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Role of Solar Radiation and Topography on Soil Moisture Variations in Semiarid Aspect-Controlled Ecosystems

Ankur Srivastava, Omer Yetemen, Nikul Kumari, and Patricia M Saco
Civil, Surveying and Environmental Engineering, The University of Newcastle, Callaghan, NSW, Australia

Water-limited ecosystems are characterized by considerable soil moisture variability (SMV) induced by the presence of a non-uniform vegetation distribution and climatic conditions, as well as the combined effects of aspect, topography, and incoming solar radiation. Partitioning of solar radiation and topographic influence is of utmost importance to know the exact source of variability in the soil moisture. To increase our understanding on this control, we used two different synthetic domains to conduct our numerical simulations that capture the joint effect of aspect and other key environmental factors on SMV. The topography of two different domains consisting of diffusion dominated (convex hillslopes) and fluvial dominated (concave hillslopes) landscapes were used. For each domain, we assume isotropic and homogeneous soil properties throughout the catchment. The sensitivity of different factors that were identified as relevant for SMV were investigated for spatially varied and uniform radiation. Simulations were performed by varying different factors within the prescribed range from the literature, and the coefficient of variation (CV) for mean soil moisture computed for analysis. We found that incoming solar radiation plays a vital role in determining SMV. In addition, SMV is exaggerated moving towards the higher latitude due to the latitudinal variation of incoming solar radiation for spatially varied radiation case. Further, fluvial dominated landscapes have higher coefficient of variation than diffusion dominated landscapes as heterogeneity in incoming solar radiation is more at steeper slopes. Heterogeneous precipitation over the landscape leads to significant variation in soil moisture for both spatially varied and uniform radiation cases. Consequently, heterogeneous precipitation with spatial varied solar radiation associated with the effect of topography could lead to the enhancement of spatio-temporal variability. These outcomes show: (1) the role of solar radiation is the major source of soil moisture heterogeneity; (2) the variability is modulated by topography under uniform soil properties and rainfall; (3) uniform changes in soil properties slightly affect SMV.