



# Software Tool PolSARpro v3.0

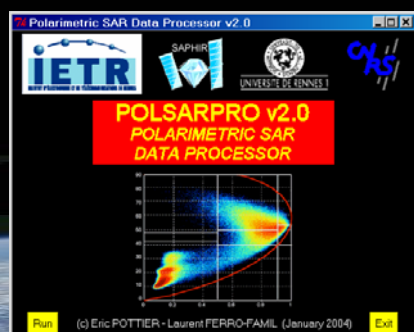
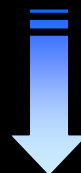
Eric POTTIER

Tuesday 4 September, Lecture D2L5-2

## CONTEXT



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.



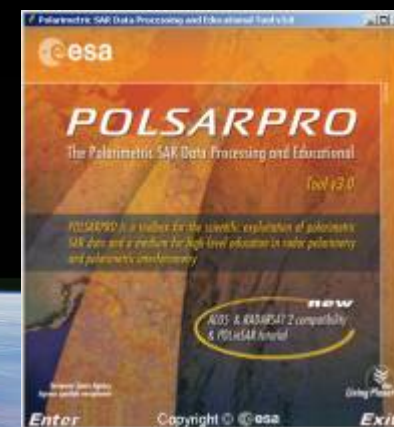
2003



2004



2005



2007



## CONTEXT

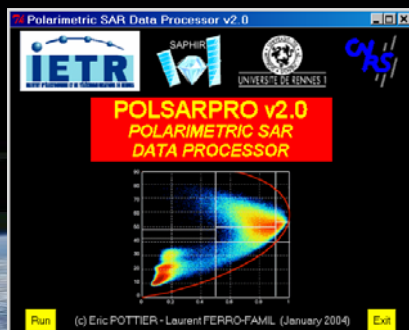
The **PolSARpro Software** is developed under contract to ESA :

*Development of a Polarimetric SAR Image Analysis Tool*

ESA – ESRIN Contract n° 17863 / 03 / I – LG (2003-2005)

*Continued Development of the PolSARpro Toolbox*

ESA – ESRIN SOW TPME-DTEX-EOPS-SW-06-0001 (2006-2008)



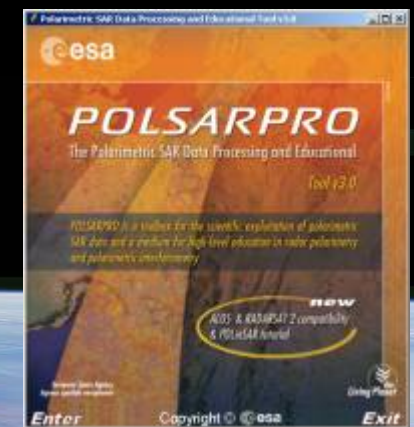
2003



2004



2005



2007





Eric Pottier



Laurent Ferro-Famil



Sophie Allain



Stéphane Méric



Shane R. Cloude



Irena Hajnsek



Kostas Papathanassiou



Mark Williams



Yves-Louis Desnos



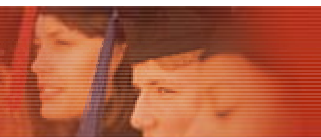
Tim Pearson  
( PolSARpro v2.0 )



Andrea Minchella  
( PolSARpro v3.0 )



## PoSARpro TEAM



In collaboration with :

And with  
The Agencies :



Thomas Ainsworth



Wolfgang M. Boerner



Martin Hellmann



Jong-Sen Lee



Carlos Lopez



Jean-Claude Souyris



Ridha Touzi



Resources naturelles  
Canada



Yoshio Yamagushi

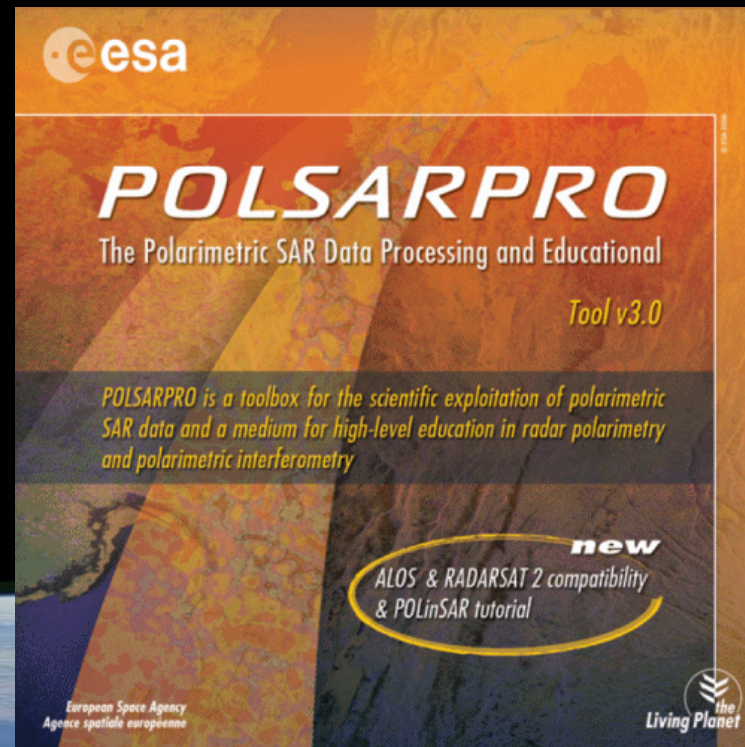


Niigata University



# PolSARpro v3.0 SOFTWARE

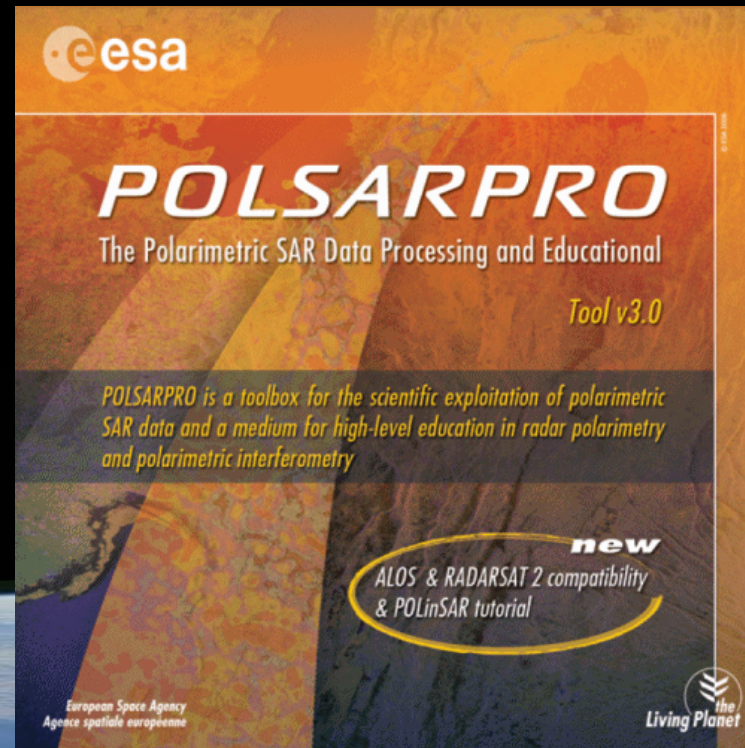
Tool specifically designed to handle :  
**Polarimetric data**  
and  
**Polarimetric Interferometric data.**





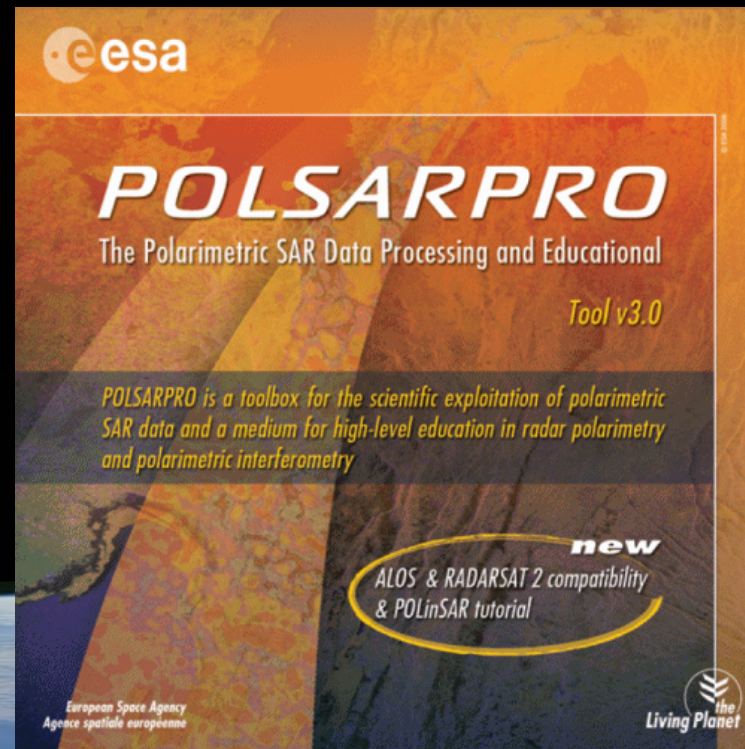
# PolSARpro v3.0 SOFTWARE

Educational Software offering a tool for  
**self-education**  
in the field of **POLSAR** and **POL-InSAR**  
data processing and analysis.





**PolSARpro v3.0 SOFTWARE**  
Developed to be **accessible** to :  
a wide range of users  
from **novices** to **experts**  
in the field of **POLSAR** and **POL-InSAR**.





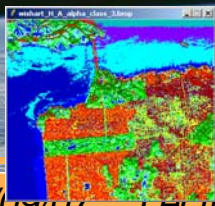


## USER INTERFACE

**PolSARpro v3.0 Software** is conceived as a flexible environment, with a friendly and intuitive Graphical User Interface (GUI)

The graphical user interface (GUI) is written in **Tcl-Tk**

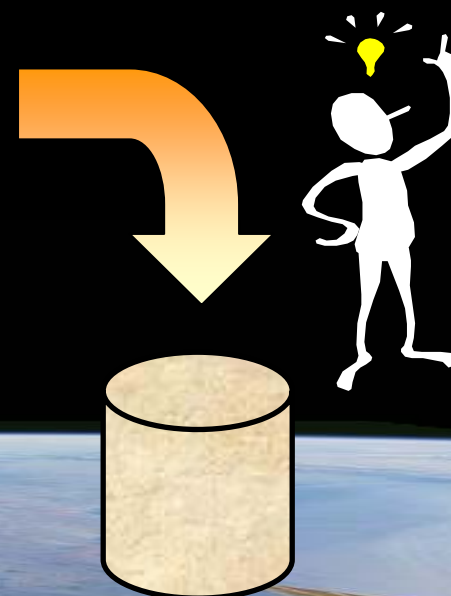
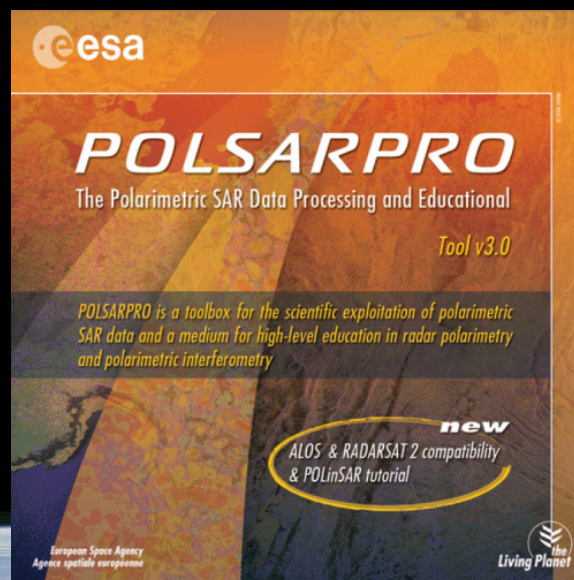
- **263369** lines managing **154** widget windows
- **681** C routines (**279839** lines) performing well-established algorithms in the field of POLSAR and POL-InSAR.





## MODULAR STRUCTURE

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

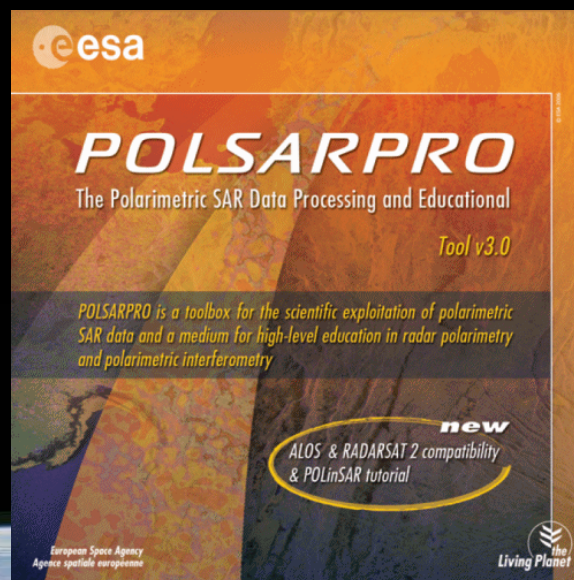
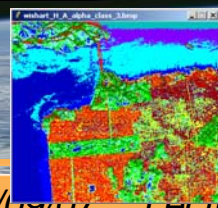




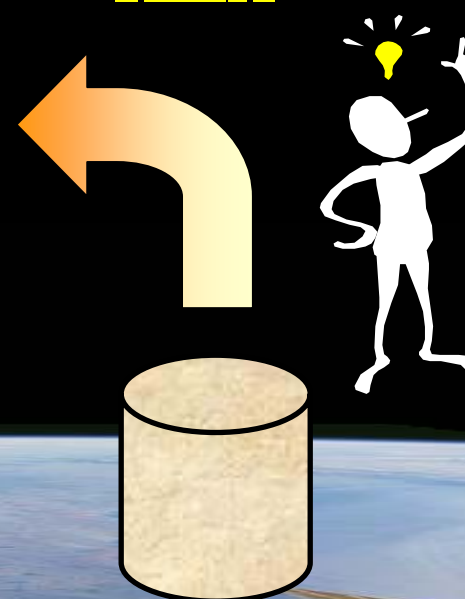


## MODULAR STRUCTURE

Users can easily **add** their own functions and components, as **PolSARpro v3.0 Software** is conceived as a flexible and open software environment.



**New!**







## OPEN SOURCE DEVELOPMENT

**PolSARpro v3.0 Software** is made available following the:

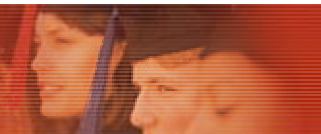
**Open Source Software Development (OSSD)** approach, and follows the:

**GNU General Public License v2 – June 1991.**

**PolSARpro v3.0 Software** runs today on:

Windows 98+, Windows 2000, Windows NT 4.0,  
Windows XP, Linux I386 and Unix SOLARIS  
(Macintosh OS in progress).

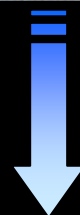
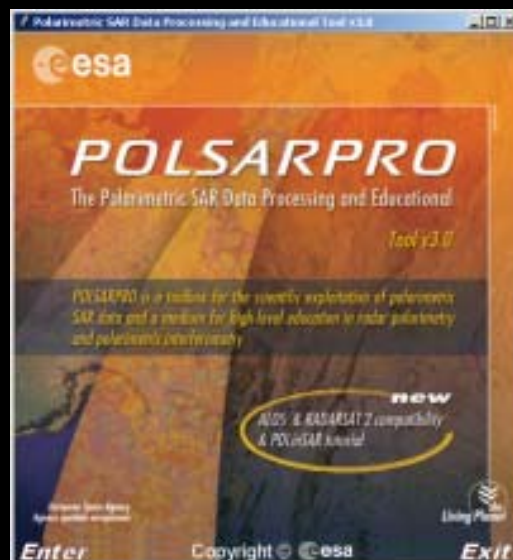




## OPEN SOURCE DEVELOPMENT

The Tool is **free download** on the Internet  
from the **ESA Web Portal (Earthnet)** at :  
**<http://earth.esa.int/polsarpro>**





## MAIN MENU



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**PolSARpro Full Software**  
– Single Data Set  
– Multi Data Sets

**Tutorial on  
POL SAR and  
POLin SAR**

**Help  
Files**

**Viewer**

**Display**

**Tools**



### Version for the EO Scientific Investigator

Spaceborne Sensors: ALOS, ENVISAT, RADARSAT2, TerraSar, SIR-C  
Airborne Sensors: AIRSAR, Convair, EMISAR, ESAR, PISAR, RAMSES

## TUTORIAL ON POLSAR and POL-InSAR

PolSARpro Full Software  
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POLsAR and  
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Version for the EO Scientific Investigator

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## Provide a grounding in SAR Polarimetry (POLSAR) and SAR Polarimetric Interferometry (POL-InSAR)



