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Shrub patterns and surface hydrological fluxes in a semiarid hillslope

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Climate-vegetation interactions and feedbacks are the subject of many studies and recently, the rainfall-plant-soil interplay in the hillslope scale is in the foci of ecohydrology. As most of the models in this scale rely on synthetic environments, there is a need for studies that use remotely sensed and *in-situ* data to examine the effect of hillslope hydrological processes on ecosystem functioning and plant population spread in a more realistic manner. A major problem is the difficulty encountered in simulating water budget and measuring vegetation at the individual level. In this research, a typical hillslope was chosen offering variations in slope decline and orientation, soil depth and vegetation cover, at the LTER Lehavim site in the center of Israel ($31^{0}20'$ N, $34^{0}45'$ E). The annual rainfall is 290 mm, the soils are brown lithosols and arid brown loess and the dominant rock formations are Eocenean limestone and chalk with patches of calcrete. The vegetation is characterized by scattered dwarf shrubs (dominant species *Sarcopoterium spinosum*) and patches of herbaceous vegetation, mostly annuals, are spread between rocks and dwarf shrubs. Eight areal photographs of the slope, between the years 1978-2005, were acquired, georeferenced and shrub cover was estimated based on supervised classification of the airphotos. An extensive spatial database of soil hydraulic and environmental parameters (e.g. slope, radiation, bulk density, soil depth) was measured in the field and interpolated to continuous maps using geostatistical techniques and physically-based modeling. This spatio-temporal database was used to characterize 1187 spatial cells serving as an input to a numeric hydrological model (Hydrus 1D) solving the flow equations to predict soil water content at the single storm and seasonal scales. The model was verified by sampling soil moisture at 63 random locations at the research site, during three consecutive storms in the 2008-09 rainy seasons. The results show that shrub-grass ratio (SGR) reached a steady state phase with 20% cover in 1992 (after 14yr). This recovery rate is in agreement with previous field studies. Quantification of the factors affecting shrub establishment was done using stepwise regression, showing that slope decline, radiation, soil texture, and rockiness are the leading physical factors. Furthermore, a regression model that was applied between the integral of predicted soil moisture (based on 30 years climate data record) and the shrub cover integral show that the soil moisture model explained 31% of shrub cover variation during this period. The use of Spatial Analysis by Distance Indices (SADIE) technique reveals that in areas of higher vegetation cover there is strong and positive association between model outputs (soil moisture predictions) and shrub cover while only weak association was observed in regions of low vegetation cover. The results also show that this relationship is not stationary throughout the slope and when the slope is divided into discrete units, based on flowdirection analysis, the factors that affect shrub establishment differ with additional effect of soil depth at the west facing slope.