Monitoring and Assessing Rice Crop with Multi-temporal RADARSAT Fine beam mode data in Pathumthani and Ayuatthaya Province of Thailand.

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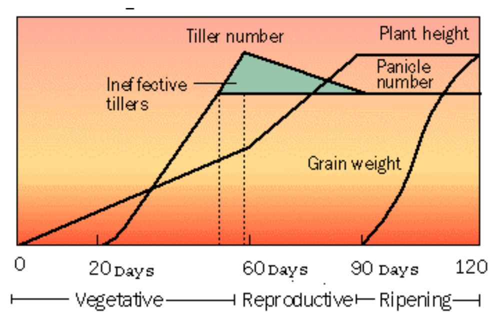
Time series RADARSAT fine beam mode data was acquired from March till June 2002 for Pathumthani, Ayutthaya Area of Thailand to assess and monitor rice crop from the space. An intensive survey was done to collect plant height and biomass information of the rice fields in this area corresponding to satellite pass. Trihedral corner reflectors of size 1meter were installed in order to perform precise geometric correction. The study focuses on exploration of relationship of field data, specially, plant height and water depth, with radar backscatter. The relationship between field parameters and radar backscatter was explored taking all fields, fields with no standing water as well as the test fields with standing water. The relationship was more significant for the fields with standing water with R square value 0.78.

Introduction

Rice plays a very important role in the economy of Thailand. Regular information on rice acreage and growth stages provides estimates of production for each year or at any particular period. Satellite remote sensing in recent years proved to be a cost effective tool for this purpose. Synthetic aperture radar (SAR) bearing capabilities to penetrate cloud and independent of solar illumination, images can be obtained in all weather conditions. The operational use of SAR data for monitoring rice acreage and growth calls for an in-depth understanding of the radar backscatter signatures of rice crop at different stages of growth and at various rice growing environments.

The various crop related studies as well as potential commercial applications of remote sensing data points out the need of use of all weather data for agricultural monitoring and management. This study basically focuses use of multi-temporal SAR data for the study of behavior of rice growth over the time. The study addresses more specifically on following topics.

- Examine the capability of RADARSAT for mapping different paddy growth stage.
- Comparison of response from paddy fields with standing water and paddy fields with no standing water.



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vegetative and reproductive-ripening stage.

Methodology

Description of data Acquisition

The study is from14° 22 N to 13° 50 N latitude and 100° 19 E to 100° 52 E longitude, located in Central Thailand. A total of 9 RADARSAT fine beam ascending mode scenes were acquired during the months of March, April, May, June, July, August and September 2002 for this study.

Table 1: RADARSAT ascending acquisition schedule for the study area

Acquisition Date	Acquisition mode	Incidence angle at scene center
13 March	Fine 1N	38.24816
6 April	Fine 1N	38.24821
24 May	Fine 1N	38.54878
17 June	Fine 1N	38.55404

In order to study the field conditions during 2002, paddy crop information was collected on 40-50 paddy fields corresponding to each satellite pass in the study area. Crop information such as height, water depth, age of the plant, and other visible characteristics were documented. At the same time, 0.5m *0.5 m size samples were cut above the and same size samples were cut just above water surface from the flooded fields ground to measure dry and wet biomass. Four-corner coordinate of field boundary were noted using hand-held GARMIN GPS.

Data pre-processing and analysis

The performance of small passive trihedral corner reflectors are 29 db larger than the power scattered by surrounding area and are easily identifiable point targets on the image (Ugsang et al., 2001). The RADARSAT data sets were geo-coded using ground control points based on the location of five trihedral (1m dimension) corner reflectors installed in the study area. In order to reduce speckle effect from the image, 3*3 lee filter was applied for 3 iteration.

Prior to image analysis, amplitude image is converted to radar brightness (β_j^o) and then to radar backscatter coefficient (σ_j^o) assuming that the Earth is a smooth ellipsoid at sea level. Hence, radar backscatter coefficient is given by:

$$\sigma_j^o = \beta_j^o + 10 \log_{10}(\sin I_j) \quad (1)$$

with, $$\beta_j^o = 10 \log_{10} (DN_j^2 / K) \quad (2)$$

where I_j is incidence angle at the jth pixel and K is calibration factor. To make the approximate conversion from radar brightness (β_j^o) to radar backscatter coefficient (σ_j^o), the value of incidence angle at scene center was used.