- Tutorial ▶
- Slides ▶
- Lectures Notes ▶
- PolSARpro Simulator

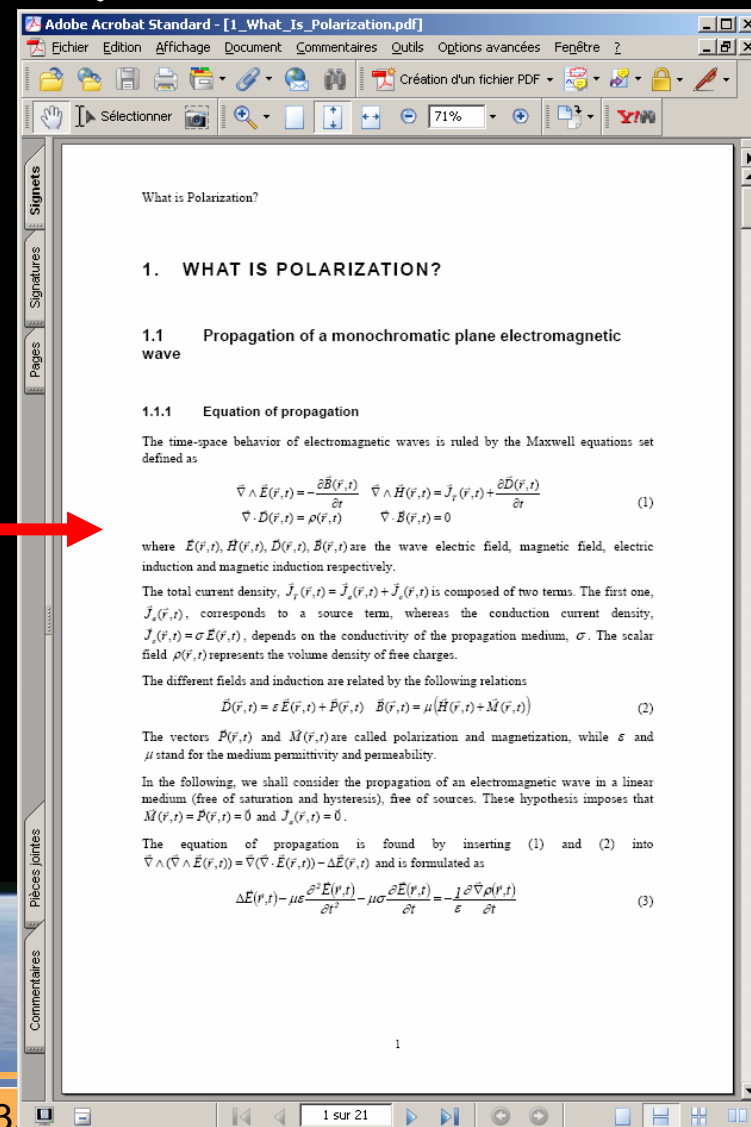
- Part 0 : Introduction
- Part I : Radar Polarimetry ▶
- Part II : Polarimetric SAR Interferometry ▶
- Part III : Surface Parameter Retrieval ▶
- Part IV : Glossary
- Part V : References
- Part VI : Do It Yourself ▶

- 1 : What is polarization ?
- 2 : Single vs multi polarization SAR data
- 3 : Speckle filtering
- 4 : Polarimetric decompositions
- 5 : Polarimetric SAR data classification
- 6 : ENVISAT - ASAR dual polarization case

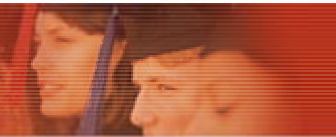
- 1 : Pol-InSAR Training Course
- 2 : Single vs multi polarization interferometry

- 11 : Description of natural surfaces
- 12 : Rough surface scattering models
- 13 : Single vs multi polarization descriptors
- 14 : Estimation of surface characteristics

**Direct access to the Tutorial while using PolSARpro facilities**  
The Tutorial is made available in PDF format.



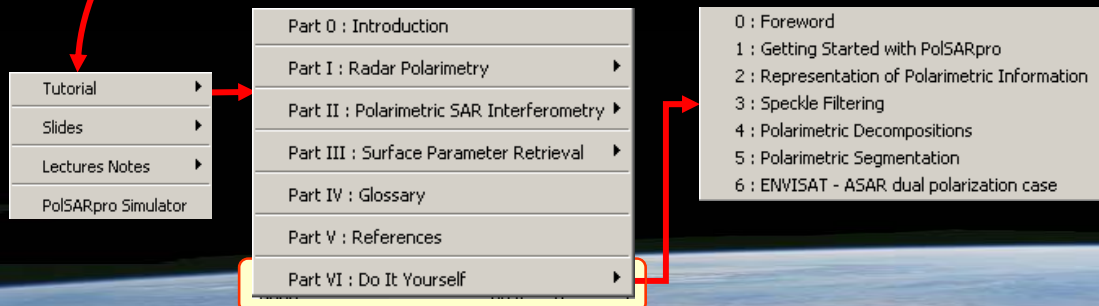




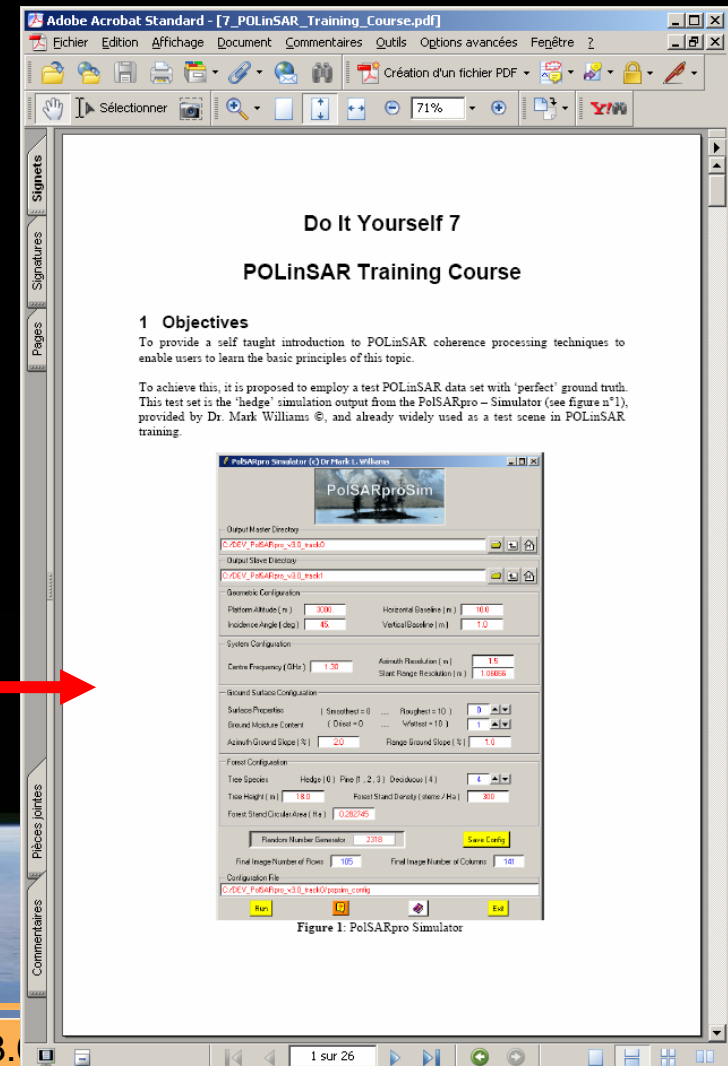
Offer a **self-education** as a low-level teaching aid illustrated with applications examples (**Do It Yourself**) showing the full range of functions that the Software proposes



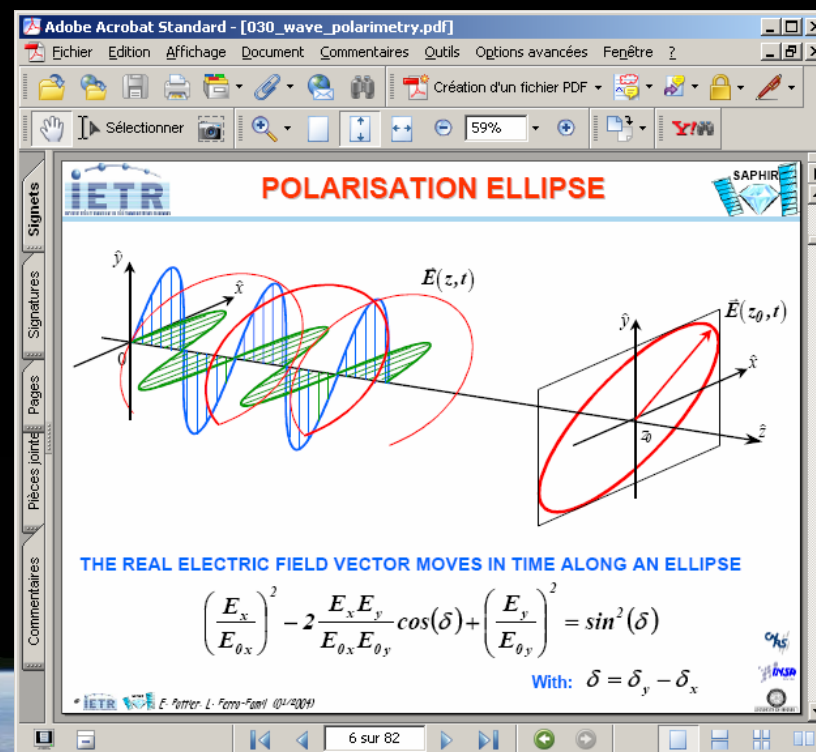
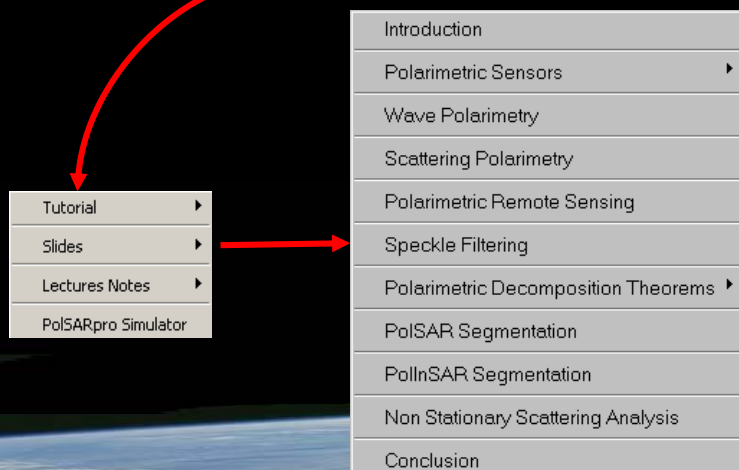
## A Progressive Approach



**Direct access to the Tutorial while using PolSARpro facilities**  
The Tutorial is made available in PDF format.



Series of **Tutorial Slide Shows** is made available to support taught courses for use as part of a self teaching programme.

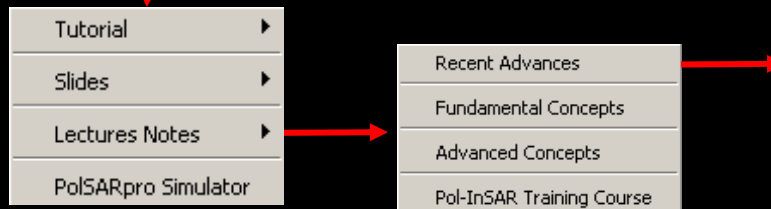


Direct access to the Slide Shows while using PolSARpro facilities  
The Tutorial is made available in PDF format.

# Series of **Lecture Notes** providing introduction to the basic theory, scattering concepts, advanced concepts and applications in SAR Polarimetry

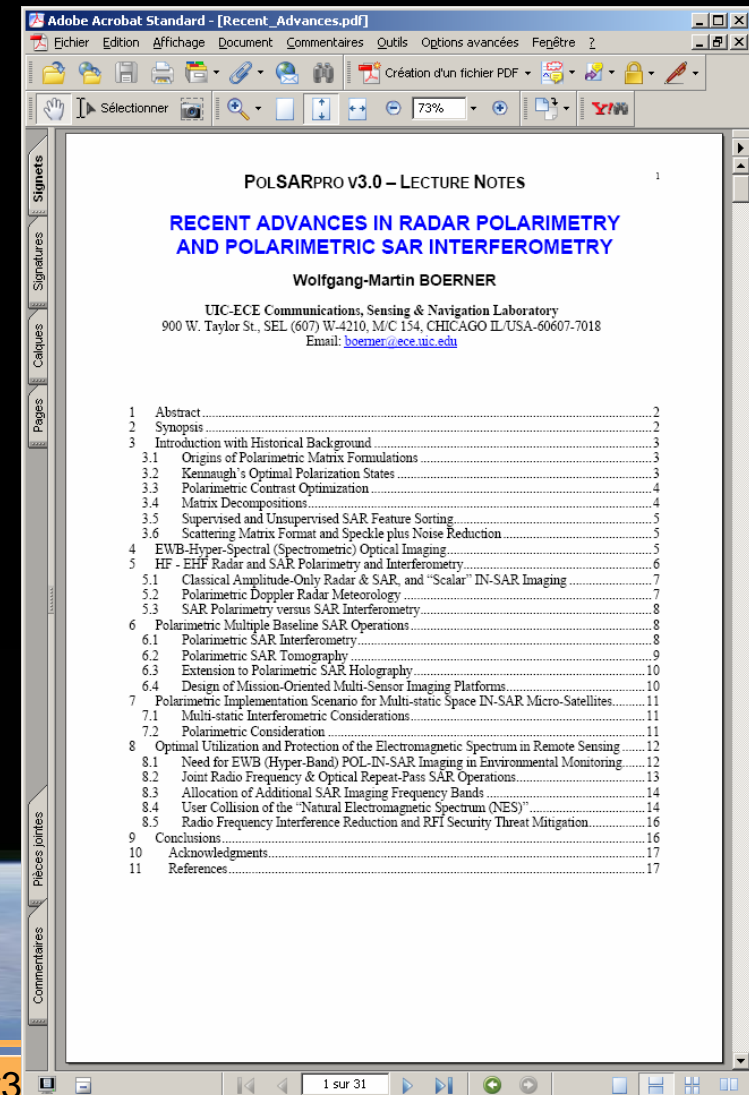


**New!**



- **Recent Advances in Radar Polarimetry and Polarimetric SAR interferometry** *W.M. Boerner* – 31 pages
- **Basic Concepts in Radar Polarimetry** *W.M. Boerner* – 100 pages
- **Advanced Concepts** *E. Pottier, J.S. Lee, L. Ferro-Famil* – 65 pages

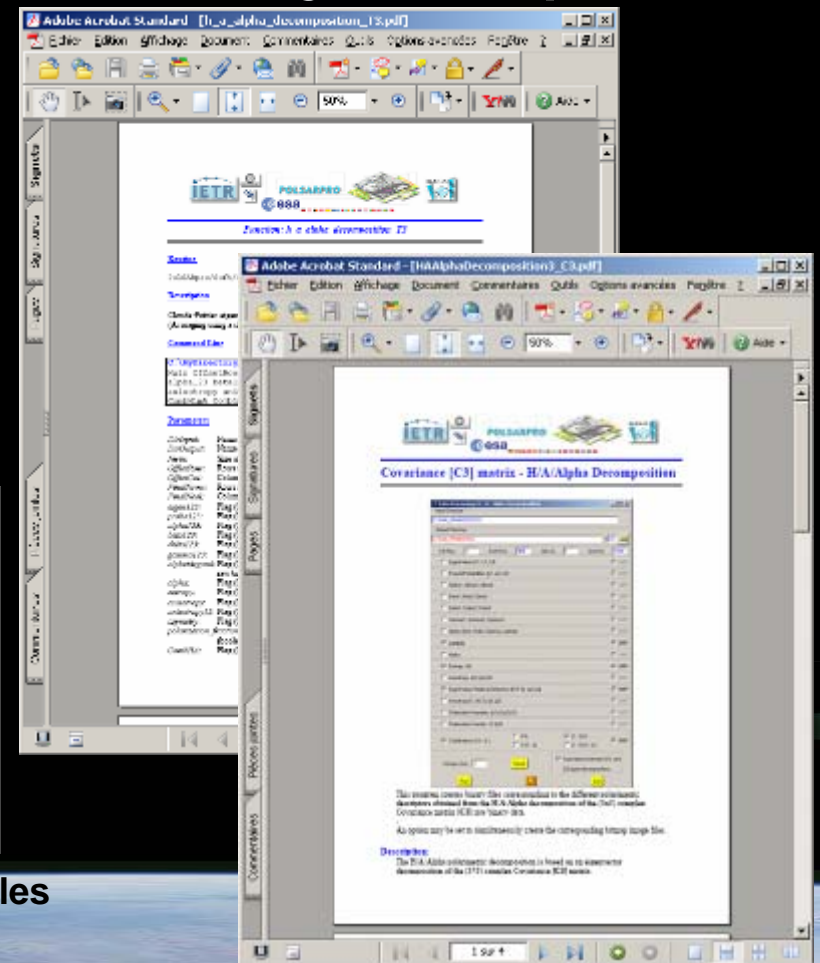
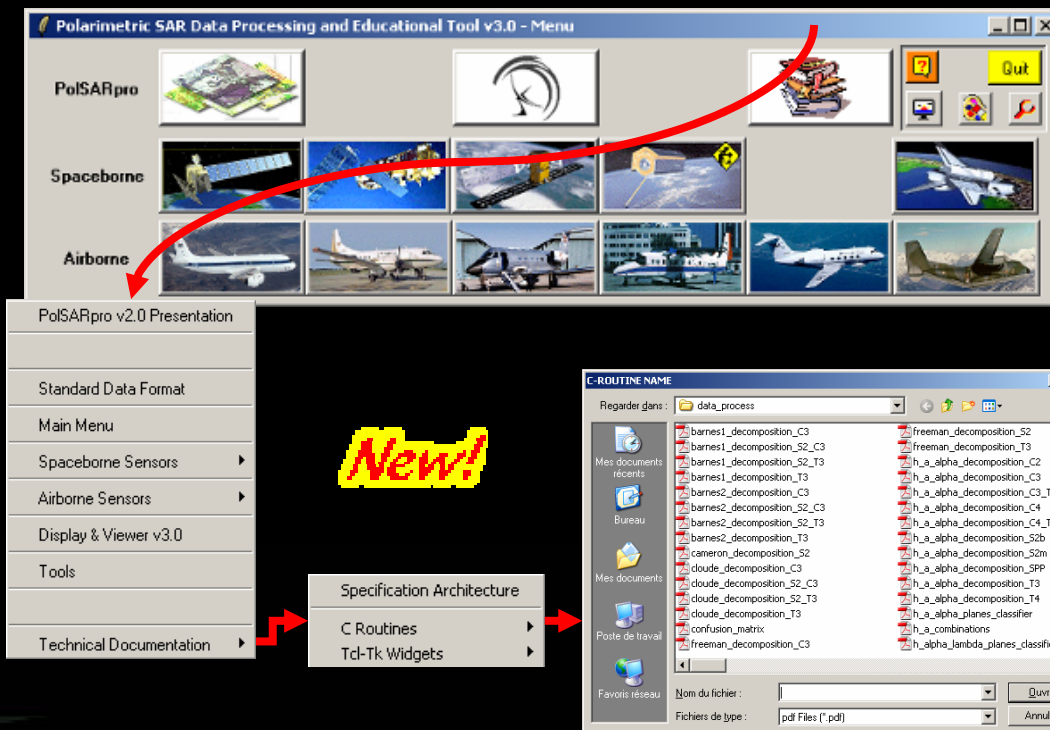
Direct access to the Tutorial while using PolSARpro facilities  
The Tutorial is made available in PDF format.







