I. SOIL MOISTURE, CROP AND VEGETATION STUDY USING AIRSAR DATA

Dr. Flaviana Hilario (1) and Dr. Juliet Mangera(2)

(1) PAGASA (Weather Bureau), ATB 1424 Quezon Ave, Quezon City, Philippines, 1100, Philippines
(2) Bureau of Soil and Water Management, ATB 1424 Quezon Ave, Quezon City, Philippines

Abstract

The use of remote sensing in monitoring rice production has been extensively done using optical sensors. The Philippines being located in the tropical region is perennially covered with clouds; hence, the use of optical sensors is not practical. The synthetic aperture radar (SAR) with its cloud penetrating capability could be very useful for rice crop monitoring. In November 1996, The DC-8 aircraft which operates in full polarimetric mode at C-band (5.6 cm), L-band (24 cm) and P-band (68 cm) flew over Central Philippines with the AIRSAR system on board with spatial resolution of about 10 meters.

The main objective of the study is to determine the usefulness of radar data in distinguishing the different stages of rice growth in some parts of Iloilo, a major rice growing area in the Visayas. The results of the study showed that the C-, L- and P-band AirSAR images are capable of distinguishing the various stages of rice growth. The use of P-band to determine soil moisture also showed promising results. However, further studies are needed and emphasis must be given on the simultaneous acquisition of groundtruth data for quantitative analysis.

I. INTRODUCTION

Rice is the staple food in the Philippines just like the rest of the Asian countries. In the recent years, the country had experienced rice shortage, which necessitates the importation of rice. Rice monitoring is important to determine the expected yield for a given season. This information is very valuable to the country’s economic managers as an input in planning purposes.

The use of remote sensing in monitoring rice production has been extensively done using optical sensors. The Philippines being located in the tropical region is perennially covered with clouds; hence, the use of optical sensors is not practical. Furthermore, the small size of many of the rice paddies also constrains the use of low-resolution sensor like the Advanced Very High Resolution Radiometer (AVHRR) of the National Oceanographic and Atmospheric Administration (NOAA) of the United States of America (USA). The synthetic aperture radar (SAR) with its cloud penetrating capability could be very useful for rice crop monitoring.

The world’s most advanced SAR system is airborne synthetic aperture radar (AirSAR) developed at the Jet Propulsion Laboratory (JPL) in Pasadena, California. In November 1996, The DC-8 aircraft flew over Central Philippines with the AIRSAR system on board. The system operates in full polarimetric mode at C-band (5.6 cm), L-band (24 cm) and P-band (68 cm). The spatial resolution is about 10 meters.

The main objective of the study is to determine of the usefulness of radar data in distinguishing the different stages of rice growth in some parts of Iloilo, a major rice growing area in the Visayas. The study area is shown in Fig. 1.

II. REVIEW OF LITERATURE

The use of radar imagery has attracted a great deal of attraction in recent years because of the radar imagery is an all-weather system. Radar images can reveal three main kinds of vegetation information: 1) geographic pattern; 2) gross structure and physiognomy; and 3) type identification. The study by S. Ross et al (1998) investigated the Radar response of three land cover classes namely rice, banana and water in Zhao Qing, China during various stages of growth. Using RADARSAT image (beam mode S5), the backscatter of various land cover such as water, rice, aqua, grass and banana at different stages of growth was studied. However, the study was focused on rice where the temporal backscatter signatures of rice paddies were determined at various stages of growth (from flooded paddies, to full grown plants, to harvested areas) as shown in figure 2. The results proved to be promising and will allow the continuation of the research on the applicability of RADARSAT for monitoring crops.

The use of multi-polarization and multi-frequency AIRSAR data in discriminating vegetation in Malaysia was studied by Laili at al.(1998). The radar backscatter of the different
vegetation such as forest, oil palm, rubber and non-vegetation including clear-cut area and suburban. The preliminary results indicated that for vegetated and non-vegetated can be easily discriminated. For oil palm and rubber, the L-band can discriminate the two. However, rubber, natural and plantation forest can hardly be discriminated.

