Next-Generation Ecosystems Experiment (NGEE Arctic): Progress and Plans

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An important challenge for Earth System Models (ESMs) is to accurately represent land surface and subsurface processes and their complex interactions in a warming climate. This is true for all regions of the world, but it is especially important for high-latitude Arctic ecosystems which are projected to warm at a rate twice that of the global average by the end of the 21st century. The Next-Generation Ecosystem Experiments (NGEE Arctic) is a 10-year project (2012 to 2022) that seeks to increase our confidence in global climate projections through a coordinated series of model-inspired investigations undertaken by a collaborative team of modelers, data managers, and empiricists spanning a range of scientific disciplines. NGEE Arctic focuses on high-latitude ecosystems underlain by carbon-rich permafrost that are vulnerable to thaw in a warmer climate. In Phase 1 (2012 to 2014), NGEE Arctic tested and applied a multi-scale measurement and modeling framework for ecosystems and watersheds characterized by cold, continuous permafrost on the North Slope of Alaska. These efforts provided datasets for model parameterization and benchmarking and knowledge on topics ranging from watershed hydrology to plant physiology. These data are being adopted by DOE's Earth System Modeling program as fundamental new developments in a next-generation ESM, the Accelerated Climate Model for Energy (ACME). In Phase 2 (2015 to 2018), we have established a southern field site on the Seward Peninsula which, compared to our research site on the North Slope, is characterized by transitional ecosystems; warm, discontinuous permafrost; higher annual precipitation; and well-defined watersheds with strong topographic gradients. Our selection of the Seward Peninsula is based on a Phase 1 analysis indicating that western Alaska is a proxy for the future ecological and climatic regime of the North Slope of Alaska toward the end of the century. New sites on the Seward Peninsula will expand our understanding and model representation of (1) landscape structure on the storage and flux of carbon, water, and nutrients, (2) edaphic and geochemical mechanisms responsible for variable CO_2 and CH_4 fluxes across a range of permafrost conditions, (3) variation in plant functional traits across space and time, and in response to changing environmental conditions, (4) controls on shrub distribution and associated climate biogeochemical and biophysical feedbacks to climate, and (5) changes in surface and groundwater hydrology expected with warming in the 21st century. Our vision in Phase 1, and now extended into Phase 2, strengthens the connection between process studies in Arctic ecosystems and high-resolution landscape modeling and scaling strategies that will foster a strong interaction across the DOE Biological and Environmental Research (BER) program. The NGEE Arctic project supports the BER mission to advance a robust predictive understanding of Earth's climate and environmental systems by delivering a process-rich ecosystem model, extending from bedrock to the top of the vegetative canopy/atmospheric interface, in which the evolution of Arctic ecosystems in a changing climate can be modeled at the scale of a high-resolution, next-generation ESM grid cell. Research in Phase 1, and now proposed for Phase 2, prepares our team for pan-Arctic simulations of ecosystem-climate feedbacks in Phase 3 (2019 to 2022). Safety, collaboration, communication and outreach, and a strong commitment to data management, sharing, and archiving are key underpinnings of our model-inspired research in the Arctic.