



HISTORY



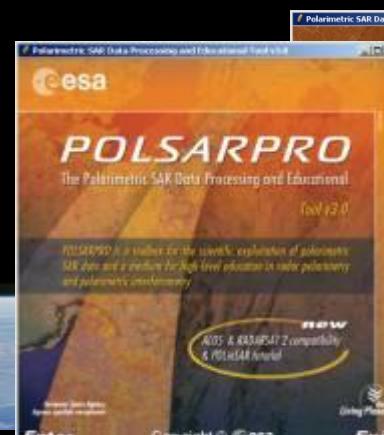
2003



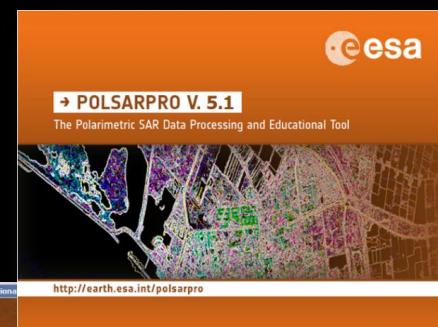
2004



2005

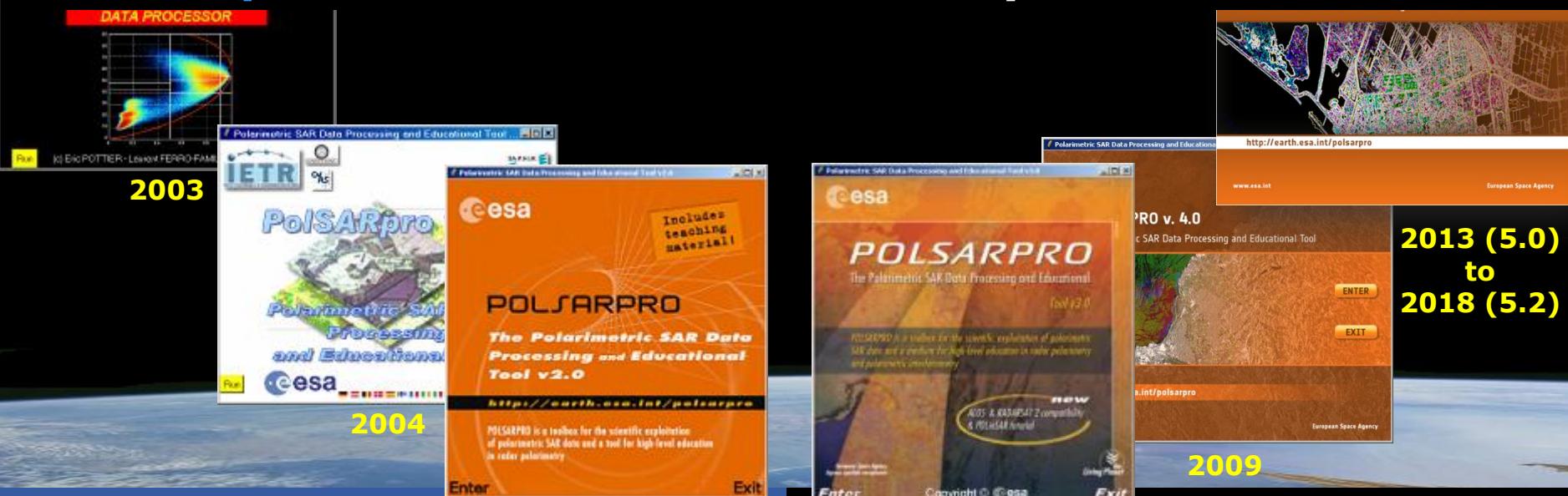


2009

2013 (5.0)
to
2018 (5.2)



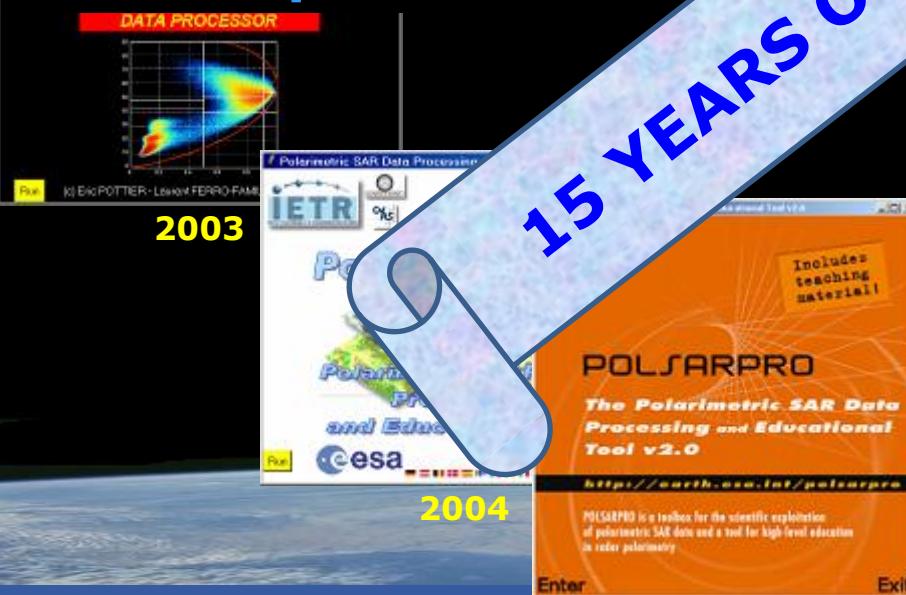
The initiative development of **PolSARpro Software** is a direct result of recommendations made during the **POLinSAR 2003 Workshop** held at ESA-ESRIN in January 2003.



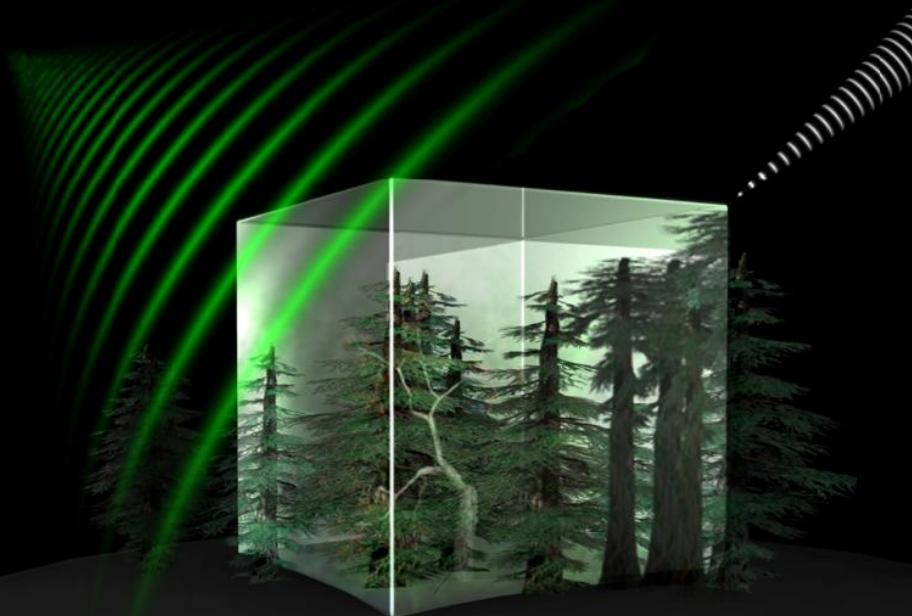


The initiative development of the PolSarPro Software is a direct result of recommendations made during the **POLinSAR 2003 Workshop** held at ESA-Esrin, Italy, 14-16 January 2003.

15 YEARS OF DEVELOPMENT



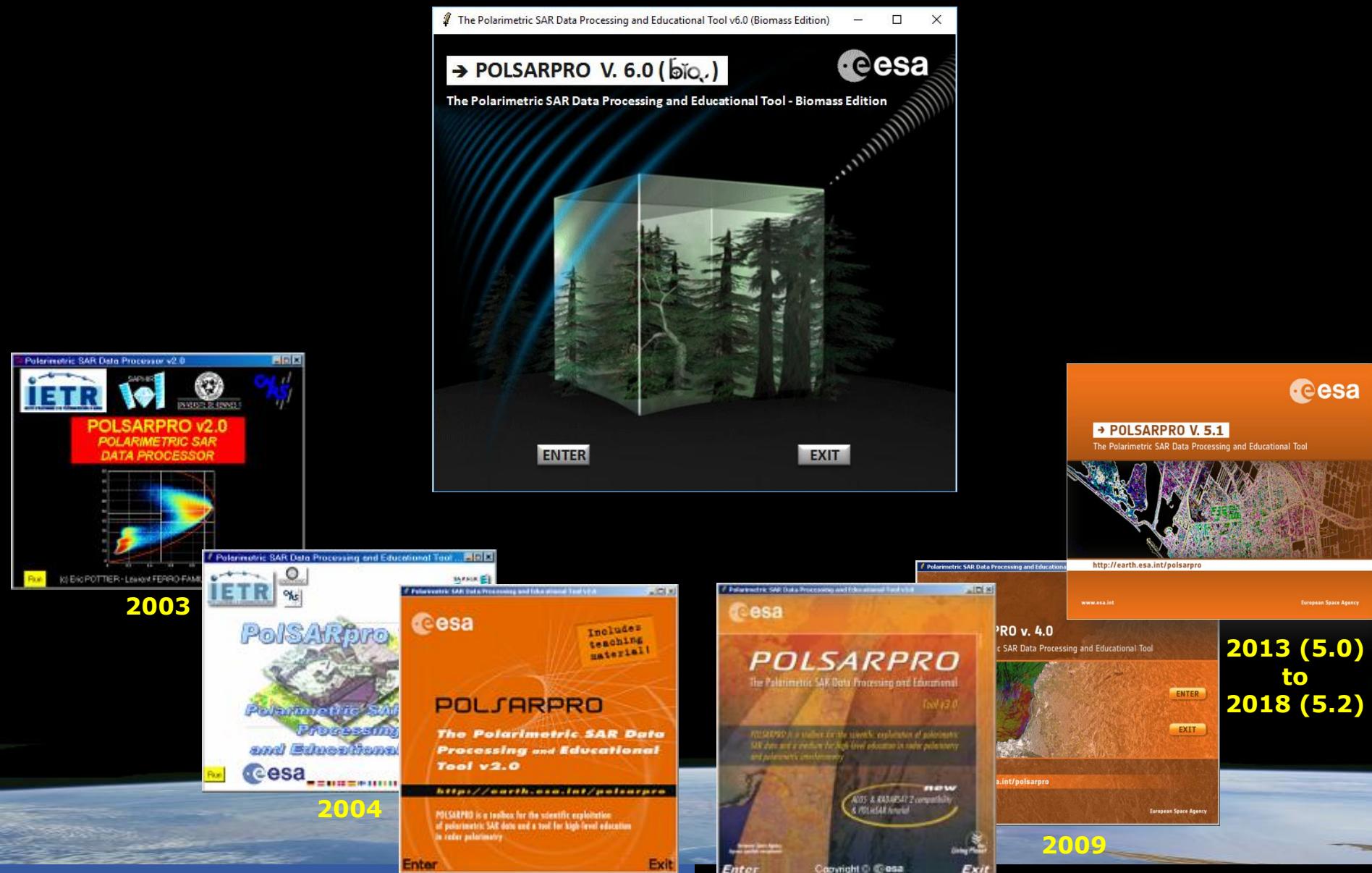
BIOMASS mission : 7th ESA Earth Explorer (2021)



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**.

