Channel networks’ emergence and evolution are controlled by the competition between the hillslopes and fluvial processes on the landscape. It is important to investigate the geomorphic and topologic properties of these networks for quantifying the roles of processes in creating distinct patterns of channel networks as well as to develop models for predicting the network dynamics under changing environment. In this dissertation, the response of landscapes to changing climatic forcing via numerical-modeling and field observations was investigated. For this, a new framework was proposed to evaluate complexity of catchments using two different representations of channel networks. The structural complexity was studied using the width function, which characterizes the spatial arrangement of channels. The incremental area function along the main channel was utilized to study the functional complexity that captures the patterns of transport of fluxes. Our analysis reveals stronger controls of topological connectivity on the functional complexity than on structural complexity, indicating unchannelized surface (hillslope) contribution to the increase of heterogeneity in transport processes.

Furthermore, A physically-based numerical landscape evolution model was used to investigate the channel network structure for varying hillslope and fluvial processes represented by different magnitudes of the soil transport (D) and fluvial incision (K) coefficients. We show that increasing (decreasing) D and K with the same proportion while keeping the same Péclet number (defined as the ratio between the timescales of advective (fluvial) to diffusive (hillslope) processes), results in distinct branching structure while the relief decreases (increases) exponentially. For example, for smaller D and K combinations (mimicking dry climate), higher number of branching channels was observed. Whereas, for larger D and K combinations (mimicking humid climate), higher number of side-branching channels is obtained. These results are consistent with the field observations suggesting that varying climatic conditions imprint distinct signatures on the branching structure of channel networks.

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The public is welcome to attend.