



Software Tool PolSARpro v3.0

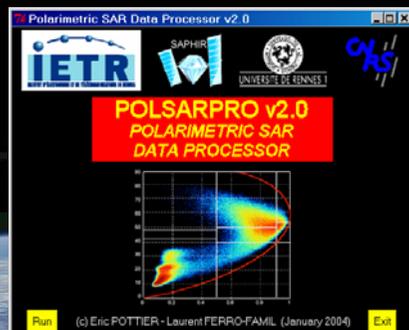
Eric POTTIER

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.



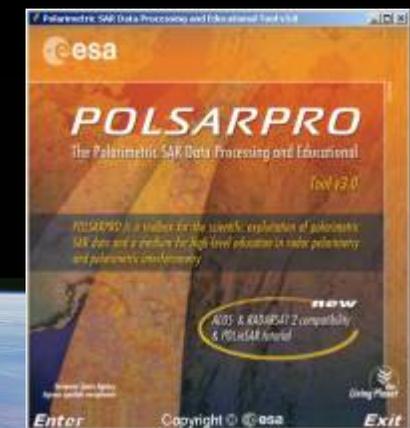
2003



2004



2005



2007



CONTEXT

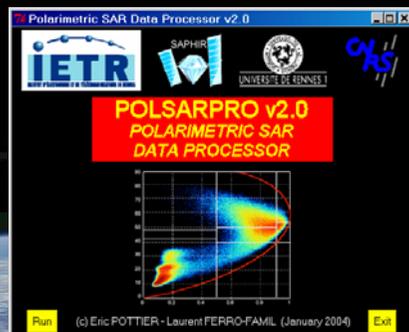
The **PoSARpro Software** is developed under contract to ESA :

Development of a Polarimetric SAR Image Analysis Tool

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

Continued Development of the PoSARpro Toolbox

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



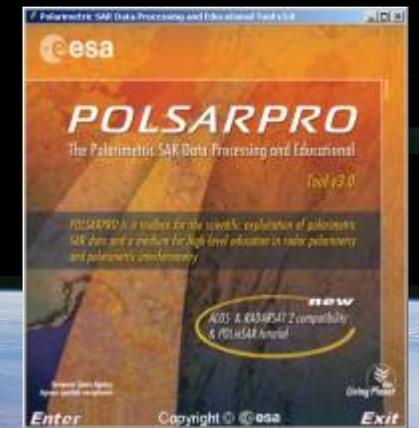
2003



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



Thomas Ainsworth



Wolfgang M. Boerner



Martin Hellmann



Jong-Sen Lee



Carlos Lopez



Jean-Claude Souyris



Ridha Touzi



Ressources naturelles
Canada



Yoshio Yamagushi



Niigata University

In collaboration with :

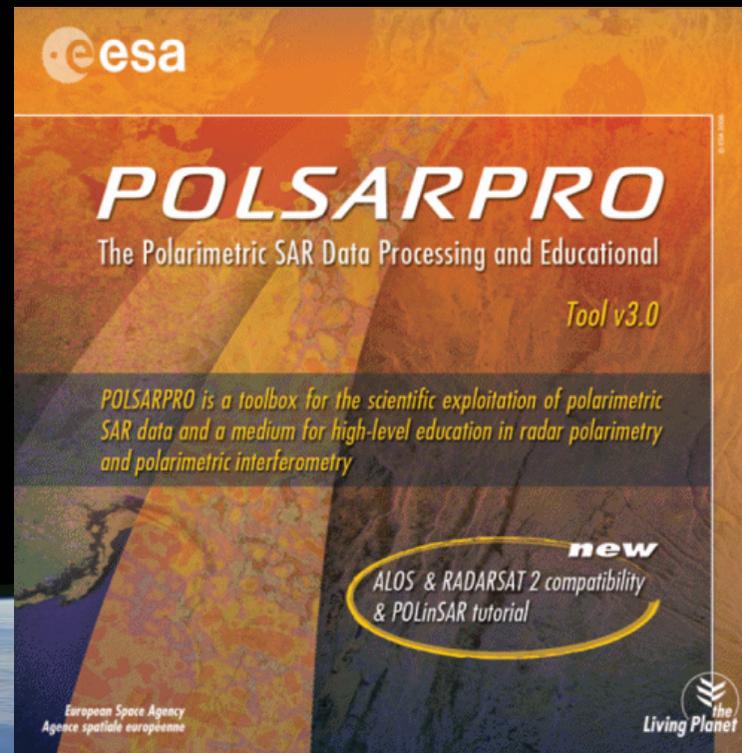
And with
The Agencies :





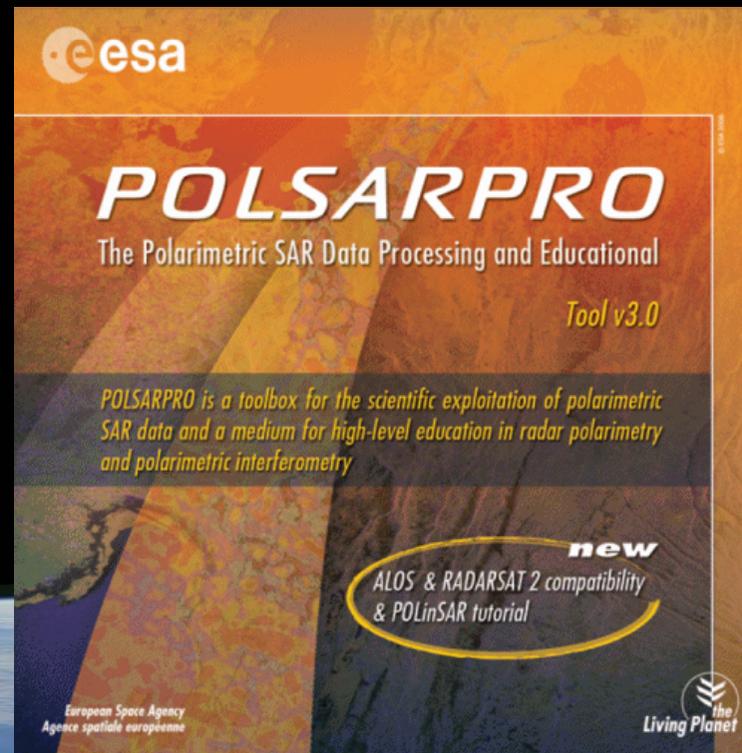
PoSARpro v3.0 SOFTWARE

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



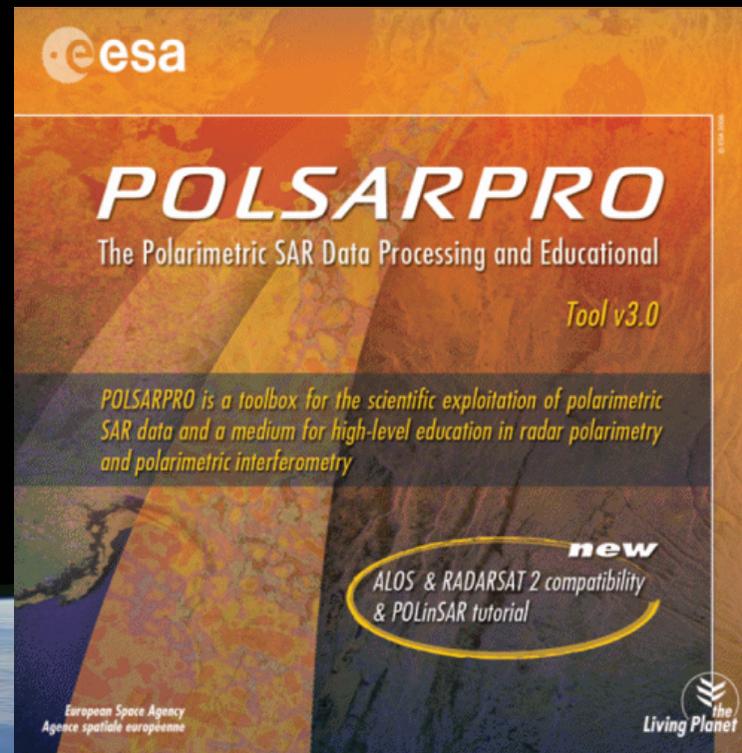
PoSARpro v3.0 SOFTWARE

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





PoSARpro 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**.



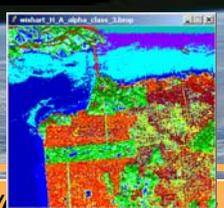


USER INTERFACE

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

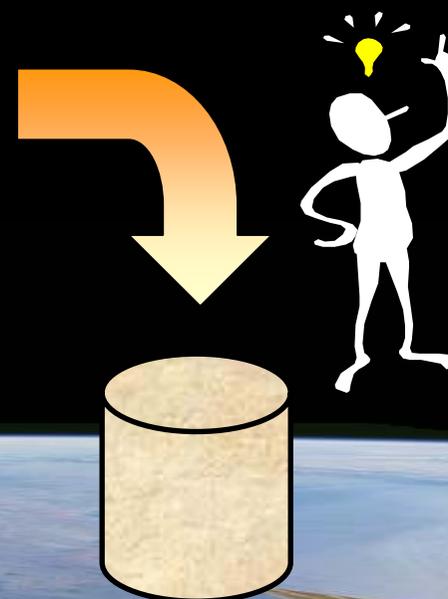
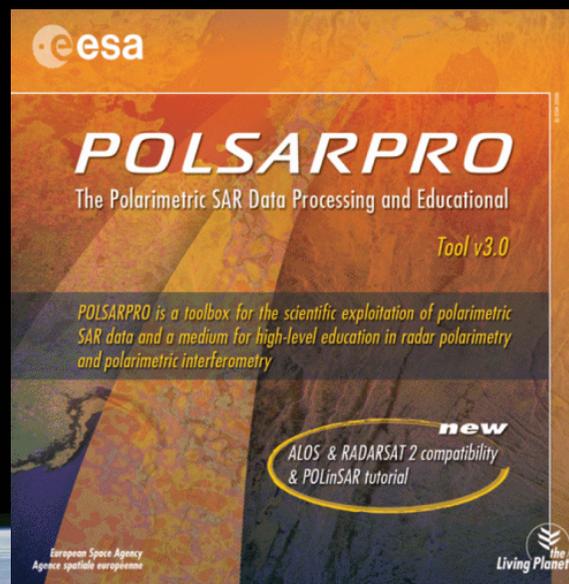
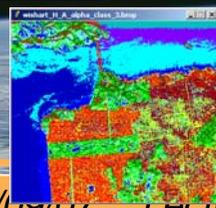
- 263369 lines managing 154 widget windows
- 681 C routines (279839 lines) performing well-established algorithms in the field of POLSAR and POL-InSAR.





MODULAR STRUCTURE

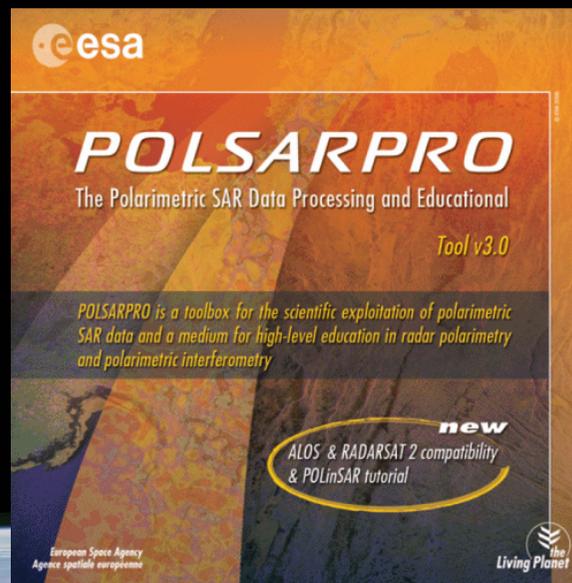
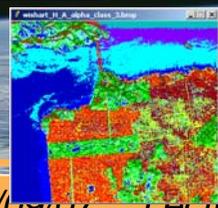
Each element of the Software (a function) can be **extracted** and **incorporated** individually into **users'** own processing software.



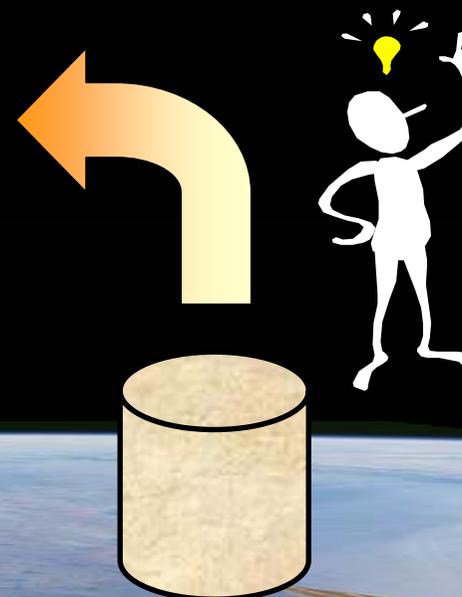


MODULAR STRUCTURE

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:

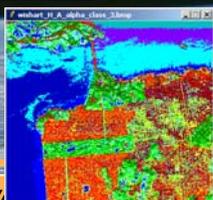
Open Source Software Development (OSSD)

approach, and follows the:

GNU General Public License v2 – June 1991.

PolSARpro v3.0 Software runs today on:

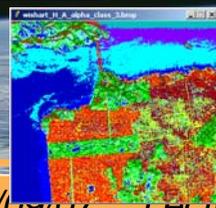
Windows 98+, Windows 2000, Windows NT 4.0,
Windows XP, Linux I 386 and Unix SOLARIS
(Macintosh OS in progress).