P-Band Pol-TomoSAR spaceborne mission

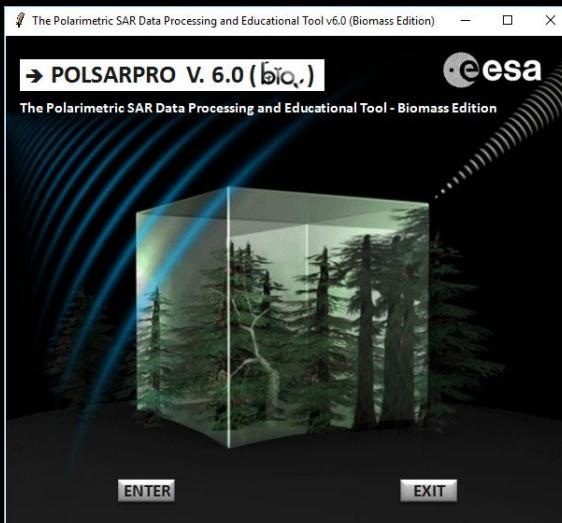




Toolbox specifically designed to handle : Pol-SAR, Pol-InSAR, Pol-TomoSAR and Pol-TimeSAR data.

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...**



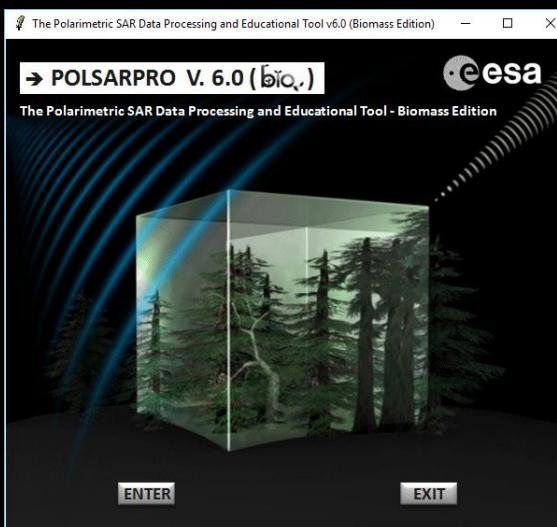
More than **1600** different
Pol-SAR, Pol-InSAR, Pol-TomSAR
and Pol-TimeSAR **functionalities**.



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



PolSARpro v5.1 Software is made available
following the: **Open Source Software Development**
(OSSD) approach, and follows the: **GNU General
Public License v2 – June 1991**.

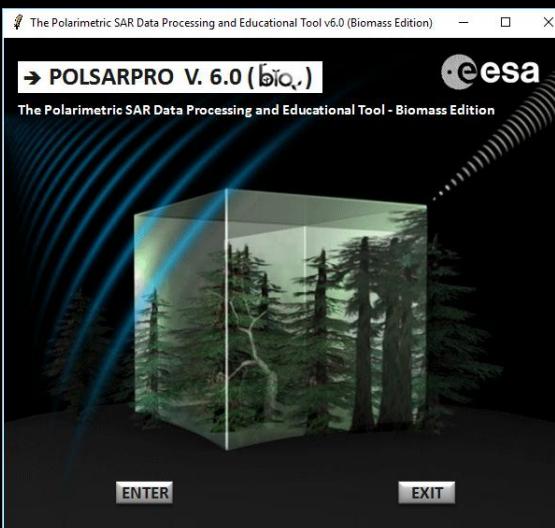


esa since 2003

- +3000 registered users
- +70 foreign countries

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





Wuhan University, China



Satellite Surveying and Mapping Application Center, China



Xidian University, China



Harbin Institute of Technology, China



Key Lab of Microwave Remote Sensing (MIRS), China



Tsinghua University, China



University of Mining and Technology, China



National Space Science Center, CAS, 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



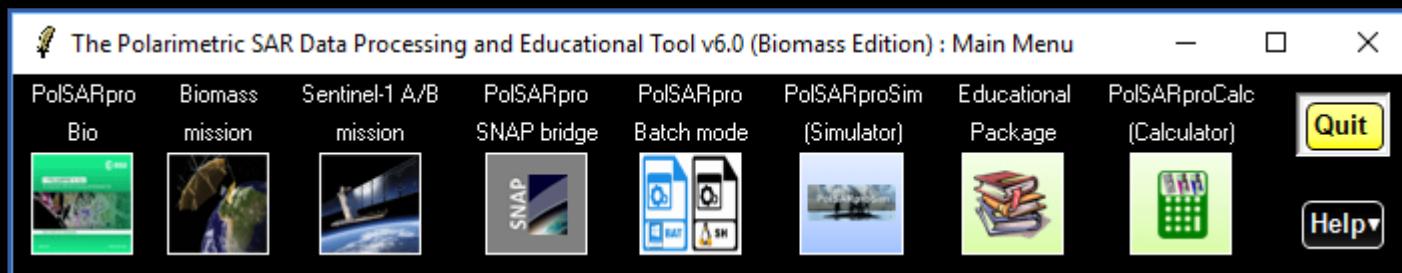
Khajeh Nasir Toosi University of Technology, Iran

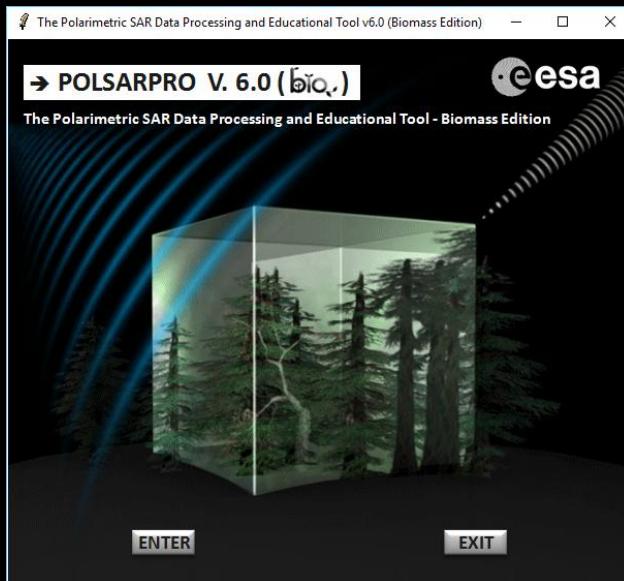
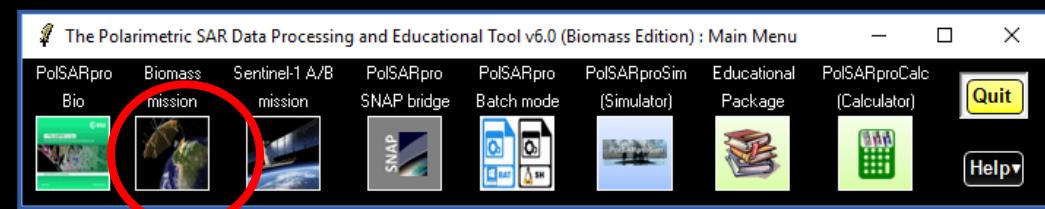
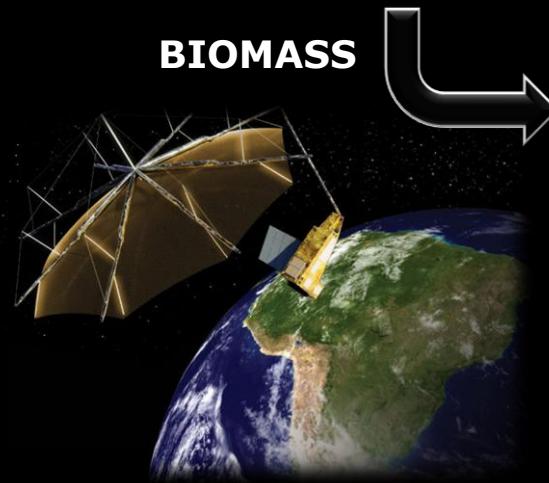


