PWS: A Friendly and Effective Tool for Polarimetric Image Analysis

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ABSTRACT

The polarimetric workstation, PWS, is a user-friendly and efficient PC platform software package that has been developed at the Canada Centre for Remote Sensing (CCRS) for the optimum extraction of polarization information from RADARSAT-2 data. PWS is currently being used by a majority of the CCRS scientists in their investigation of polarimetric applications. In order to prepare federal and provincial governments, educational institutions, and industry for integration of this new source of information into their research and operational activities, PWS has been licensed for free to Canadian governmental institutions, universities, and colleges; and for a nominal price to Canadian industry. In this paper, PWS is presented and its main functions and products are described. Future upgrades of the PWS are also presented.

INTRODUCTION

To promote the unique polarimetric capabilities of RADARSAT-2, scientists at the Canada Centre for Remote Sensing (CCRS), Natural Resources Canada, have investigated various applications using fully polarimetric data. The results obtained depend significantly on the tools used for polarimetric information extraction. For the optimum extraction of polarization information from RADARSAT-2 data, CCRS has developed a software system, the polarimetric workstation (PWS), which is currently being used by most of the CCRS scientists in their investigation of polarimetric applications [Van der Sanden et al. 2002, McNairn et al. 2002, McNairn et al. 2003, Gauthier et al. 2001, Sokol et al. 2002, Sokol et al. 2001, Hugenholtz and Van der Sanden 2001, Touzi et al. 2004b, Touzi et al. 2004c]. The PWS is based on leading edge technology that will provide Canadian industry, through technology transfer, a competitive advantage in exploiting the information potential of RADARSAT-2.

In order to prepare federal and provincial governments, educational institutions, and industry for integration of this new source of information into their research and operational activities, PWS has been licensed for free to Canadian governmental institutions, universities, and colleges; and for a nominal price to Canadian industry [Table 1].

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Table 1 PWS Licensees to date

Canadian governmental institutions	Universities and Colleges	Canadian industry
Agriculture Canada	C-CORE (Memorial University of Newfoundland)	AUG signal Inc.
Canadian Ice Service Environment Canada	CRIM (University of Montreal)	Geomat International Inc.
Canadian Space Agency	INRS-ETE (Québec)	Noetix Research Inc.
DRDC of National Defence	Nova Scotia Community College	RADARSAT International Ltd.
Emergencies Science and Technology Division Environment Canada	Royal Military College (Kingston)	Vantage Point International Inc.
Geological Survey of Canada and Canadian Forest Service Natural Resources of Canada	University of Montreal	
Statistics Canada	University of British Columbia	
	University of Manitoba	
	York University	

In the following, the PWS is presented and its main functions are described in the following Section I. Future upgrades of the PWS are also presented. Examples of products generated by the PWS are included in Section II.

I. PWS PRESENTATION AND FUNCTIONS DESCRIPTION

A. PWS Presentation:

PWS is a user-friendly and efficient PC (environment Microsoft Windows 2000/NT® or later) platform software package. PWS includes a set of polarimetric tools that were selected from the wide set of tools published in the open literature. Many polarimetric parameters have been developed for target characterization since 1950 (Please see the review paper of polarimetry in this issue [Touzi et al. 2004a]). The appearance of the first imaging radar polarimeter, the NASA-JPL AirSAR [Van Zyl et al. 1987], gave an impulse in the 1990s to further tool development, which were validated using polarimetric data collected by airborne SARs (AirSAR, Convair-580 SAR [Livingstone et al. 1995], and SIR-C [Jordan et al. 1995]). Since 1996, Cloude's target decomposition [Cloude 1986, Cloude and Pottier 1996] has been widely recognized and the Cloude's parameters $H|\alpha|\beta$ and Anisotropy [Cloude 1986] are currently being used as standard tools for target characterization. Unfortunately, many effective tools of high potential that were introduced in the 1990s, such as the parameters of scattered and received waves [Evans et al. 1988, Kostinski and Boerner 1988, Touzi et al. 1992a, Van Zyl et al. 1987], were abandoned. In order to fully exploit the capabilities of polarimetric SAR, PWS includes the most well known polarimetric tools developed in the 1990s, as well as the most recent tools such as Cloude's parameters. Only the tools that were thoroughly analyzed and validated are included. PWS has been conceived as a user-friendly tool, which can be easily upgraded in order to maintain polarimetric information extraction at the leading edge of the endeavor.

