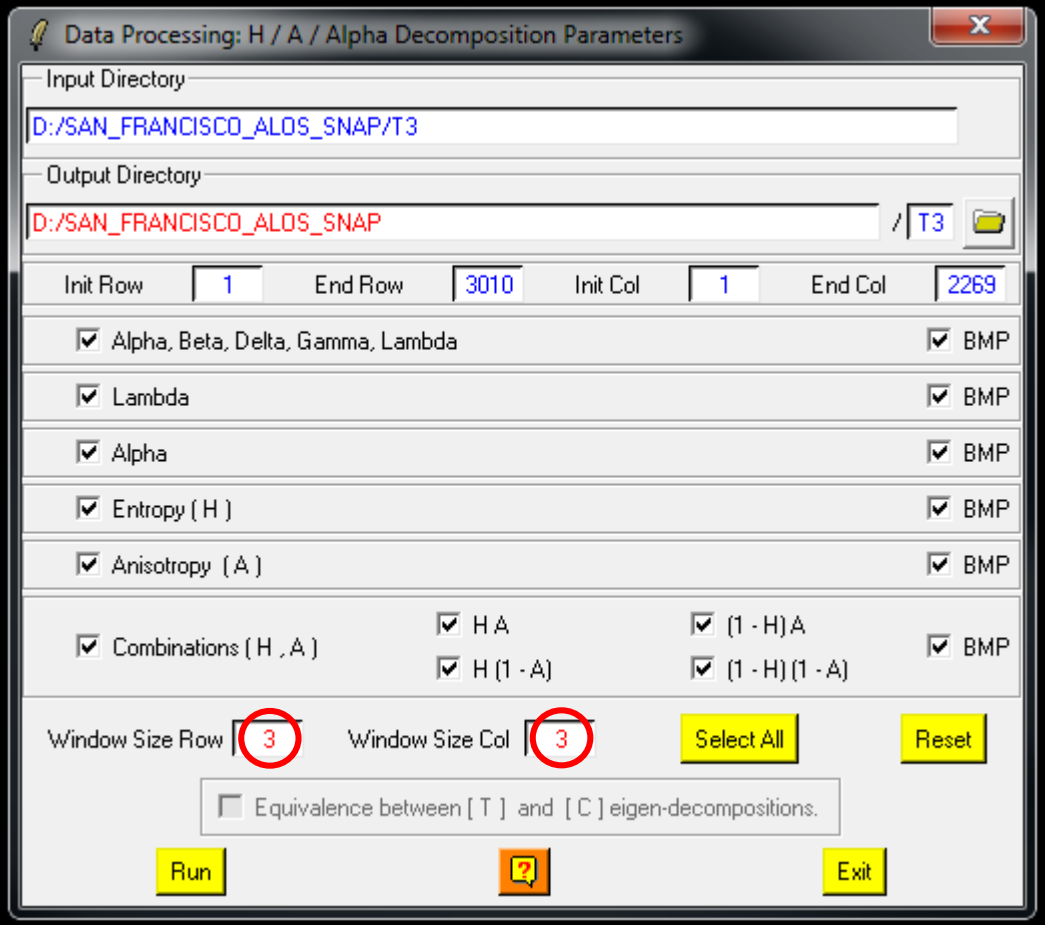
PolSARpro - Bio SOFTWARE



DECOMPOSITION PARAMETE

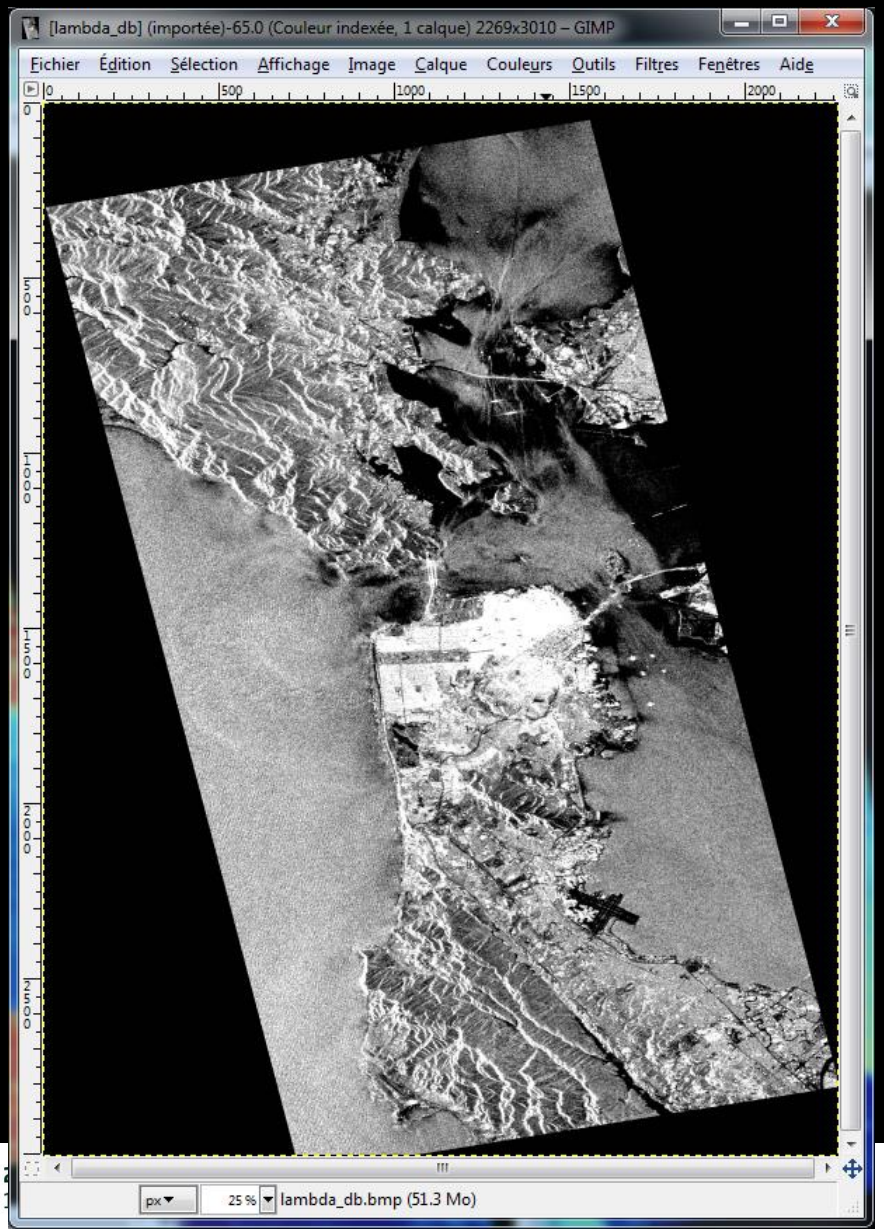


Do it Yourself:
Select some elements, set the parameters (Nwin = 3) and view the corresponding BMP files (select BMP).