ENTRY SCREEN



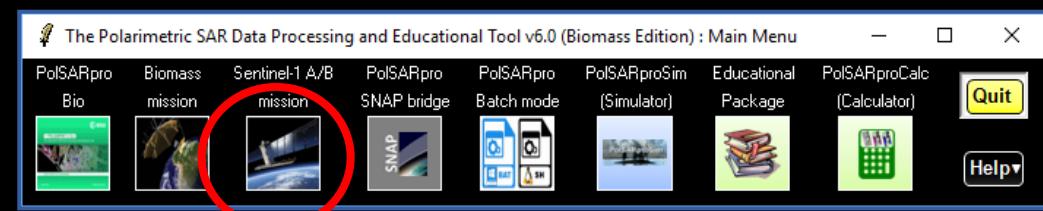
MAIN WINDOW



**MAIN WINDOW****ENTRY SCREEN****BIOMASS**



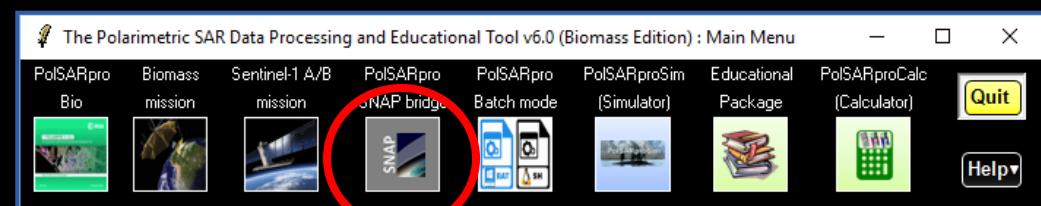
MAIN WINDOW



ENTRY SCREEN

SENTINEL 1A / 1B



**ENTRY SCREEN****MAIN WINDOW**

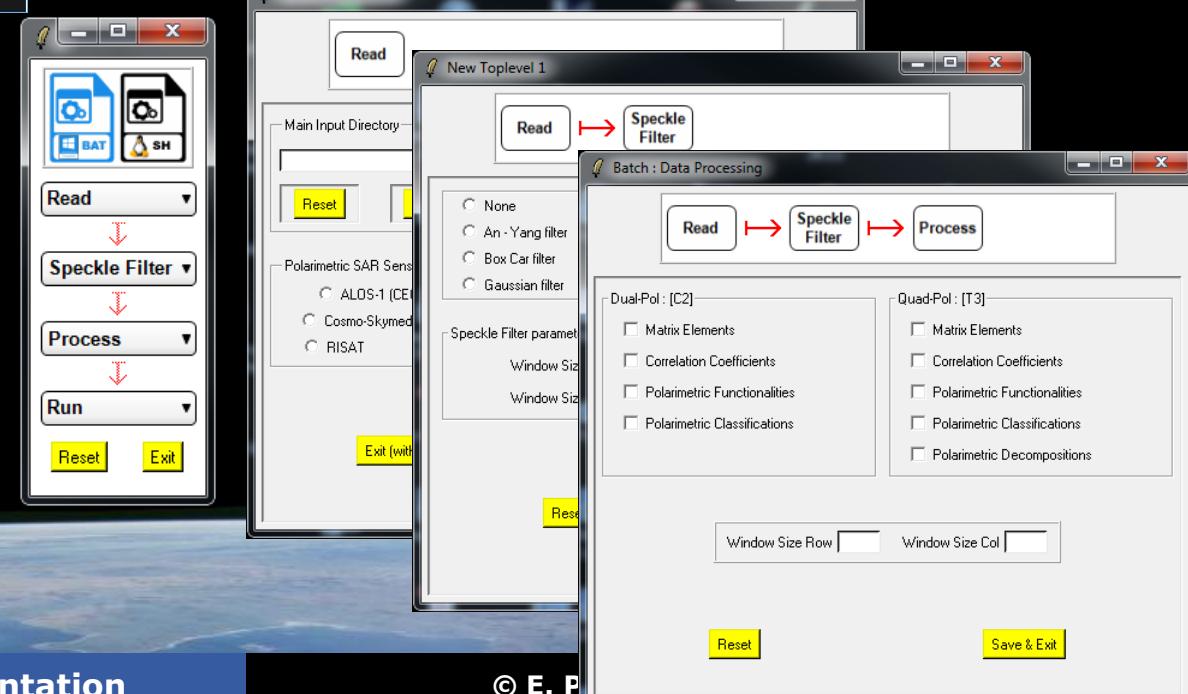
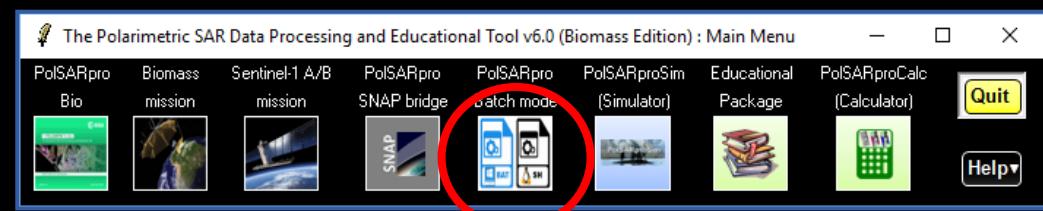
- **S1 toolbox**
(split, deburst, merge ...)
- **Geocoding toolbox**
- **Terrain correction**
- **Interferometric toolbox**
(co-registration, flat Earth estimation ...)



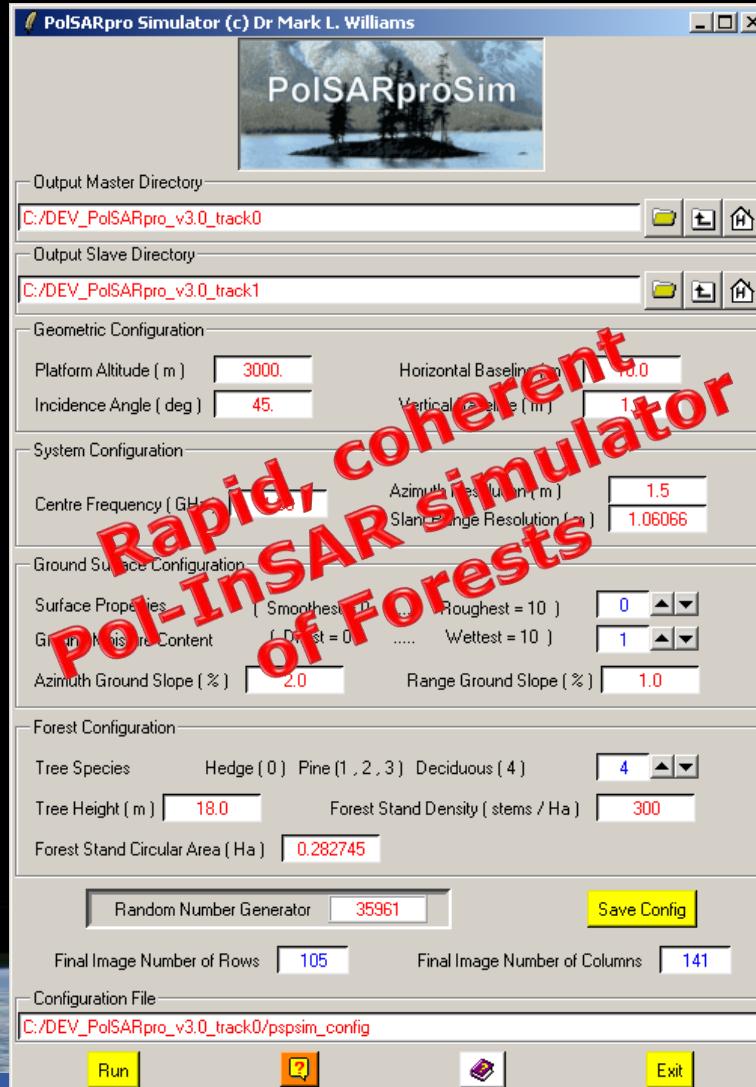
ENTRY SCREEN



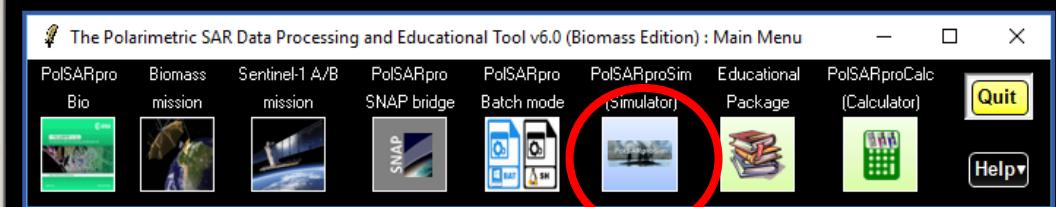
MAIN WINDOW



PolSARpro-SIM++



MAIN WINDOW

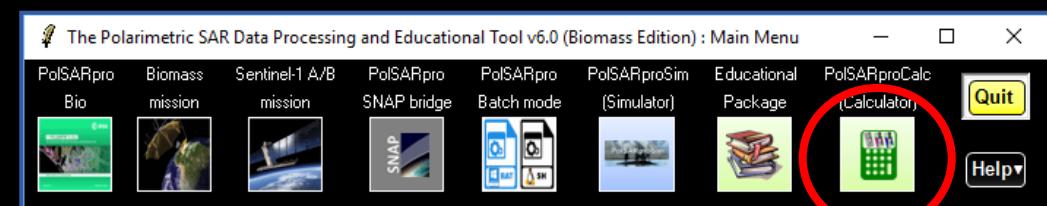




ENTRY SCREEN



MAIN WINDOW



PolSARpro Calculator v1.0

Operator : File

- [file] + value [file] - value [file] * value [file] / value
- [file] .+ [file] [file] .- [file] [file].* [file] [file]./ [file]
- .real (...) .imag (...) .arg (...) .abs (...)
- .cos (...) .sin (...) .tan (...) .conj (...)
- .acos (...) .asin (...) .atan (...) .boxcar (?x?)
- .sqrt (...) .(.)^2 .(.)^3 .(.)^(?)
- .log (...) .ln (...) .10^(...) .exp (...)
- .10log (...) .20log (...) .(.)< (?) .(.)> (?)

OK

Operator : Sinclair Matrix : S2-

- [S] + value [S] - value [S]^* value [S] / value
- [S].+ [file] [S].- [file] [S].* [file] [S]./ [file]
- [S].+ [S'] [S].+ [mat] [S].* [S'] [S].* [mat]
- [S].*[S] [U].*[S].*[U] .det [S] .inv [S]
- .conj [S] .tr [S] .det [S] .inv [S]
- .eig1 [S] .eig2 [S] .eig1 [G] .eig2 [G]

OK

Operator : Hermitian Matrix : C2, C3, C4, T2, T3, T4

- [M] + value [M] - value [M]^* value [M] / value
- [M].+ [file] [M].- [file] [M].* [file] [M]./ [file]
- [M].+ [M'] [M].+ [mat] .inv [M] [U].*[M].*inv [U]
- .conj [M] .tr [M] .det [M] tr (inv [mat].*[M])
- .eig1 [M] .eig2 [M] .eig1 [G] .eig2 [G]

OK

Operator : Complex / Hermitian / Float / Special Unitary NxN Matrix

- [mat] + value [mat] - value [mat]^* value [mat] / value
- [mat].+ [mat] [mat].- [mat] [mat].* [mat] [mat]./ [mat]
- .det [mat] .tr [mat] .conj [mat] .inv [mat]
- .eig1 [mat] .eig2 [mat] .eig3 [mat] .eig4 [mat]

OK

Input File

Input File Format: Init Row: End Row: Init Col: End Col:

Input Matrix Directory:

Input Matrix Data Format: Init Row: End Row: Init Col: End Col:

Input Value Type: Complex Value Float Value Integer Value Input Value:

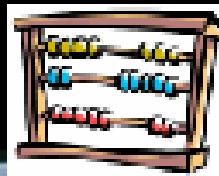
N x N Matrix:

Complex Float Hermitian Special Unitary

m11	+i	m12	+i	m13	+i	m14	+i
m21	+i	m22	+i	m23	+i	m24	+i
m31	+i	m32	+i	m33	+i	m34	+i
m41	+i	m42	+i	m43	+i	m44	+i

Load Save

Output Value: Exec



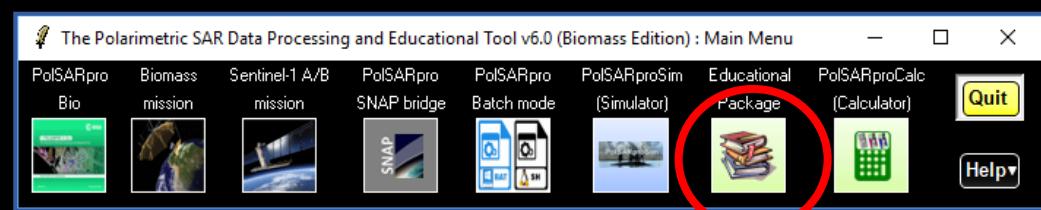
Pocket Polarimetric Calculator +



ENTRY SCREEN



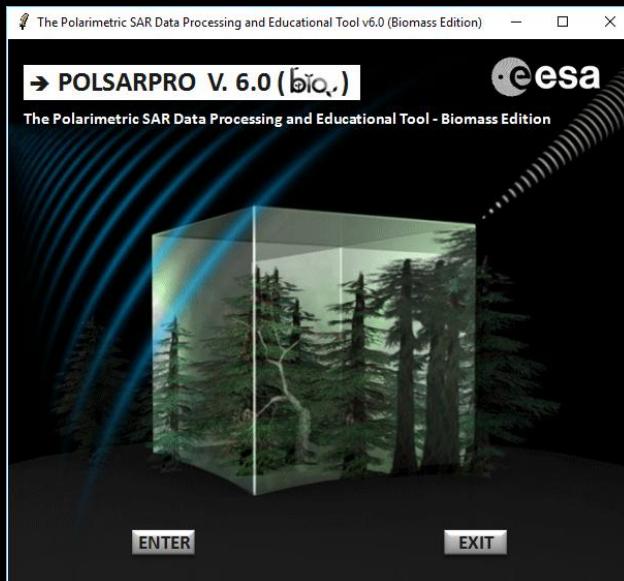
MAIN WINDOW



**New lecture course
New topics
Re-design of the *Do It Yourself***

PolSARpro-Bio web site

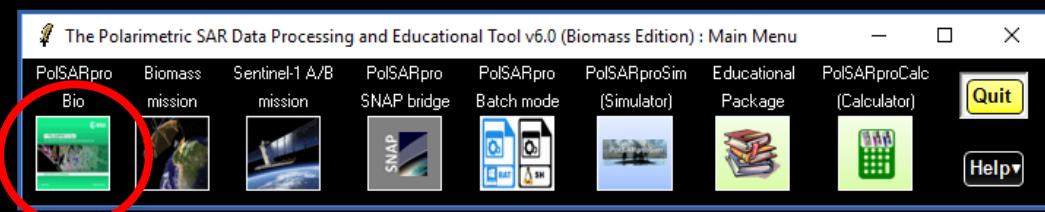
- On-line tutorials***
- On-line self training packages***
- Video / Quizz***
- Blog / Forum***



