RICE AREAS MAPPING USING ALOS PALSAR FBD DATA CONSIDERING THE BRAGG SCATTERING IN L-BAND SAR IMAGES OF RICE FIELDS

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1. INTRODUCTION

Information on rice growing area in China is necessary to food security and green house gas emission. The objective of this paper is to assess the use of FBD mode (Fine Beam Double Polarisation) data of the Phased Array type L-band Synthetic Aperture Radar (PALSAR) onboard ALOS satellite to map rice growing areas. While past studies have demonstrated the use of C-band Synthetic Aperture Radar (SAR) data (ERS-1/2, RADARSAT-1) to map rice areas[1,2,3], L-band SAR data (JERS-1) have been regarded ineffective due to the Bragg resonance scattering phenomena observed in some mechanically planted rice fields[4,5]. PALSAR provides higher performance than its predecessor JERS-1 SAR. In this paper, we examined the temporal backscattering behaviors of rice fields in Haian, Jiangsu province at PALSAR HH and HV polarisation data. Image enhancement in backscattering intensity as a result of Bragg resonance scattering was found only at HH polarisation since double-bounce scattering is a prerequisite to Bragg resonance scattering for radar backscatter from bunches of rice plants. A classification method for rice growing areas mapping was developed and applied to the multi-temporal PALSAR HV data at Haian test site. Validation by the field work showed that rice areas mapping using L-band SAR is promising when cross-polarized data are available to cope with the Bragg resonance scattering effects.

2. TEST SITE AND DATA

Haian, Jiangsu province is located in the east of China, extending between 32˚32’-32˚43’N and 120˚12’-120˚53’E. The life cycle of rice growth in Haian is from early June to the middle of October within 135 days. Rice field and mulberry plantation are two major agricultural land cover types in this region. Six ALOS PALSAR data were acquired in 2008, among which three were in the rice growing period. The parameters of the data were listed in Table 1.

3. L-BAND SAR BACKSCATTER OF RICE FIELDS

3.1. Bragg Resonance Scattering

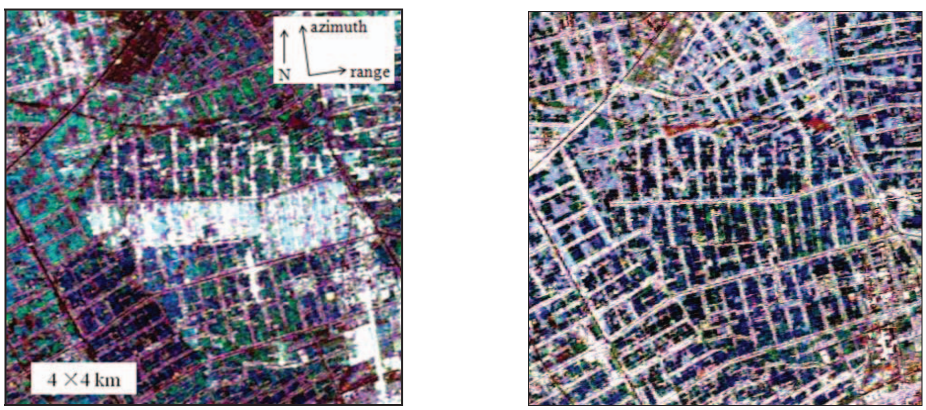
The first condition for the Bragg resonance scattering to occur is defined as formula (1) in terms of the structure parameters of the rice fields

$$\Delta y = \frac{\lambda}{2\sin\theta\cos\gamma} \tag{1}$$

Where Δy is the bunch spacing in range direction; γ is the off-range angle of planting direction; λ and θ are the wavelength of the microwave and incidence angle.

Table 1 ALOS PALSAR data acquisition parameters

Parameters	Descriptions
Wavelength, polarisation, incidence angle and Orbit inclination	23.6 cm, HH and HV, 38.7^o ,Ascending , 98.16^o
Data acquisition dates (year-month-date)	2008-02-13, 2008-03-30, 2008-05-15, 2008-06-30, 2008-08-15, 2008-09-30



(a) HH (b) HV

Fig.1 Color composites PALSAR images for rice field (R: 2008-06-30; G: 2008-08-15; B: 2008-09-30)

Enhanced radar backscatter was observed and confirmed by field work measurements in some machine-planted rice fields in Haian test site as shown in the center of Fig.1 (a). The measured Δy is about 20.1 cm. The angle between north and planting direction is 12^o off north to east. Considering the orbit inclination 98.16^o, γ = 20.16^o. These measurements satisfy well the first condition.

The second condition for the Bragg resonance scattering to occur requires well defined phase difference between neighboring scattering elements. The enhanced backscattering was only found in HH polarisation images as indicated by the bright white area in the center of Fig.1(a). The dominant scattering mechanism in HV polarisation is due to the multiple scattering from the quasi-randomly distributed elements within the bunches of rice, et., leaves, stems. The phases of the received signals are also randomly distributed and the resonance condition does not hold.

The difference in backscattering of the machine-planted rice fields between HH and HV images is further confirmed by quantitatively comparing the dB values of the two types of rice fields as shown in Fig.2. Therefore, the rice fields can be regarded as two different land covers which may raise confusion if classification to be applied to HH polarisation images. Fortunately, in HV shown by the right picture of Fig.2, the machine-planted rice fields and the manually planted rice fields have almost the same backscattering coefficients.

