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Soil moisture, dielectric permittivity and emissivity of soil: effective depth of emission measured by the L-band radiometer ELBARA

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Due to the large variation of soil moisture in space and in time, obtaining soil water balance with an aid of data acquired from the surface is still a challenge. Microwave remote sensing is widely used to determine the water content in soil. It is based on the fact that the dielectric constant of the soil is strongly dependent on its water content. This method provides the data in both local and global scales.
Very important issue that is still not solved, is the soil depth at which radiometer "sees" the incoming radiation and how this "depth of view" depends on water content and physical properties of soil. The microwave emission comes from its entire profile, but much of this energy is absorbed by the upper layers of soil. As a result, the contribution of each layer to radiation visible for radiometer decreases with depth. The thickness of the surface layer, which significantly contributes to the energy measured by the radiometer is defined as the "penetration depth".
In order to improve the physical base of the methodology of soil moisture measurements using microwave remote sensing and to determine the effective emission depth seen by the radiometer, a new algorithm was developed. This algorithm determines the reflectance coefficient from Fresnel equations, and, what is new, the complex dielectric constant of the soil, calculated from the Usowicz's statistical-physical model (S-PM) of dielectric permittivity and conductivity of soil. The model is expressed in terms of electrical resistance and capacity. The unit volume of soil in the model consists of solid, water and air, and is treated as a system made up of spheres, filling volume by overlapping layers. It was assumed that connections between layers and spheres in the layer are represented by serial and parallel connections of "resistors" and "capacitors". The emissivity of the soil surface is calculated from the ratio between the brightness temperature measured by the ELBARA radiometer (GAMMA Remote Sensing AG) and the physical temperature of the soil surface measured by infrared sensor. As the input data for S-PM: volumes of soil components, mineralogical composition, organic matter content, specific surface area and bulk density of the soil were used. Water contents in the model are iteratively changed, until emissivities calculated from the S-PM reach the best agreement with emissivities measured by the radiometer. Final water content will correspond to the soil moisture measured by the radiometer. Then, the examined soil profile will be virtually divided into thin slices where moisture, temperature and thermal properties will be measured and simultaneously modelled via S-PM. In the next step, the slices will be "added" starting from top (soil surface), until the effective soil moisture will be equal to the soil moisture measured by ELBARA. The thickness of obtained stack will be equal to desired "penetration depth". Moreover, it will be verified further by measuring the moisture content using thermal inertia.

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