BENCH SCALE MEASUREMENT OF SOIL USING EMI, IP, TDR, AND GPR

D. Glaser, US Army Cold Regions Research & Engineering Laboratory, Hanover, NH
B. Barrowes, US Army Cold Regions Research & Engineering Laboratory, Hanover, NH
M. Prishvin, Thayer School of Engineering, Dartmouth College, Hanover, NH
K. O'Neill, Thayer School of Engineering, Dartmouth College, Hanover, NH
F. Shubitidze, Thayer School of Engineering, Dartmouth College, Hanover, NH

Abstract

Standoff electromagnetic (EM) measurements of complex conductivity for engineering soil properties has the potential to revolutionize the way the US Army handles route planning and infrastructure assessment. An unmanned aerial system (UAS) based EM platform for soil interrogation will have a wide reaching impact on missions ranging from civil infrastructure inspection to in-theater ingress and egress routing to reduction of false positives in IED detection to permafrost mapping. Yet, in order to achieve these applications, a fundamental understanding of key petrophysical models with regards to EM measurements must be obtained. In an effort to illuminate the interrelationship of various electrical and electromagnetic methods at a scale suitable for soil property estimation, we perform side-by-side measurements using galvanic geoelectrical methods (resistivity, induced polarization), electromagnetics, time-domain reflectometry (TDR) and ground penetrating radar (GPR). We compare EM obtained dielectric values to TDR and GPR. Additionally, we compare EM obtained complex conductivity values to those of direct contact measurements for saturated soils. Results are evaluated statistically amongst the different methods. We investigate the relationship between the complex electrical conductivity and dielectric permittivity of soils and their relationship to critical engineering soil parameters as obtained through standoff electromagnetic measurements. Further, we examine the results in the context of classical predictive mechanistic petrophysical models of Archie, Topps, and Kronig-Kramers which historically assume direct contact measurements.

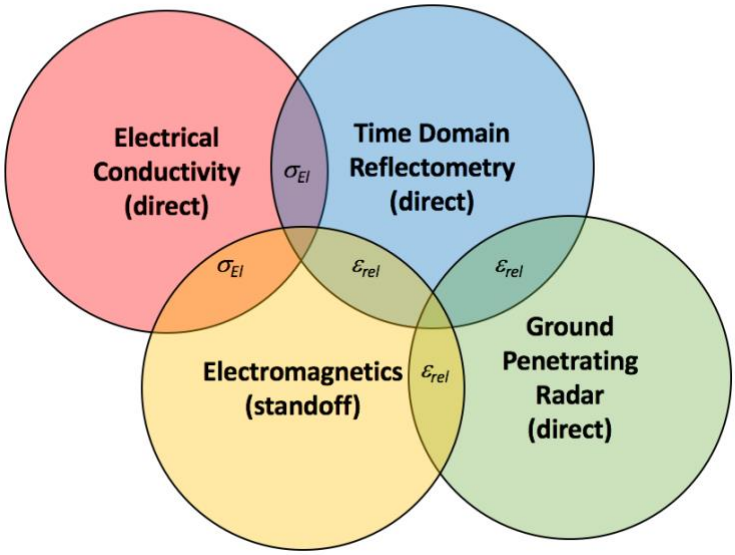

Figure 1. Interrelationship of direct contact and standoff geophysical methods for measuring electrical conductivity and dielectric permittivity.