MONITORING TREE FARMS AND COASTAL ENVIRONMENTS USING RADARSAT-2 POLSAR DATA

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1. INTRODUCTION

Monitoring crop, forest and fishery farms in coastal zones have the paramount importance for global food supply. Forests play an important role as a natural resource in carbon (biomass) storage and carbon dynamic cycles. Polarimetric SAR (PolSAR) has the capability of discriminating crop and forest types and growing status based on scattering mechanisms. Most algorithms were developed for L-band PolSAR data [1-3]. However, C-band is more sensitive to canopy than L-band. Consequently it could be effective for crop discrimination and for monitoring young tree growth. It has been found that C-band is more effective than L-band in distinguishing fire scarred or infested forest, especially with quad-polarizations. VV is very sensitive to vertical structure of vegetation, and HH has a better penetration of canopy than VV. The cross-pol (HV) senses the multiple bounces associated with volume scattering. The fine quad-pol mode RADARSAT-2 data with various incidence angles and interferometric configuration provide sufficient scattering information for crop/tree classification and coastal environment monitoring.

Temporal interferometric decorrelation, introduced by the 24 day repeat cycle of RADARSAT-2, could be a problem for estimating tree heights due to temporal decorrelation effect, but the weak correlation can be of advantage as they are also related to structural, geometric, and dielectric properties of the individual scatterer, which could be associated with vegetation growth, or insect infestation. Consequently, in addition to interferometric phase, the magnitude of coherence is also important for vegetation discrimination.

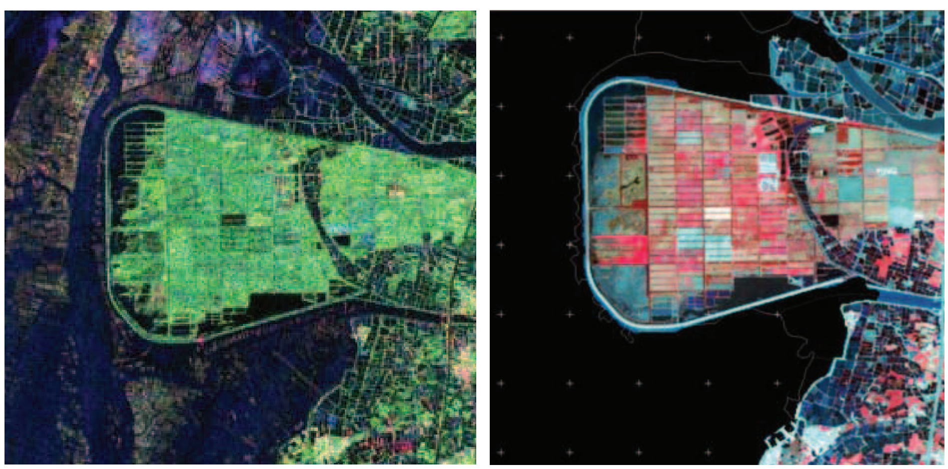
2. RADARSAT-2 SOAR PROJECT

This paper is based on the research results of a RADARSAT-2 Science and Operational Applications Research (SOAR) project (#: 3595) jointly proposed by U.S. Naval Research Laboratory and National Central University, Taiwan. The purpose of this project is to study the feasibility of C-band Pol-InSAR data for crop and young tree classification. The high-resolution fully polarimetric RADARSAT-2 data should provide sufficient scattering information even with the limited penetration at C-band. An experimental tree farm

Table 1 RADARSAT-2 Fine Quad-Pol Mode data acquisitions

Acquisition #	Date	Incidence Angle	Orbit	Beam
1	2009-03-15	34.62°	18-76A	FQ15
2	2009-04-08	34.62°	19-119A	FQ15
3	2009-05-26	34.62°	21-119A	FQ15
4	2009-06-19	34.62°	22-119A	FQ15
5	2009-08-06	34.62°	24-119A	FQ15
6	2009-08-30	34.62°	25-119A	FQ15

Fig. 1 Ground truth measurement of trees, rice paddy and oyster estuary at the test site of Dongshih Farm



(A) Pauli color coded RADARSAT-2 image *(B) SPOT Image*

Fig. 2 RADARSAT-2 data was ortho-rectified and Pauli color coded and the test site is cropped. The Dongshih farm is shown in (A). The corresponding SPOT optical image is shown in (B).

