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Rice crop parameter retrieval using multi-temporal, multi-incidence angle Radarsat SAR data

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Abstract

Temporal RADARSAT Standard beam SAR data of different incidence angle were analysed to study the temporal backscatter of rice crop for a predominant rice-growing region in West Bengal, India. Correlation studies of backscatter with crop growth parameters were carried out. Second order polynomial was the best fit obtained for crop age and crop height. Shallow angle data (>40°) was found better correlated to crop height than steep angle (23°) data. Inversion algorithm was used to generate spatial maps of crop height and age. The results validated over a village showed an over all 90% accuracy.

Keywords: rice crop; RADARSAT SAR; standard beam; incidence angle; crop age; crop height; correlation analysis

1. Introduction

Since the launch of the European ERS-1/2 satellites and the Canadian RADARSAT satellites, a number of studies have shown the usefulness of C band Synthetic Aperture Radar data for the detection of rice crop (Aschbacher et al., 1995; ESA, 1995; Kurosu et al., 1997; Chakraborty et al., 1997; Panigrahy et al., 1998, 1999; Le Toan et al., 1997). Rice area monitoring is of particular significance in India, as the crop is grown in the rainy season, and occupies the largest share of the food grains. Use of C band SAR data for rice area estimation started as early as 1995 in India (Panigrahy et al., 1997). The experience has led to the operational programme "National Rice Crop Monitoring" that uses multi-date RADARSAT SAR (C-band, 5.3 GHz and HH polarization) data to estimate rice area early in the season in the country (Chakraborty and Panigrahy, 2000). Efforts are now concentrated on the possibility of retrieving rice plant parameter such as plant age, height, biomass etc., that are the basic inputs in crop yield and condition models (Brisco and Brown, 1998). The understanding of the radar backscatter of rice fields as a function of rice growth is essential for the

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development of reliable and robust methods to retrieve such parameters. Short wavelength SAR such as X and C band interact mainly with the top part of the canopy layers, thus making these bands very potential in the attempt to retrieve canopy biophysical parameters (Ulaby et al., 1984). The utility of such bands for this purpose, however, to a certain extent relies on the penetration depth of such signal within the crown layers that largely depend on whether or not the biophysical parameters of the scatterers within layers can enhance or degrade the strength of radar–scatterer's-interaction. The growth of the vegetation canopy is commonly followed by the changes of the water content and sizes of the scatterers within the canopy. In this context, the sensitivity of different incidence angles (within a given frequency) to the changes in scatterer's size and water content can provide a better understanding of monitoring growth stages. Some work in this direction has been carried out in few rice growing countries. Rabaute et al. (Rabaute et al., 1998) tried to correlate ERS-1 SAR radar images into plant parameters like plant age, plant height, and plant biomass. Some studies had reported that the inversion in parameter such as plant biomass, using RADARSAT SAR data, is more delicate as the amplitude of the backscatter variation appeared smaller due to higher values of backscatter at early stages (Ribbes and Le Toan, 1999). The objective of this study was to evaluate the practical utility of such methods over a large area. The study also evaluates the effect of incidence angle, so that one can select an optimum dataset that may lead to a better/sensitive approach for parameter retrieval. This is the first ever attempt in this direction in Indian context.

2. Study area and data used

The study area lies in the West Bengal state, India, that extends from 23° 00′ to 23° 30′ N latitude and 87° 40′–88° 20′ E longitude. The study area is predominantly agricultural and rice is the major crop. The crop is grown in two distinct seasons, rainy (June–October) and summer (February–May) season. The rainy season accounts for the main crop and occupies more than 90% of the agricultural area. Our study addresses the main season crop. The area has a gentle gradient and the field bunds (dykes) vary from 20 to 50 cm in height. Transplanting of 20-day-old seedlings to puddle fields is the common method of planting. A semi-dwarf 120-day cycle crop (Lal Swarna) is the commonly grown variety in the region.

Table 1
Details of the RADARSAT standard beam SAR data used in the study

Data set	Beam	Incidence angle (deg.)	Date of pass (Year 1997)
1	S1	21–27	July 10, August 03, August 27
2	S5	39–42	July 06, July 30, August, 23
3	S6	42–46	July 08, August 01, August 25
4	S7	45–49	July 13, August 06, August 30

RADARSAT (C-band, 5.3 GHz, HH polarization) standard beam data is used in the study. RADARSAT has 25 beams that offer a wide range of SAR data with incidence angles and resolutions. The standard beam has 100 km swath, 25 m resolution with 8 m-pixel spacing (RSI, 2000). There are seven beam positions in standard beam (S1–S7) with incidence angle varying from 21° to 49°. The standard beams S1, S5, S6 and S7 were used in the study. Three date data of each beam acquired with a 24-day repeat cycle were used as given in Table 1.

3. Methodology

3.1. Ground truth data collection

RADARSAT Beams S1, S5, S6 and S7 with 100% overlap for the study area are selected as ground truth area. Ten villages within this area were selected for intensive ground truth data collection. Eight villages were used for data analysis and the rest were used as blind sites for accuracy analysis. Since the date of image acquisition of different beams was different (offset by 3–4 days) and ground truth data collection for each beam was also spread over 2–3 days, a special scheme for ground truth data collection and database preparation was used in order to identify episodic events that may otherwise confuse with SAR–target interaction. The following approach was used:

Record the Date of Data (DD) by Calendar date for all beams and all passes and determine appropriate