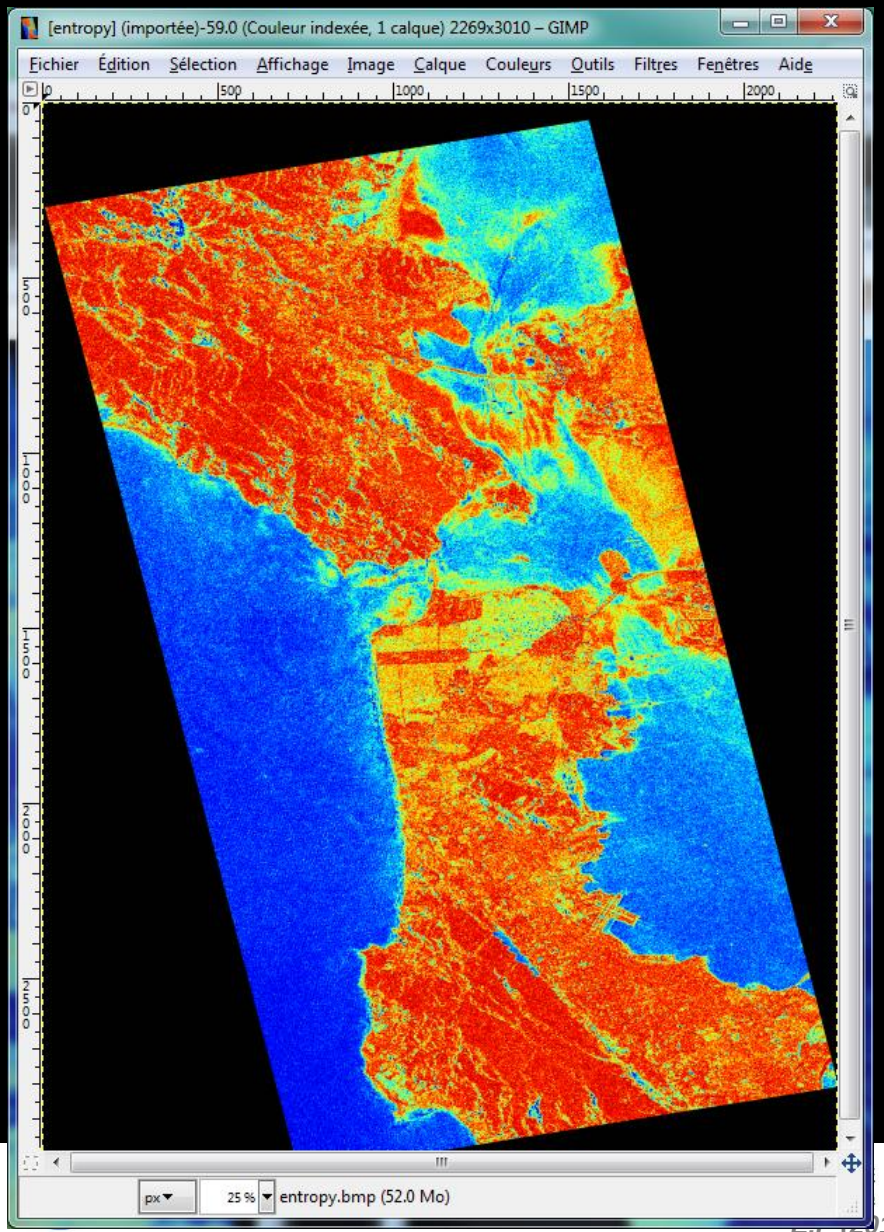


DECOMPOSITION PARAMETERS

Lambda

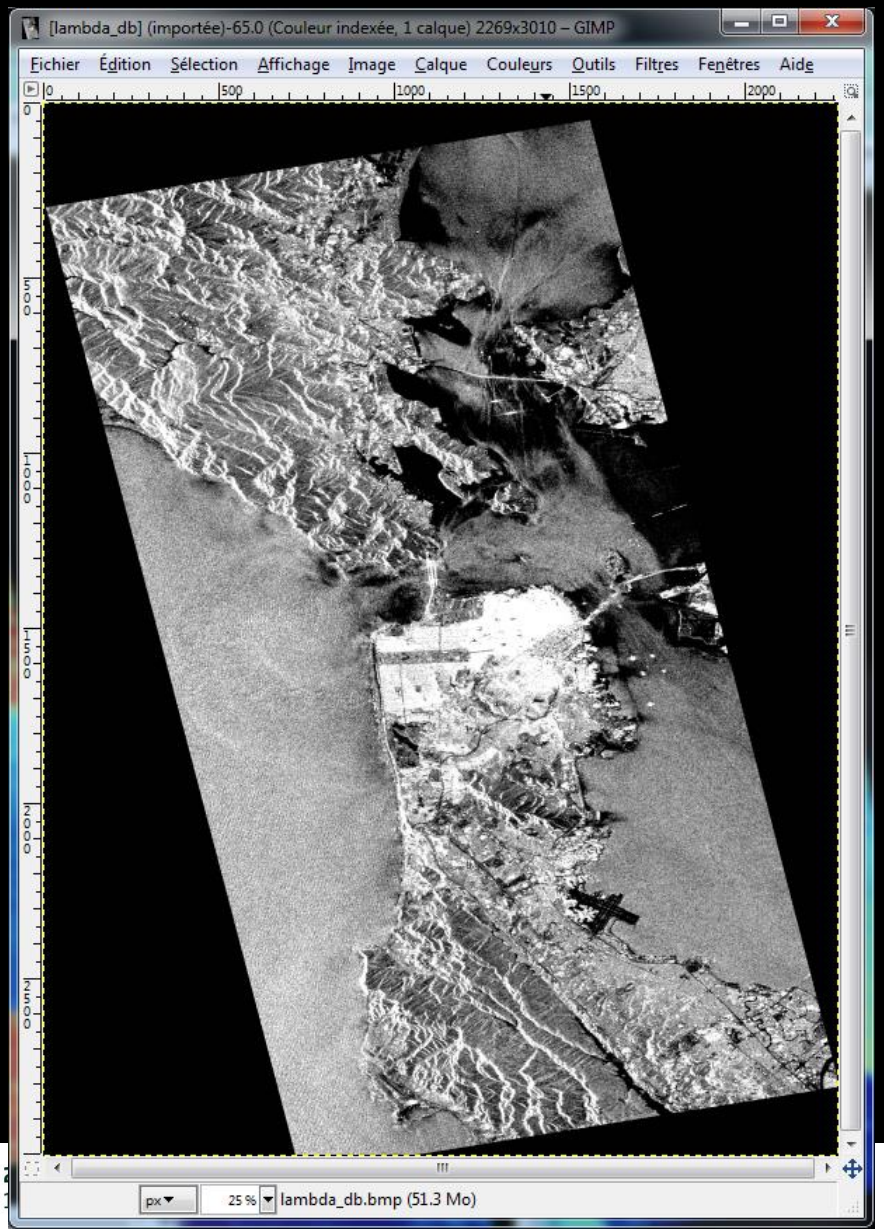


Entropy

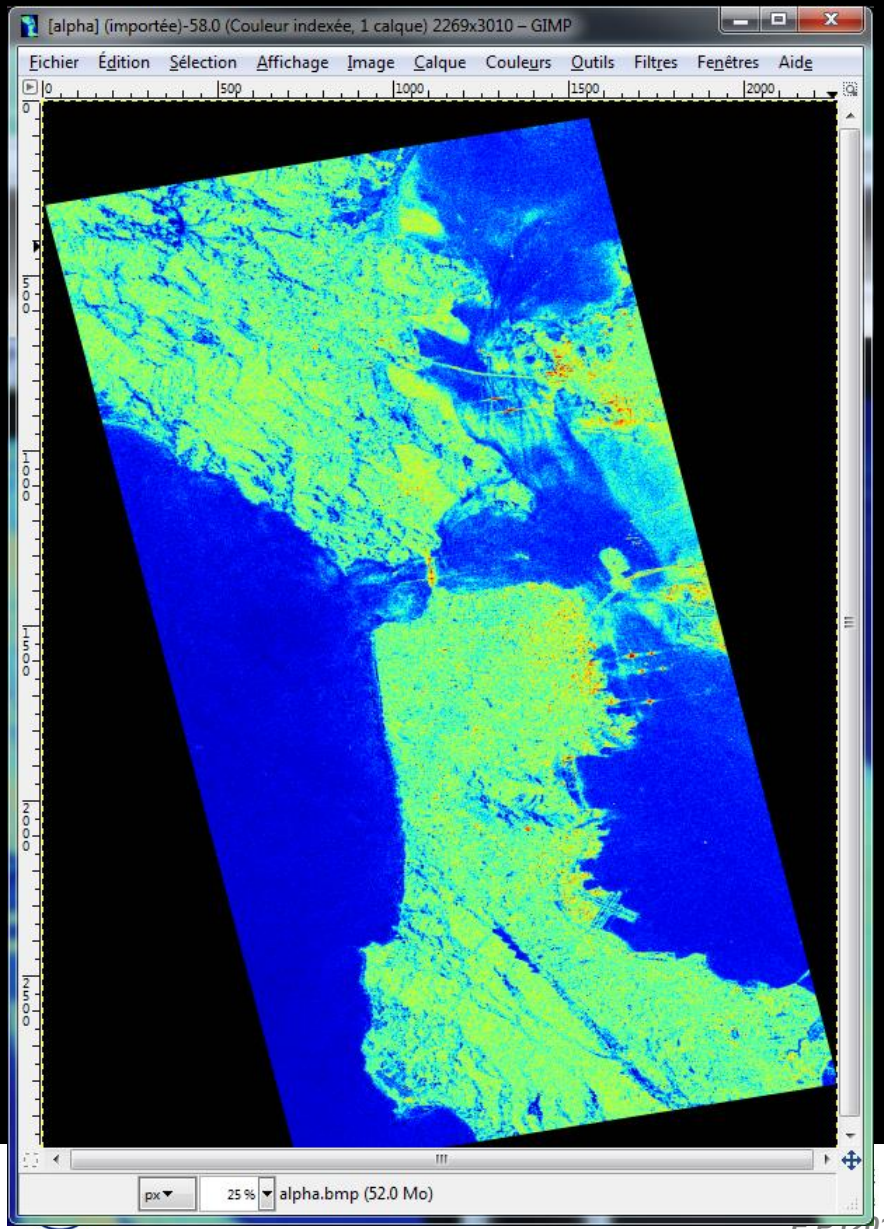


DECOMPOSITION PARAMETERS

Lambda

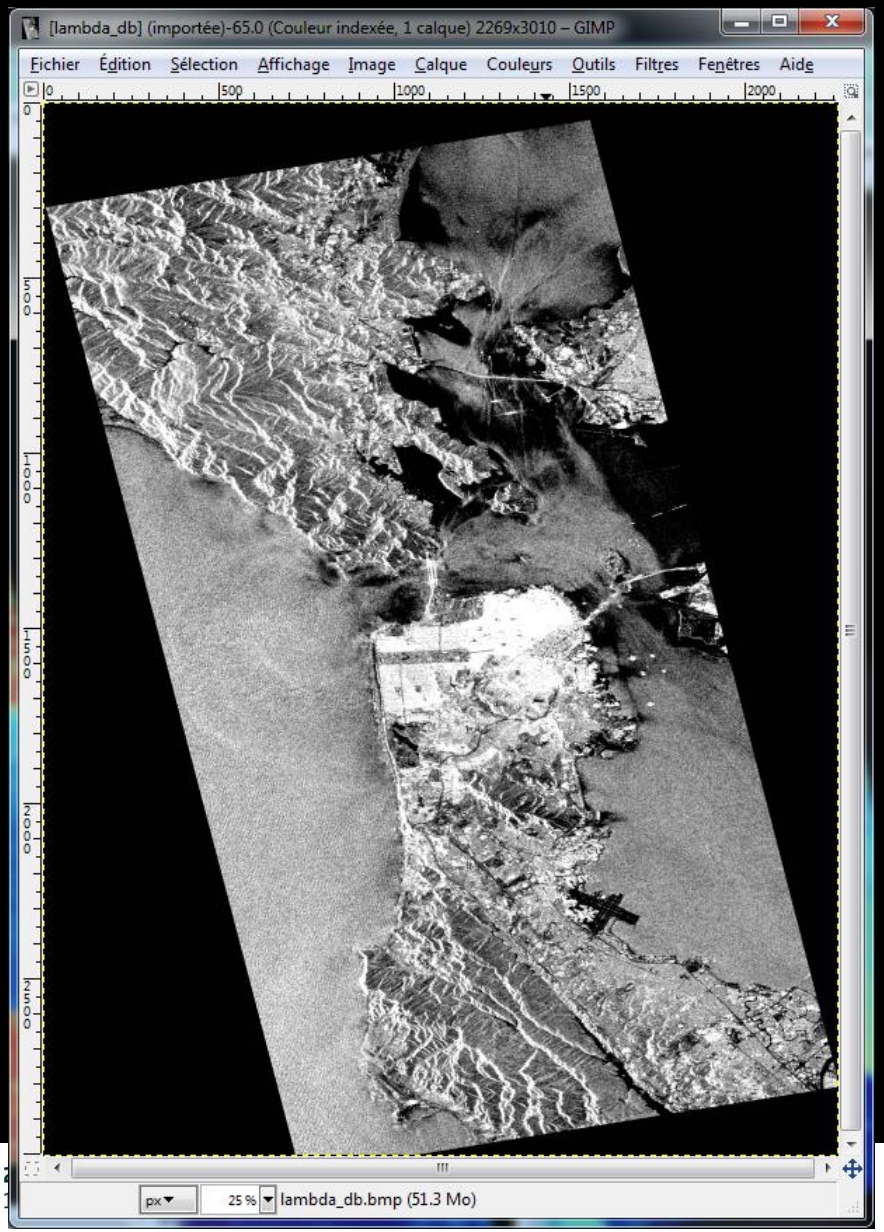


Alpha

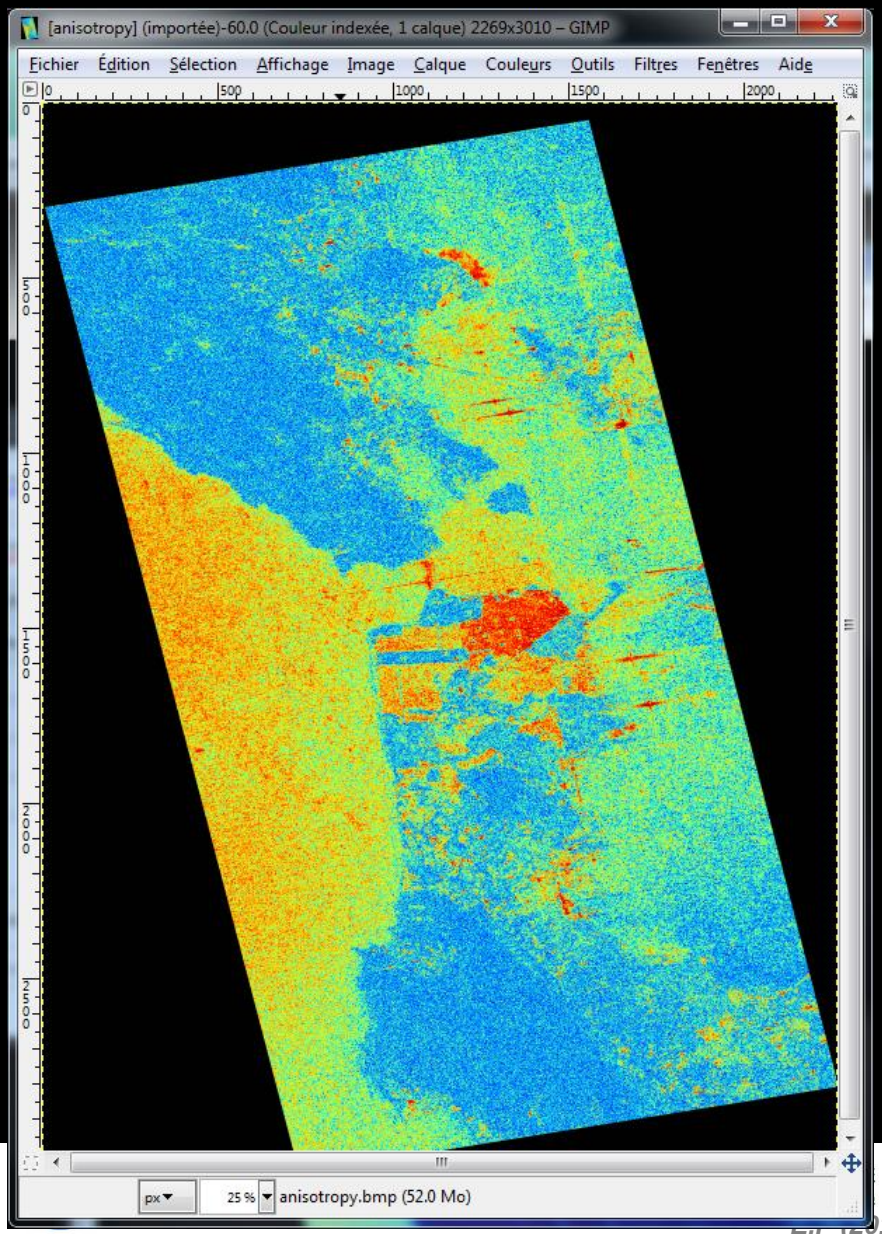


DECOMPOSITION PARAMETERS

Lambda

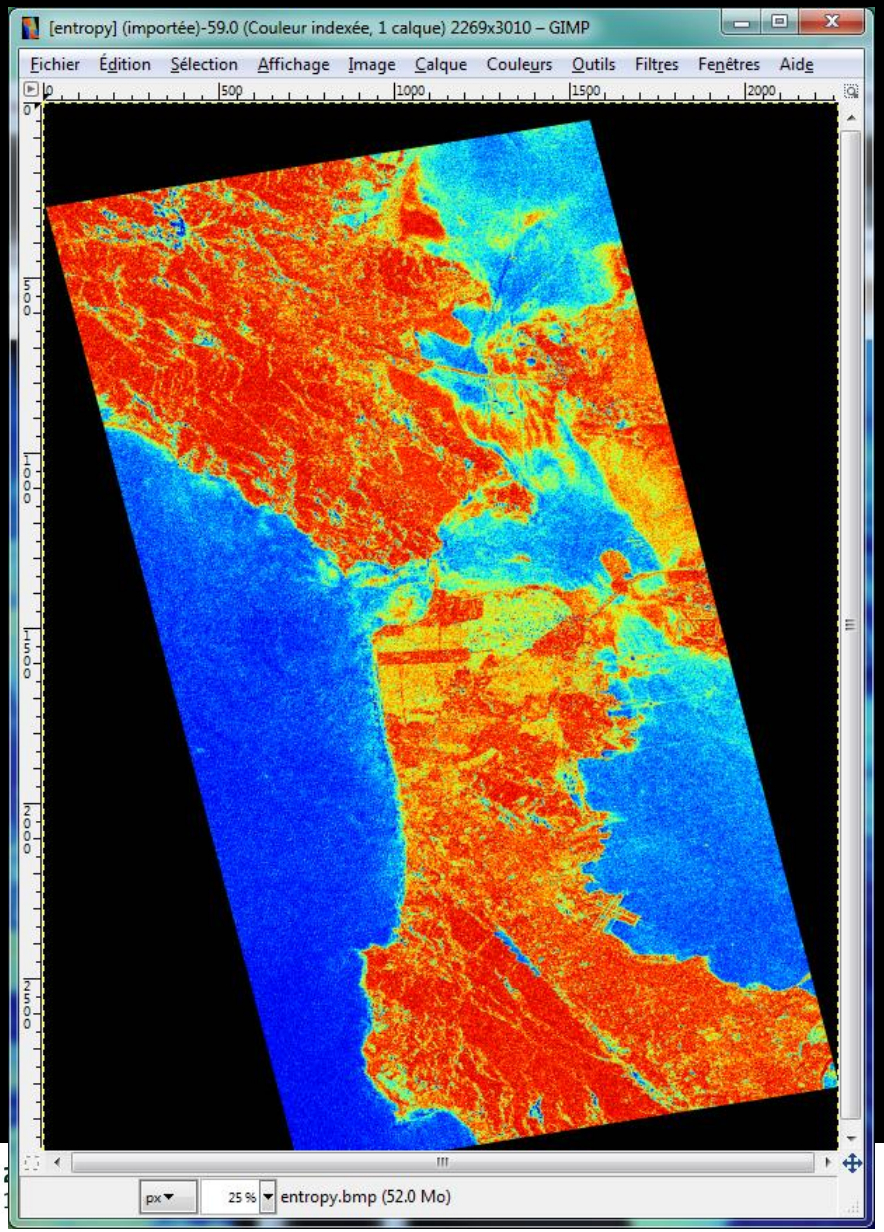


Anisotropy

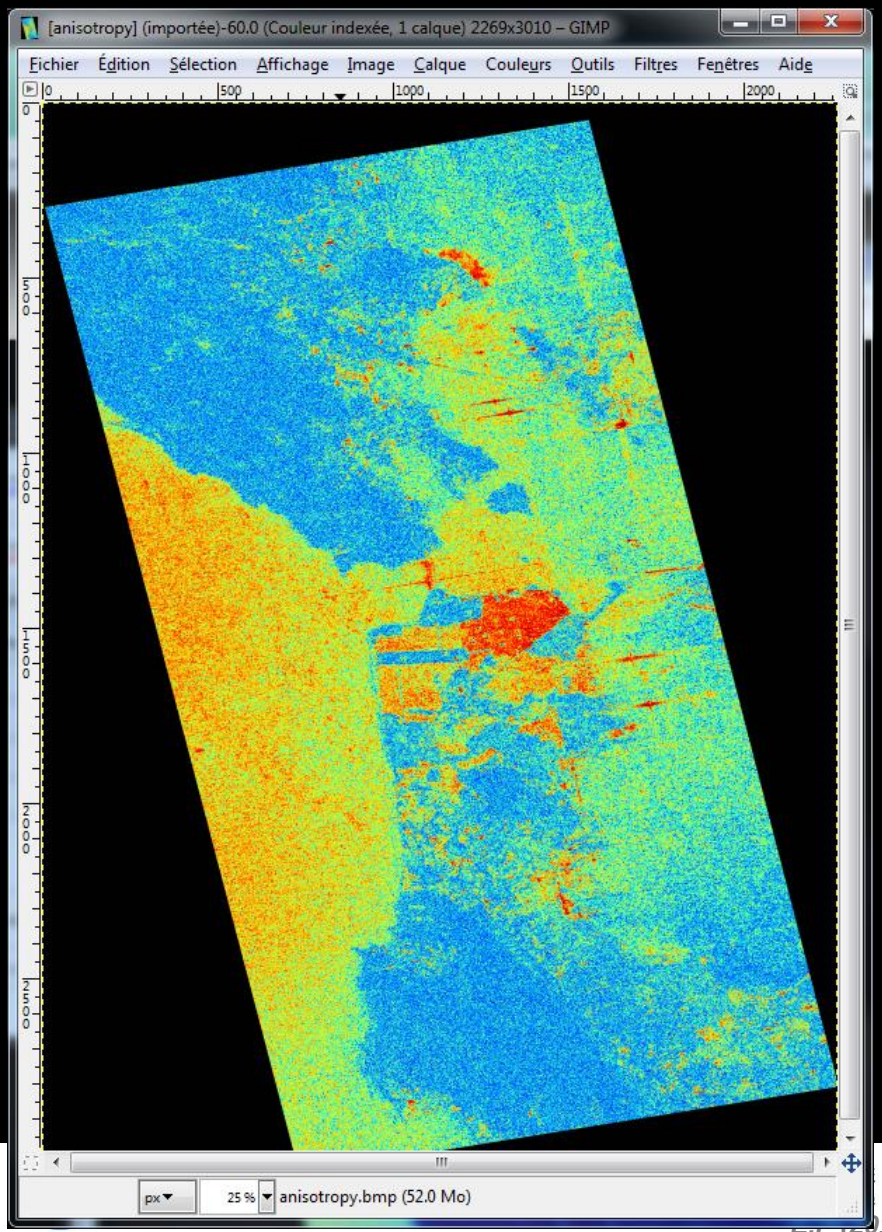


DECOMPOSITION PARAMETERS

Entropy

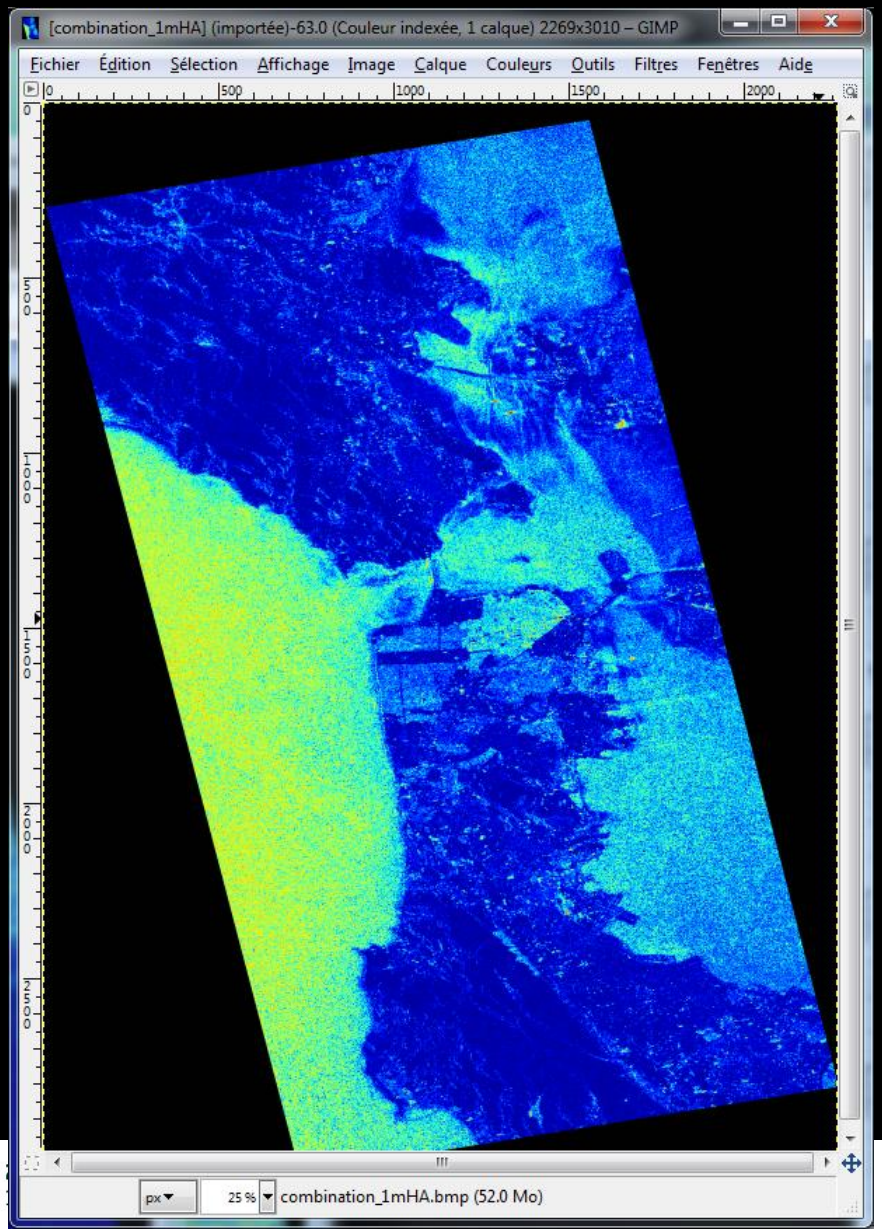


Anisotropy

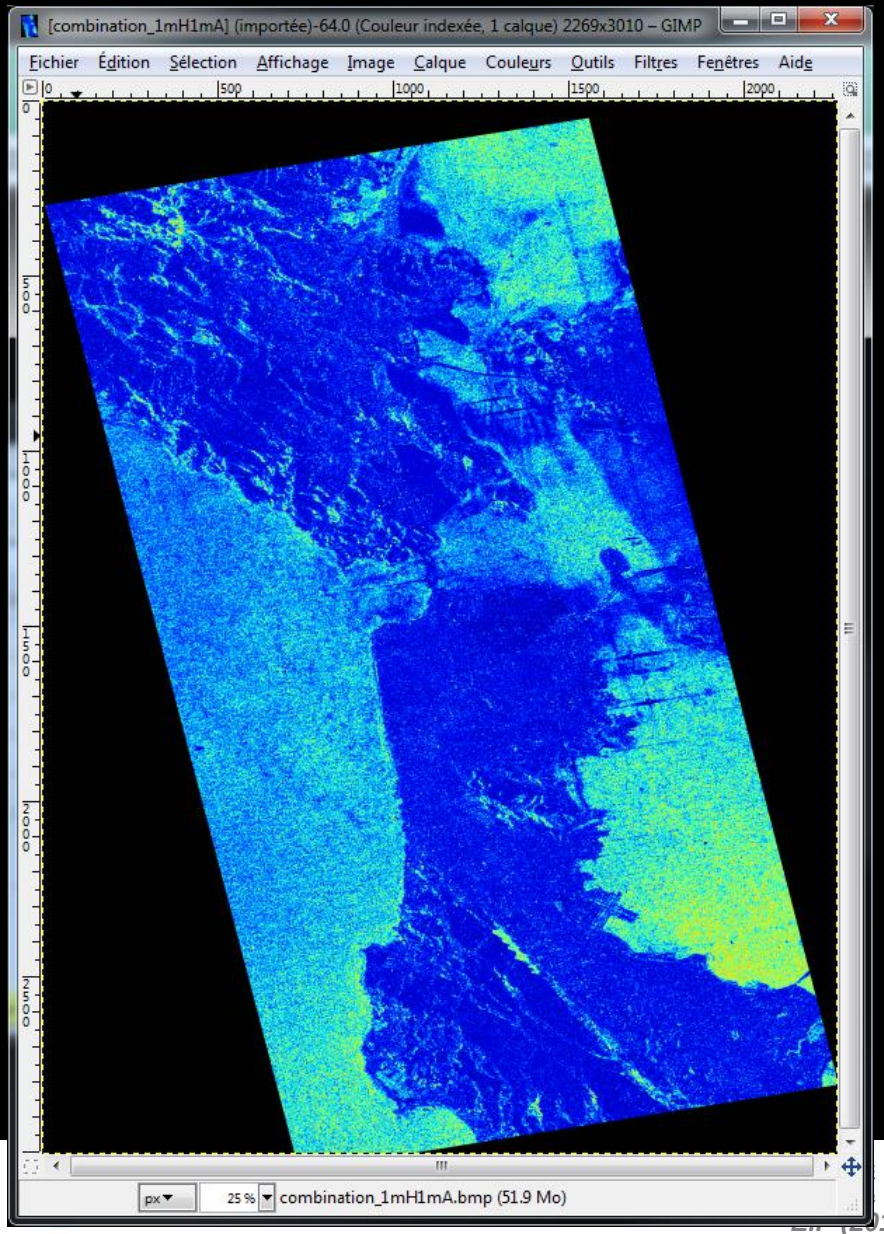


DECOMPOSITION PARAMETE

(1–H) A

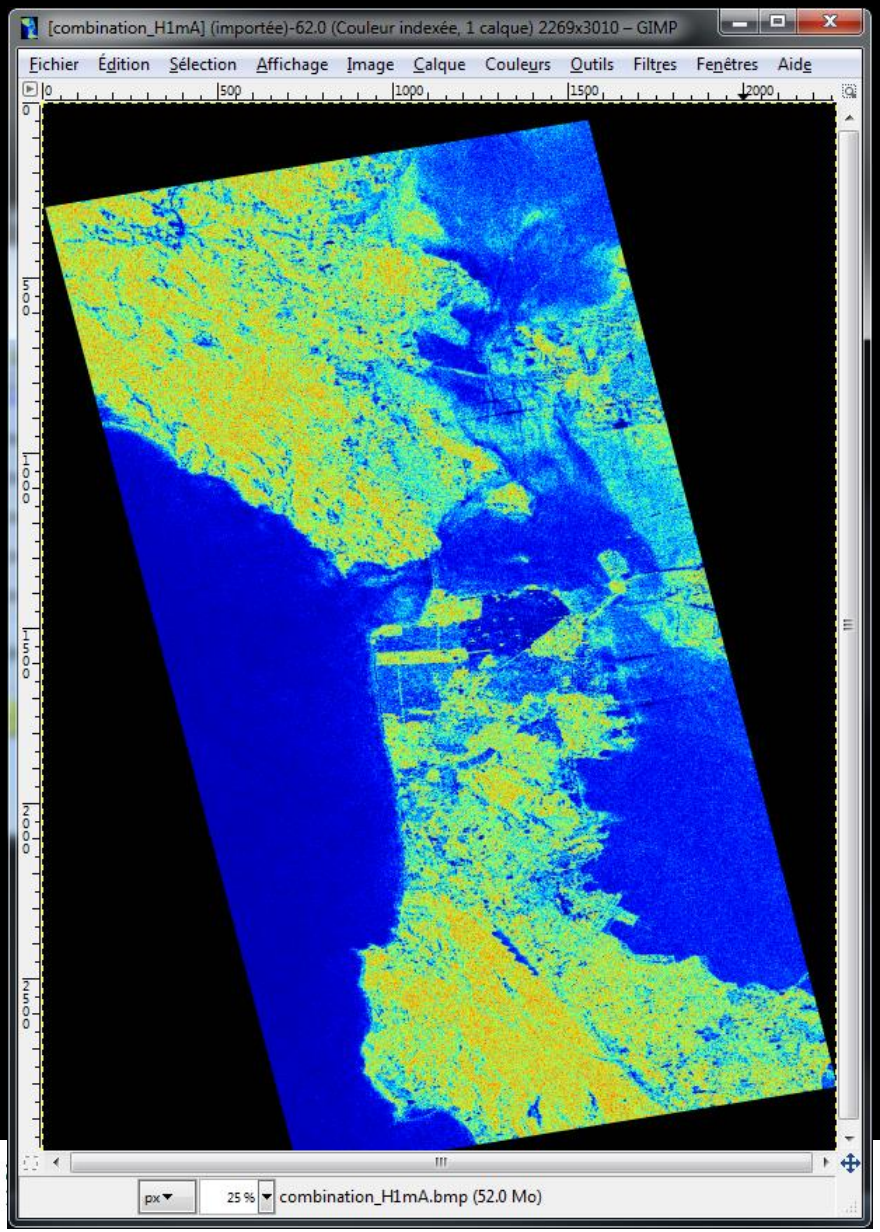


(1-H) (1-A)

