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Recent advances in microwave sensing of soil moisture

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ABSTRACT

A new approach for retrieving surface soil moisture from satellite microwave brightness temperature is described. The approach uses radiative transfer theory together with a non-linear optimization routine to partition the observed microwave signal into its soil and vegetation components. Vegetation optical depth is derived directly from the microwave polarization difference index, while the soil component is solved in terms of the soil dielectric constant. A global data base of soil physical properties is then used to derive soil moisture from the soil dielectric constant. The approach is tested with historical SMMR data to produce time series of surface soil moisture over several global test sites. Comparisons with ground observations of soil moisture are made. Preliminary results over several global test sites are provided.

Keywords: Remote sensing, microwave brightness temperature, soil moisture, radiative transfer

1. INTRODUCTION

Satellite remote sensing offers potentially the greatest single contribution to large-scale monitoring of the Earth's surface. While ground measurements typically provide the greatest accuracy, they are manpower-intensive, costly, and time consuming. In addition, they are still point measurements, and are usually difficult to aggregate to provide reliable spatial averages. Satellite systems can offer the spatial, temporal, and spectral resolution necessary for consistent and continuous uninterrupted coverage of the whole Earth environment and its surrounding atmosphere. Such detailed observations are necessary in order to detect often-subtle environmental changes. Microwave remote sensing is unique, in that it is the only technology which responds directly to the absolute volume of water which is present in the environment. Radiometric temperature readings in the microwave region have been shown to yield information on soil moisture, precipitable water in clouds, precipitation, and snow. Remote sensing technology is central to the integration of the many interrelated but highly variable point scale phenomena to more useful, regionally-oriented land surface processes. Soil moisture retrieval by microwave is the only remote sensing technique that provides a direct measure of the absolute volume of water in the top soil layer. While the physics of modelling soil emission is relatively straight-forward, accounting for the effects of the overlying vegetation has always presented a more difficult challenge. The signal which emanates from the soil, results from the natural thermal emission in the microwave region, the magnitude of which is determined by the dielectric properties of the combined soil water mixture. However, a vegetation canopy will influence this signal, both by attenuating the soil emission, and by contributing a signal of its own. Emission characteristics of the vegetation are a function of the vegetation dielectric properties. The signal that is subsequently observed by a microwave sensor is highly complex, and must be partitioned into its source components before any soil moisture information can be extracted. Several new approaches for retrieving surface soil moisture from satellite radiometer data have been developed recently [1]. The approach presented here uses radiative transfer theory to solve for surface moisture and the vegetation optical depth. The methodology is somewhat unique, in that it does not require any field observations of soil moisture or canopy biophysical properties for calibration purposes and may be applied at any wavelength. The procedure is being tested with historical 6.6 GHz brightness temperature observations from the Scanning Multichannel Microwave Radiometer (SMMR) [2]. Some microwave theory is presented, along with some preliminary results from several validation studies. Comparisons are made to in-situ observations of soil moisture from several global test sites.

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