Science Societies

The instrumentation of unfrozen water content: Considering the importance of conversion curves

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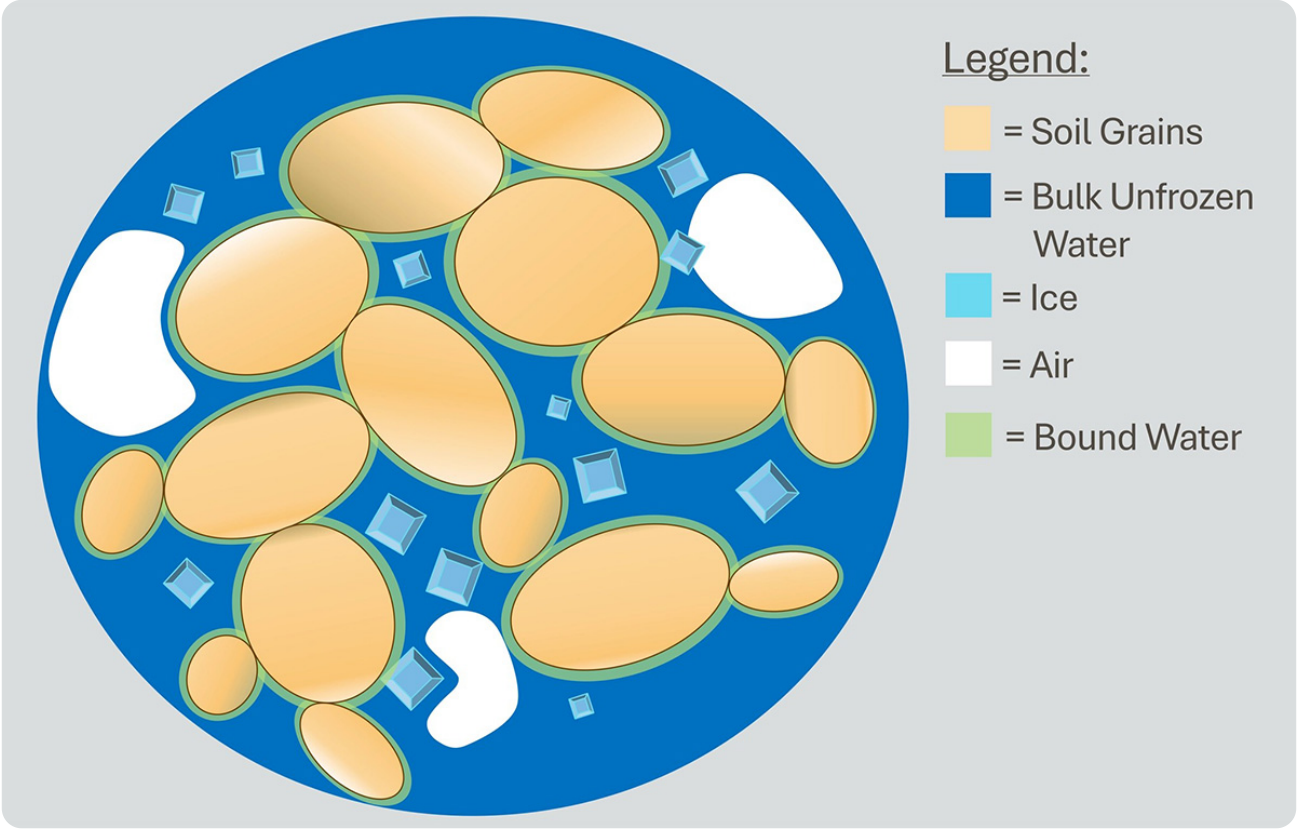

Schematic representation of a soil sample in cryotic conditions. The Sihvola multiphase mix model can be adapted to represent the soil sample in an environment of liquid water in which the other phases exist. Note that while ice and air phases are not depicted as round

for ease of visualization, they are mathematically represented as such. Image courtesy of Quentin "Quinn" Sapin, Queen's University.

As permafrost regions warm and thaw, the parametrization of unfrozen water content (θ_{uwc}) in cryotic (< 0°C) soil has become a priority in the study of permafrost behavior under a warming climate. Many of the physical properties of soils are governed by θ_{uwc}, but it is difficult to measure because all current measurement techniques are indirect.

One of the standard procedures to measure θ_{uwc} involves the use of a capacitance base moisture sensor. In this case, the sensor measures an electrical property of the soil: its relative dielectric permittivity (ε_{eff}). It then transforms this measurement into θ_{uwc} through a mathematical function called a conversion curve. The current default conversion curve for many moisture sensors was never meant to be used in the range of temperatures relevant to cryotic soils. Researchers from Queen's University suggest a new physics-based conversion curve based on a dielectric mixing model which encompasses elementary physical parameters representative of the soil studied.

Using this new conversion curve greatly alters the final readings of θ_{uwc}, tripling its value. This paper's findings provide evidence supporting the reevaluation of the default conversion curve in moisture sensors when applied to cryotic soils.

Dig deeper

Sapin, Q. Q., & Devoie, E. (2026). Assessing unfrozen water content using capacitance sensors in frozen soils: A new physics-based conversion curve. *Vadose Zone Journal*, *25*, e70113. https://doi.org/10.1002/vzj2.70113

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