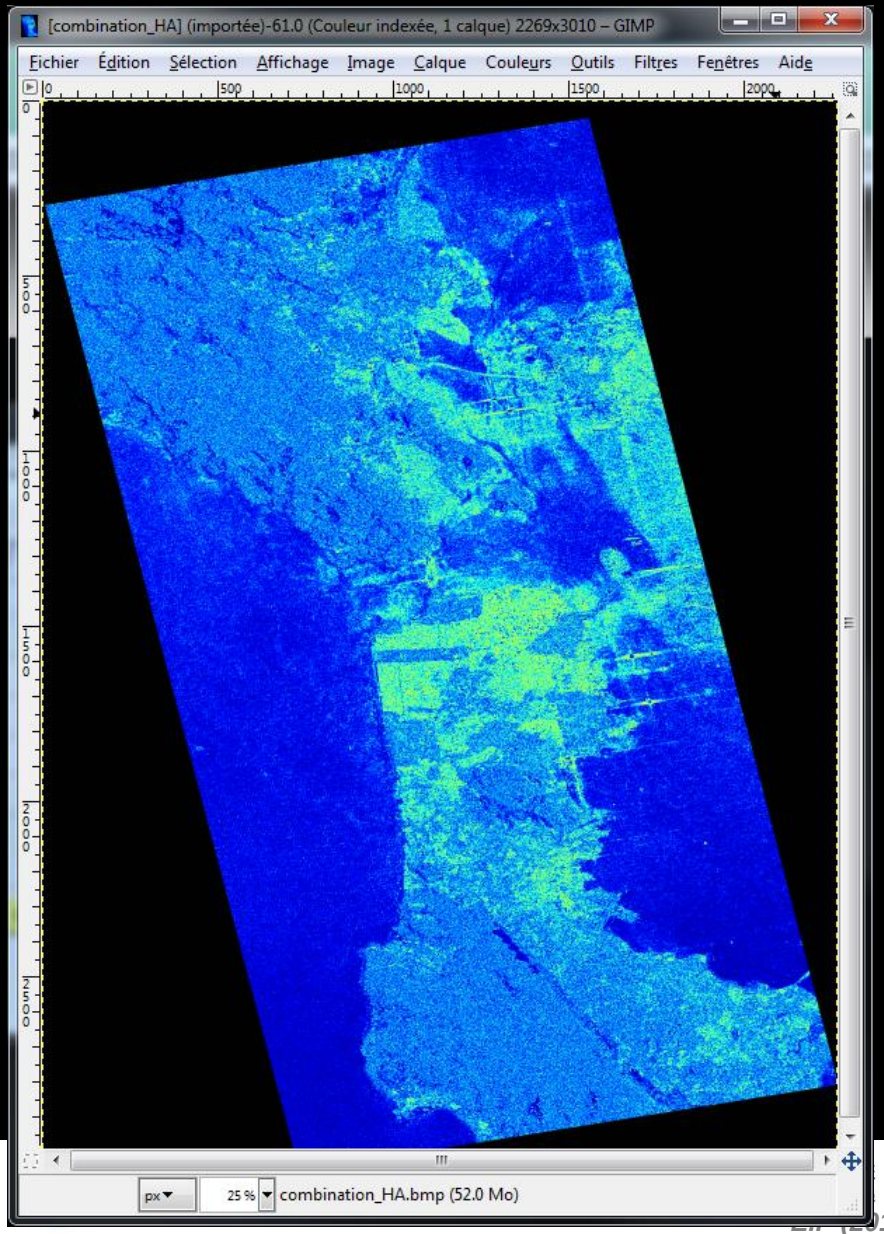


DECOMPOSITION PARAMETERS

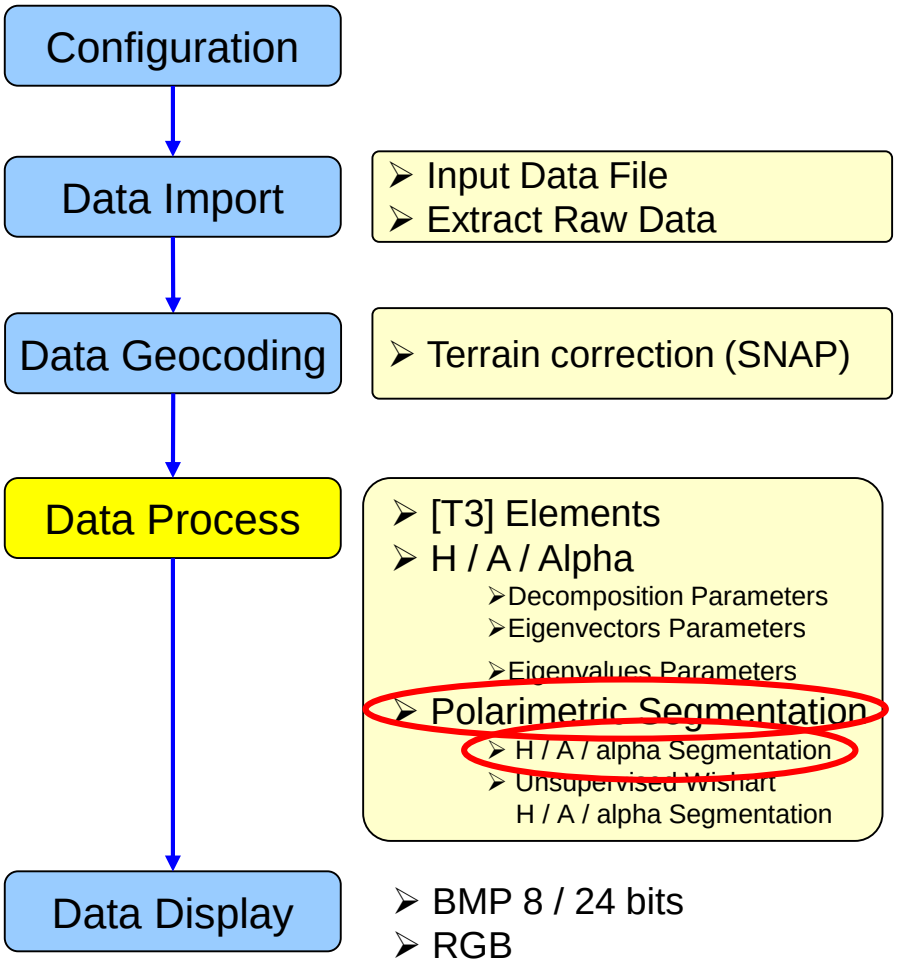
H (1-A)



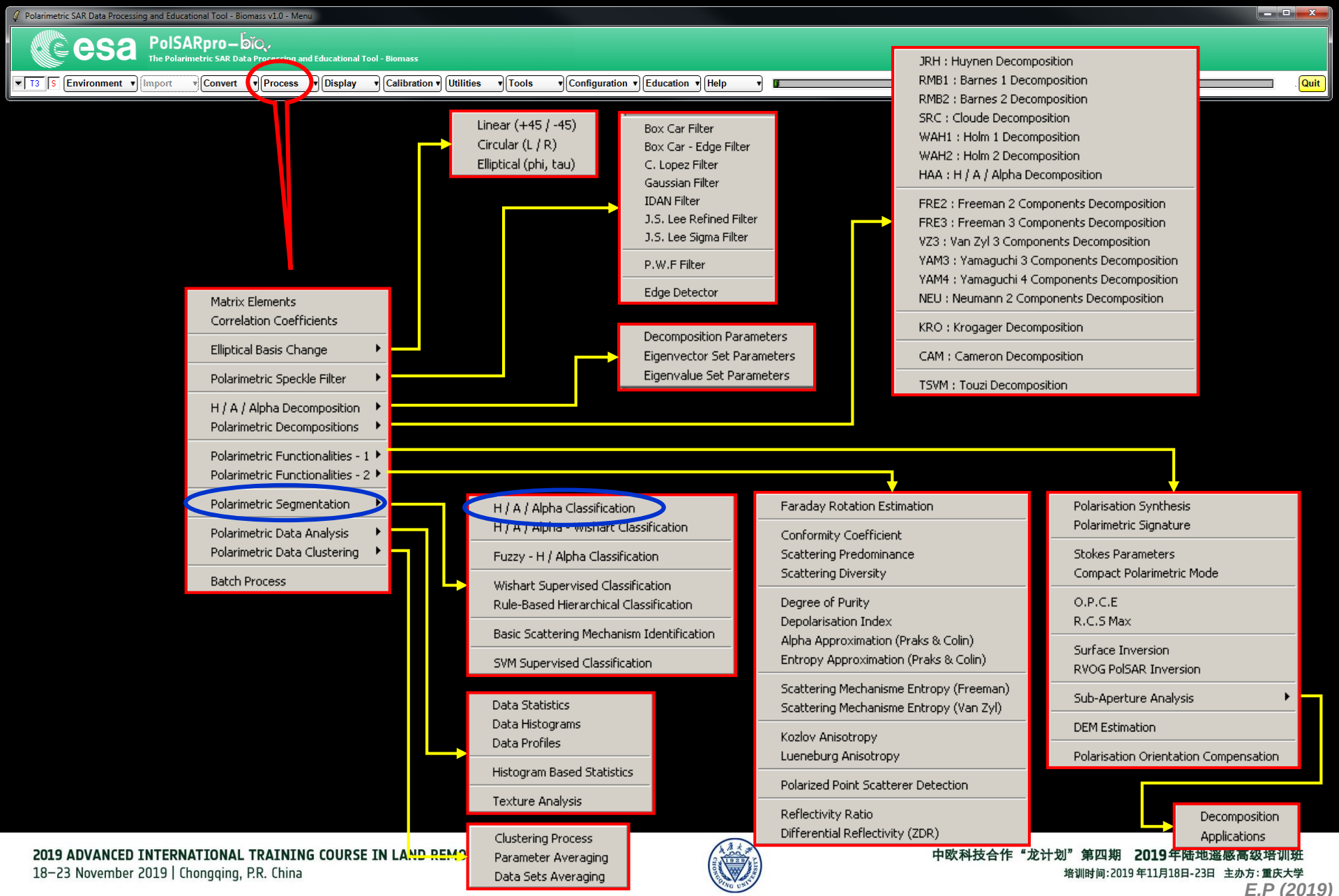
HA



PROCESSING CHAIN

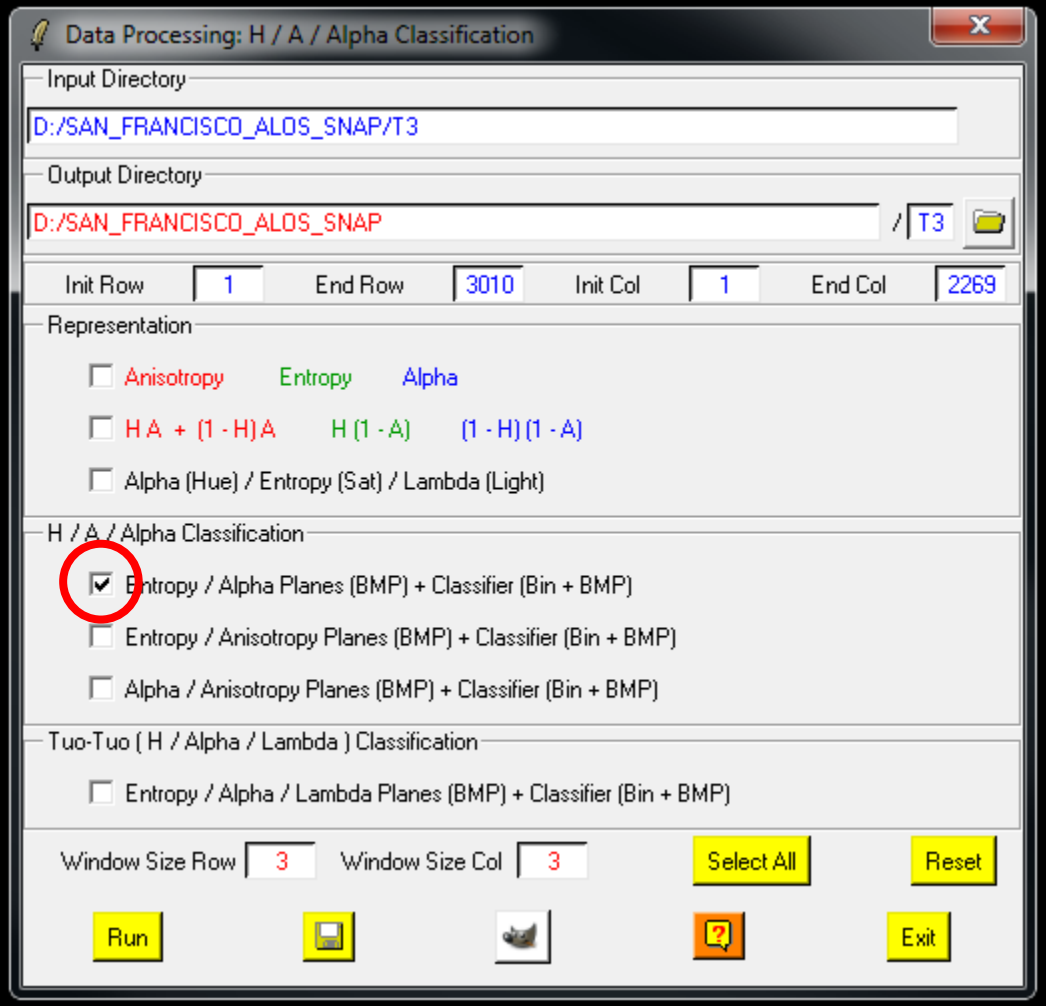


PolSARpro - Bio SOFTWARE

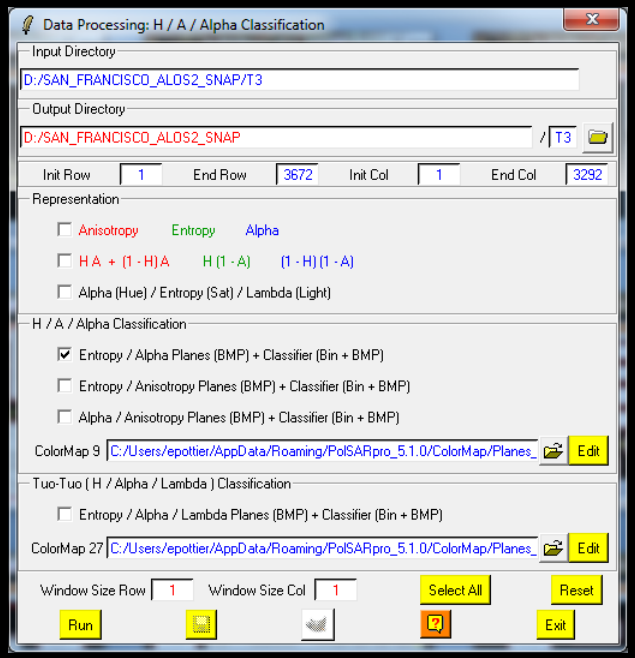


H / A / alpha CLASSIFICATIO

Do it Yourself:
Select some elements, set the parameters (Nwin = 3) and view the corresponding BMP files.



H / A / alpha CLASSIFICATION



Do it Yourself:
Select some elements, set the parameters (Nwin = 3) and view the corresponding BMP files.

DATADIR

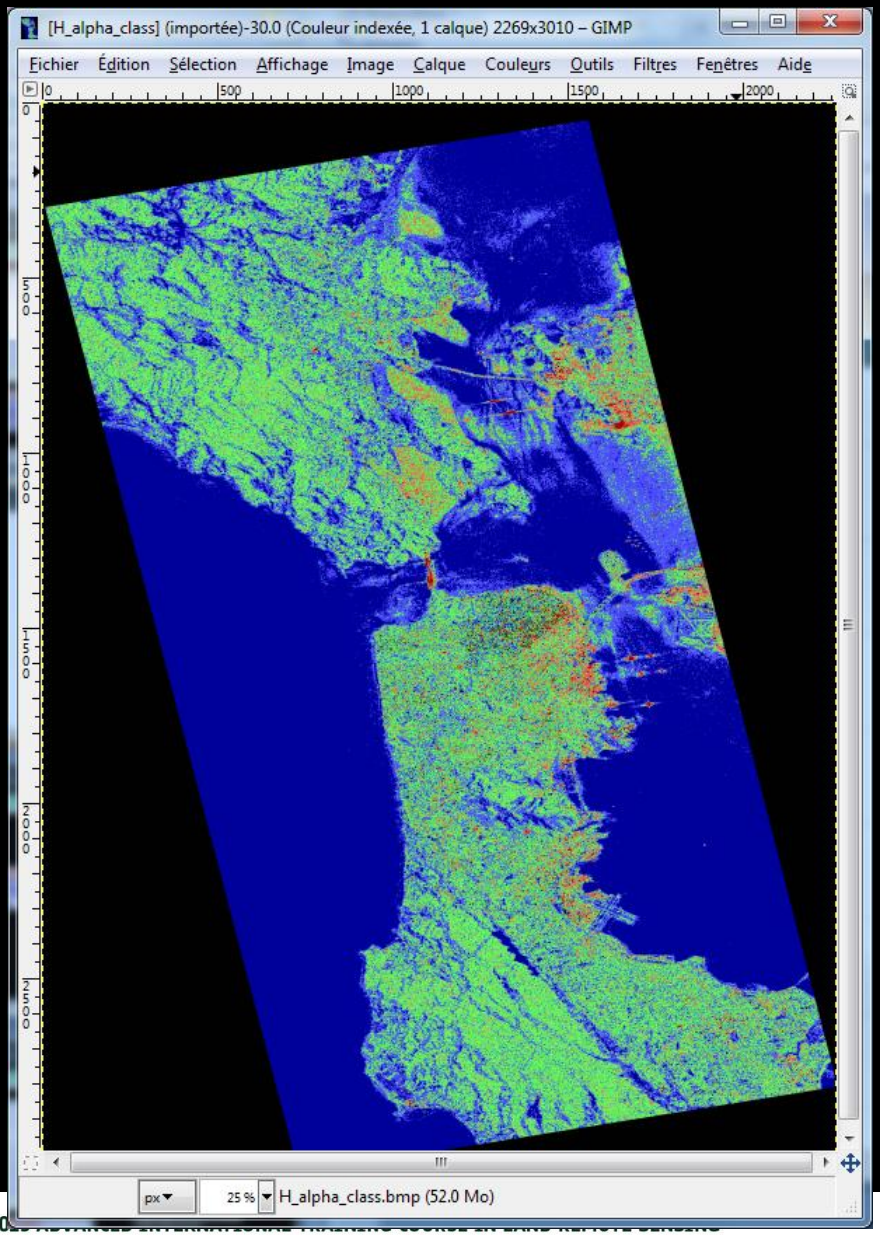
config.txt

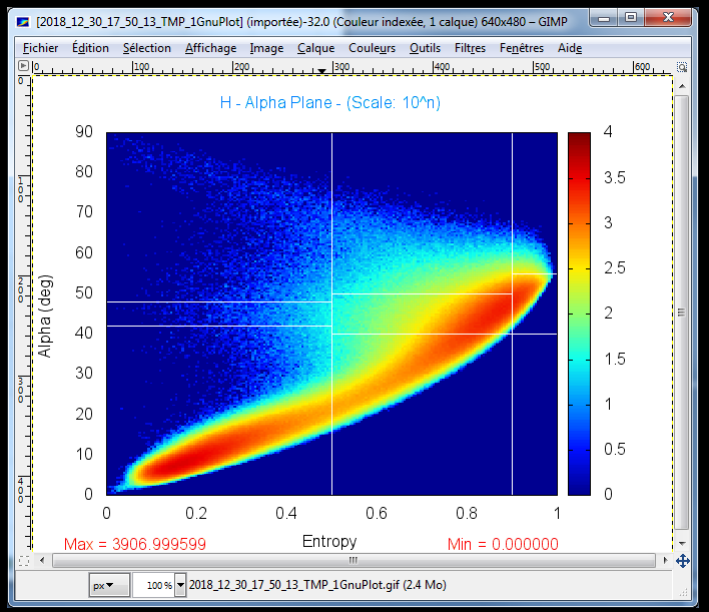
[T3x3] Elements

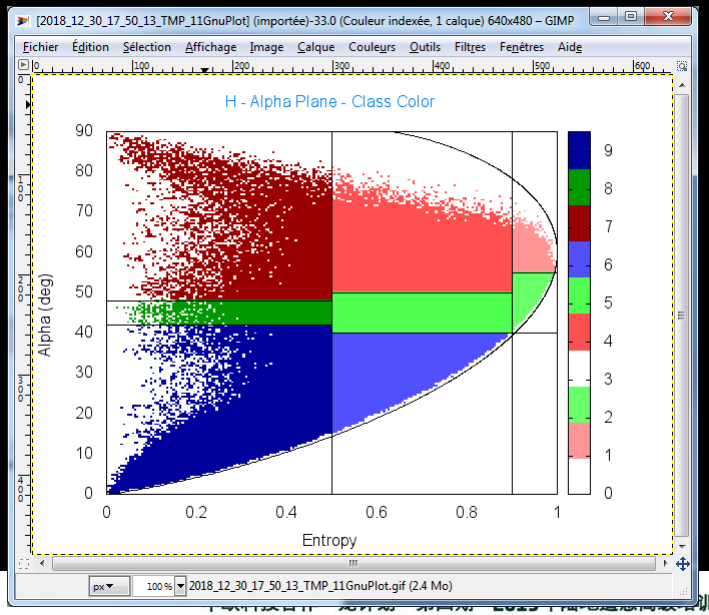
entropy.bin, anisotropy.bin, alpha.bin
combination_HA.bin, combination_1mHA.bin,
combination_H1mA.bin, combination_1mH1mA.bin
H_A_class.bin, H_Alpha_class.bin, A_Alpha_class.bin

entropy.bmp, anisotropy.bmp, alpha.bmp
combination_HA.bmp, combination_1mHA.bmp,
combination_H1mA.bmp, combination_1mH1mA.bmp
H_A_class.bmp, H_Alpha_class.bmp, A_Alpha_class.bmp
H_A_occurence.bmp, H_Alpha_ occurence.bmp,
A_Alpha_ occurence.bmp, H_A_segmented.bmp,
H_Alpha_ segmented.bmp, A_Alpha_ segmented.bmp
HAlphaLambda_RGB.bmp, HAAlpha_RGB.bmp
HACombinations_RGB.bmp