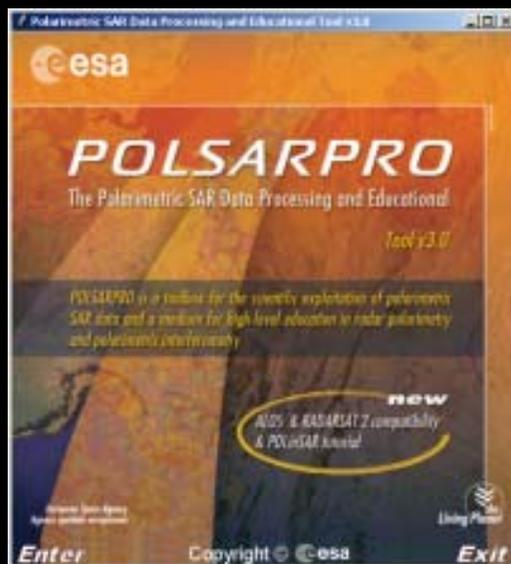




OPEN SOURCE DEVELOPMENT

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





MAIN MENU



MAIN MENU

PoISARpro 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

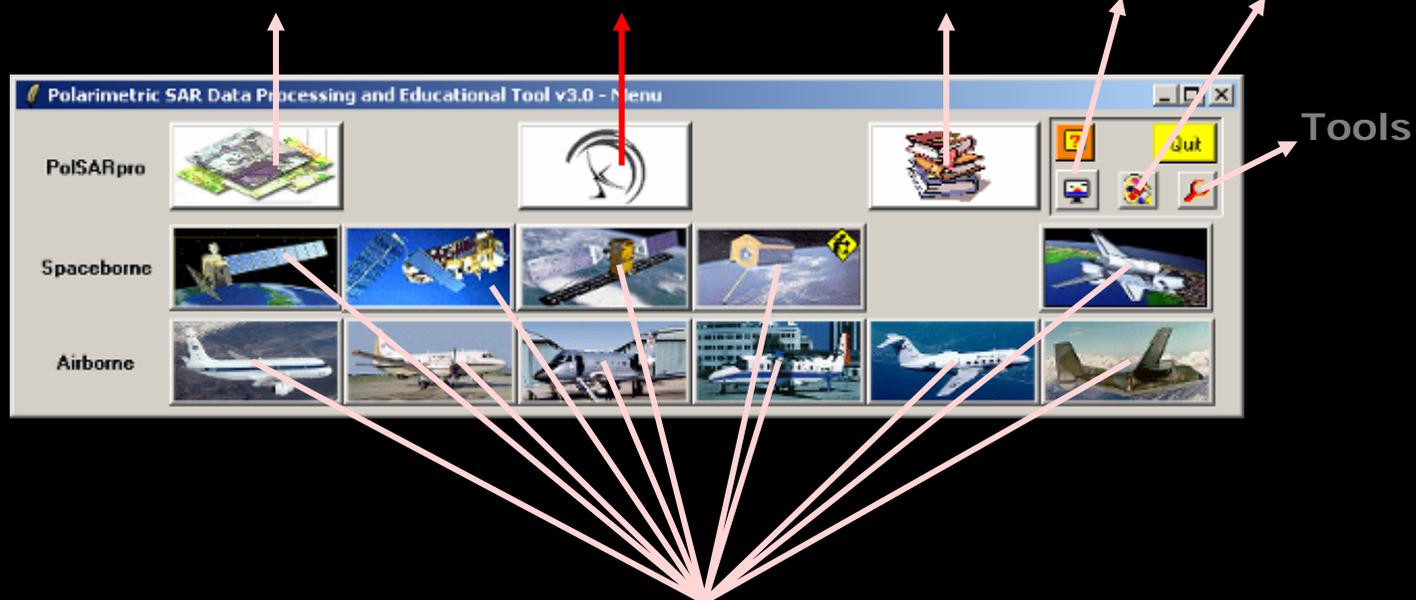
PoISARpro Full Software
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Tutorial on
POLsAR and
POLInSAR

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Version for the EO Scientific Investigator

Spaceborne Sensors: ALOS, ENVISAT, RADARSAT2, TerraSar, SIR-C
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Provide a grounding in SAR Polarimetry (POL-SAR) and SAR Polarimetric Interferometry (POL-InSAR)



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

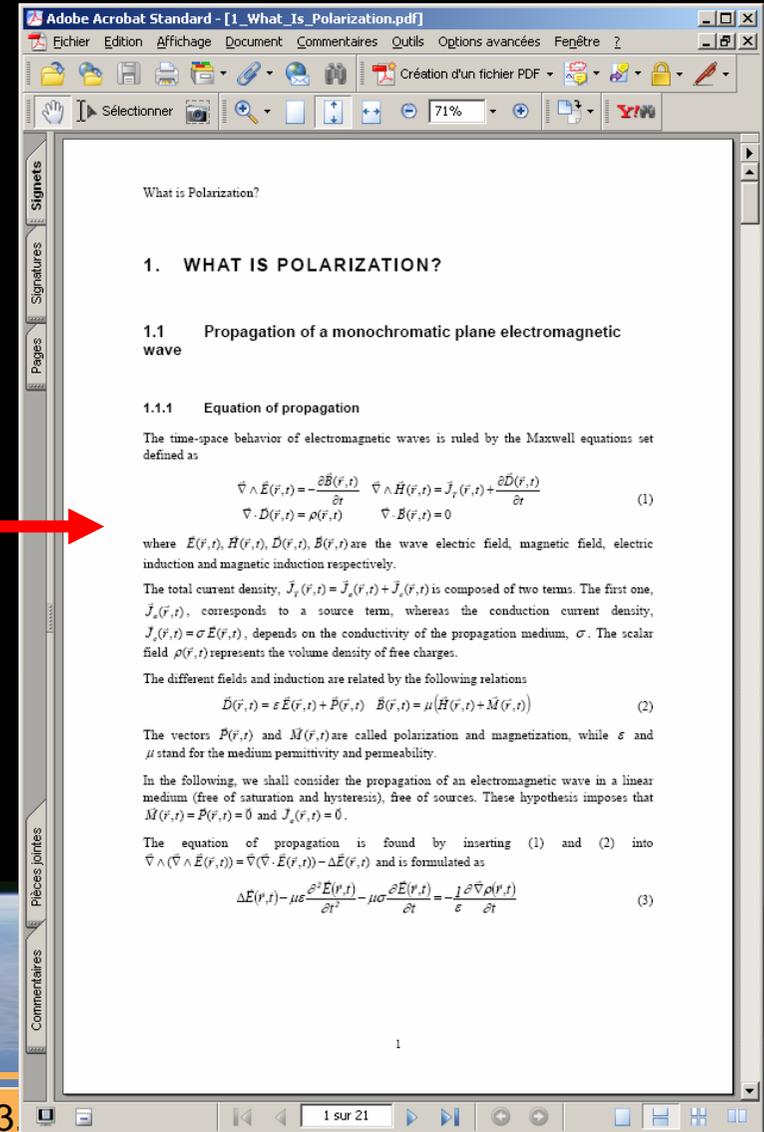
- Part 0 : Introduction
- Part I : Radar Polarimetry
- Part II : Polarimetric SAR Interferometry
- Part III : Surface Parameter Retrieval
- Part IV : Glossary
- Part V : References
- Part VI : Do It Yourself

- 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

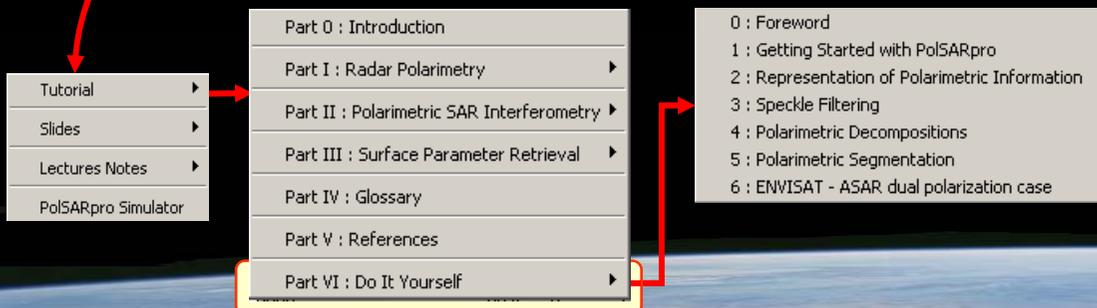
- 11 : Description of natural surfaces
- 12 : Rough surface scattering models
- 13 : Single vs multi polarization descriptors
- 14 : Estimation of surface characteristics

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



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

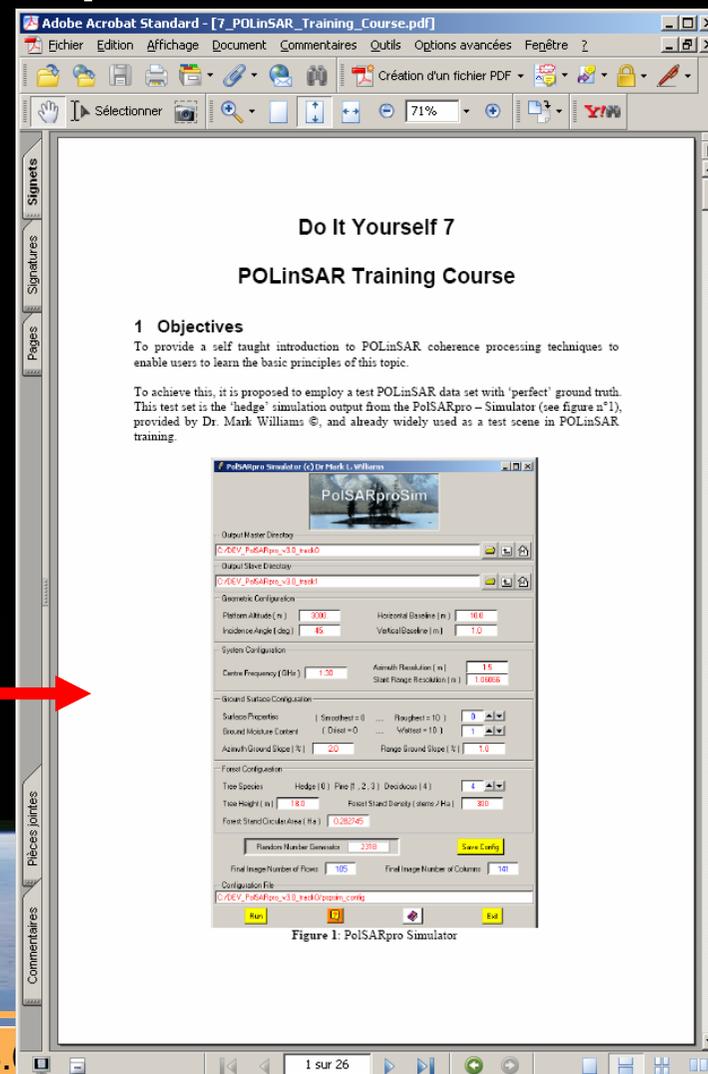
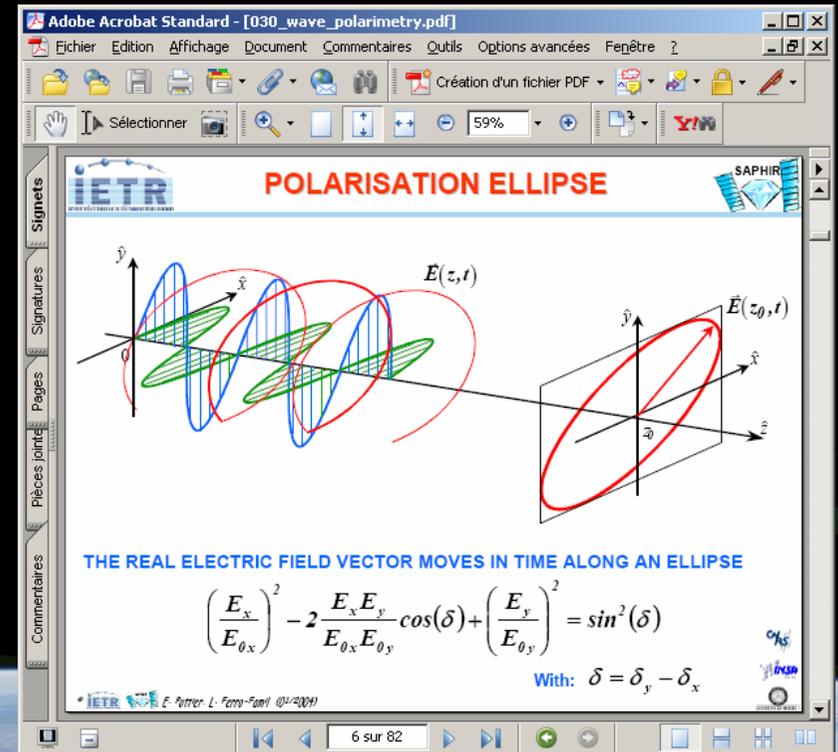
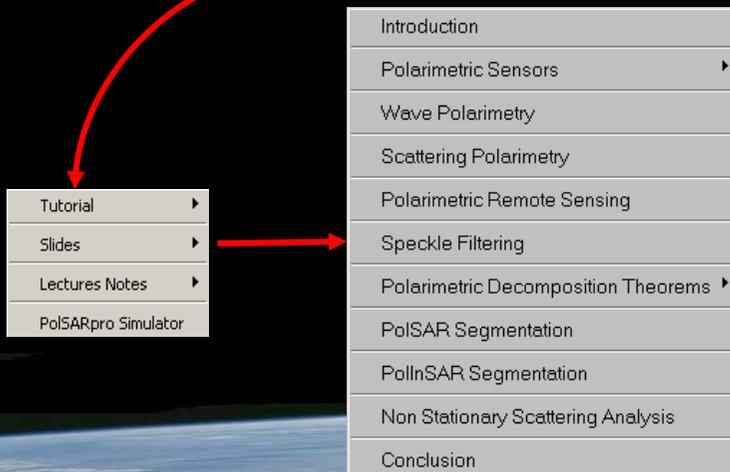


Figure 1: PolSARpro Simulator



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



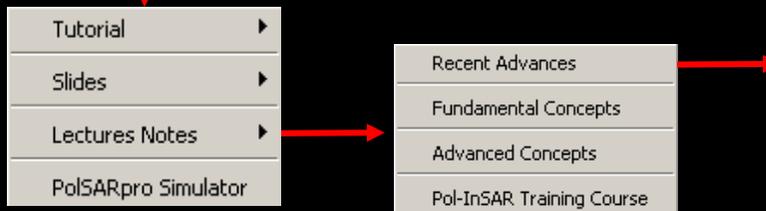
Direct access to the Slide Shows while using PolSARpro facilities

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

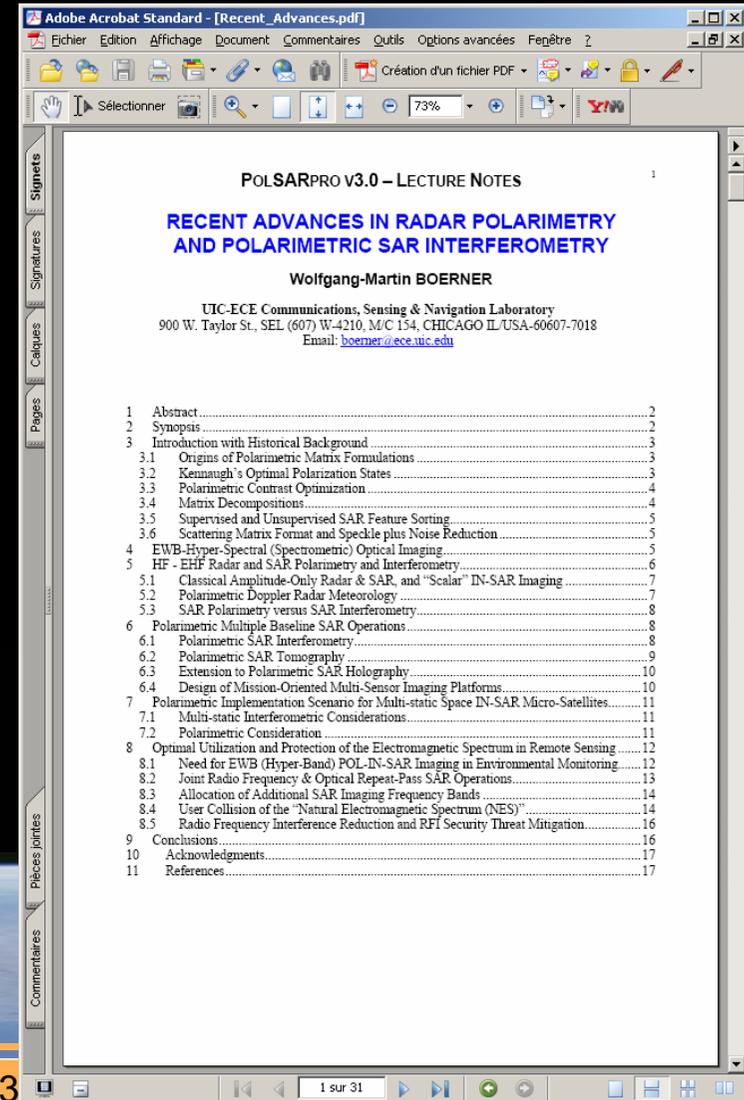


New!

