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# Physics-based hydrological modeling of the joint variations of stream network length and catchment discharge

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Understanding the spatiotemporal dynamics of runoff generation in headwater streams is crucial for better characterizing catchment functioning under current and projected climatic conditions. In this context, experimental data on the expansion and contraction of the stream network can be especially valuable. These data can be gathered exploiting different tools and techniques, from visual surveys to cameras, from remote sensing to electrical conductivity probes. New available data are often used to study joint variations of active stream length and discharge at the catchment outlet and allowed the scientific community to derive general laws for describing and interpreting such complex behavior. However, field mapping is highly time consuming, e.g. because the instruments deployed required an intense supervision to ensure the reliability of the data collected. Using physically based numerical models to simulate the spatial configuration of the wet channels and the corresponding catchment discharge thus represents a promising application. In this study, we used CATHY (CATchment HYdrology), an integrated surface–subsurface hydrological model, to study event-based dynamics of catchment discharge and active stream network in two synthetic catchments with pre-defined geological characteristics (hydraulic conductivity, porosity, water retention curve, depth to bedrock) and different morphometric properties (shape and slope). We run a set of simulations under time-variant conditions and under steady state conditions for different levels of catchment wetness and we analyzed the emerging relationship between total active length (L) and outlet discharge (Q). The numerical simulations were used to investigate the role of topography, climate and morphology on the dynamics of L and Q, and the ensuing L(Q) relationship. Numerical models can be a valuable tool for investigating the internal dynamics of the soil moisture that eventually drives the joint changes of river network length and discharge in response to precipitation.