Precise estimation of rice growth status using multi-temporal RADARSAT images

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Abstract: The accurate control of rice growth enables high quality rice production. Vegetation cover rate of rice is one of the useful parameter for representing rice growth status like LAI. In order to estimate the rice growth status over a wide area, the relation between the vegetation cover rate of rice and the radar backscatter coefficient of RADARSAT has been analyzed in this paper. The relation of the radar backscatter increase in rice growth until the heading stage of rice was obtained. Based on its relation, seasonal variation of the vegetation cover rate of rice was estimated from multi-temporal RADARSAT images.

Keywords: Rice growth status, RADARSAT, Farmland outline vector data, Vegetation cover rate

1. Introduction

High quality rice production requires periodically collecting rice growth status data to control the growth of rice. The rice leaf color, leaf age, stem height and LAI are well known parameters to indicate rice growth status. Also vegetation cover rate of rice was an effective parameter indicating rice growth status [1], [2]. Vegetation cover rate was an easily observed parameter than LAI.

In Japan, rice growth status is collected based on field work by the agricultural cooperative producing high quality rice. Field work needs a lot of labor and cost, therefore it is difficult to increase the spatial density of the field work point. Because of this, the spatial density of collected data by field work is insufficient for estimating rice growth status of each paddy field. Satellite data is useful to monitor the rice growth status each paddy field over a wide area. Yun et al. monitored the rice types and production over a wide area using multi-temporal radar satellite data in China [3]. However, the unit of monitoring was based on a pixel size of the satellite data which was not same as the rice paddy field. This study tried to estimate vegetation cover rate for each paddy field using multi-temporal RADARSAT data and farmland outline vector data.

2. Test Site and Materials

2.1 Test Site

The test site is located in Tyuetsu region, Niigata prefecture, Japan. Niigata prefecture is well known as the best quality rice production area in Japan. Also the core test site is established in the test site. It is located in Nagaoka city, Niigata prefecture, Japan, centered at latitude 37.40ºN, longitude 138.78ºE. The pilot studies of high precision farming in the core test site are carried out actively using satellite remote sensing and GIS analysis. The core test site area is 5.5 km from east to west, 7.5 km from north to south.

2.2 Farmland Outline Vector Data

Farmland outline vector data expresses numerically, the spatial position and form of farmlands. A field of farmland is expressed by one polygon on the farmland outline vector data. It is possible to create the farmland outline vector data from land-register maps, aerial photographs or high resolution satellite images. The farmland outline vector data for this study was created by modifying the existing data produced by a land improvement district using QuickBird data observed at 5th Sep. 2003. The farmland outline vector data for analysis was projected onto the Japan plain coordinate system, zone eight.

2.3 RADARSAT Images

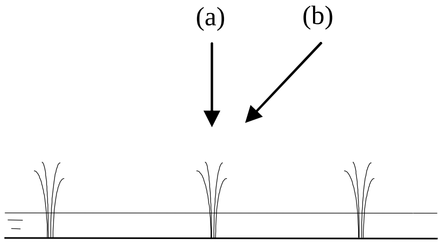
The backscatter from the rice-planted fields changes dramatically from the rice-transplanting season to the rice-growing season. Accordingly we require the observation of paddy fields corresponding to the rice-planted season and the rice-growing season by RADARSAT. Table 1 shows the date and observation mode of RADARSAT data.

Table 1 Observation date and beam mode of RADARSAT

Date	Orbit Type	Beam Mode	incident angle [degree]	Spatial Resolution [m]
May 22, 2003	Descending	FR3F	43	6.25
June 15, 2003	Descending	FR3F	43	6.25
July 9, 2003	Descending	FR3F	43	6.25
August 2, 2003	Descending	FR3F	43	6.25

3. Ground Observation of Vegetation Cover Rate

Vegetation cover rate was observed taking digital photograph of rice on the ground. After taking digital photograph, vegetation cover rate was calculated by a binary image which discriminated the rice area. Following above process, vegetation cover rate was observed on the same day as the RADARSAT data acquisition. Observations were carried out for 6 paddy fields. In addition, considering the limitation of estimation, apparent vegetation cover rate was also collected from RADARSAT's observational direction was collected. Additional observations were carried out for 12 paddy fields. The directions of observation of vegetation cover rate were shown in Figure 1.



(a) is nadir direction, (b) is same as RADARSAT's observational direction

Figure 1 Directions of observation of vegetation cover rate on the ground

4. Method

4.1 Comparing Vegetation Cover Rate

It was considered that RADARSAT backscatter coefficient was sensitive to apparent vegetation cover rate observed from RADARSAT's observational direction. Comparing apparent vegetation cover rate with vegetation cover rate, the limitation of vegetation cover rate estimation from RADARSAT data was calculated.

4.2 Estimating Vegetation Cover Rate from RADARSAT Data

In order to estimate vegetation cover rate for each paddy field in this paper, it was assumed that rice growth status was uniform in a same paddy field. On this assumption, each paddy field on the RADARSAT images was determined by farmland outline vector data. Following this, the averaged RADARSAT backscatter coefficient for each paddy field was calculated excluding pixels which had a backscatter coefficient above 0dB. The relationship between vegetation cover rate and the averaged backscatter coefficient was determined by fitting a linear equation to these.