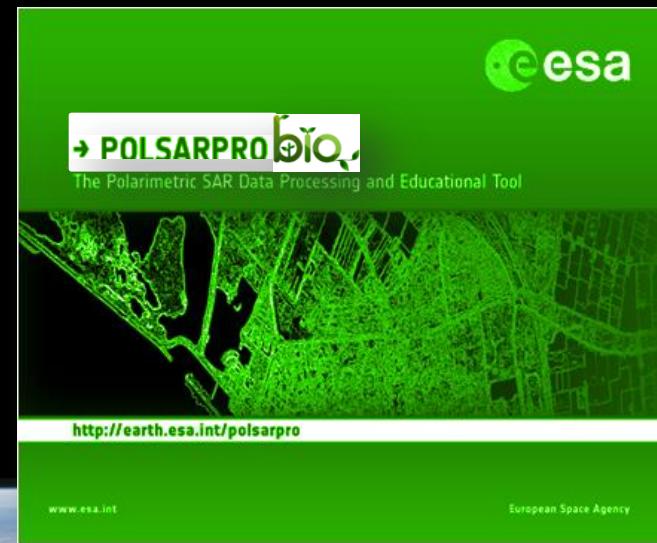
ENTRY SCREEN

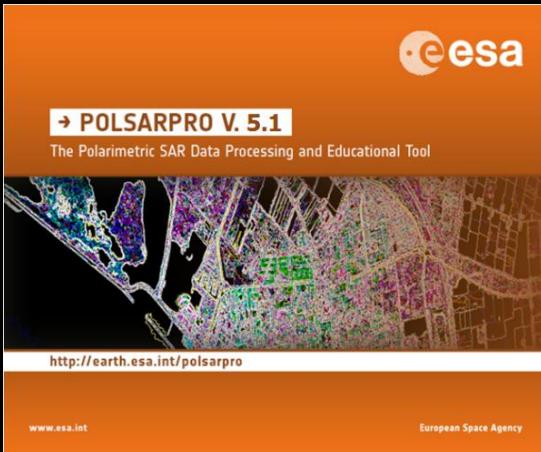


MAIN WINDOW



PolSARpro - Bio SOFTWARE

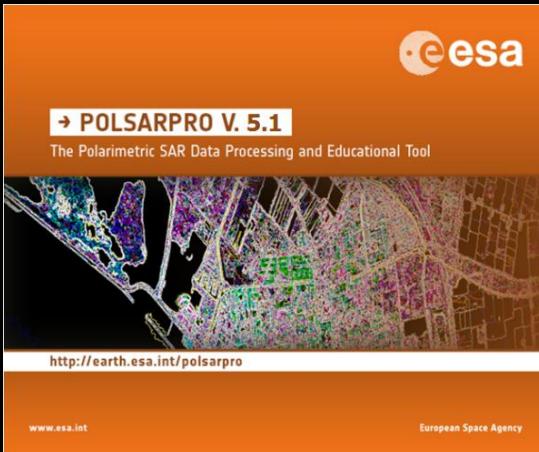




CURRENT

PolSARpro v5.1 Software offers the possibility to handle and convert polarimetric data from a range of well established CURRENT polarimetric airborne platforms.

PolSARpro v5.2 SOFTWARE



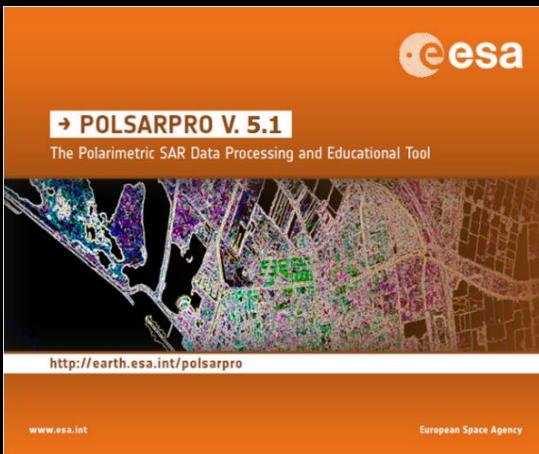
ALOS – PALSAR



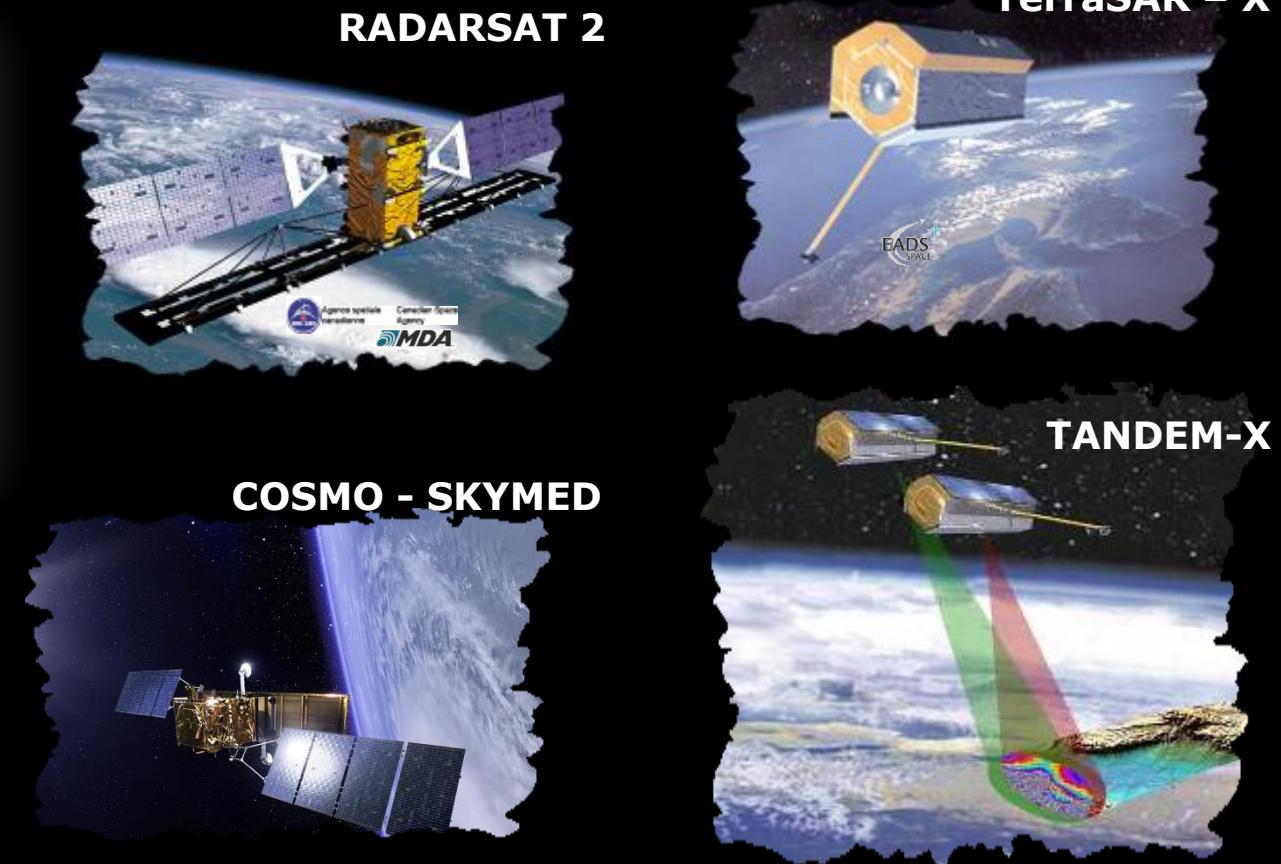
PAST

PolSARpro v5.1 Software offers the possibility to handle and convert polarimetric data from a range of well established PAST polarimetric spaceborne platforms.

PolSARpro v5.2 SOFTWARE

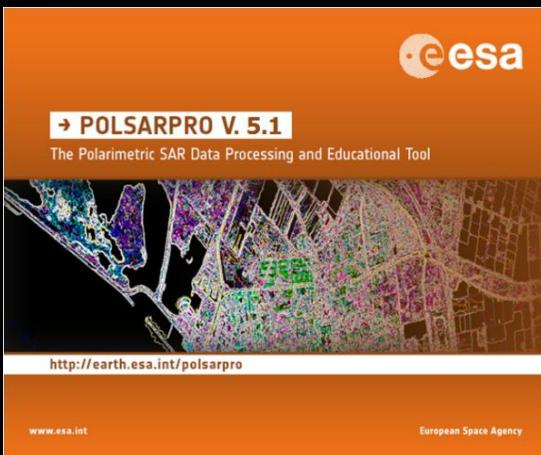


CURRENT

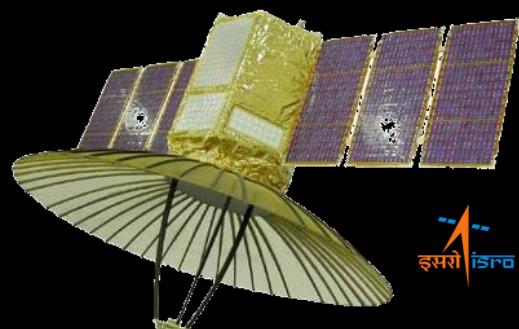


PolSARpro v5.1 Software offers the possibility to handle and convert polarimetric data from a range of well established CURRENT polarimetric spaceborne platforms.