Field boundary was overlaid on the geocoded imagery to calculate site-specific mean backscatter values were calculated. McNairn et al, 2002 stated that filtering coupled with a 100 pixel sample sufficiently reduce speckle to limit of scene radiometric accuracy. In order to avoid within field variation, field boundaries were redefined. To quantify relationship between paddy crop growth and radar data, site-specific variables (crop height) were plotted against SAR backscatter coefficient.

Results and Discussion

Influence of paddy growth stages

The following figure clearly explains the relationship of paddy growth stages and Radar backscattering. The four adjoining fields were planted on four different dates. So, crop height at each field differs accordingly. Two fields at left side of the images were 20cm-30cm in height, have low backscatter values on 17 July image. On the same image, fields at the right side with crop height 80-90cm have relatively higher backscatter values than that of fields with young paddy.

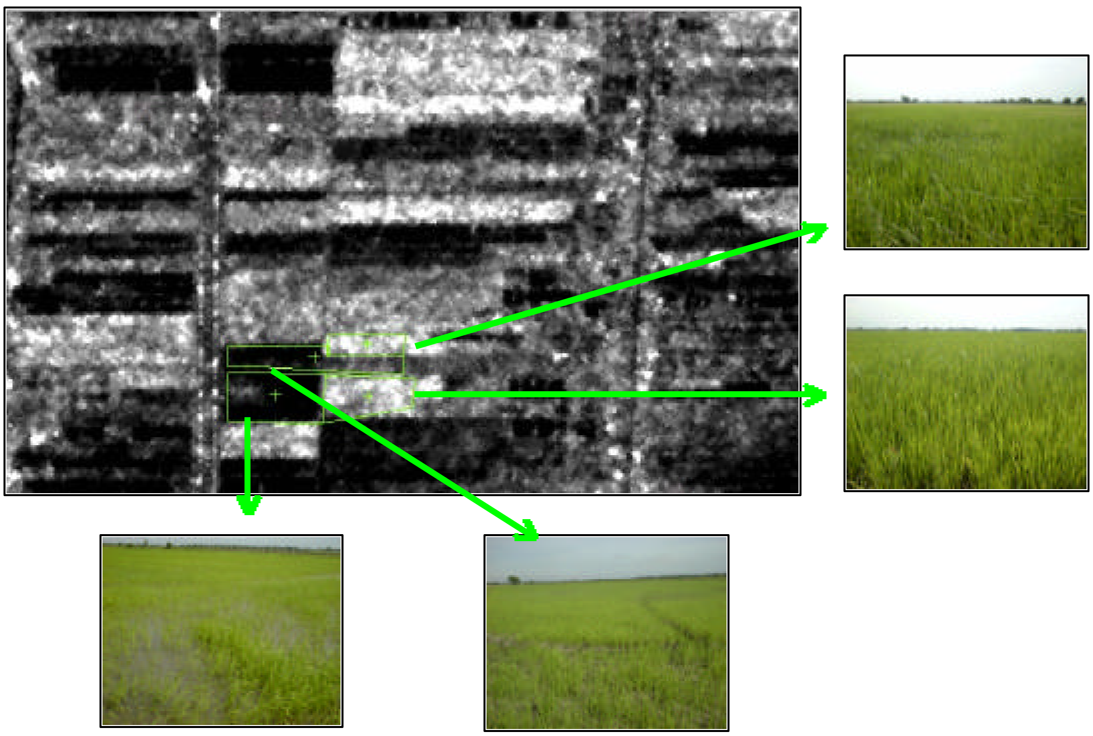
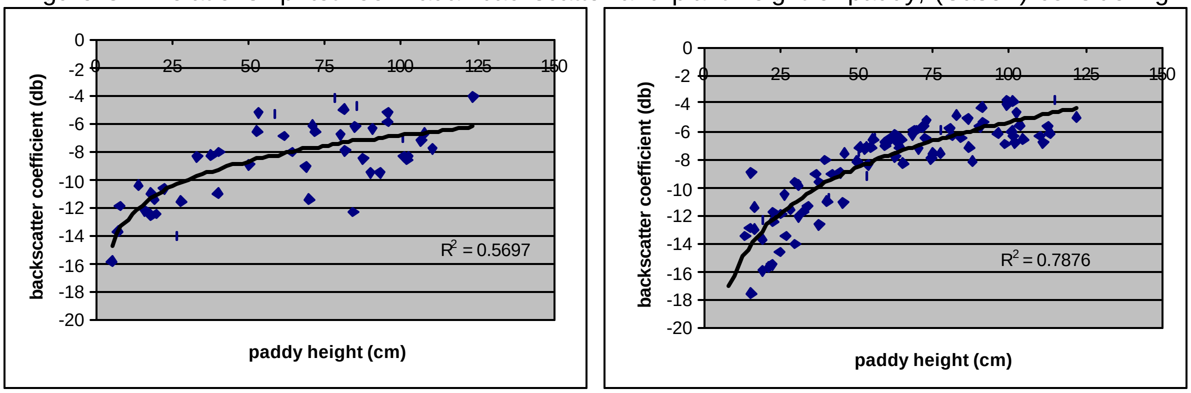