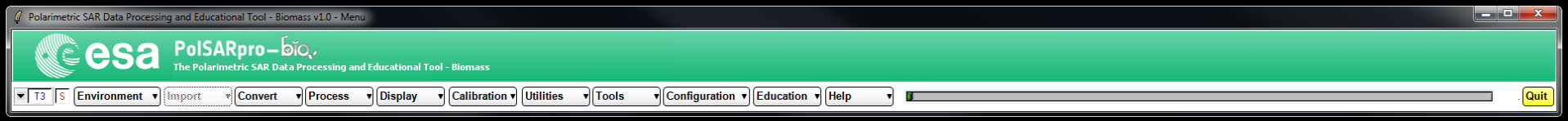
H / A / alpha CLASSIFICATIO



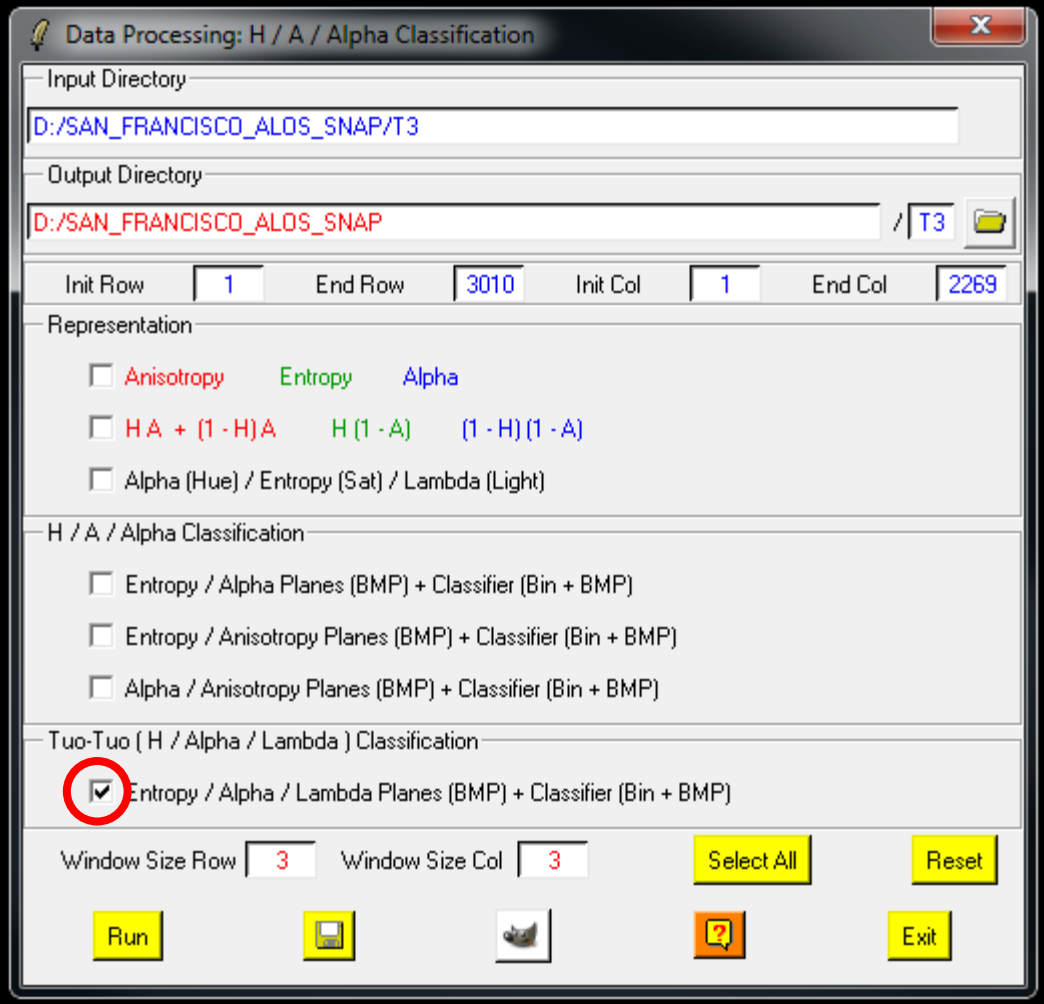




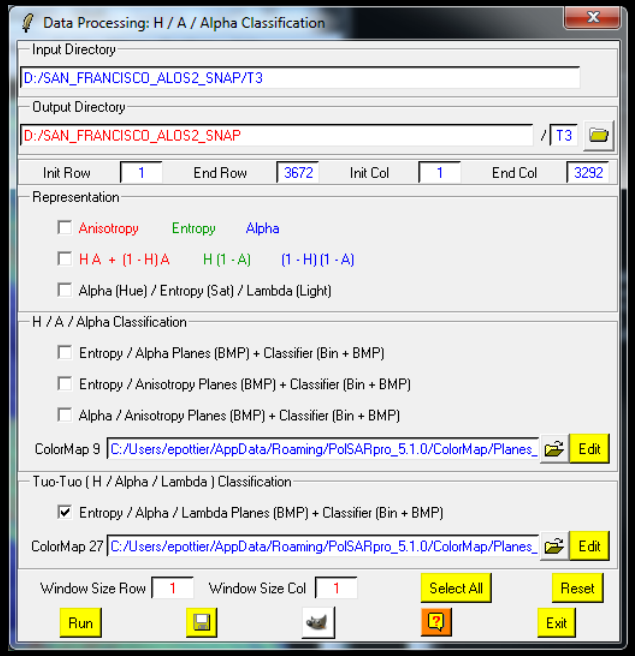
H / A / alpha CLASSIFICATION



Do it Yourself:
Select some elements, set the parameters (Nwin = 3) and view the corresponding BMP files.



H / A / alpha CLASSIFICATION

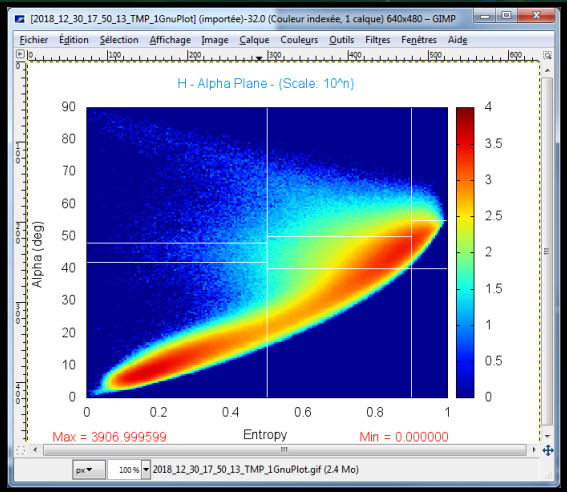


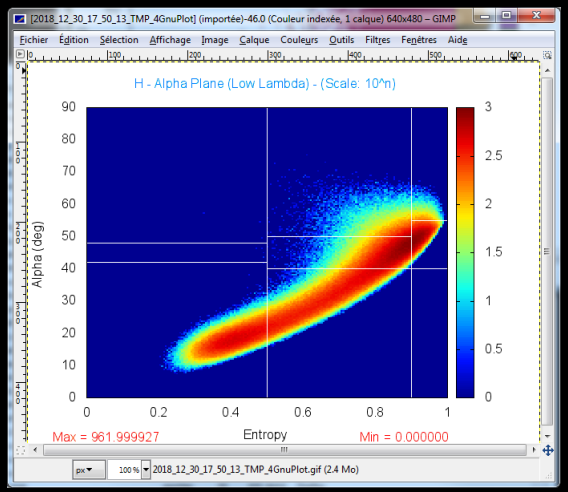
Do it Yourself:
Select some elements, set the parameters (Nwin = 3) and view the corresponding BMP files.

DATADIR

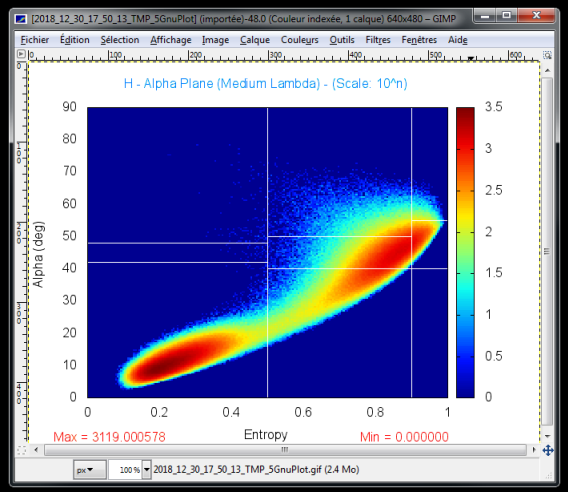
- **config.txt**
- **[T3x3] Elements**
- **H_alpha_lambda_class1(2,3).bin,**
  H_alpha_lambda_occurence_class1(2,3).bin,
  H_alpha_lambda_segmented_class1(2,3).bin,
  H_alpha_lambda_class.bin,
- **H_alpha_lambda_class1(2,3).bmp,**
  H_alpha_lambda_occurence_class1(2,3).bmp,
  H_alpha_lambda_segmented_class1(2,3).bmp,
  H_alpha_lambda_class.bmp,

