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Solar radiation and landscape evolution: co-evolution of topography, vegetation, and erosion rates in a semi-arid ecosystem

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In this study CHILD landscape evolution model (LEM) is used to study the role of solar radiation on the co-evolution of landscape morphology, vegetation patterns, and erosion rates in a central New Mexico catchment. In the study site north facing slopes (NFS) are characterized by steep diffusion-dominated planar hillslopes covered by co-exiting juniper pine and grass vegetation. South facing slopes (SFS) are characterized by shallow slopes and covered by sparse shrub vegetation. Measured short-term and Holocene-averaged erosion rates show higher soil loss on SFS than NFS. In this study CHILD LEM is first confirmed with ecohydrologic field data and used to systematically examine the co-evolution of topography, vegetation pattern, and erosion rates. Aspect- and network-control are identified as the two main topographic drivers of soil moisture and vegetation organization on the landscape. Landscape-scale and long-term implications of solar radiation driven ecohdrologic patterns emerged in modeled landscape: NFS supported denser vegetation cover and became steeper and planar, while on SFS vegetation grew sparser and slopes declined with more fluvial activity. At the landscape scale, these differential erosion processes led to asymmetric development of catchment forms, consistent with regional observations. While the general patterns of vegetation and topography were reproduced by the model using a stationary representation of the current climate, the observed differential Holocene erosion rates were captured by the model only when cyclic climate is used. This suggests sensitivity of Holocene erosion rates to long-term climate fluctuations.