**Geophysics-based Multiscale Characterization of the Arctic Tundra Ecosystem**

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Working within an Arctic ice-wedge polygonal region near Barrow AK, we have developed geophysics-based strategies to estimate the spatially heterogeneous aboveground/belowground ecosystem properties – such as vegetation, soil moisture, soil temperature, thaw depth, soil hydrological and mechanical properties, and greenhouse gas (GHG) fluxes – as well as to understand their interaction and dynamics from the core-scale (~10cm) to the site-scale (~1km). Laboratory core analysis provided new insights into biogeochemical processes and associated geophysical signatures. Freeze-thaw experiments using a soil column were performed to quantify how progression of a thaw front influences biogeochemical and mechanical responses, and the associated electrical signature. Results revealed a significant ‘spring burp’ of GHG at first thaw (also detected in field data), and changes in electrical responses associated with soil mechanical failure, controlling GHG fluxes. Seismic petrophysical studies provided information needed to interpret and validate field seismic imaging of an unfrozen region of saline permafrost. X-ray computed tomography was used to identify the structure of active and permafrost layers, aiding the interpretation of field geophysical data and revealing fine-scale cyrostructures that may play a significant role in gas transport. Core measurements of hydrological, mechanical and electrical properties provided direct information for model parameterization such as hydraulic conductivities.

Field data collection focused on establishing and quantifying the spatiotemporal linkage among various above/belowground properties in high resolution, using spatially extensive remote sensing and surface geophysical data. We developed a nested monitoring strategy, including seasonal campaigns along 500x40 m ‘intensive sampling’ corridors, as well as continuous autonomous monitoring of ecosystem dynamics at high temporal/spatial resolution along a 35 m transect. Continuous monitoring enabled us to visualize a tightly coupled system such as the correlation between the electrical conductivity (sensitive to water content and soil structure) and thawed layer thickening and vegetation development during the growing season. The datasets at the ‘intensive sampling’ corridors were used to develop a ‘functional zone’ approach for integrating multi-type multiscale datasets and for distributing critical land- and subsurface properties over the landscape. A statistical analysis confirmed that polygon types could be regarded as Arctic ecosystem functional zones, capturing the variations in important ecosystem properties (including GHG fluxes). In addition, seismic data provided the properties of deep permafrost units, in particular the vertical and lateral extent of partially frozen soils beneath the surficial ice wedge complex. Together, the geophysics-based acquisition and inversion approaches are providing unique high-resolution information and new insights about the Arctic ecosystem functioning as well as providing information to models - at scales and resolutions useful for predicting terrestrial ecosystem feedbacks to the climate.