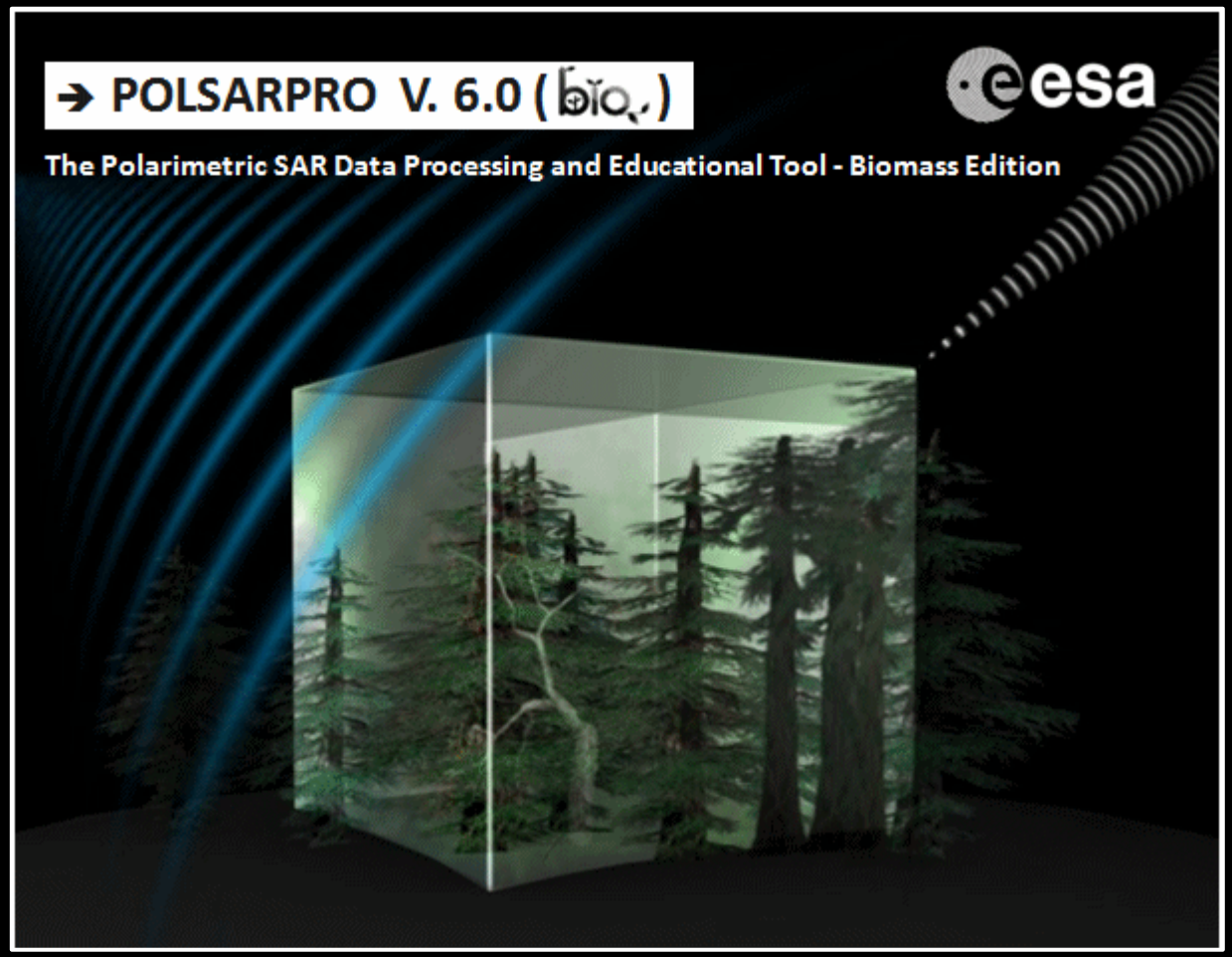
PolSARpro v6.0 (Bio) SOFTWARE



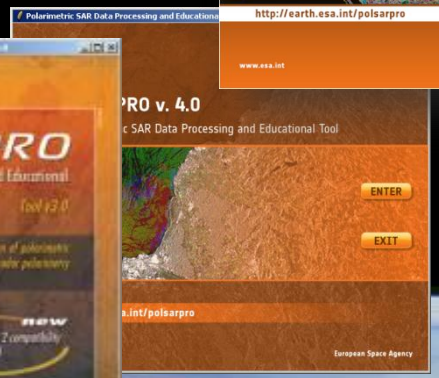
HISTORY

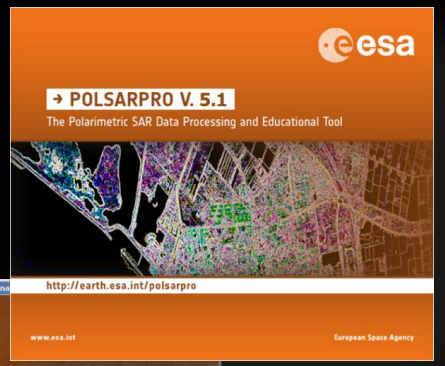
2003

2004

2005

2009





2013 (5.0)
to
2018 (5.2)

HISTORY

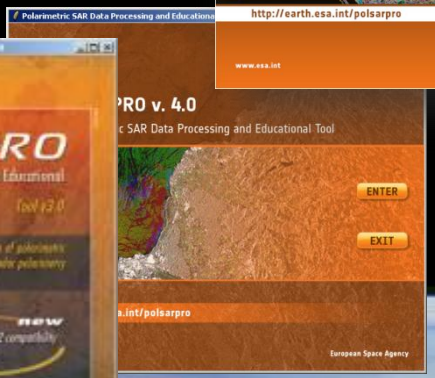
The initiative development of PolSARpro Software is a direct result of recommendations made during the POLinSAR 2003 Workshop held at ESA-ESRIN in January 2003.

2003

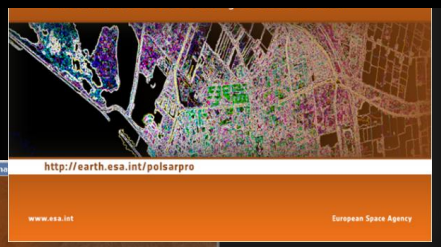
2004

2005

2007



2009



2013 (5.0)
to
2018 (5.2)

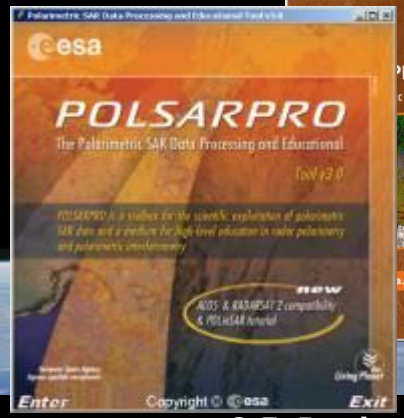
HISTORY

15 YEARS OF DEVELOPMENT

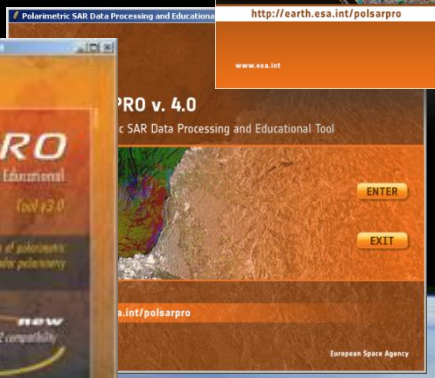
The initiative development of PolSARpro Software is a direct result of recommendations during the POLinSAR 2003 Workshop held at ESA-ESRIN in January 2003.

2003

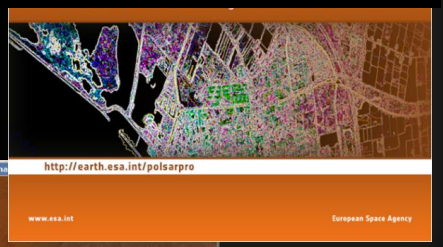
2004 2005



2007



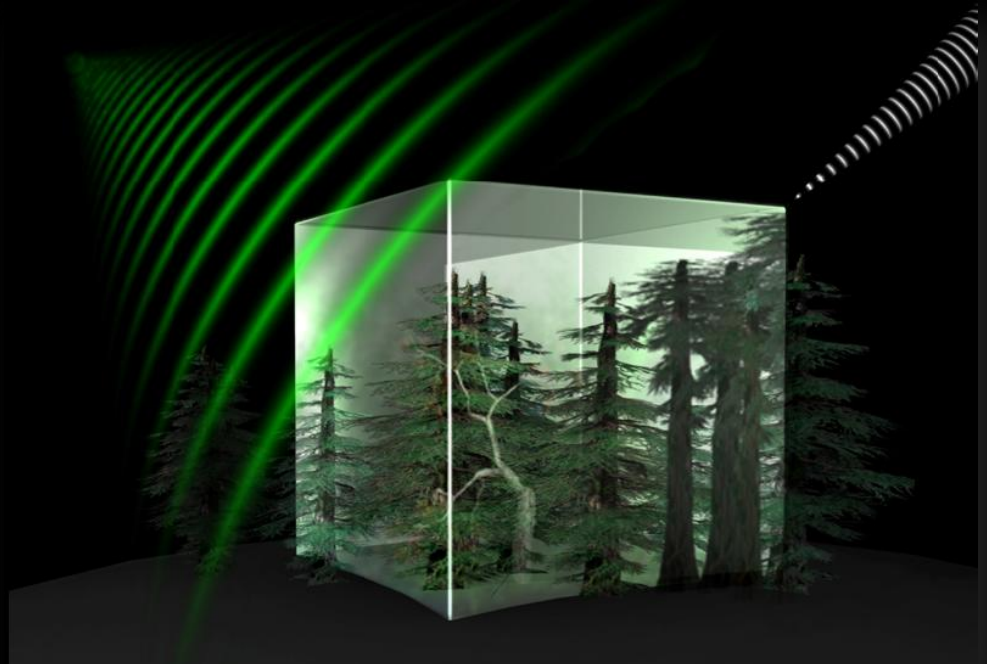
2009



2013 (5.0) to 2018 (5.2)

BIOMASS MISSION

BIOMASS mission : 7th ESA Earth Explorer (2021)

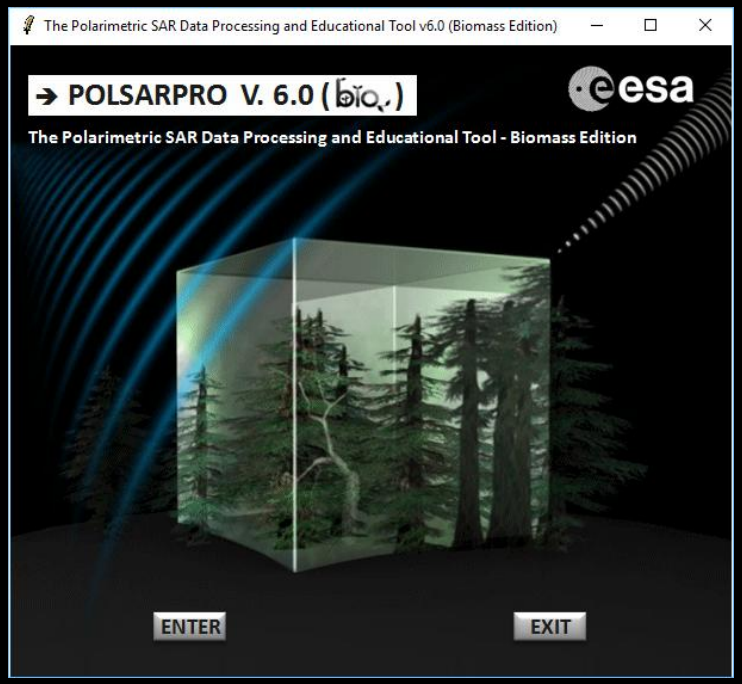


Biomass will provide global maps of the amount of carbon stored in the world's forests and how this changes over time.

