Geophysical Research Abstracts
Vol. 17, EGU2015-4795-1, 2015
EGU General Assembly 2015

Soil thermal diffusivity as related to water content, texture, bulk density and organic carbon

Tatiana Arkhangelskaya, Ksenia Lukyashchenko, and Mariia Velichenko
Soil Science Faculty, Moscow State University, Moscow, Russian Federation (arhangelskaia@gmail.com)

Thermal diffusivity is equal to thermal conductivity divided by volumetric heat capacity and reflects both the ability of soil to transfer heat and its ability to change temperature when heat is supplied or withdrawn. The higher thermal diffusivity is, the thicker is the soil/ground layer in which diurnal and seasonal fluctuations of temperature are registered and the smaller is the phase shift of soil temperature waves compared to surface fluctuations.

Volumetric heat capacity grows linearly with water content, bulk density and organic carbon. Thermal conductivity also depends on these three properties, but the relationships are essentially non-linear. Besides, thermal conductivity is strongly influenced by soil texture. As a result, the thermal diffusivity vs. water content dependences obtained for different soils vary greatly in the range of values and shape.

Thermal diffusivity of clays, loams and sands of the East European Plain was studied at different water contents using the unsteady-state method. The range of sand content in 105 analyzed soil samples was from 0 to 97 %, the bulk density varied from 0.85 to 1.82 g cm^{-3}, the organic carbon varied from 0.1 to 6.5 %. Thermal diffusivity of air-dry samples was from 0.86×10^{-7}m^{2}s^{-1} for clays to 4.49×10^{-7}m^{2}s^{-1} for sandy soils; the values of thermal diffusivity for saturated samples were 3.08×10^{-7}m^{2}s^{-1} for clays, 9.69×10^{-7}m^{2}s^{-1} for loams and 9.52×10^{-7}m^{2}s^{-1} for sands. Thermal diffusivity vs. water content dependencies had different shapes. At low sand contents the thermal diffusivity increased with water content in the whole studied range from the air-dry samples to the capillary moistened ones. The increase in sand contents resulted in more pronounced S-shape of the experimental curves, which was also typical for compacted soils. At high sand contents the curves had a pronounced maximum within the range of water contents between 0.10 and 0.25 m^{3}m^{-3} and then decreased.

The experimental $\kappa(\theta)$ curves, where κ is soil thermal diffusivity and θ is water content, were parameterized with the approximating function:

$$\kappa = \kappa_0 + a \exp\left[-0.5\left(\frac{\ln\left(\frac{\theta}{\theta_0}\right)}{b}\right)^2\right],$$

where κ_0 is the thermal diffusivity of dry soil, a is the difference between the highest thermal diffusivity at the optional water content θ_0 and the thermal diffusivity of dry soil, b is the half-width of the peak of the $\kappa(\theta)$ curve. In the case of non-peak curves parameter θ_0 can be interpreted as the coordinate of “virtual maximum”, which moves right as the $\kappa(\theta)$ curve becomes less sigmoid and more linear-like. Parameter a is still a measure of κ growth with moisture, and b characterizes the width of moisture interval, where the main growth of κ occurs. The increase of sand contents in studied soils was accompanied by the increase of κ_0, a and b parameters and the decrease of θ_0 parameter. The bulk density correlated positively with κ_0 and a parameters and negatively – with θ_0 parameter. On the contrary, the organic carbon had positive correlation with θ_0 and correlated negatively with κ_0 and a. Correlations with b parameter were non-significant at $p<0.05$.