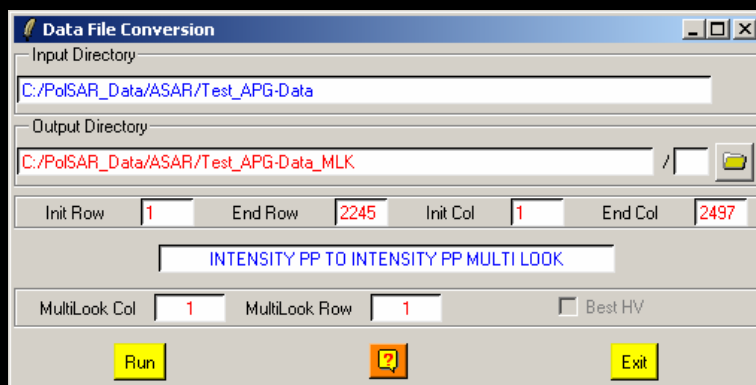
Series of concatenated sub-sections of the **User Manual**, containing all the individual pages necessary for a specific interface (**Tech Doc**).




**228 Tcl-Tk Widget description files**  
**526 C Routine description files**

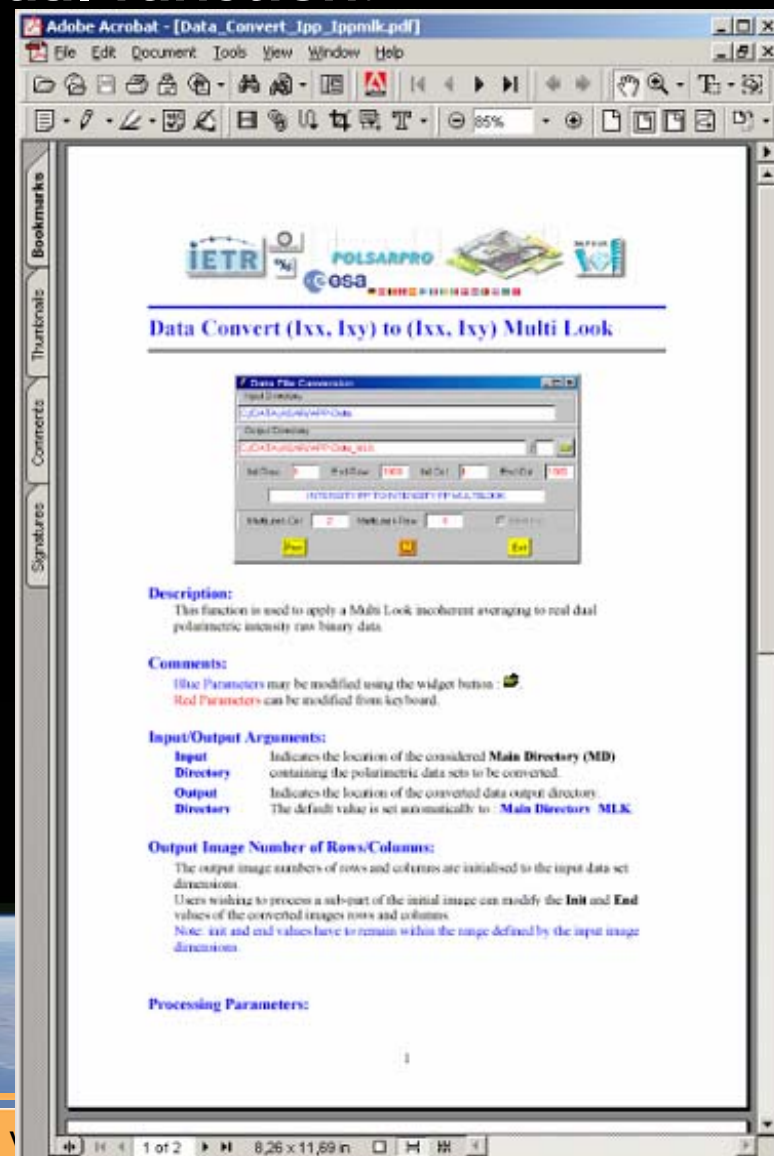
**Direct access to the Technical Documentation while using PolSARpro facilities**  
**The Technical Documentation is made available in PDF format.**

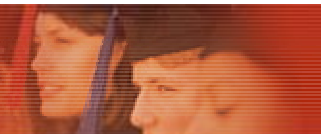
**PolSARpro v3.0 Software** is accompanied by a comprehensive set of **228 Help Files** for each individual function.



Individual **Help Files** are accessible from within the software by clicking on the help icon  present in the relevant dialogue box.

**User Manual** is made available in PDF format.





## VERSION FOR THE E.O. SCIENTIFIC INVESTIGATOR

PolSARpro Full Software  
– Single Data Set  
– Multi Data Sets

Tutorial on  
POLAR and  
POLInSAR

Help  
Files

Viewer

Display



Tools

**Spaceborne Sensors:**

**ALOS, ENVISAT, RADARSAT2, TerraSar, SIR-C**

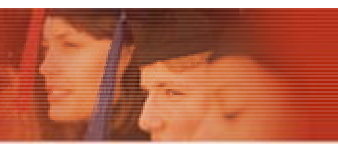
**Airborne Sensors:**

**AIRSAR, Convair, EMISAR, ESAR, PISAR, RAMSES**

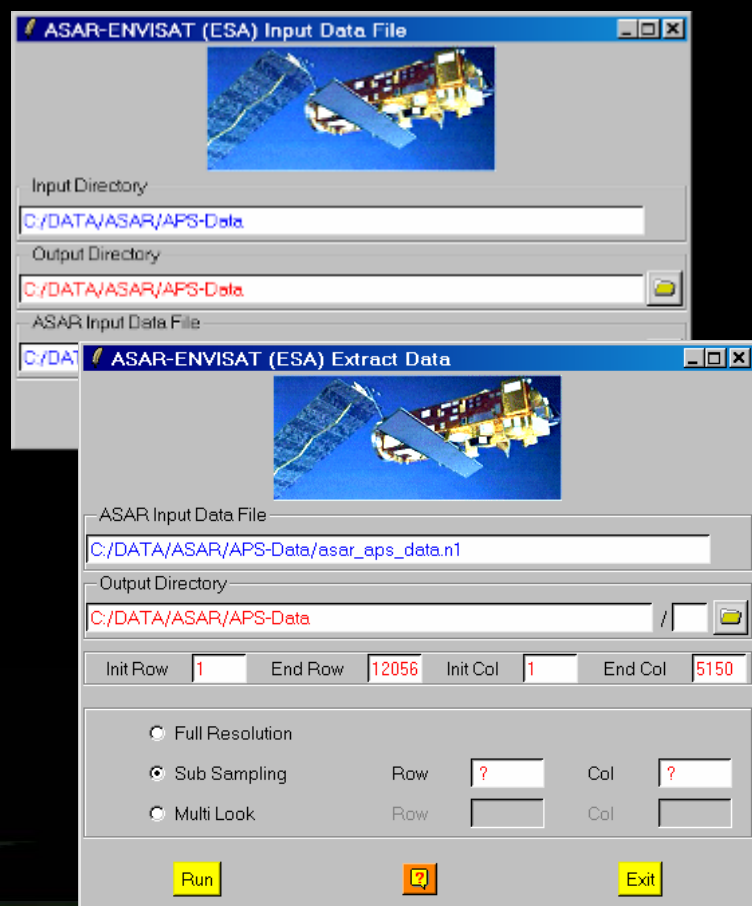




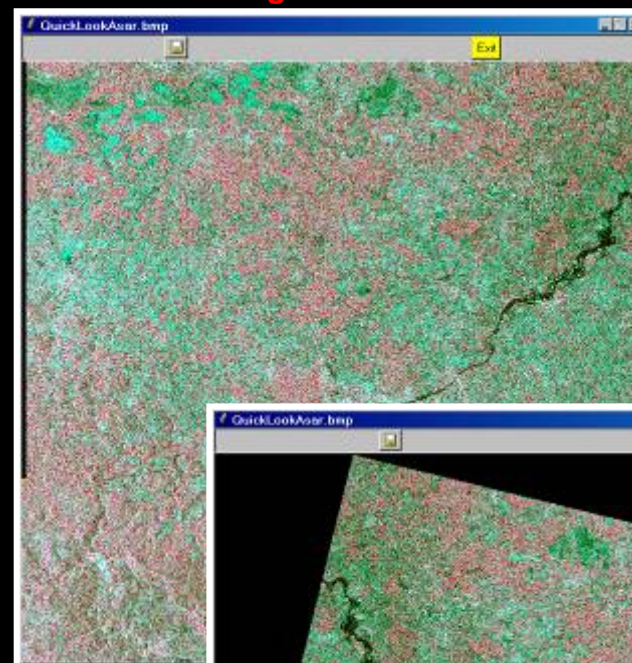
**PolSARpro v3.0 Software** handles and converts polarimetric data from a range of current, planned or future **polarimetric spaceborne platforms**.



# ENVISAT - ASAR Sensor

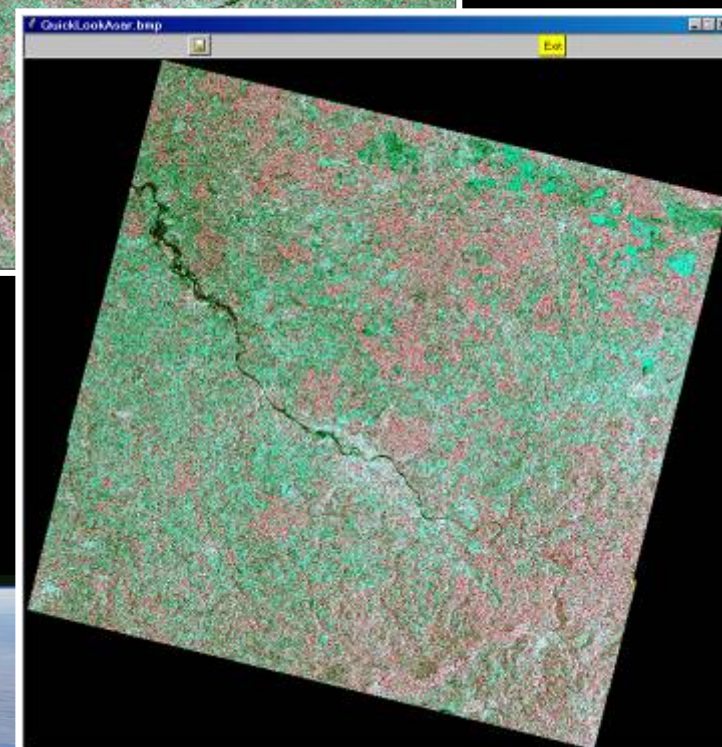


Quick Look Image BMP File



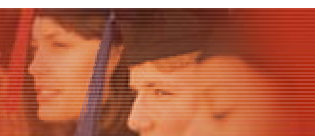
Mode APG

Mode APS



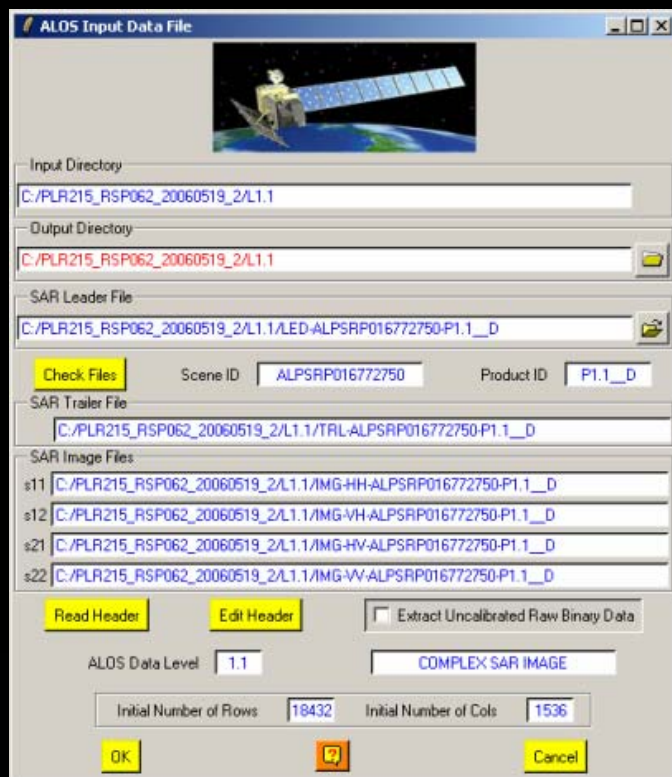
- ASAR Dual POL
- ASAR Data Mode APS, APP, APG





