Geophysical Research Abstracts
Vol. 12, EGU2010-6749, 2010
EGU General Assembly 2010

Statistical Modelling of the Soil Dielectric Constant

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The dielectric constant of soil is the physical property being very sensitive on water content. It funds several electrical measurement techniques for determining the water content by means of direct (TDR, FDR, and others related to effects of electrical conductance and/or capacitance) and indirect RS (Remote Sensing) methods. The work is devoted to a particular statistical manner of modelling the dielectric constant as the property accounting a wide range of specific soil composition, porosity, and mass density, within the unsaturated water content. Usually, similar models are determined for few particular soil types, and changing the soil type one needs switching the model on another type or to adjust it by parametrization of soil compounds. Therefore, it is difficult comparing and referring results between models. The presented model was developed for a generic representation of soil being a hypothetical mixture of spheres, each representing a soil fraction, in its proper phase state. The model generates a serial-parallel mesh of conductive and capacitive paths, which is analysed for a total conductive or capacitive property. The model was firstly developed to determine the thermal conductivity property, and now it is extended on the dielectric constant by analysing the capacitive mesh. The analysis is provided by statistical means obeying physical laws related to the serial-parallel branching of the representative electrical mesh. Physical relevance of the analysis is established electrically, but the definition of the electrical mesh is controlled statistically by parametrization of compound fractions, by determining the number of representative spheres per unitary volume per fraction, and by determining the number of fractions. That way the model is capable covering properties of nearly all possible soil types, all phase states within recognition of the Lorenz and Knudsen conditions. In effect the model allows on generating a hypothetical representative of the soil type, and that way it enables clear comparing to results from other soil type dependent models.

The paper is focused on proper representing possible range of porosity in commonly existing soils.

This work is done with aim of implementing the statistical-physical model of the dielectric constant to a use in the model CMEM (Community Microwave Emission Model), applicable to SMOS (Soil Moisture and Ocean Salinity ESA Mission) data. The input data to the model clearly accepts definition of soil fractions in common physical measures, and in opposition to other empirical models, does not need calibrating. It is not dependent on recognition of the soil by type, but instead it offers the control of accuracy by proper determination of the soil compound fractions. SMOS employs CMEM being funded only by the sand-clay-silt composition. Common use of the soil data, is split on tens or even hundreds soil types depending on the region. We hope that only by determining three element compounds of sand-clay-silt, in few fractions may help resolving the question of relevance of soil data to the input of CMEM, for SMOS. Now, traditionally employed soil types are converted on sand-clay-silt compounds, but hardly cover effects of other specific properties like the porosity. It should bring advantageous effects in validating SMOS observation data, and is taken for the aim in the Cal/Val project 3275, in the campaigns for SVRT (SMOS Validation and Retrieval Team).
Acknowledgements. This work was funded in part by the PECS – Programme for European Cooperating States, No. 98084 „SWEX/R – Soil Water and Energy Exchange/Research".