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Effects of corn on c- and l-band radar backscatter: a correction method for soil moisture retrieval

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Abstract

Past research has demonstrated the potential of mapping soil moisture using both low frequency passive and active microwave measurements (e.g. Jackson et al., 1999; Wagner & Scipal, 2000). This resulted in formulating satellite missions carrying L-band microwave sensors capable of monitoring soil moisture globally. For example, a microwave radiometer has recently been launched by European Space Agency (ESA) onboard the SMOS (Soil moisture and Ocean Salinity) satellite. Additionally, NASA is in preparation of two missions that will include both active and passive L-band microwave instrumentation: Aquarius (expected launch: spring 2010) and SMAP (Soil Moisture Active Passive; expected launch: 2015). Apart from these prospects on the availability of global L-band data sets, also C- band passive and active measurements have been used in the past for retrieving soil moisture from space. For instance, using C-band brightness temperature measured by AMSR (Advanced Microwave Scanning Radiometer) and backscattering (σ_o) provided by ASCAT (Advanced Scatterometer), various soil moisture products have been generated (e.g. Njoku et al., 2003; Owe et al., 2008; Wagner et al., 2007). Despite many successful retrieval studies, one of the challenges for soil moisture retrieval remains correcting both active and passive microwave observations for the effects of vegetation.

The general framework for retrieving soil moisture from passive microwave has been well established and is based on the semi-empirical radiative transfer approach proposed by Mo et al. (1982). Therefore, improvements of the algorithms focus often on deriving the necessary vegetation parameters (e.g. Bindlish et al., 2003; Wen et al., 2003; Wigneron et al., 2007). Active microwave soil moisture retrieval algorithms, however, are still being improved. Various semi-empirical and empirical approaches have been considered. Some treat the effects of vegetation explicitly (e.g. De Roo et al., 2001; Wen & Su, 2003). However, increasingly these effects are assumed constant over specific time intervals (e.g. Bartalis et al., 2007; Narayan et al., 2006). The application of the so-called "change detection" approaches is, thus, restricted to regions with sparse vegetation or to time intervals with limited vegetation growth. A better understanding of the vegetation effects on σ_o measurements could contribute to more robust soil moisture retrievals over areas with large biomass variations.

This paper discusses the effects of a corn canopy on the co-polarized (HH and VV), multi-angular C- (4.75 GHz) and L- (1.6 GHz) band backscattering $\sigma_o$throughout the 2002 growth cycle. The utilized σ_o data set has been measured by a truck mounted scatterometer stationed at the edge of a field on the grounds of the Beltsville Agricultural Research Center (BARC) near Beltsville, Maryland (USA). Starting from May 10th (6 days after corn plant emerged) until the harvest on October 2nd, this scatterometer took measurements once a week from incidence angles of 15, 35, and 55°. In support of the remote sensing observations, a detailed ground characterization took place around the footprint, which included soil moisture and biomass measurements. In this investigation, the C- and L-band σ_o measurements are compared to simulations by the Integral Equation Method (IEM) surface scattering model (e.g. Fung et al., 1992) for analyzing the effects of vegetation. Subsequently, two methods are applied for the simulation of C-band σ_o and soil moisture retrieval, which are the semi-empirical water cloud model (Attema & Ulaby, 1978) and a method recently proposed by Joseph et al. (2008). This novel method corrects σ_o measurements for vegetation assuming relationships between the vegetation water content (W) and the ratio of the bare soil and measured σ_o. The σ_o simulations and soil moisture retrievals by both methods are validated against measurements. Further, the potential application of Joseph's method to larger scales is discussed, and the sensitivity of its soil moisture retrievals to W and surface roughness parameter uncertainties is evaluated.

Comparison of σ_o measurement against simulations by the Integral Equation Method (IEM) surface scattering model (Fung et al., 1992) shows that the σ_o measurements are dominated either by an attenuated soil return or by scattering from vegetation depending on the antenna configuration and growth stage. Further, the measured σ_o is found to be sensitive to soil moisture even at peak biomass and large incidence angles, which is attributed to scattering along the soil-vegetation pathway. For the simulation of C-band σ_o and the retrieval of soil moisture two methods have been applied, which are the semi-empirical water cloud model (Attema & Ulaby, 1978) and a novel method. This alternative method uses the empirical relationships between the vegetation water content (W) and the ratio of the bare soil and 35 the measured σ_o to correct for vegetation. It is found that this alternative method is superior in reproducing 36 the measured σ_o as well as retrieving soil moisture. The highest retrieval accuracies are obtained at a 35° incidence angle leading to RMSD's of 0.044 and 0.037 m3 m-3 for the HH and VV-polarization, respectively.

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