# MICROWAVE SOIL MOISTURE RETRIEVAL UNDER TREES USING A MODIFIED TAU-OMEGA SCATTERING MODEL

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## ABSTRACT

Soil moisture is recognized as an important component of the water, energy, and carbon cycles at the interface between the Earth's surface and atmosphere. Current baseline soil moisture retrieval algorithms for microwave space missions have been developed and validated historically only over grasslands, agricultural crops, and generally light to moderate vegetation. While tree areas are expected to have a large effect on masking the microwave response to the underlying soil moisture, our understanding of the microwave properties of trees of various sizes and their impact on soil moisture retrieval algorithms at L band is presently limited. In addition, the coarse spatial resolution of the L band radiometers on upcoming space missions such as ESA's SMOS (2009) and NASA's Aquarius (2010) and SMAP (2013) missions will likely result in a number of pixels which are at least partially tree-covered, requiring an improved understanding of the microwave response to soil moisture through tree canopies in order to retrieve soil moisture at desired accuracies over a wide variety of heterogeneous land cover conditions. To address this issue, a number of studies are being conducted by researchers in the microwave soil moisture community in Europe, the United States, and elsewhere over a variety of tree stands of different types and sizes using a range of modeling approaches [1-3].

Most microwave soil moisture retrieval algorithms developed for use at L band frequencies are based on the tau-omega model, a simplified zero-order radiative transfer approach where scattering is largely ignored and vegetation canopies are generally treated as a bulk attenuating layer. In this approach, vegetation effects are parameterized by tau and omega, the microwave vegetation opacity and single scattering albedo. One goal of our current research is to determine whether the tau-omega model can work for tree canopies given the increased scatter from trees compared to grasses and crops, and if so, what are effective values for tau and omega for trees. Another goal is to more accurately account for tree canopy scattering by modifying the basic tau-omega model to include the first-order scattering term, and then to assess the performance of both versions of the tau-omega model in retrieving the underlying soil moisture.

As part of this research effort, a coordinated sequence of field measurements involving the ComRAD (for Combined Radar/Radiometer) active/passive microwave truck instrument system has been undertaken. Jointly developed and operated by NASA Goddard Space Flight Center and George Washington University, ComRAD consists of dual-polarized 1.4 GHz total-power radiometers (LH, LV) and a quad-polarized 1.25 GHz L band radar sharing a single parabolic dish antenna with a novel broadband stacked patch dual-polarized feed, a quad-polarized 4.75 GHz C band radar, and a single channel 10 GHz XHH radar. The instruments are deployed on a mobile truck with a 19-m hydraulic boom and share common control software, real-time calibrated signals, and the capability for automated data collection for unattended operation.

During 2006 and 2007 ComRAD microwave measurements and supporting ground truth data (including size/angle distributions of tree constituents) were collected over stands of deciduous paulownia trees of different densities under full canopy and leaf-drop conditions. In 2008 similar measurements were acquired over a natural stand of Virginia pine coniferous trees. For the deciduous trees, changes in H polarization emissivity on the order of 0.07-0.09 were observed due to seasonal changes in the tree canopy condition (leaf vs leaf-drop) for similar soil moisture conditions. Using ComRAD measurements of the tree canopies and a vegetation scattering model [4], estimates of the tree layer attenuation resulted in variations of 0.1 in microwave transmissivity due to seasonal changes in the canopy (leaf/no leaf). However, the scattering model overestimated vegetation effects at larger incidence angles, and reasonable soil moisture retrieval accuracies (RMSE ~ 3.3 %) were possible only after averaging estimated transmissivities across all observed incidence angles during the experiment. These results for the deciduous trees will be compared to results from coniferous canopies once spring measurements have been obtained over the pine trees in early 2009. Preliminary work has been completed on modifying the tau-omega model to include first-order scattering from the tree canopies, and soil moisture retrieval using both versions of the tau-omega model will be presented.

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