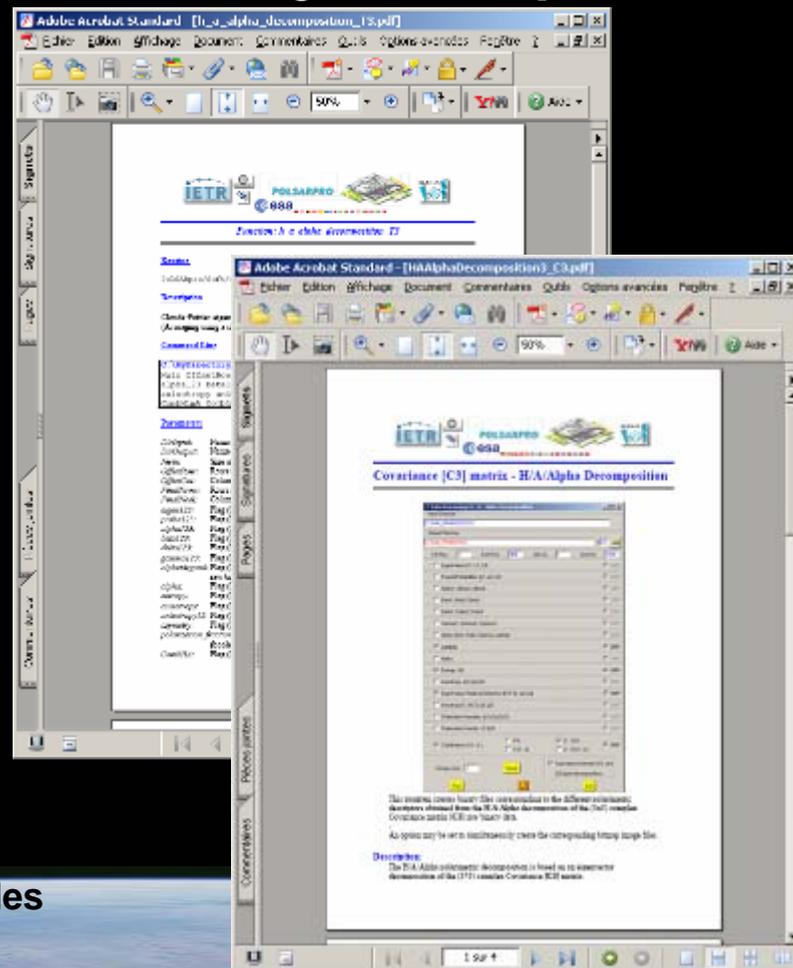


- **Recent Advances in Radar Polarimetry and Polarimetric SAR interferometry** *W.M. Boerner* – 31 pages
- **Basic Concepts in Radar Polarimetry** *W.M. Boerner* – 100 pages
- **Advanced Concepts** *E. Pottier, J.S. Lee, L. Ferro-Famil* – 65 pages

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



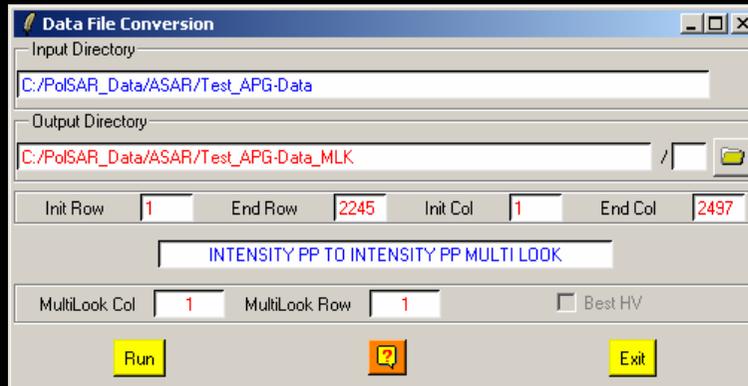
Series of concatenated sub-sections of the **User Manual**, containing all the individual pages necessary for a specific interface (**Tech Doc**).



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

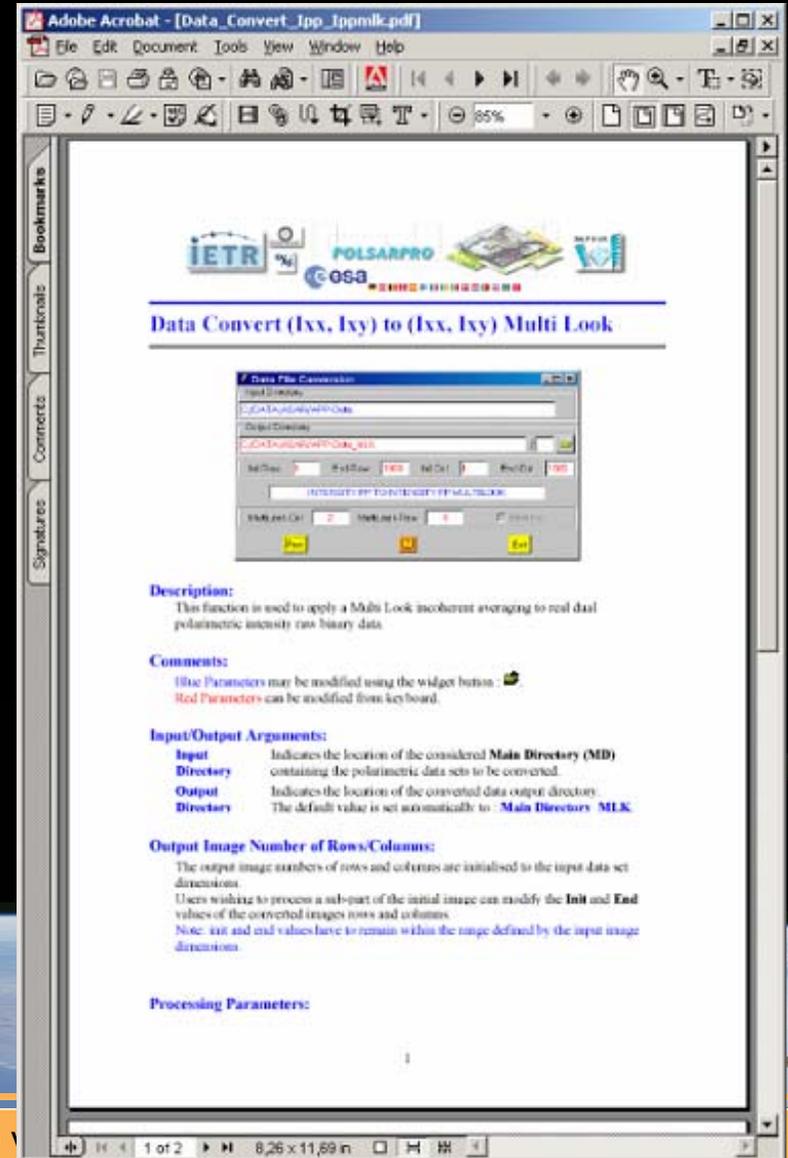
Direct access to the Technical Documentation while using PolSARpro facilities
The Technical Documentation is made available in PDF format.

PoSARpro 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

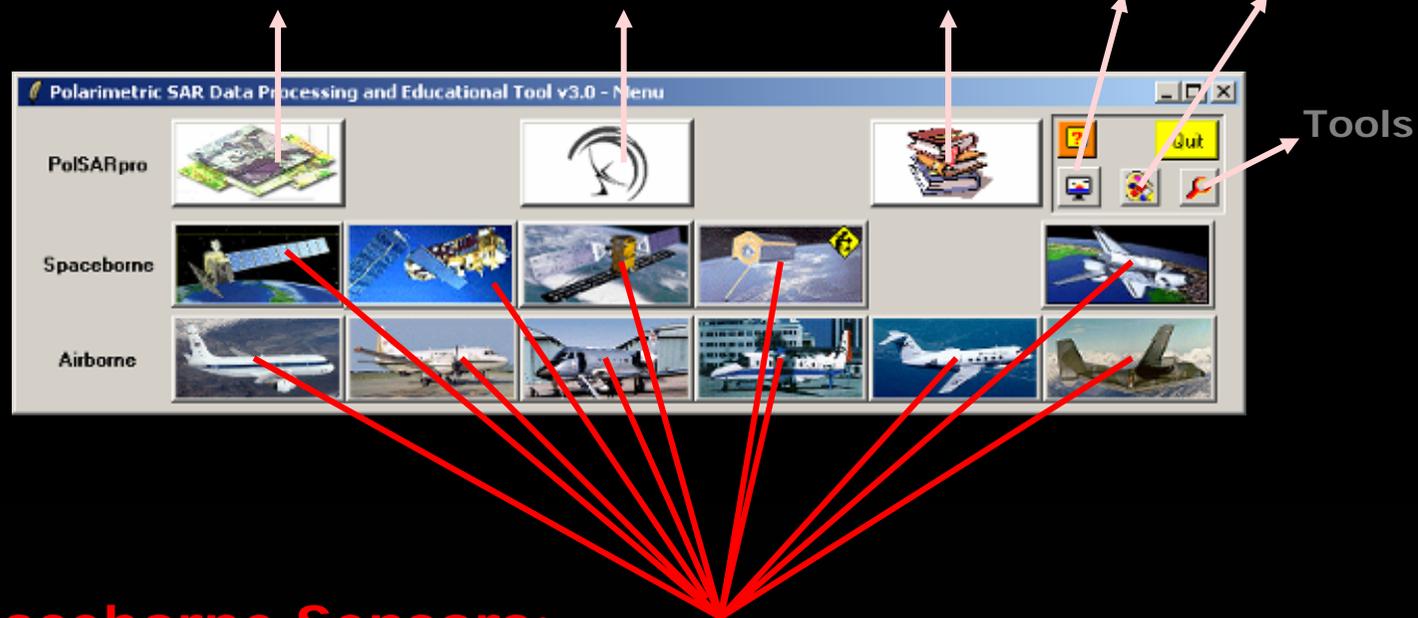
PoISARpro Full Software
– Single Data Set
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Tutorial on
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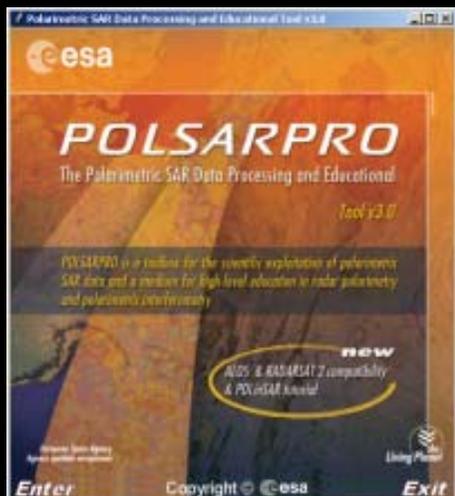


Spaceborne Sensors:

ALOS, ENVISAT, RADARSAT2, TerraSar, SIR-C

Airborne Sensors:

AIRSAR, Convair, EMISAR, ESAR, PISAR, RAMSES



ENVISAT – ASAR



SIR-C



ALOS – PALSAR



TerraSAR – X



RADARSAT 2

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



ENVISAT - ASAR Sensor

ASAR-ENVISAT (ESA) Input Data File

Input Directory: C:/DATA/ASAR/APS-Data

Output Directory: C:/DATA/ASAR/APS-Data

ASAR Input Data File: C:/DATA/ASAR/APS-Data/asar_aps_data.n1

Output Directory: C:/DATA/ASAR/APS-Data

Init Row: 1 End Row: 12056 Init Col: 1 End Col: 5150

Full Resolution
 Sub Sampling Row: ? Col: ?
 Multi Look Row: Col:

