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Spatial modelling of dielectric permittivity of soil

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Soil Moisture (SM) is one of key variables determining water and energy exchange in natural environment. Thus it belongs to those ECVs (Environment Climate Variables) which contribute to the climate through all possible scales of evaluations and observations, from local to global scales. Observing SM is important because it is directly related to the flux of water being under current exchange of water with atmosphere, but fluxes are difficult for determining, in particular on large scales because it varies very much in spatial and temporal domains. Water determines conditions to many other physical and biological processes, and they all are more or less but differently coupled. From one side, SM is the condition determining and forcing other processes, but is also dependent on other environmental elements, and from another side SM is also is determined by existence and state of the environmental elements, including their physical and biological heterogeneity. Effects of SM on the environment and effects in the environment on SM carry essentially statistical meaning of that coupling between physical and environmental conditions. Even modeling exclusively physical properties of soil in terms of SM is in fact coupling physical properties which can be expressed analytically or statistically. We select a physical-statistical method of modeling SM, in specific measures, expressing SM by means of abstract structures, in order to control elements of the texture, and capable for expressing effects formally by means of universal statistical methods. SM is an observable accessible directly, or by means of another physical property of the soil dielectric permittivity as it is used for TDR (Time Domain Reflectometry) methods. Therefore, the work is aimed for extending the statistical-physical method, from SM on the soil dielectric constant.

Additional motivation is that the soil dielectric permittivity is the variable taking a very high position in the hierarchy of variables, build in modeling effects of the microwave emission from soil, in the model CMEM (Community Microwave Emission Model) employed by SMOS (Soil Moisture and Ocean Salinity). The purpose is to enhance relevance of the dielectric constants on SM, by a better dependence on the texture, than it is in the models from Dobson and Mironov. These models employ analytical forms of empirical expressions, which represent a relation to the texture mainly by the bulk density and sand, clay fractions, while the statistical-physical model does it statistically and respects three phase states of the water, air and solid matter in fractions, fully respecting other physical forcing conditions. The proposed model seems to be able representing better soil water status in the range from bound through plant available (field water capacity) to free water and the effective specific soil surface developed under particular fractions of grain components. Particular effects of modeling the spatial distribution of the dielectric permittivity shall be presented at various scales, ranging from the field to the commune, in the validation test site at Polesie Wetland, in Poland.