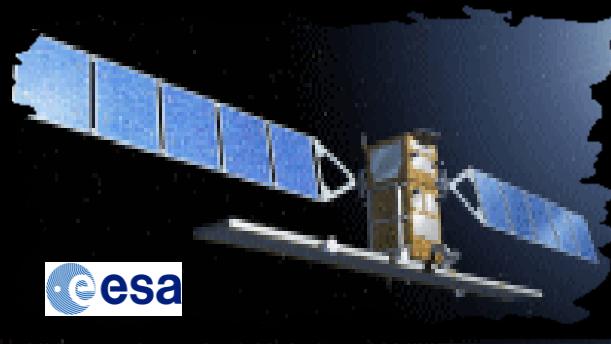
PolSARpro v5.2 SOFTWARE



RISAT

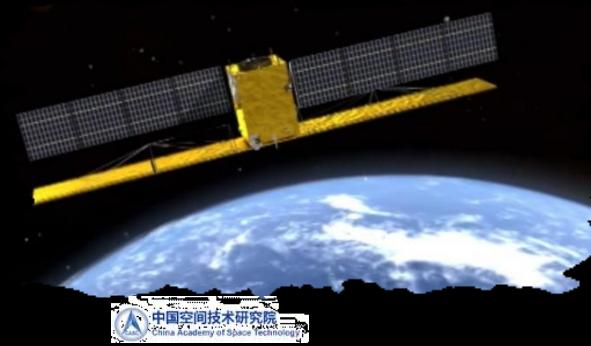


SENTINEL 1A / 1B

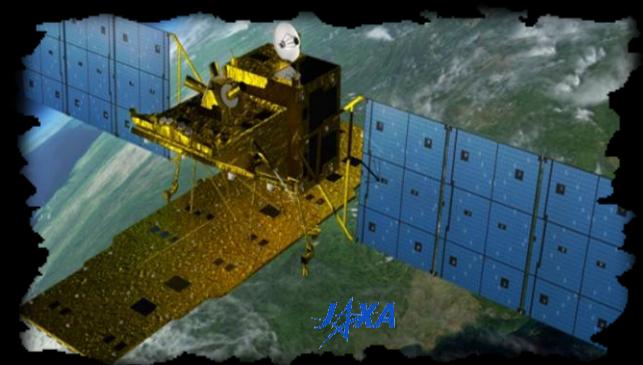


CURRENT

GaoFen 3 (GF3)



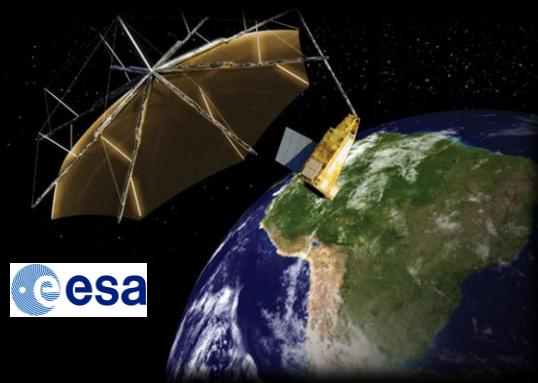
ALOS-2 – PALSAR-2



PolSARpro v5.1 Software offers the possibility to handle and convert polarimetric data from a range of well established CURRENT polarimetric spaceborne platforms.



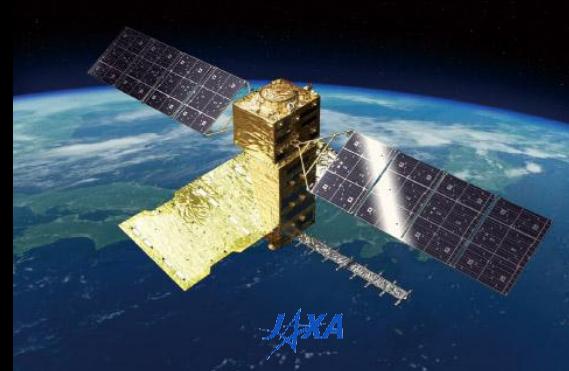
BIOMASS



Radarsat Constellation Mission (RCM)

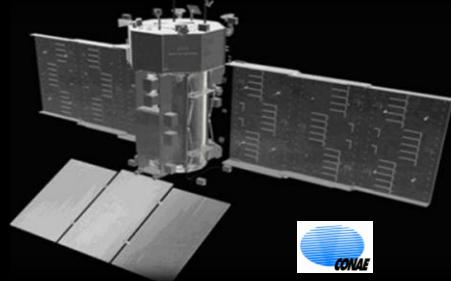


ALOS-4- PALSAR-3



FUTURE

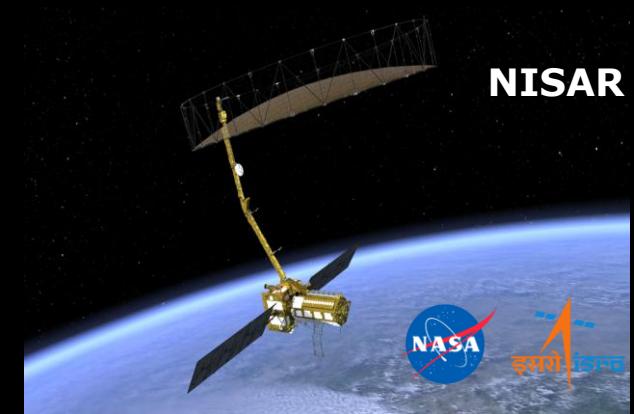
SAOCOM



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



NovaSAR - S



NISAR

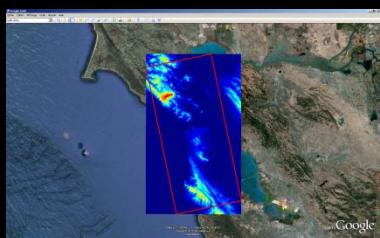
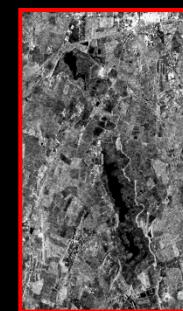
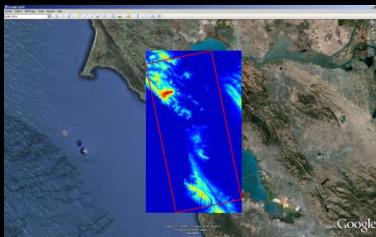
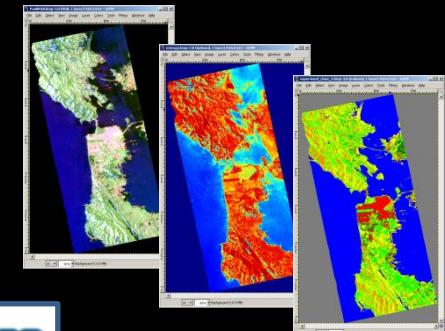
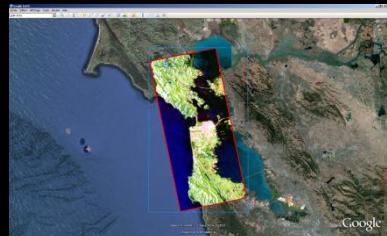
Tandem-L



