Published online May 10, 2018

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

Yili Lu
College of Resources and Environmental Science
China Agricultural Univ.
Beijing China 100193

Xiaona Liu
College of Environment and Safety Taiyuan Univ. of Science and Technology
Taiyuan, China 030000

Meng Zhang
College of Resources and Environmental Science
China Agricultural Univ.
Beijing China 100193

Joshua Heitman
Soil Science Dep.
North Carolina State Univ.
Raleigh, NC 27695

Robert Horton
Dep. of Agronomy
Iowa State Univ.
Ames, IA 50011

Tusheng Ren*
College of Resources and Environmental Science
China Agricultural Univ.
Beijing China 100193

Soil bulk density (ρ_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, ρ_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 ρ_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 ρ_b (Lu et al., 2017).

A thermo-TDR sensor (Fig. 1) measures soil thermal properties and water content (θ) 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 (λ) to soil texture, θ, and ρ_b. With the prior information of sand/clay fractions and specific heat of soil solids, ρ_b is estimated inversely from θ and C or λ measurements made with thermo-TDR sensors. Laboratory and field tests have shown that the relative errors in ρ_b estimates are generally within 10%. The new method provides in situ and continuous ρ_b measurements with no calibration requirement, thus offers the potential for studying coupled heat and water processes in deformable soils where ρ_b changes with time and depth.

REFERENCES

Liu, X.,T. Ren, and R. Horton. 2008. Determination of soil bulk density with thermo-time domain reflectometry sensors.Soil Sci. Soc. Am. J. 72:1000–1005. doi:10.2136/sssaj2007.0332

Lu, Y., X. Liu, M. Zhang, J. Heitman, R. Horton, and T. Ren. 2017. Thermo–time domain reflectometry method: Advances in monitoring in situ soil bulk density. Methods of Soil Analysis 2. doi:10.2136/msa2015.0031

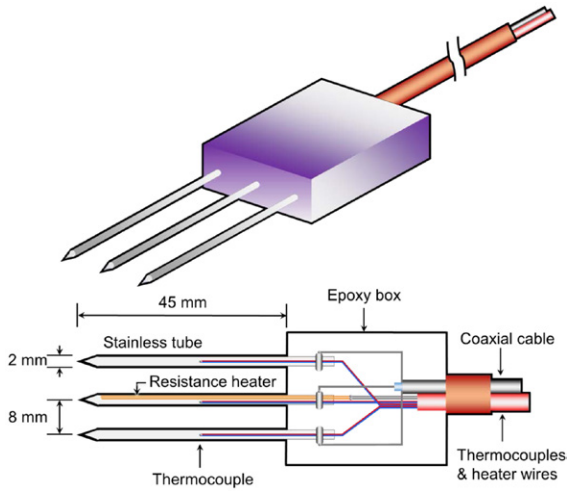

Fig. 1. Schematic view of the configuration for the Liu et al. (2008) thermo-TDR sensor. The drawings are not to scale.

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.**

Soil Sci. Soc. Am. J.
doi:10.2136/sssaj2018.01.0053
Received 26 Jan. 2018.
Accepted 28 Mar. 2018.
*Corresponding author (tsren@cau.edu.cn).