(Dongshih Farm) in Taiwan that is on a piece of reclaimed coastal land was selected as the test site. Six data sets were collected, and they are listed in Table 1. Fig. 1 shows the photos of the test site taken during ground truth measurement on May 25, 2009. The RADARSAT-2 data has very high quality in low noise floor and cross-talk. Fig. 2 shows RADARSAT-2 data acquired on April 8, 2009 and the SPOT optical image as a reference. The image is display with Pauli color coding in Fig. 2A. The green areas reveal young trees in various growing stages as shown in the left of Fig. 1. The two dark plots in the middle are the site of rice paddy field before rice was planted. The farm is surrounded with dike on the ocean side, and the SPOT image failed to show the oyster farming in the estuarine areas. The oyster farming with group of sticks as shown in the right of Fig. 1 is dominated by double bounce scatterings between the sticks and the ocean surface, and they are clearly displayed in brownish red in Fig. 2A.

3. ANALYSIS METHODOLOGY

3.1 Pol-InSAR Classification

Crop classification methods are developed based on the Wishart classifier (Lee et al, IJRS, 1994) and scattering decompositions [2]. In particular, the proposed classification algorithm is based on the Freeman-Durden decomposition. Volume scattering in the Freeman-Durden decomposition is modified by using a vertical-oriented random volume model to suit our application [7]. An unsupervised algorithm will be developed using this modified decomposition and the Wishart classifier for crop and young tree classification.

The algorithm will also be extended to interferometric mode to classify vegetation based on interferometric coherence in additional to scattering mechanisms. In the six RADARSAT acquisitions, we have three pairs of repeated pass interferometric data with 24 days repeat cycles. Between the pairs, there is a 48 day delay to allow sufficient tree growth for PolSAR detection.   Classification based on polarimetric SAR interferometry data is still in its infancy. Pol-InSAR data can be formed into 6x6 covariance matrices. The Wishart classifier can be generalized to include interferometry information. Optimal coherences can also be used

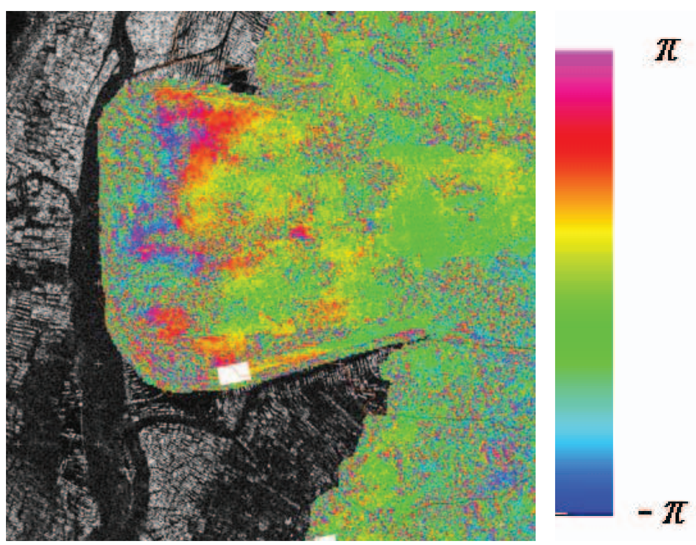


Fig. 3 HH interferometric phase image of the test site.

3.2 Interferometric Phase Classification

The usefulness of interferometric phase in tree areas was in doubt due to temporal decorrelations and possible windy conditions. We tested the first pair of Interferometric data, and as shown it in Fig. 3, and we are pleasantly surprise that the interferometric phase does contain useful information. Consequently, the Pol-InSAR random volume over ground (RVoG) technique [4] will be test for tree height measurements.

3.3 Polarimetric Coherent Change Detection

Polarimetric change detection studies [5] have been applied to agriculture fields using multi-temporal polarimetric SAR data. In principal, a measure (or distance) between two multi-look polarimetric covariance matrices is applied to evaluate crop growth. Other techniques, such as optimal polarization contrast [6] and the Wishart distance between classes [2] could also be used. The RADARSAT-2 data taken over a period of five and a half months could be used for such a comparison.

4. SUMMARY AND CONCLUSION

In this paper, high resolution RADARSAT-2 data in fully polarimetric mode and in repeat-pass interferometry shows the capability for classifying crops and monitoring the growth of young trees. Classification based on Pol-InSAR data is still very much in its infancy, especially at C-band. The availability of RADARSAT-2 data facilitates the development of an efficient algorithm for crop/young tree classification and monitoring. This research enhances the understanding of scattering characteristics of C-band polarimetric SAR interferometry.

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