FUTURE

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

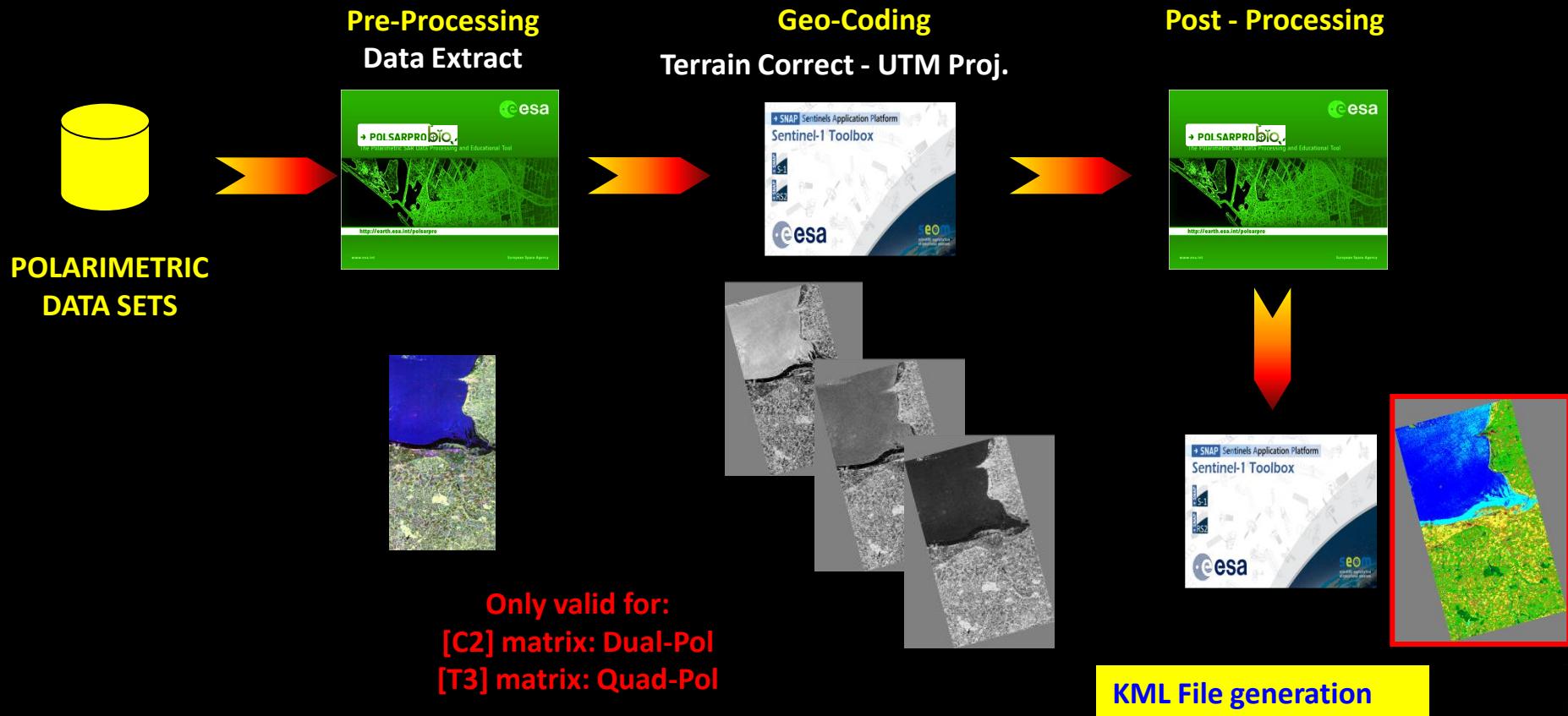
External Softwares



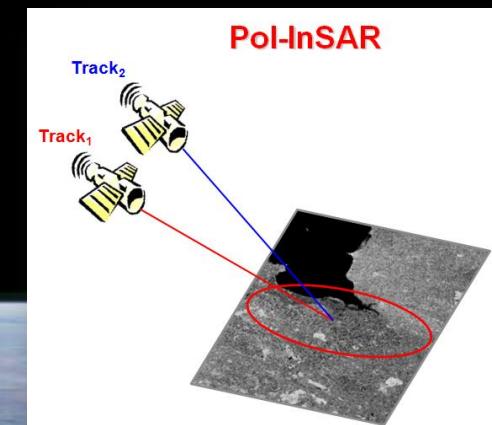
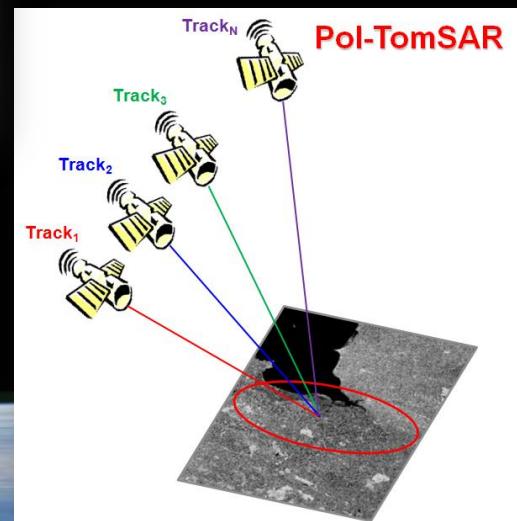
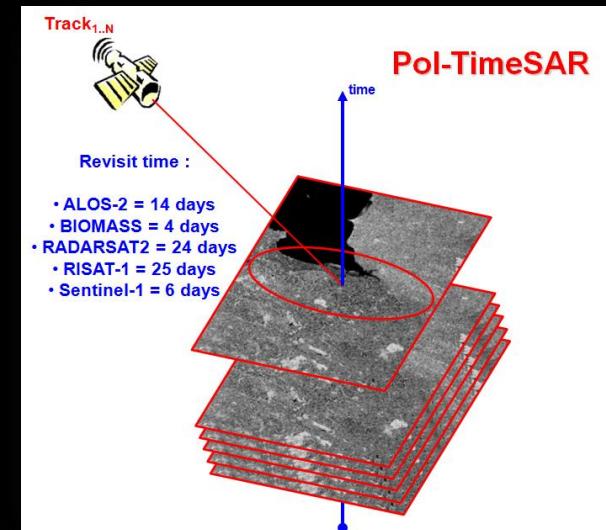
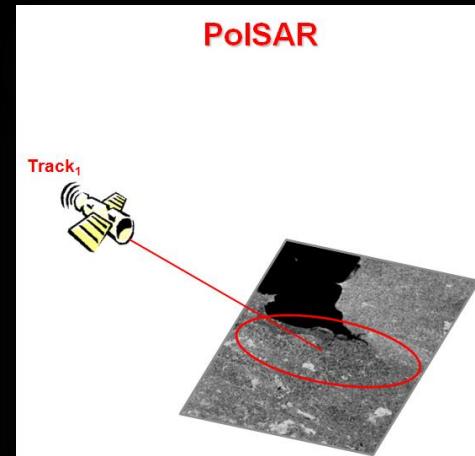
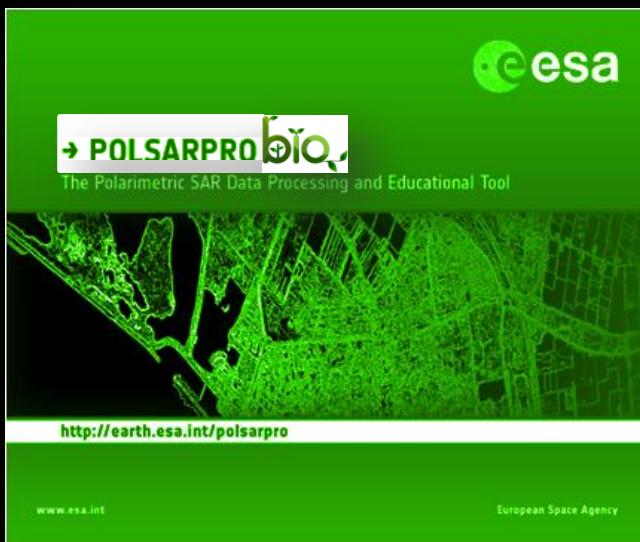
ASTER



ESA - SNAP / Sentinel-1 Toolbox



New functionalities



Dual – PolSAR (Spp, C2)

Quad – PolSAR (S2, C3,C4,T3,T4)

v6 · **Process**

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

**An-Yang Filter
Box Car Filter
Box Car - Edge Filter
Gaussian Filter
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**

**SIPV Model Estimation
Decomposition Parameters
Eigenvector Set Parameters
Eigenvalue Set Parameters**

**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**

**Wishart Supervised Classification
G.P.F. Supervised Classification
Rule-Based Hierarchical Classification
Basic Scattering Mechanism Identification
SVM Supervised Classification
Histogram Based Statistics
Texture Analysis**

**Clustering Process
Parameter Averaging
Data Sets Averaging**

**KRO : Krogager Decomposition
CAM : Cameron Decomposition
HAA : H / A / Alpha Decomposition
JRH : Huynen Decomposition
RMB1 : Barnes 1 Decomposition
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 : Arii 3 Component Decomposition
ANNED : Arii 3 Component Decomposition
VZ3 : Van Zyl (1992) 3 Component Decomposition
SIN4 : Singh 4 Component Decomposition
YAM3 : Yamaguchi 3 Component Decomposition
YAM4 : Yamaguchi 4 Component Decomposition
L. Zhang 5 Component Decomposition
Luzi Decomposition
Lee Decomposition
Freeman Decomposition
Koay Decomposition
Impact-Pol Decomposition
Degree of Purity
Depolarisation Index
Alpha Approximation (Praks & Colin)
Entropy Approximation (Praks & Colin)
Scattering Mechanism Entropy (Freeman)
Scattering Mechanism Entropy (Van Zyl)
Kozlov Anisotropy
Lueneburg Anisotropy
Polarized Point Scatterer Detection
Reflectivity Ratio
Differential Reflectivity (ZDR)**

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

Decomposition Applications

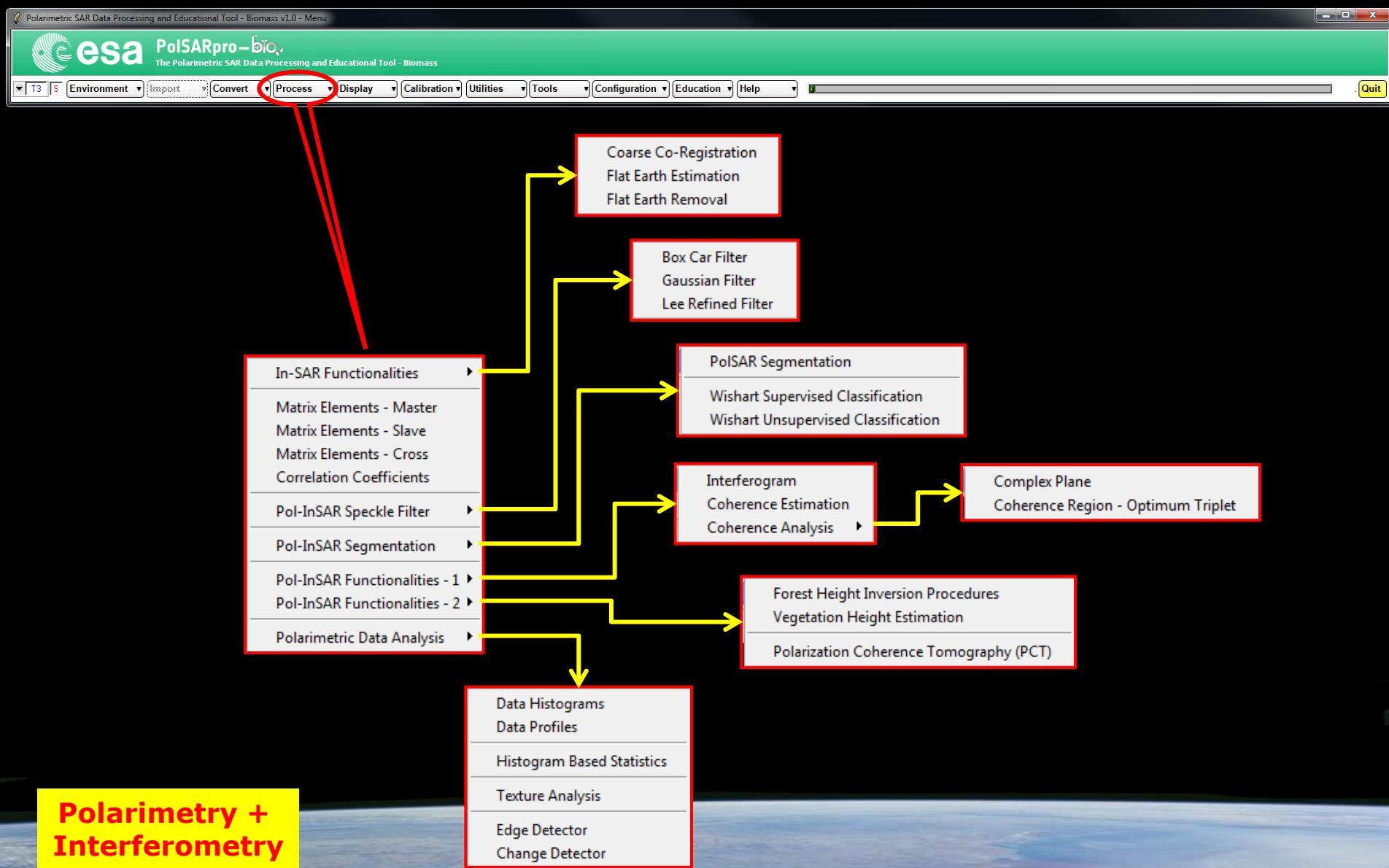
Environment Import Convert Process Display Calibration Utilities

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

Faraday Rotation Estimation Conformity Coefficient Scattering Predominance Scattering Diversity