Run Exit

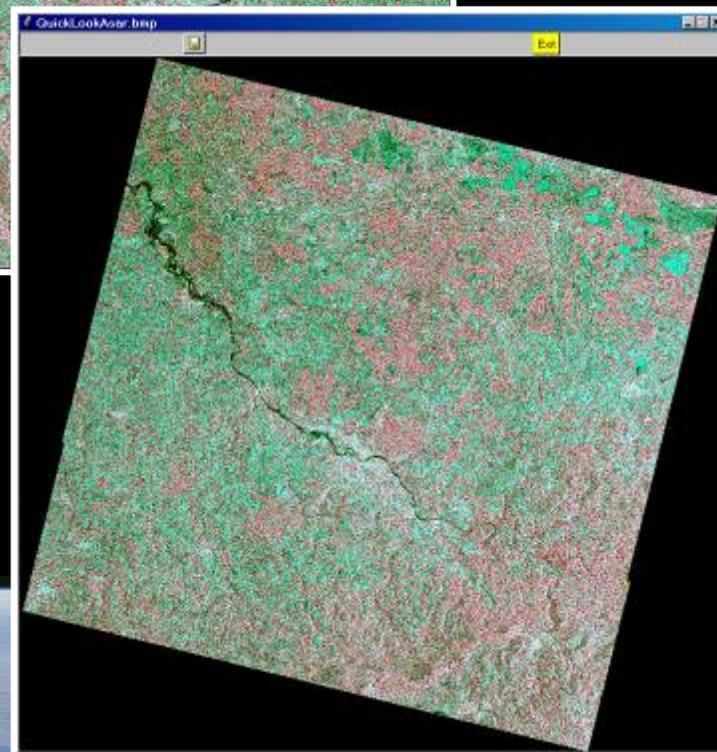


Quick Look Image BMP File



Mode APG

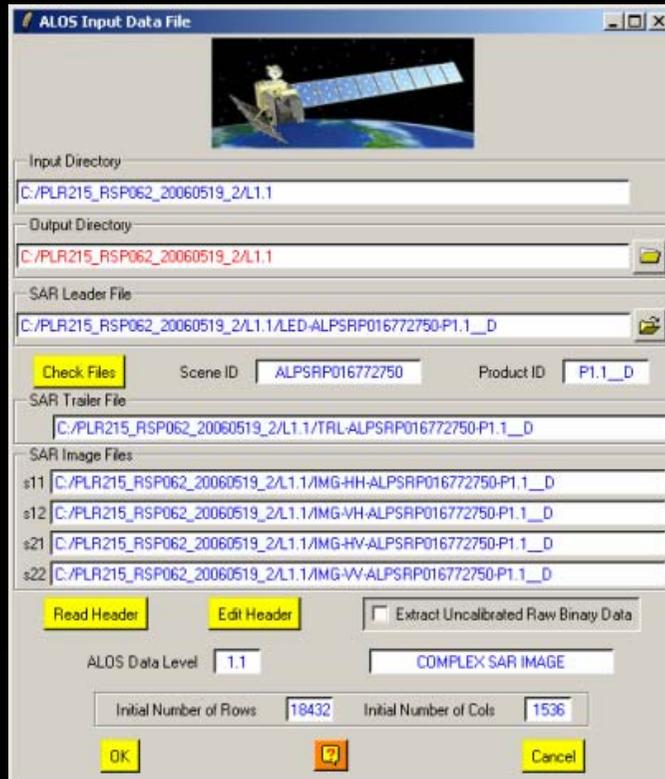
Mode APS



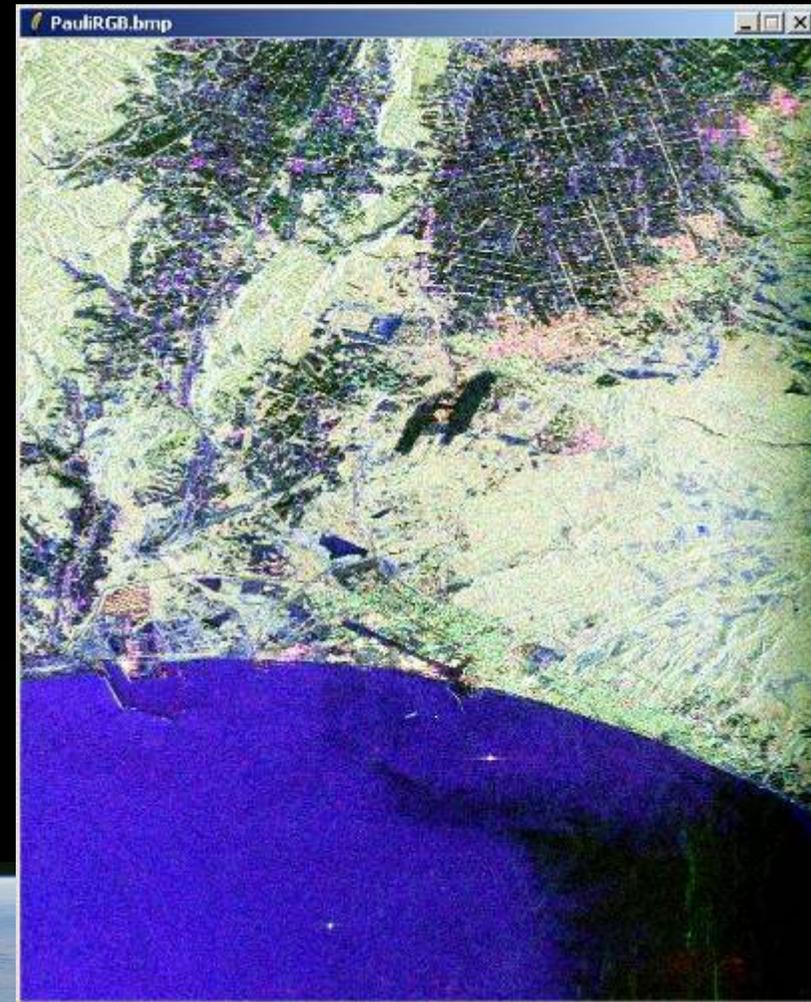
- ASAR Dual POL
- ASAR Data Mode APS, APP, APG



ALOS - PALSAR Sensor



Quick Look Image BMP File



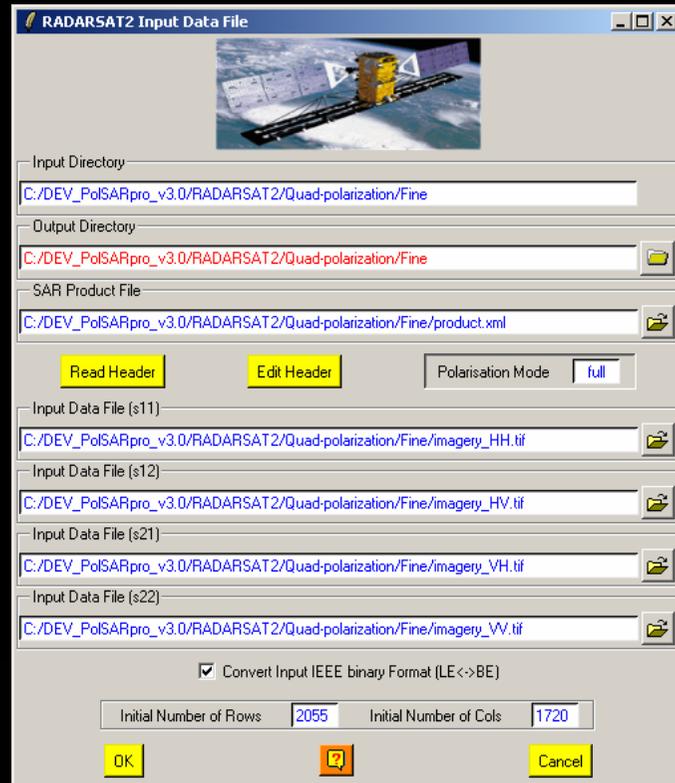
- PALSAR Dual & Quad POL

- PALSAR Data Level 1.1 and 1.5



RADARSAT - 2 Sensor

Quick Look Image BMP File



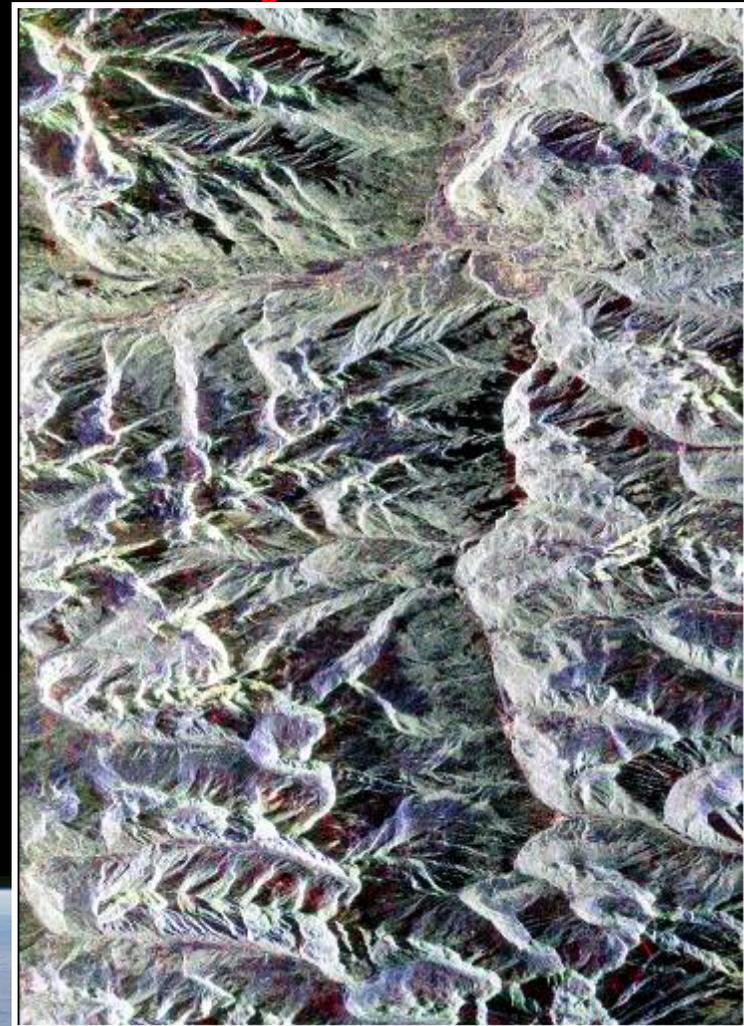
• RADARSAT-2 Dual & Quad POL



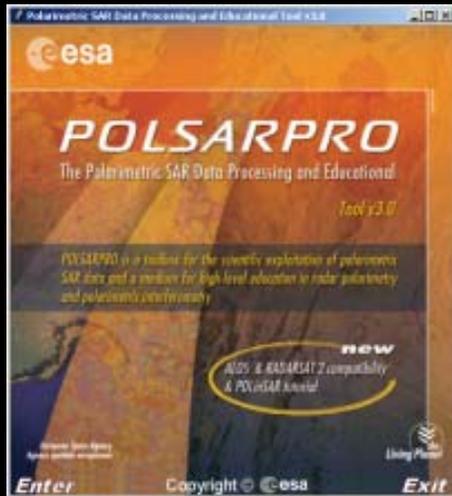
SIR – C Sensor



Quick Look Image BMP File



- SIR-C Quad POL Stokes Data



EMISAR



CONVAIR



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

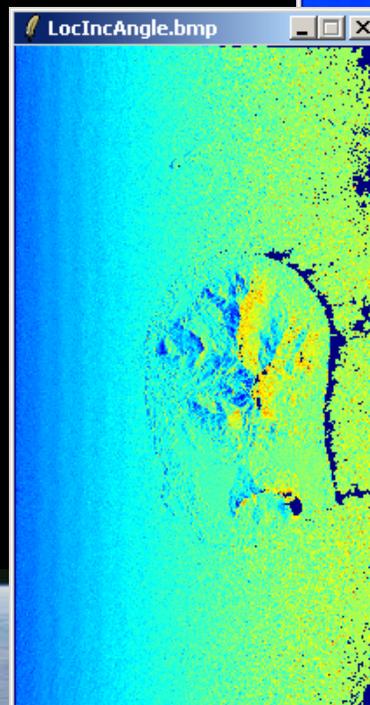


TOPSAR - AIRSAR Sensor

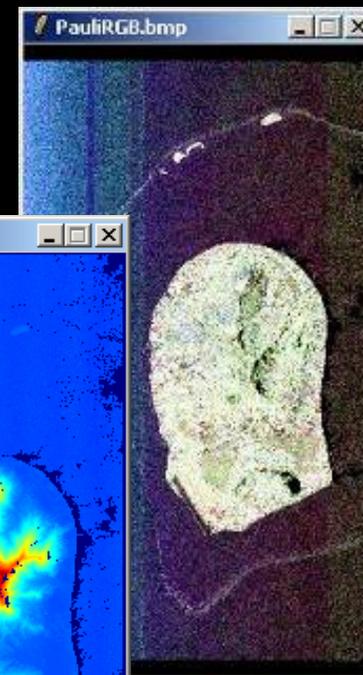
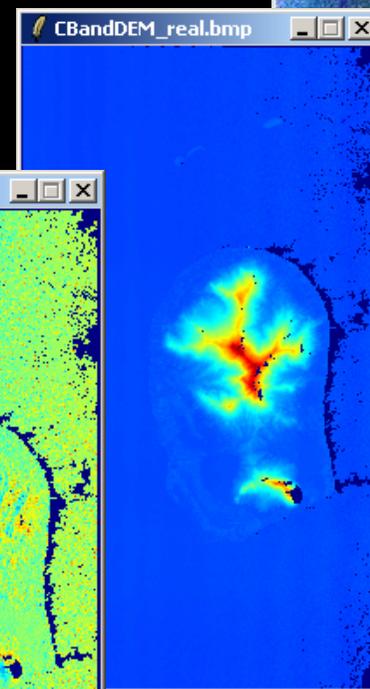
Quick Look Image BMP File



L.O.I. File



DEM File



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

- TOPSAR Quad POL
- TOPSAR LOI and DEM Data



CONVAIR Sensor



Quick Look Image BMP File

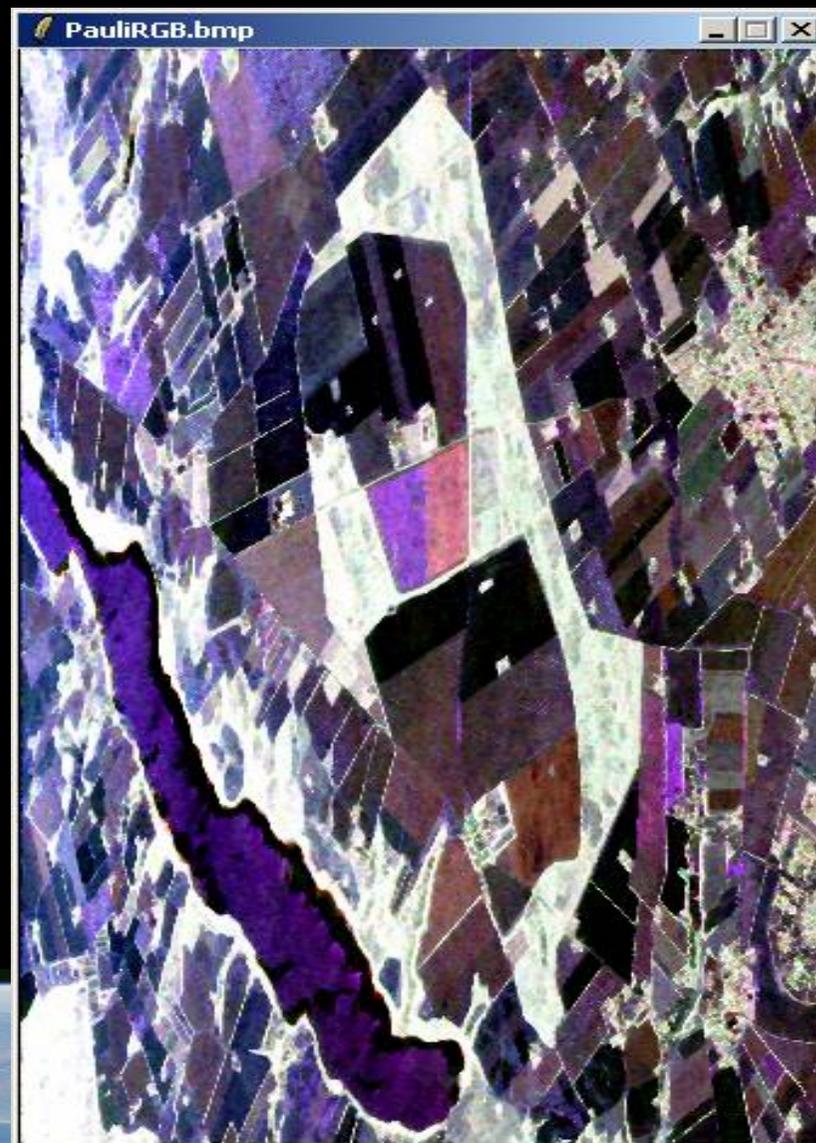
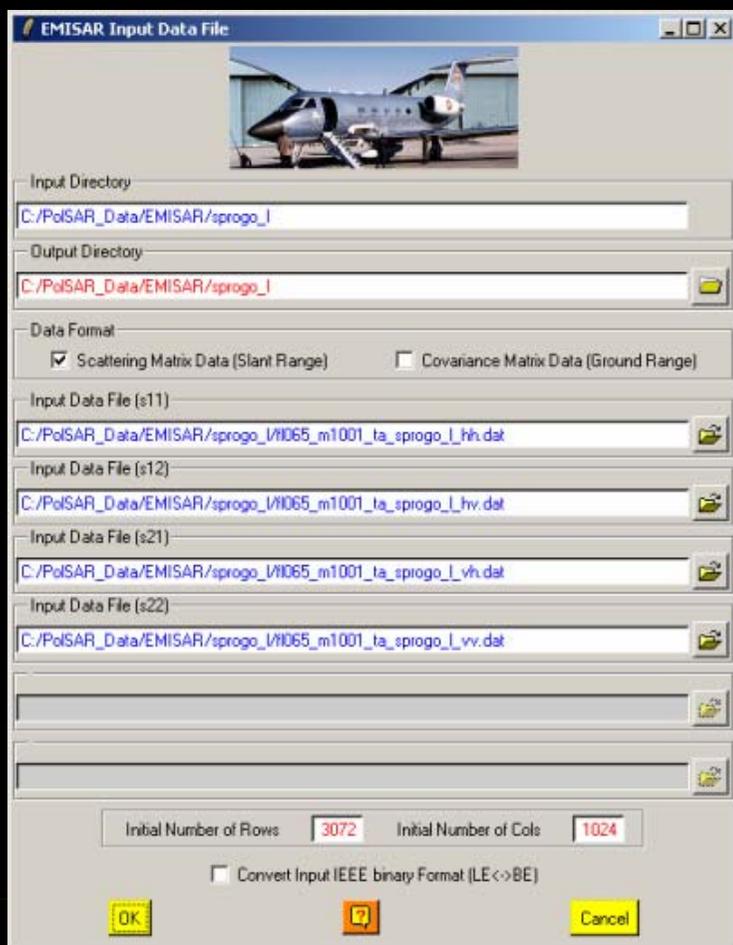


