Geophysical Research Abstracts
Vol. 19, EGU2017-5919, 2017
EGU General Assembly 2017

A new method for measuring unfrozen water content of frozen soil based on soil resistivity

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In the field of permafrost engineering, in order to determine the unfrozen water content of frozen soil in a more economical and quick way, a resistivity-based method is proposed to predict the unfrozen water content by building the relationship of resistivity (ρ), water content (θ) and temperature (T) through laboratory experiments. In the experiments, advanced Mile soil sample boxes are used to shape groups of soil samples with an initial water content of 5%, 10%, 15%, 20% and 25% separately. The experiment is composed of two parts. In the first part, oven drying method is used to dry the soil sample until the water content is less than 1%, and the resistivity of samples is continuously measured for each decrease of 0.5g water in soil samples; the relationship between water content (ρ) and resistivity (θ) at normal temperatures is established and expressed as a ρ-θ mode, which accords with power function. In the second part, the freezing method is used to freeze soil samples. When soil samples' temperature decreases from 0°C to -25°C, the resistivity of samples is continuously measured for each decrease of 0.1°C; the relationship between resistivity (ρ) and temperature (T) at minus degrees is established and expressed as a ρ-T mode, which accords with power function. The ρ-θ model at normal temperature is introduced to indirectly reflect the ρ-θu model at negative degree of temperature, which has been verified through a series of experiments with the NMR method. Combined with the ρ-T mode at minus degree of temperature, the relationship between unfrozen water content and temperature is deduced and established as θu-T model. By contrastive analysis, the accuracy to measure unfrozen water content with the resistivity-based method is validated by the NMR method, which is used to obtain the relationship between the unfrozen water contents and temperature. Based on the research results, the surface model related to resistivity, temperature and unfrozen water content is built by MATLAB programming, and can be used to predict the unfrozen water content in practical projects.