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Quantifying and Relating Subsurface and Land-surface Variability in Permafrost Environments using Surface Geophysical and LIDAR Datasets.

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A new U.S. Department of Energy project, called the Next-Generation Ecosystem Experiments (NGEE), has recently been initiated to address how permafrost thaw and degradation - and the associated changes in landscape evolution, hydrology, soil biogeochemical processes, and plant community dynamics - affect feedbacks to the climate system. Quantifying subsurface properties and states that govern permafrost dynamics is challenging due to the need to sample over large spatial regions in high resolution and with minimal disturbance to the ecosystem. Here, we explore the use of remotely sensed, high resolution topographic and surface geophysical data together with point-based soil measurements to characterize active layer and shallow permafrost variability, topographic variability, and their linkages. This quantification represents a first step towards improved initialization and parameterization of climate models in poorly understood, but globally important terrestrial ecosystems. Our study is performed within the Arctic Coastal Plain in Alaska in the Barrow Environmental Observatory.

The data were collected along and in the vicinity of several ~500m transects and included (a) high resolution LIDAR measurements; (b) surface-based ground penetrating radar, electrical resistivity and phase data and electromagnetic data; and (c) point-based soil temperature, moisture, geochemistry and texture as well as active layer thickness measurements. The presentation will describe the acquisition, inversion and analysis of the different datasets. It will also describe the approaches used to explore relationships between the geophysical attributes (including electrical conductivity, electrical phase, and radar travel time, velocity and amplitude) to subsurface and surficial properties and states.

Interpretation of the data leads to three main findings. First, advanced assessment of the LIDAR data in terms of permafrost degradation metrics indicates that the land surface can be delineated into three distinct classes of polygonal ground along the transects: high-centered, moderately-low centered, and a region of low-centered polygonal ground. Secondly, analysis of the geophysical and point measurements reveals that there are distinct geophysical responses to active layer and shallow permafrost heterogeneities. Finally, we find that the geophysically-defined subsurface zonation corresponds with the three surficially-identified classes of polygonal ground. These findings document the potential of surface geophysical methods for quantifying subsurface controls on permafrost degradation. Furthermore, if linkages between subsurface and land-surface variabilities (such as documented here) are common in permafrost environments, our study suggests that integration of surface geophysical and LIDAR datasets should permit estimates of properties and states that influence ecosystem feedbacks to climate to be transferred from below to above ground and across scales.