5. Results and Discussion

5.1 Limit of Estimation for Vegetation Cover Rate

Figure 2 shows the relationship between apparent vegetation cover rate and vegetation cover rate. A linear relationship exists between these until vegetation cover rate reaches approximately 80%. Calculating a linear regression line, a linear regression equation was obtained as shown in Equation (1).

$$VCR = 0.78 \times AVCR \quad (1)$$

Where *VCR* is vegetation cover rate in %, *AVR* is apparent vegetation cover rate in %.
By equation (1), vegetation cover rate is able to be estimated up to 78%. Therefore, the limit of estimation for vegetation cover rate was determined as 78% in this study.

5.2 Relationship between the averaged RADARSAT data and vegetation cover rate

On basis of the limit of estimation for vegetation cover rate, a model equation was calculated based on the relationship between the averaged RADARSAT backscatter coefficient and vegetation which was shown in Figure 3.The model equation shown in Equation (2) derived by applying the least square fitting. The root mean square error of this model equation was 11.8 %.

$$\log_{10} VCR = 0.10 \times S + 2.43 \quad (2)$$

Where *VCR* is vegetation cover rate in %, *S* is the averaged RADARSAT backscatter coefficient in dB.

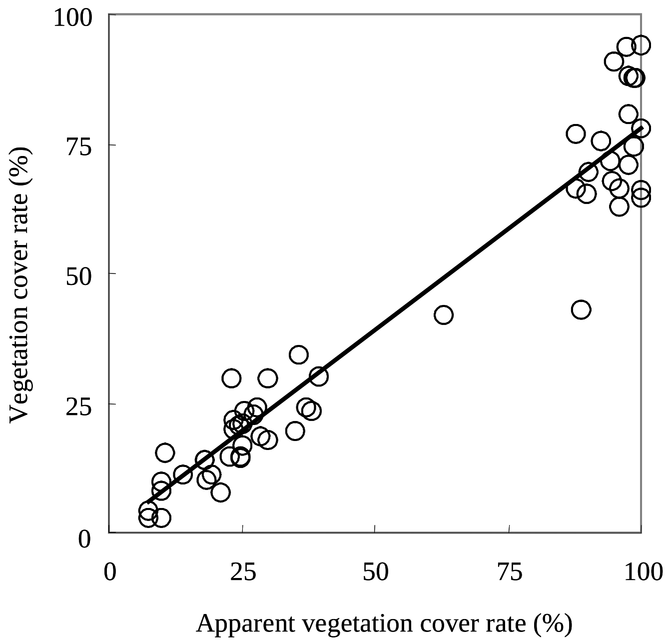


Figure 2 Relationship between vegetation cover rate and apparent cover rate

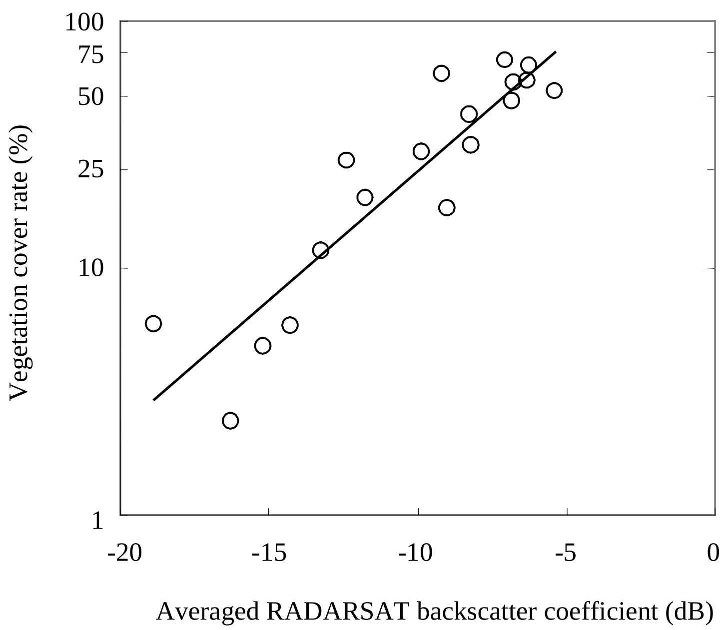


Figure 3 Relationship between averaged RADARSAT backscatter coefficient and vegetation cover rate

5.3 Estimated vegetation cover rate for each paddy field

Applying the equation (2) to each paddy field, vegetation cover rate was estimated excluding non rice planted fields where the averaged RADARSAT backscatter coefficient at May 22, 2003 were above -10 dB. Estimated vegetation cover rate for each paddy field in the top left area of the core test site was shown in Figure 4. In Figure 4, the value of vegetation cover rate was expressed in three classes: low, medium and high. Figure 4 (a), (b) ,(c) correspond to the early growing period, the middle growing period and the late growing period respectively.

The class occupied most of paddy field was changed following: low and middle classes, middle class and middle and high classes were corresponded to Figure 4 (a), (b) and (c) respectively. Therefore we coincided that Figure 4 was reasonable to indicate rice growth status.

6. Summary

This study tried to estimate vegetation cover rate for each paddy field using multi-temporal RADARSAT and farmland outline vector data.

The study found the following results;

(1) A model was built which estimates vegetation cover rate from RADARSAT data.
(2) The root mean square error of the model was 11.8 %.
(3) Using this model, it was possible to estimate vegetation cover rate up to approximately 78%.

References

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(a) Jun. 15, 2003

(b) Jul. 9, 2003

(c) Aug. 2, 2003

Figure 4 Estimated vegetation cover rate for each paddy field