Multi-scale Geophysical Studies at the NGEE-Arctic Site

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Improving climate change prediction in high latitude systems requires an accurate understanding of both continuous and threshold-dominated permafrost dynamics. Quantifying the properties and states that govern permafrost dynamics (including variations of ground ice, active layer thickness, soil moisture, soil texture, infiltration pathways, temperature gradients, snow and permafrost distribution, cryopegs) and their impacts on the soil biogeochemistry and geomorphology is challenging because of the coupled nature and wide range of space and time scales over which these processes are manifest. As part of the Next Generation Ecosystem Experiments (NGEE-Arctic), we are developing geophysical-based methods to improve understanding of the complex and dynamic Arctic system across scales. Our studies are underway at the NGEE site in the Arctic Coastal Plain, a region vulnerable to global warming and where significant uncertainties with ecosystem feedbacks to climate exist. Our efforts are fourfold. We are:

(1) Advancing and deploying geophysical methods for improved characterization and monitoring of the Arctic tundra systems. Examples include improved approaches for inverting surface based electromagnetic data and novel multichannel analysis of seismic surface wave for characterizing the permafrost. These studies have revealed the presence of a partially unfrozen saline layer below a shallow permafrost layer which was later confirmed by drilling. Efforts are ongoing to explore if microbial degradation of organic carbon is active in this deeper zone.

(2) Developing stochastic methods to integrate geophysical, remote sensing, and point based measurements to estimate subsurface properties that can be used to initialize or parameterize models or lead to new understanding of system characteristics. Examples include the use of ground penetrating radar and electrical resistivity tomography to estimate active layer thickness, moisture content and snow depth..

(3) Performing dynamic experiments to advance understanding of coupled hydro-biogeochemical processes and associated geophysical signatures. Controlled freeze thaw column experiments are being conducted in the laboratory and include the co-acquisition of geophysical, geochemical and microbiological measurements. Early results are revealing good correlations between geophysical signals and freeze thaw state as well as between surface greenhouse gas fluxes with temperature and thaw depth in the column.

(4) Developing tractable approaches to characterize Arctic systems and the properties that control system functioning across scales. Through jointly using ground- and aerial-based imaging methods, a strong correspondence between land and subsurface property variations has been identified and a zonation approach has been developed to delineate regions having unique distributions of properties that influence microbial carbon degradation and greenhouse gas fluxes.