Quantitative Soil-landscape Modeling: A Key to Linking Ecosystem Processes on Hillslopes

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Quantitative soil-landscape models provide a spatial and structural component of the soil subsystem that may be integrated into broader ecosystem models for studying process dynamics and ecosystem function over time. With a plethora of new tools (i.e. remote sensing, digital elevation modeling, GPS, GIS, spatial statistics) available for quantifying soil-landscape patterns, soil-landscape models should supplant traditional "static" soil maps in most applications because specific models can be developed based on the situational circumstances (available data, spatial dispersion, laboratory analyses, quality of available continuous variables for environmental correlation, scale of application). Because of the diversity of factors influencing soil formation in different environments and the broad mix of potential tools for sensing and quantifying patterns, it is likely that standard methods should not be advocated, but rather a mix of tools and techniques applied within a flexible implementation framework.

Existing simulation models for carbon cycling, water and nutrient movement in ecosystems often do not deal explicitly with the critical role of topography as a modifier of local climate and parent material patterns. On hillslopes, ecosystem processes commonly operate in response to redistribution of soil water along flow lines that can be quantified using digital terrain attributes incorporated into soil-landscape models as explanatory variables. Simulation models linked to soil-landscape models provide more realistic ecosystem simulation because of better characterization of hillslope shape and convergence or divergence of water flow.

For greater detail on soil-ecosystem processes, we must rely on in-situ monitoring of fluxes of soil water and temperature, soil gas and nutrients. In addition, unraveling complex ecosystem processes often requires use of isotopic tracers to determine features such as soil-carbon turnover (^{13}C and ^{14}C), soil-water evaporation and transpiration (^{18}O), and source of ecosystem nutrients (^{87}Sr). Process studies require expensive, intensive site-specific sampling that must be linked to a broader context. Soil-landscape models provide a powerful scaling mechanism that can link results of site specific process analyses into a spatiotemporal framework. This talk will discuss and demonstrate the integration of tools and techniques for the study of ecosystem processes.