Scaling Process Studies and Observations in the Arctic for Improved Climate Predictability

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A fundamental goal of the Next-Generation Ecosystem Experiments (NGEE-Arctic) project is to improve climate prediction through process understanding and representation of that knowledge in Earth System models. Geomorphological units, including thaw lakes, drained thaw lake basins, and ice-rich polygonal ground provide the organizing framework for our model scaling approach for the coastal plains of the North Slope of Alaska. A comprehensive suite of process studies and observations of hydrology, geomorphology, biogeochemistry, vegetation patterns, and energy exchange and their couplings will be undertaken across nested scales to populate the NGEE hierarchical modeling framework and to achieve a broader goal of optimally informing process representations in a global-scale model. A central focus of this challenge is to advance process understanding and prediction of the evolution of permafrost degradation and its impact on topography and thermal conditions and how these changes control the spatial and temporal availability of water for biogeochemical, ecological, and physical feedbacks to the climate system. Field activities to inform model development is being carried out across a gradient of polygonal ground nested within a drained thaw lake basin age gradient near Barrow, Alaska. Co-analysis of in-situ observations with ground based geophysical and airborne and satellite based remote sensing products from the single polygon to multiple drained lake basin scale is revealing surface-subsurface variability and interactions that influence or control local hydrology, greenhouse gas production, vegetation and the energy balance. We are using a range of data assimilation and fusion techniques to combine spatially extensive data sets developed from multi-scale field data with intensive data being collected from both controlled laboratory experiments using field cores and in-situ thermal, hydrologic, biogeochemical and ecologic observations to improve process understanding and parameterize, calibrate and evaluate models. Process studies that have the greatest potential for reducing prediction uncertainty were prioritized, including studies focused on: improving the mechanistic understanding of permafrost degradation and its influence on water distribution; quantifying mechanisms and rates associated with organic carbon decomposition in Arctic soils; and developing response functions relating plant community composition and phenology to resource gradients created by high-centered and low-centered polygons and other permafrost landscape features. A metric of effectiveness for our scaling approach will be the degree to which prediction at each successive scale is improved as the result of integration of observations and models.

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