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Improved understanding of effects of soil saturation on induced polarization

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Induced polarization (IP) is an emerging technology that provides unique information on the physical and chemical properties of the interconnected pores and pore surfaces. While previous studies focused on fluid chemistry and matrix composition, more research into the effects of saturation (θ) and matric potential on IP is needed. The objective of this study was to determine the effects of unsaturated water content dynamics on IP parameters.

IP measurements were conducted over a range of moisture contents on a laboratory grade sand, an undisturbed agricultural soil consisting of silty sand. A soil column apparatus was designed that allowed for IP measurements at varying suctions, while also permitting measurements of in situ water tension and θ. Using these measurements we determined the soil hydraulic properties of the undisturbed soil samples and collected and correlated the IP data with observed hydraulic properties, primarily changes in saturation.

Similar to previous studies, decreases in θ resulted in a decrease in real conductivity and imaginary conductivity due to the removal of conductive pore fluid and the decrease in specific polarizability as pore fluid is removed. Due to an increase in salinity during the experiment, we observed a complex response of real conductivity during the course of the experiment. Unlike the real conductivity, imaginary conductivity was much less influenced by salinity. While imaginary conductivity exhibits a weaker dependence on saturation compared to real conductivity, its relative insensitivity to salinity may allow for a more robust measure of moisture content in the presence of changing salinities and under transient flow conditions. As changes in pore fluid conductivity are likely to occur in the field simultaneously with water content changes, we argue that, although IP has traditionally been used to discriminate lithology, time-lapse IP measurements may additionally provide a robust indicator of changes in saturation state.