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Vegetation controls on soil hydraulic properties and and co-evolution in semi-arid hillslopes: fieldwork and modelling

Ciaran Harman (1), Kathleen Lohse (2), Peter Troch (3), Murugesu Sivapalan (1,4,5)

(1) University of Illinois at Urbana-Champaign, Civil and Environmental Engineering, Urbana, United States (charman2@uiuc.edu), (2) School of Natural Resources, University of Arizona, Tucson, AZ, USA, (3) Hydrology and Water Resources, University of Arizona, Tucson, AZ, USA, (4) Department of Geography, University of Illinois at Urbana-Champaign, Illinois, USA, (5) Water Resources Section, Faculty of Civil Engineering and Geosciences, Delft University of Technology, The Netherlands

Soil properties and their associated spatial structure exert major controls on the storage and fluxes of water through surface soils and provide habitat and resources for life in the critical zone. Rather than being static properties of the landscape, these properties and structures are dynamics. In particular it has been observed that a range of biotic processes are responsible for the formation and maintenance of these properties. For example the build up of organic matter in soils can affect the water retention properties, and root channels can create soil macropores, increasing infiltration rates. These observation suggest that feedbacks between vegetation and soils may occur, such that the action of vegetation on its soil environment alters the hydrologic variability of soil, with consequences (positive and negative) for plant functions. To investigate this possibility, a model of the feedbacks between hydrologic variability, vegetation function and soil formation in a three-dimensional domain was constructed. This model uses simplified representations of the relevant processes in order to avoid excessive parameterization and model complexity. It will be used to examine how vegetation, soils and hydrologic processes co-evolve in the landscape, generating three-dimensional spatial patterns, and how these patterns control the hydrologic variability of those landscapes.

A key, unavoidable area of process uncertainty in this model is the connection between alterations in soil composition and alterations in hydraulic properties. To parameterize these relationships for some characteristic cases, the associations between vegetation and soil hydraulic properties were examined in four semi-arid ecosystems in southern Arizona, encompassing two lithologies and two climates. The results demonstrate that the build-up of organic matter under vegetation can significantly alter soil hydraulic properties over small spatial scales. We will present the results of the field-work and modeling, and suggest directions for future research.