

Improving prediction of climate change impacts on wetland-rich landscapes: Testing model mechanisms with flux-data assimilation at multiple sites

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ABSTRACT

Objectives

Prediction of climate change impacts on terrestrial carbon fluxes is highly uncertain. Upland ecosystem models, even when constrained with flux tower data, fail to explain interannual variability in CO₂ fluxes in the upper Midwest. One possible reason is lack of model mechanisms for wetland biogeochemistry and hydrology, where fluxes would be expected to vary with changes in depth to saturation. Wetlands are expected to be highly sensitive to climate change. We propose to develop a wetland-landscape model and assimilate long-term multiple flux tower observations to simulate wetland and upland mechanisms simultaneously, with evaluation against unassimilated flux observations. Model evaluation is typically limited to single sites and extrapolation of these results across larger regions is questionable. This research will improve understanding of carbon-rich forest-wetland landscape response to climatic change.

Hypotheses

We hypothesize that 1.) integration of wetland biogeochemistry and hydrology into a terrestrial carbon cycle model will permit observed interannual variability and trends in carbon and water fluxes to be explained for wetland landscapes and 2.) assimilation of flux data from multiple spatially co-located upland and wetland sites into a common model will lead to improved capability to predict regional scale fluxes.

Location

Northern Wisconsin, USA including Lost Creek, WLEF, and other regional Ameriflux tower sites.

Methods

We will incorporate wetland hydrology and biogeochemistry into the existing TREES model, which has been successfully used in the region to simulate transpiration. Observational data and Bayesian sensitivity analyses will investigate primary controls on wetland CO₂ flux variability. Established parameter optimization methods will incorporate data from a suite of upland and wetland flux towers to constrain parameters that control CO₂ and H₂O flux. The optimized model will be evaluated against unassimilated upland and wetland fluxes. Long-term climate change scenarios will be run to quantify the effect of constraining model predictions of vegetation responses to climate change. This proposal also supports continued maintenance of flux tower observations essential to this study.

Deliverables and Outcomes

The new model is expected to fill a major gap in mechanistic understanding of forested wetlands. It will provide 1.) tested wetland model mechanisms with multi-year, multi-site evaluation and 2.) reduction in uncertainty of wetland landscape regional flux and its response to future climatic change. Model code, parameter sets and data output will be available online. Publications detailing model development, optimization, evaluation, scaling and long-term prediction are expected. This proposal also supports training of a graduate student and postdoctoral scholar.