Representing northern peatland microtopography and hydrology within the Community Land Model

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Abstract

Predictive understanding of northern peatland hydrology is a necessary precursor to understanding the fate of massive carbon stores in these systems under the influence of present and future climate change. Current models have begun to address microtopographic controls on peatland hydrology, but none have included a prognostic calculation of peatland water table depth for a vegetated wetland, independent of prescribed regional water tables. We introduce here a new configuration of the Community Land Model (CLM) which includes a fully prognostic water table calculation for a vegetated peatland. Our structural and process changes to CLM focus on modifications needed to represent the hydrologic cycle of bogs environment with perched water tables, as well as distinct hydrologic dynamics and vegetation communities of the raised hummock and sunken hollow microtopography characteristic of peatland bogs. The modified model was parameterized and independently evaluated against observations from an ombrotrophic raised-dome bog in northern Minnesota (S1-Bog), the site for the Spruce and Peatland Responses Under Climatic and Environmental Change experiment (SPRUCE). Simulated water table levels compared well with site-level observations. The new model predicts significant hydrologic changes in response to planned warming at the SPRUCE site. At present, standing water is commonly observed in bog hollows after large rainfall events during the growing season, but simulations suggest a sharp decrease in water table levels due to increased evapotranspiration under the most extreme warming level, nearly eliminating the occurrence of standing water in the growing season. Simulated soil energy balance

was strongly influenced by reduced winter snowpack under warming simulations, with the warming influence on soil temperature partly offset by the loss of insulating snowpack in early and late winter. The new model provides improved predictive capacity for seasonal hydrological dynamics in northern peatlands, and provides a useful foundation for investigation of northern peatland carbon exchange.