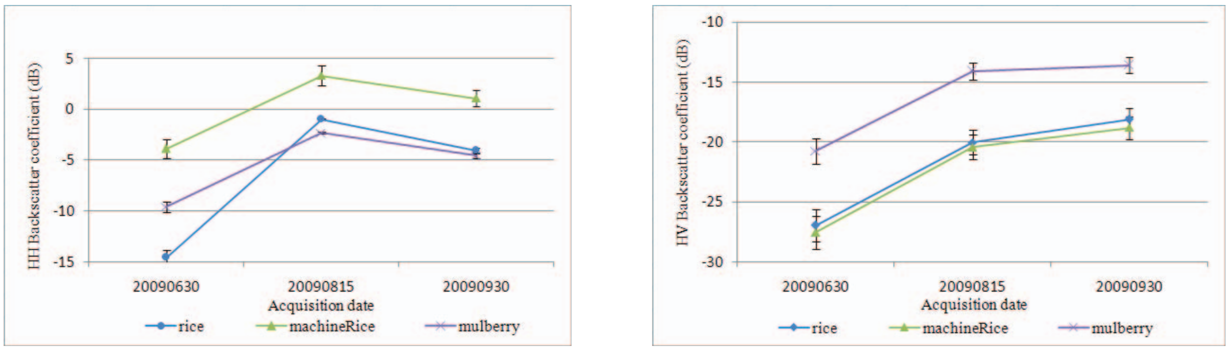


Fig.2 Backscatter coefficients as a function of time

3.2. Temporal Backscatter Behavior

Similar to the C-band SAR backscatter, rice fields show strong variation in backscatter intensity at both HH and HV polarization with the crop growth. As shown in Fig.2, rice fields show an increase of backscatter in HH polarization with time until a plateau which occurs approximately at heading stage. In HH, the attenuation to the water-stem double bounce pulses increases by the leaves and ears of rice plants after heading stage.

The HV polarization shows a different trend in temporal change of backscatter from HH data. The randomness of the scattering elements continues to increase with the growth of the rice plants. Thus more depolarization occurs when the microwave interacts with the rice plants. The continuous increase of backscatter in HV polarization shown in Fig.2 is consistent with the above physical analysis. Mulberry plantation also has similar trend in temporal changes of backscatter to that of the rice filed in both HH and HV polarization images. But the two crops have distinct difference in the absolute backscatter values in HV polarization.

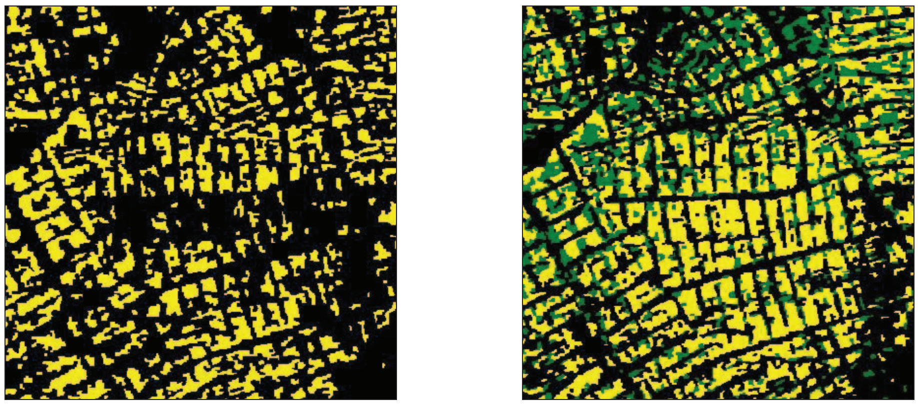
4. RICE AREAS MAPPING

The above analysis on the ALOS PALSAR backscatter of rice fields show that HV polarisation is more promising for rice growing areas mapping. Our proposed rice areas mapping method is based on the temporal change threshold algorithm. Firstly we calculated the PALSAR HV intensity ratio of the data acquired on June 30 and August 30. The following two threshold rules were then applied to the ratio image and a HV image:

1) 6dB was set as a threshold to ratio image to separate rice and mulberry fields (> 6dB) from other land covers;
2) -15dB was set as a threshold to the August 30 HV image to separate rice fields from mulberry fields (> -

15dB).

The derived rice maps are shown in Figure 3. The rice fields subject to the Bragg resonance scattering were not mapped as rice with HH polarisation data. However, with HV the result is more accurate which can be seen by merely visual comparison. In addition, mulberry plantation was also mapped well with two temporal HV images using the proposed rice mapping method. Quantitative accuracy assessment will be described in numbers in the full paper to be submitted.



(a) HH (b) HV

Fig.3 Rice area maps from PALSAR data (Yellow-rice, Green-mulberry)

5. CONCLUSIONS

In conclusion, the major objective of the study was to assess the use of ALOS PALSAR FBD data for the identification of rice growing areas. It is confirmed that L-band HH polarisation SAR data is not suitable for rice fields mapping because of the strong Bragg scattering effect. The alternative is to use the HV data, the other polarization of PALSAR FBD data, which is not subject to the Bragg scattering effect. A method on rice areas mapping using ALOS PALSAR HV data was proposed by exploiting the characteristic increasing temporal behavior in radar backscattering of rice plants.

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