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Hydrological connectivity: From hillslopes to watersheds

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Research on runoff processes has focused on the differences between the main divisions of runoff partitioning. Indeed, our major advancements in runoff theory have come with new differentiations of various forms of overland flow and subsurface stormflow. These studies of 'how runoff processes are different' have resulted in our current summaries of runoff regimes conceptually (e.g. the Variable Source Area concept) and codified in our models (e.g. TOPMODEL and its derivatives). While such process differentiation was useful as new dominant forms of runoff were "discovered" in different climates with different soils, slope morphologies and vegetation cover continued differentiation does not appear helpful for improved understanding of soil runoff dynamics and streamflow generation. We seem to have exhausted the main list of runoff classes some decades ago, with perhaps the last wave of minor updates to these processes coming in the 1980s and early 1990s in response to isotope tracing demonstrating the importance of stored water and clarifying the differences between soil water velocities and celerities.

This talk explores the similarities (and not differences) between all forms of runoff. Our main thesis is that across diverse environments and scales, one key prerequisite for runoff generation exists: connectivity. We will show how the sequence of soil filling and spilling, transmission loss along the flowpath and resulting threshold runoff are all connectivity-based—and we hypothesize, common to all overland and subsurface forms of runoff. We suggest that by asking if 'all runoff processes are the same' this may be a new way to come at improved process measurement, understanding and prediction across diverse regions. We use a connectivity perspective to examine specific questions of: What can we learn about subsurface stormflow from overland flow (and vice versa)? Can we recognize things on the soil surface (where boundary conditions are visible) that may help guide new theory for the subsurface where such soil boundary controls are hidden? Examples are given from hillslope and watershed scales, frozen and unfrozen soils and field-model combinations from sites in the Georgia, South Carolina, Oregon and Saskatchewan.