HYDRAULIC RESISTANCE TO OVERLAND FLOW ON VEGETATED HILLSLOPES WITH MOBILE BED

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Estimation of hydraulic resistance to overland flow on vegetated hillslopes is crucial for appropriate modeling of flow routing determining sediment transport capacity, and quantifying soil erosion. In areas covered with patches of shrubs or woody plants, the hydraulic resistance may vary markedly over short distances and is largely determined by bed roughness and local flow conditions. Furthermore, erosion processes and bed mobility may lead to morphological changes that can alter the flow resistance by changing the surface roughness. There exists a large body of research on flow resistance. However, most of this work has investigated only a limited range of possible flow conditions and surface characteristics. Little information exists on how to relate the roughness coefficient of vegetated hillslopes with mobile bed to flow variables and erosion characteristics. Accurate quantitative predictions thus remain a challenge.

The objective of this study is to investigate the upscaling properties of the resistance coefficient by resolving the details of the flow process at very fine scales. A coupled model that considers a range of relevant physical processes, such as runoff generation, shallow water flow, soil erosion, and morphological changes is developed. Specifically, a hydrologic watershed model is coupled with a 2-D numerical solution of the Saint-Venant equations and the 2-D Hairsine-Rose erosion equations. The flow model provides accurate information on overland flow conditions, and the erosion model simulates sediment concentrations and deposited mass for various grain sizes. Several simulations are presented for a domain conceptualized as a sloped plane with a number of "obstacles" whose size is of the order of a few centimeters representing vegetation stems of infinite height. The numerical model permits the computation of spatially variable friction slopes and the estimation of time-dependent changes of bed elevation. The simulations explore how the resistance coefficient varies with different vegetation covers, domain slopes, flow rates, and degrees of bed mobility.