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

P-Band Pol-TomoSAR spaceborne mission

PolSARpro v6.0 (Bio) SOFTWARE

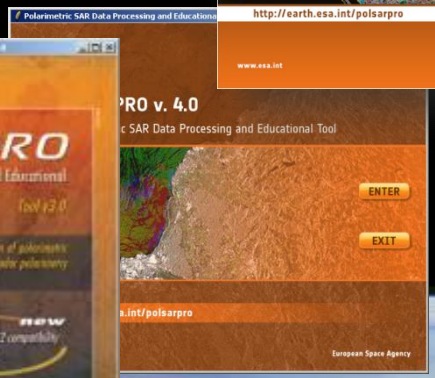


2003

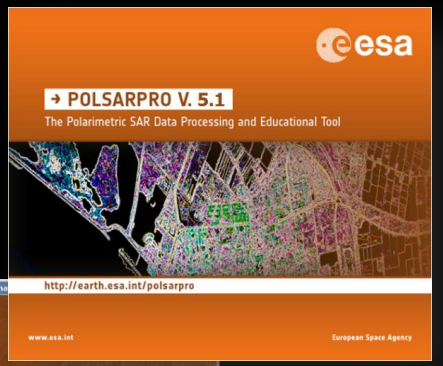
2004

2005

2007

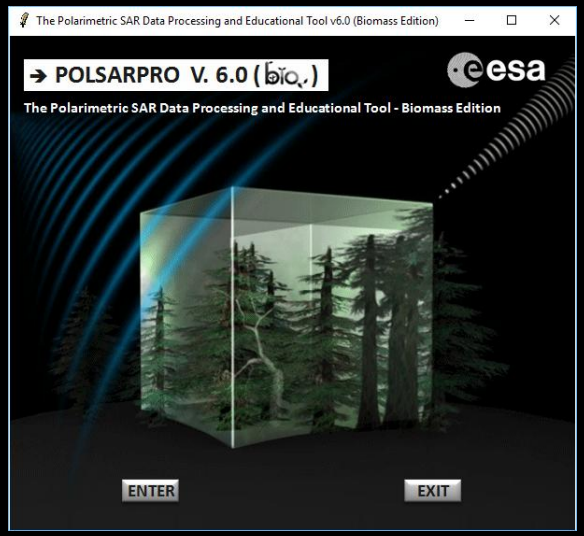


2009



2013 (5.0)
to
2018 (5.2)

PolSARpro v6.0 (Bio) SOFTWARE

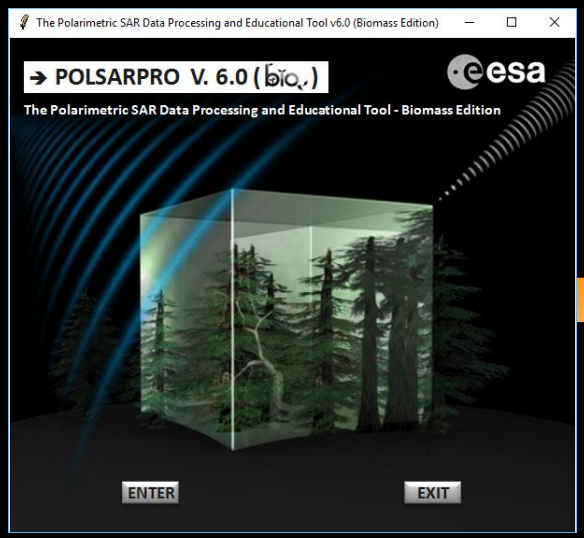


Toolbox specifically designed to handle : **Pol-SAR**, **Pol-InSAR**, **Pol-TomoSAR** and **Pol-TimeSAR** data.

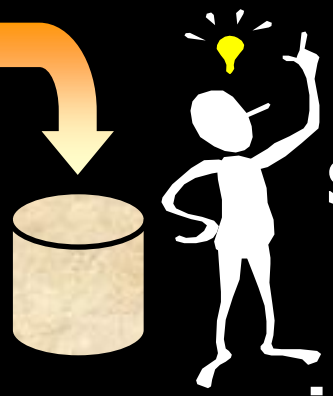
Educational Software offering a tool for **self-education** in the field of **Polarimetric SAR** data processing and analysis.

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**....

PolSARpro v6.0 (Bio) SOFTWARE



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

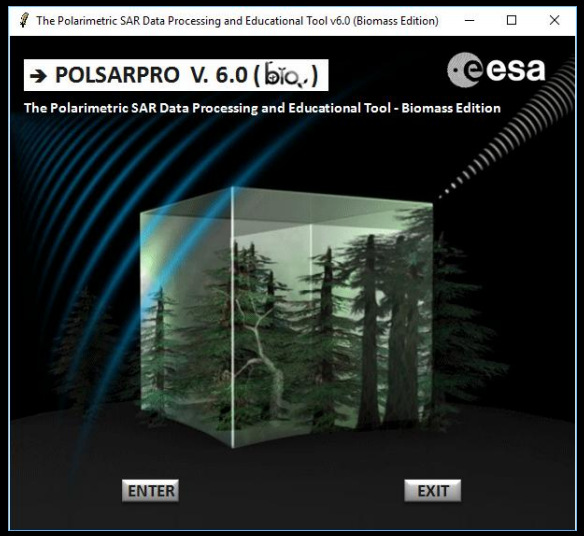


Each element of the Software (*a function*) can be extracted and incorporated individually into users' own processing software.

Windows 10 Compatible

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.

PolSARpro v6.0 (Bio) SOFTWARE



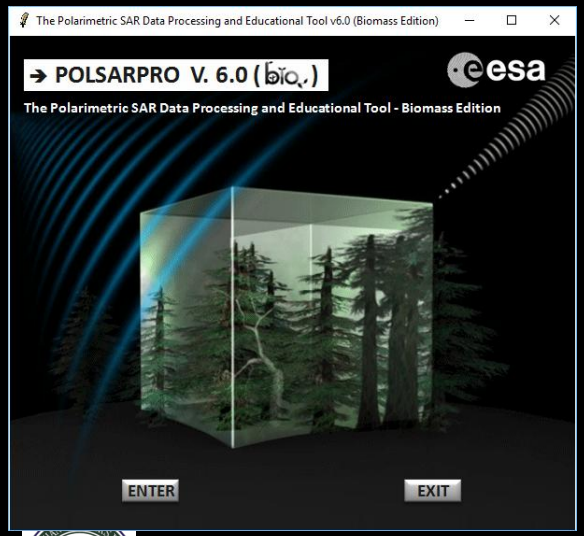
esa since 2003

- +3000 registered users
- +70 foreign countries

International Collaborative Project

(4 Agencies, 15 Research Centres, 14 Universities)

PolSARpro v6.0 (Bio) SOFTWARE



Last contributors

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

Wuhan University, China

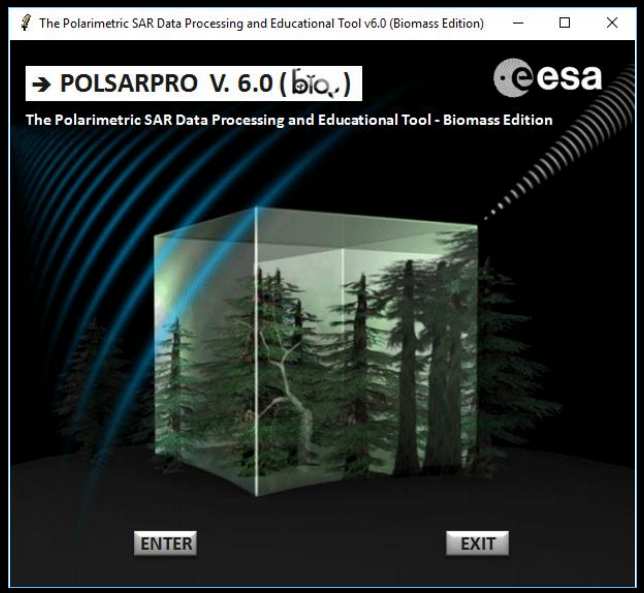
Satellite Surveying and Mapping Application Center, China

Xidian University, China

Harbin Institute of Technology China

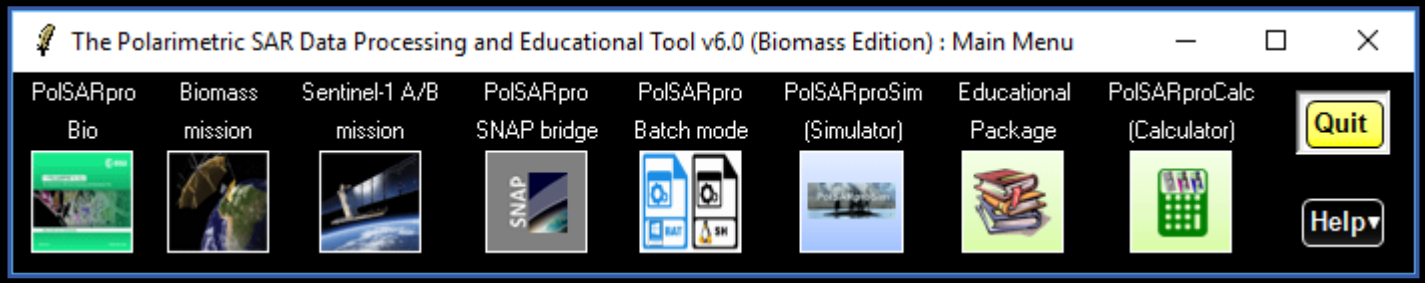
Key Lab of Microwave Remote Sensing, CAS, China

