DETERMINATION OF SCATTERING MECHANISMS INSIDE RICE PLANTS BY MEANS OF PCT AND HIGH RESOLUTION RADAR IMAGING

J. David Ballester-Berman, Juan M. Lopez-Sanchez, Maria-Jose Sanjuan

Signals, Systems and Telecommunication (SST) Group
DFISTS, University of Alacant, P.O. Box 99, E-03080 Alacant/Alicante, Spain
Phone / Fax: +34965903400 2442 / +34965909750,
E-mail: davidb@ua.es, juanma.lopez@ua.es, Maria.SanjuanFerrer@dlr.de

1. INTRODUCTION

Studies on monitorization of rice fields have been object of an intense research due to the socio-economic implications that cultivation of this crop have world-wide. Investigations have focused on the observation and analysis of time series of polarimetric SAR images at C-band [1, 2] and the retrieval of empirical relationships between backscattering coefficients and polarimetric ratios with phenology and biophysical parameters (i.e. biomass, LAI, ...) of rice from L- to Ka-band [3]. In this sense, the use of X-band seems to be a promising choice for rice fields since it offers a good balance between volume penetration and plant particles sensitivity issues. However, in the context of parameter estimation by means of polarimetric SAR techniques, an accurate electromagnetic modeling of scattering processes inside the crop field is required since identification of dominant scattering mechanisms provides valuable information for quantifying the sensitivity of SAR images to target parameters. The complexity of these models is variable, and they must adapted in accordance to the different phenological stages of the crop and the sensor configuration as well.

In the framework of exploitation of dual-pol SAR data acquired by the recently launched TerraSAR-X mission, first results on the analysis of the potential of X-band radar imagery for rice monitorization were presented in [4]. In that work, an electromagnetic model for the initial phenological stages, that is, for the first part of the vegetative phase was implemented. In this case the model considers the scene as a set of lossy dielectric cylinders uniformly distributed over a flooded soil surface [5]. It was shown that the HH/VV power ratio computed with this model clearly fits the evolution within early growth stages of rice fields, as a consequence of the important double-bounce interaction between the stems and the flooded ground, which is specific of this crop type, and the effect of differential extinction between polarizations. Modeling later phenologial stages would involve the modification of the geometry of plants and the addition of leaves as well as the incorporation of multiple scattering effects, which also are important at C-band [6].

In this context, the analysis of high resolution radar imagery can provide valuable information about the presence and location of dominant scattering mechanisms, which could facilitate the development of more accurate electromagnetic models. One approach to perform this task is the Polarization Coherence Tomography (PCT) approach [7], which was applied on indoor data acquired on a rice sample with several sensor configurations [8]. It was shown that the single-baseline PCT was unable to retrieve the expected vertical profile of rice plant and a dual-baseline approach was required. However, the estimated profiles did not exhibit any polarization dependence due to the low canopy density and the coherence definition itself, which is a normalized magnitude and, hence, it does not depend on the backscattered power. Therefore, the confirmation of the actual scattering mechanisms taking place inside the rice plant is still pending.

The present work deals with the analysis of laboratory high-resolution polarimetric SAR images from a rice plant. The aim is twofold: 1) to compare the information provided by high-resolution imaging with the dual-baseline PCT concerning the location of dominant scattering mechanisms on a rice sample, and 2) to use this information for driving the next steps in the rice model development suited for later phenological stages.

2. METHODOLOGY

Wide-band fully polarimetric SAR data from a mature rice sample have been collected at the EMSL, JRC-Ispra (Italy), which have been used to compute 3-D high-resolution SAR images in order to identify the dominant scatterers and their location inside the vegetation sample. The rice stand is made up by 9×9 plants of about 0.6 m high uniformly distributed in a square container of 1 m side length. The soil is flooded to replicate the natural conditions of such a crop. Measurements were acquired from 1 GHz to 9.5 GHz with 5 cm ground-range resolution and 5 cm and 12 cm for vertical and horizontal cross-range resolutions, respectively.

Imaging results computed by means of a focusing algorithm are compared to the vertical density profiles produced by the PCT approach and conclusions concerning the electromagnetic modeling of advanced growing stages of rice are drawn.

3. REFERENCES

[1] T. Kurosu, M. Fujita, K. Chiba, "Monitoring of Rice Crop Growth From Space Using the ERS-1 C-Band SAR," *IEEE Trans. Geosci. Remote Sensing*, Vol. 33, No. 4, pp. 1092–1096, Jul. 1995.

[2] T. Le Toan, F. Ribbes, L.-F. Wang, N. Floury, K.-H. Ding, J. A. Kong, M. Fujita, T. Kurosu, "Rice Crop Mapping and Monitoring Using ERS-1 Data Based on Experiment and Modeling Results," *IEEE Trans. Geosci. Remote Sensing*, Vol. 35, No. 1, pp. 41–56, Jan. 1997.

[3] Y. Inoue and others, "Season-long daily measurements of multifrequency (Ka, Ku, X, C, and L) and full-polarization backscatter signatures over paddy rice field and their relationship with biological variables," *Remote Sensing of Environment*, Vol. 81, pp. 194–204, 2002.

[4] J. M. Lopez-Sanchez, J. D. Ballester-Berman, I. Hajnsek, "Rice Monitoring in Spain by means of Time Series of TerraSAR-X Dual-Pol Images," *3rd TerraSAR-X Science Team Meeting*, DLR Oberpfaffenhofen, 25-26 November 2008.

[5] L. Tsang, K. Ding, G. Zhang, J. A. Kong, "Backscattering Enhancement and Clustering Effects of Randomly Distributed Dielectric Cilinders Overlying a Dielectric Half Space Based on Monte-Carlo Simulations," *IEEE Trans. Antennas Propagat.*, Vol. 43, No. 5, pp. 488–499, May 1995.

[6] T. Chiu, K. Sarabandi, "Electromagnetic scattering from short branching vegetation," *IEEE Trans. Geosci. Remote Sensing*, Vol. 38, No. 2, pp. 911–925, Mar. 2000.

[7] S. R. Cloude, "Polarization Coherence Tomography," *Radio Science*, Vol. 41, April 2006.

[8] M. J. Sanjuan, J. M. Lopez-Sanchez, J. D. Ballester-Berman, "Microwave Scattering Profiles Of A Rice Sample By Means Of Polarization Coherence Tomography," *Proc. of IEEE Intl. Geosci. Remote Sensing Symp. (IGARSS)*, Boston, USA, July 2008.