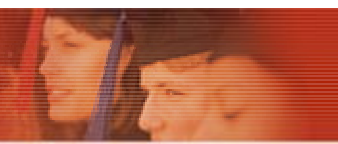
# ALOS - PALSAR Sensor

Quick Look Image BMP File

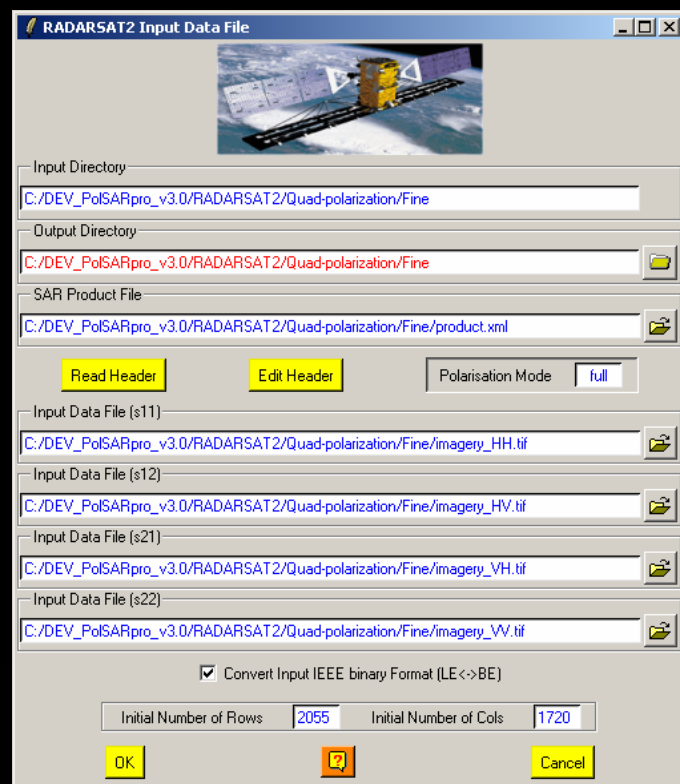


- PALSAR Dual & Quad POL
- PALSAR Data Level 1.1 and 1.5

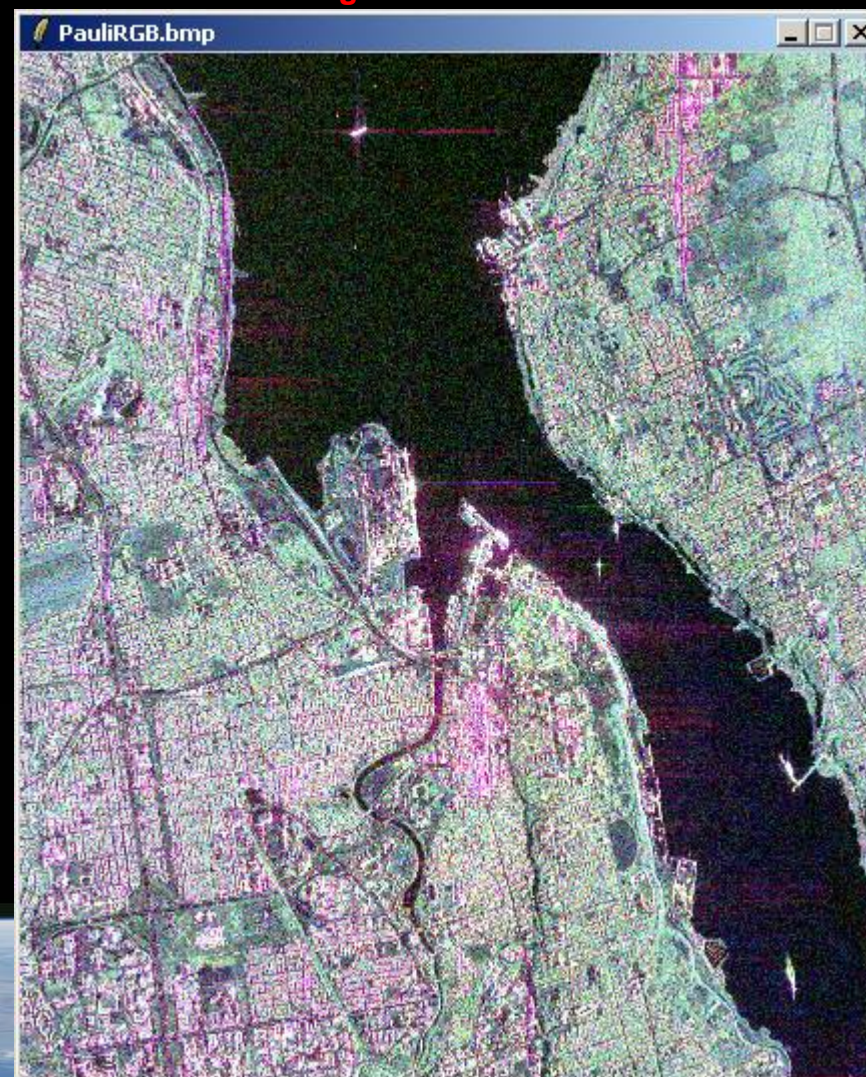




# RADARSAT - 2 Sensor

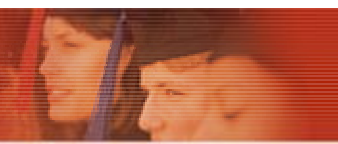


Quick Look Image BMP File



- RADARSAT-2 Dual & Quad POL

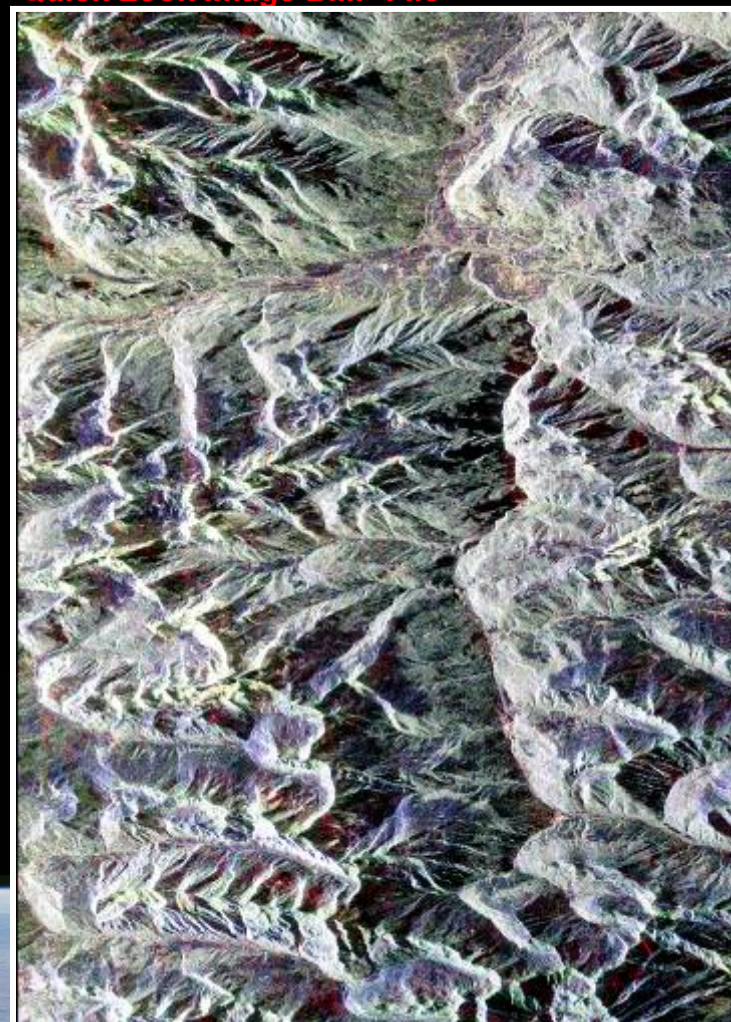




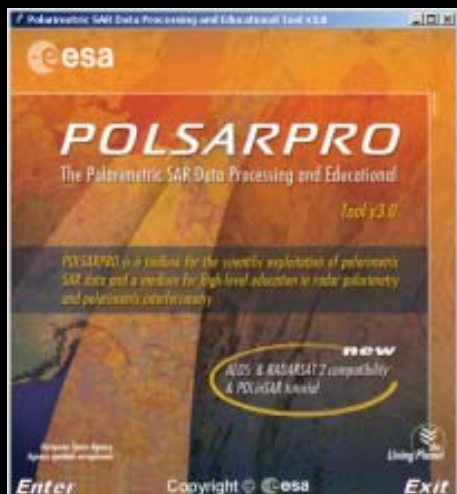
# SIR – C Sensor



Quick Look Image BMP File



- SIR-C Quad POL Stokes Data



AIRSAR



RAMSES



EMISAR



ESAR



CONVAIR



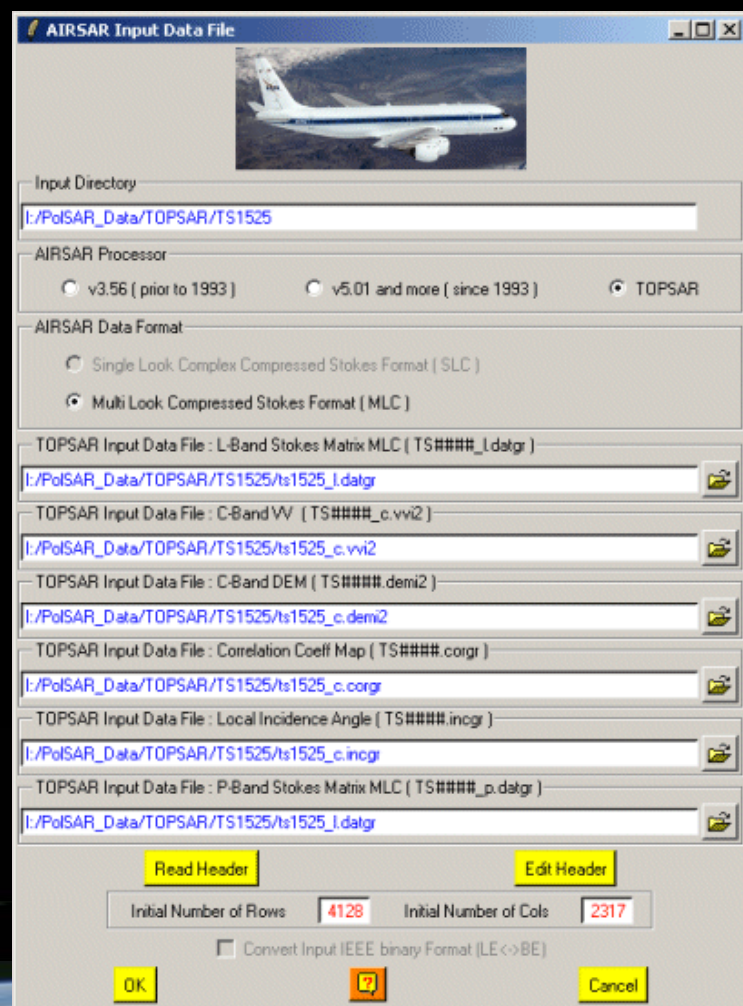
PISAR

NASDA  
CRL

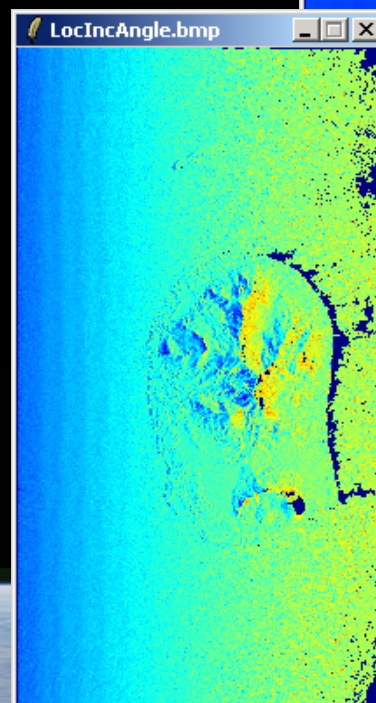
**PolSARpro v3.0 Software** offers the possibility to handle and convert polarimetric data from a range of well established **polarimetric airborne platforms**.



# TOPSAR - AIRSAR Sensor

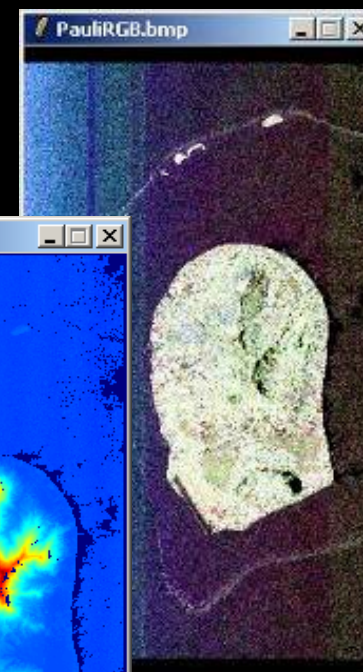


L.O.I. File

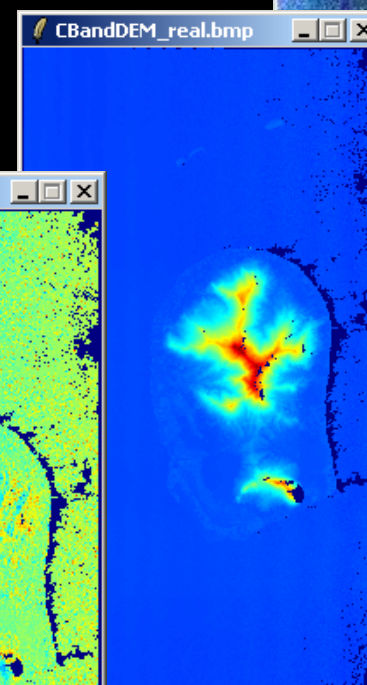


Courtesy of Pr J.P Rudant (U.M.L.V)