PolSARpro v6.0 (Bio) SOFTWARE

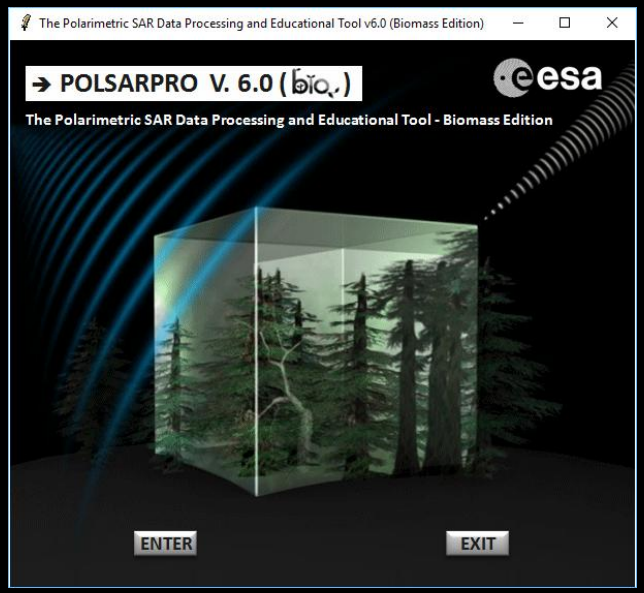


ENTRY SCREEN

MAIN WINDOW

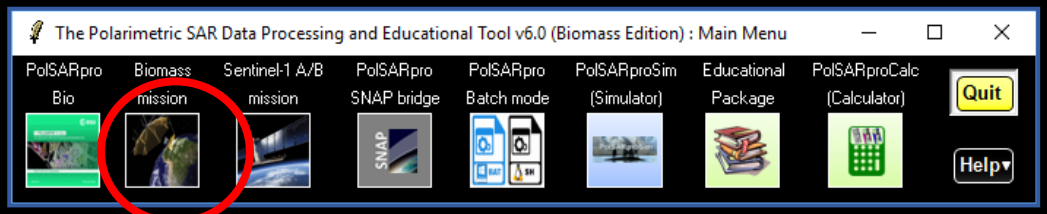


PolSARpro v6.0 (Bio) SOFTWARE

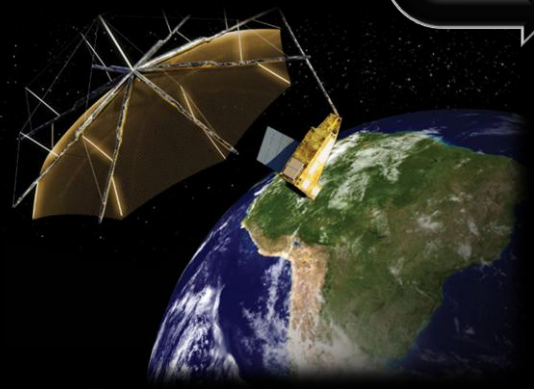


ENTRY SCREEN

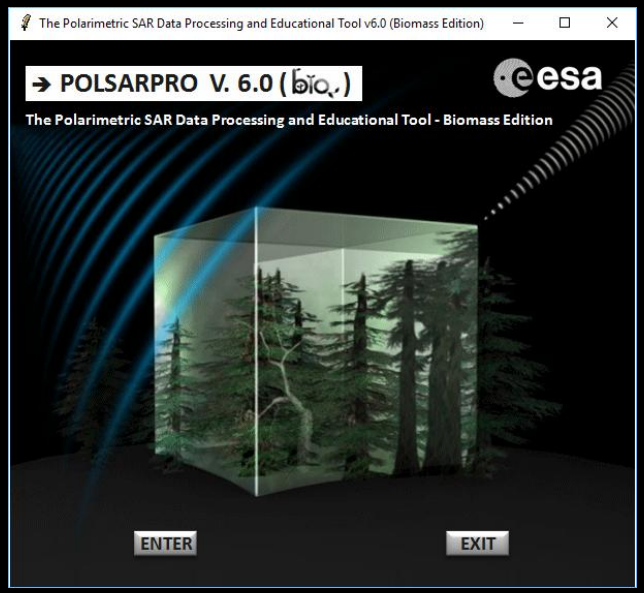
MAIN WINDOW



BIOMASS

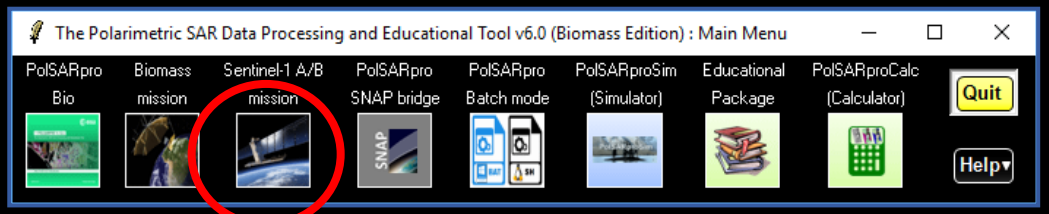


PolSARpro v6.0 (Bio) SOFTWARE

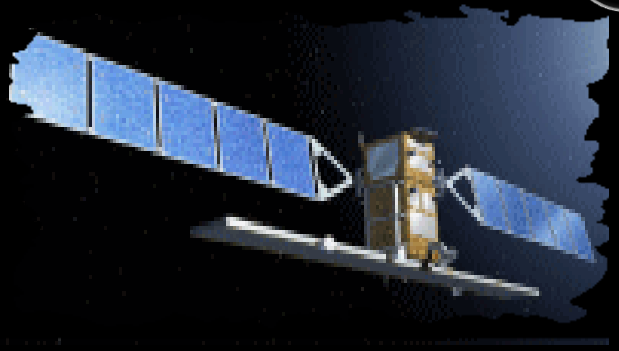


ENTRY SCREEN

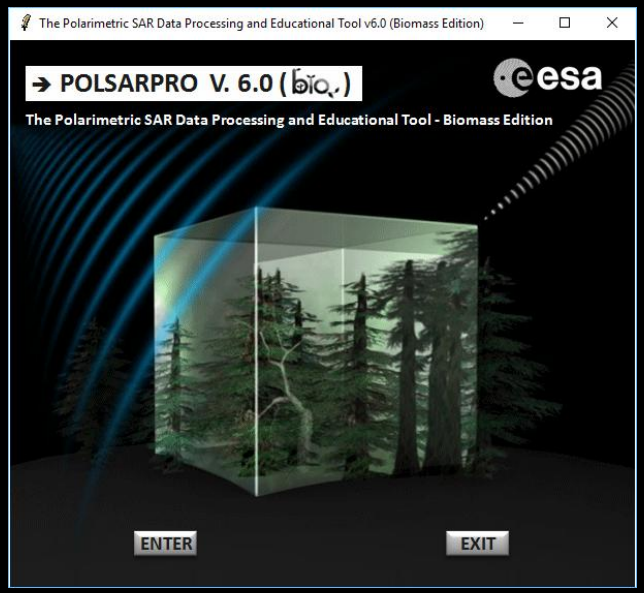
MAIN WINDOW



SENTINEL 1A / 1B

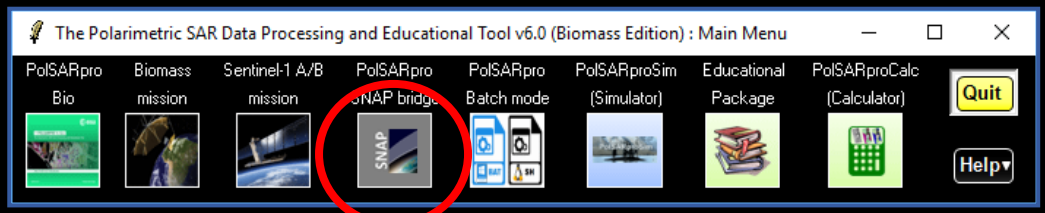


PolSARpro v6.0 (Bio) SOFTWARE



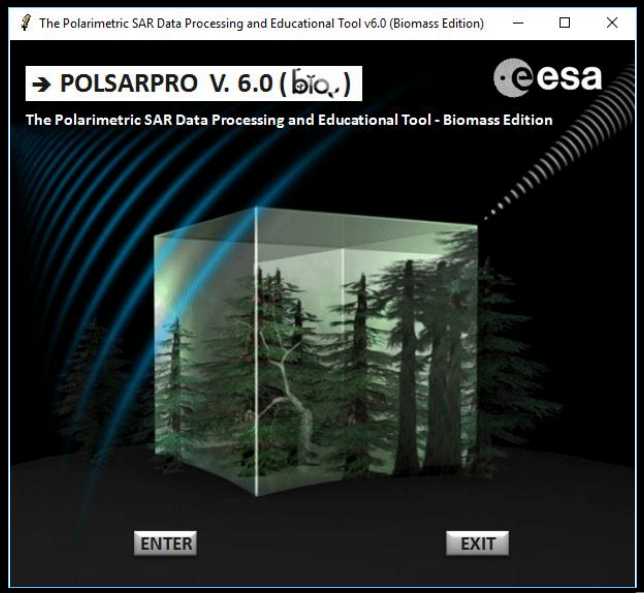
ENTRY SCREEN

MAIN WINDOW



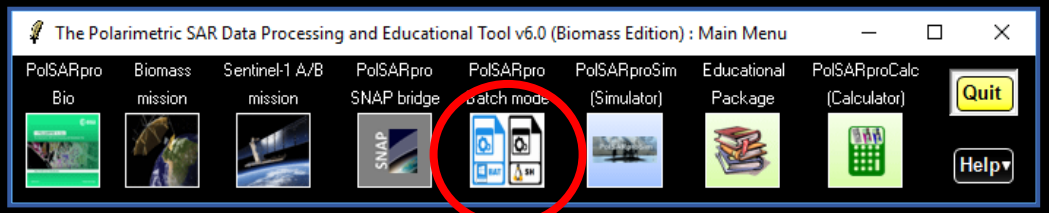
- **S1 toolbox**
  (split, deburst, merge …)
- **Geocoding toolbox**
- **Terrain correction**
- **Interferometric toolbox**
  (co-registration, flat Earth estimation …