- CONVAIR Quad POL



EMISAR Sensor

Quick Look Image BMP File



- EMISAR Quad POL



ESAR Sensor



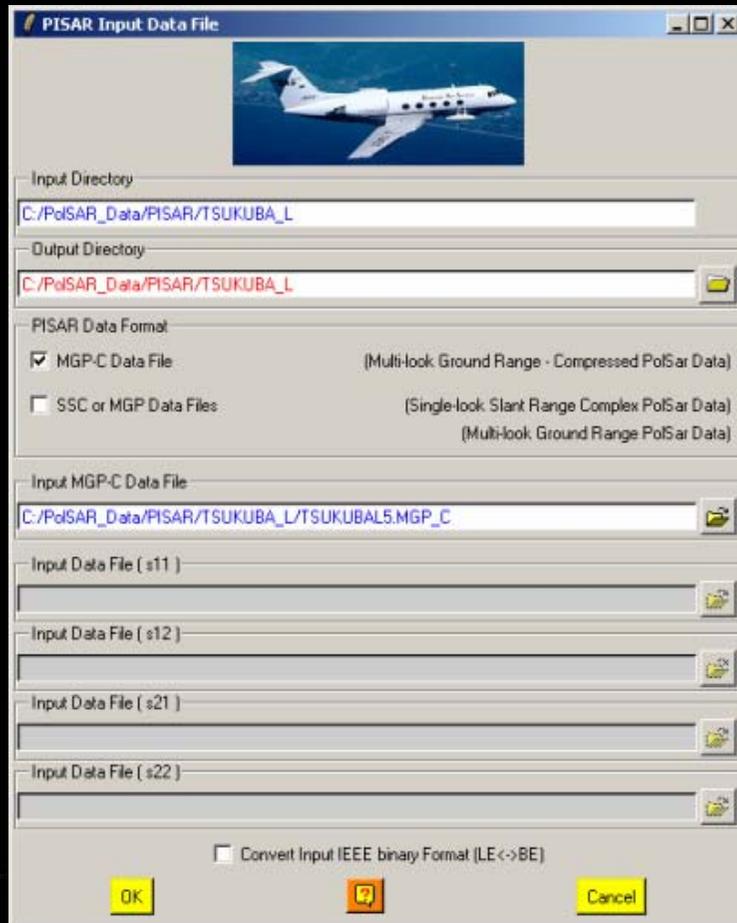
Quick Look Image BMP File



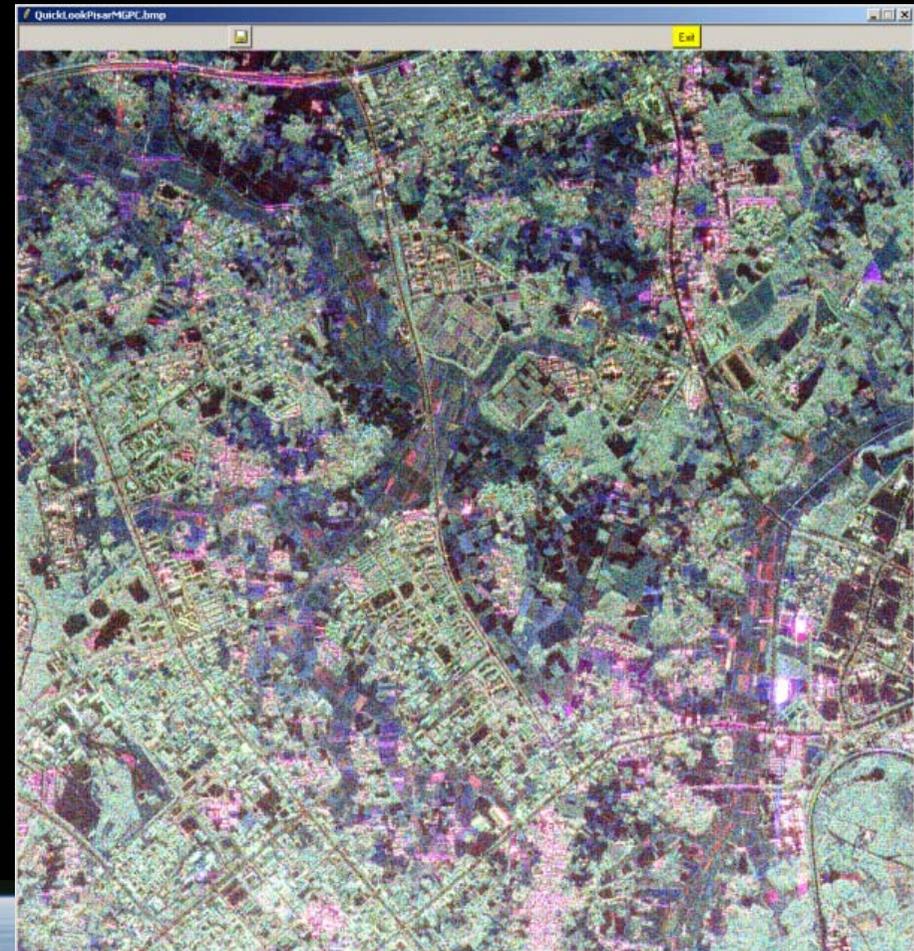
• ESAR Quad POL



PISAR Sensor



Quick Look Image BMP File



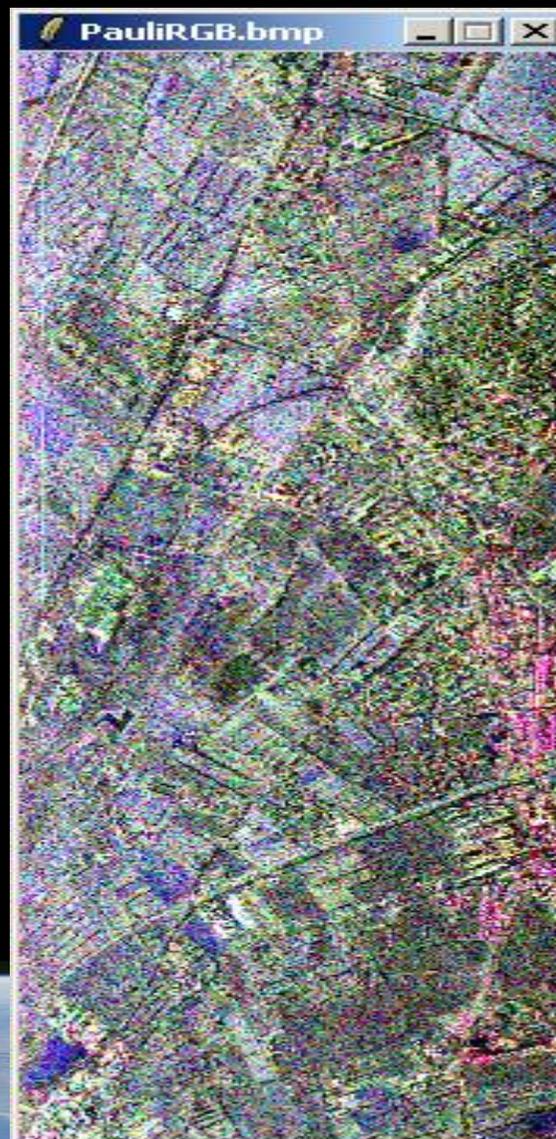
- PISAR Quad POL – MGP-C Mode
- PISAR Quad POL – SSC / MGP Modes



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

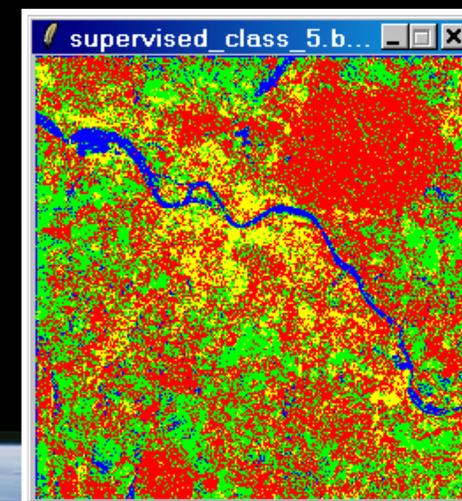
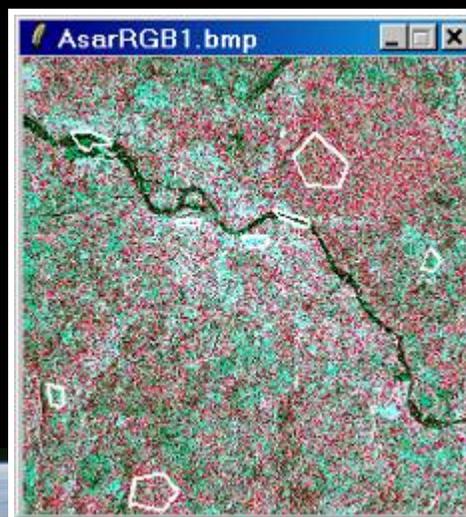
- Batch Process
 - Speckle Filtering
 - H / A / alpha Decomposition
 - Unsupervised Wishart
 - H / A / alpha Segmentation

- BMP 8 / 24 bits
- RGB



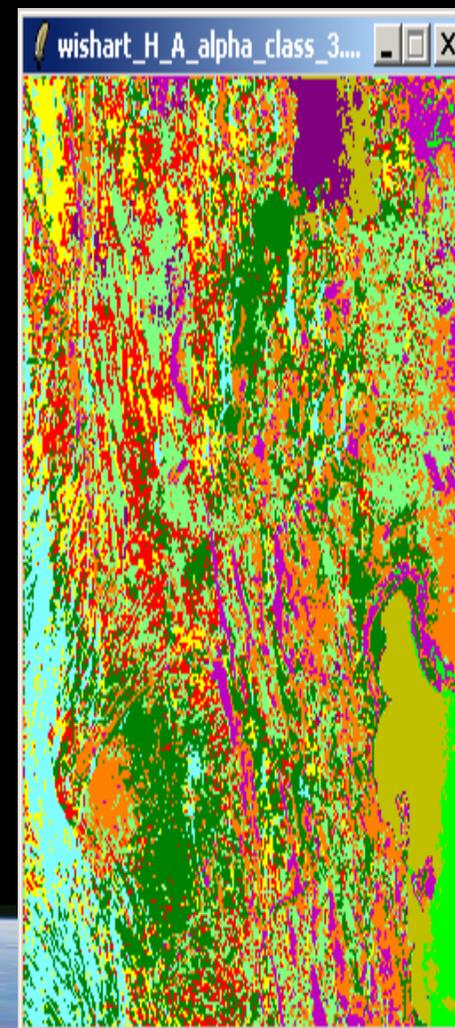
EXAMPLE
RESULT OF A POLSAR
UNSUPERVISED SEGMENTATION

SAN FRANCISCO BAY JPL - AIRSAR L-band



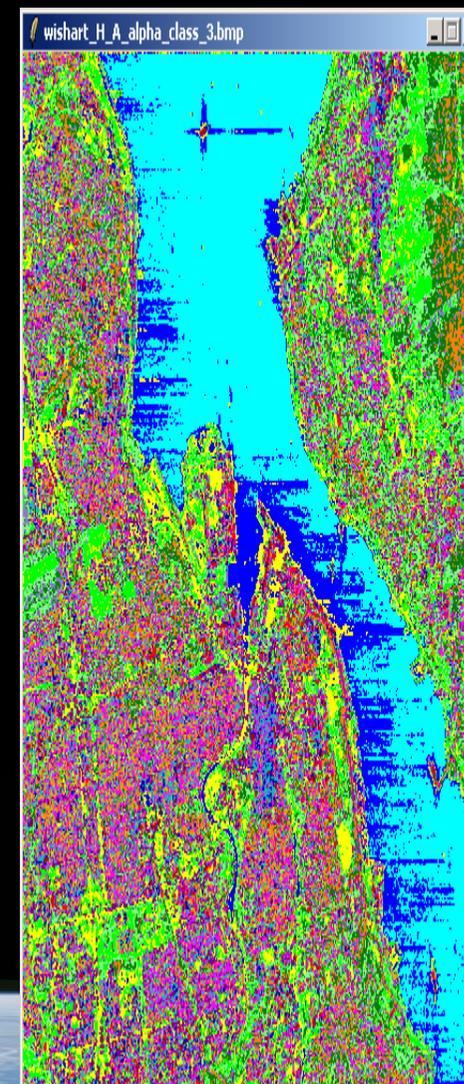
EXAMPLE
RESULT OF A POLSAR
UNSUPERVISED SEGMENTATION

ENVISAT – ASAR APG Mode Data



EXAMPLE
RESULT OF A POLSAR
UNSUPERVISED SEGMENTATION

ALOS – PALSAR Quad POL Mode

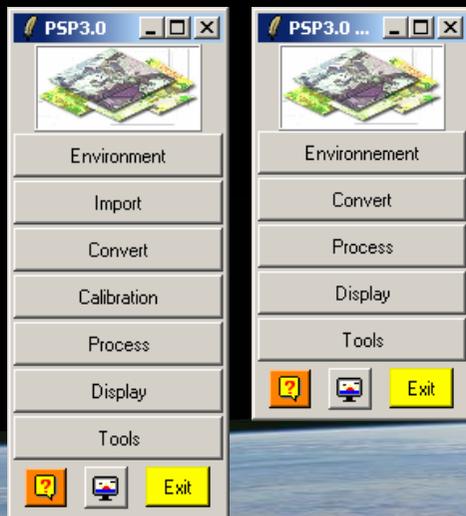


EXAMPLE
RESULT OF A POLSAR
UNSUPERVISED SEGMENTATION

RADARSAT 2 – Quad POL Simulated Data



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



PoISARpro 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

Polarimetric Signatures

Representation:

