

# **RECENT ADVANCES IN THE DEVELOPMENT OF THE OPEN SOURCE TOOLBOX FOR POLARIMETRIC AND INTERFEROMETRIC POLARIMETRIC SAR DATA PROCESSING: THE POLSARPRO V4.1.5 SOFTWARE**

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## **1. ABSTRACT**

The objective of this paper is to make a review of the current status of the PolSARpro v4.1.5 Software (Polarimetric SAR Data Processing and Educational Toolbox), developed under contract to ESA by a consortium comprising I.E.T.R at the University of Rennes 1, AELc, DLR-HR and Dr mark Williams from Adelaide. The objective of this current project is to provide Educational Software that offers a tool for self-education in the field of Polarimetric SAR data analysis at University level and a comprehensive suite of functions for the scientific exploitation of fully and partially polarimetric multi-data sets and the development of applications for such data. The PolSARpro v4.1.5 Software establishes a foundation for the exploitation of Polarimetric techniques for scientific developments and stimulates research and applications developments using PolSAR and PolInSAR data.

## **2. INTRODUCTION**

SAR remote sensing allows all weather, global scale imaging and estimation of important bio and geophysical parameters about the Earth's surface. It is achieved by sensing scattered electromagnetic fields reflected from the Earth surface when emitted by an electromagnetic energy source situated on an aircraft, spacecraft or satellite outside of the Earth's atmosphere. The development of multi-parameter SAR techniques such as Polarimetric SAR (POLSAR) and Polarimetric Interferometric SAR (POLInSAR) is advancing rapidly, and these novel radar technologies are constantly extending decisively the range of applications of radar in remote sensing. Due to the polarimetric radar sensors (ENVISAT ASAR, ALOS-PALSAR, TerraSAR-X and RADARSAT-2), it is now shown that the accelerated advancement of POLSAR techniques is of direct relevance and of priority to local-to-global environmental ground-truth measurement and validation, stress assessment, and stress-change monitoring of the terrestrial and planetary covers. POLSAR and POLINSAR remote sensing techniques offer efficient and reliable means of collecting information required to extract biophysical and geophysical parameters about the Earth's surface and have found successful applications in crop monitoring and damage assessment, in forestry

clear cut mapping, deforestation and burn mapping, in land surface structure (geology) land cover (biomass) and land use, in hydrology (soil moisture, flood delineation), in sea ice monitoring, in oceans and coastal monitoring (oil spill detection) etc ....

### **3. CONTEXT AND PRINCIPAL OBJECTIVES**

Due to, both, the ESA's desire to augment his collection of software packages, known as the Envisat Toolboxes, and the feedback from the Workshop on "*Applications of SAR Polarimetry and Polarimetric Interferometry*", held at ESA-ESRIN, Frascati, Italy, on 14-16 January 2003, it was proposed to expand the existing PolSARpro software to handle data from current and future spaceborne missions (in addition to those airborne missions already supported), thus providing a comprehensive suite of functions for the scientific exploitation of fully and partially polarimetric data and the development of applications for such data.

PolSARpro v2.0 was developed under contracts to ESA "Development of a Polarimetric SAR Image Analysis Tool" (ESA-ESRIN Contract n° 17863/03/I-LG) and "Continued Development of PolSARpro Software", (C.C.N to ESA-ESRIN Contract n° 17863/03/I-LG) by a consortium comprising I.E.T.R at the University of Rennes 1, DLR-HR, AELc and Dr Mark L. Williams. Today a new version of the software (PolSARpro v4.1.5) is continued to be developed under contract to ESA "PolSARpro Toolbox Maintenance and Extension" (ESA-ESRIN Contract n° 22799/09/I-LG).

Figure n°1 proposes the PolSARpro v4.1.5 Main Entry Screen in its actual version (January 2009). The objective of the current project is to provide an Educational Software that offers a tool for self-education in the field of Polarimetric SAR data analysis at University level and a comprehensive suite of functions for the scientific exploitation of fully and partially polarimetric multi-data sets and the development of applications for such data. The PolSARpro v4.1.5 Software establishes a foundation for the exploitation of Polarimetric techniques for scientific developments and stimulates research and applications developments using PolSAR and PolInSAR data.