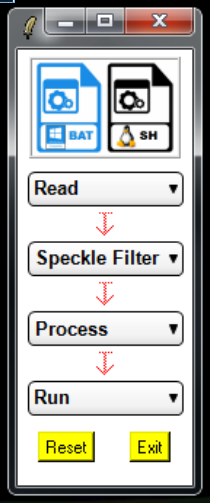
PolSARpro v6.0 (Bio) SOFTWARE

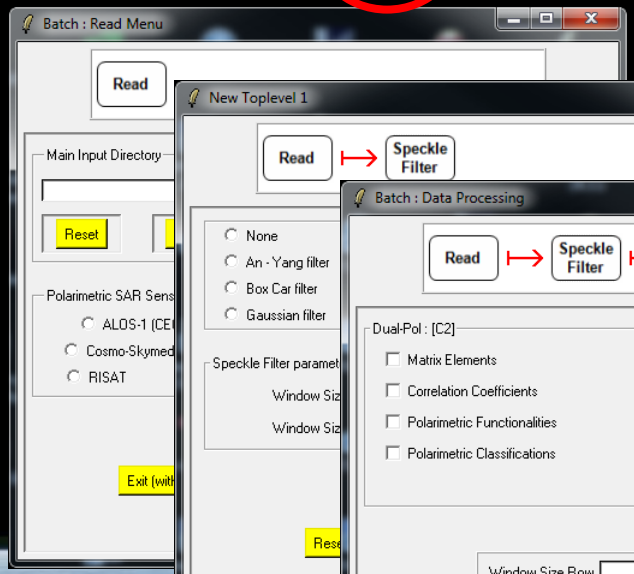


ENTRY SCREEN

MAIN WINDOW



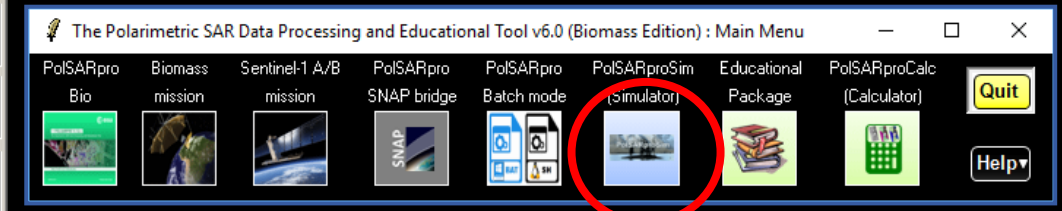


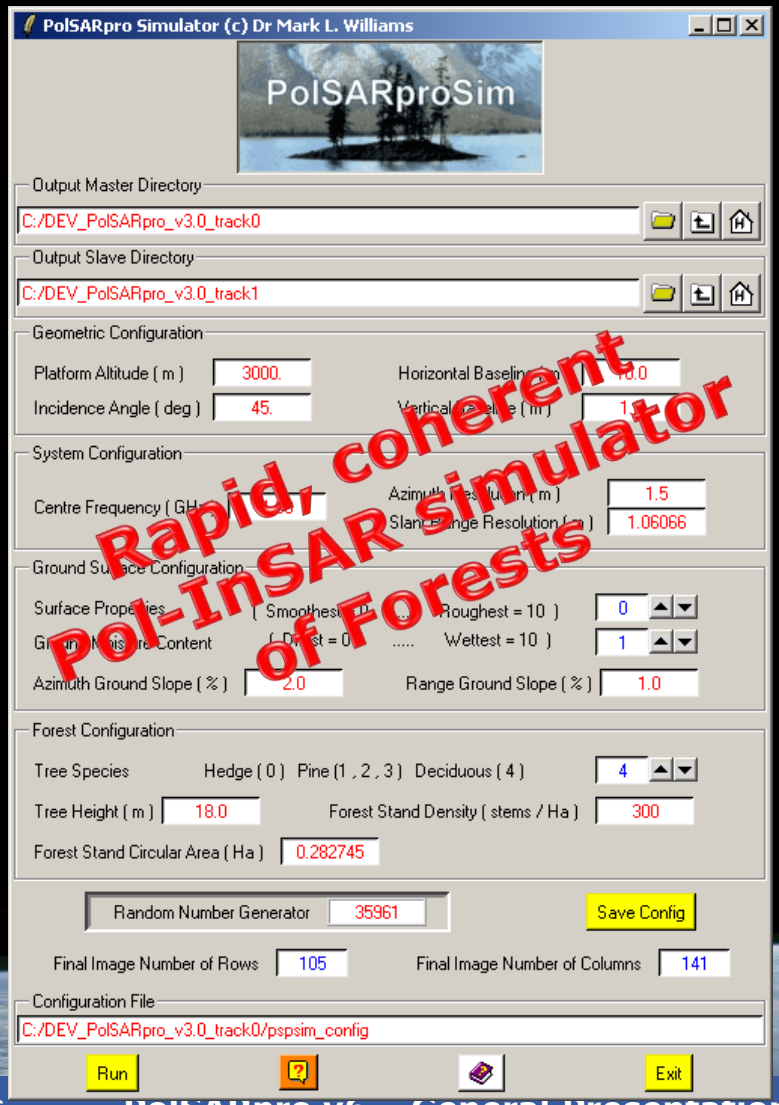


PolSARpro v6.0 (Bio) SOFTWARE

PolSARpro-SIM++

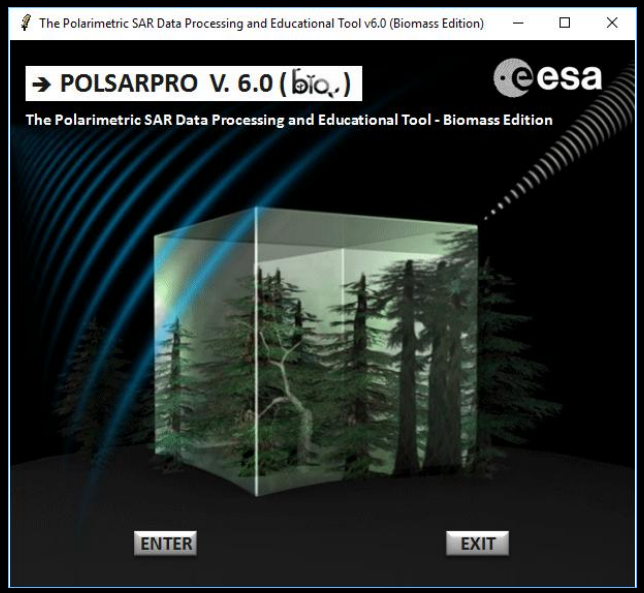
MAIN WINDOW





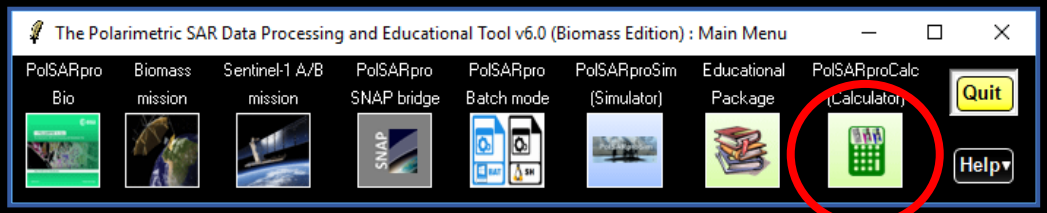
Rapid, coherent Pol-InSAR simulator of Forests

PolSARpro v6.0 (Bio) SOFTWARE

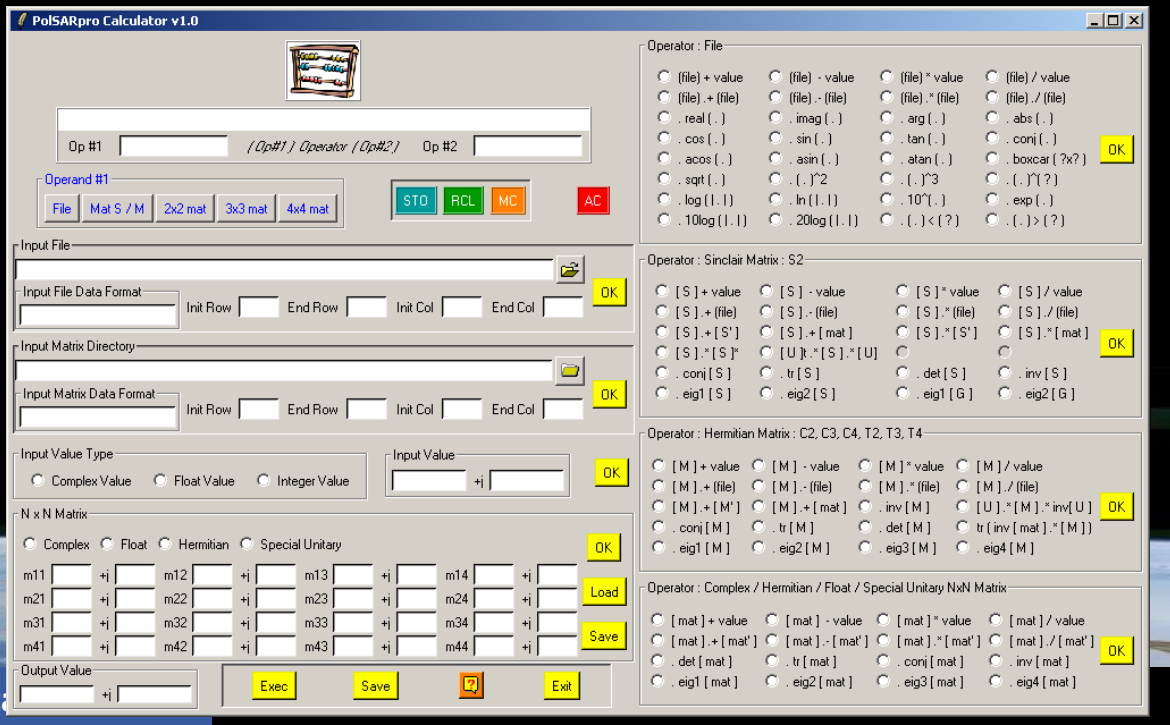


ENTRY SCREEN

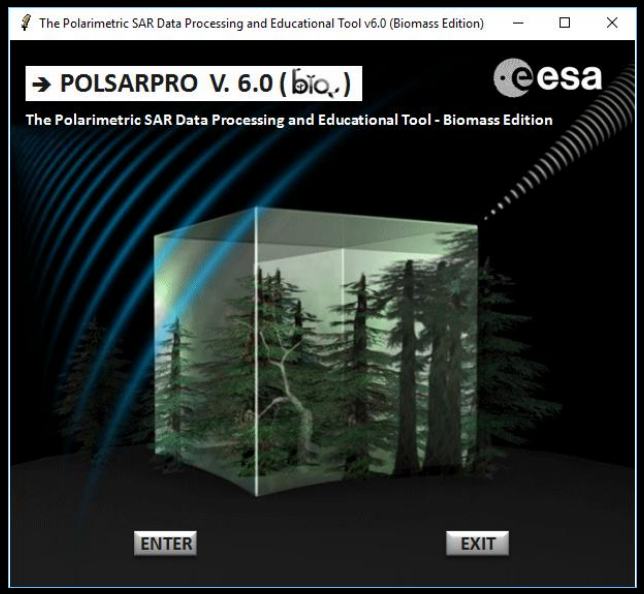
MAIN WINDOW



Pocket Polarimetric Calculator +

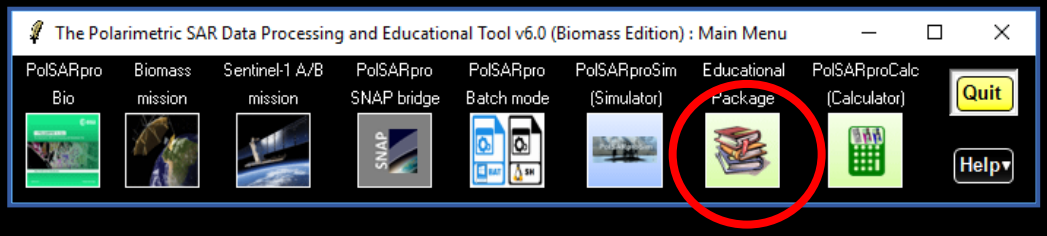


PolSARpro v6.0 (Bio) SOFTWARE



ENTRY SCREEN

MAIN WINDOW



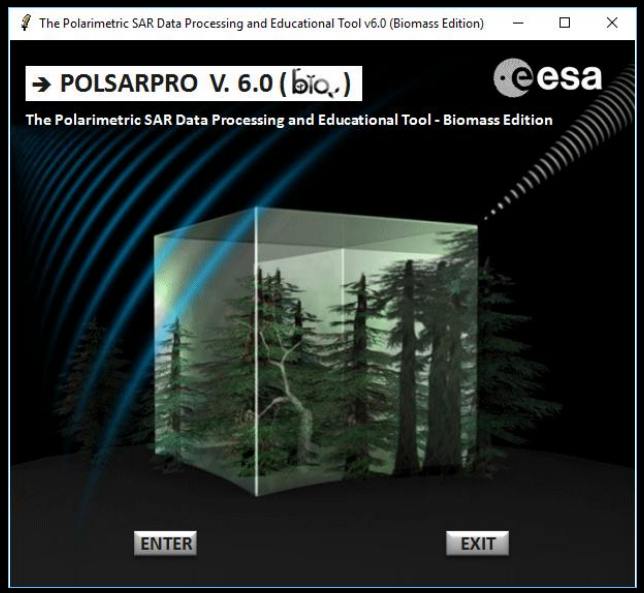
New lecture course
New topics
Re-design of the *Do It Yourself*

PolSARpro-Bio web site

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

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

PolSARpro v6.0 (Bio) SOFTWARE



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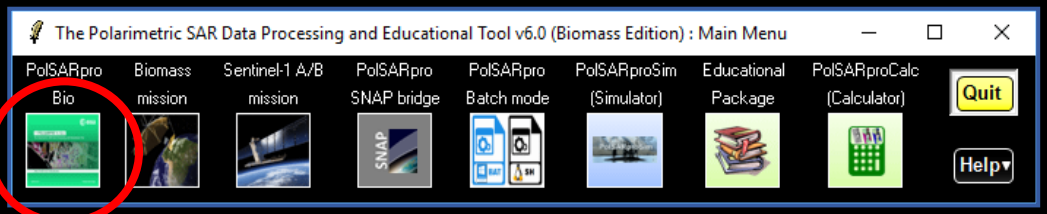
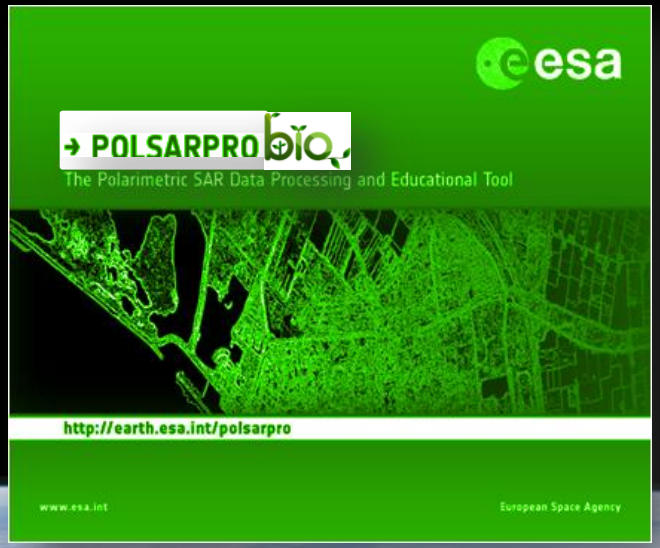
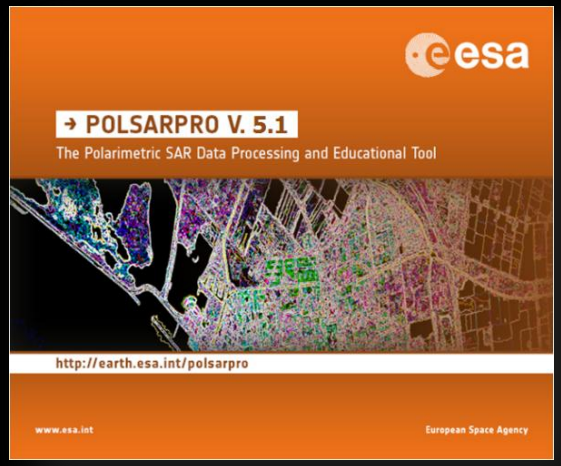
MAIN WINDOW