- Mesh
- Mesh-Color
- Contour
- Mesh & Contour
- Surface
- Mesh & Surface

Pixel Values:

X: 366
Y: 470
Val: []

Format:

- dB
- lin

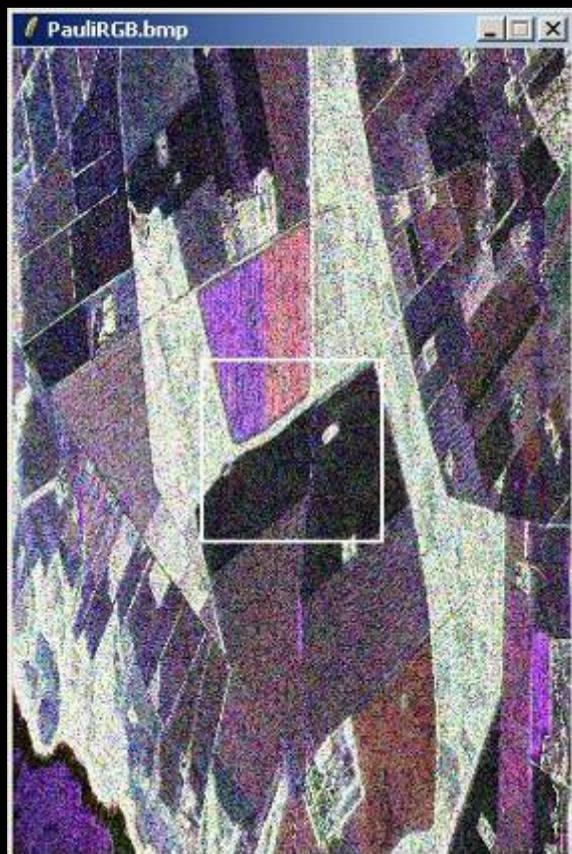
Orientation:

[] [] 60
[] [] 30

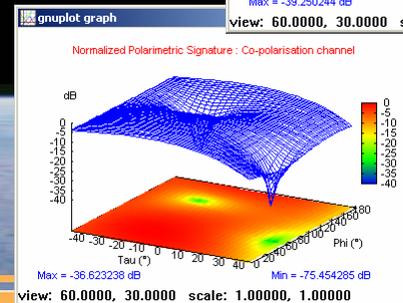
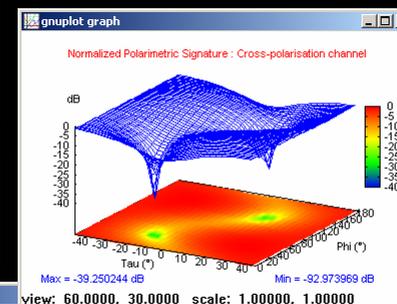
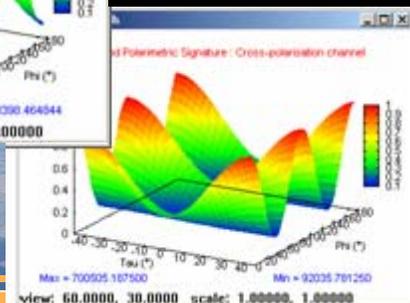
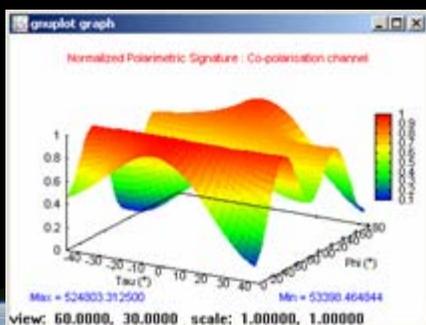
Mouse Position:

X: 351 Y: 474 Val: []

[Plot] [Save] [Close] [Exit]



New!





POLARIMETRIC SEGMENTATION

Unsupervised H / A / Alpha Classification

Data Processing: H / A / Alpha Classification

Input Directory: C:/EMISAR/Foulum_L

Output Directory: C:/EMISAR/Foulum_L

Init Row: 1 End Row: 891 Init Col: 1 End Col: 621

Representation:

- Anisotropy Entropy Alpha
- $HA + (1-H)A$ $H(1-A)$ $(1-H)(1-A)$
- Alpha (Hue) / Entropy (Sat) / Lambda (Light)

H / A / Alpha Classification:

- Entropy / Alpha Planes (BMP) + Classifier (Bin + BMP)
- Entropy / Anisotropy Planes (BMP) + Classifier (Bin + BMP)
- Alpha / Anisotropy Planes (BMP) + Classifier (Bin + BMP)

ColorMap 9: ColorMap/Planes_H_A_Alpha_ColorMap9.pal [Edit]

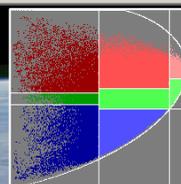
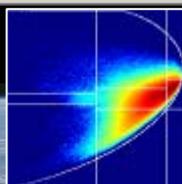
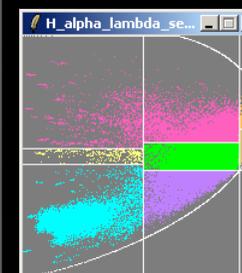
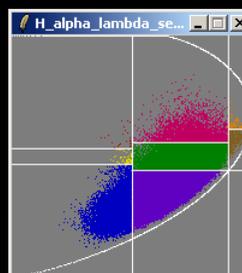
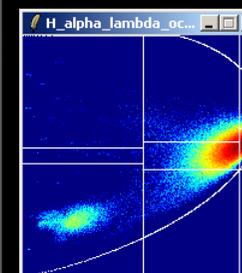
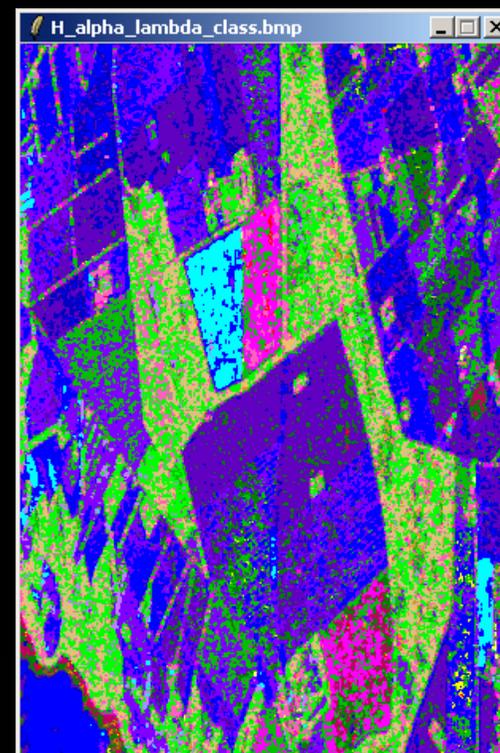
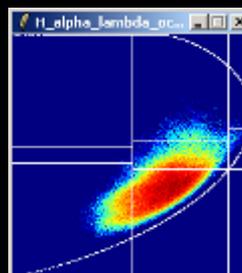
Tuo-Tuo (H / Alpha / Lambda) Classification:

- Entropy / Alpha / Lambda Planes (BMP) + Classifier (Bin + BMP)

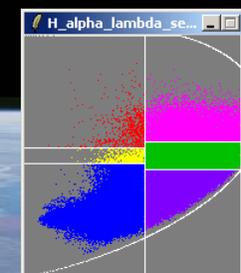
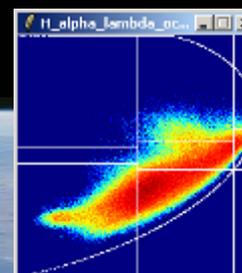
ColorMap 27: ColorMap/Planes_H_Alpha_Lambda_ColorMap27.pal [Edit]

Window Size: 1 [Reset]

[Run] [Help] [Exit]



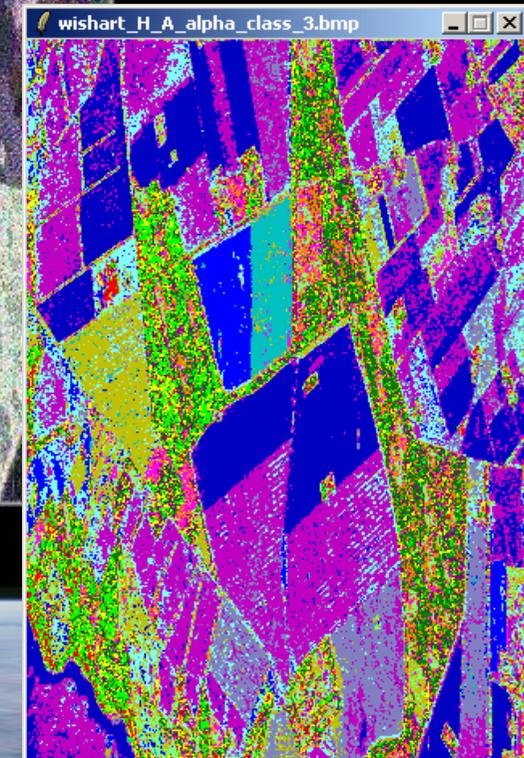
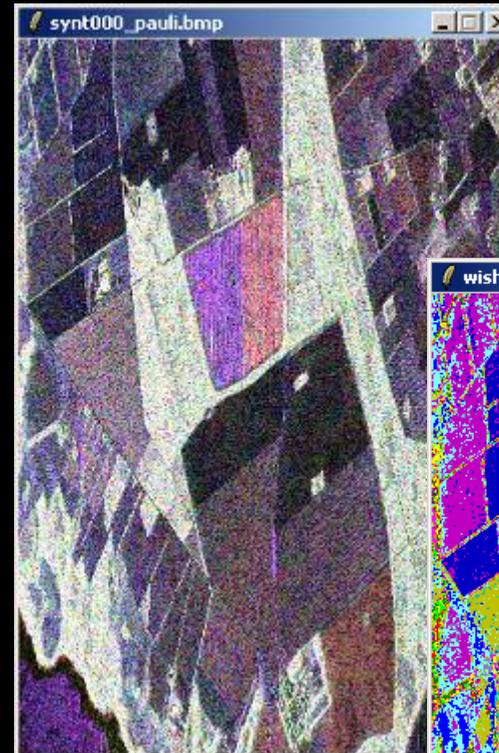
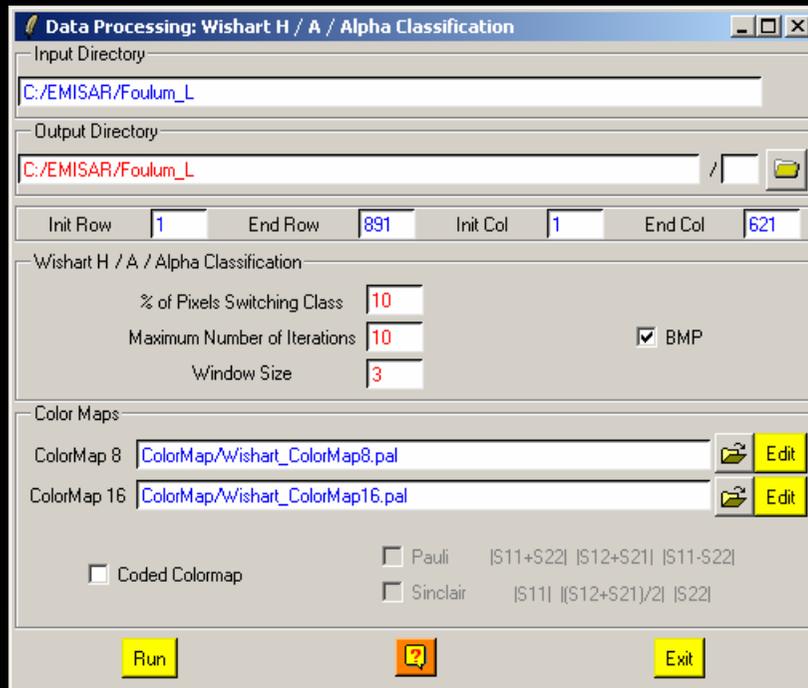
X_Y_occurrence_plane X_Y_segmented_plane





POLARIMETRIC SEGMENTATION

Unsupervised H / A / Alpha - Wishart Classification





POLARIMETRIC SEGMENTATION

Rule-Based Hierarchical Classification

Data Processing: Rule-Based Hierarchical Classification

Input Directory: C:/EMISAR/Foulum_C

Output Directory: C:/EMISAR/Foulum_C

Init Row: 1 End Row: 1024 Init Col: 1 End Col: 1024

Classification Configuration

K-Mean Procedure Maximum Number of Iterations: 10
 % of Pixels Switching Class: 10

Input Parameters Specification

Parameters File: C:/EMISAR/Foulum_C/tree_parameters_list.txt

Input Parameters List Editor

Hierarchical Structure Definition

Structure File: C:/EMISAR/Foulum_C/tree_structure.txt

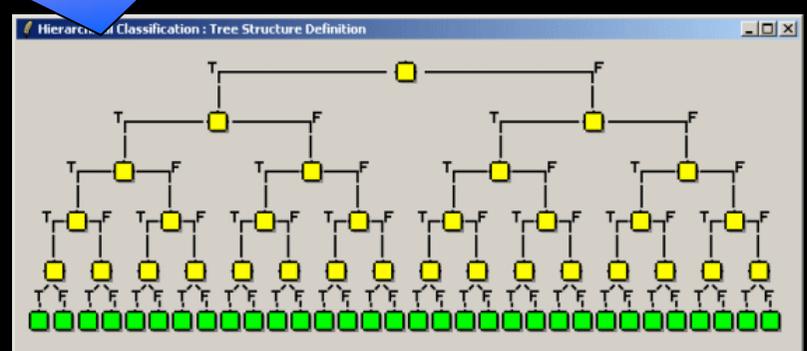
Hierarchical Structure Editor

Color Maps

ColorMap 32: ColorMap/Random_ColorMap32.pal **Edit**

Run **Exit**

New!



