SPACEBORNE FULLY POLARIMETRIC TIME-SERIES DATASETS FOR LAND COVER ANALYSIS

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1. INTRODUCTION

Remotely sensed data are currently used to identify, delineate and characterize wetlands. Optical data provide interesting information on land-use and land cover but are limited to cloud-free periods and to a description of the top layer of the vegetation strata because penetration depth is very small. For these reasons it is not possible to precisely inventory wetland vegetation and agricultural practices, as well as water cycles and water levels in these areas with optical data. For this purpose, spaceborne fully polarimetric and time-series datasets show great potential for mapping wetlands with a sufficient level of precision. The two main objectives of this paper are:

- Evaluating fully polarimetric time-series datasets to (1) delineate precisely effective and potential wetlands, (2) map detailed vegetation distribution and identify agricultural practices, and (3) determine water cycle and waterlevels;

- Using both very high resolution optical data and radar data -LIDAR data and quad-pol SAR data to evaluate the contribution of the latter for wetlands delineation and characterization.

2. OBJECTIVES

Land use changes, especially in agricultural landscapes, are the major cause of biodiversity loss, which can be aggravated by climate change. Wetlands are vital to the water cycle and havens for wildlife, but are under threat for several decades. Therefore, inventory and characterization of wetlands are an important stake from an environmental but also socio-economical point of view. In these last years, intensive research efforts have focused on the identification and broad delineation of wetlands. Few attention has been devoted to the evaluation of wetlands functionalities (hydrologic, biochemical and ecological functions), whereas they play a major role from environmental and socio-economical points of view. Remotely sensed data are currently used to identify, delineate and characterize wetlands. Optical data provide interesting information on land-use and land cover but are limited to cloud-free periods and to a description of the top layer of the vegetation strata because penetration depth is very small. For these reasons it is not possible to precisely inventory wetland vegetation and agricultural practices, as well as water cycles and water levels in these areas with optical data. The research project, presented in this paper, contributes to the Application Development And Demonstration for the exploitation of fully polarimetric time-series datasets for an environmental application: the functional assessment of wetlands, and covers the following fields and thematic areas: Land Environment (Cartography / Mapping) and Hydrology (Wetlands).

The investigated area is the site of Pleine-Fougères referenced in the LTER-Europe (http://lter-europe.net) and the ILTER (http://www.ilternet.edu) networks. Numerous research programs are being conducted on this study site (http://www.caren.univ-rennes1.fr/pleine-fougeres/). This project is funded by the French national program "Zone atelier" (http://www.caren.univ-rennes1.fr/pleine-fougeres/index.php?page=projet-za)

A large set of remote sensing data is already available on the study site: SPOT images, Landsat images, Aster images, Quickbird image, Kompsat image, numerous aerial photos and LIDAR data. Field campaigns are regularly conducted to augment routine data acquisitions on land cover-land use, vegetation and waterlevels, and to test and to validate new remote sensing instruments and image processing methods.

3. METHODOLOGICAL ISSUES

Information on the land cover is of paramount importance for monitoring and management of the environment on a local, regional and global scale. In natural areas, land cover presents complicated structures and highly complex scattering responses, due to various scattering contributions, dielectric and shape properties and volumetric structures. The complementarities of polarimetric, high-resolution observations and time-series datasets will be necessary to provide enough information for general land classification, characterization and mapping. The proposed research activities that are presented in this paper will aim at developing and validating a general supervised and/or unsupervised PolSAR segmentation methodology, including multi-temporal analysis of land cover evolution, and investigating polarimetric decomposition methods for physical parameter inversion algorithms [1][2].

Figure 1 shows the ALOS / PALSAR footprint over the investigated area located in Pleine Fougères (Britanny – France) and acquired on 18/04/2007. Figure 2 shows the corresponding polarimetric Pauli color-coded image (red = HH-VV, green = HV+VH, blue=HH+VV). Figures 3, 4 and 5 show the different parameters resulting of the Entropy / Alpha / Anisotropy polarimetric decomposition theorem [1] and figure 6 shows the result of the unsupervised Wishart - Entropy / Alpha / Anisotropy segmentation [1].

The potential impact of multi-frequency (ALOS L-Band, RADARSAT-2 C-Band) PolSAR data for land cover segmentation techniques will be assessed, in addition to the investigation of the applicability of the time series PolSAR data processing technique for land cover deformation monitoring, for the determination of the water cycle maps and water extent statistics and the determination of high (i.e. flooded), low (i.e. drought) and mean waterlevels.