PolSARpro - Bio SOFTWARE

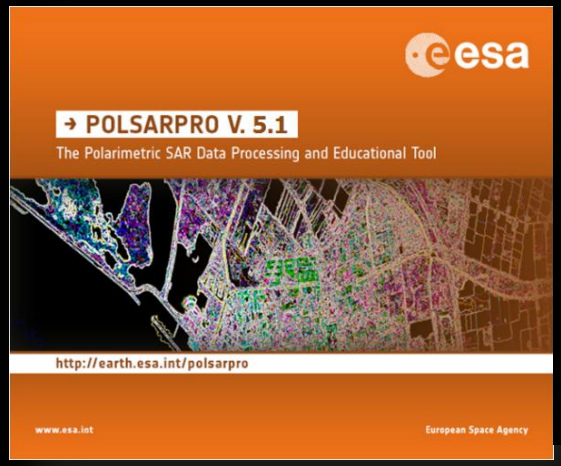
PolSARpro v5.2 SOFTWARE



CURRENT

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

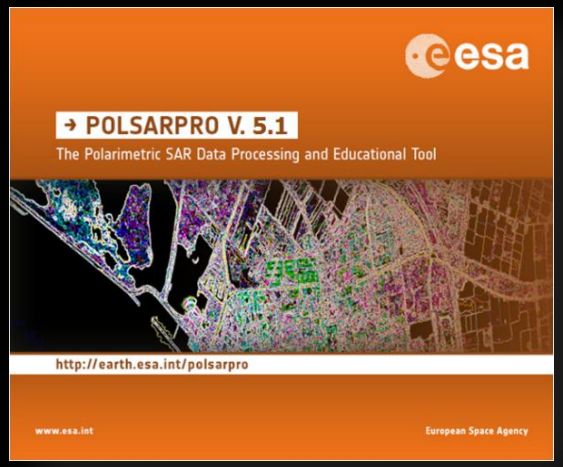
PolSARpro v5.2 SOFTWARE



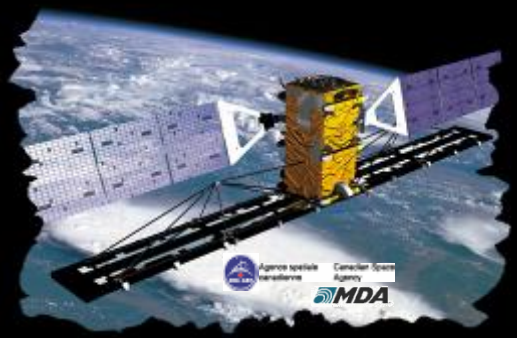
PAST

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

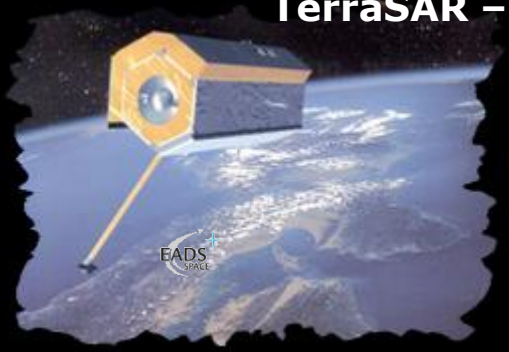
PolSARpro v5.2 SOFTWARE



RADARSAT 2

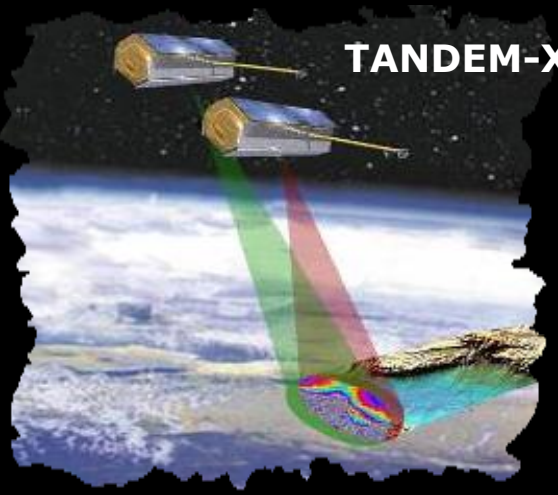


TerraSAR – X



COSMO - SKYMED

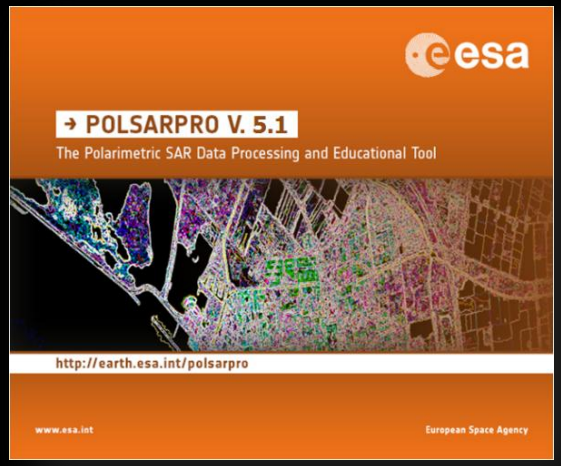
TANDEM-X



CURRENT

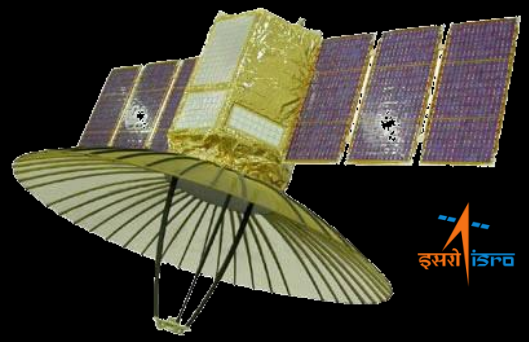
PolSARpro v5.1 Software offers the possibility to handle and convert polarimetric data from a range of well established CURRENT polarimetric spaceborne platforms.

PolSARpro v5.2 SOFTWARE

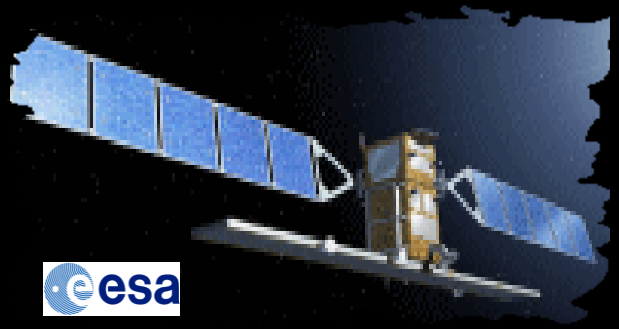


CURRENT

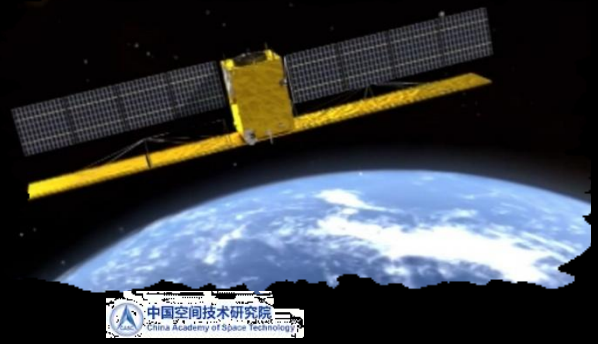
RISAT



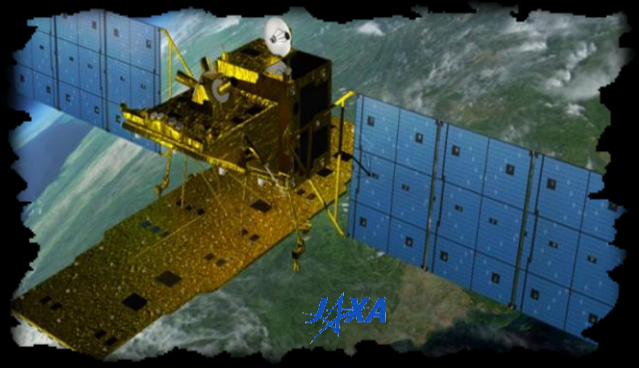
SENTINEL 1A / 1B



GaoFen 3 (GF3)

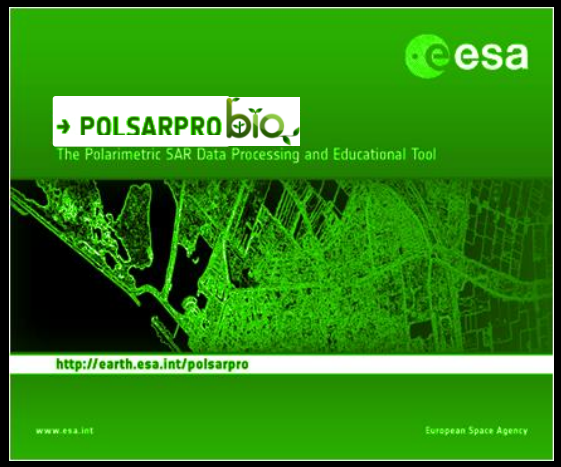


ALOS-2 – PALSAR-2



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

PolSARpro v6.0 (Bio) SOFTWARE



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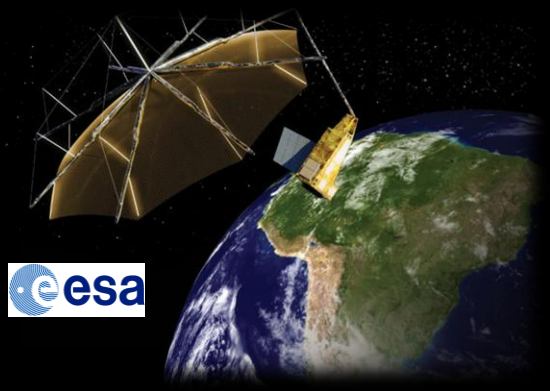
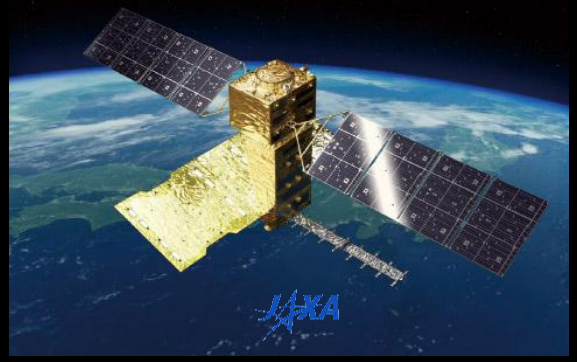


Radarsat Constellation Mission (RCM)

ALOS-4– PALSAR-3



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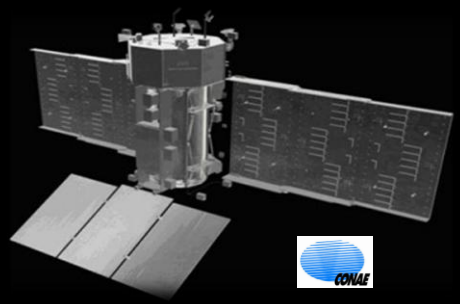
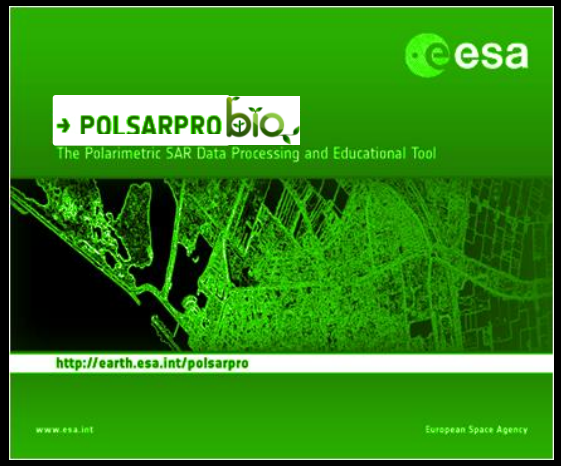


FUTURE

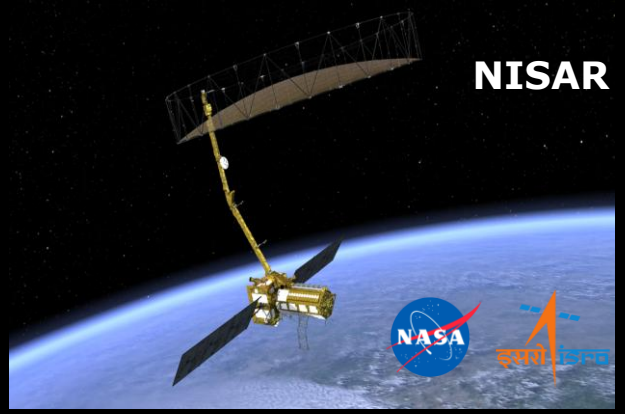
PolSARpro - Bio will offer the possibility to handle and convert polarimetric data of FUTURE polarimetric spaceborne platforms.

