Integrating Arctic Vegetation and Biogeochemical Processes into the E3SM Land Model

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Earth system models are a critical tool for projecting future changes in climate and ecosystems. A major goal of the NGEE Arctic project is to integrate improved scientific understanding of Arctic systems into the Energy Exascale Earth System Model (E3SM) to connect scientific discoveries from observations, experiments, and detailed modeling of the Arctic into global-scale predictive models. New understanding of Arctic processes is being incorporated into hydrological, physical, biogeochemical, and vegetation process modules in the E3SM Land Model (ELM) through multiple integrative modeling efforts as part of NGEE Arctic Phase 3. I will highlight recent progress in two of these integrative modeling efforts. First, improvements to ELM with the goal of better representing vegetation traits by integrating nine tundra-specific plant functional types (PFTs); several that are new to the model, including nonvascular mosses and lichens, graminoids, forbs, and shrubs of various height classes as well as a nitrogen fixing alder shrub. These developments leverage extensive field sampling of vegetation species distributions and biomass and are now being integrated with remote sensing of vegetation communities and traits to configure ELM model simulations of tundra vegetation carbon and nutrient cycling across the Seward Peninsula of Alaska. Second, we have implemented new soil biogeochemical capabilities with the goal of better representing greenhouse gas production across complex tundra landscapes. We have developed a reaction network in the geochemical simulator PFLOTRAN including pH dynamics, iron redox cycling, oxygen consumption, methanogenesis, and soil nitrogen cycling informed by experimental and field measurements of tundra soil processes. Furthermore, we have coupled this reaction network to ELM representation of soil organic matter decomposition within a coupled ELM-PFLOTRAN framework, allowing fully integrated simulations of complex biogeochemical cycling within E3SM. Altogether, these developments translate discovery science from a range of observations, experiments, and detailed modeling studies within the NGEE Arctic project into concrete improvements in E3SM modeling capabilities.