H / A / alpha CLASSIFICATION

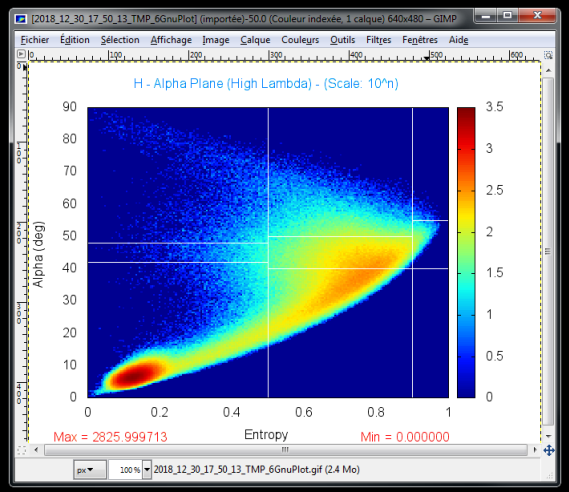




Low λ

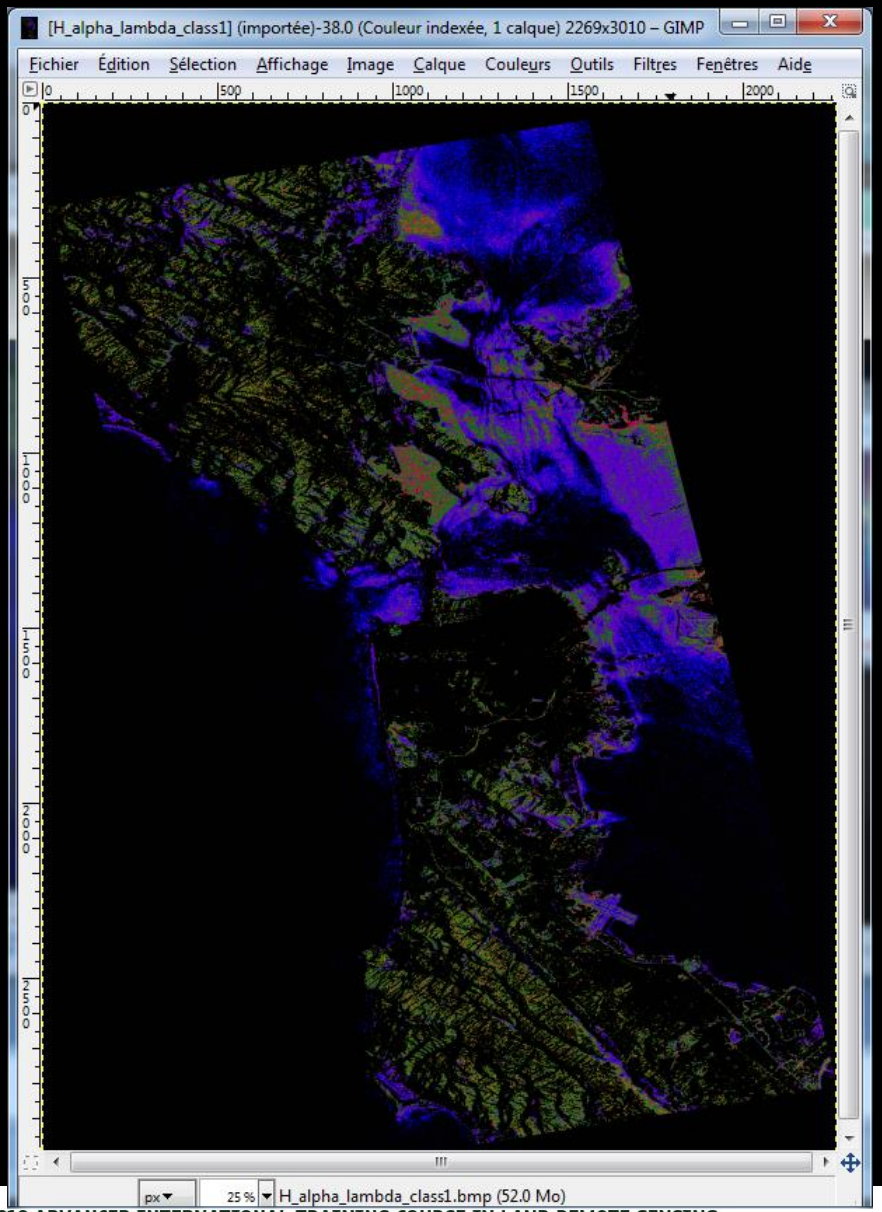


Medium λ

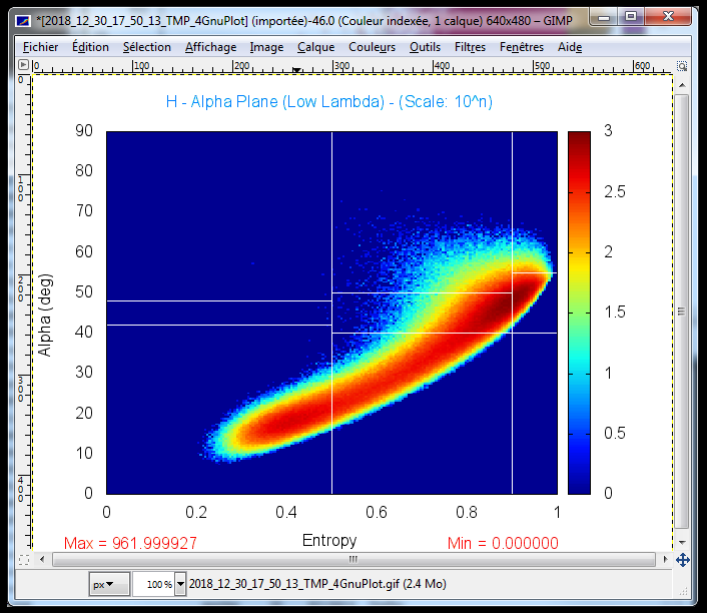


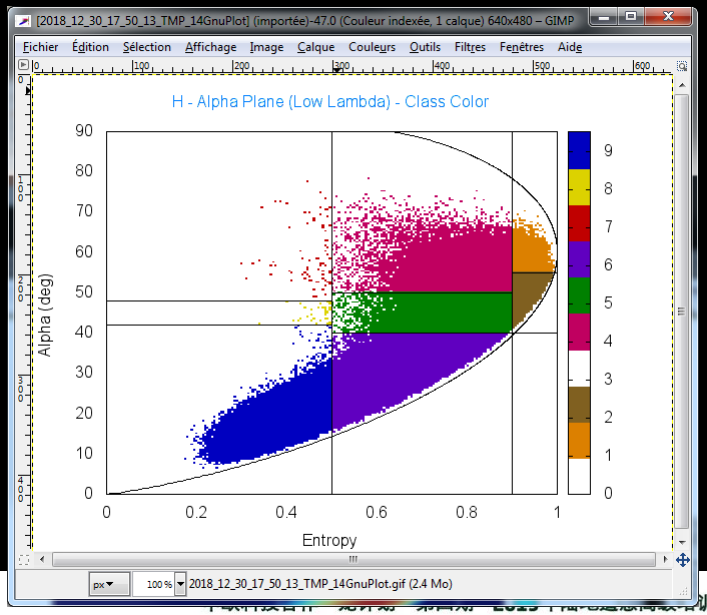
High λ

H / A / alpha CLASSIFICATIO

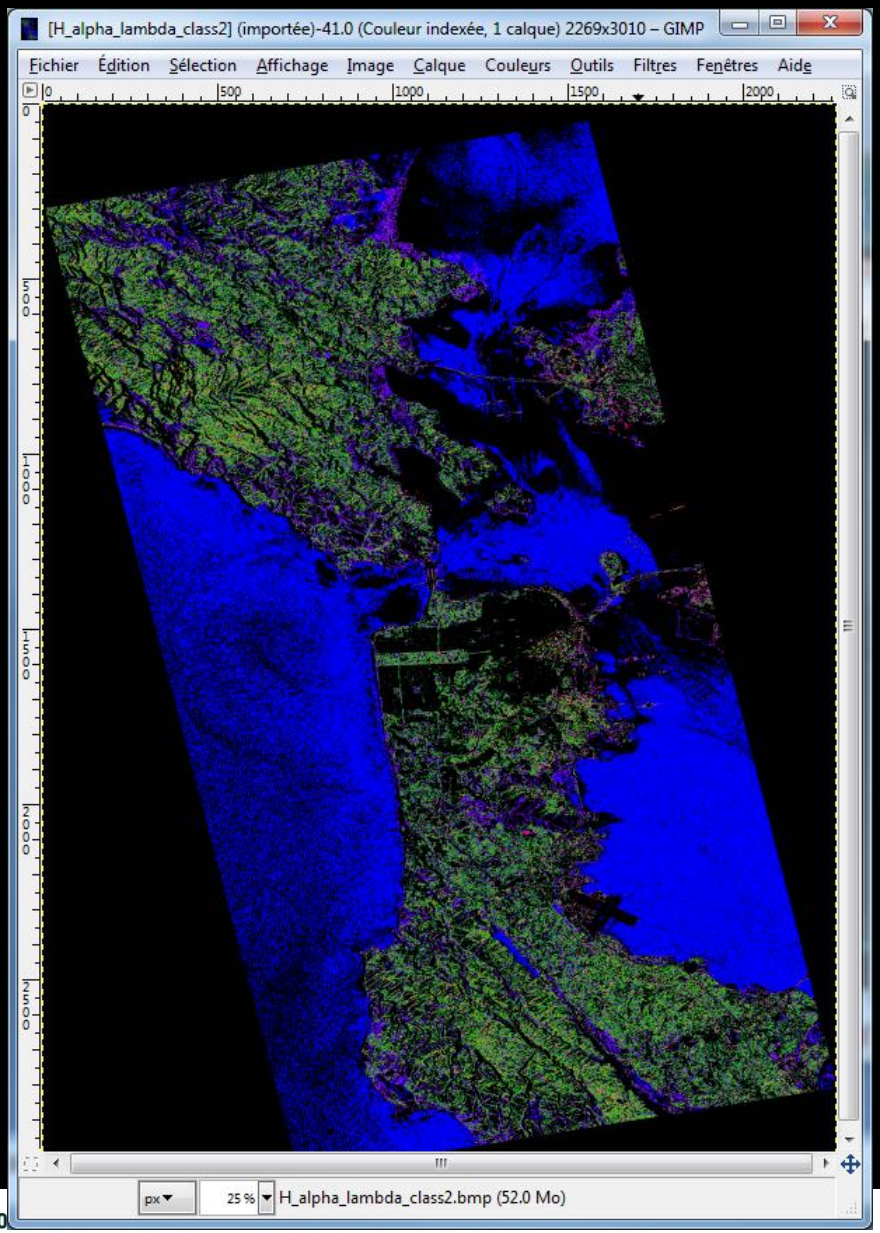


Low λ

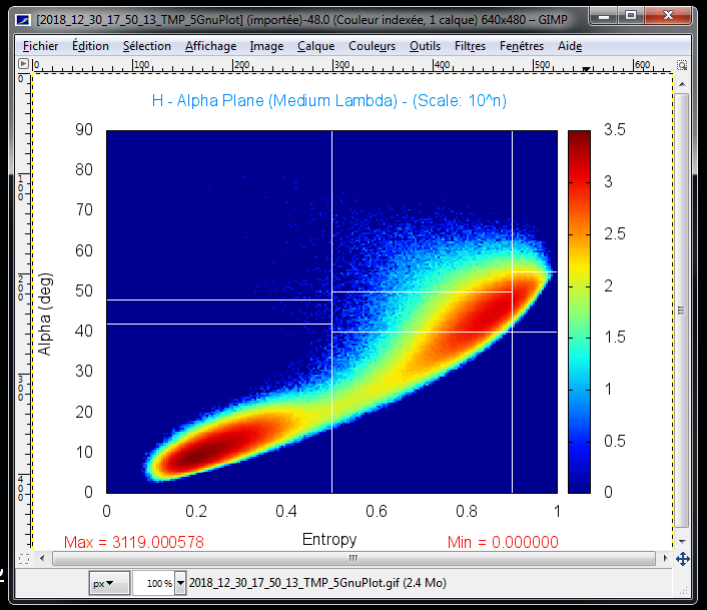


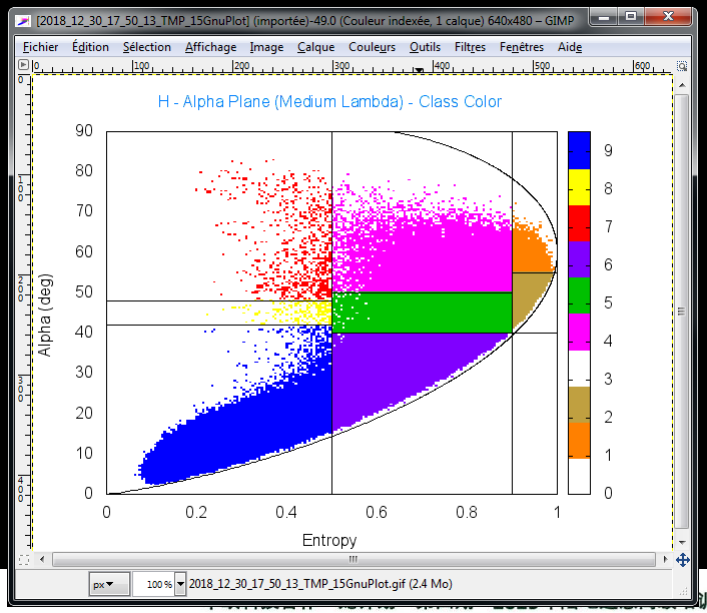


H / A / alpha CLASSIFICATIO

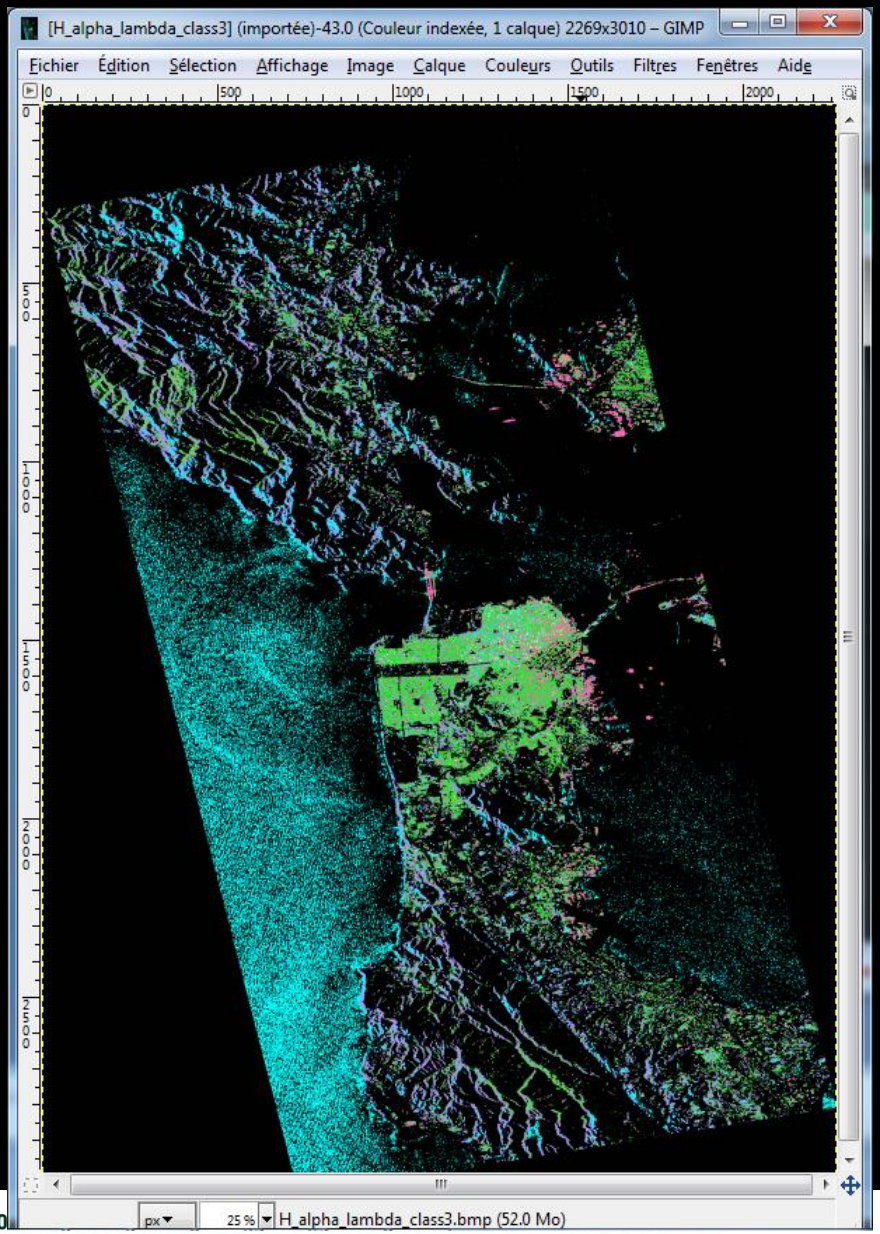


Medium λ

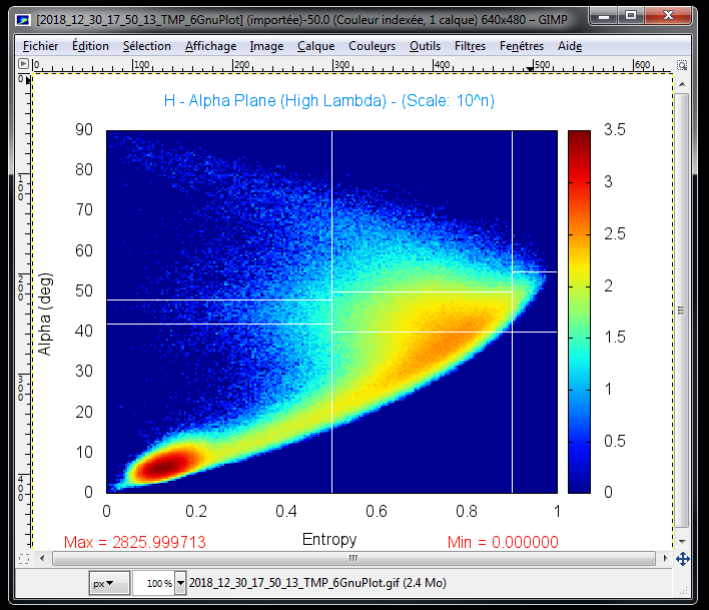


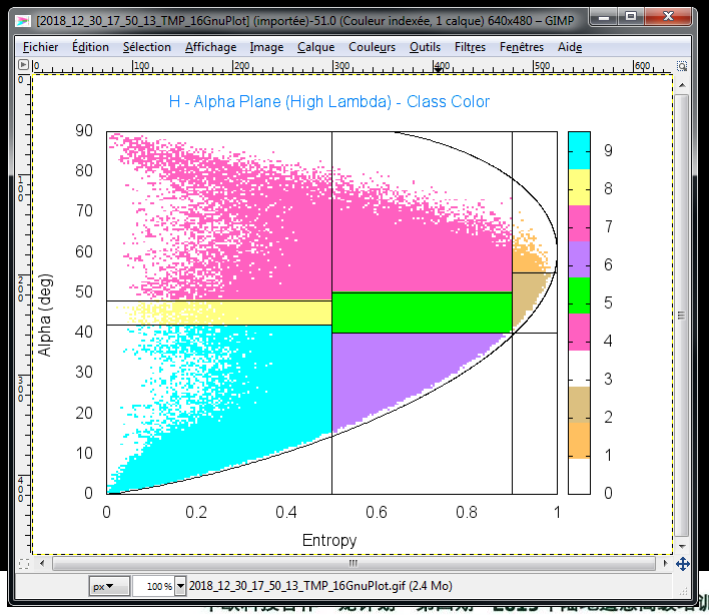


H / A / alpha CLASSIFICATIO

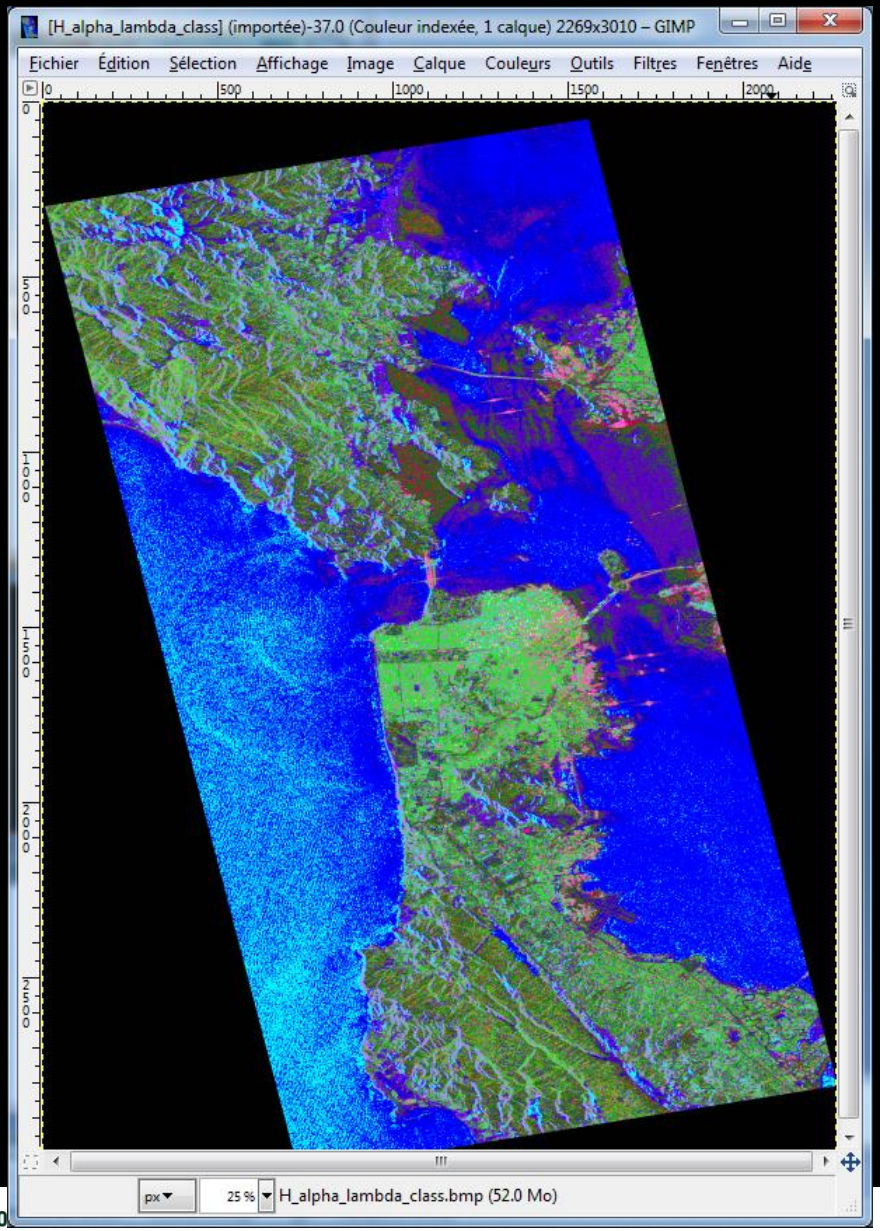


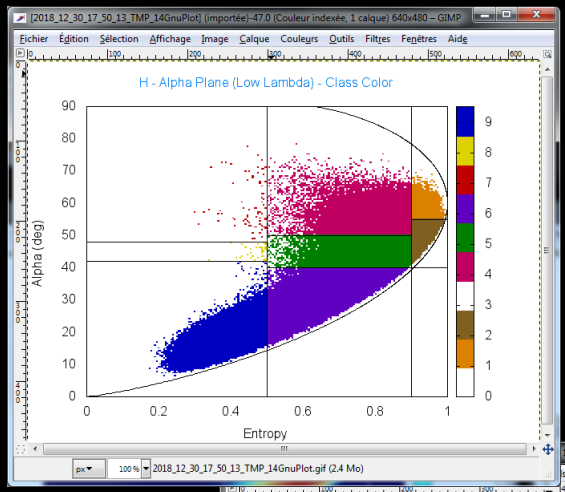
High $\underline{\lambda}$

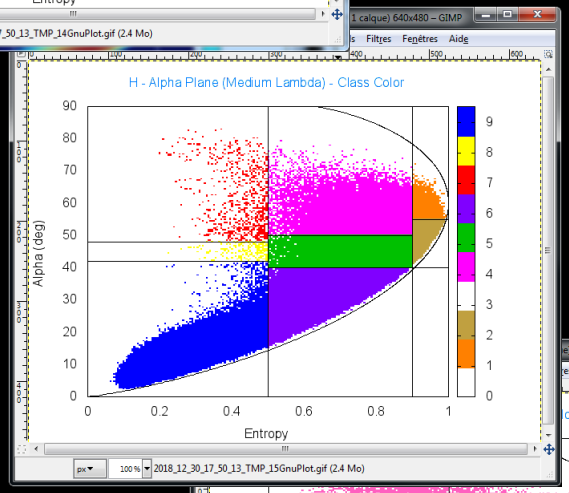


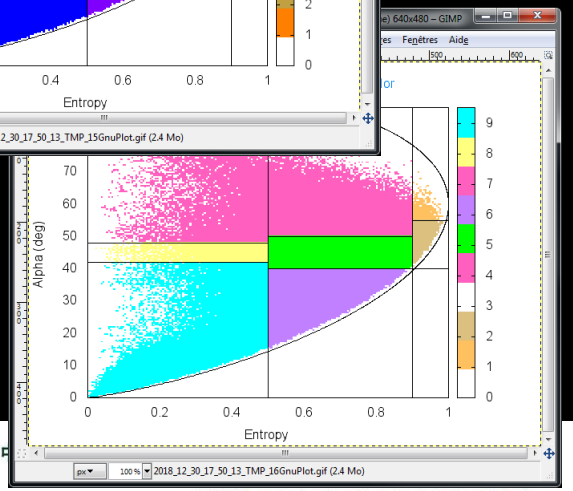


H / A / alpha CLASSIFICATIO



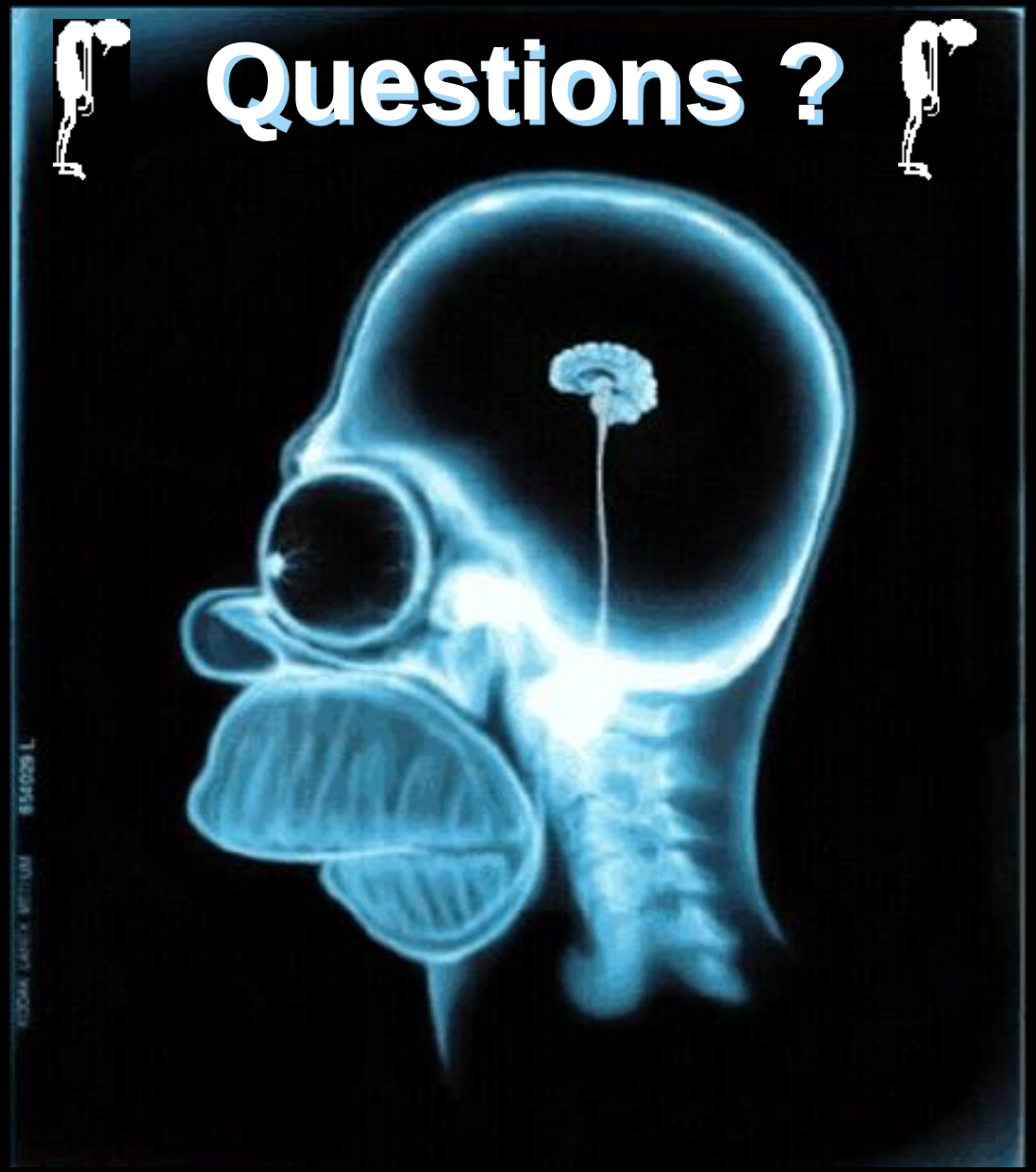




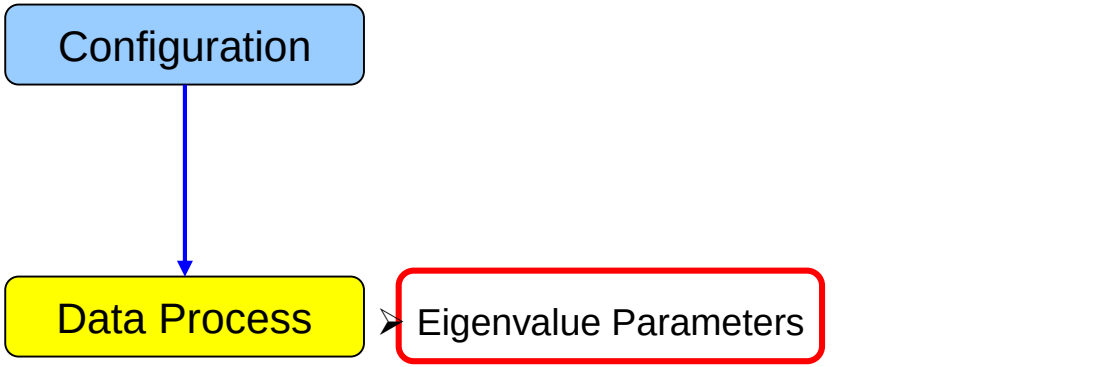


E.P (2019)

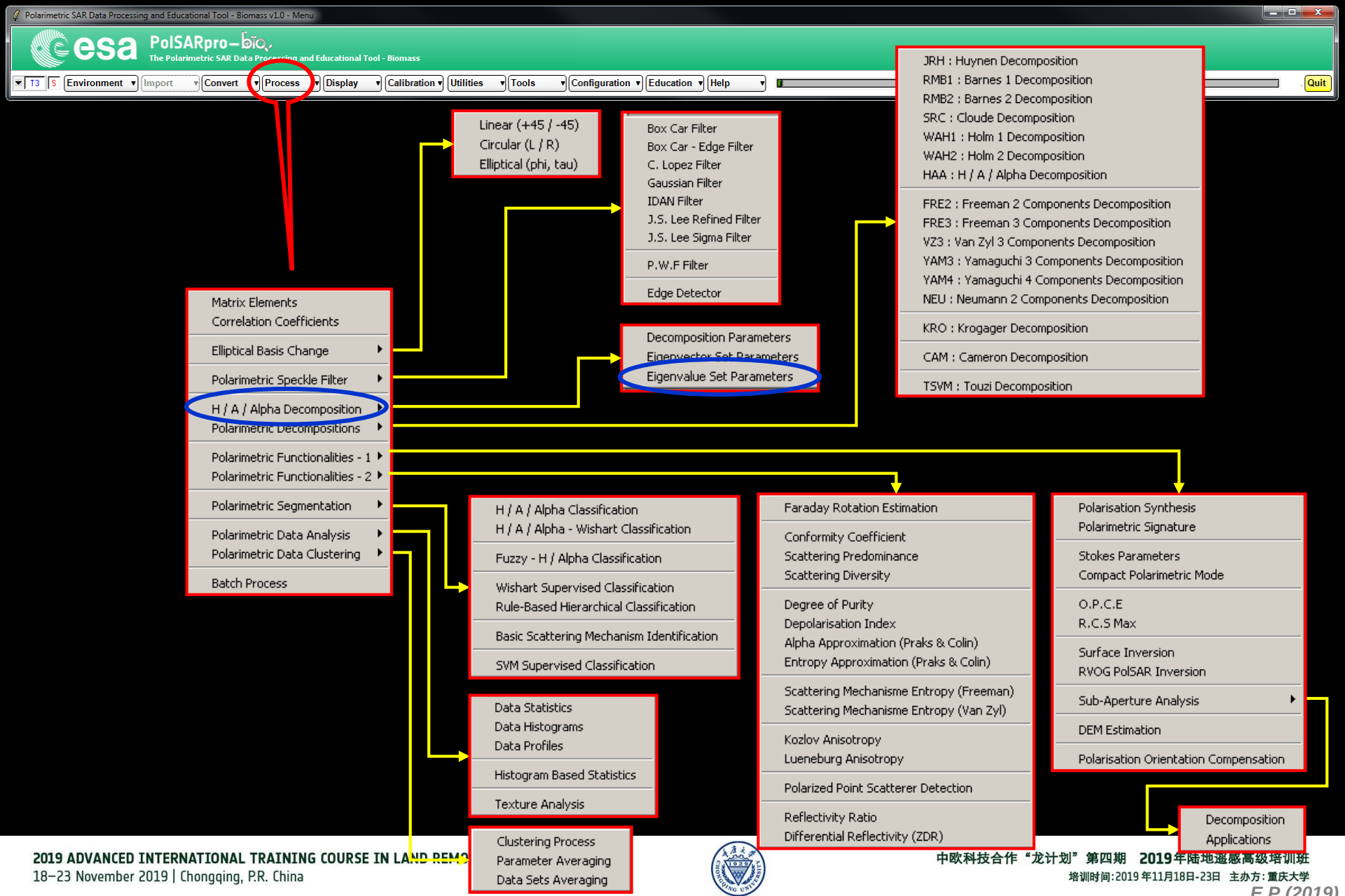
Questions ?