PolSARpro v6.0 (Bio) SOFTWARE



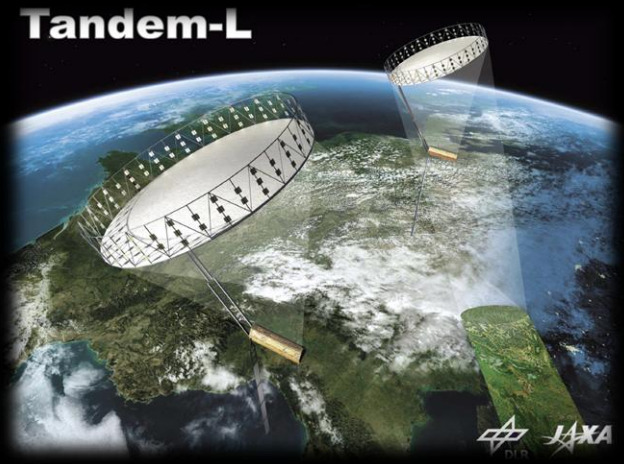
NovaSAR - S

NISAR



FUTURE

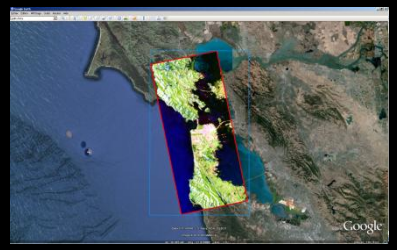
Tandem-L

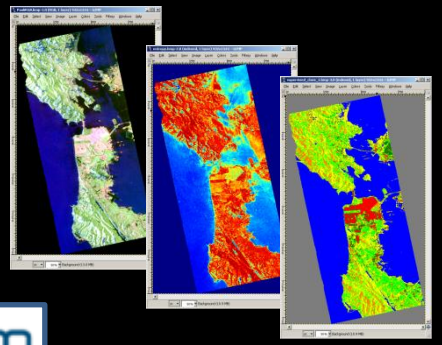


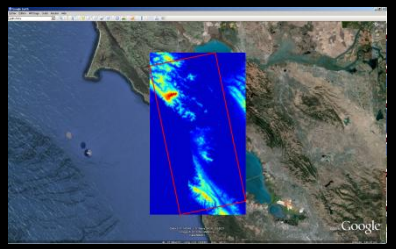
PolSARpro - Bio will offer the possibility to handle and convert polarimetric data of **FUTURE** polarimetric spaceborne platforms.

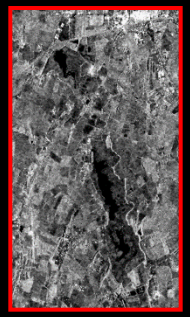
PolSARpro v6.0 (Bio) SOFTWARE

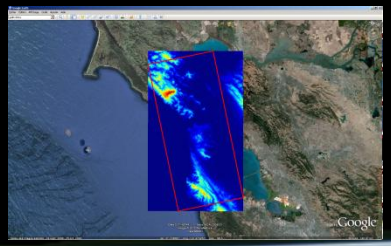
External Softwares

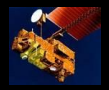












PolSARpro v6.0 (Bio) SOFTWARE

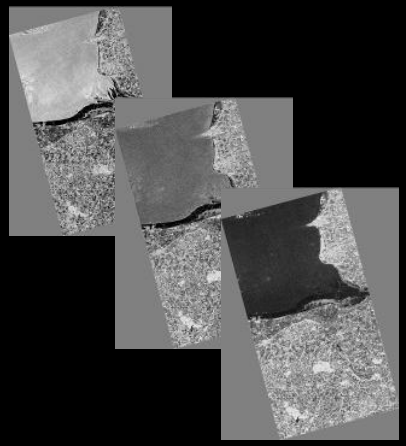
ESA - SNAP / Sentinel-1 Toolbox

Pre-Processing
Data Extract

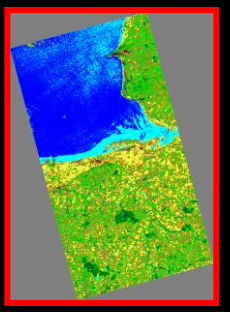
Geo-Coding
Terrain Correct - UTM Proj.

Post - Processing

POLARIMETRIC DATA SETS



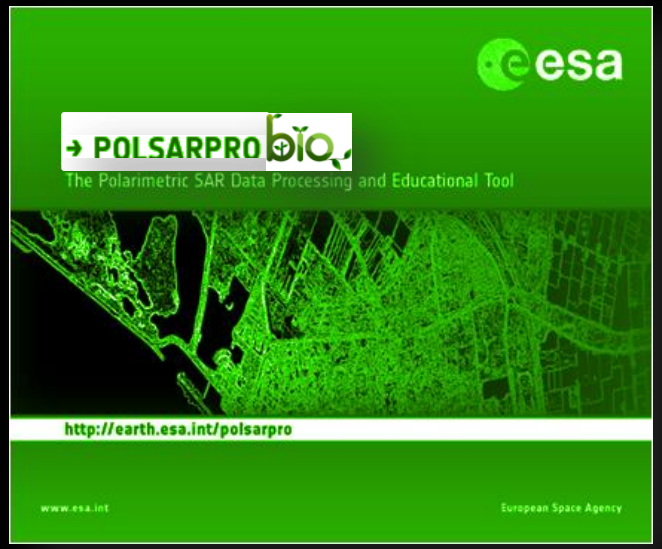
Only valid for:
[C2] matrix: Dual-Pol
[T3] matrix: Quad-Pol