Quick Look Image BMP File



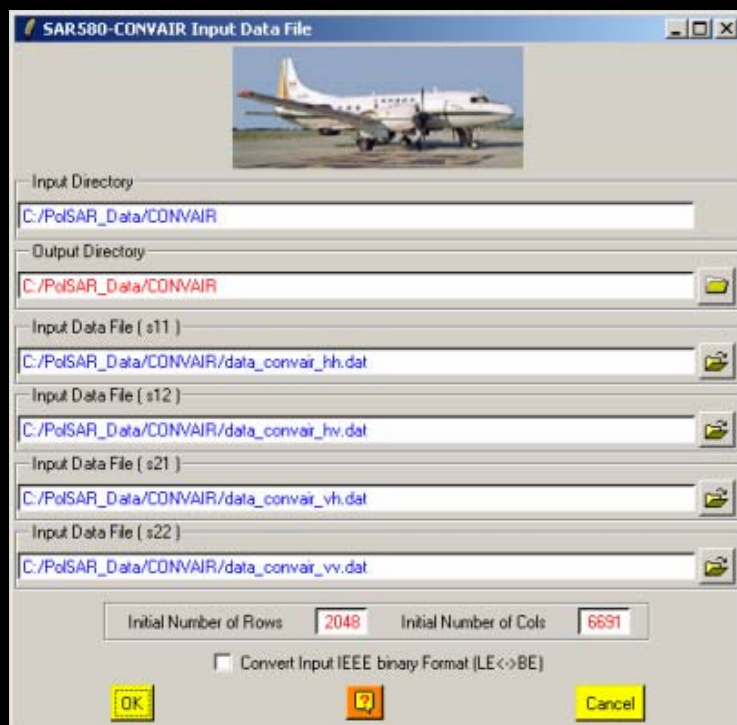
DEM File



- TOPSAR Quad POL
- TOPSAR LOI and DEM Data



# CONVAIR Sensor

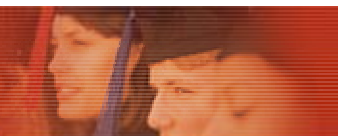


Quick Look Image BMP File

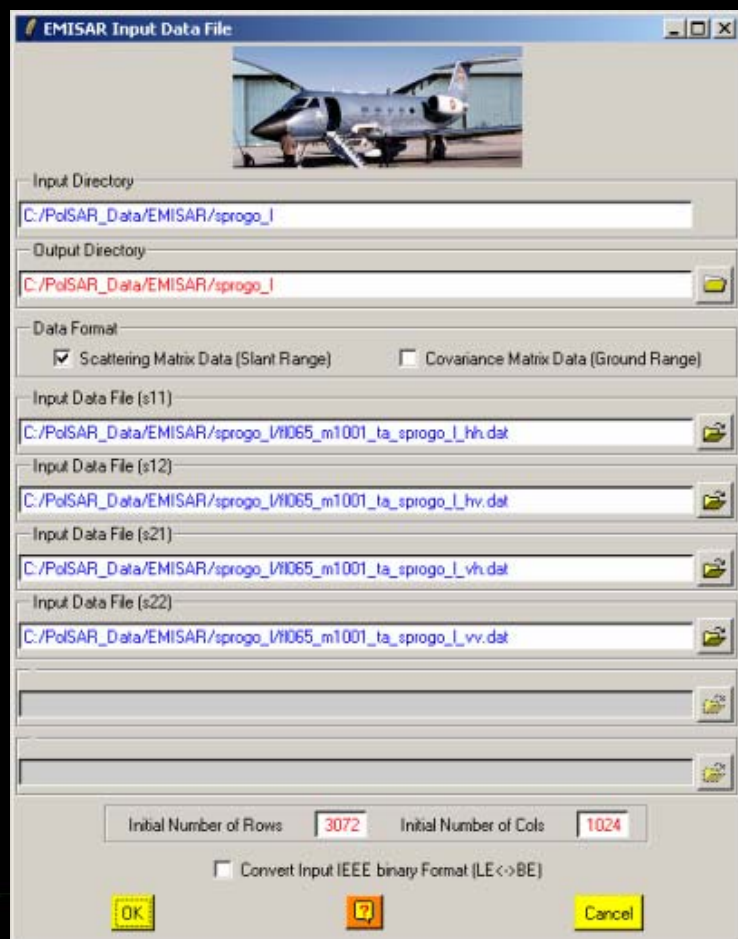


- CONVAIR Quad POL

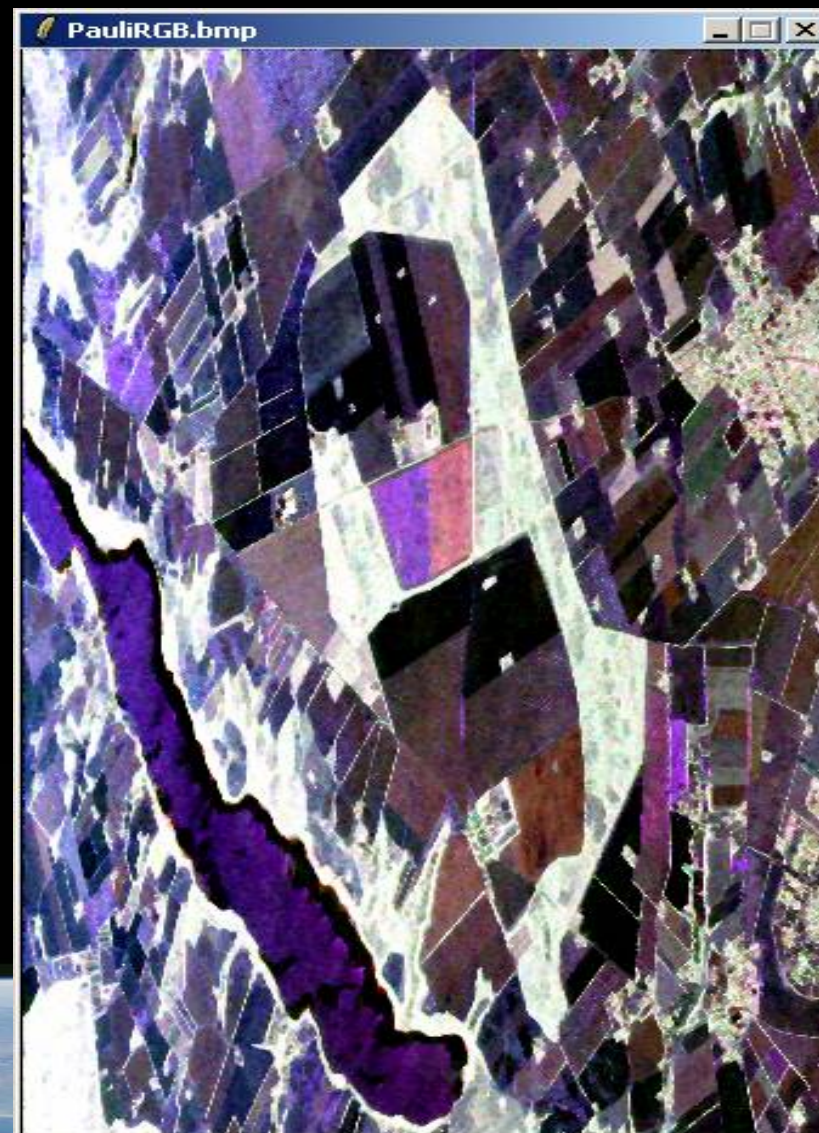




# EMISAR Sensor



Quick Look Image BMP File



- EMISAR Quad POL





# ESAR Sensor

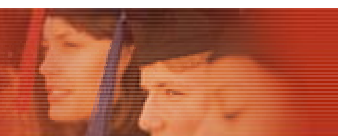


Quick Look Image BMP File

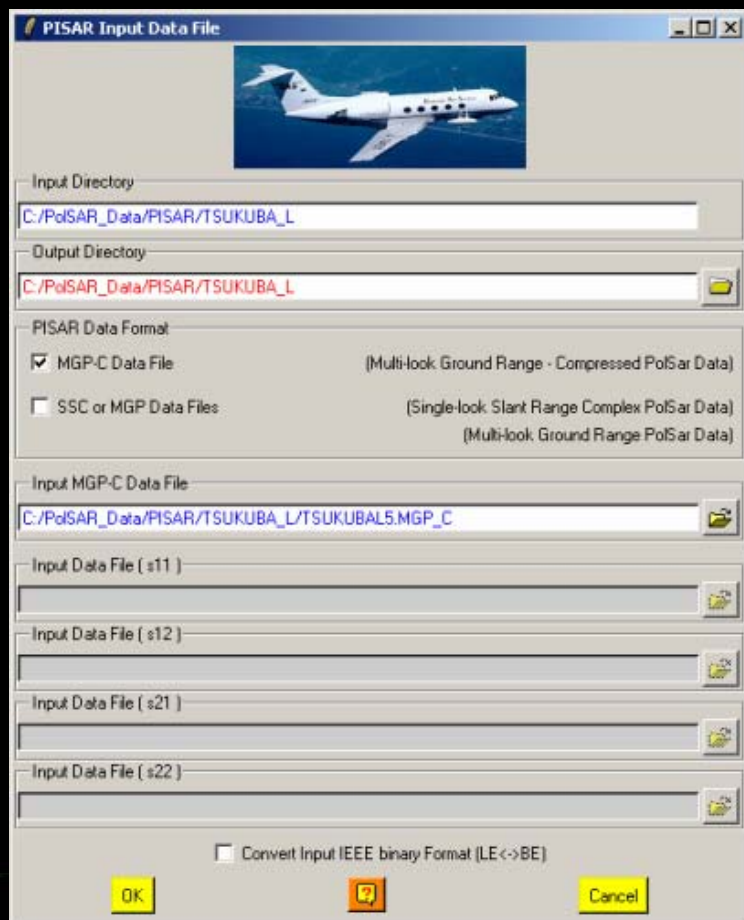


- ESAR Quad POL

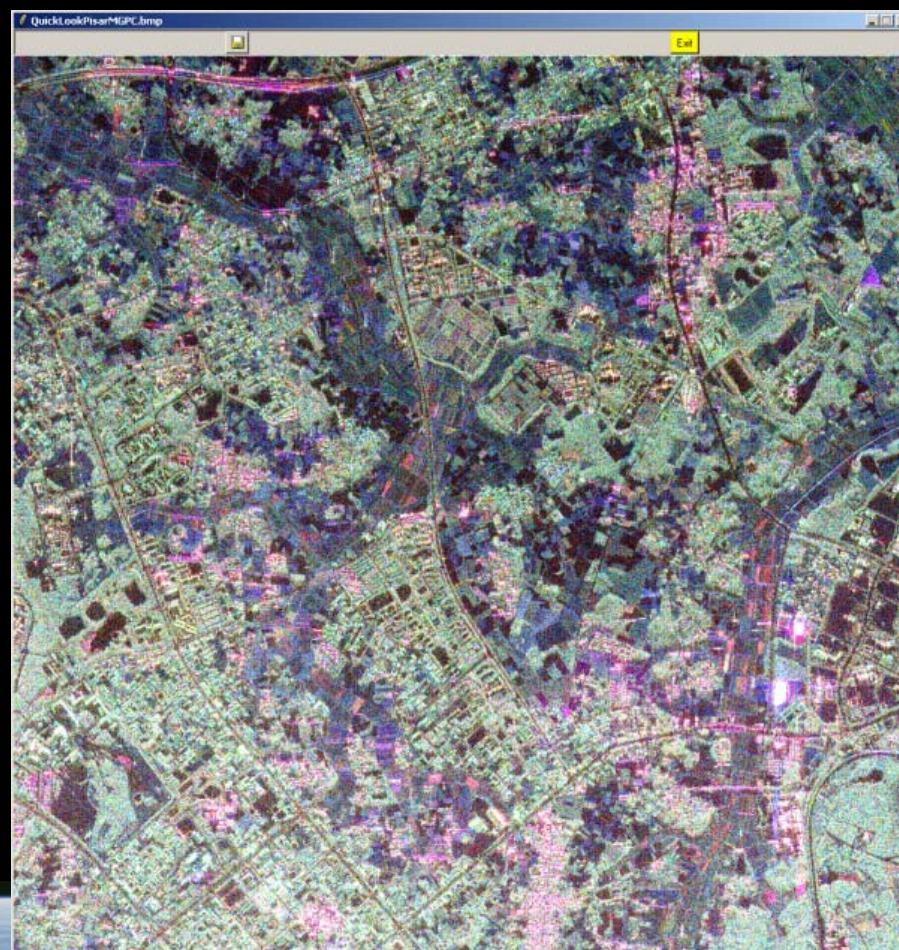




# PISAR Sensor



Quick Look Image BMP File



- PISAR Quad POL – MGP-C Mode
- PISAR Quad POL – SSC / MGP Modes

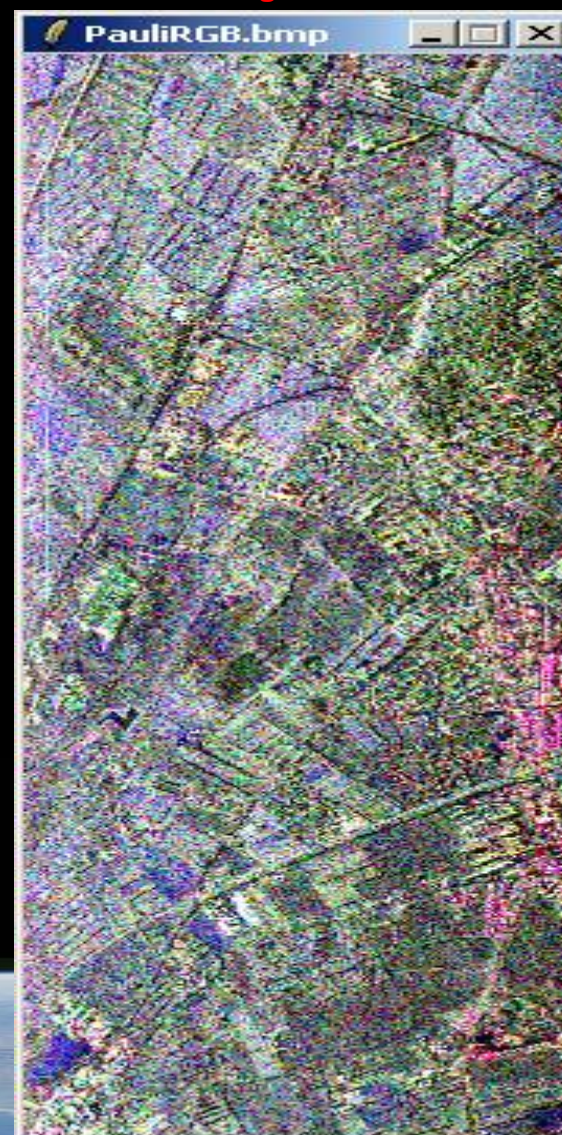




# RAMSES Sensor



Quick Look Image BMP File



- RAMSES Quad POL



# VERSION FOR THE E.O. SCIENTIFIC INVESTIGATOR



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

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

# PROCESSING CHAIN



Configuration

Data Import

Data Process

Data Display

- Input Data File
- QuickLook
- Extract Raw Data

- [T3] Elements
- Speckle Filtering
  - Box Car
  - Gaussian
  - Lee Refined
- H / A / Alpha
  - Decomposition Parameters
  - Eigenvectors Parameters
  - Eigenvalues Parameters
- Polarimetric Segmentation
  - H / A / alpha Segmentation
  - Unsupervised Wishart
  - H / A / alpha Segmentation
  - Supervised Wishart
  - H / A / alpha Segmentation

- Batch Process
  - Speckle Filtering
  - H / A / alpha Decomposition
  - Unsupervised Wishart
  - H / A / alpha Segmentation

- BMP 8 / 24 bits
- RGB

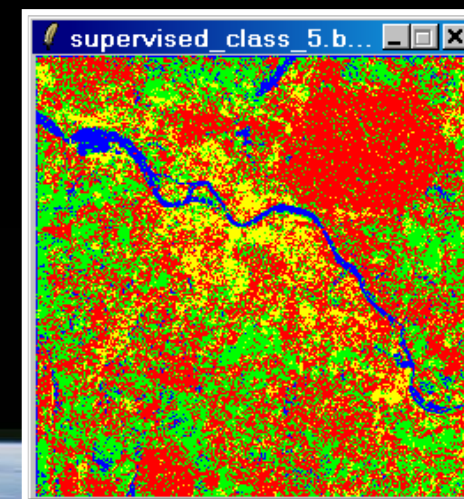
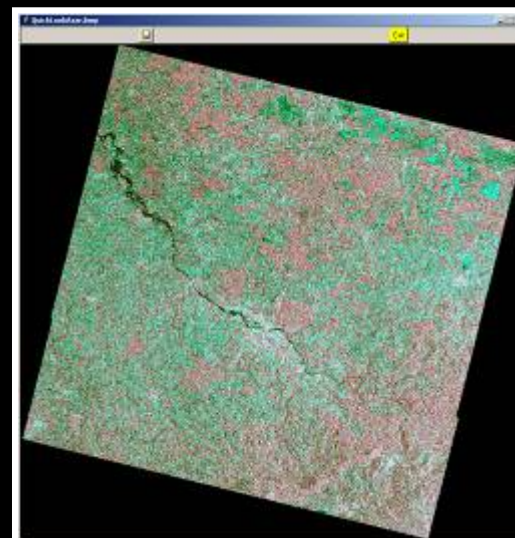
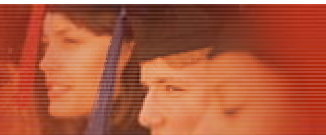




**EXAMPLE**  
**RESULT OF A POLSAR**  
**UNSUPERVISED SEGMENTATION**

**SAN FRANCISCO BAY JPL - AIRSAR L-band**

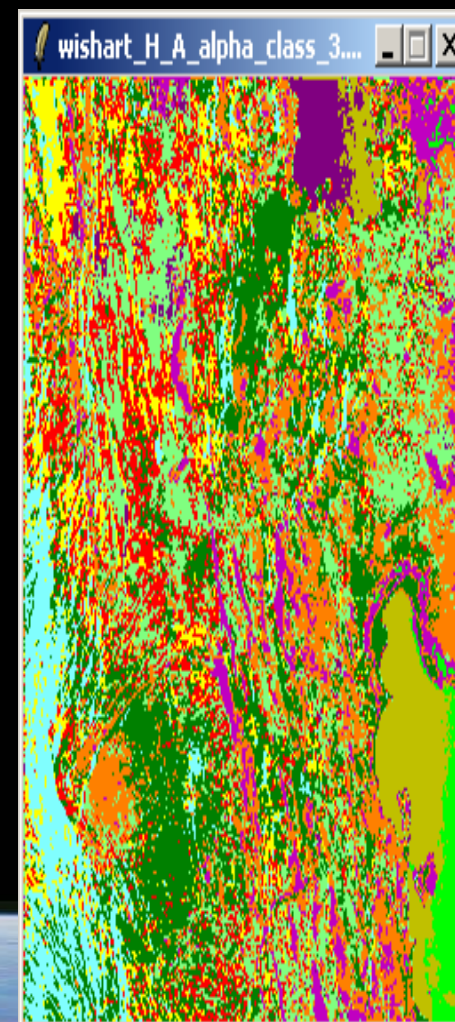
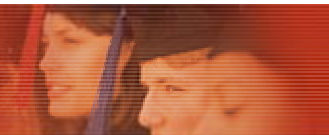




**EXAMPLE**  
**RESULT OF A POLSAR**  
**UNSUPERVISED SEGMENTATION**

**ENVISAT – ASAR APG Mode Data**

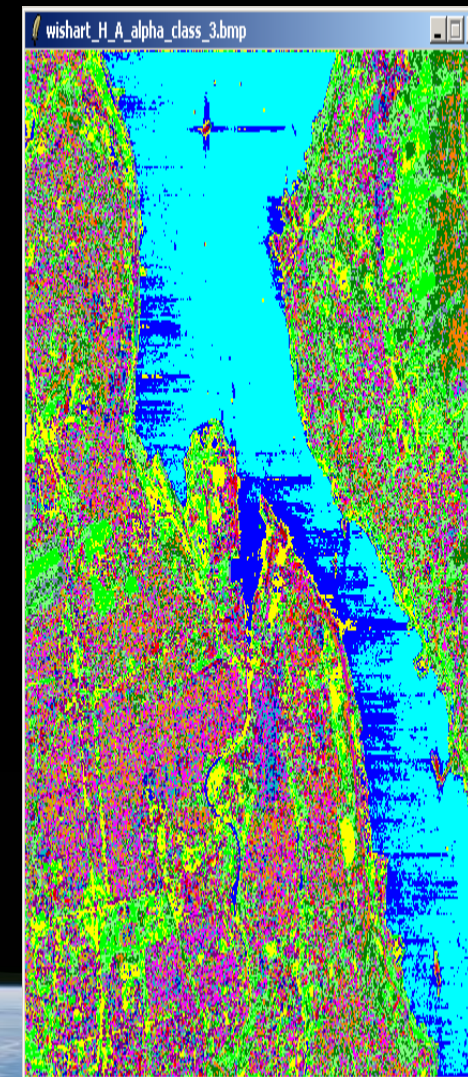
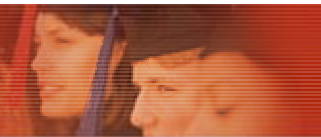




**EXAMPLE**  
**RESULT OF A POLSAR**  
**UNSUPERVISED SEGMENTATION**

**ALOS – PALSAR Quad POL Mode**



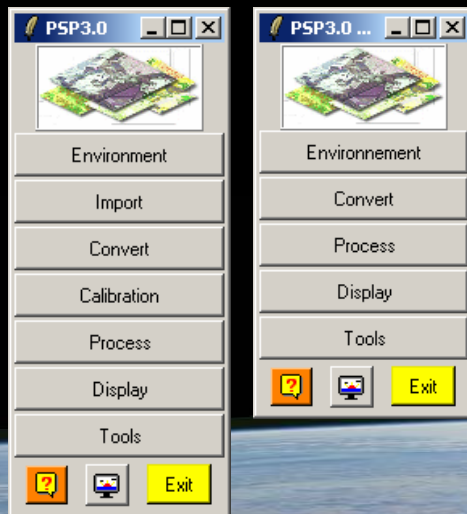


**EXAMPLE**  
**RESULT OF A POLSAR**  
**UNSUPERVISED SEGMENTATION**

**RADARSAT 2 – Quad POL Simulated Data**



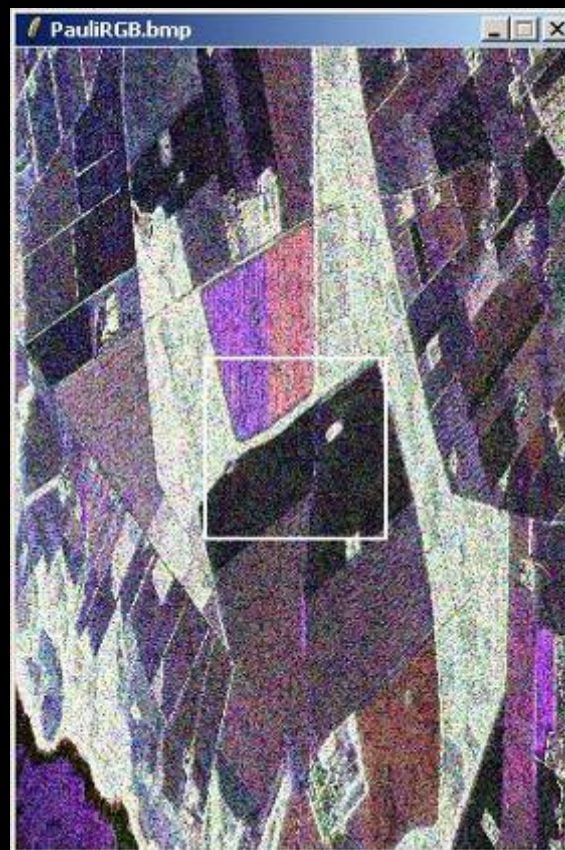
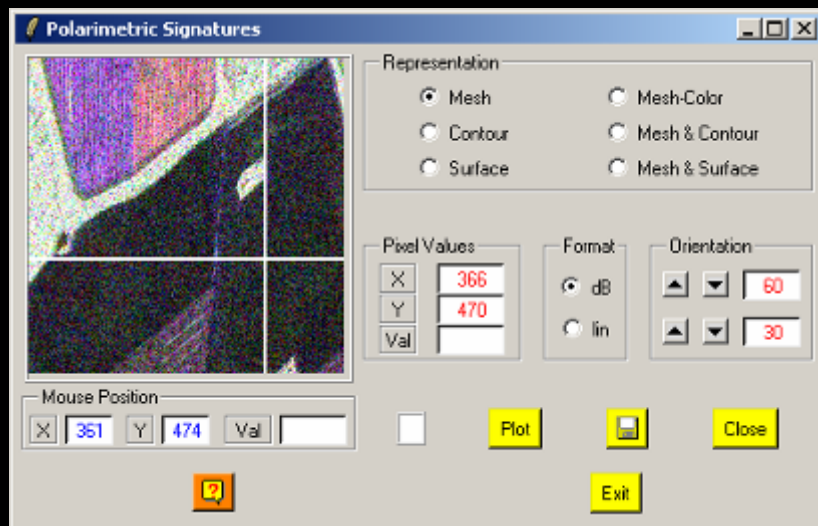
**PolSARpro V3.0 Software** performs complete **end-to-end processing** without the need for any other software.