B. Historical:

The first version of PWS, referred to as PolTool, was developed by R. Touzi in 1988-1990, while he was research scientist at the Centre d'Etude Spatiale des Rayonnements (CESR, Toulouse, France). Most of the tools that were implemented in PolTool, were described in [Touzi et al. 1992a]. PolTool was used at CCRS to validate the results of the X-band Convair-580 SAR calibration [Touzi et al. 1993]. In 1994, it was renamed as Polsig and was used at CCRS in various applications [Livingstone et al. 1996, Brisco et al. 1996, Sokol et al. 1998]. In 1999, Polsig is integrated in a Graphical User Interface (Gui) Matlab environment, and new functions were added such as, the Poincaré sphere representation, and Cloude's parameters. This leads to the so-called PWS, which has since been used for promoting the polarimetric capabilities of RADARSAT 2 at CCRS, and by other Canadian Institutions and companies that have licensed the software [Bugden et al. 2003a, Bugden et al. 2003b, Geldsetzer and Yackel 2003], as well as for educational purposes [Touzi and Charbonneau 2001a, Brisco and Decker 2003, Charbonneau and Touzi 2003, Gauthier 2003].

C. Main functions:

PWS is a PC platform software that permits the analysis of polarimetric data collected with various polarimeters, such as the Convair-580 SAR (Single Look Complex and geocoded formats), as well as the NASA-Jet Propulsion Laboratory Airborne Synthetic Aperture Radar (AIRSAR, [Van Zyl et la. 1987]) and the Spaceborne Imaging Radar SIR-C [Jordan et al. 1995]. PWS permits the synthesis of the radar backscattering coefficient $\sigma°$ image at any combination of transmitting-receiving antenna polarizations. In addition, PWS generates for a selected target, key parameters and products which characterize the type and complexity of target scattering and thus allows the user to learn more about the physical properties of the target being studied. PWS permits to generate[1]:

1. The co- and cross-polarized signatures
2. Poincaré sphere representation of the scattered wave
3. Histogram of the 4 polarization amplitude
4. Extrema of the received power and Van Zyl coefficient of variation [Van Zyl 1987]
5. Channel coherence amplitude γ and phase ϕ for HH-VV, HH-HV, and VV-HV
6. Kostinski and Boerner's scattered wave parameters [Kostinski and Boerner 1988]; extrema of the completely polarized and unpolarized wave intensity, and the corresponding optimum transmitting-antenna polarizations.
7. Touzi's discriminators [Touzi et al. 1992a]; extrema of the scattered wave intensity R_o^{max} and R_o^{min}, and extrema of the degree of polarization p_{max} and p_{min}.
8. Cloude 's parameters [Cloude 86, Cloude and Pottier 97]; $H|\alpha|\beta$ and the anisotropy A

[1] All the tools implemented at the PWS are defined in the Touzi et al.'s review paper [Touzi et al. 2004a]

9. Optimization contrast parameters; PWS generates the image at the antenna polarization combination which optimizes the contrast between two selected targets, using the Swartz method [Swartz et al., 1988].
10. Point target analysis; This tool analyses and computes reference point target signals for data calibration [Touzi et al. 1993]. Peak signal intensity location is given for the 4 channels to assess channel registration. Channels are over sampled (by 8) using the zero-padding method, to give the exact position of the peak signal intensity. The phase and intensity of the peak, as well as the peak intensity-to-clutter ratio are computed. The complex integration method [Touzi, 1992b] is implemented in order to provide an accurate estimate of target phase and magnitude at the presence of system mis-focussing.

D. Additional functions:

The following algorithms are currently being implemented:

1. Touzi and Lopes's polarimetric speckle filter [Touzi and Lopes 1994] and Lee's filter [Lee et al. 1999].
2. The SSCM [Touzi and Charbonneau 2002], which was introduced for optimum characterization of symmetric scattering, and has been shown very promising for ship identification [Touzi et al. 2004b, in press].
3. A new classification method that preserves the texture information. In contrast to all the existing tools that are based on the Wishart distribution, which is not suitable for texture areas [Beaulieu and Touzi 2003, Touzi et al. 2004a], the new classification method currently being developed integrates the vectoriel K-distribution for textured areas