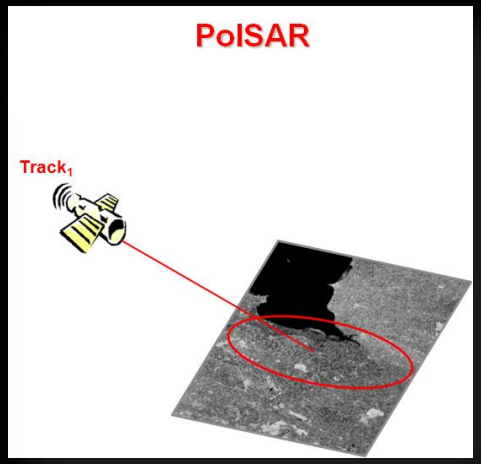


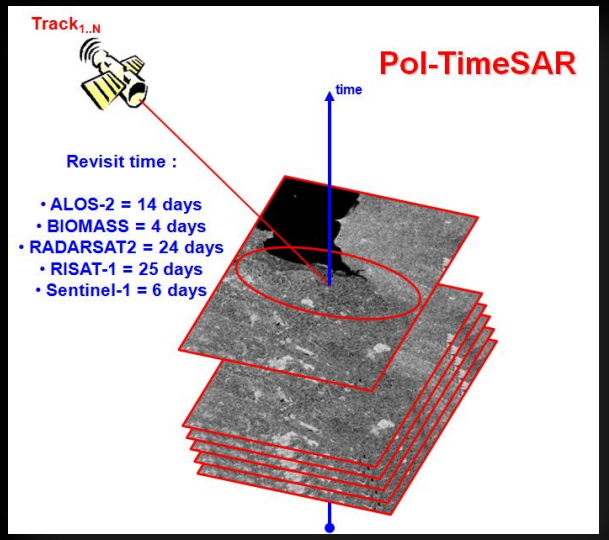
KML File generation

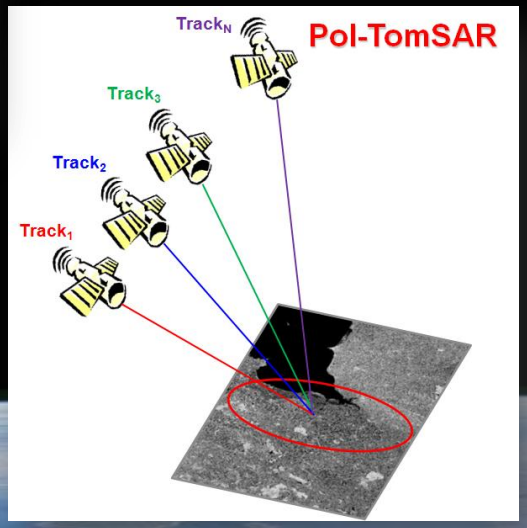
PolSARpro v6.0 (Bio) SOFTWARE

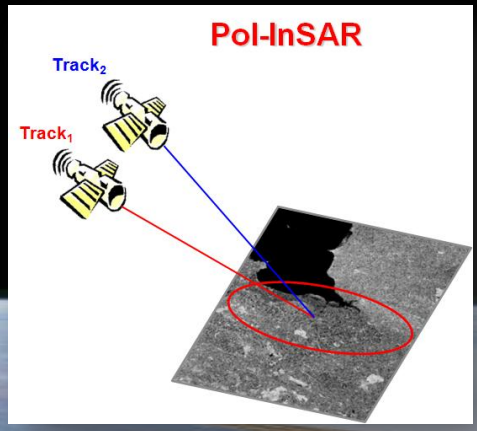
New functionalities



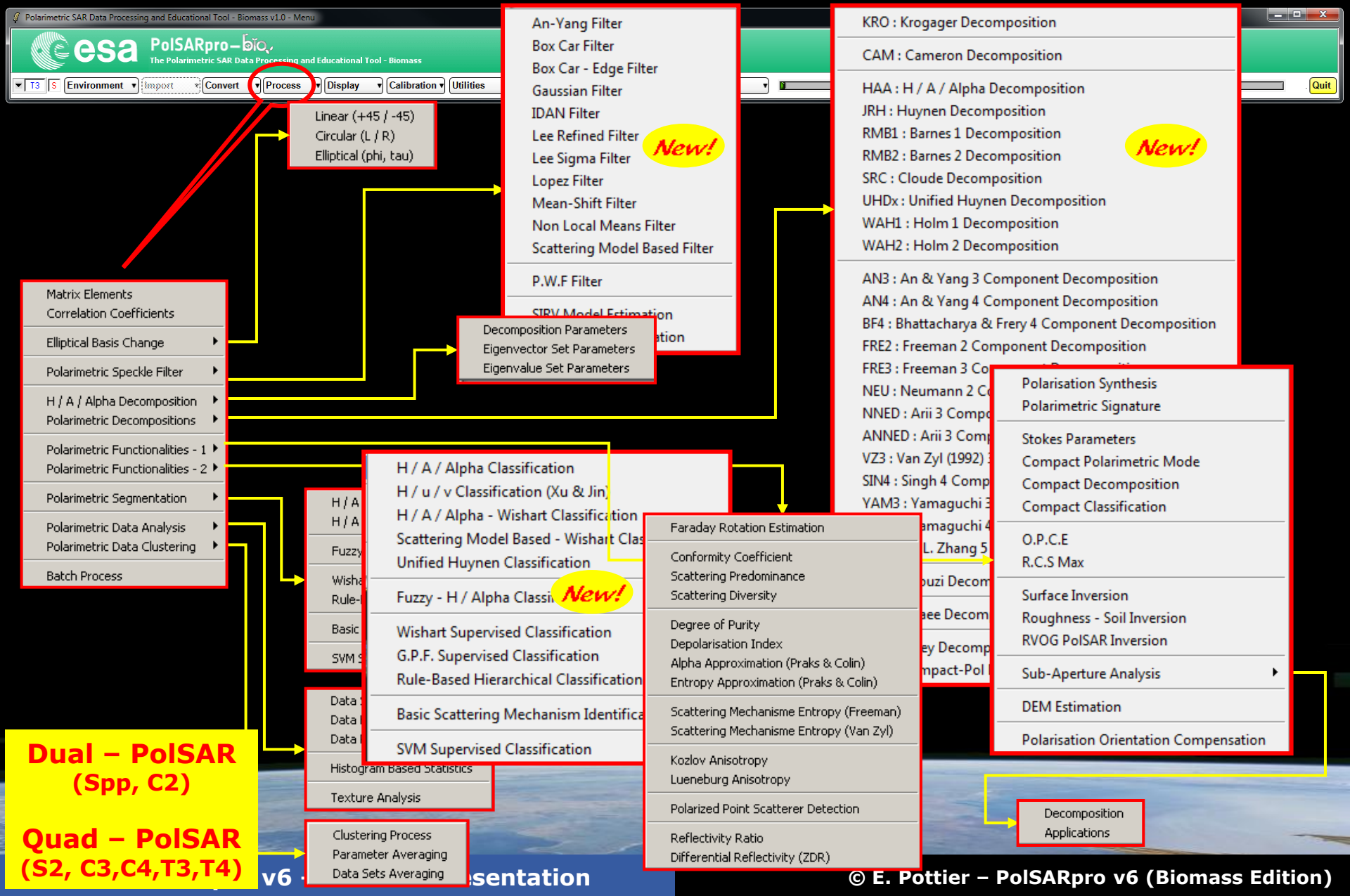








PolSARpro v6.0 (Bio) SOFTWARE



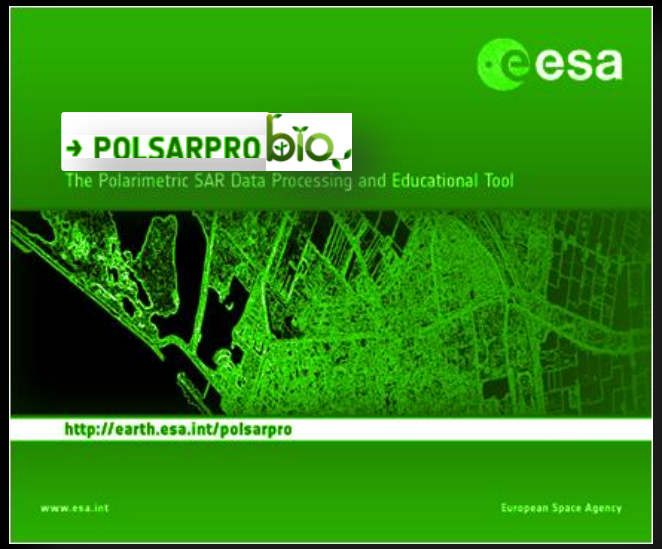
PolSARpro v6.0 (Bio) SOFTWARE

- 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

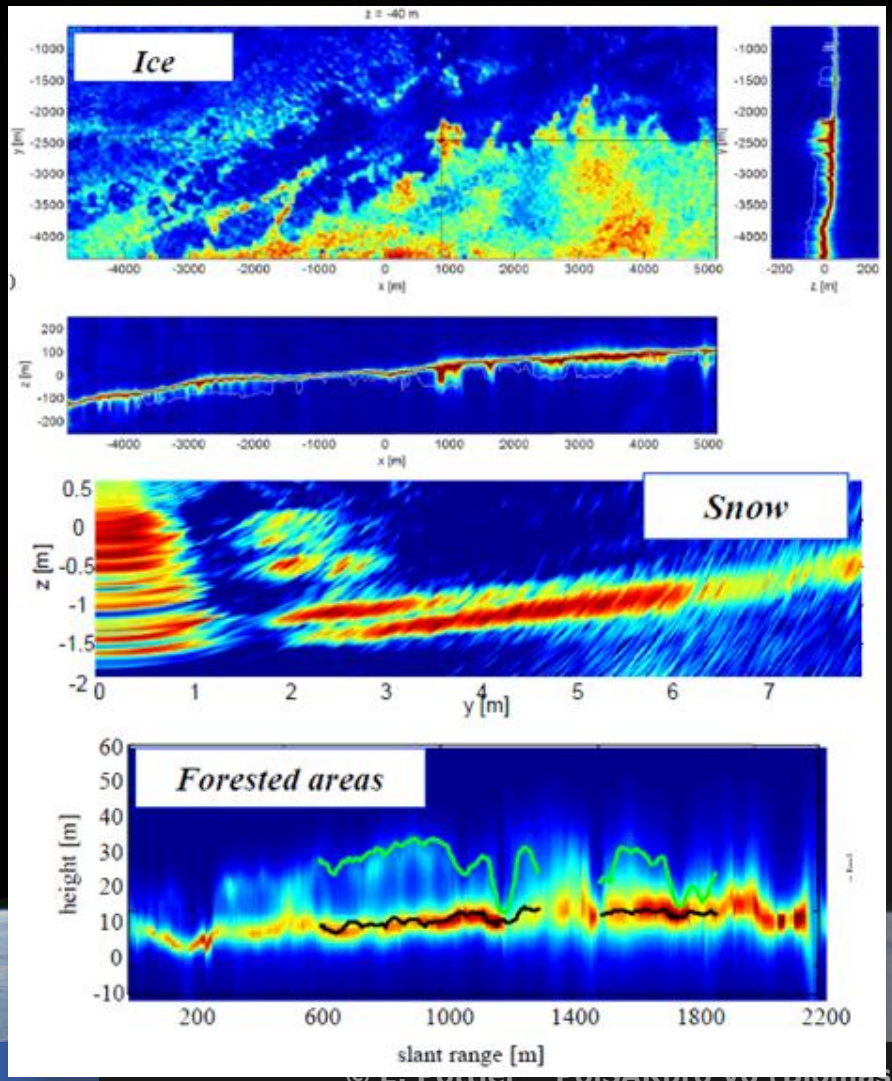
Polarimetry + Interferometry

Pol-InSAR

PolSARpro v6.0 (Bio) SOFTWARE



Pol-TomoSAR processor



PolSARpro v6.0 (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!

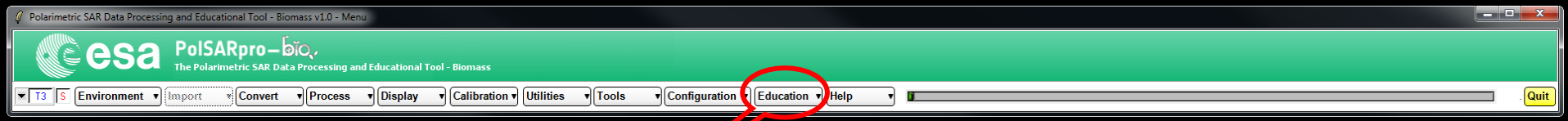
Polarimetry + Time series

Pol-TimeSAR

Polarimetry + Tomography

Pol-TomoSAR

PolSARpro v6.0 (Bio) SOFTWARE



- PolSARap Tutorial (C. Lopez - E. Pottier)
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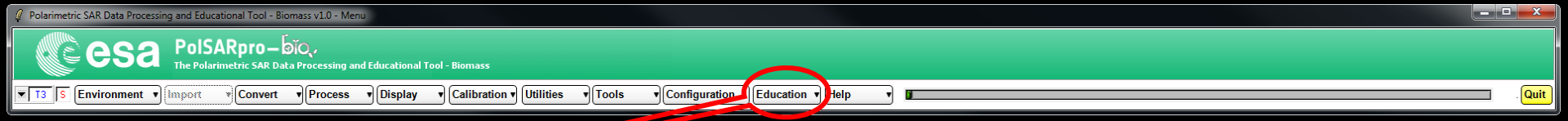
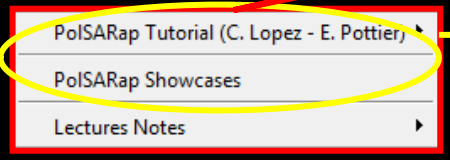
- Surface Parameter Retrieval (I. Hajnsek, K. Papathanassiou)

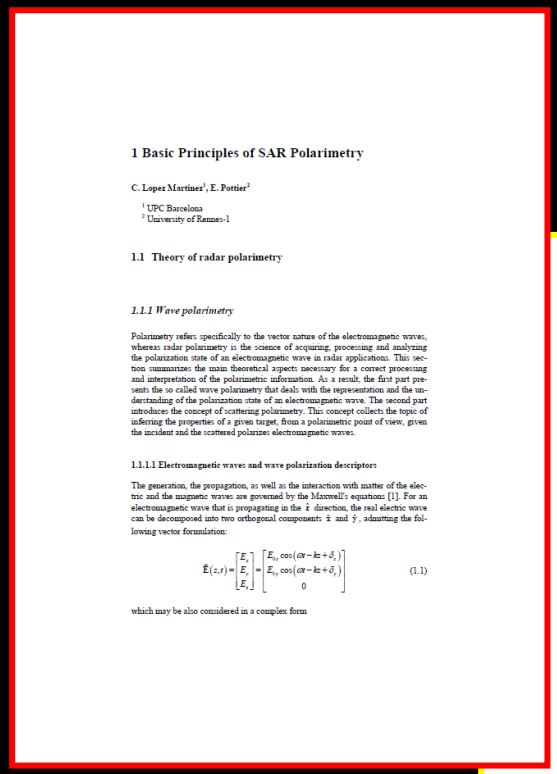
- Single vs multi polarization interferometry
- Pol-InSAR (Training Course)
- Polarization Coherence Tomography (Training Course)

Learning / Training Next P.I Generations

PolSARpro v6.0 (Bio) SOFTWARE







1 Basic Principles of SAR Polarimetry

C. Lopez Martinez[1], E. Pottier[2]

[1] UPC Barcelona
[2] University of Rennes-1

1.1 Theory of radar polarimetry

1.1.1 Wave polarimetry

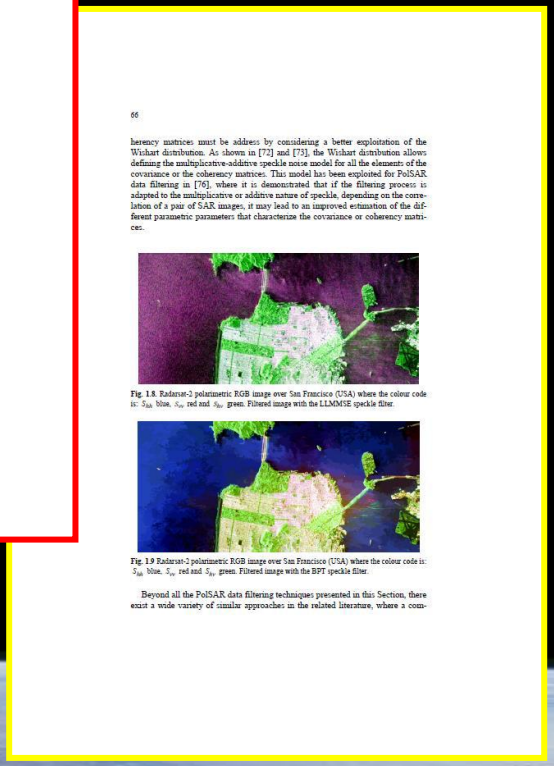
Polarimetry refers specifically to the vector nature of the electromagnetic waves, whereas radar polarimetry is the science of acquiring, processing and analyzing the polarization state of an electromagnetic wave in radar applications. This section summarizes the main theoretical aspects necessary for a correct processing and interpretation of the polarimetric information. As a result, the first part presents the so called wave polarimetry that deals with the representation and 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 polarizes electromagnetic waves.

1.1.1.1 Electromagnetic waves and wave polarization descriptors

The generation, the propagation, as well as the interaction with matter of the electric and the magnetic waves are governed by the Maxwell's equations [1]. For an electromagnetic wave that is propagating in the $\hat{k}$ direction, the real electric wave can be decomposed into two orthogonal components: $\hat{x}$ and $\hat{y}$, admitting the following vector formulation:

$$\vec{E}(z,t) = \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix} = \begin{bmatrix} E_{0x}\cos(\omega t - kz + \delta_x) \\ E_{0y}\cos(\omega t - kz + \delta_y) \\ 0 \end{bmatrix} \quad (1.1)$$

which may be also considered in a complex form



66

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

Fig. 1.8. Radarsat-2 polarimetric RGB image over San Francisco (USA) where the colour code is: S_{hh} blue, S_{vv} red and S_{hv} green. Filtered image with the LLMMSE speckle filter.

Fig. 1.9 Radarsat-2 polarimetric RGB image over San Francisco (USA) where the colour code is: S_{hh} blue, S_{vv} red and S_{hv} green. Filtered image with the BPT speckle filter.

