Summary of Thermo–Time Domain Reflectometry Method: Advances in Monitoring In Situ Soil Bulk Density

 Soil bulk density ($\rho_b$) is a key indicator of soil compaction and soil health that relates to water infiltration, plant rooting depth, nutrient availability, and soil microbial activity. Under field conditions, $\rho_b$ usually varies with time and depth because of agronomic practices, root growth, and environmental processes (e.g., rainfall events, wetting/drying, and freezing/thawing). The traditional technique (i.e., the coring method) for determining $\rho_b$ has the problems of destructive sampling, labor intensive, and is unable to capture the spatial and temporal variations. In a chapter of the recent Methods of Soil Analysis book, we present a review of the theory, instrumentation, and procedures of the thermo–time domain reflectometry (thermo-TDR) technique for monitoring in situ $\rho_b$ (Lu et al., 2017).

A thermo-TDR sensor (Fig. 1) measures soil thermal properties and water content ($q$) concurrently by integrating the functions of the heat-pulse and TDR sensors. The method employs available models that relate heat capacity (C) or thermal conductivity ($\lambda$) to soil texture, $\theta$, and $\rho_b$. With the prior information of sand/clay fractions and specific heat of soil solids, $\rho_b$ is estimated inversely from $\theta$ and C or $\lambda$ measurements made with thermo-TDR sensors. Laboratory and field tests have shown that the relative errors in $\rho_b$ estimates are generally within 10%. The new method provides in situ and continuous $\rho_b$ measurements with no calibration requirement, thus offers the potential for studying coupled heat and water processes in deformable soils where $\rho_b$ changes with time and depth.

REFERENCES

Core Ideas
- Thermo-TDR technology is used for obtaining soil bulk density.
- Soil water content and thermal properties are monitored simultaneously.
- Bulk density is estimated by using thermal property models.

Fig. 1. Schematic view of the configuration for the Liu et al. (2008) thermo-TDR sensor. The drawings are not to scale.