Monitoring Freeze Thaw Transitions in Arctic Soils using Complex Resistivity Method

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The Arctic region, which is a sensitive system that has emerged as a focal point for climate change studies, is characterized by a large amount of stored carbon and a rapidly changing landscape. Seasonal freeze-thaw transitions in the Arctic alter subsurface biogeochemical processes that control greenhouse gas fluxes from the subsurface. Our ability to monitor freeze thaw cycles and associated biogeochemical transformations is critical to the development of process rich ecosystem models, which are in turn important for gaining a predictive understanding of Arctic terrestrial system evolution and feedbacks with climate.

In this study, we conducted both laboratory and field investigations to explore the use of the complex resistivity method to monitor freeze thaw transitions of arctic soil in Barrow, AK. In the lab studies, freeze thaw transitions were induced on soil samples having different average carbon content through exposing the arctic soil to temperature controlled environments at +4 ^{o}C and -20 ^{o}C. Complex resistivity and temperature measurements were collected using electrical and temperature sensors installed along the soil columns. During the laboratory experiments, resistivity gradually changed over two orders of magnitude as the temperature was increased or decreased between -20 ^{o}C and 0 ^{o}C. Electrical phase responses at 1 Hz showed a dramatic and immediate response to the onset of freeze and thaw. Unlike the resistivity response, the phase response was found to be exclusively related to unfrozen water in the soil matrix, suggesting that this geophysical attribute can be used as a proxy for the monitoring of the onset and progression of the freeze-thaw transitions. Spectral electrical responses contained additional information about the controls of soil grain size distribution on the freeze thaw dynamics. Based on the demonstrated sensitivity of complex resistivity signals to the freeze thaw transitions, field complex resistivity data were collected over time at the DOE Next Generation Ecosystem Experiment study site in Barrow, AK. This presentation will discuss the use of the laboratory and field experiments to gain a better understanding of the spatial and temporal dynamics of freeze-thaw processes that critically control subsurface biogeochemical functioning in Artic systems.