ANALYSIS AND OBSERVATION OF POLARIMETRIC SCATTERING BEHAVIOR IN WETLAND AREA

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1. INTRODUCTION

According to recent progress of global warming, monitoring and observation of natural resources have been regarded as more and more important tasks. As the ALOS/PALSAR system, space-borne Polarimetric Synthetic Aperture Radar (POLSAR) sensing using fully or quad polarimetric scattering information is one of the most useful techniques for the periodic or continuous environmental monitoring. It also makes the required wide area natural resources monitoring possible under severe conditions where one cannot carry out on-site inspection for understanding the circumstances. So far, by using the POLSAR image analysis, we investigated water area change of a wetland, 'SAKATA (Niigata City, Japan)'[1]. The investigation was carried out based on the image analysis using the scattering power decomposition scheme [2, 3]. It was found from the result of the image analysis that the double-bounce scattering generated from the boundaries between the water area of the wetland and the surrounding emerged-plants is considered as a useful marker for estimating the actual wetland water area [1].

In this paper, to verify the generating mechanism of the peculiar double-bounce scattering P_d, we shall carry out detailed polarimetric scattering analysis for a simple boundary model by using the Finite-Difference Time-Domain (FDTD) method [4]. The considered model consists of lots of vertical thin dielectric pillars on a perfectly electric conductor (PEC) plate, and simulates the local boundary between emerged-plants and water areas of the wetland when water level is relatively high. Here, we make an intensive investigation on the specific feature of P_d for the variations of the material parameters and the biomass change of the emerged-plants. In the presentation, we will also consider the emerged-plants' height dependency with respect to the incident angle change [5],[6].

2. SCATTERED POWER DECOMPOSITION

Let us briefly show the scattering power decomposition procedure for the coherency matrix $\langle[T]\rangle$ derived by the scattering vectors $\boldsymbol{k}_P = 1/\sqrt{2}\,[S_{HH} + S_{VV} \;\; S_{HH} - S_{VV} \;\; 2\,S_{HV}]^T$. By using a four-component scattering model [3], $\langle[T]\rangle$ can be expanded into double-bounce scattering, surface scattering, volume scattering and helix scattering as

$$\langle[T]\rangle = f_d[T]_{double} + f_s[T]_{surface} + f_v\langle[T]\rangle_{vol} + f_c\langle[T]\rangle_{helix}. \tag{1}$$

According to the decomposition algorithm in Ref.[3], the total scattered power can be successfully decomposed into each scattering component, P_d, P_s, P_v and P_c. In wetland area monitoring, the double-bounce scattering P_d may be generated from right angle dihedral structures composed of vertical stems of emerged-plants and water surface when the water level becomes relatively high. Hence, it can be utilized as a useful marker for distinguishing the true water area of the wetland .

3. FDTD POLARIMETRIC SCATTERING ANALYSIS

As depicted in Fig.1(a), we shall consider polarimetric scattering problem when H and V linear polarized plane waves impinge on a simplified boundary model, which simulates local boundary region around the wetland and consists of lots of vertical

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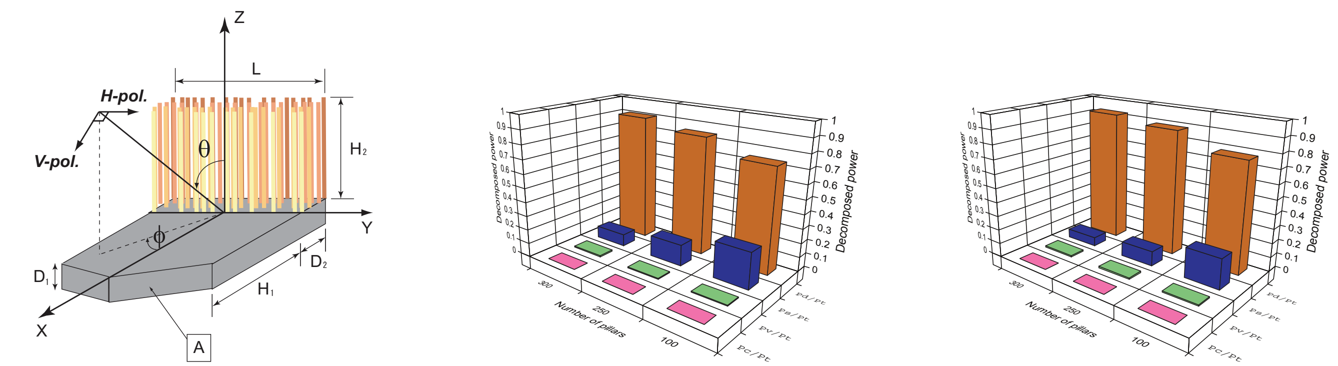

(a) Simplified local boundary model. (b) $\varepsilon_r = 2.0 - j0.05$ (c) $\varepsilon_r = 2.5 - j0.30$

Fig. 1. Geometry of the problem and the FDTD statistical evaluation results for the variation of the biomass. (a) Simplified local boundary model (b) FDTD result for dry case (c) FDTD result for slightly wet case

thin dielectric pillars on a perfect electric conductor (PEC) plate. Here, we utilize the Finite-Difference Time-Domain (FDTD) method to obtain the elements of the scattering vector $\boldsymbol{k}_P$ for the considered model. In the FDTD analysis, the cubic cell size Δ is 0.01 m, and the analytical region is 350 × 350 × 350 cells. Each dimension size of the model is $L = 10.17\lambda$ (2.40 m), $H_1 = H_2 = 5.93\lambda$ (1.40 m), $D_1 = 2.54\lambda$ (0.60 m) and $D_2 = 3.60\lambda$ (0.85 m) at L-band frequency (1.27 GHz). Additionally, a trigonal part 'A' is attached to reduce the unnecessary back scattering from the horizontal edge of the front side. Thin square dielectric pillars are randomly located on a part of the base plate ($D_2 \times L$ area). The cross section of each pillar is 0.01m × 0.01m. The incident and squint angles are fixed as $\theta = \theta_i = 45^o$ and $\phi = \phi_i = 0^o$.

We shall show the results of the three different density models (300, 250, and 100 pillars are located on the base plate in each model), to examine the dependency of the polarimetric scattering feature on the biomass or the volume density of the emerged-plants. Here the relative permittivity the dielectric pillars is set as $\varepsilon_r = 2.0 - j0.05$ for dry case, and $\varepsilon_r = 2.5 - j0.30$ for slightly wet case. It is observed from the results for both dry (Fig.1 (b)) and wet (Fig.1 (c)) pillars cases that the double-bounce scattering contribution P_d becomes predominant, regardless of the change of the volume density. The specific polarimetric feature, large P_d, is still observed even for the sparse volume density case (100 pillars case), although P_s gradually increases with decrease of the volume density.

Taking into account the above results, we conclude that the double-bounce scattering from the water-emergent boundary is still considered as a useful marker for distinguishing true water area of the wetland surrounded by not only dense and wet emerged-plants but also sparse and dry ones.

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