### **4. POLSARPRO V4.1.5 NEW FUNCTIONALITIES**

The PolSARpro v4.1.5 Software offers the possibility to handle and convert polarimetric data from a range of well established polarimetric airborne platforms and spaceborne missions. The PolSARpro v4.1.5 proposes different specific interfaces, with identical functionalities, dedicated to different Polarimetric Spaceborne Sensors (ALOS-PALSAR, ENVISAT-ASAR, RADARSAT2, TerraSAR X, SIRc) and Airborne Sensors (AIRSAR, TOPSAR, Convair, EMISAR, ESAR, PISAR, RAMSES) data processing selectable from the main menu.

The PolSARpro v4.1.5 Software proposes a great collection of well-established algorithms and tools designed for the analysis of only Single Data Set, Dual Data Sets (Interferometry) and Multi Time / Freq Data Sets Polarimetric SAR data with specialized functionalities for in-depth analysis of fully and partially polarimetric data

and the development of applications for such data. The PolSARpro v4.1.5 specific interface performs complete end-to-end processing without the need for other software and is selectable from the main menu.

The PolSARpro v4.1.5 software can process polarimetric or partially polarimetric data sets under many different formats. The different polarimetric data formats handled by PolSARpro v4.1.5 are the following: The (2x2) complex Sinclair [**S2**] matrix, the (3x3) and (4x4) complex Coherency [**T3**], [**T4**] or Covariance [**C3**], [**C4**] matrices and Partial Polarimetry representation.

## **5. EDUCATIONAL SOFTWARE**

Due to the polarimetric radar sensors (ENVISAT ASAR, ALOS-PALSAR and the future RADARSAT-2 and TerraSAR-X), it is now shown that the accelerated advancement of POLSAR techniques is of direct relevance and of priority to local-to-global environmental ground-truth measurement and validation, stress assessment, and stress-change monitoring of the terrestrial and planetary covers. Scientists and engineers already engaged in the fields of radar remote sensing generally gain their specialist knowledge in polarimetry by working through scientific papers and specialized literature available on the subject. The aim of this Tutorial is to provide a substantial and balanced introduction to the basic theory, scattering concepts, systems and advanced concepts and applications typical to Radar Polarimetry and Interferometry.

This Tutorial on Radar Polarimetry is completed with a review of some important aspects of radar polarimetry and interferometry to learn how to generate multiple polarization interferograms and how to use them with simple inversion models to estimate surface parameters, vegetation height and ground topography. This tutorial can be used as a low level teaching aid for polarimetric SAR processing and is illustrated with application examples showing the full range of functions that the Tool offers (*Do it yourself sections*). The PolSARpro v4.1.5 software is thus provided with a comprehensive in-depth documentation permitting self-education to a high level (radar experts and post graduate students). User has access to this wide-ranging tutorial, available in PDF format, providing grounding in SAR Polarimetry (PolSAR) and SAR Polarimetric Interferometry (POLinSAR) from the main menu. User have also access to different series of Tutorial Slide Shows, that are made available to support taught courses of for use as part of a self teaching programme.

The PolSARpro v4.1.5 Software is also accompanied by a detailed set of 228 Help Files, made available in PDF format, for each individual function. The User Manual provides comprehensive documentation of the software. As each new version of the PolSARpro v4.1.5 software becomes available, extra content are added. The PolSARpro v4.1.5 Software is also accompanied by a detailed set of 526 Technical Documentation Files, made available in PDF format, for each individual C Routine in order to provide to users information about how modules can be extracted from the Tool, modified and / or incorporated into their own systems.

## 6. OUTLOOK

Currently in its development stage, PolSARpro v4.1.5 Software (source code and elements software packages) is added gradually throughout 2010 and made publicly available for free download on the Internet from the ESA Web Portal (Earthnet) at: <http://earth.esa.int/polsarpro>

A global overview of all the main functionalities proposed in the PolSARpro v4.1.5 Software will be presented during the symposium, accompanied with demonstrations of the Tool. The presentation will be also focused on the new specific links and associations of PolSARpro v4.1.5 Software with NEST (New ESA Software Toolbox) and MapReady (ASF Toolbox) softwares. Time-series of ALOS-PALSAR will be analysed and demonstrated using PolSARpro v4.1.5 Software.



Figure n°1 : PolSARpro v4.1.5 Main Entry Screen