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Streamflow generation in fully integrated surface-subsurface hydrological models for temporary streams with varying catchment and environmental characteristics

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For temporary streams (intermittent and ephemeral streams) the processes that control streamflow generation remain poorly understood, challenging our ability to characterize the dynamic behaviour of one of earth's most widespread water systems. With complex temporal and spatial interactions between surface water and groundwater, variable flow regimes, flashy and erosive flows, and unpredictable timing, field-based research is challenging and often not feasible in such systems. Integrated Surface-Subsurface Hydrological Models (ISSHM) can serve as a proxy to overcome these challenges. ISSHMs have been widely used in recent years for their ability to fully integrate the surface and subsurface flow domains and produce physically consistent simulations; however, most models are still limited to large scale spatial and temporal variability of the hydrological processes controlling streamflow generation The previous is particularly relevant for temporary streams, where streamflow generated at the catchment scale is often segmented. With losing, gaining and variably losing-gaining stream sections commonly present in temporary streams, it is necessary to be able to interrogate the models at any point within the catchment. ISSHMs combined with the Hydraulic Mixing-Cell method overcome this issue by allowing the identification and quantification of the contribution of all streamflow generation mechanisms to the hydrograph at any chosen point along the stream. This study implements an ISSHM coupled with the Hydraulic Mixing-Cell method to determine the main processes involved in runoff and streamflow generation for a range of synthetic catchments. A simple configuration of a symmetrical catchment with one river crossing in the middle was used to develop the synthetic scenarios. Contrasting catchment characteristics and environmental inputs were tested to examine their influence in model results with a total of 1080 unique model combinations. Varying catchment characteristics included a round and an elongated catchment shape with Form Factors of 0.44 and 0.82 respectively, a mild (0.02) and steep (0.05) hill slope, and soil hydraulic properties for a sandy and sandy loam soil. Similarly, a total of 27 rainfall and 5 potential evapotranspiration (ET_o) inputs were developed using maximum, minimum and average values typical of a South Australian catchment with Mediterranean climate. Rainfall datasets were developed by combining three total rainfall amounts (min, max and average) with event durations of 1, 2, and 3 days and inter-event lapses of 2, 5, and 8 days. ET_o was varied from min to max values in even increments. Additionally, hydrograph nodes were distributed every kilometer along the stream to determine the partitioning of contributing flow generation mechanisms into infiltration-saturation excess overland flow, stream interception, and groundwater discharge. The goal of this study is to understand the influences of catchment and environmental parameters and to identify the main drivers controlling streamflow generation and their spatiotemporal variability, in particular the threshold behaviour that results in temporary streams at the catchment scale.