Figure 2: Paddy fields at different stage on 17 June RADARSAT fine beam mode image. In this image depicts paddy fields with different stages of paddy- from 20 days old to 120 days old (plant height varies from 20 cm to 100cm).

To further explore the relationship between paddy growth stage and radar backscatter, mean backscatter values were calculated for all the test fields for four different dates. The plants showed very low backscattering in early stage of plantation –18db to -20db. It started increasing in up –8 db during vegetative phase of the plants, which is due to increase in height as well canopy cover. There was an increase up to –5 db further in reproductive stage of the plants. During ripening phase, backscatter remained almost same until field was being harvested. This is due to not much change in plant growth during the ripening period. Staples C. *et al*., 1994 and Kurosu T *et al*.,1997, reported a similar temporal backscatter characteristic in their study using simulated RADARSAT data. Specular reflection from water decreases backscatter during the early stage. Corner reflection and volume scattering increases backscatter as it grows vertically and horizontally.

Influence of standing water in the paddy fields

Figure 3: Relationship between radar backscatter and plant height of paddy, (Case I) considering



test fields with no standing water and (Case II) considering fields with standing water

In this study also, it is prevalent that there exists a relationship between plant height and radar backscatter for paddy. Since, water content attributes high influence on backscatter, it is interesting to study the response from fields with standing water and field without standing water. In order to explore the response from fields, backscatter values were plotted against crop height in both cases.

It was found that the relationship between crop height and radar backscatter is more significant for the fields with standing water (R square =0.7876) compared to the test fields with standing water (R square = 0.5697).

In case of fields with no standing water, there is response from soil beneath the paddy plants. Variation in soil condition attributed the fluctuation in backscatter values. This may the reason for not having significant relationship in the cases of fields with no standing water. Whereas, in second case, the fields with flooded water demonstrated a significant relationship compared to first case. In the study using ERS1-SAR, Doll *et. al,* 1997 stated that relationship exits between the backscatter and plant height. The plotted variation of backscatter over time with respect to plant height in the study of Doll *et al*, 1997 resembles the growth curve obtained in second case (fields with standing water).

Conclusion

Results from the studies, indicates that rice growth stages can identified using multi-temporal synthetic aperture data(SAR) data. In order to get the accurate information about paddy growth stage, a through field work should be done to gather enough information about the paddy and about field condition.

Field condition varies from field to field. Even adjacent fields have different stage of paddy crop. While selecting test sample, a good care should be taken in selecting homogeneous area within a test field.

The fields with standing water shows significant relationship with crop height than taking fields with no standing water. There is sharp increase in backscatter during the vegetative stage. It goes on increasing till the reproductive stage with lower rate of increase. At the final stage of cycle(ie, ripening stage), the backscatter remains almost same.

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