PROCESSING CHAIN



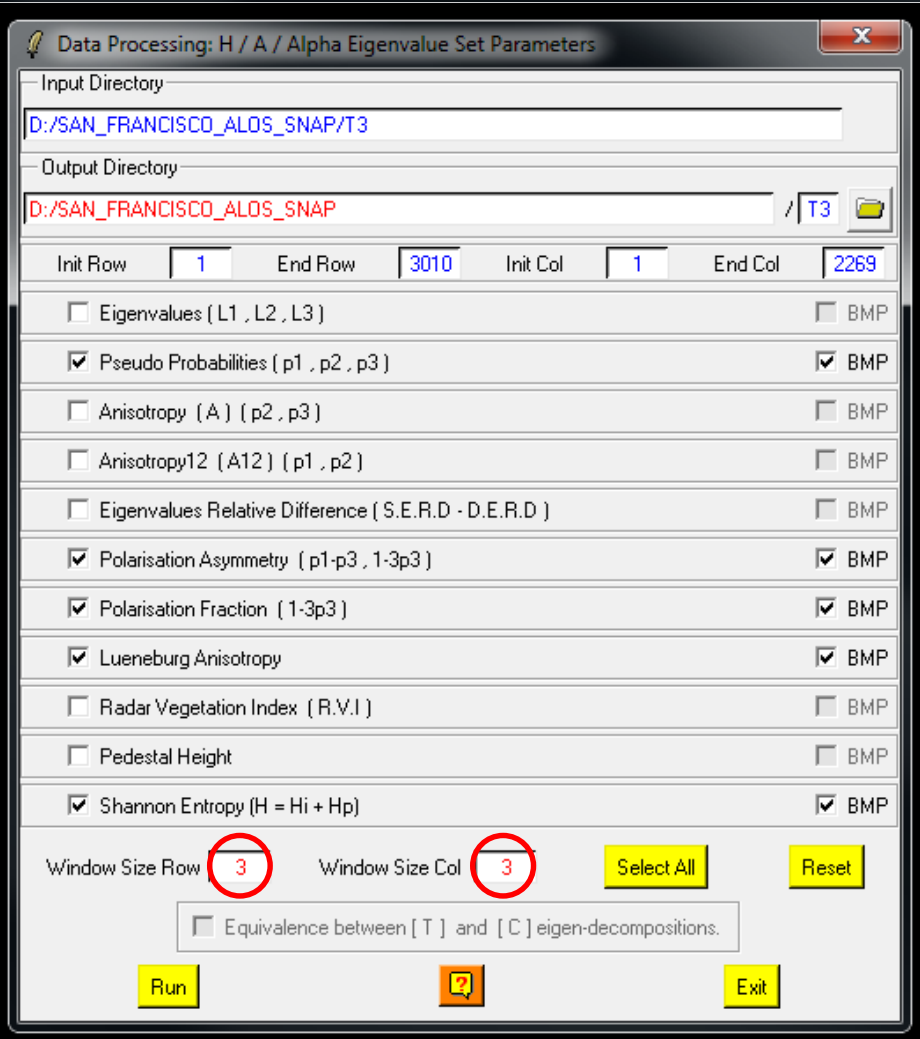
PolSARpro v5.1 SOFTWARE



EIGENVALUE SET PARAMETE

Do it Yourself:
Select some elements, set the parameters and view the corresponding BMP files (select BMP).