The use of AIRSAR (C-, L- and P-bands) in discriminating crop type was studied by Baronti et al. (1995). In July 1991, the NASA DC-8 flew over a composite landscape of forests, oliveyards, vineyards and agricultural fields in Europe. The results indicate that P-band data are successful in discriminating among broad land surface categories. The well developed “broad leaf” crops such as sunflower and corn can be identified using the L-band data. The herbaceous crops on the other hand, can be determined using C-band data.

The study of Borgeaud and Noll (1994) the SAR data were used to assess the performance of several theoretical surface scattering models for rough surfaces. The polarimetric properties of bare soil fields evaluated by and then compared to the values estimated by theoretical models for rough surface backscattering was studied. Soil permittivity and surface roughness are included as inputs to the models. The results showed that the models performed satisfactorily.

Fig. 1. The study area consisting of Iloilo City and some nearby towns of Iloilo Province.
III. METHODOLOGY

The study area includes Iloilo City and the nearby municipalities of Iloilo Province. It is one of the major rice growing area in the country. The area has a relatively flat topography. It has Type I climate characterized by two pronounced seasons, wet from June to November and dry from December to May. The soil is predominantly loam and is fertile which makes it suitable for many types of crops. The water resources for irrigation consisted of one hundred fifty rivers and creeks.

The major agricultural crop in the area is rice. There are two growing seasons for rice; from June to September and from October to January. Rice is normally grown for four months. The usual planting practice of the farmers in the area starts with transplanting of young seedlings. The ricefield is flooded during this period and remains flooded through the vegetative up to the maturity stage. The soil moisture levels decreases after the plants have fully matured. The water supposed to be drained during the harvesting period.

On November 26, 1996, the National Aeronautic and Space Agency (NASA) DC-8 flew over Panay Island. It acquired multi-frequency polarimetric SAR data. C-, L- and P-band at various polarization HH, VV and HV were gathered. However, the field data gathering was done in February 1999. Ground control points were gathered during this period.

The Environment for Visualizing Images (ENVI) software was used to process the AIRSAR data. This software is highly suitable to process radar data with its many subroutines such as decompress-synthesize and slant-to-ground range as examples. The image was registered using ground control points gathered during the field survey.

IV. DISCUSSION OF RESULTS

The AIRSAR data taken November 26, 1996 shown in Fig. 3. The figure is a color composite of bands C (red), L (green) and P (blue) in the VV polarization mode. The image revealed that the rice fields are irregular in shape and the sizes varies with some fields as small as 1 hectare. Visual inspection showed that the rice fields are in various stages of growth as indicated by the different colors of the fields.

The image shown in gray level values of the three bands are shown in figure 4. At a glance, the figure showed more distinctive characteristics of rice crops at various stages of growth. For the newly transplanted rice crops, the backscatter for the three bands are low as shown by the...
darker gray color. The rice plants at this stage are still small and field is flooded so that most of the SAR is absorbed by water.

Fig. 3. Color composite map of C_{vv}, L_{vv}, and P_{vv} of the study area.
Fig. 4. Subset AirSAR images showing rice fields.
The figures also indicate that rice crops at maturity stage, three bands showed varied backscatter. The P-band showed darker gray color indicating lower backscatter than that C- and L-bands. This could be explained by the fact that P-band has the longest wavelength which can penetrate the crop canopy and is absorbed by water underneath the plants.

The study also tried to determine the soil moisture during the growing season. Unfortunately, the field data gathering was not done simultaneously with the radar data collection. However, the average backscatter coefficient, $\sigma$ of the three channels at various polarizations (figure 5) showed very interesting results. The $\sigma$ of the P-band at various polarization for the various stages of rice growth have nearly the same values. This means that the soil moisture are almost the same in these various stages. Since lowland paddy rice is usually grown with flooded fields, the soil is always saturated during the growing season. This explains the observation that the average backscatter for P-band from transplanting to maturity stage have almost the same values. However, the identification of the stage of growth is not possible with the use of the P-band.

V. SUMMARY AND CONCLUSIONS

The results of the study showed that the C-, L- and P-band AirSAR images are capable of distinguishing the various stages of rice growth. The use of P-band to determine soil moisture also showed promising results. However further studies are needed and emphasis must be given on the simultaneous acquisition of ground truth data for quantitative analysis.
VI. LITERATURE CITED


