ESTIMATION OF SOIL MOISTURE FROM RADARSAT-2 MULTI-POLARIZED SAR DATA OVER WHEAT FIELDS

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ABSTRACT

Radar data has important implications in agricultural fields monitoring, particularly in the retrieval of the crop height, leaf area index (LAI) and soil moisture information. The objective of this study was to estimate soil moisture contents based on RADARSAT-2 synthetic aperture radar (SAR) data acquired over wheat fields. The soil moisture inversion algorithm was based on semi-empirical backscattering models and the prior estimation of wheat heights and wheat water contents from RADARSAT-2 data. The co-polarized correlation coefficient and the ratio of the absolute value of the cross polarization to the crop height were analyzed with respect to variations in wheat height and wheat water content. Furthermore, Landsat5 TM data were used to classify the planted wheat area. The results showed average relative errors of 14%, 32% and 24% for the retrieval of wheat height, wheat water content and soil moisture, respectively.

Keywords: RADARSAT-2, wheat field, wheat height, wheat water content, soil moisture

INTRODUCTION

Radar remote sensing is widely used for monitoring agricultural crop growth, yield and mapping as well as soil moisture estimations. The goal of this study was to investigate the potential use of RADARSAT-2 SAR data for the retrieval of soil moisture contents of wheat fields. Several previous studies have used radar remote sensing to estimate soil moistures in agricultural fields, although these approaches encountered various limitations due to a low temporal frequency of data acquisition, noise associated with vegetation cover, soil surface roughness and soil texture (Ulaby et al., 1986).

Several empirical relationships between polarization and/or dual frequency ratios and crop parameters have been developed for vegetated surfaces. For example, many scientists evaluated the biomass level of a corn crop based on the radar vegetation index (RVI) computed in the L-band. Although the HV/VV in the L-band has been shown to be closely related to the soybean water content (De Roo et al., 2001), VV/HV values in the S- and C-bands have been correlated to the height and biomass of maize and wheat. The HV/HH ratio computed from

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C-band data has been used to estimate the leaf area index (LAI) of sugarcane. In this study, the widely used semi-empirical Water-Cloud model was employed to generate volume scattering data for the vegetation elements of retrieved crop parameters according to the aforementioned empirical methods.

MATERIALS AND METHODS

I. Study area and materials

The study area is a relatively flat agricultural region located in Qingyuan county (Longitude: 115°23′E, Latitude: 38°43′N), Hebei province, China. The area was mainly covered by winter wheat and villages. Within the winter wheat area, 20 fields were selected to conduct ground measurements of soil and vegetation characteristics between May 13 and 15, 2010. The sizes of the fields, together with the variety of winter wheat growth, make this area suitable for testing the soil and vegetation parameter monitoring capabilities of SAR remote sensing.

II. Methods

A diagram of the soil moisture inversion is presented in Fig. 2. This inversion consists of three steps: 1) Estimate the wheat height and wheat water content for each field from the RADARSAT-2 data using new empirical relationships.2) Simulate the volume scattering of the vegetation using the Water-Cloud model together with the retrieved crop parameters. 3) Calculate the soil surface scattering based on multi-polarization SAR data and the simulated vegetation volume scattering, and perform an inversion of the soil moisture for each field based on the Oh model.

RESULTS AND ACCURACY ANALYSIS

The soil moisture inversion algorithm was based on semi-empirical backscattering models and the prior estimation of wheat heights and wheat water contents from RADARSAT-2 data. The co-polarized correlation coefficient and the ratio of the absolute value of the cross polarization to the crop height were analyzed with respect to variations in wheat height and wheat water content. The results showed average relative errors of 14%, 32% and 24% for the retrieval of wheat height, wheat water content and soil moisture, respectively.

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