Poster #1-11

Quantifying Ecosystem Functional Zones and Associated Relationships between Permafrost, Soil, Land Surface and Vegetation Properties in Arctic Systems using Geophysical Datasets

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BER Program: TES
Project: NGEE Arctic
Project Website: https://ngee-arctic.ornl.gov/

Understanding interactions between permafrost, soil, land surface and vegetation processes is critical for predicting the storage and flux of carbon, particularly in Arctic environments. However, quantifying above-below ground interactions is challenging due to process complexity, lack of sensing systems jointly monitoring key processes in different compartments, and the spatial variability of above-below ground interactions as a function of position within the ecosystem and season. Below we describe key advances developed during NGEE-Arctic Phase 2 to address these challenges. Advanced quantification and understanding of surface-subsurface interactions has been enabled by the development of several innovative acquisition and numerical techniques including (1) an autonomous above-below ground sensing system using pole-mounted cameras and geophysical datasets to monitor the spatiotemporal relationship between plant vigor, soil thaw depth and soil moisture, (2) a low-cost dense sensor network for Distributed Temperature Profiling (DTP) that provides unprecedented vertical and horizontal distribution of soil temperature and is adapted for integration with remote sensing data (incl., UAV), and (3) a novel inverse modeling technique that takes advantage of streaming hydro- thermal-geophysical datasets to estimate conventionally difficult to quantify properties, such as soil organic carbon. With the above novel approaches we have highlighted significant relationships between above- and belowground characteristics including: (1) the control of polygon geomorphology on soil hydro-physicochemical properties, the snow thickness, and the plant vigor at the Utqiaġvik site, (2) the effects of topography and vegetation on snow depth, and with subsurface characteristics on the distribution of near-surface permafrost and taliks in warm permafrost environments, and (3) the significant influence of soil hydrological and thermal behavior on the biogeochemical CO_2 and CH_4 fluxes. Using the newly developed relationships between permafrost, soil, land surface and vegetation processes, as well as the identification of distinct ecosystem functional zones, we documented how localized ground based 'point' measurements can tractably be scaled to landscape scales. For example, we integrated net ecosystem exchange (NEE) measurements acquired using sparse ground-based chambers with collocated time-series of normalized difference vegetation index (NDVI) and with spatially extensive airborne LiDAR and NDVI datasets to estimate C fluxes as a function of polygon- based zones. Overall, advances and integration of new sensors and inversion approaches and ecosystem zonation construct has allowed us to quantify how complex Arctic systems behave at local scales as well as their aggregated responses at landscape scales. The obtained information is expected to be useful for improving predictions of Arctic ecosystem feedbacks to climate.