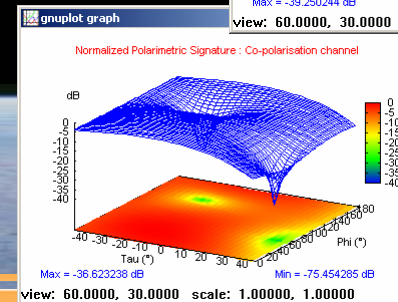
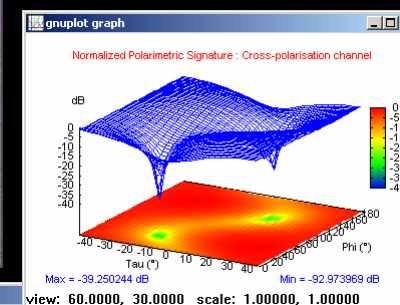
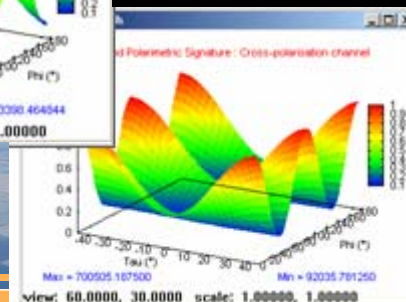
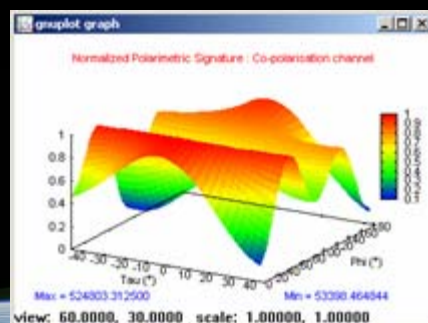
**PolSARpro V3.0 Software** provides a comprehensive suite of functions for the scientific exploitation of :

- Fully and Partially **POLSAR** data
- **POLSAR** and **POL-InSAR** data

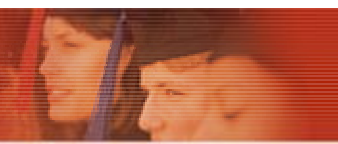
# POLARISATION SIGNATURE



**New!**







# POLARIMETRIC DECOMPOSITION

**Data Processing: H / A / Alpha Decomposition Parameters**

Input Directory:

Output Directory:

Init Row:  End Row:  Init Col:  End Col:

☐ Alpha, Beta, Delta, Gamma, Lambda ☐ BMP

☒ Lambda ☒ BMP

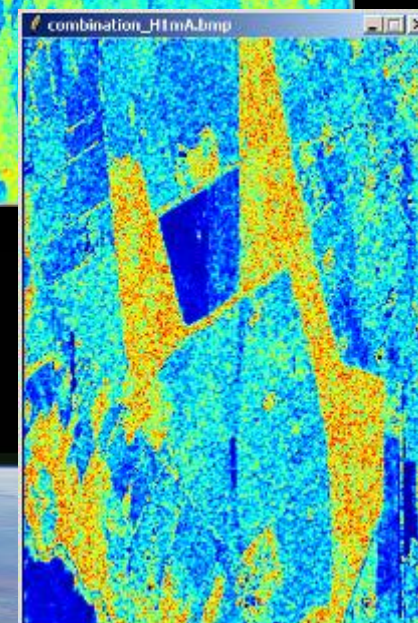
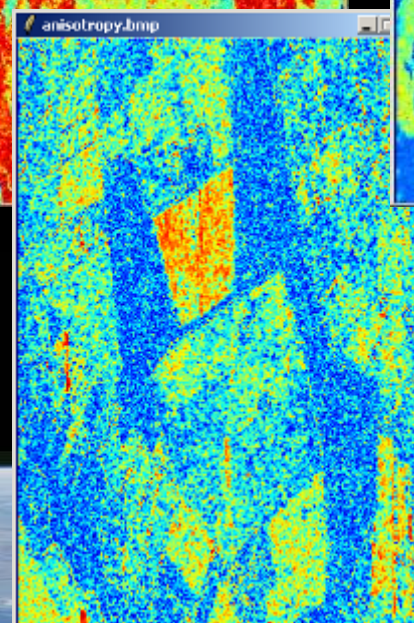
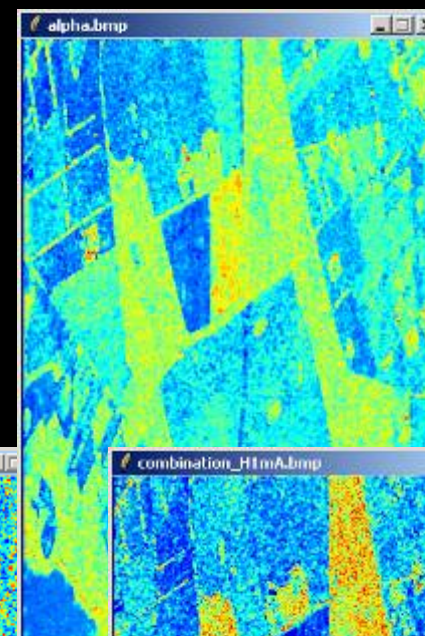
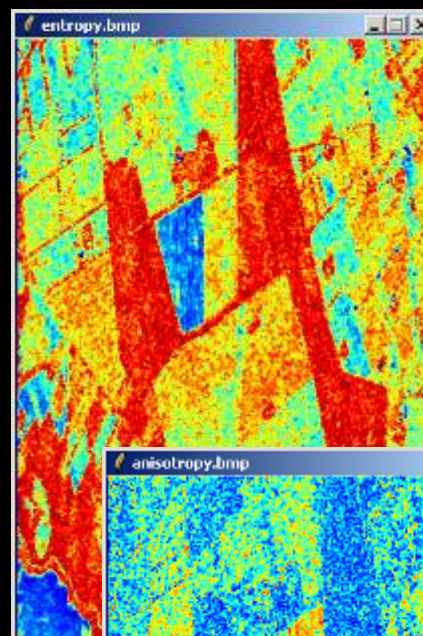
☒ Alpha ☒ BMP

☒ Entropy (H) ☒ BMP

☒ Anisotropy (A) ☒ BMP

☒ Combinations (H, A) ☒ H A ☒ (1 - H) A ☒ H (1 - A) ☒ (1 - H) (1 - A) ☒ BMP

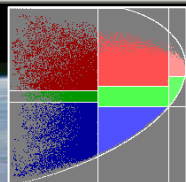
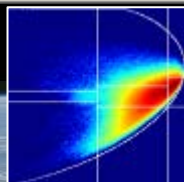
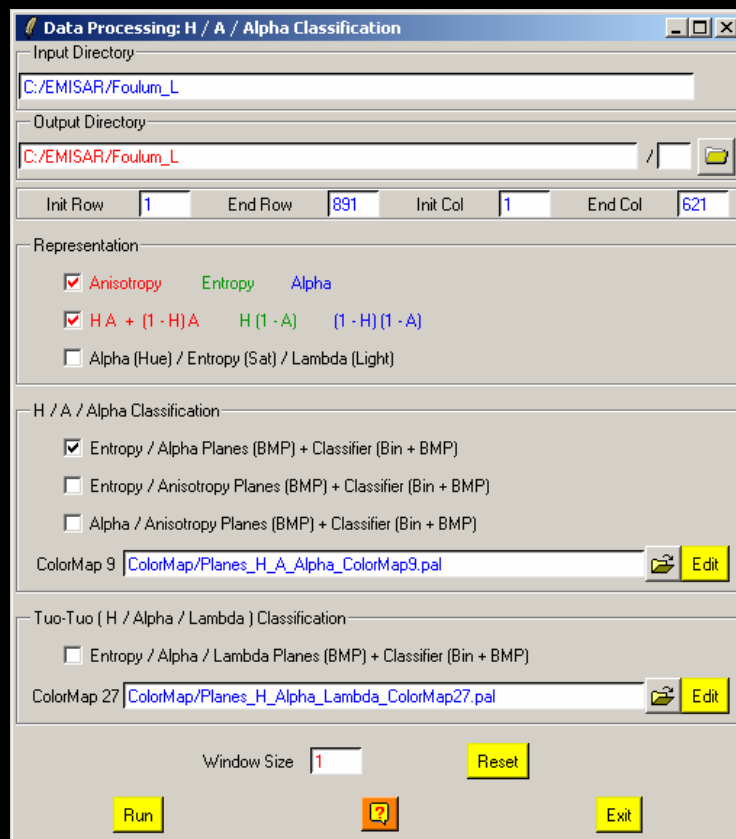
Window Size:   ☐ Equivalence between [T] and [C] eigen-decompositions.



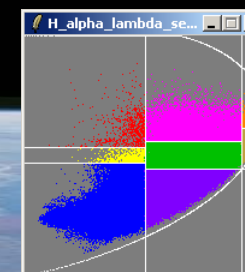
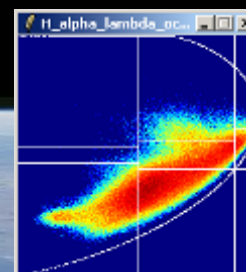
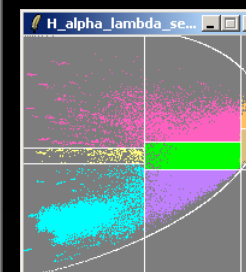
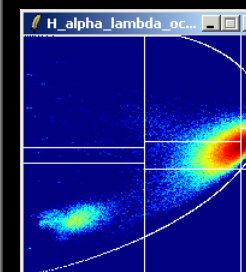
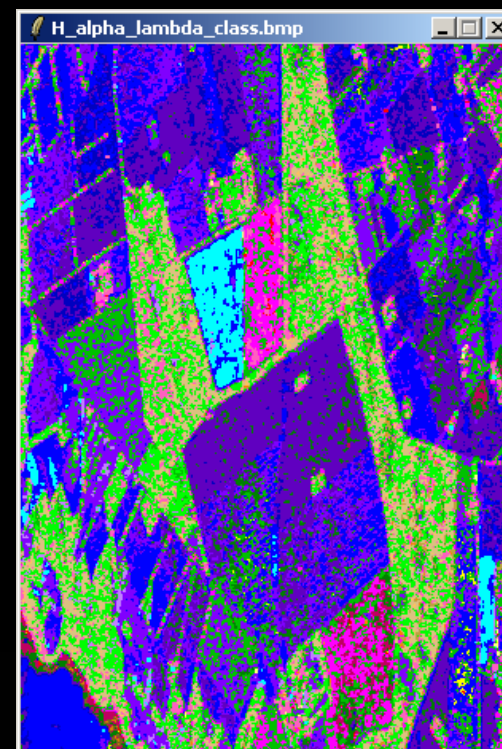
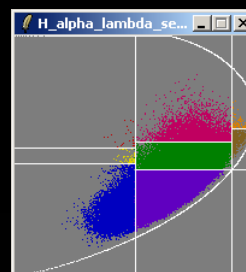
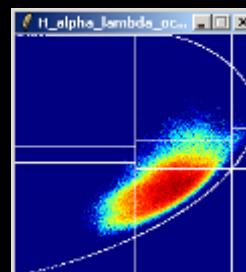


# POLARIMETRIC SEGMENTATION

## Unsupervised H / A / Alpha Classification



X\_Y\_occurrence\_plane X\_Y\_segmented\_plane

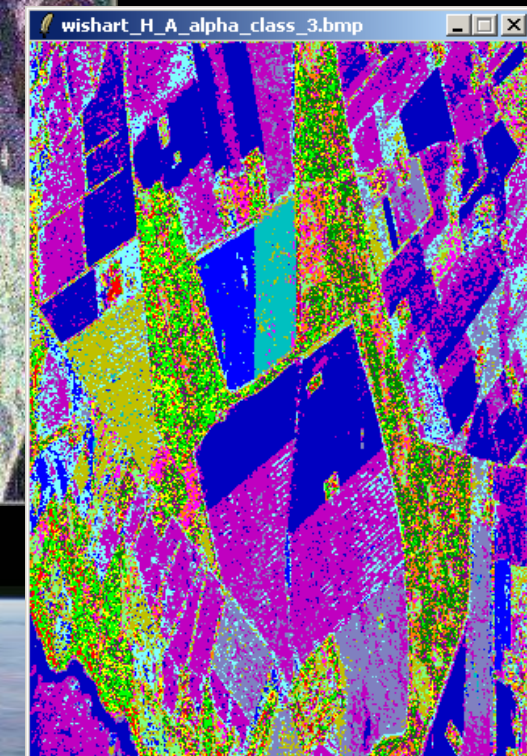
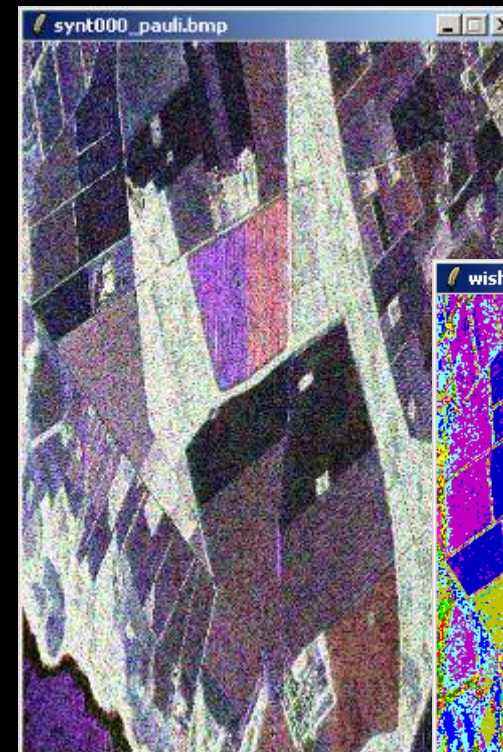
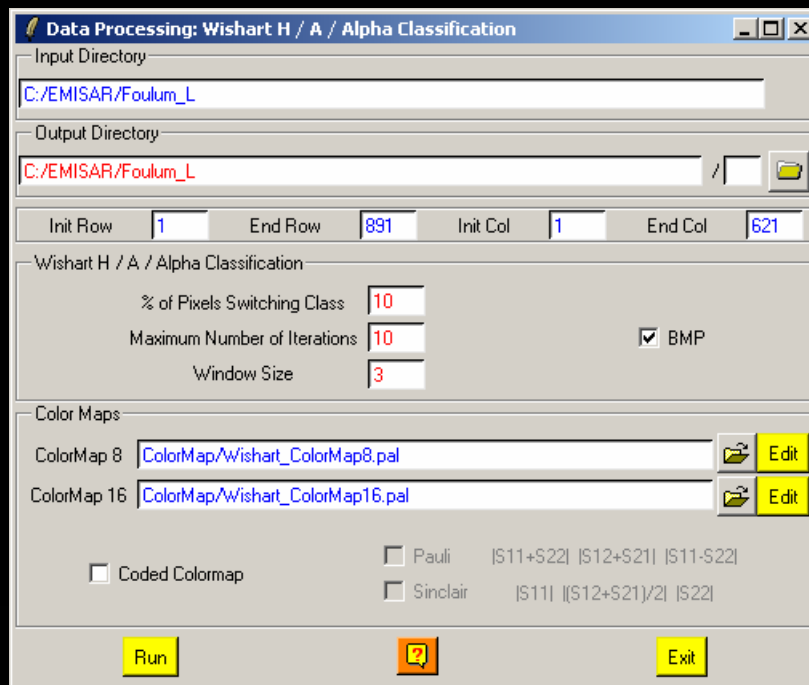






# POLARIMETRIC SEGMENTATION

## Unsupervised H / A / Alpha - Wishart Classification



# POLARIMETRIC SEGMENTATION

## Rule-Based Hierarchical Classification

**Data Processing: Rule-Based Hierarchical Classification**

Input Directory:

Output Directory:

Init Row:  End Row:  Init Col:  End Col:

Classification Configuration

☒ K-Mean Procedure

Maximum Number of Iterations:

% of Pixels Switching Class:

Input Parameters Specification

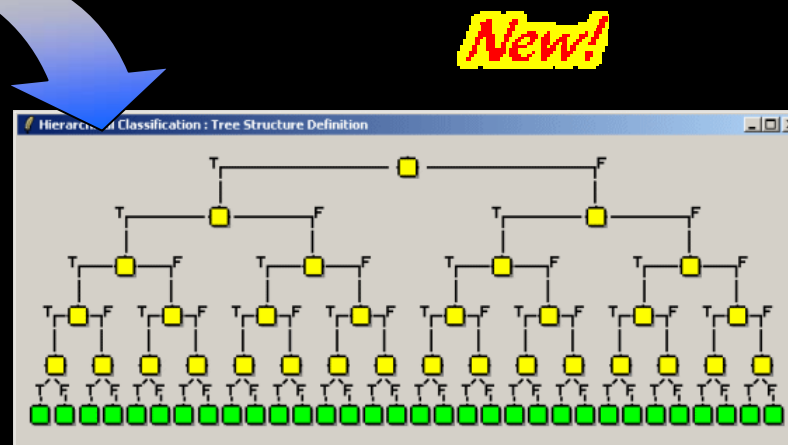
Parameters File:

Hierarchical Structure Definition

Structure File:

Color Maps

ColorMap 32:



**Hierarchical Classification : Tree Structure Definition**

Node Definition

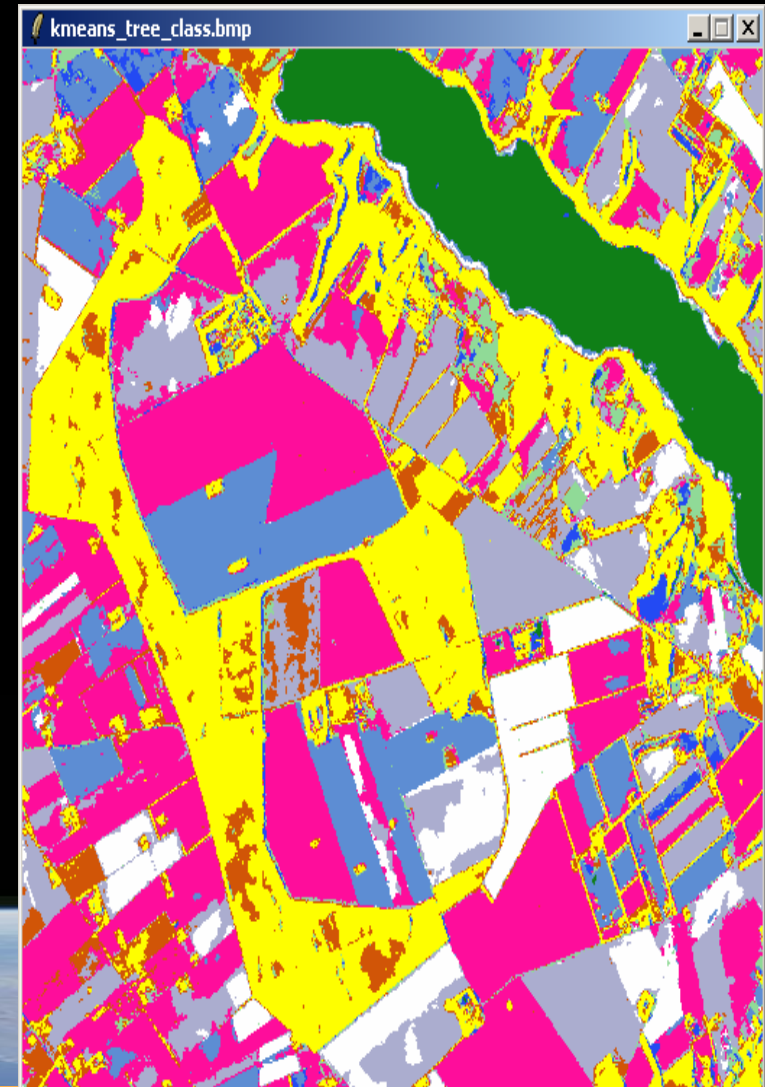
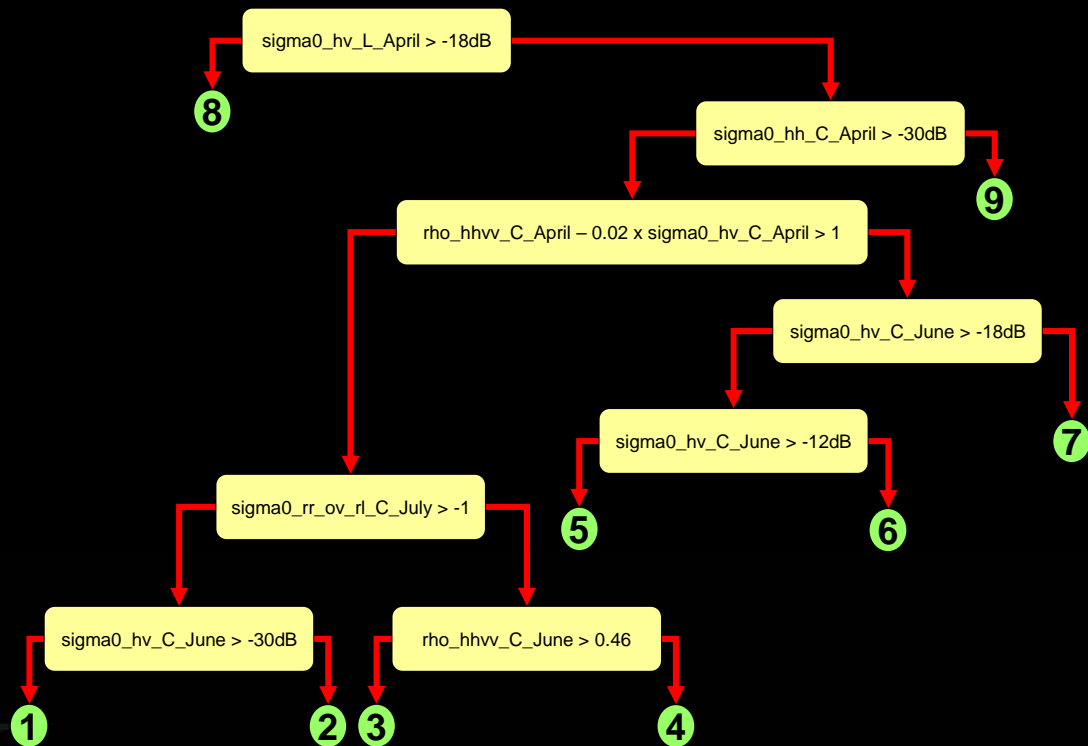
Parameter 1:  Parameter 2:

Weighting Coeff 1:  Weighting Coeff 2:  Operator:  Threshold Coeff:

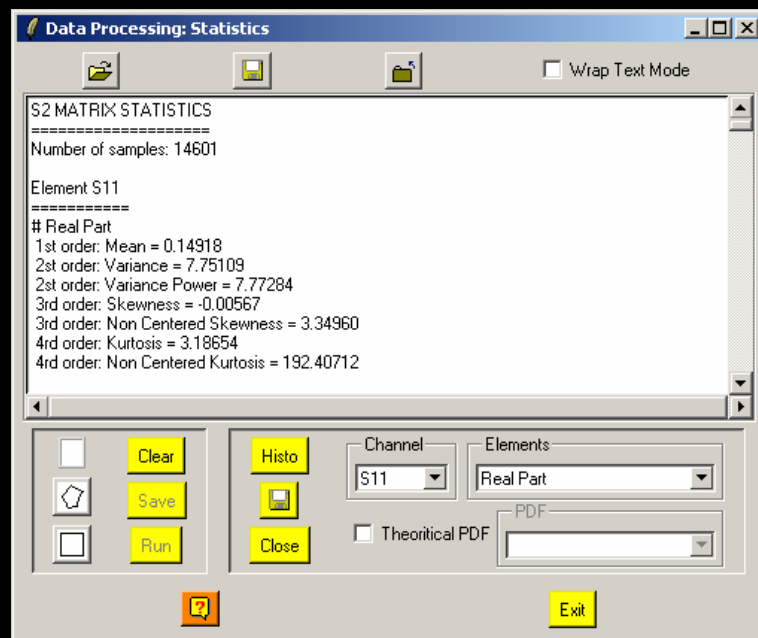


# POLARIMETRIC SEGMENTATION

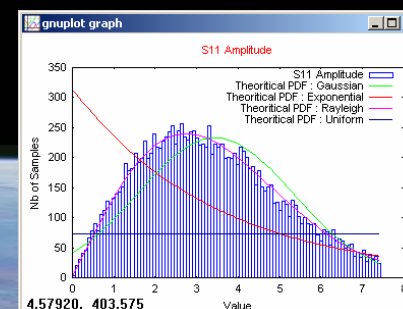
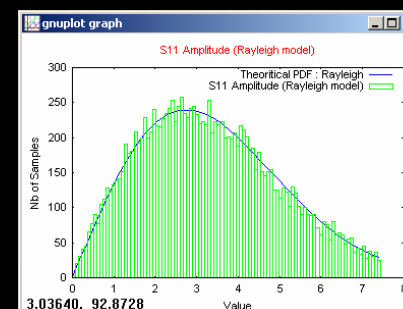
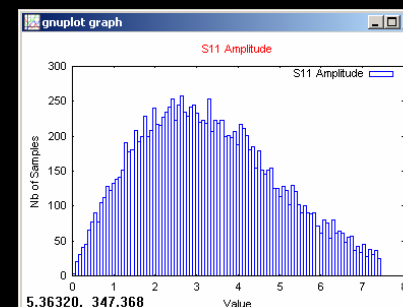
## Rule-Based Hierarchical Classification



# DATA ANALYSIS - STATISTICS

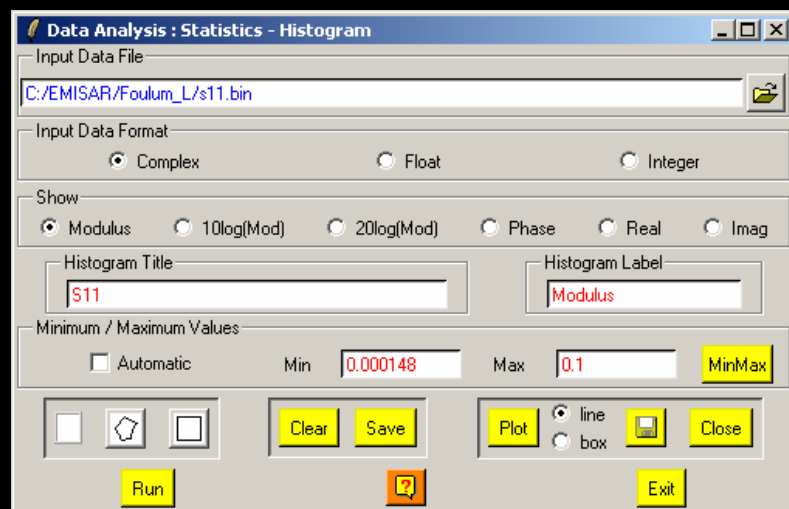


**New!**

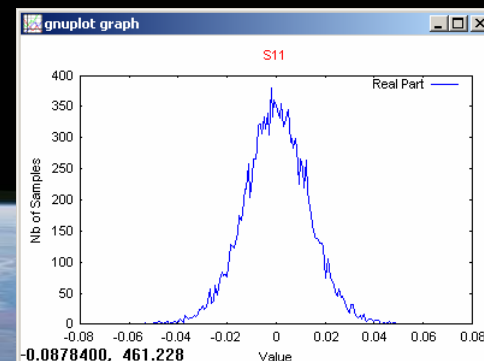
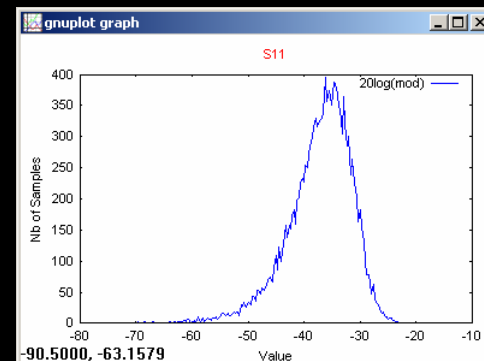
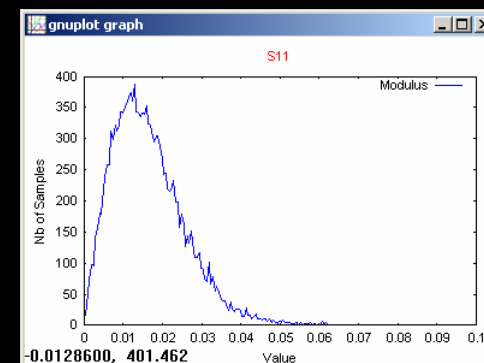




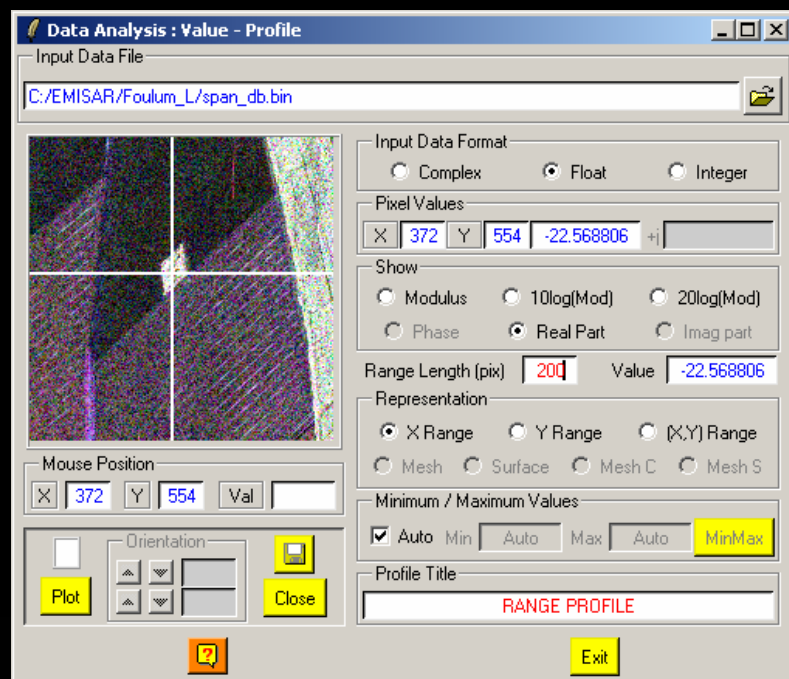
# DATA ANALYSIS - HISTOGRAMS



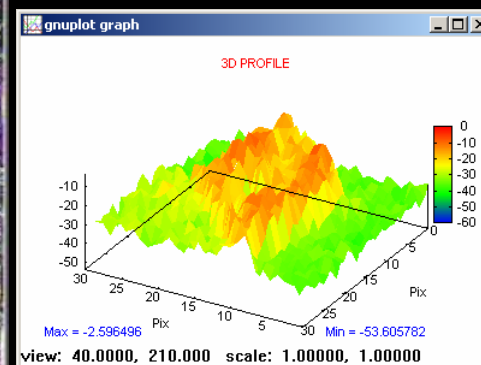
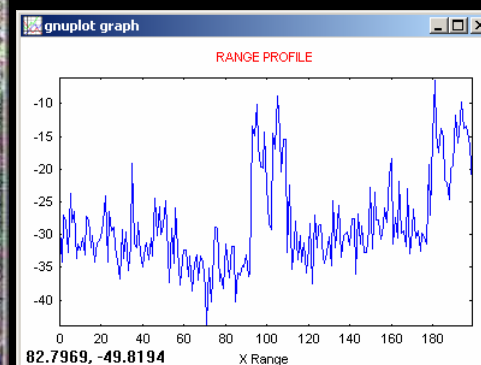
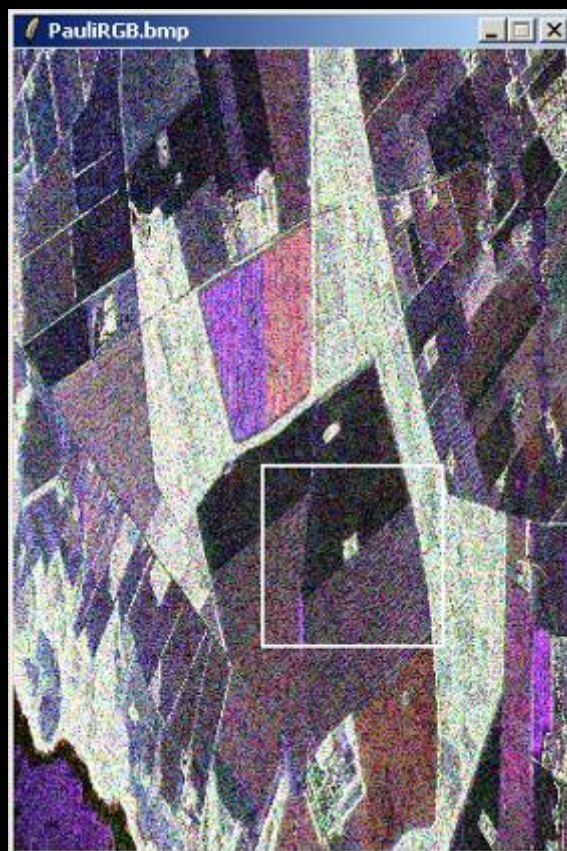
**New!**



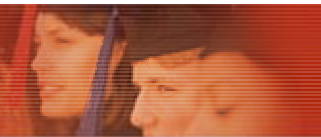
## DATA ANALYSIS - PROFILES



**New!**

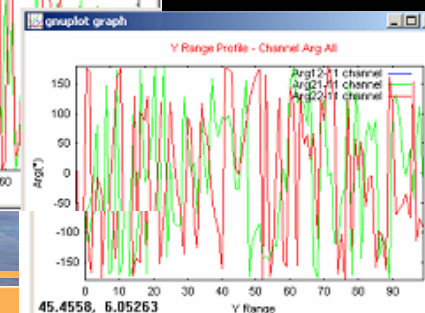
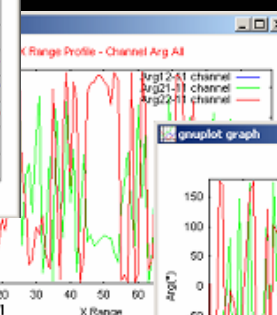
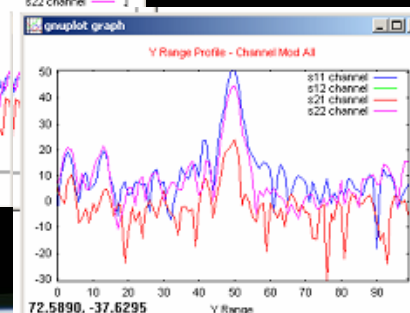
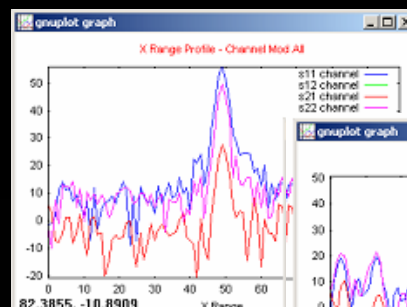
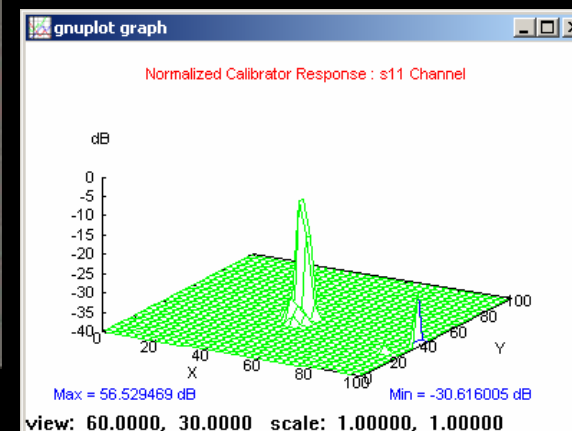
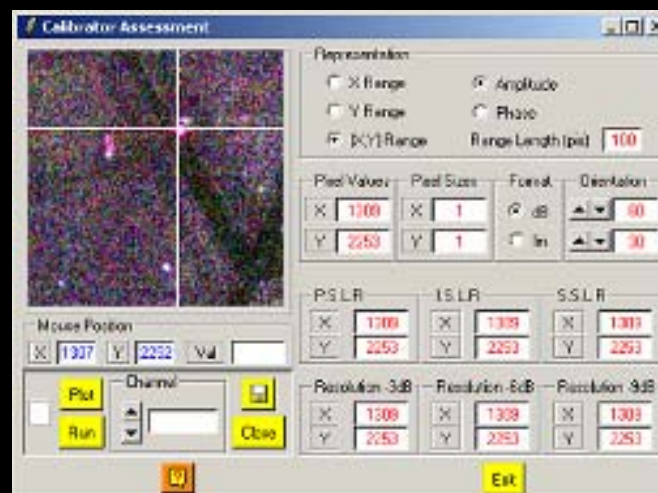
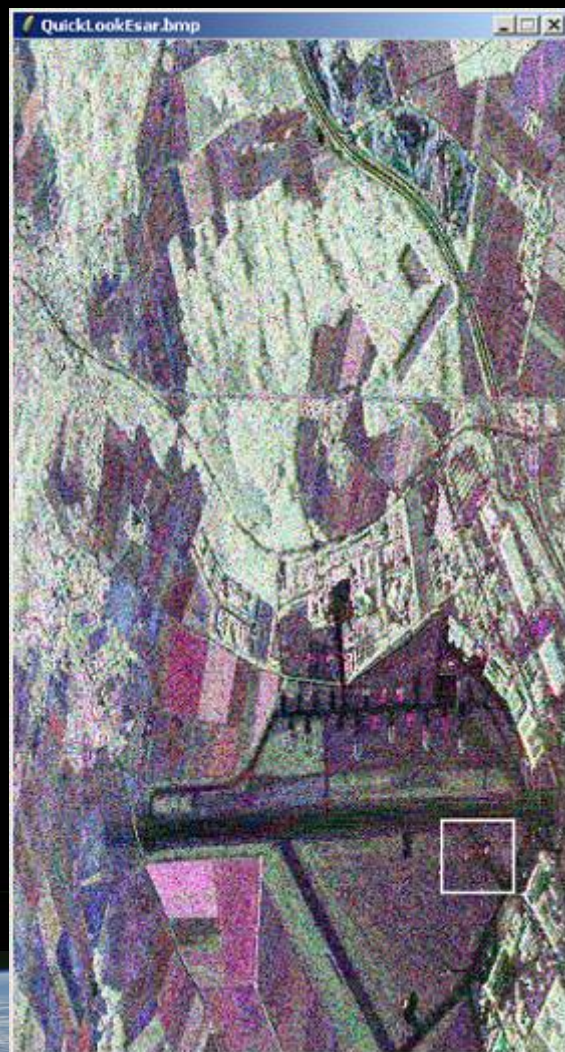