II. EXAMPLES

Figures 1, 2, and 3 are examples of products generated by the PWS for a white spruce field illuminated by the Convair-580 SAR in July 1998. Figure 1 represents $\sigma°$ variations with transmitting antenna polarization when the transmitting and receiving antenna have the same polarization. Analysis of the two-dimensional representation, currently referenced to as the co-polarized polarimetric signature, reveals a maximum radar return at the horizontal polarization. The large pedestal value of the polarimetric signature (about 0.5) is an indicator of target multiple scattering complexity. Figure 2 is an original representation of the Poincaré sphere, which is currently used to map wave polarization states. Analysis of Figure 2, obtained for an horizontally transmitting polarization, reveals a large concentration of scattered waves in the Poincaré sphere equator that corresponds to linearly polarized waves with a dominating return at the horizontal polarization. The sphere transversal section permits a better allocation of the polarization states of the partially polarized waves inside the Poincaré sphere; the big concentration of scattering at about 0.6 from the sphere origin indicates a significant unpolarized component in the target backscattering. Figure 3 represents Cloude's $H|\alpha$ for the white spruce field; the target shows a dominant dipole scattering (α about 0.5) very heterogeneous with an entropy H of about 0.8.

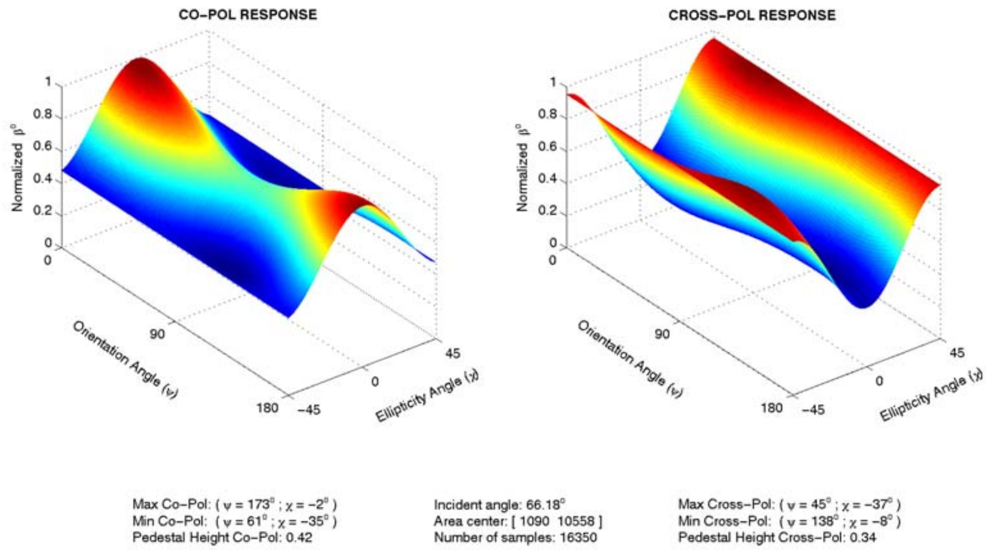

Figure 1: Polarimetric signature of the white spruce field

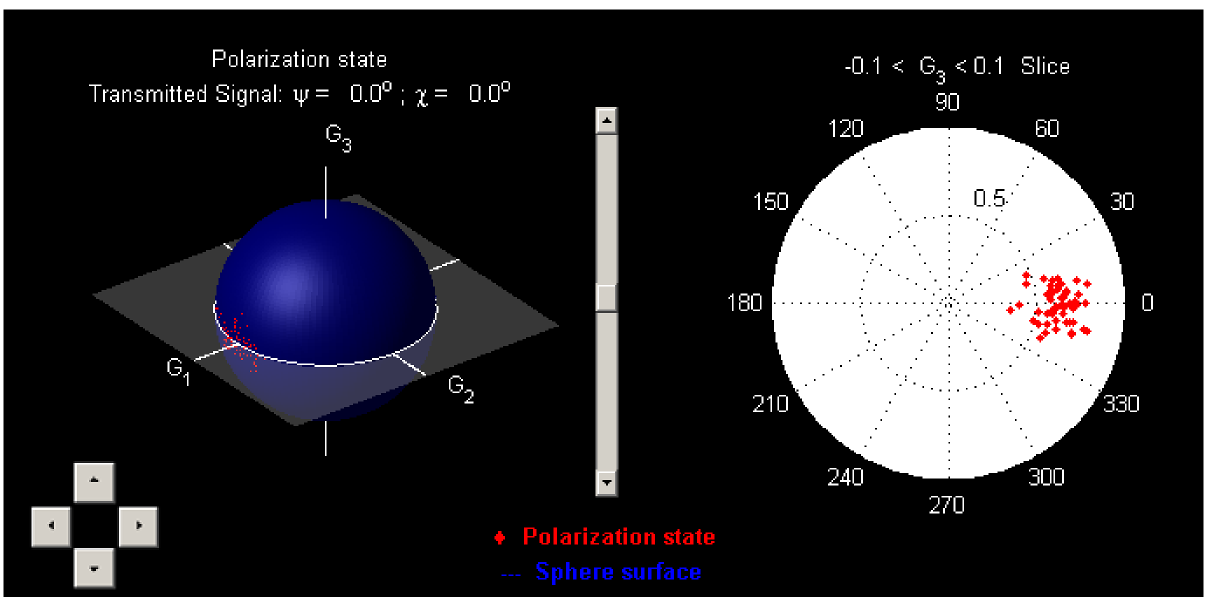

Figure 2: Poincaré sphere representation of the scattered wave polarization for an horizontally polarized transmitted wave (ψ=0°, χ=0°)

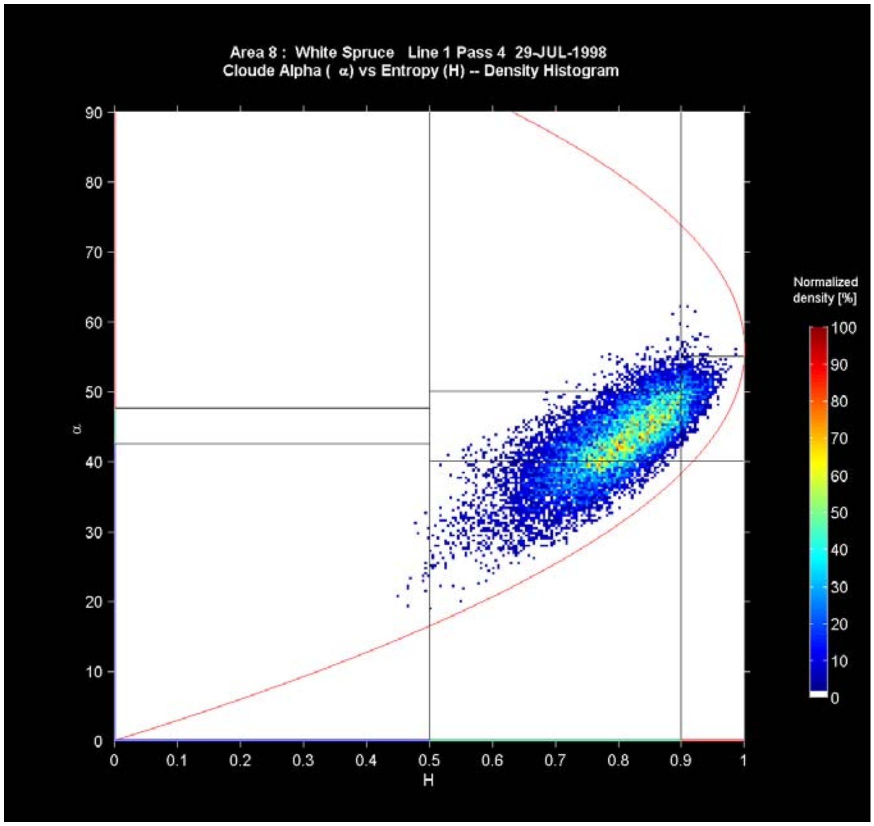

Figure 3: Cloude's H| α for the white spruce field

CONCLUSION

PWS is efficient PC-platform software that was developed in order to prepare federal and provincial governments, educational institutions, and industry for integration of RADARSAT-2's unique polarimetric capability into their research and operational activities. PWS includes a set of polarimetric tools, which were selected from the wide set of tools published in the open literature. Only the tools that were thoroughly analyzed and validated are included. With all the upcoming satellite polarimetric SARs, such as RADARSAT 2, ALOS-PALSAR [Shimada et al. 2001], and TerraSAR [Mathew 2001], polarimetric SAR data will be easily accessible, and more effective new polarimetric tools will be developed by a wider community of earth scientists all over the world. In order to maintain polarimetric information extraction at the leading edge of the endeavor, PWS has been conceived as a user-friendly tool, which can be easily, and will be continuously, upgraded.

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