4. THEMATIC ISSUES

Studies have shown that the length of the contact between wetlands and the dry land play an important role in the denitrification process, and that the area between effective and potential wetlands can be considered as negotiation areas for restoration purposes. For these reasons, a precise determination of the limits of effective and potential wetlands appears as an important stake from an environmental point of view. The combination of radar and optical data is needed to provide a better assessment of wetlands functionalities, almost for hydrologic processes, but also for ecological and biogeochemical processes. The use of fully polarimetric time-series datasets (ALOS/PALSAR and RADARSAT-2) and the development of novel remote sensing techniques fusioning radar and optical data is an important aspect for future research activities. This permits to improve our knowledge on wetlands functional processes. The information derived from remotely sensed data will thus be integrated in hydrological and ecological models to predict water fluxes and biodiversity levels. Furthermore, the common work between remote sensing and practices analysis in wetlands opens the possibility to detect evidences for changes in agricultural practices in these areas.

5. REFERENCES

[1] J.S. Lee and E. Pottier, *Polarimetric Radar Imaging: From basics to applications*, CRC Press, Taylor & Francis editor, 397 pages, janvier 2009, ISBN: 978-1-4200-5497-2

[2] F. Cao, W. Hong, Y.R. Wu, E. Pottier, *An Unsupervised Segmentation With an Adaptive Number of Clusters Using the SPAN / H / alpha / A Space and the Complex Wishart Clustering for Fully Polarimetric SAR Data Analysis.* IEEE Transactions on Geoscience and Remote Sensing, Vol 45, n° 11, pp 3454 – 3467, November 2007.

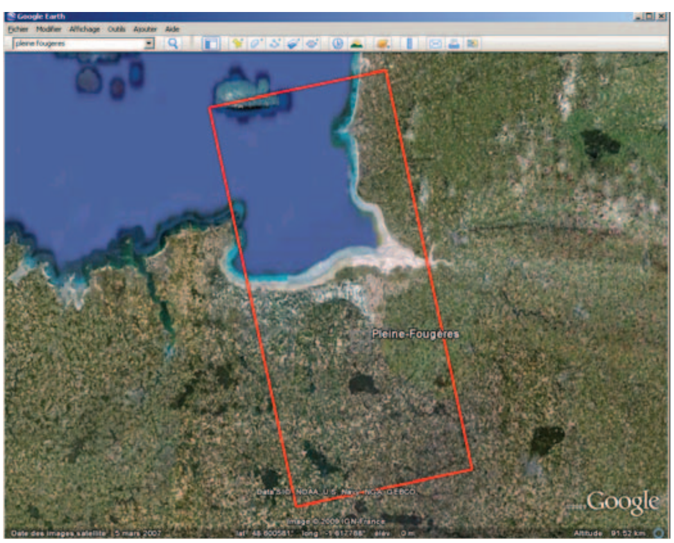

Fig. 1: ALOS / PALSAR footprint over the investigated area located in Pleine Fougères (Britanny – France) – 18/04/2007

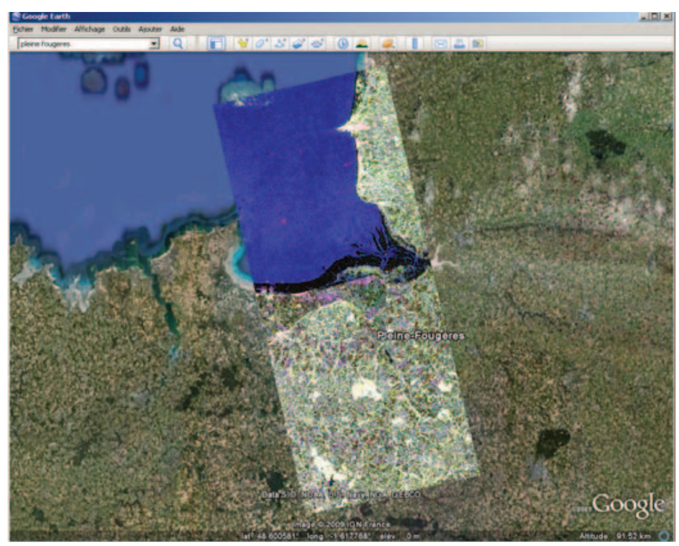

Fig. 2: Polarimetric Pauli color-coded image of the investigated area.