Clustering Process Parameter Averaging Data Sets Averaging

Presentation



Polarimetry +
Interferometry

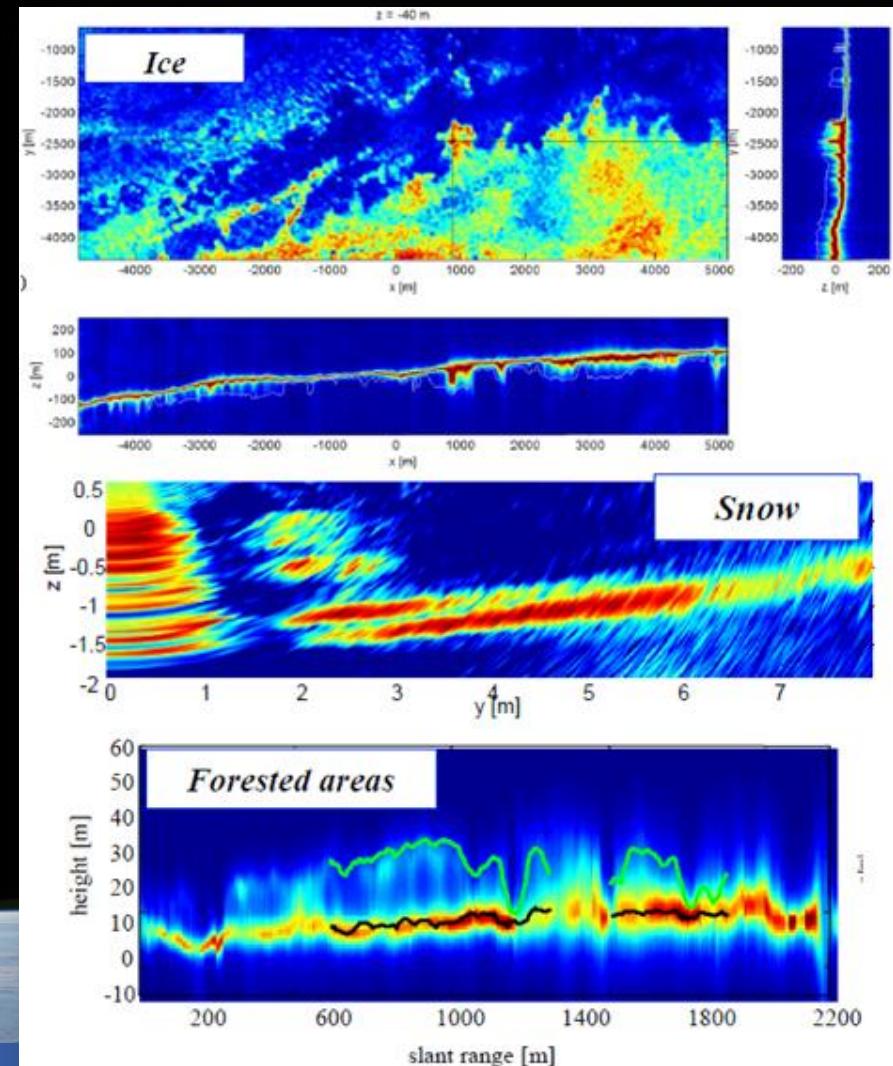
Pol-InSAR

30

- General Presentation

© E. Pottier – PolSARpro v6 (Biomass Edition)

Pol-TomoSAR processor



The screenshot shows the PolSARpro v6.0 (Bio) SOFTWARE interface. The main window title is "Polarimetric SAR Data Processing and Educational Tool - Biomass v1.0 - Menu". The top menu bar includes "T3", "S", "Environment", "Import", "Convert", "Process" (highlighted with a red circle), "Display", "Calibration", "Utilities", "Tools", "Configuration", "Education", "Help", and "Quit". A yellow callout bubble labeled "New!" points to the "Polarimetric Tomography" option in the "Process" menu.

The "Process" menu is expanded, showing:

- Coarse Co-Registration
- Matrix Elements
- Polarimetric Speckle Filter
- H / A / Alpha Decomposition
- Polarimetric Segmentation
- Polarimetric Functionalities
- Polarimetric Tomography** (circled in red)
- Multi-Datasets Analysis

Below the "Polarimetric Tomography" option are two additional items:

- Avg / Std / CV
- Time / Freq Averaging
- Animated GIF

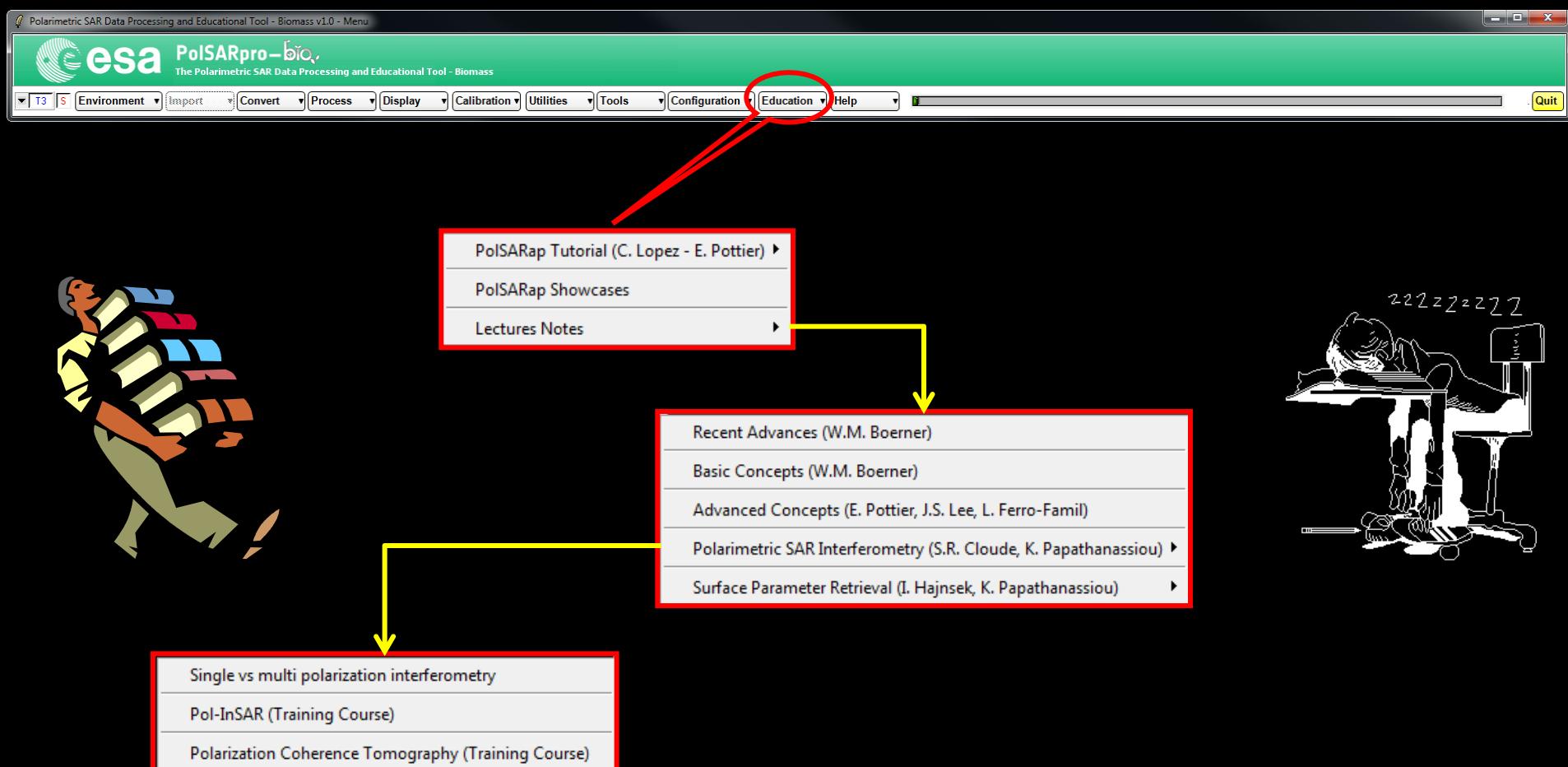
Arrows from the "Polarimetric Tomography" and "Multi-Datasets Analysis" options point to the following groups of tools:

- Box Car Filter**, **C. Lopez Filter**, **Gaussian Filter**, **IDAN Filter**, **J.S. Lee Refined Filter**, **J.S. Lee Sigma Filter** (under "Polarimetric Tomography")
- Decomposition Parameters**, **Eigenvector Set Parameters**, **Eigenvalue Set Parameters** (under "Multi-Datasets Analysis")
- Faraday Rotation Estimation**, **Conformity Coefficient**, **Scattering Predominance**, **Scattering Diversity** (under "Multi-Datasets Analysis")
- Degree of Purity**, **Depolarisation Index**, **Alpha Approximation (Praks & Colin)**, **Entropy Approximation (Praks & Colin)** (under "Multi-Datasets Analysis")
- Scattering Mechanism Entropy (Freeman)**, **Scattering Mechanism Entropy (Van Zyl)** (under "Multi-Datasets Analysis")
- Kozlov Anisotropy**, **Lueneburg Anisotropy** (under "Multi-Datasets Analysis")
- Polarized Point Scatterer Detection** (under "Multi-Datasets Analysis")
- Reflectivity Ratio**, **Differential Reflectivity (ZDR)** (under "Multi-Datasets Analysis")
- H / A / Alpha Classification**, **H / A / Alpha - Wishart Classification**, **Wishart Supervised Classification** (under "Multi-Datasets Analysis")

On the left side of the interface, there are three yellow boxes with red text:

- Polarimetry + Time series**
- Pol-TimeSAR**
- Polarimetry + Tomography**
- Pol-TomoSAR**

At the bottom left, it says "32" and at the bottom right, it says "6 – General Presentation © E. Pottier – PolSARpro v6 (Biomass Edition)"



Learning / Training Next P.I Generations

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

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

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

PolSARap Tutorial (C. Lopez - E. Pottier)

PolSARap Showcases

Lectures Notes

1 Basic Principles of SAR Polarimetry

C. Lopez Martinez¹, E. Pottier²
¹UPC Barcelona
²University of Rennes-1

1.1 Theory of radar polarimetry

1.1.1 Wave polarimetry

Polarimetry refers specifically to the vector nature of the electromagnetic wave, whereas radar polarimetry is the science of acquiring, processing and analysing the polarization state of an electromagnetic wave in radar applications. This section summarizes the main theoretical aspects necessary for a correct processing and analysis of the polarimetric data. As a result, the first part presents the so called polarimetry that deals with the theory of the understanding of the polarization state of an electromagnetic wave. The second part introduces the concept of scattering polarimetry. This concept collects the topic of inferring 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 descriptor:

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 \hat{x} direction, the real electric wave can be decomposed into two orthogonal components \hat{x} and \hat{y} , adopting the following vector formulation:

$$\hat{\mathbf{E}}(z, t) = \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix} = \begin{bmatrix} E_x \cos(\alpha z - kt + \delta_x) \\ E_y \cos(\alpha z - kt + \delta_y) \\ 0 \end{bmatrix} \quad (1.1)$$

which may also be considered in a complex form

66

hence, matrices must be taken by considering a 'wave' exploitation of the Whittier distribution. As shown in [72] and [73], the Whittier distribution over-defining the amplitudes of the double matrix 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 characteristics 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. 18 Radarsat-2 polarimetric RGB image over San Francisco (USA) where the colour code is: S_{11} blue, S_{12} red and S_{22} green. Filtered image with the LLNMSE speckle filter.



Fig. 19 Radarsat-2 polarimetric RGB image over San Francisco (USA) where the colour code is: S_{11} blue, S_{12} red and S_{22} green. Filtered image with the EPT speckle filter.