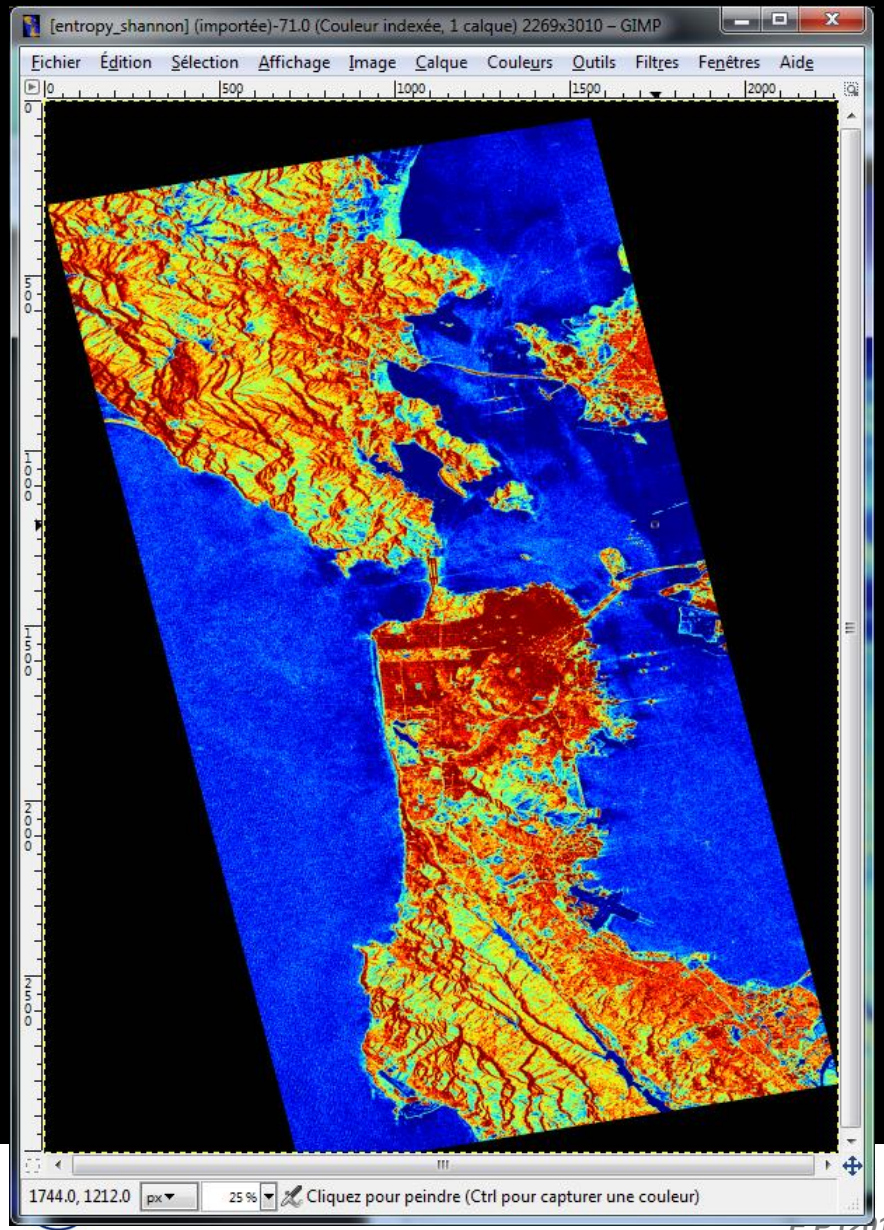
Window Size = 3



EIGENVALUE SET PARAMETERS

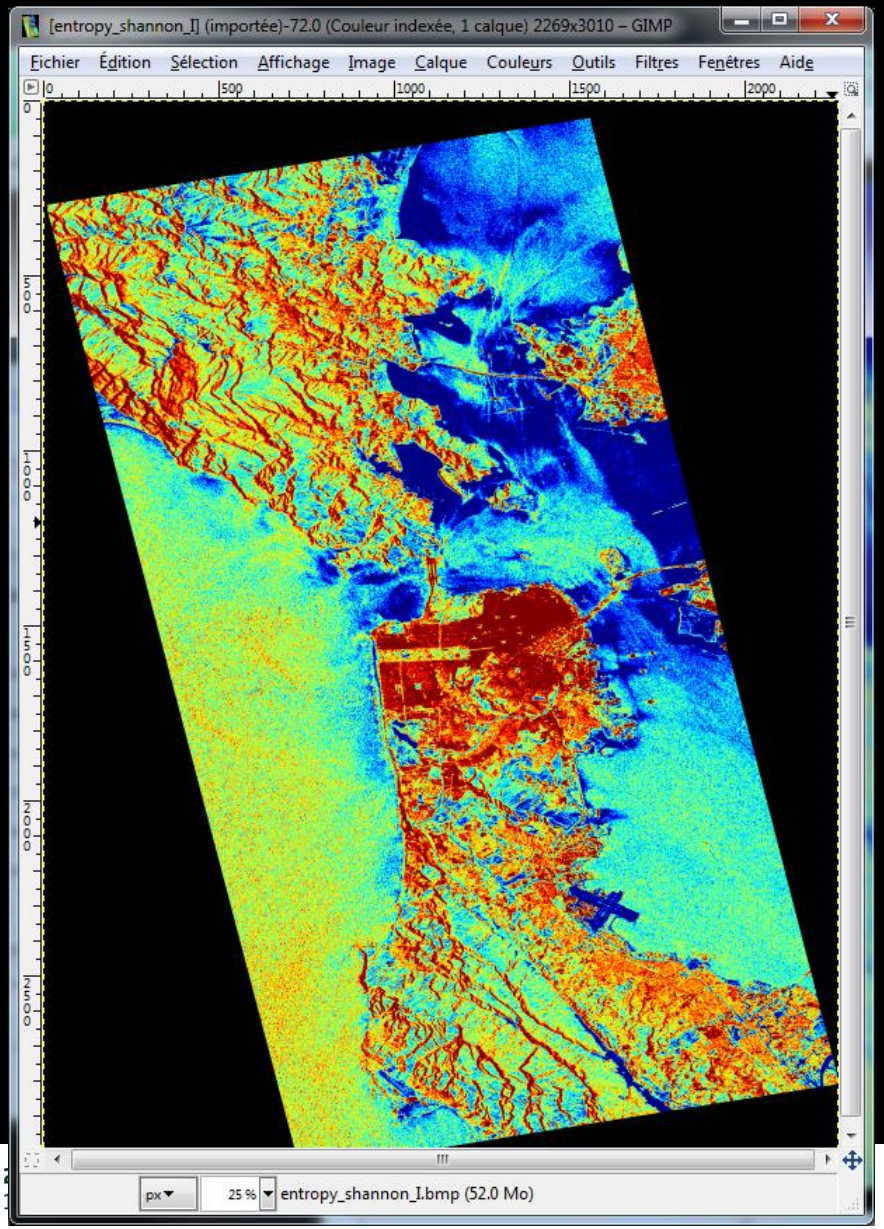
Pauli RGB

Entropy Shannon

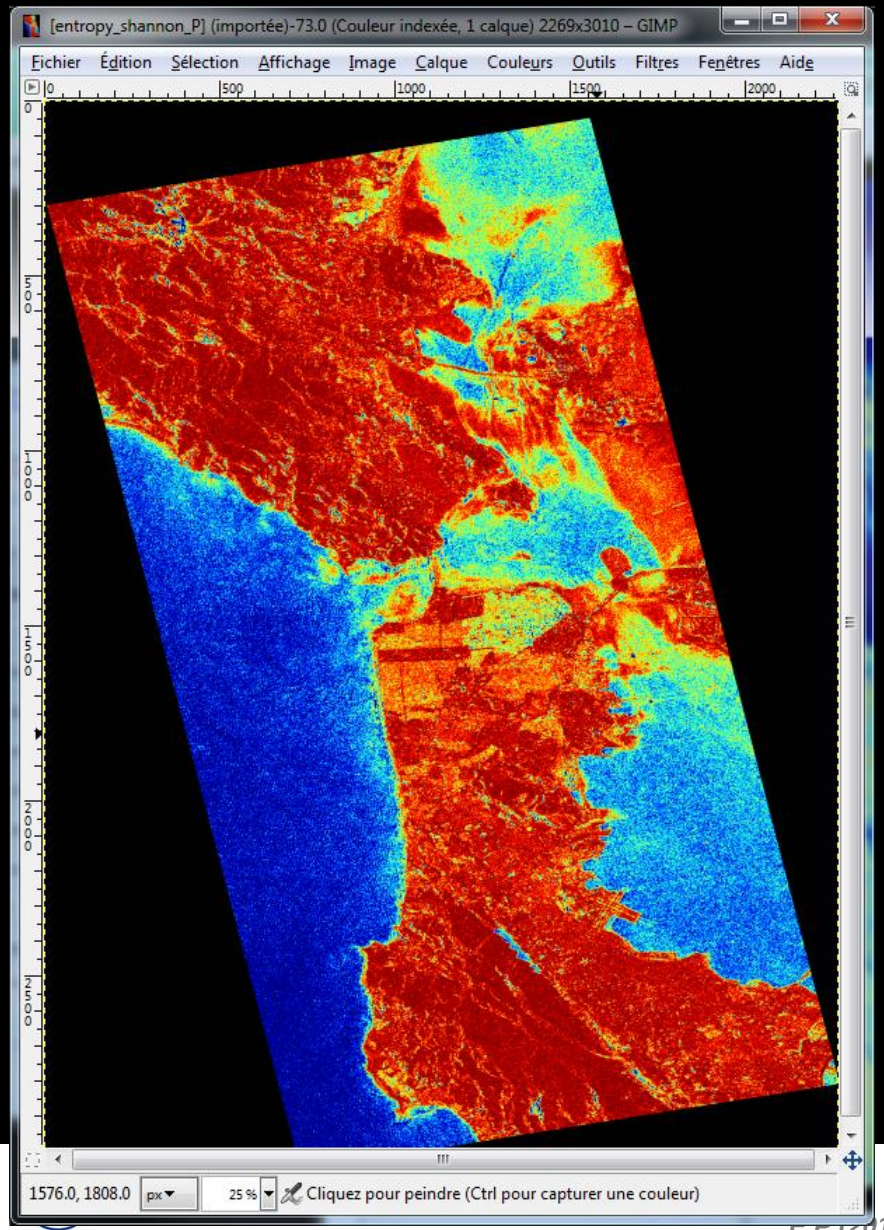


EIGENVALUE SET PARAMETER

Entropy I

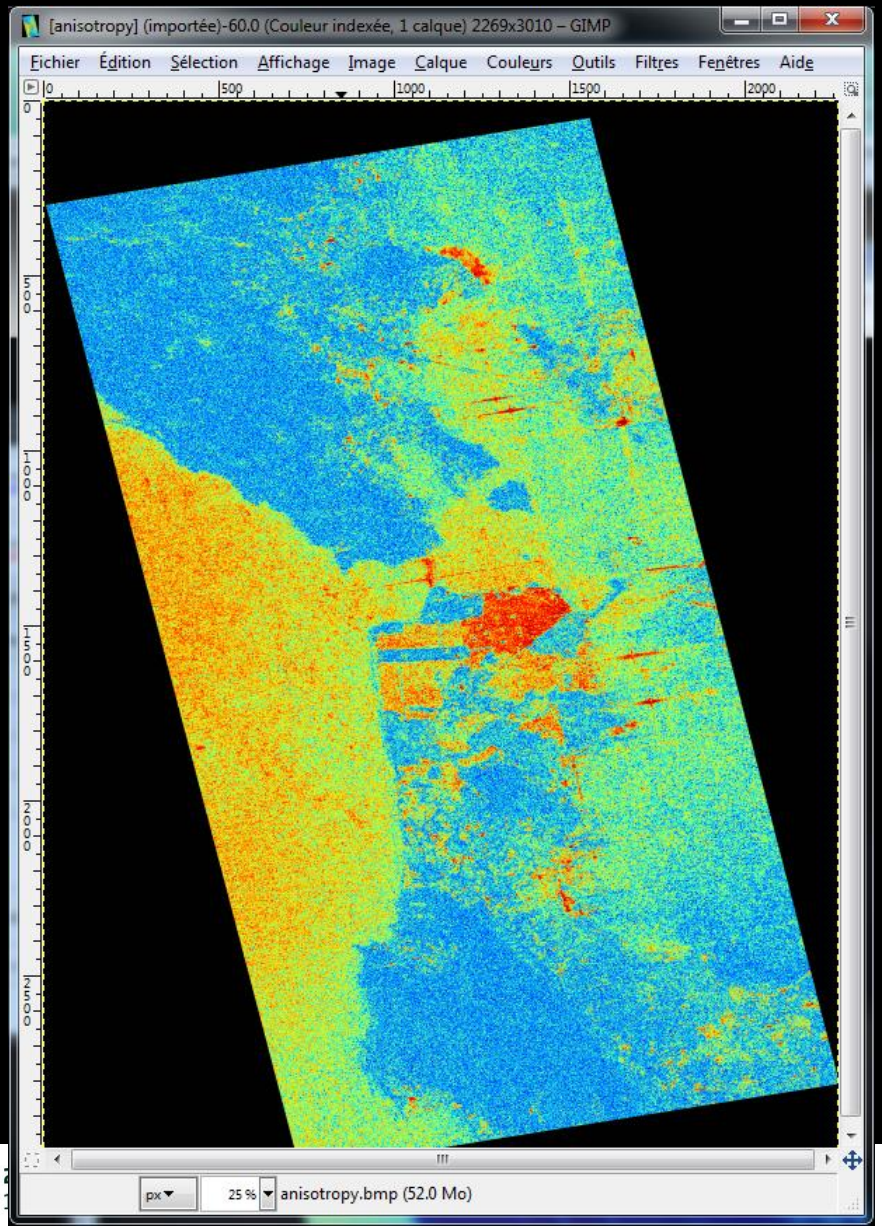


Entropy P

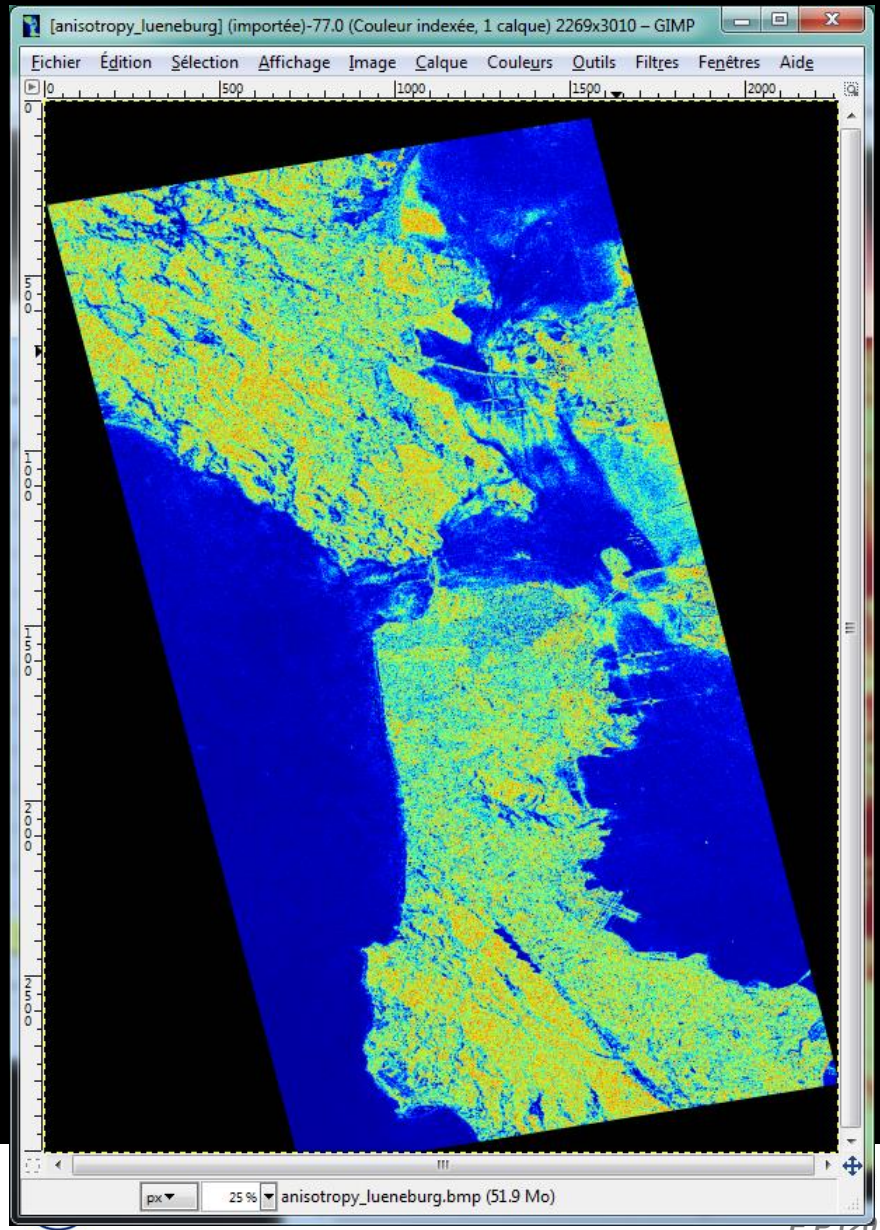


EIGENVALUE SET PARAMETE

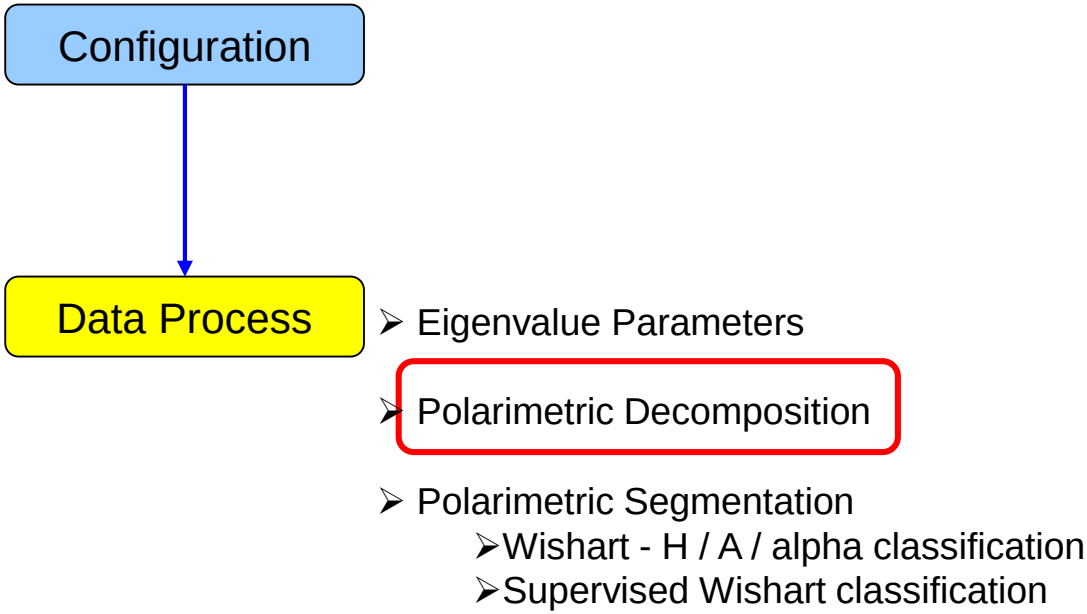
Anisotropy



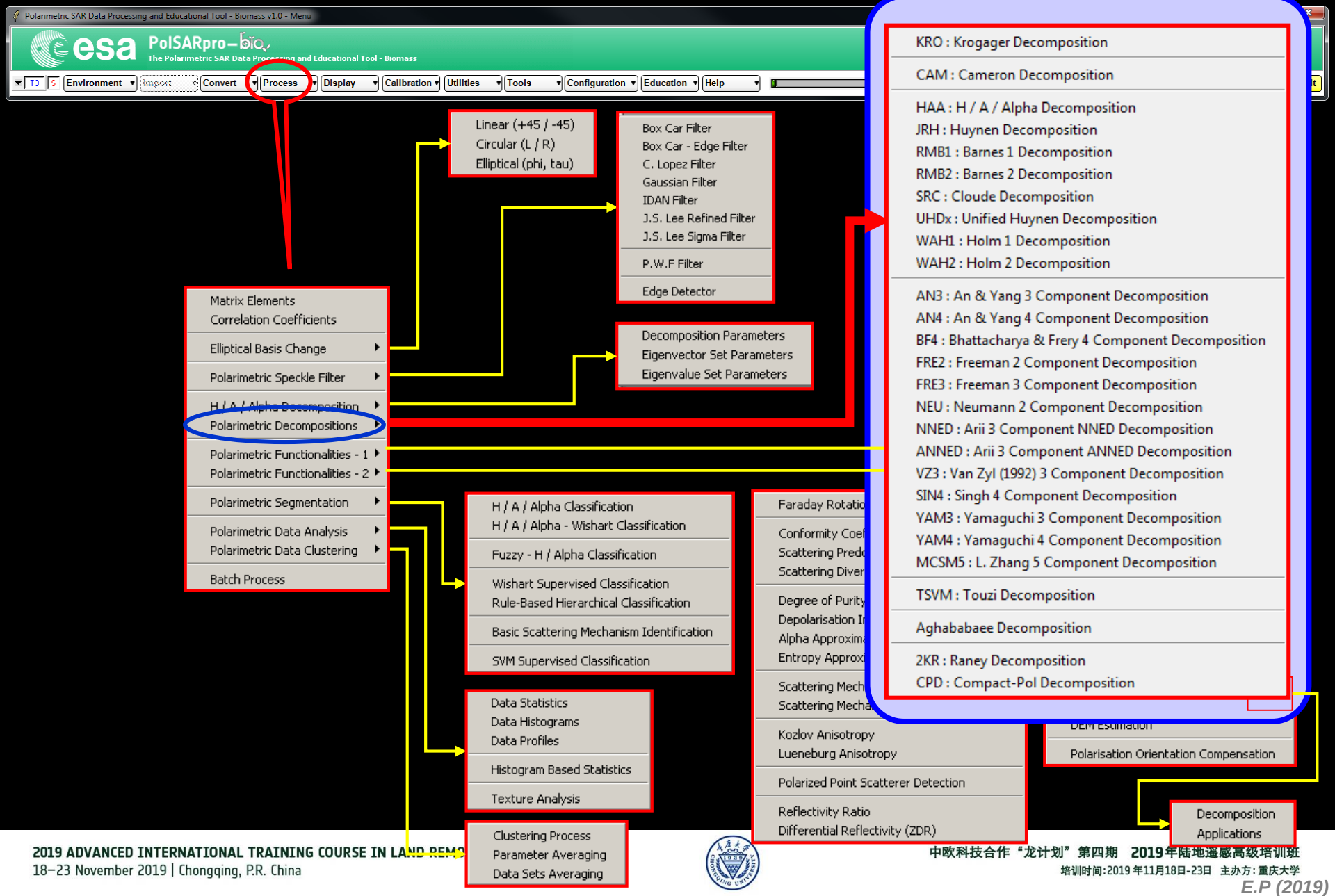
Lueneburg Anisotropy



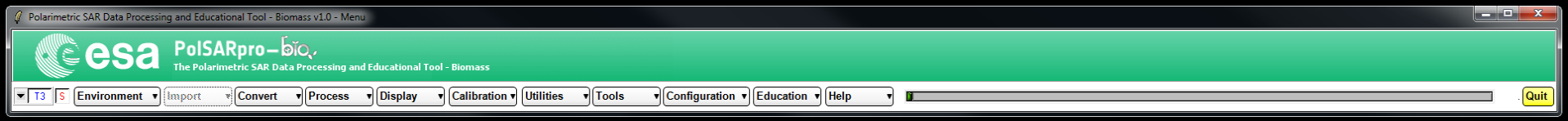
PROCESSING CHAIN



PolSARpro v5.1 SOFTWARE



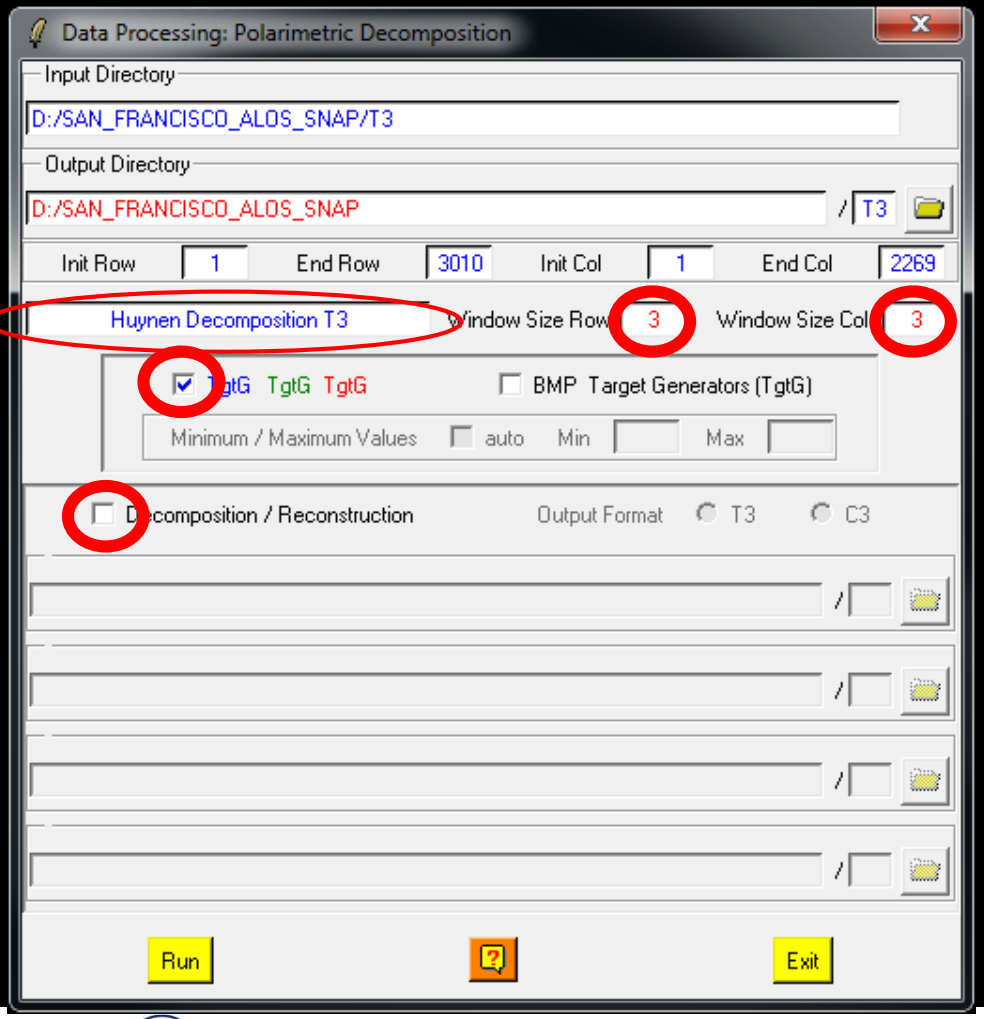
POLARIMETRIC DECOMPOSITION



Do it Yourself:
Select a decomposition,
Select the pauli RGB generation.

Don't select Decomposition / Reconstruction

Window Size = 3



POLARIMETRIC DECOMPOSITION

Pauli RGB

Pauli Huynen

POLARIMETRIC DECOMPOSITION

Pauli RGB

Pauli Cloude

POLARIMETRIC DECOMPOSITION

Pauli RGB

Pauli H-A-Alpha

POLARIMETRIC DECOMPOSITION

Pauli RGB

Pauli Van Zyl 3

POLARIMETRIC DECOMPOSITION

Pauli RGB

Pauli Freeman 3

POLARIMETRIC DECOMPOSITION

Pauli RGB

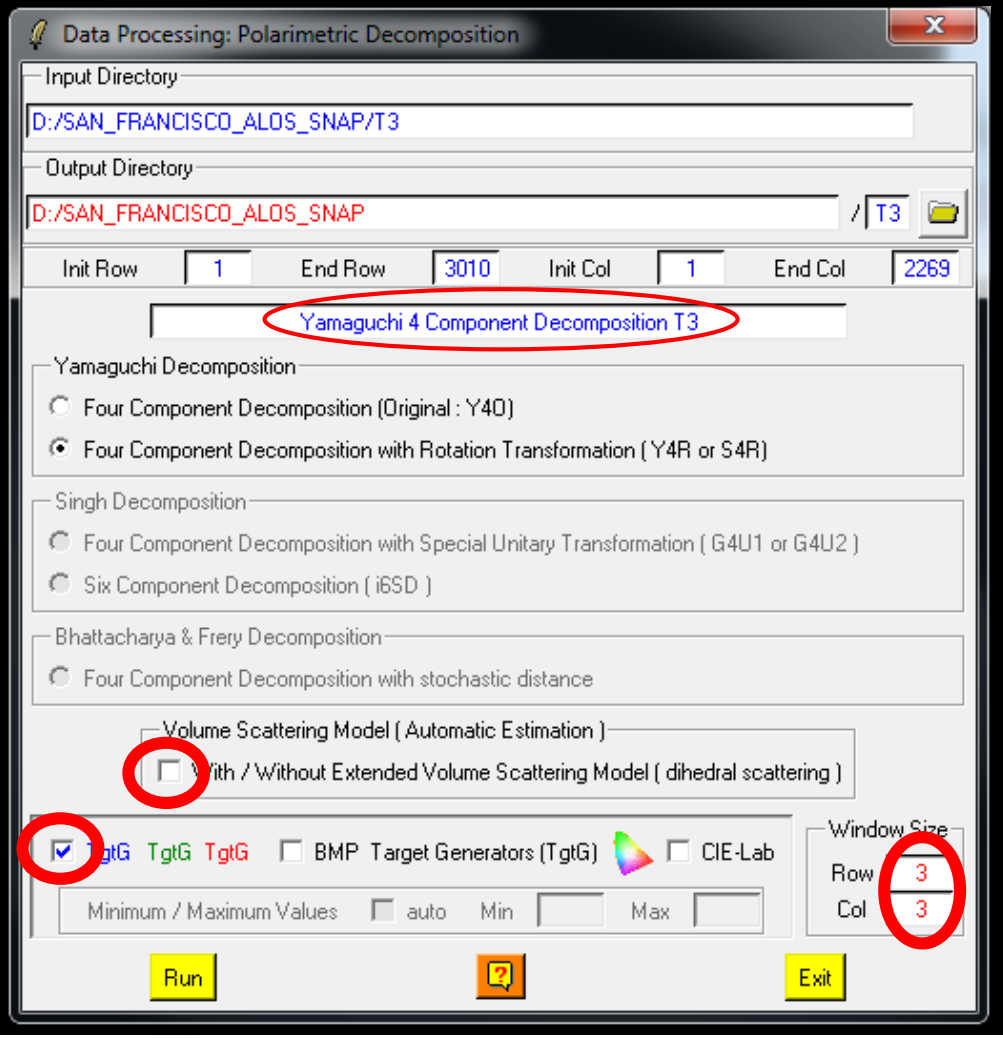
Pauli Yamaguchi 3

POLARIMETRIC DECOMPOSITION

Do it Yourself:
Select a decomposition,
Select the pauli RGB generation.

