POLARIMETRIC SCATTERING FEATURE ESTIMATION FOR ACCURATE VEGETATION AREA CLASSIFICATION

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1. INTRODUCTION

In the field of land cover monitoring based on POLSAR image analysis, scattering power decomposition [1, 2], which makes full use of quad. polarimetric SAR data, is one of the most powerful tools for observing natural resources. According to the scattering power decomposition scheme, the total received power can be decomposed into the fundamental scattering models as double-bounce scattering, surface scattering, volume scattering, and helix scattering. So, by appropriately evaluating each decomposed scattering component, one can carry out accurate land cover classification. As a practical application of the decomposition method, we previously succeeded to examine seasonal water area change of wetlands [3]. In the L-band POLSAR image, specific pixels with strong volume scattering feature generally correspond to vegetation area as forest, grove, reed bed, and so on. However, such strong volume scattering is also observed in urban area where the radar illumination direction is not normal to the alignment of the man-made buildings. Hence, it may cause classification errors in the case that the target area includes both vegetation and urban areas.

In this paper, to try to reduce the classification errors due to the unexpected volume scattering from the oblique man-made targets (we here call it "urban volume scattering"), we shall propose a compensate polarimetric marker. The compensate marker proposed here is simply derived by the elements of 3×3 average coherency matrix. Taking into account polarimetric feature of the additional marker, it is found from the result of the image analysis that the classification accuracy for vegetation area can be improved. Furthermore, detailed classification algorithm, analyses, and considerations will be carried out in the presentation.

2. COHERENCY MATRIX AND A COMPENSATE POLARIMETRIC MARKER

We shall briefly show the scattering power decomposition procedure for the average coherency matrix $\langle [T] \rangle$ acquired by quad. POLSAR system. $\langle [T] \rangle$ is derived by the scattering vectors $\boldsymbol{k}_P = 1/\sqrt{2}\,[a+b \;\; a-b \;\; 2c]^T$, where $a = S_{HH}$, $b = S_{VV}$, $c = S_{HV}$, and T denotes transposition, . By using a four-component scattering model [2], $\langle [T] \rangle$ can be expanded into double-bounce scattering, surface scattering, volume scattering, and helix scattering as

$$\begin{aligned}\langle [T] \rangle &= \begin{bmatrix} \frac{1}{2}\langle |a+b|^2 \rangle & \frac{1}{2}\langle (a+b)(a-b)^* \rangle & \frac{1}{2}\langle (a+b)c^* \rangle \\ \frac{1}{2}\langle (a-b)(a+b)^* \rangle & \frac{1}{2}\langle |a-b|^2 \rangle & \frac{1}{2}\langle (a-b)c^* \rangle \\ \frac{1}{2}\langle c(a+b)^* \rangle & \frac{1}{2}\langle c(a-b)^* \rangle & \frac{1}{2}\langle 2|c|^2 \rangle \end{bmatrix} \\ &= f_d \begin{bmatrix} |\alpha|^2 & \alpha & 0 \\ \alpha^* & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} + f_s \begin{bmatrix} 1 & \beta^* & 0 \\ \beta & |\beta|^2 & 0 \\ 0 & 0 & 0 \end{bmatrix} + \frac{f_v}{4} \begin{bmatrix} 2 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} + \frac{f_c}{2} \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & \pm j \\ 0 & \mp j & 1 \end{bmatrix}. \end{aligned} \tag{1}$$

According to the decomposition algorithm in Ref.[2], the total scattered power can be successfully decomposed into each scattering component, P_d, P_s, P_v and P_c.

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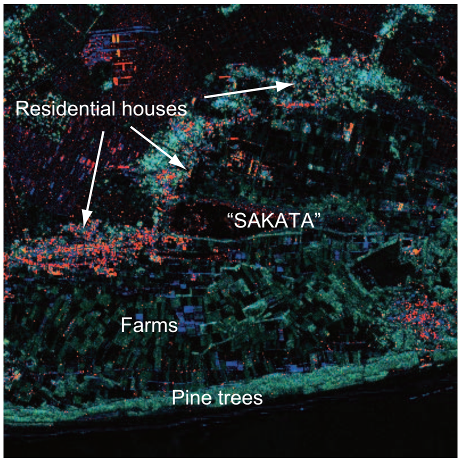
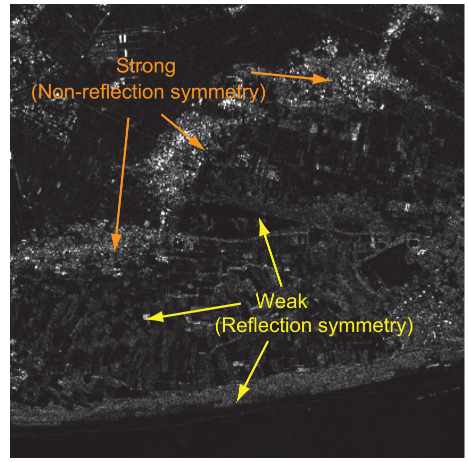


(a) Color composite image of P_d, P_v, P_s



(b) The image of the (1,3) element in $\langle [T] \rangle$

Fig. 1. Result of POLSAR image analysis (Aug.4, 2004).

It is found from Eq.(1) that the (1,3) and (3,1) elements of $\langle [T] \rangle$, $1/2\langle (a+b)c^* \rangle$ and $1/2\langle c(a+b)^* \rangle$, are not utilized in determining the unknown expansion coefficients in the decomposed procedure. However, they may become useful markers for judging whether or not the considered target area is under reflection symmetry or not. So we here suppose the following scenario. 1) When the (1,3) and (3,1) elements tend to be zero or very small values, the target area is considered as reflection symmetry. 2) Whereas, for large values of the (1,3) and (3,1) elements, the area is considered as non-reflection symmetry. This assumption makes good a deficiency of the scattering power decomposition and improve its classification accuracy for vegetation area.

3. RESULTS OF POLSAR IMAGE ANALYSIS

To check the validity of the proposed polarimetric marker, let us show the result of the POLSAR image analysis. Figure 1(a) shows the scattering power decomposed result around a wetland "SAKATA" (Niigata, Japan) acquired by airborne Pi-SAR system. In the figure, the decomposed powers are color-coded as follows. 1) Red is painted for double-bounce scattering P_d, 2) Blue is for surface scattering P_s, and 3) Green is for volume scattering P_v. Also, Figure 1(b) depicts the result for the (1,3) element of $\langle [T] \rangle$.

It is found from Fig.1(a) that one can see the bright green color for the volume scattering P_v not only in the vegetation areas (wetland, pine trees, farms) but also in the residential areas. If one utilizes only this color composite image, vegetation areas are not precisely classified. However, in addition to Fig.1(a), taking into account the information of Fig.1(b), *i.e.* reflection symmetry or not, one can easily distinguish between vegetation area and residential area.

In the presentation, a simple land cover classification algorithm using the proposed polarimetric marker and the detailed considerations will be carried out.

4. REFERENCES

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