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Refining ELM Simulations of Arctic Field Sites Using Vegetation Community and Biomass Measurements

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Land surface models, including the E3SM Land Model (ELM), conceptualize plant communities using mixtures of plant functional types (PFTs) with fixed parameter values. PFT definitions and parameters defined in the context of global simulations often do not correspond well with plant communities at the scale of individual sites. This is an especially important issue in Arctic ecosystems, where plant communities vary over small spatial scales and are often dominated by grass, shrub, moss, and lichen vegetation types that are not well represented in global models. We used a combination of plant community surveys and biomass measurements to define and parameterize plant communities specific to the Kougarok field site, located on the Seward Peninsula and part of the NGEE-Arctic field program. The Kougarok site encompasses a range of ecotypes, including alder shrubland, tussock tundra, and rocky areas dominated by dwarf shrubs and lichens. We defined new arctic-specific PFTs within ELM, including dwarf evergreen shrubs, arctic mosses, and arctic grasses, and modified their allometric and stoichiometric parameters based on site measurements of biomass, productivity, and tissue stoichiometry.

Compared to model simulations using baseline ELM parameters, site-specific PFTs and parameterizations yielded more accurate simulations of canopy height, total biomass, aboveground-belowground partitioning of biomass, and annual net primary production. Differences in plant communities and vegetation traits across the Kougarok site led to variations in both total vegetation biomass and soil carbon stocks that could not be reproduced using baseline ELM PFTs. Simulations with updated PFTs also produced significantly different ecosystem-level responses of biomass and soil carbon to projected warming scenarios at the Kougarok site. These results highlight the value of site-specific vegetation measurements for developing accurate simulations of current and future carbon and nutrient cycling in arctic ecosystems.