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

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esa DLR HR ETH AEL consultants IETR INSTITUT D'ÉLECTRONIQUE ET DE TÉLÉCOMMUNICATIONS DE RENNES ONERA UPC UNIVERSITÀ DEGLI STUDI DI NAPOLI PARTHENOPE

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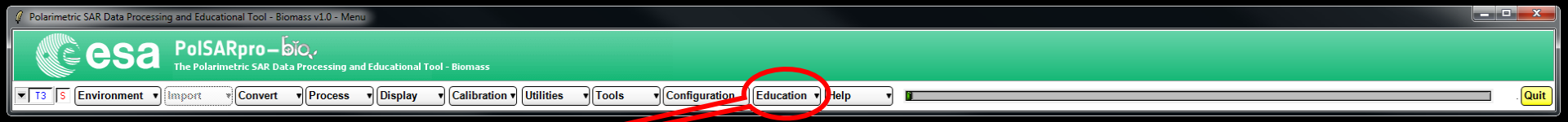

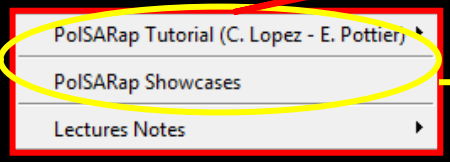

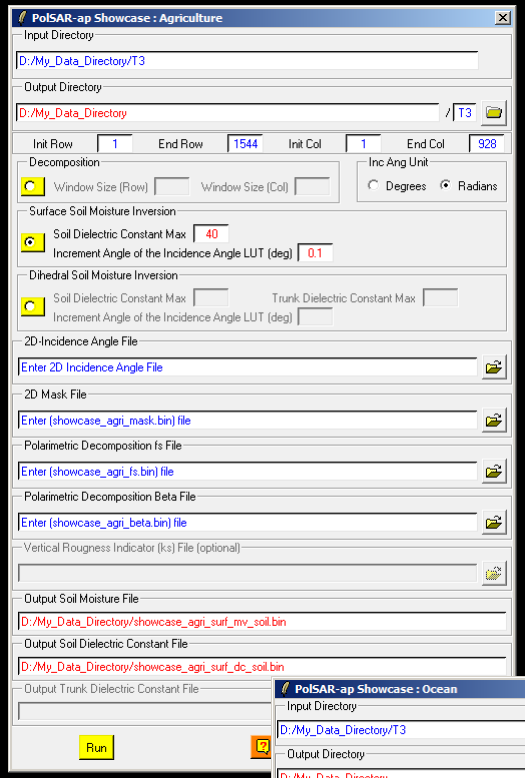

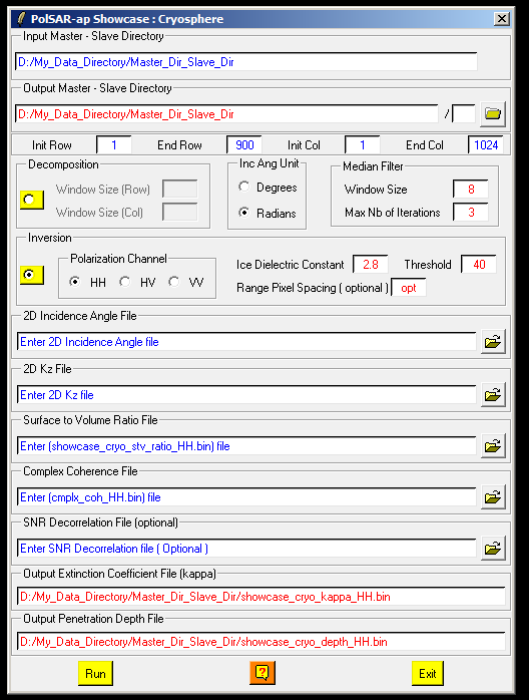

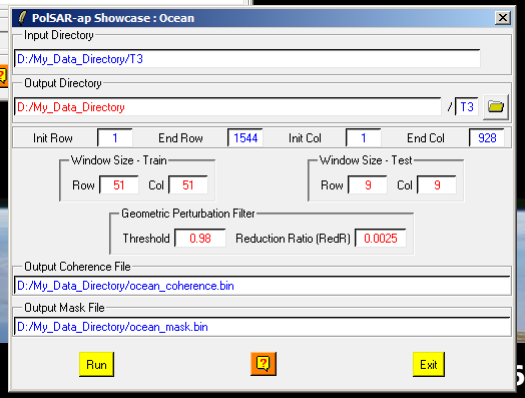

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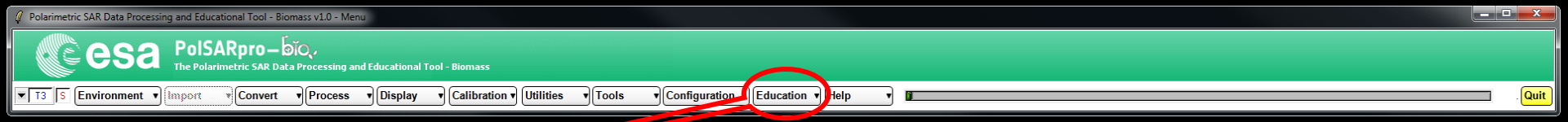
esa DLR HR ETH AEL consultants IETR ONERA UPC

PolSARpro v6.0 (Bio) SOFTWARE



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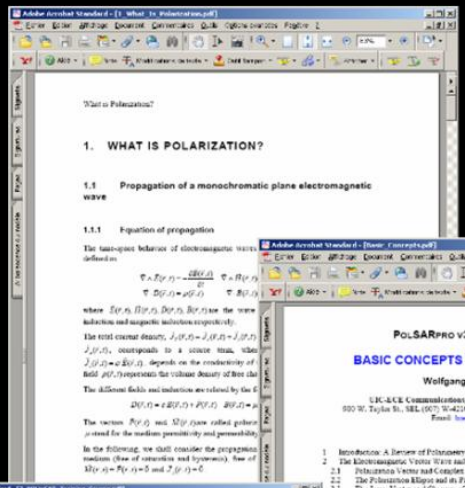
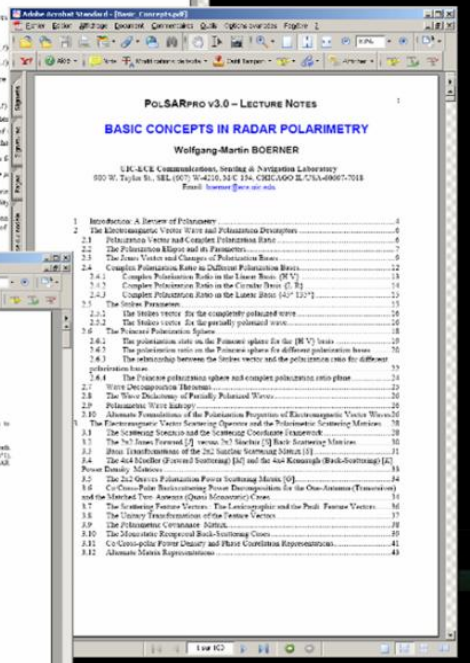
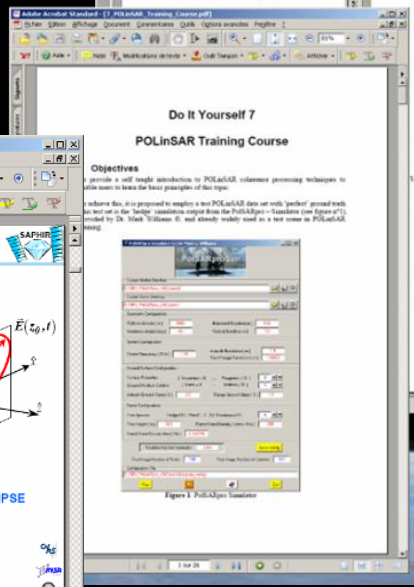
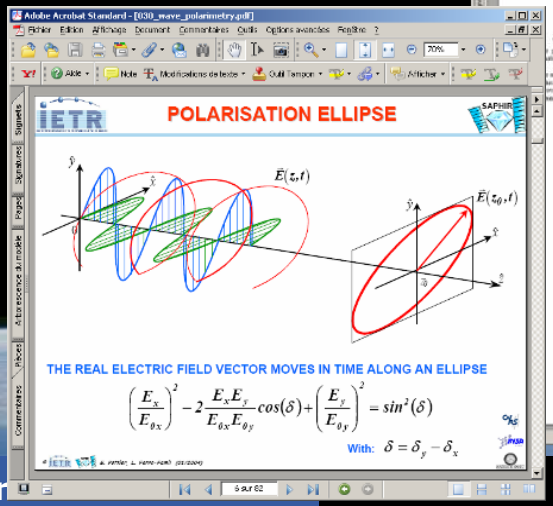


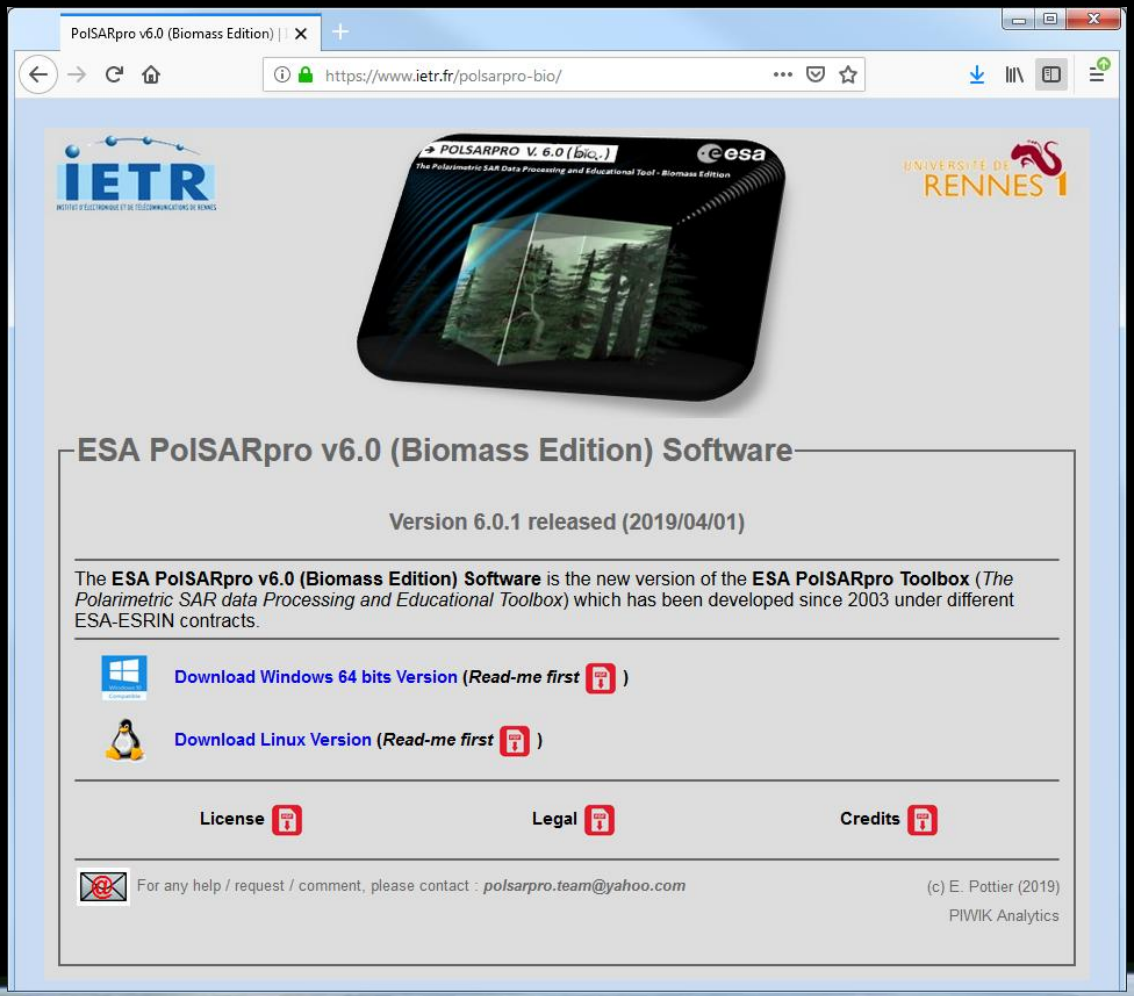






PolSARpro v6.0 (Bio) SOFTWARE

https://www.ietr.fr/polsarpro



polsarpro.team@yahoo.com