Geophysical Research Abstracts, Vol. 9, 02781, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-02781

Modelling the dielectric permittivity of porous media using statistical-physical model

B. Usowicz (1), J. Lipiec (1), J.B. Usowicz (2), W. Marczewski (3)

(1) Institute of Agrophysics, Polish Academy of Sciences, Doswiadczalna 4, 20-290 Lublin, Poland, (2) Torun Centre of Astronomy of the Nicolaus Copernicus University, Gagarina 11, 87-100 Torun, Poland, (3) Space Research Centre, Polish Academy of Sciences, Bartycka 18A, 00-716 Warsaw, Poland, (Usowicz@demeter.ipan.lublin.pl / Fax: +48 81 7445067 / Phone: +48 81 7445061)

The dielectric permittivity is an important property describing the ability of the material, to react on the electric field, especially in soils, by means of the polarization moment of the water molecules contained in the terrestrial media, under direct investigations. The indirect sensing means employed for remote surveying also need studying the dielectric permittivity of media to validate observations. The dielectric permittivity measurements provided in-situ, required specialized probes, dependent on the measurement method. The work employs the TDR (Time Domain Reflectometry) method for the terrestrial media. Our earlier studies proved that the permittivity of the soil media is determined in some extent by the texture and the mineralogical composition, and by more variable factors related to the water and the water vapour content, the temperature, the pressure, and other environmental parameters determining possible mass transport. That variables, considered separately and together, were employed similarly by the statistical-physical model of the thermal properties of soil, proposed by B. Usowicz. Now, the same approach is employed for combining these physical and environmental conditions to model the dielectric permittivity. The model is aimed for studying individual and combined effects of solid, gas and liquid phases on the dielectric permittivity of porous media, under terrestrial conditions. The purpose of this work was to determine the dielectric permittivity of various porous media from the TDR and confront the observed data to the data predicted by the statistical-physical model, within variety of the physical and environmental conditions. The model is built as a mesh of elementary electric capacitors in a way enabling expressing porosity and other physical conditions.

The porous media under study include mineral and organic terrestrial soils, glass beads and snow. The assessed permittivity is dependent on the water contents, the bulk density, the specific surface area of grains and the temperature. It was found that increase of water content in expense of the air content, caused the increase of the permittivity to the extent greater in media consisted of coarse than fine mineral grains. In the fine grained media, characterized by a greater specific surface area of grains, this increase was less within the lower than the higher water contents. This lesser increase resulted from the decrease of the dielectric permittivity of the water bounded by the grain surfaces. In the coarse grain media, the temperature rise caused a drop of the permittivity. The drop was higher within the high than within the low water contents. However, in the fine grained media, increase of the temperature caused increase of the permittivity at low water contents and its decrease at high water contents. This increase at low water contents in the fine grained media can be a result of lowering thickness of bounded water layer as a result of an enhanced rotation of polar molecules in the liquid with an increase of temperature. Decrease of the porosity of the porous media leads to increase of the permittivity to different extent depending on the volumetric content of particular components of the solid phase. The statistical-physical model predicts the dielectric permittivity well for the porous media and can be useful for validating the electro-magnetic surveying by the remote sensing means.

This work was funded in part by the Polish Ministry of Science and Higher Education (Grant No. N305 046 31/1707).