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Dynamics of soil humidity parameters

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Many of the soil properties e.g. electro-magnetic (electrical conductivity, magnetic susceptibility), thermal (heat capacity, thermal conductivity) and acoustic characteristics depend strongly on soil moisture content and their values may have to be specified at a number of selected moisture contents. These parameters depend strongly on soil texture but also on the water content, especially because of the soil moisture variation with the weather conditions. It is therefore necessary to monitor day-by-day soil parameters as a function of known environmental conditions. Moreover, it has been recently evidenced[1)] that the soil moisture has a strong small scale variation. Such effect would certainly reflect also on other soil parameters. As a result the performance of many geophysical and other sensors will strongly depend on the soil water content.

The field measurements of soil water content could be very demanding and time-consuming. In some cases such as mine fields they can not be performed. The aim of the research presented here was to understand better the soil moisture variability and to find the soil humidity parameters that can predict the water content under different weather conditions.

In order to obtain the soil humidity parameters we have analyzed soil characteristics (density, particle size distribution, chemical composition) and measured one-year long soil moisture time-series for 6 different soils in the test field at the Ruđer Bošković Institute. Soil moisture contents at four depths as well as precipitation were measured daily. The data obtained for the soil moisture content time variations were fitted with the Eq (1):

$$\Theta\ (t)\ =\ \sum_i \left[p_1\, e^{-d_1(t\,-\,t_i)}\ +\ p_2\, e^{\,-d_2(t\,-\,t_i)}\right]\ A_i\ \frac{1}{1+e^{-5\,(t\,-\,t_i)}} \quad \text{, Eq (1)}$$

where:

Θ (t) – volumetric water content for a given day,

t – time scale (days),

p_1, p_2, - infiltration parameters,

d_1, d_2 – retention parameters,

A_i – precipitation on the day (t_i).

Four parameters (p_1,p_2,d_1,d_2) obtained from the fitting of experimentally determined time-series are found to be soil type specific.

Cumulative curves of particle size distributions for each type of soil were analyzed by Andersson's model[2)] as shown by Eq (2):

$$y\ =\ y_0\ +\ b\ \ \text{arctan}\ \left[c\ \ln\ \frac{x}{x_0}\right] \text{, Eq (2)}$$

where:

x – is a particle diameter in μm,

x_0 – the most frequent particle diameter corresponding to the cumulative percent y_0.

b, c- parameters of the curve shape.

Experimentally determined particle size distributions were well reproduced and the four parameters obtained are found to be also soil type specific.

Mathematical relations between parameters of the soil moisture time variations fit by Eq (1) and parameters from Andersson's model fit to particle size distributions were established. These relations are the key for the model of the water content prediction under the different weather conditions.

A model for soil water content prediction is relevant : (i) for the performance of humanitarian de-mining tools, (ii) forest fire prevention, (iii) agriculture practice and (iv) for the performance of the different kinds of remote sensors. The soil moisture prediction capability will allow optimizing the de-mining operations, installation of an early warning system for forest fire prevention, optimizing the agriculture interventions and improve sensor's capabilities.

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2) Andersson, S.: Markfysikaliska undersökningar i odlad jord, XXVI. Om mineraljordens och mullens rumsutfyllande egenskaper. En teoretisk studie. (In Swedish), Swedish University of Agricultural Sciences, Uppsala, 1990.