Using a spatially-distributed hydrologic biogeochemistry model to study the spatial variation of carbon processes in a Critical Zone Observatory

Yuning Shi[1], David Eissenstat[1], Kenneth Davis[2,3], Jason Kaye[1]

Forest carbon processes are affected by soil moisture, soil temperature, Nitrogen availability and solar radiation. Most of the current biogeochemical models are 1-D and represent one point in space. Therefore they can neither resolve topographically driven hill-slope soil moisture patterns, nor simulate the nonlinear effects of soil moisture on carbon processes. A spatially-distributed ecosystem-hydrologic model, Flux-PIHM-BGC, has been developed by coupling the Biome-BGC (BBGC) model with a coupled physically-based land surface hydrologic model, Flux-PIHM. Flux-PIHM incorporates a land-surface scheme (adapted from the Noah land surface model) into the Penn State Integrated Hydrologic Model (PIHM). Because PIHM is capable of simulating lateral water flow and deep groundwater, Flux-PIHM is able to represent the link between groundwater and the surface energy balance, as well as the land surface heterogeneities caused by topography.

Flux-PIHM-BGC model was tested at the Susquehanna/Shale Hills critical zone observatory (SSHCZO). The abundant observations at the SSHCZO, including eddy covariance fluxes, soil moisture, groundwater level, sap flux, stream discharge, litterfall, leaf area index, aboveground carbon stock, and soil carbon efflux, provided an ideal test bed for the coupled model. Model results show that the vegetation and soil carbon distribution is primarily constrained by N availability (affected by N transport driven by topography), and also constrained by solar radiation and root zone soil moisture. The predicted vegetation and soil carbon distribution generally agrees with the macro pattern observed within the watershed. The coupled ecosystem-hydrologic model provides an important tool to study the impact of topography on watershed C processes.

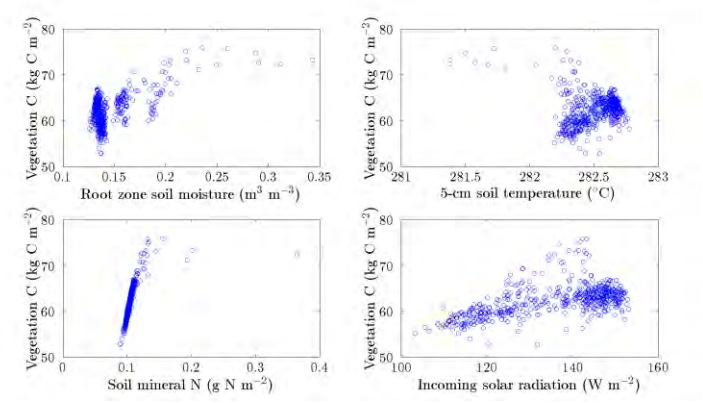

Figure 1 Annual average vegetation carbon plotted as functions of root zone soil moisture, soil temperature, soil mineral N, and incoming solar radiation from Flux-PIHM-BGC simulation. Each point represent on grid in the Shale Hills watershed model domain.

[1] Department of Ecosystem Science and Management, The Pennsylvania State University.
[2] Department of Meteorology, The Pennsylvania State University.
[3] Earth and Environmental Systems Institute, The Pennsylvania State University.