EIGEN DECOMPOSITION PARAMETER BASED FOREST MAPPING USING RADARSAT-2 POLSAR DATA

Yang Li [1,2], Wen Hong [1,2], Fang Cao[1,2], Erxue Chen[3], David G. Goodenough[4,5], Hao Chen[4], Ashlin Richardson[4]

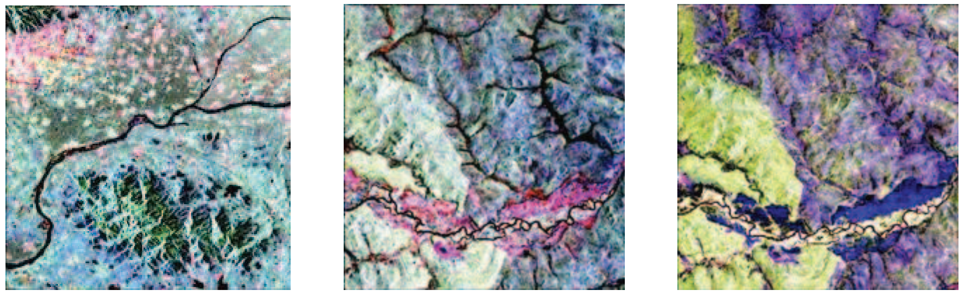
[1]National Key Laboratory of Microwave Imaging Technology, Beijing, 100190, P.R. China
[2]Institute of Electronics, Chinese Academy of Sciences
[3]Institute of Forest Resources Information Techniques, Chinese Academy of Forestry
[4]Pacific Forestry Centre, Natural Resources Canada
[5]Department of Computer Science, University of Victoria, Victoria, BC, Canada
No.19 Bei Si Huan Xi Lu, Beijing, China, 100080
(Tel: 86-10-5888-7104 Fax : 86-10-5888-7526 Email: liyang@mail.ie.ac.cn)

1. INTRODUCTION

Radarsat-2 is the first active C-band space-borne SAR sensor with fully polarimetric (PolSAR) data receiving capability. There are roles for Radarsat-2 in forestry applications. By providing alternate information and augmenting other data sources for forest uses, Radarsat-2 will contribute to national programs on global warming and carbon emissions. Key components of these are monitoring forest change, estimating biomass, and providing forest type classifications. Due to the short wavelength of the C-band PolSAR data, the SAR backscatter sigma value or intensity saturates quickly compared to PolSAR data at L- or P-band. However, the above applications may be achieved through the benefit of polarimetric eigenvector analysis. In this paper, we will introduce roll-invariant parameters derived from the correlation of the eigenvector terms. The use of these parameters makes it possible to map forest areas and monitor forest change from space with C-band polarimetric SAR. The $H/\bar{\alpha}/A$ polarimetric decomposition theorem provides a reasonable scheme to characterize the scattering behavior of pure target and the dominant contribution of random media [1]. Based on this scheme, we found the second term real part of dominant eigenvector presents a great potential for distinguishing forest and non-forest areas at C-band, which is very useful to separate forest from clear-cut, fire scars and vegetation areas without threshold value estimation. This property reveals strong adaptability to a wide range of time and terrain relief variation.

2. STUDY SITES AND DATA SETS

Two forest study sites in China were selected for the forest mapping experiment. One is in Tai-An and the other in Ta-He. The Tai-An study site in Figure.1 (a) shows rougher and steeper topographic features than the Ta-He test site (Figure 1 (b) and (c)). There was a wild forest fire that occurred on September 29th, 2001, in the Ta-He area. Multi-date Radarsat-2 quad-pol data were collected over both the study sites.



(a) (b) (c)

Figure 1 (a) PolSAR image (dB) of Tai-An in August (b) PolSAR image (dB) of Ta-He in July **(c)** PolSAR image (dB) of Ta-He in October. (Red=|HH-HV|, Green=|HV|, Blue=|HH+VV|)

A SPOT5 Level 1A image was used for ground reference. This data set was collected on July 27th, 2006, and has a panchromatic channel with a 2.5m resolution and multi-spectral channels with a 10m spatial resolution. The fusion of the orthophoto image and ISODATA classification result is displayed in Figure 2.