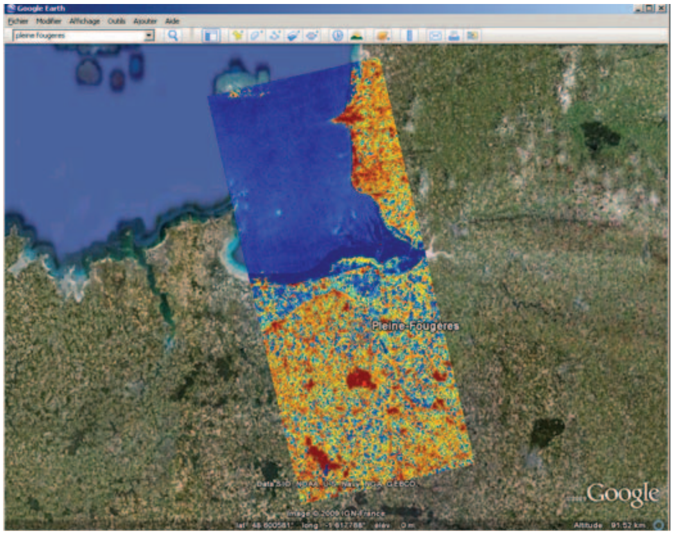

Fig. 3: Entropy parameter color-coded image of the investigated area.

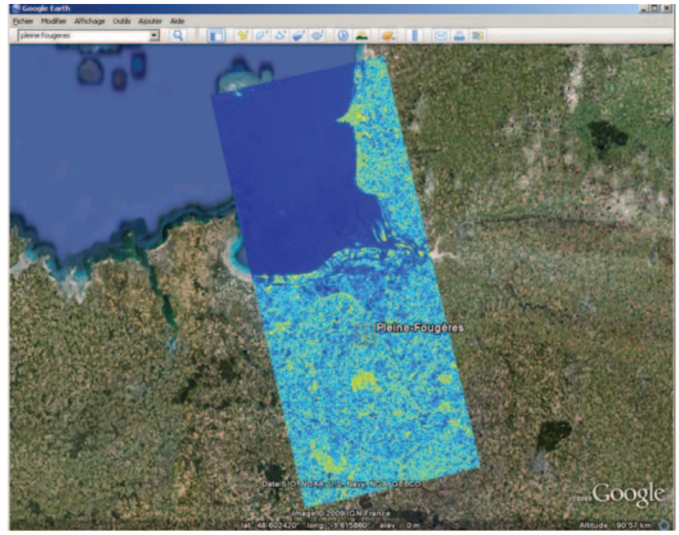

Fig. 4: Alpha parameter color-coded image of the investigated area.

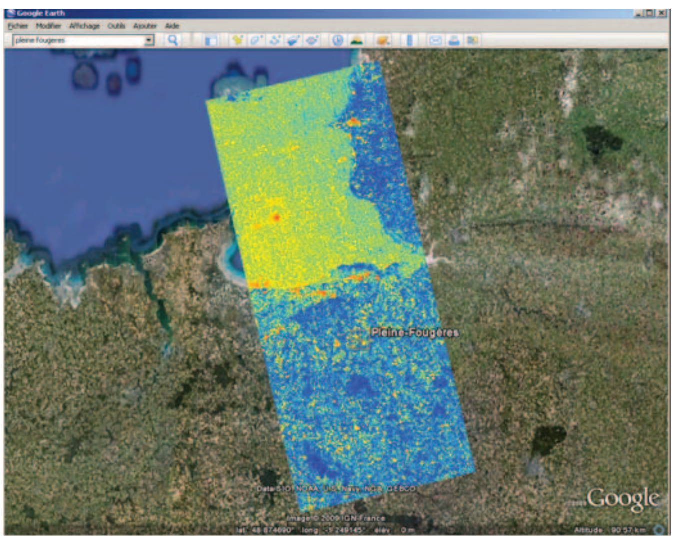

Fig. 5: Anisotropy parameter color-coded image of the investigated area.

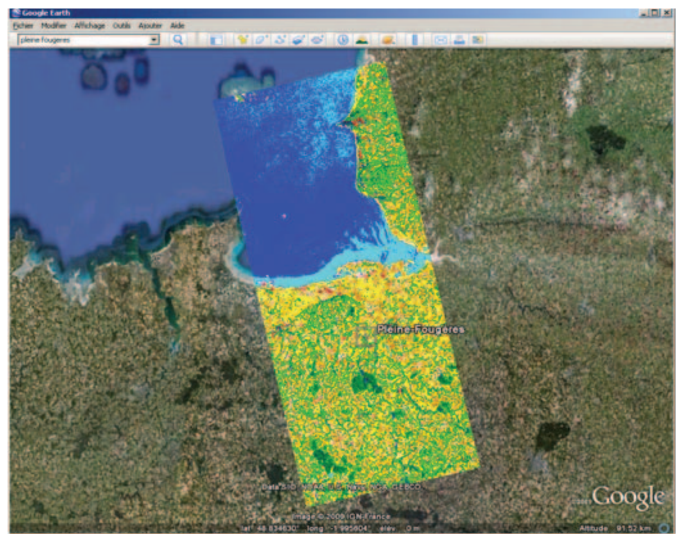

Fig. 6: Unsupervised Wishart – Entropy / Alpha / Anisotropy segmentation of the investigated area.