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Hillslope inter-site comparisons to determine the controls on hillslope-stream connectivity and threshold catchment responses

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The relation between precipitation and streamflow is often characterized by a threshold, with runoff ratios or streamflow volumes being small during small events and dry conditions and increasing significantly during large events and wet conditions. These streamflow thresholds are frequently attributed to the addition of hillslope runoff to streamflow during large events and wet conditions and thus the hydrologic connection of hillslopes to the stream network. The addition of hillslope water to the stream can also lead to large changes in water quality. In areas where overland flow is uncommon, such as forested catchments in temperate climates, hillslope-stream connectivity requires the generation of lateral subsurface flow from hillslopes and a connection of saturated zones in hillslopes with each other and the riparian zone or the stream network.
Most hillslope hydrological studies have focused on the subsurface flow and groundwater responses at individual research sites, rather than extracting more general rules and controls on how saturated zones in hillslopes connect with each other and the riparian zone or stream. Even for well-studied hillslopes, it is difficult to determine the main controls on the expansion of saturated areas and hillslope-stream connectivity because of our limited ability to observe flow pathways in the soil, the spatial variability in soil properties, the limited spatial scale of our measurements, temporal variability in antecedent moisture conditions and because datasets are usually short and do not include extreme events. Numerical simulation allows for systematic analyses of hillslope hydrological responses without requiring a large number of observations. However, most hillslope modelling studies so far are based on datasets from a few intensively studied hillslopes for which data is made publicly available, and are thus partly biased to these hillslopes. Inter-site comparisons have been shown to provide useful information on commonalities and differences in the factors that control subsurface flow but remain rare, in part because of the different experimental approaches at each site and because of a lack of publicly available data from experimental hillslopes.
This presentation will provide an overview of how transient saturated zones in hillslopes connect with each other and the riparian zone and how this affects hillslope-stream connectivity and threshold streamflow responses. The initial comparison of groundwater responses at different experimental hillslope sites suggests that soil depth, soil type, bedrock permeability and surface and bedrock topography lead to different functional hillslope types. Comparison of these different functional hillslope types in terms of their structure and hydrological functioning allows classification of different hillslopes. This classification allows extrapolation of results from research hillslopes to other sites and helps with determining suitable field measurement campaigns and simulation approaches to describe hillslope-stream connectivity. It would, therefore, be useful for researchers from different experimental hillslopes to work together to compare hillslope groundwater and subsurface flow responses to obtain a more robust classification of functional hillslope types and the controls on hillslope-stream connectivity. Open sharing of data from experimental hillslope sites would promote these kind of inter-comparisons and advance our understanding of the controls on subsurface flow generation, hillslope-stream connectivity and threshold streamflow responses.