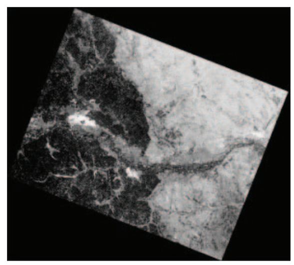


Figure 2 Classification image using SPOT5 data (ground truth).

3. EIGEN DECOMPOSITION PARAMETER

The 3×3 polarimetric coherency matrix T can be presented by the product of eigenvalues and eignvectors, i.e.

$$T = \sum_{i=1}^{3} \lambda_i u_i \cdot u_i^{*T} \tag{1}$$

where λ_i are the eigenvalues of T, $\lambda_1 \geq \lambda_2 \geq \lambda_3 \geq 0$ represent the statistical weight and the order of three kinds of scattering mechanisms. The unit orthogonal eigenvectors u_i can be written as

$$u_i = [u_{1i,} u_{2i,} u_{3i}]^{*T} = e^{j\phi_i} \left[\cos\alpha_i, \sin\alpha_i \cos\beta_i e^{j\delta_i}, \sin\alpha_i \sin\beta_i e^{j\gamma_i} \right]^{*T} \tag{2}$$

The radar vegetation index (RVI) has been introduced by Van Zyl [2] and is used to differentiate forest area from other scattering media. This parameter describes the size of cylinders, ranging from 0 to 4/3. The threshold value is determined during the experiment.

$$RVI = 4\lambda_3 / (\lambda_1 + \lambda_2 + \lambda_3) \tag{3}$$

The other roll-invariant parameter, used to map forests and introduced in this paper, is the correlation term real part of the first eigenvector, i.e.

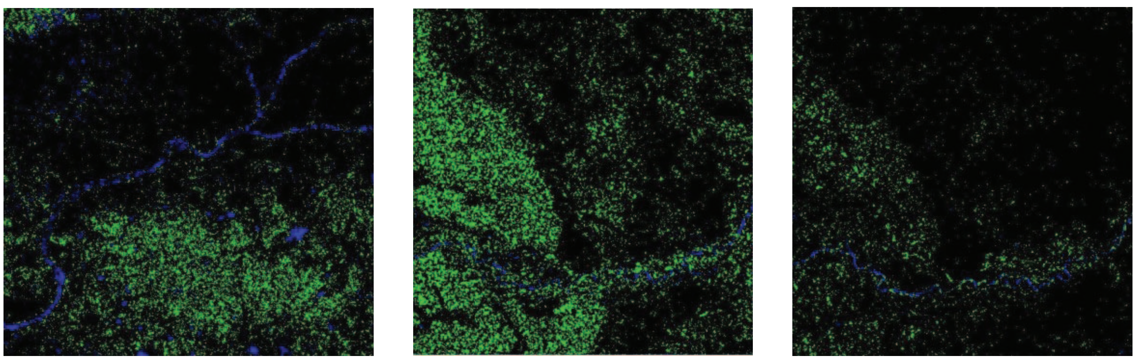
$$\mu_1 = real(\langle u_{21} \cdot u_{11}^{*} \rangle / \langle |u_{21}| \cdot |u_{11}| \rangle) \tag{4}$$

The forested areas are found corresponding to the pixels that satisfy $\mu_1 < 0$. The correlation term real part of the second eigenvector μ_2 and the anisotropy A is used to exclude the pixels which belong to water bodies.

$$\mu_2 = real(\langle u_{22} \cdot u_{12}^* \rangle / \langle |u_{22}| \cdot |u_{12}| \rangle) \tag{5}$$

4. INITIAL ANALYSIS RESULTS

The estimated forest maps in summer and winter from μ_1, μ_2 and A (Figure 3 (b) and (c)) will be evaluated quantitatively using ground truth data. And these forest maps present good correlation with SPAN images and SPOT5 data.



(a) (b) (c)

Figure 3 (a) Tai-An forest map in August (b) Ta-He forest map in July (c) Ta-He forest map in October. (Green= forest areas, Blue= water bodies, Black= others)

5. CONCLUSION

The eigenvalue and eigenvector based parameters are used to segment forested areas and the preliminary study results over our study sites showed the C-band polarimetric SAR potential for fire scar detections. The validity of the results is being further evaluated using the ground reference data created from SPOT5.

6. REFERENCES

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