# CALIBRATION ASSESSMENT

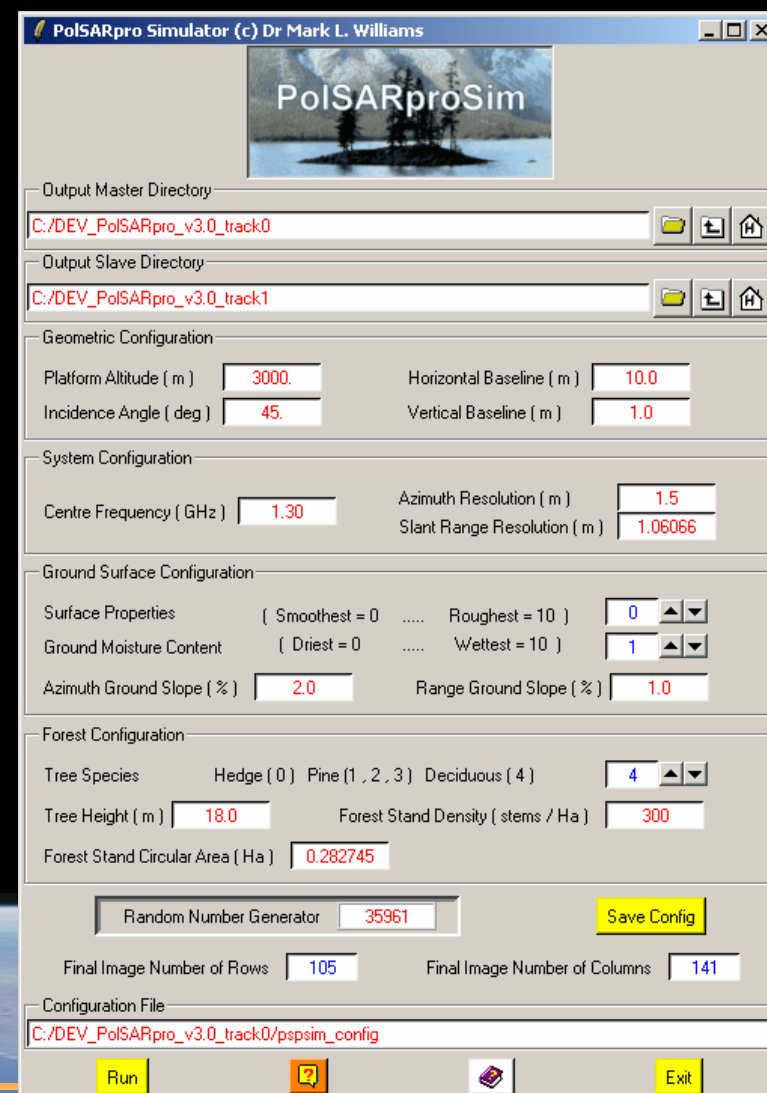
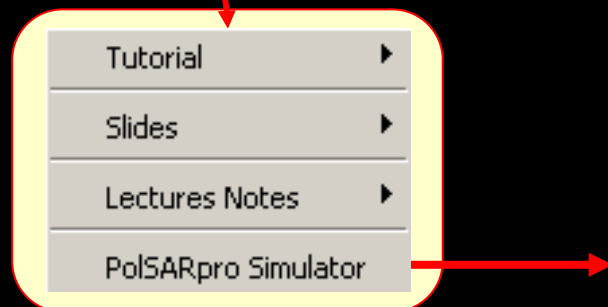
**New!**



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



**New!**





# PolSARpro - SIM

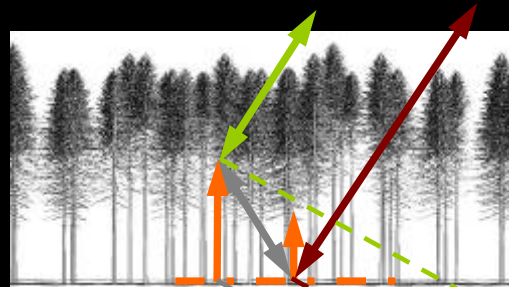
The SAR image is evaluated as a coherent sum of scattering events from small elements of the scene



PINE



DECIDIOUS



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

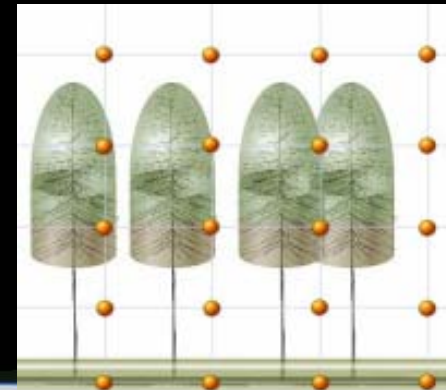
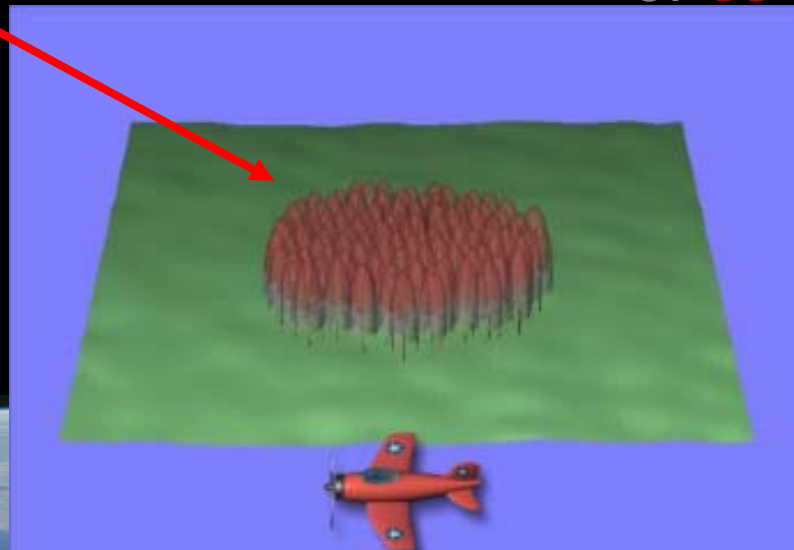


GV DG

DV

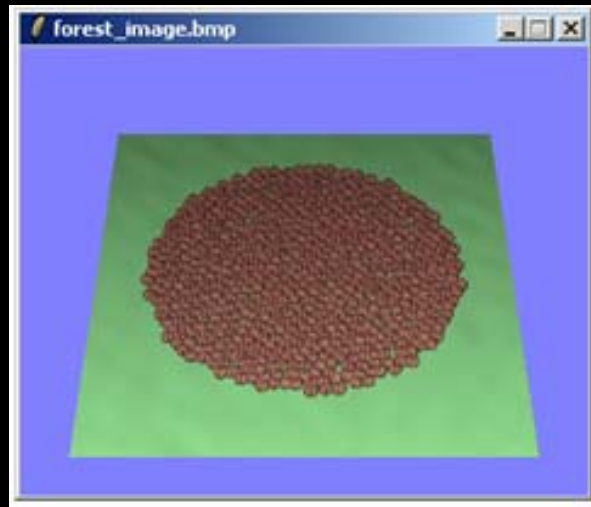


RANDOM HEDGE

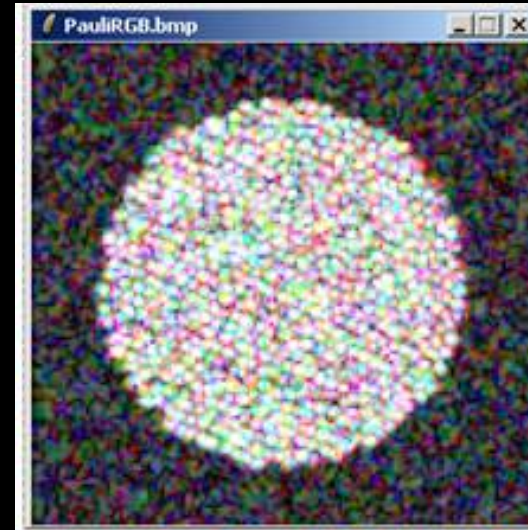


Given the map of tree locations and dimensions a grid of points is used to sample the attenuation of the coherent wave in 3D

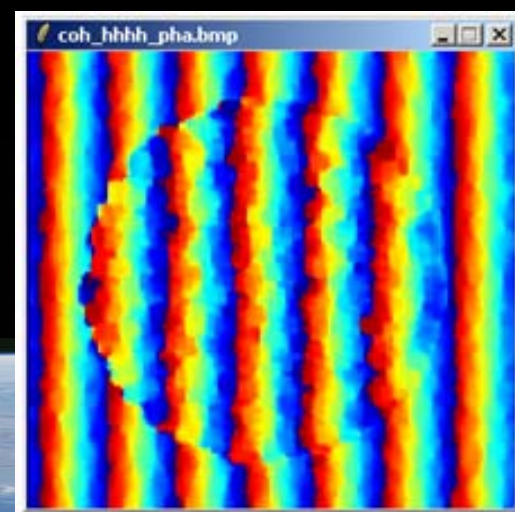
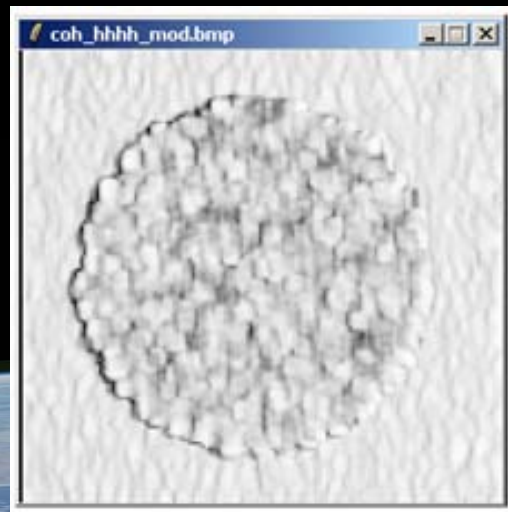
# PoSARpro - SIM



View from Radar



Pauli RGB Image



Coherence Map using a 5x5 window (Amplitude (left) and Phase (right))



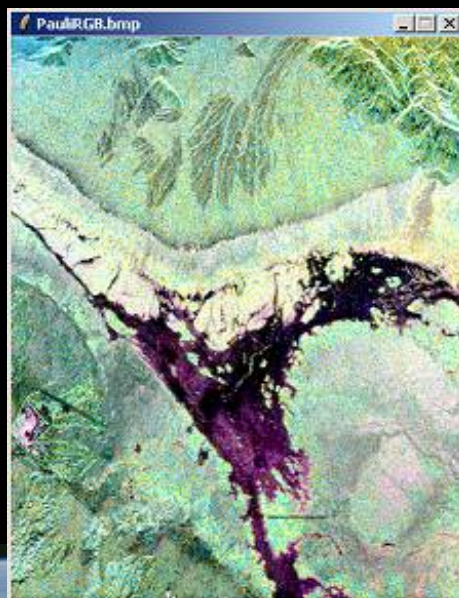
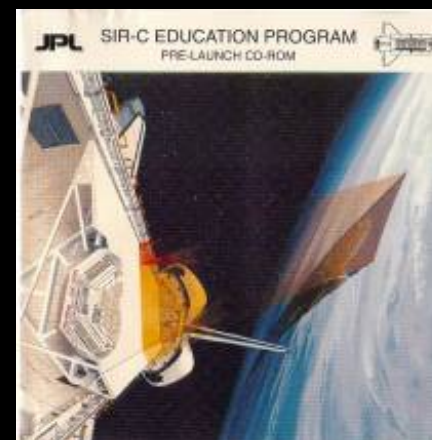
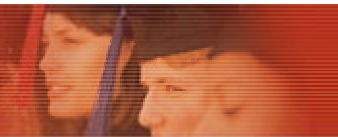


<http://earth.esa.int/polsarpro>



**The Web Site provides**

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



**Death Valley**  
(1279 rows x 1024 cols)



**Flevoland**  
(750 rows x 1024 cols)

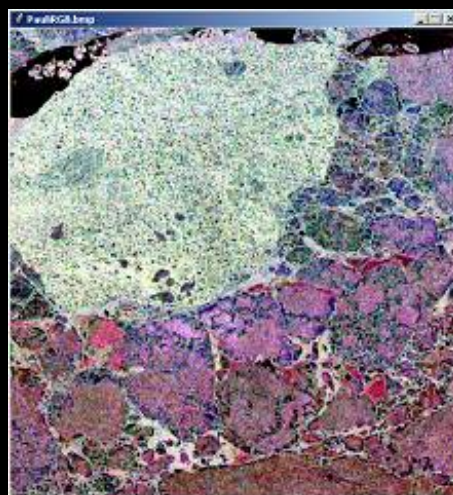


**San Francisco Bay**  
(900 rows x 1024 cols)





**Ottawa Area**  
(222 rows x 3429 cols)



**Ice Area**  
(544 rows x 5238 cols)

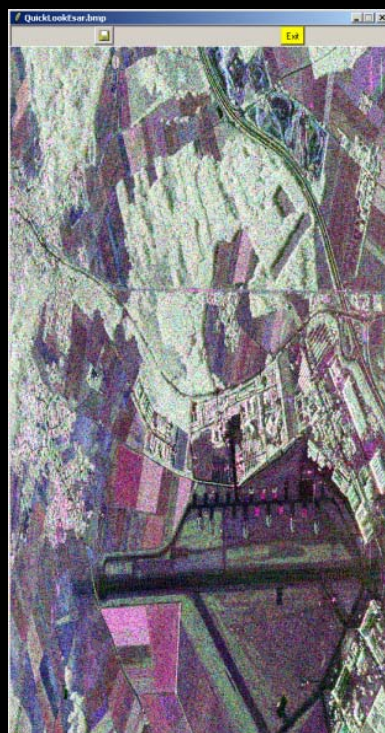
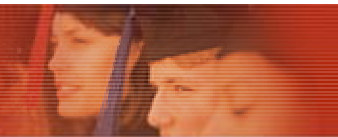


**Foulum (Slant Range)**  
(1750 rows x 1000 cols)

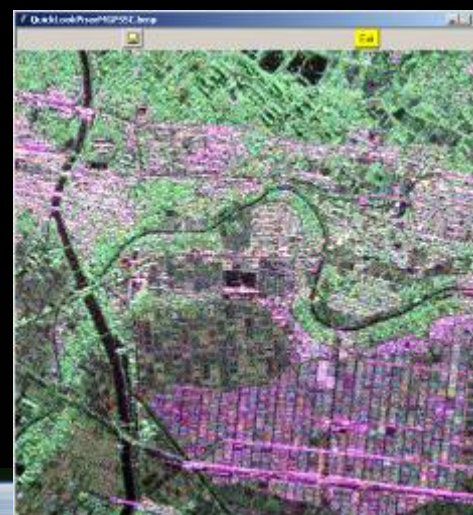


**Foulum (Ground Range)**  
(1100 rows x 1752 cols)

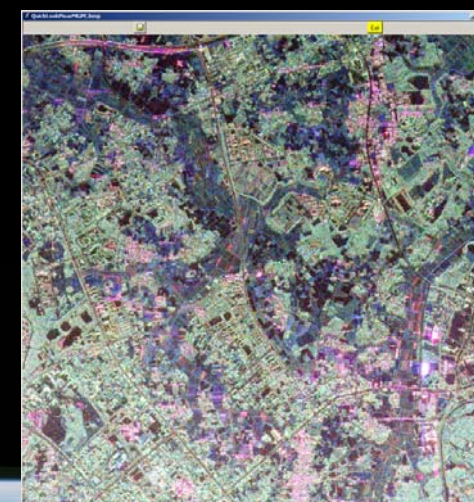




**Oberpfaffenhofen Test Site Area**  
(2816 rows x 1540 cols)



**Niigata Area**  
MGPSSC Format  
(1200 rows x 1200 cols)



**Tsukuba Area**  
MGP Format  
(2000 rows x 2000 cols)



# The Polarimetric SAR Data Processing and Educational Tool v3.0