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

PolSAR-Ap Project

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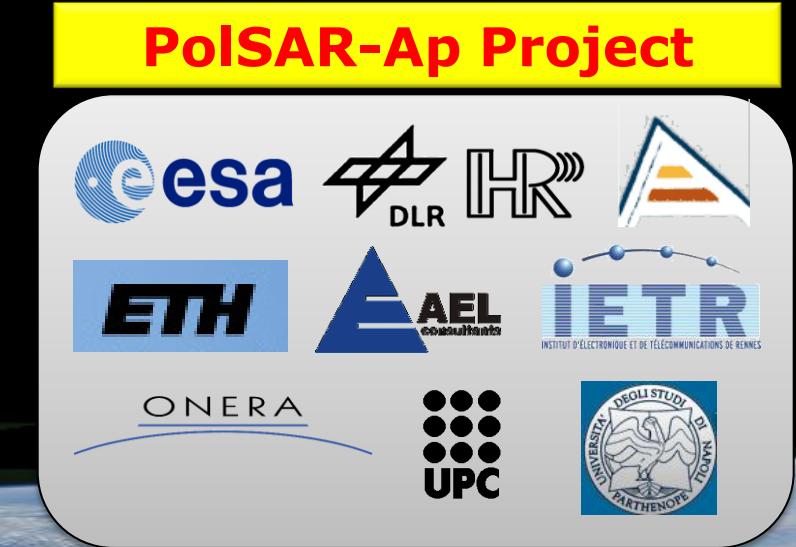
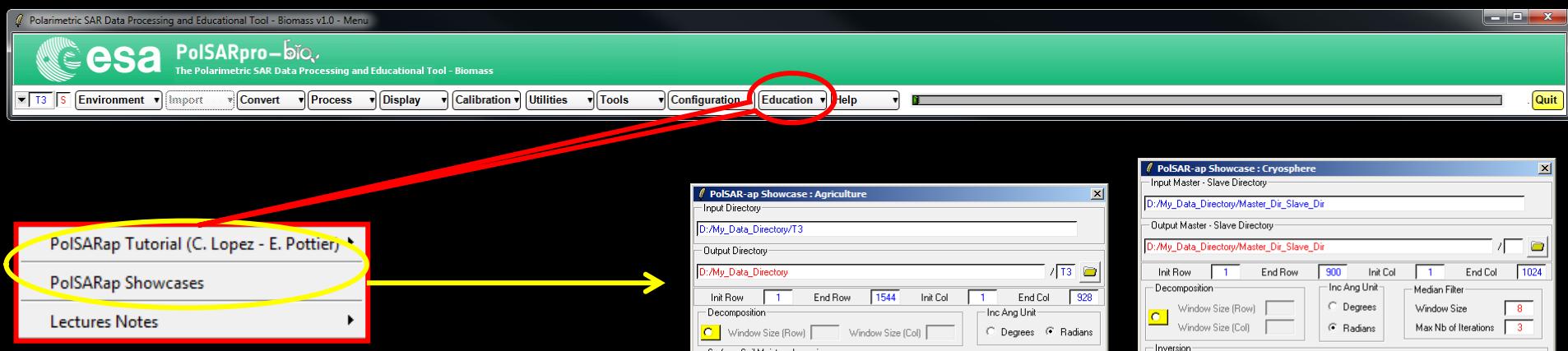
ETH AEL

IETR INSTITUT D'ÉLECTRONIQUE ET DE TÉLÉCOMMUNICATIONS DE RENNES

ONERA

UPC

UNIVERSITÀ DEGLI STUDI DI NAPOLI PARTHENOPÉ



PolSAR-ap Showcase : Agriculture

- Input Directory: D:/My_Data_Directory/T3
- Output Directory: D:/My_Data_Directory
- Init Row: 1 End Row: 1544 Init Col: 1 End Col: 928
- Decomposition: Window Size (Row): 1544 Window Size (Col): 1544 Inc Ang Unit: Degrees
- Surface Soil Moisture Inversion: Soil Dielectric Constant Max: 40 Increment Angle of the Incidence Angle LUT (deg): 0.1
- Dihedral Soil Moisture Inversion: Soil Dielectric Constant Max: Trunk Dielectric Constant Max: Increment Angle of the Incidence Angle LUT (deg):
- 2D-Incidence Angle File: Enter 2D Incidence Angle file
- 2D Mask File: Enter (showcase_agri_mask.bin) file
- Polarimetric Decomposition f's File: Enter (showcase_agri_ls.bin) file
- Polarimetric Decomposition Beta File: Enter (showcase_agri_beta.bin) file
- Vertical Roughness Indicator (k_s) File (optional):
- Output Soil Moisture File: D:/My_Data_Directory/showcase_agri_surf_mv_soil.bin
- Output Soil Dielectric Constant File: D:/My_Data_Directory/showcase_agri_surf_de_soil.bin
- Output Trunk Dielectric Constant File:

PolSAR-ap Showcase : Cryosphere

- Input Master - Slave Directory: D:/My_Data_Directory/Master_Dir_Slave_Dir
- Output Master - Slave Directory: D:/My_Data_Directory/Master_Dir_Slave_Dir
- Init Row: 1 End Row: 900 Init Col: 1 End Col: 1024
- Decomposition: Window Size (Row): 1544 Window Size (Col): 1544 Inc Ang Unit: Degrees
- Inversion: Polarization Channel: HH HV VV Ice Dielectric Constant: 2.8 Threshold: 40 Range Pixel Spacing (optional): opt
- 2D Incidence Angle File: Enter 2D Incidence Angle file
- 2D Kz File: Enter 2D Kz file
- Surface to Volume Ratio File: Enter (showcase_cryo_stv_ratio_HH.bin) file
- Complex Coherence File: Enter (cmplx_coh_HH.bin) file
- SNR Decorrelation File (optional): Enter SNR Decorrelation file (Optional)
- Output Extinction Coefficient File (kappa): D:/My_Data_Directory/Master_Dir_Slave_Dir/showcase_cryo_kappa_HH.bin
- Output Penetration Depth File: D:/My_Data_Directory/Master_Dir_Slave_Dir/showcase_cryo_depth_HH.bin

PolSAR-ap Showcase : Ocean

- Input Directory: D:/My_Data_Directory/T3
- Output Directory: D:/My_Data_Directory
- Init Row: 1 End Row: 1544 Init Col: 1 End Col: 928
- Window Size - Train: Row: 51 Col: 51 Window Size - Test: Row: 9 Col: 9
- Geometric Perturbation Filter: Threshold: 0.98 Reduction Ratio (RedR): 0.0025
- Output Coherence File: D:/My_Data_Directory/ocean_coherence.bin
- Output Mask File: D:/My_Data_Directory/ocean_mask.bin

The screenshot shows the PolSARpro-bio software interface. A red box highlights the 'Education' menu item in the top navigation bar. A yellow arrow points from the 'Recent Advances' section in the main content area down to the 'Single vs multi polarization interferometry' section in the bottom-left sidebar. Another yellow arrow points from the 'Polarimetric SAR Interferometry' section in the main content area down to the 'Pol-InSAR (Training Course)' section in the bottom-left sidebar.

Top Bar:

- T3
- S
- Environment
- Import
- Convert
- Process
- Display
- Calibration
- Utilities
- Tools
- Configuration
- Education** (highlighted with a red circle)
- Help

Bottom Left Sidebar:

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

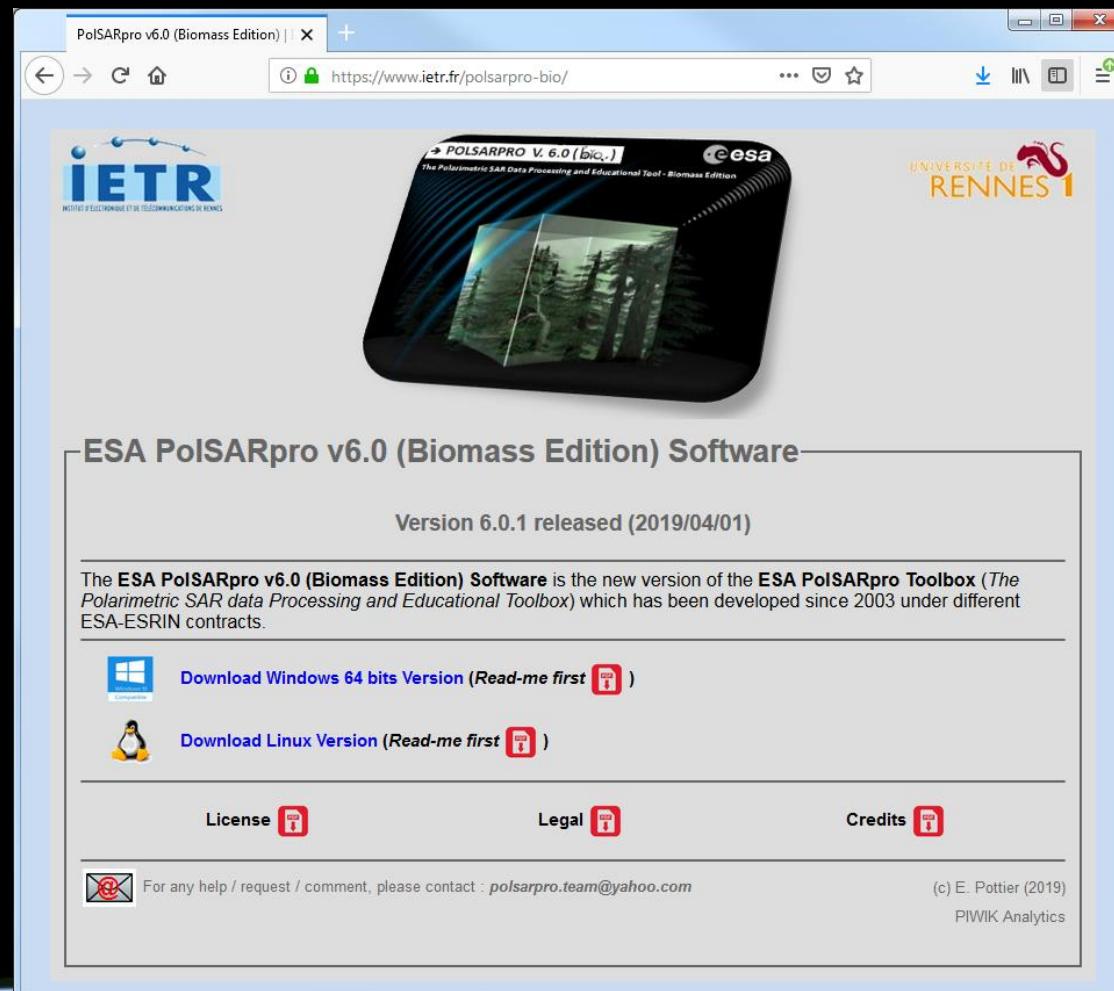
Main Content Area:

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

Right Side Panels:

- Recent Advances (W.M. Boerner):** Displays a PDF document titled 'POLARISATION ELLIPSE' from IETR, showing a diagram of an elliptical polarization ellipse and the equation for the real electric field vector: $\left(\frac{E_x}{E_{\theta x}}\right)^2 - 2 \frac{E_x E_y}{E_{\theta x} E_{\theta y}} \cos(\delta) + \left(\frac{E_y}{E_{\theta y}}\right)^2 = \sin^2(\delta)$. It also includes the formula $\text{With: } \delta = \delta_y - \delta_x$.
- Pol-InSAR Training Course:** Displays a PDF document titled 'POLInSAR Training Course' with a table of contents for 'Do It Yourself 7'.
- Polarimetric SAR Interferometry (S.R. Cloude, K. Papathanassiou):** Displays two PDF documents: 'POLARISATION ELLIPSE' and 'POLInSAR Training Course'.

<https://www.ietr.fr/polsarpro>



polsarpro.team@yahoo.com