Hierarchical Classification: Tree Structure Definition

Node Definition

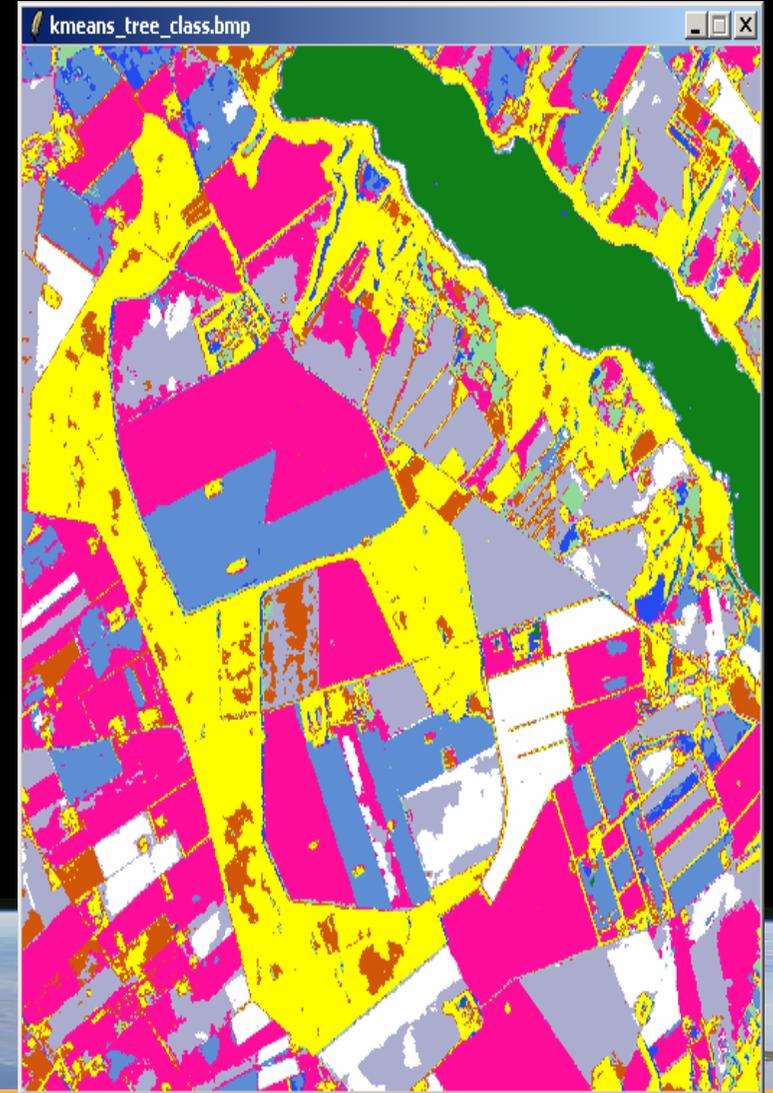
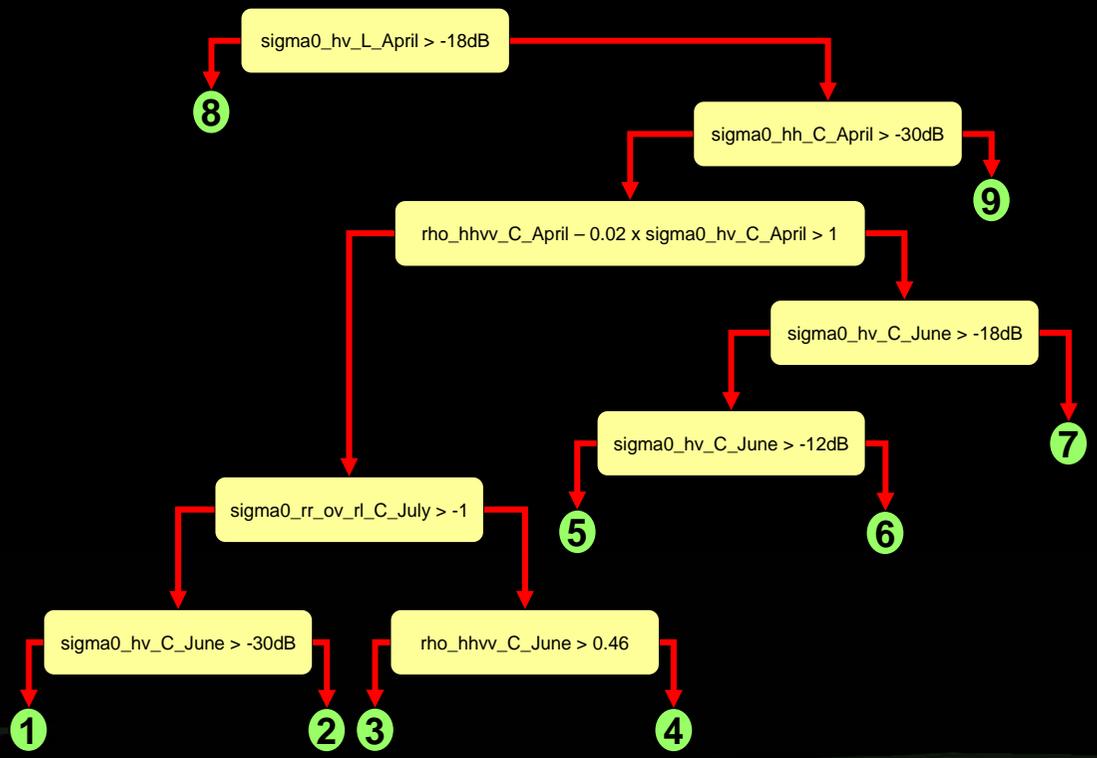
Parameter 1: rho_hhvv_C_June Parameter 2: rho_hhvv_C_June

Weighting Coeff 1: 1 Weighting Coeff 2: 0 Operator: > Threshold Coeff: 0.40

Reset **Save & Exit**



POLARIMETRIC SEGMENTATION Rule-Based Hierarchical Classification





DATA ANALYSIS - STATISTICS

Data Processing: Statistics

Wrap Text Mode

S2 MATRIX STATISTICS
=====

Number of samples: 14601

Element S11
=====

Real Part

1st order: Mean = 0.14918
2nd order: Variance = 7.75109
3rd order: Variance Power = 7.77284
3rd order: Skewness = -0.00567
3rd order: Non Centered Skewness = 3.34960
4rd order: Kurtosis = 3.18654
4rd order: Non Centered Kurtosis = 192.40712

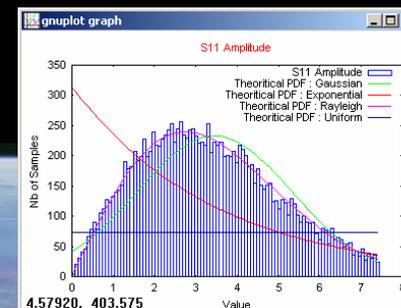
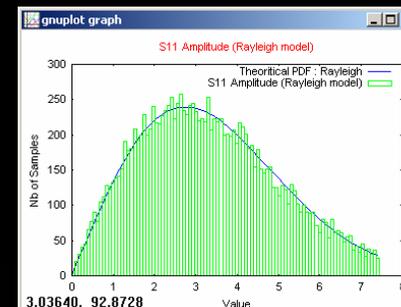
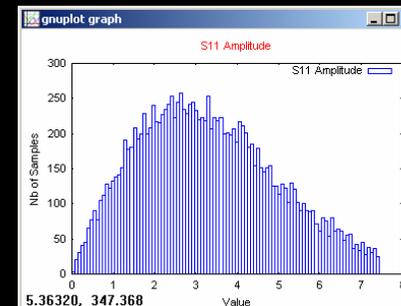
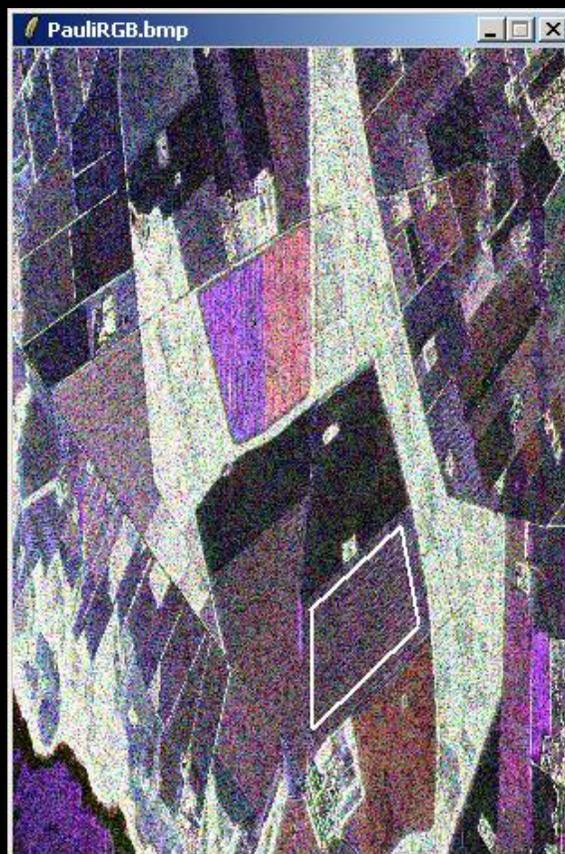
Channel: S11 Elements: Real Part

Theoretical PDF

PDF: _____

Buttons: Clear, Save, Run, Histo, Close, Exit

New!





DATA ANALYSIS - HISTOGRAMS

Data Analysis : Statistics - Histogram

Input Data File
C:/EMISAR/Foulum_L/s11.bin

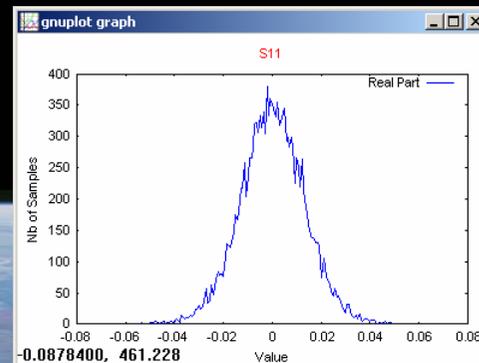
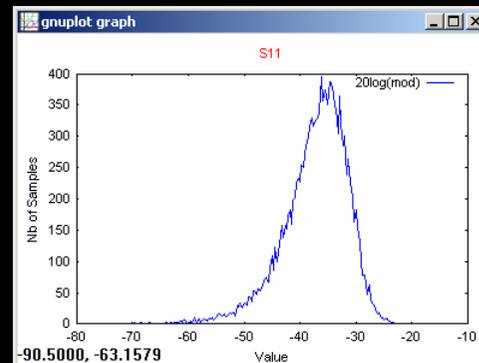
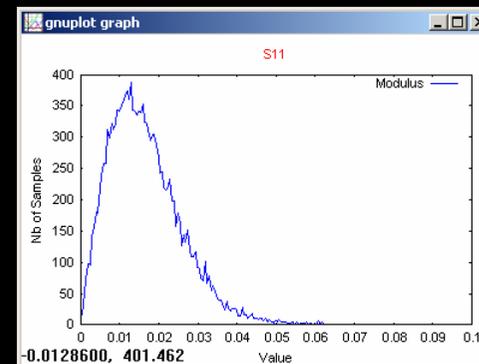
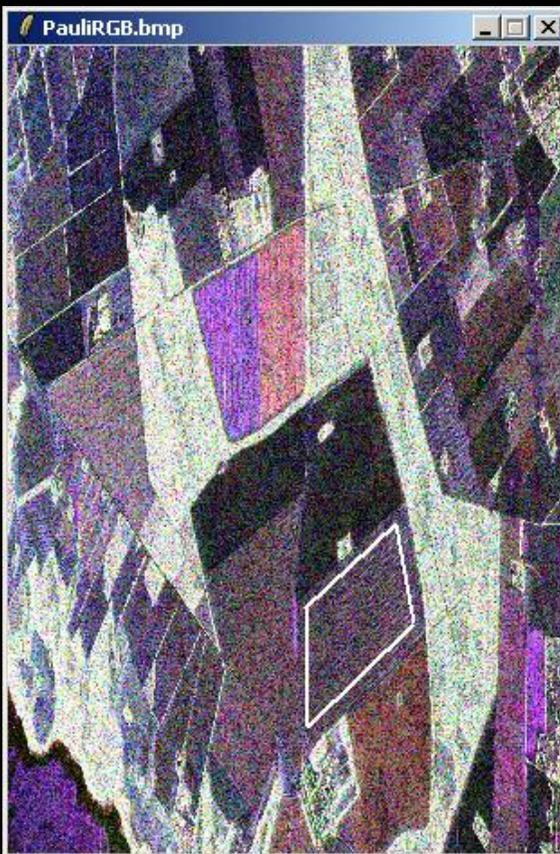
Input Data Format
 Complex Float Integer

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

Histogram Title: S11 Histogram Label: Modulus

Minimum / Maximum Values
 Automatic Min: 0.000148 Max: 0.1 MinMax

 Clear Save Plot line box Close
 Run Exit



New!



DATA ANALYSIS - PROFILES

Data Analysis : Value - Profile

Input Data File
C:/EMISAR/Foulum_L/span_db.bin

Input Data Format
 Complex Float Integer

Pixel Values
 X: 372 Y: 554 Value: -22.568806

Show
 Modulus 10log(Mod) 20log(Mod)
 Phase Real Part Imag part

Range Length (pix) 200 Value -22.568806

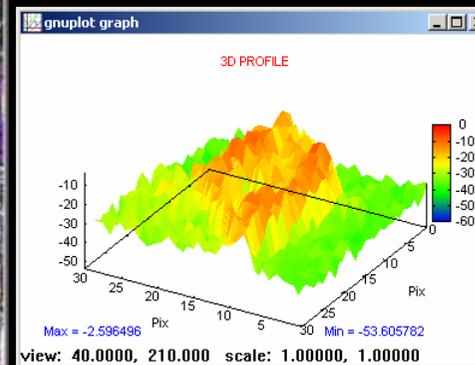
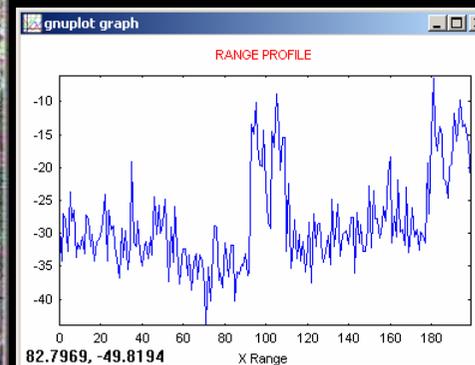
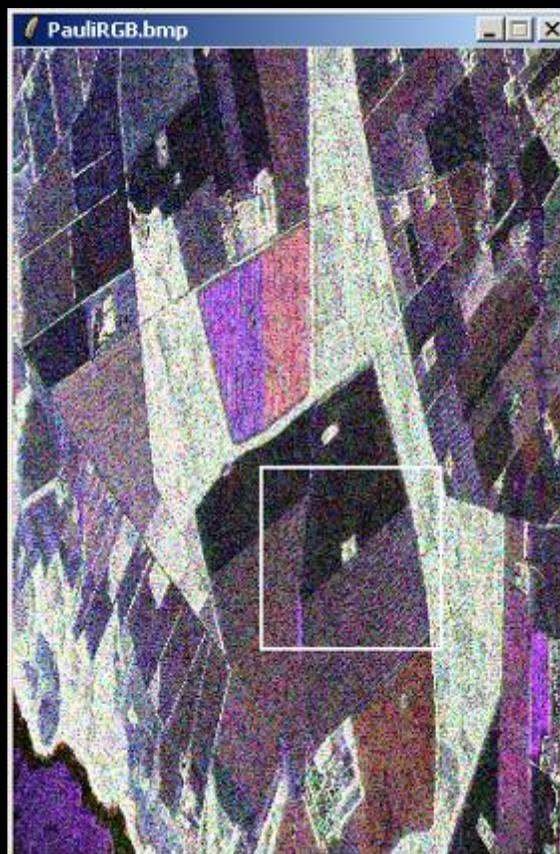
Representation
 X Range Y Range (X,Y) Range
 Mesh Surface Mesh C Mesh S

Minimum / Maximum Values
 Auto Min Auto Max Auto MinMax

Profile Title
RANGE PROFILE

Buttons: Plot, Close, Exit

New!



