Exploring the Influence of Topography on Belowground C Processes at the Shale Hills Critical Zone Observatory

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Belowground carbon processes are strongly affected by soil moisture and soil temperature. Current studies are generally limited to sites with relatively uniform topography, and seldom connect the impacts of natural variation in soil moisture associated with topography to multiple C cycle processes. Likewise, current biogeochemical models are 1-D and cannot resolve topographically driven hill-slope soil moisture patterns, and cannot simulate the nonlinear effects of soil moisture on carbon processes. In this project we will assess the influence of topography on multiple belowground processes (soil CO_2 efflux, soil C, microbial biomass, root density, root production, and root turnover) and develop a coupled modeling system capable of simulating the water and carbon dynamics of this complex system.

A spatially distributed forest ecosystem model has been developed by coupling a 1-D mechanistic biogeochemistry model Biome-BGC (BBGC) with a spatially distributed land surface hydrologic model, Flux-PIHM. Flux-PIHM is a coupled physically based model, which incorporates a land-surface scheme into the Penn State Integrated Hydrologic Model (PIHM). The land surface scheme is adapted from the Noah land surface model. 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. In the coupled Flux-PIHM-BBGC model, each Flux-PIHM model grid couples a 1-D BBGC model. Flux-PIHM provides BBGC with soil moisture and soil temperature information, while BBGC provides Flux-PIHM with leaf area index.

The coupled Flux-PIHM-BGC model has been implemented at the Susquehanna/Shale Hills critical zone observatory (SSHCZO). Preliminary results show that the Flux-PIHM-BBGC simulated soil carbon pool shows clear impact from topography. The simulated vegetation carbon pool is mainly affected by vegetation type.

We have collected root length density at 250 sites in the Shale Hills catchment to a maximum depth of 165 cm. Initial results show relatively modest differences in root distribution by depth based on topographic position at the site. Soil analysis from each core sample is currently being processed. The combination of root and soil measurements will also be used as important input parameters and calibration and evaluation data for the Flux-PIHM-BGC model.

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