Integrating In-situ Data with a Model for Examining Community-level CO_2 and CH4 flux in a Carbon-rich Peatland in Northern Minnesota

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Peatlands are featured as carbon-rich and vertically dynamic for hydrological and biogeochemical processes, which will significantly influence the ecosystem function and their responses to environmental changes. Therefore, the investigation of community-level flux of carbon dioxide (CO_2) and methane (CH4), the two most important greenhouse gases, requires a focus on belowground dynamics of hydrological and biogeochemical mechanisms. An ombrotrophic Picea-Sphagnum peatland located on the Marcell Experimental Forest in northern Minnesota is being prepared for experimental manipulations to evaluate carbon cycle responses to warming and elevated CO_2. A custom-designed chamber, which encloses the hummock-hollow topography and allows point-in-time measurements of the shrub, forb, Sphagnum and the complex microbial community, are designed and applied to seasonal measurements of the flux of CO_2 and CH4 from experimental plots. Periodic observations from August 2011 through July 2013 showed clear seasonal trends with temperature being the obvious driving variable. Interpolation of the observed C flux across annual periods showed dark CO_2 and CH4 flux to be ~1000 and ~25 gC m-2y-1, respectively. After accounting for daytime photosynthetic CO_2 uptake, the net CO_2 efflux from the bog was approximately ~100 gC m-2y-1.

These field observational data of CO_2 and CH4 flux and data of soil and vegetation properties were integrated with a model (improved version of the Community Land Model 4.5) which explicitly represents the carbon processes for CO_2 and CH4 production and consumption and lateral flow, the critical hydrological processes for wetlands. The modeled seasonality and annual budget of both CO_2 and CH4 flux and hydrological processes are consistent with field observations. The vertical profiles of concentrations and productions of dissolved organic carbon, CO_2, and CH4, are examined for their linkages with land-surface fluxes. The reliable performance of the model in simulating hydrological and biogeochemical processes for CO_2 and CH4 flux suggests that the model is a robust tool for evaluating peatland carbon cycling and its responses to future environmental change. The presented data-model integration approach helps advance our understanding of belowground biogeochemical mechanisms, and would be valuable for supplementing planned manipulative experiments.