SCATTERING COMPONENT DECOMPOSITION FOR POL-INSAR DATASET AND ITS APPLICATIONS

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1. INTRODUCTION

Image Classification is one of the important applications of POLSAR (Polarimetric SAR) analysis. Since the POLSAR images have multi-polarization images of HH, HV, VH, and HH polarization, the scattering nature of terrain can be discriminated. To extract features of terrain, decomposition technique is effective. Many POLSAR image decomposition techniques have been proposed such as eigenvector-based and model-based techniques. The model-based techniques are the techniques that decompose the images into sum of several images corresponding to canonical scattering targets.

As for the model decomposition techniques, the method proposed by Freeman and Durden[1] will be the most popular technique, which can decompose the total power into single bounce (surface) scattering power, double bounce scattering power, and volume scattering power[1]. Covariance matrix is used for the decomposition. The number of independent observables is limited in POLSAR images. Therefore they adopt some assumptions to remove ambiguity of the decomposition. The first assumption is that the volume scattering components can be modeled by return from cloud of randomly oriented dipoles. The second is that (1,1)-element of the covariance matrix for double-bounce component is -1 when surface scatter is dominant otherwise (1,1)-element of that for double-bounce component is 1[2]. These assumptions are required to derive a unique solution. However power of decomposed components sometimes becomes negative. This is caused by the inadequate assumptions in the decomposition.

We have proposed a modified method for the decomposition for POLSAR data analysis [3]-[5]. In the method, we have introduced three types of volume scattering matrices as well as additional component, Helix component. The suitable volume scattering matrix is selected according to Co-pol power ratio. With these modifications, almost stable decomposition can be realized. However, there still sometimes appears negative power of the single and/or double bounce component especially in vegetation/forest area. This would be caused by selection of improper model for the volume scattering component. Number of candidates can be increased easily, however it is hard to make a proper criteria of the selection for POLSAR dataset.

To overcome these difficulties, additional observables will be necessary. Recent progress of POLSAR platform makes us easy to access fully polarimetric and interferometric data set. Of course, the interferometric image pair has additional unknowns of interferometric phase which corresponds to slight difference of incident angle. However, the image itself is still almost unchanged which means decomposed results of master POLSAR images and slave POLSAR images should be coincide with each other. Base on these concepts, the authors have proposed a scattering component decomposition technique with Pol-InSAR images [6],[7]. In this abstract, basic concept of the Pol-InSAR image decomposition technique is summarized. In the final paper, quantitative analysis in resolution, number of multi-looks, selection of volume scattering candidates for the decomposition technique will be presented. Also application for the image classification will be discussed.

2. SCATERING COMPONENT DECOMPOSITION FOR POLSAR IMAGES

The conventional scattering component decomposition techniques employ covariance matrices derived by the POLSAR image pixels. The Freeman decomposition technique decomposes the matrix into three scattering models corresponding to surface (single bounce), diplane (double bounce) and volume (random) scattering component [1]. Yamaguchi *et al.* extend the method into 4-componnent decomposition with the additional helix scattering component [3]. It can be shown by

$$\boldsymbol{C} = f_s\boldsymbol{C}_s + f_d\boldsymbol{C}_d + f_v\boldsymbol{C}_v + f_h\boldsymbol{C}_h\,, \tag{1}$$

where the subscripts s, d, v, and h denotes single-bounce, double-bounce, volume and helix component, respectively. The matrices $\boldsymbol{C_i}$ and f_i (i=s,d,v,h) denote covariance matrix and real-valued coefficient of each component, respectively. The

(1,2)-*th* and (2,1)-*th* elements in $\boldsymbol{C}$ is assumed to be equal in the technique, then we have 5 independent observables. This means that we can estimate only one unknown in addition to f_i (i=s,d,v,h). To solve (1) uniquely, $\boldsymbol{C}_v$ and $\mathbf{C}_h$ are assumed to be known. The one additional unknown is assigned to one of the elements in $\boldsymbol{C}_s$ or $\mathbf{C}_d$ corresponding to their contributions. As described here, several assumptions are required due to limitation of the number of observables. These assumptions sometimes cause physically unacceptable decomposition results such as negative power components.

3. SCATTERING COMPONENT DECOMPOSITION FOR POL-INSAR IMAGES

For realizing a robust decomposition technique, it would be the key to increase the number of independent observables. The authors have focused on the interferometric observations. Since the incident angles in interferometric pair observations are almost the same, therefore decomposed results in each data set will be also assumed the same. They can be written by

$$\boldsymbol{C}_{MM} = f_s\boldsymbol{C}_s + f_d\boldsymbol{C}_d + f_v\boldsymbol{C}_v + f_h\boldsymbol{C}_h, \quad (2)$$

$$\boldsymbol{C}_{MS} = f_s\boldsymbol{C}_s e^{j\phi_s} + f_d\boldsymbol{C}_d e^{j\phi_d} + f_v\boldsymbol{C}_v e^{j\phi_v} + f_h\boldsymbol{C}_h e^{j\phi_h}, \quad (3)$$

where $\boldsymbol{C}_{MM}$ and $\boldsymbol{C}_{MS}$ are auto-covariance matrix of master data and covariance matrix between master and slave data, respectively. The additional observables in $\boldsymbol{C}_{MS}$ bring us new 5 independent observables. The number of new unknowns, which correspond to interferometric phase of each component as ϕ_s, ϕ_d, ϕ_v, and ϕ_h, are 4. Therefore we can determine one more unknown without assumptions. In [6] and [7], we used additional freedom to determine unknowns in $\boldsymbol{C}_s$ and $\mathbf{C}_d$. Furthermore, we apply the ESPRIT to select suitable volume scattering matrix, $\boldsymbol{C}_v$, among potential candidates[8]. As discussed here, the polarimetric and interferometric observation has potential to realize stable scattering mechanism decomposition with fewer assumptions than those in conventional decomposition with POLSAR data.

4. CONCLUSION

In this abstract, we describe the concept of scattering component decomposition technique for Pol-InSAR data set. Decorrelation effect, especially for the temporal decorrelation in repeat-pass observation, will severely affect the method. Quantitative analysis with E-SAR, SIR-C/X-SAR and ALOS/PALSAR data will be provided in the final paper. Also application results for classification of terrain and so forth will be shown.

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