Window Size = 3

Yamaguchi Y40, Y4R, S4R
Singh G4U1, G4U2



POLARIMETRIC DECOMPOSITION

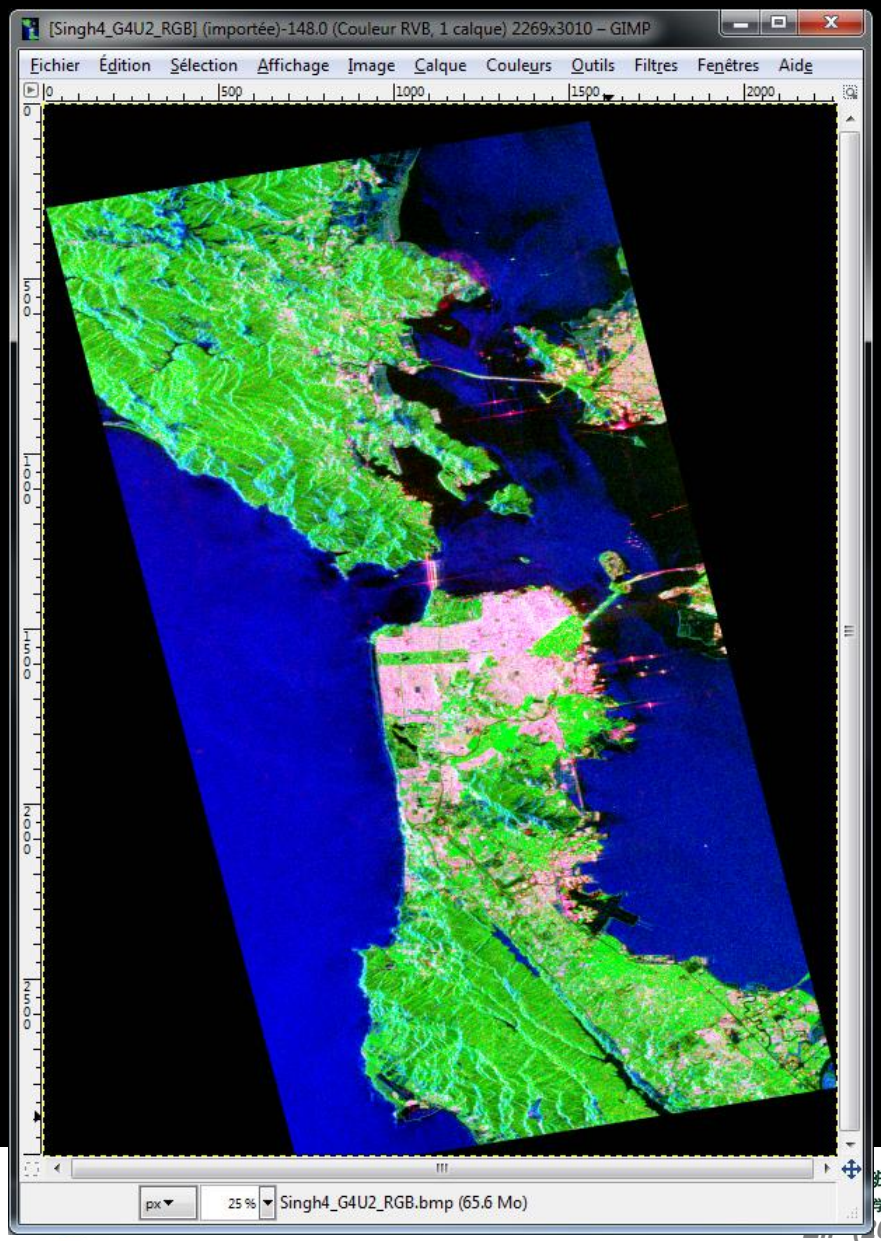
Pauli Yamaguchi 3

Pauli Yamaguchi Y4R

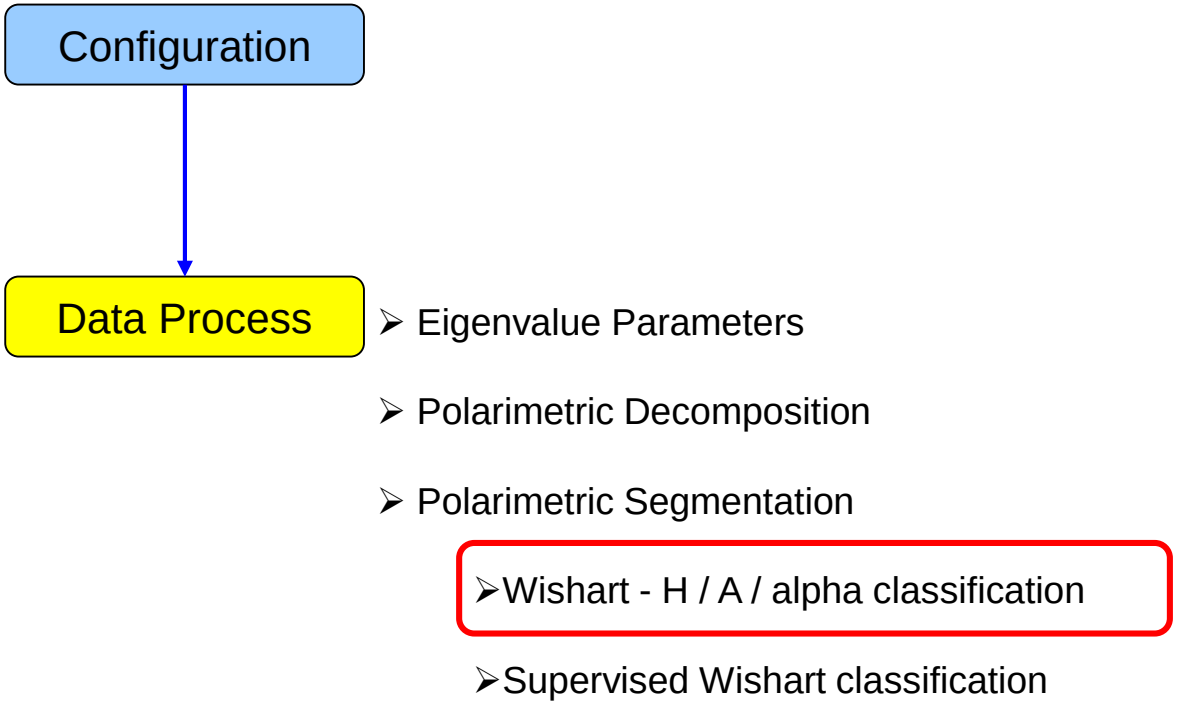
POLARIMETRIC DECOMPOSITION

Pauli Yamaguchi Y4R

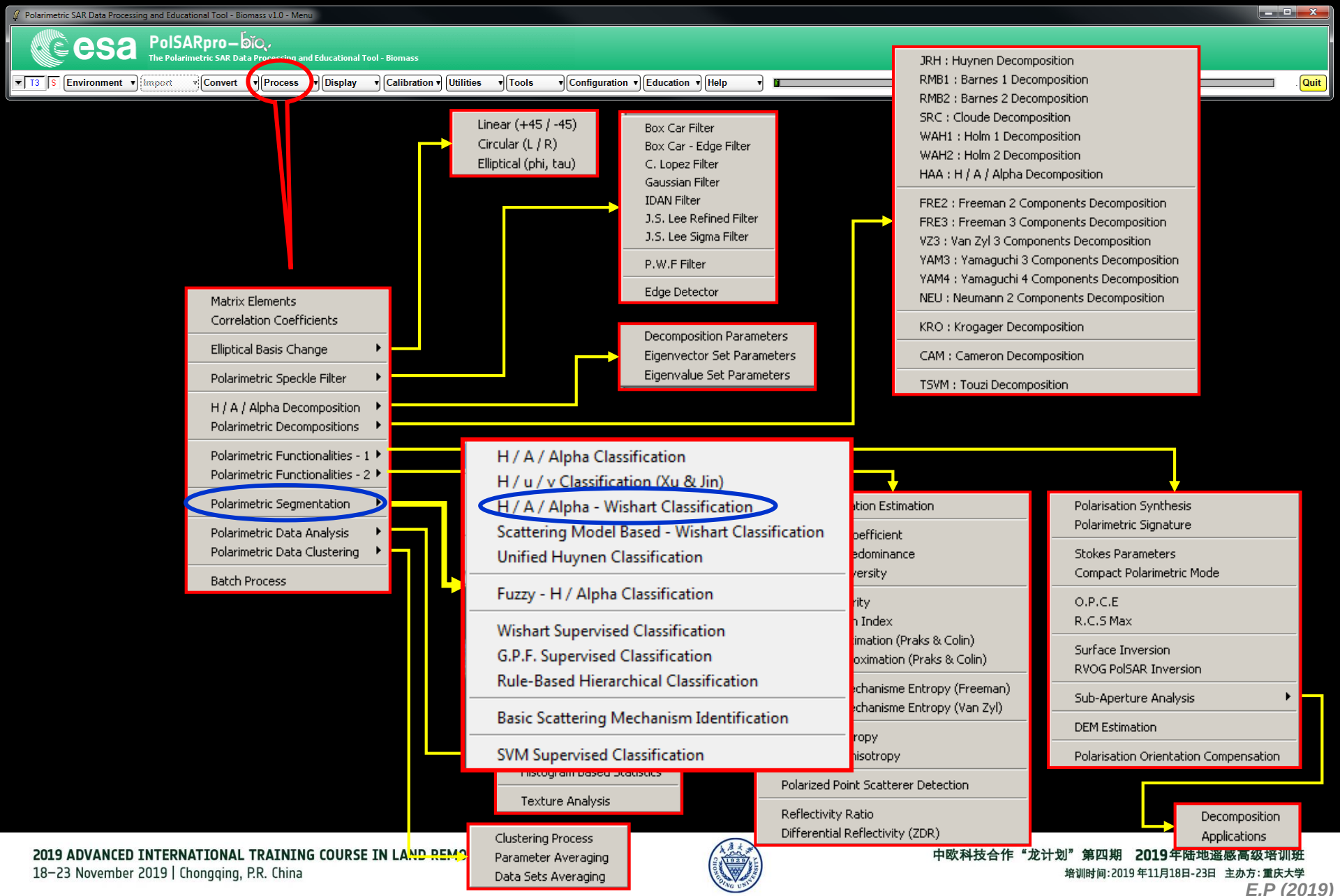
Pauli Singh - Yamaguchi G4U2



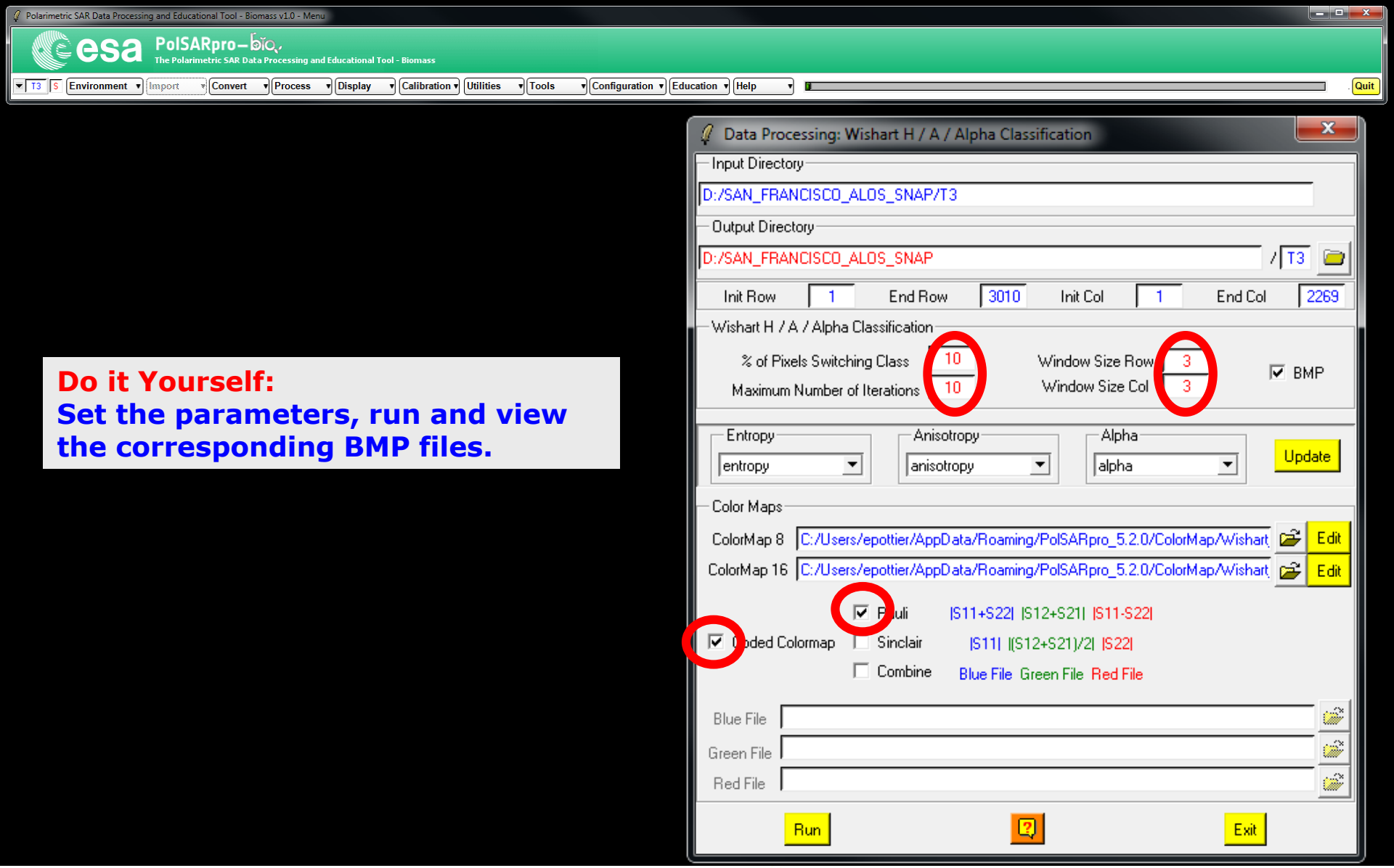
PROCESSING CHAIN



PolSARpro v5.1 SOFTWARE

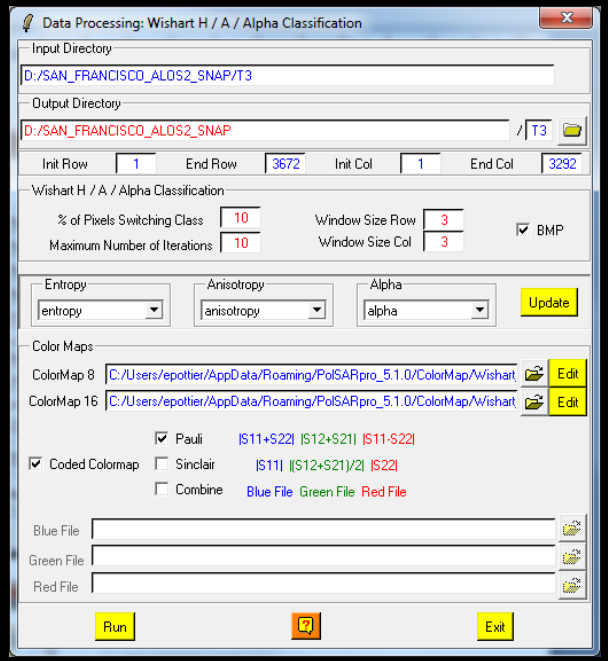


WISHART - H/A/alpha CLASSIFICATION



Do it Yourself:
Set the parameters, run and view the corresponding BMP files.

WISHART - H/A/alpha CLASSIFICATION



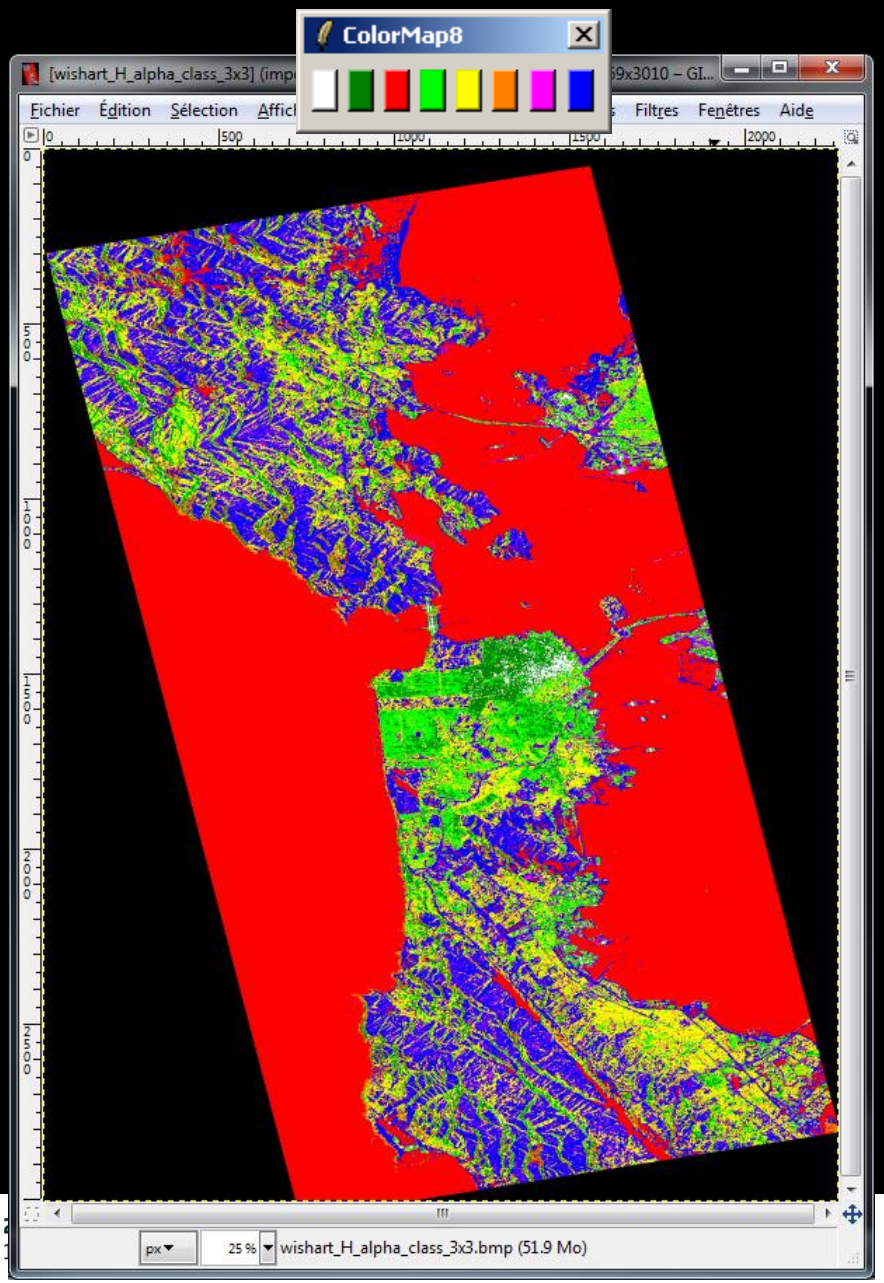
DATADIR

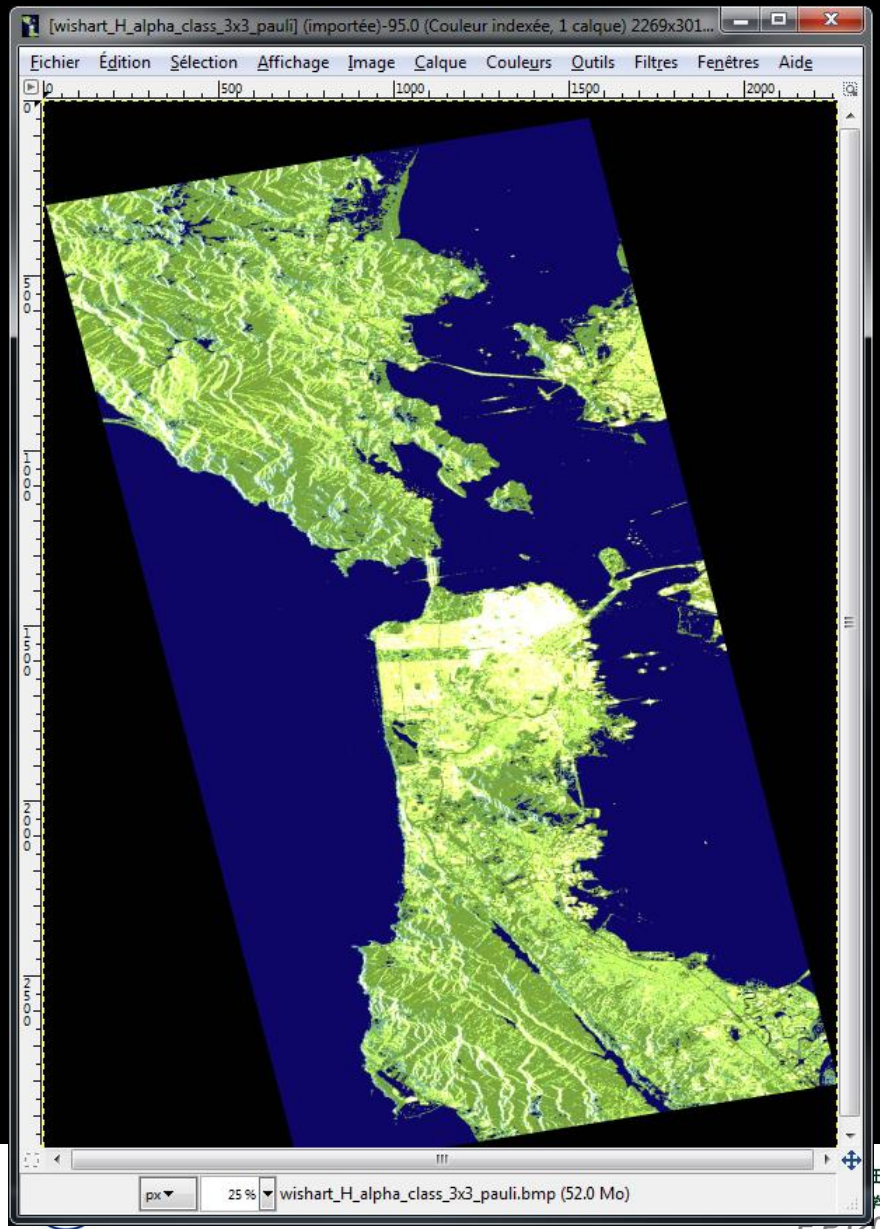
- config.txt
- [T3x3] Elements
- Wishart_H_alpha_class_X.bin
  Wishart_H_A_alpha_class_X.bin
- Wishart_H_alpha_class_X.bmp
  Wishart_H_A_alpha_class_X.bmp

X = window size

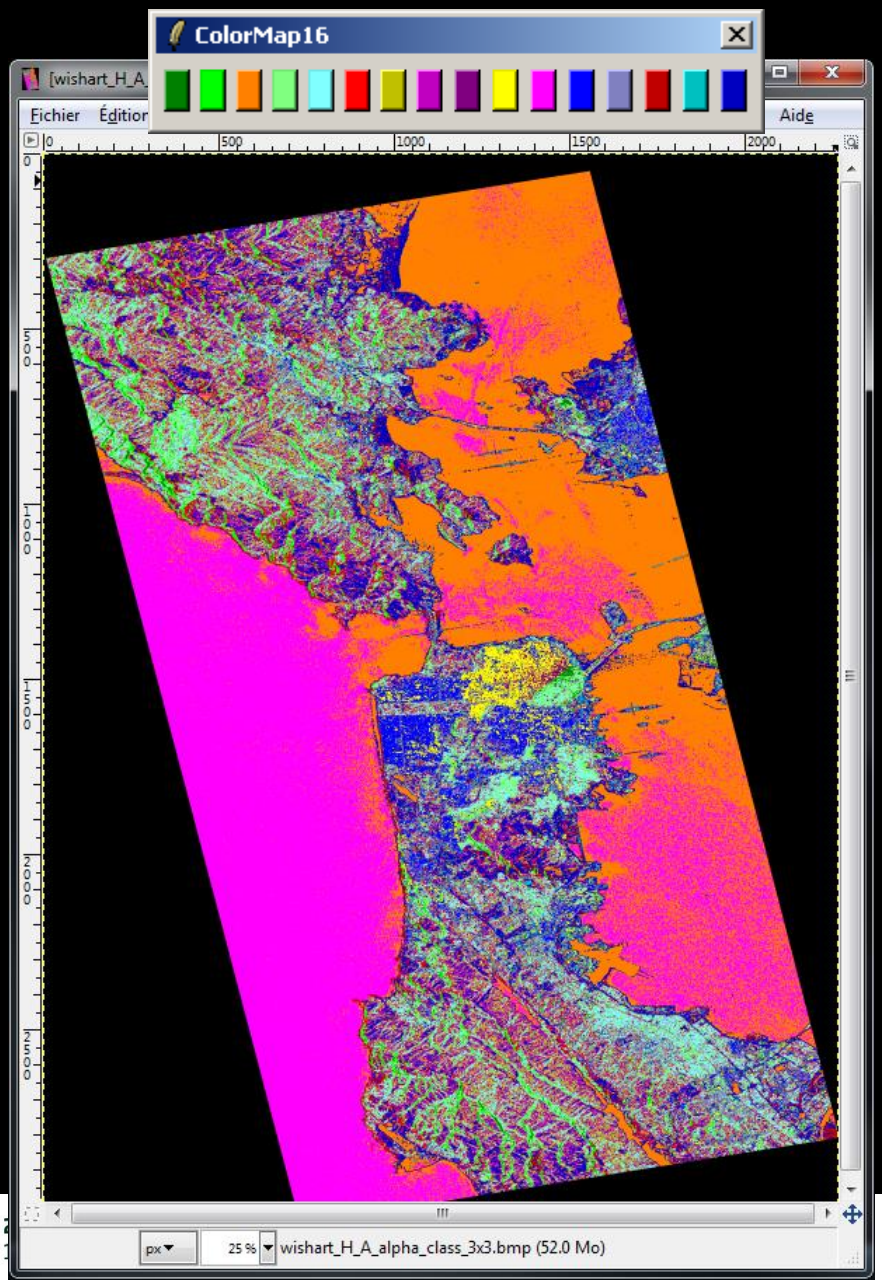
Do it Yourself:
Set the parameters, run and view the corresponding BMP files.

WISHART - H/A/alpha CLASSIFICATION





WISHART - H/A/alpha CLASSIFICATION



Questions ?