New!

CALIBRATION ASSESSMENT



Calibrator Assessment

Representation:
 X Range Amplitude
 Y Range Phase
 X/Y Range Range Length (pix): 100

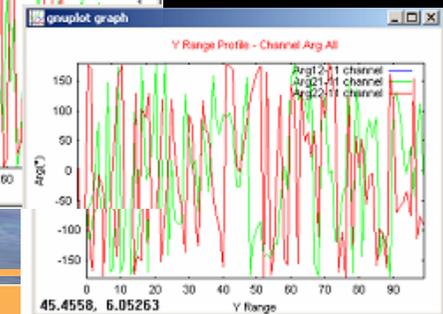
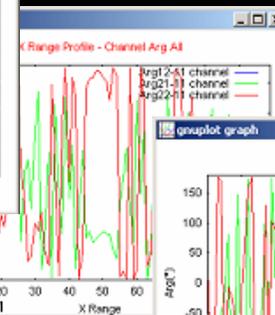
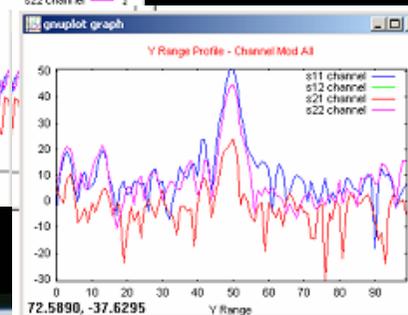
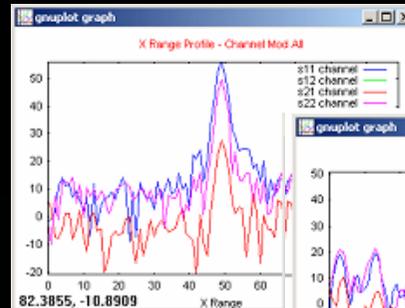
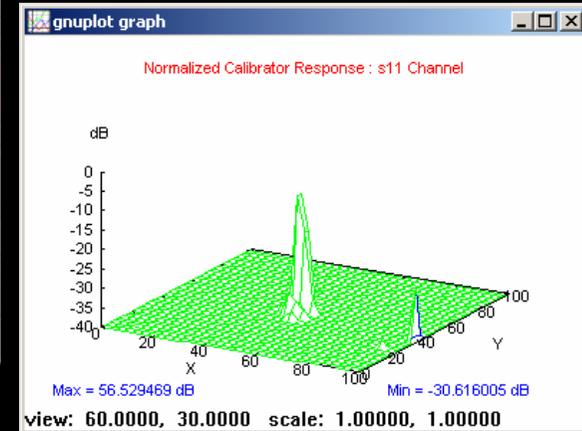
Ped Values: Ped Size: Format: Decimation:
 X: 1309 X: 1 dB 40
 Y: 2253 Y: 1 in 30

PSLR 1S L/R S.S L/R
 X: 1309 X: 1309 X: 1309
 Y: 2253 Y: 2253 Y: 2253

Resolution 3dB Resolution 6dB Resolution 9dB
 X: 1309 X: 1309 X: 1309
 Y: 2253 Y: 2253 Y: 2253

Mouse Position: X: 1307 Y: 2232

Buttons: Plot, Run, Close, Exit



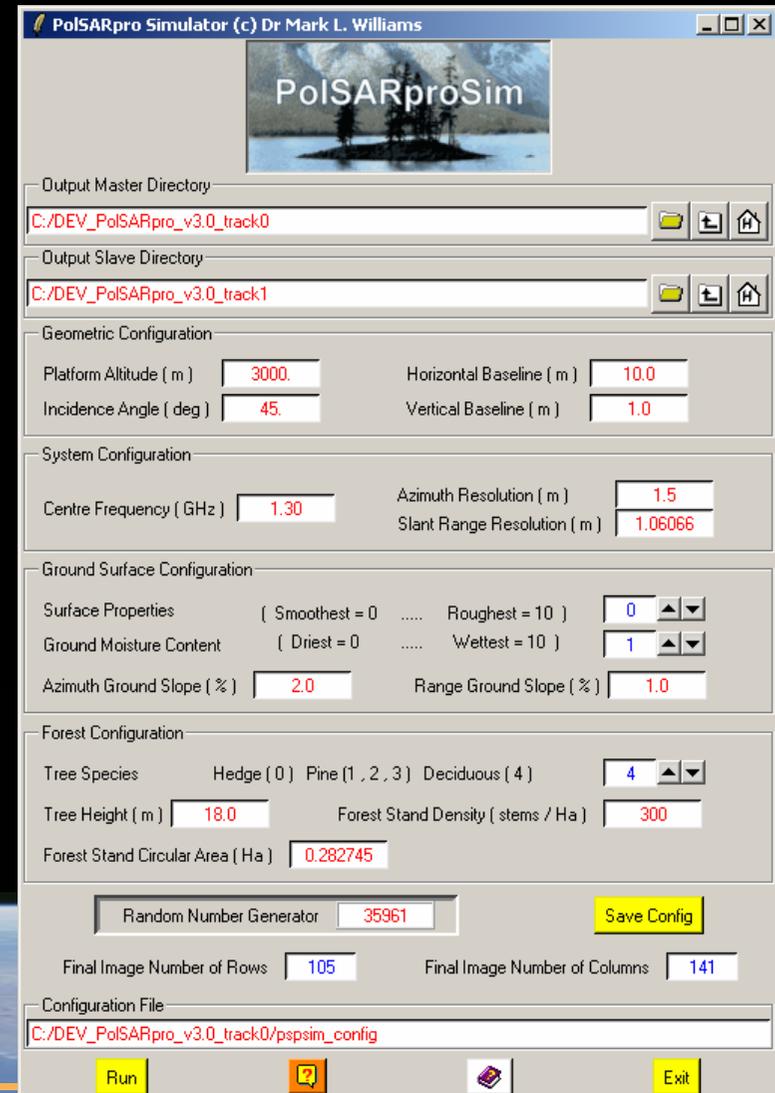


PoSARproSim is a rapid, coherent, fully polarimetric and interferometric SAR simulation of forest.



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

New!





PoSARpro - SIM

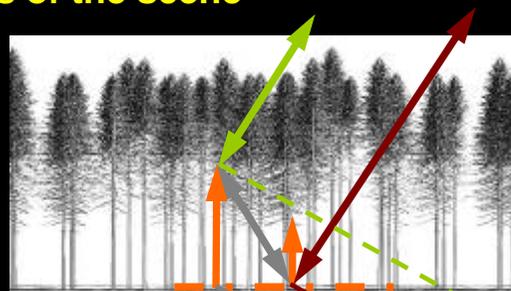
The SAR image is evaluated as a coherent sum of scattering events from small elements of the scene



PINE



DECIDIOUS



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

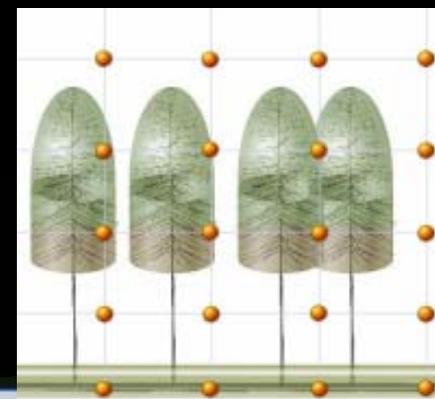
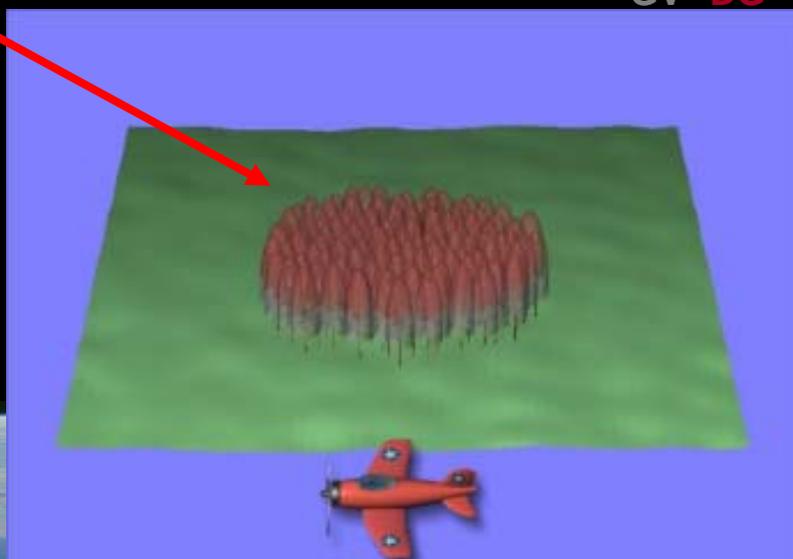


GV DG

DV



RANDOM HEDGE

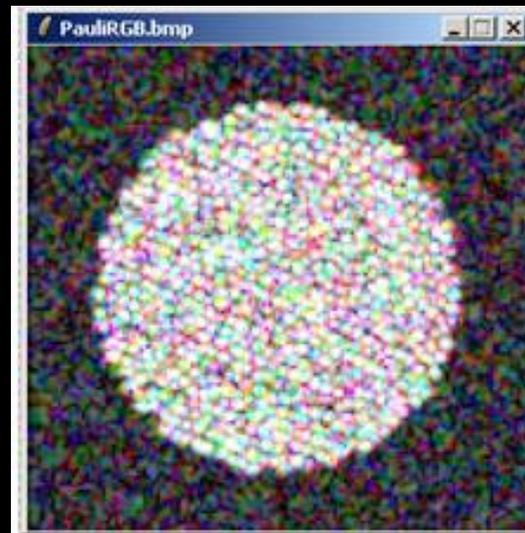


Given the map of tree locations and dimensions a grid of points is used to sample the attenuation of the coherent wave in 3D

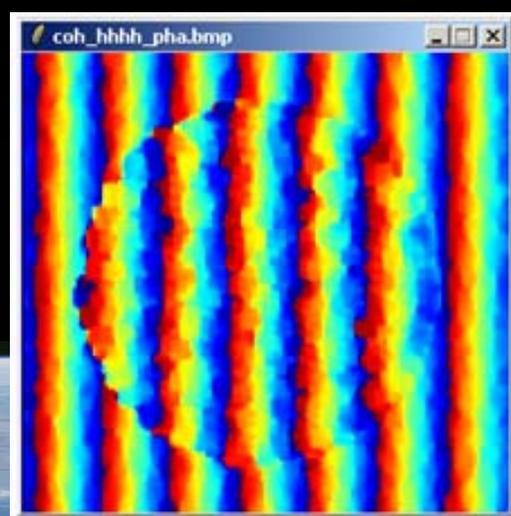
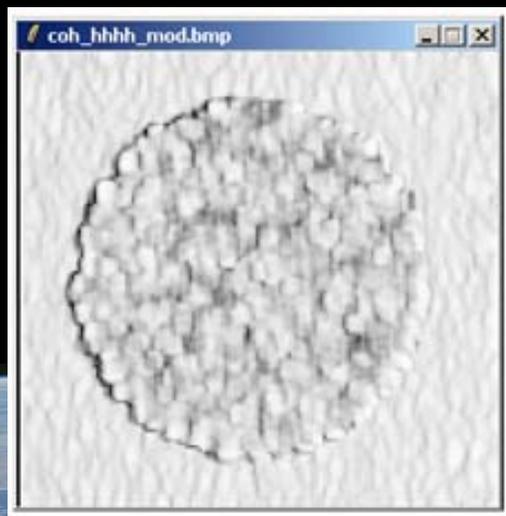
PoSARpro - SIM



View from Radar



Pauli RGB Image



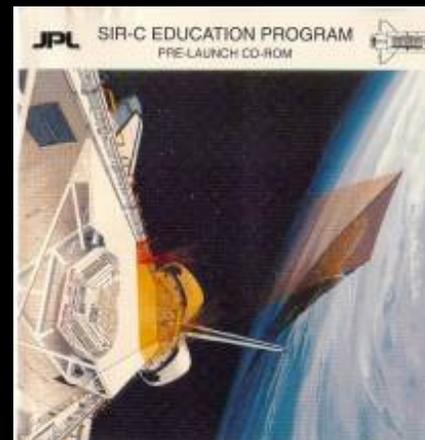


<http://earth.esa.int/polsarpro>



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)



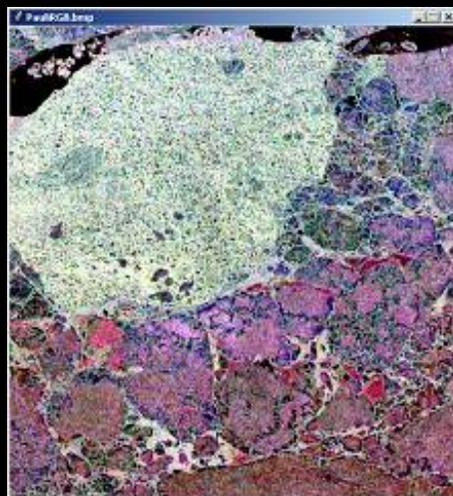
Flevoland
(750 rows x 1024 cols)



San Francisco Bay
(900 rows x 1024 cols)



Ottawa Area
(222 rows x 3429 cols)



Ice Area
(544 rows x 5238 cols)



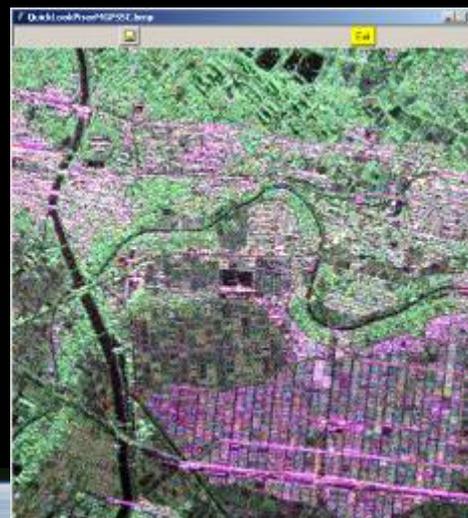
Foulum (Slant Range)
(1750 rows x 1000 cols)



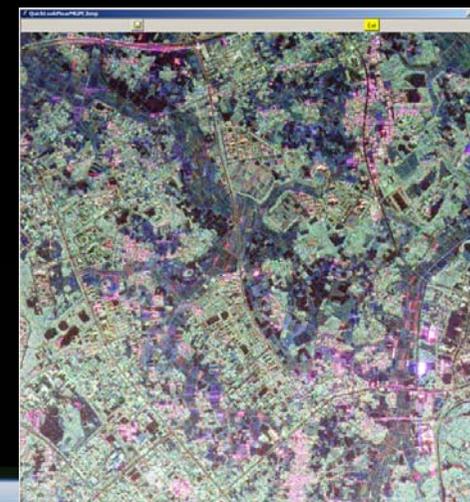
Foulum (Ground Range)
(1100 rows x 1752 cols)



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

