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Subsurface and terrain controls on runoff generation in deep soil landscapes

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Our understanding of runoff generation in regions characterized by deep, highly weathered soils is incomplete despite the prevalence of this setting worldwide. To address this, we instrumented a first-order watershed in the Piedmont of South Carolina, USA. The Piedmont region of the United States extends east of the Appalachians from Maryland to Alabama, and is home to some of the most rapid population growth in the country. Regional and local relief is modest, although the landscape is highly dissected and local slope can be quite variable. The region's soils are ancient, deeply weathered, and characterized by sharp changes in hydrologic properties due to concentration of clay in the Bt horizon. Despite a mild climate and consistent precipitation, seasonally variable energy availability and deciduous tree cover create a strong evapotranspiration mediated seasonal hydrologic dynamic: while moist soils and extended stream networks are typical of the late fall through spring, relatively dry soils and contracting stream networks emerge in the summer and early fall. To elucidate the control of the complex vertical and planform structure of this region, as well as the strongly seasonal subsurface hydrology, on runoff generation, we installed a network of nested, shallow groundwater wells across an ephemeral to first-order watershed to continuously measure internal water levels. We also recorded local precipitation and discharge at the outlet of this watershed, a similar adjacent watershed, and in the second to third order downstream watershed. Subsurface water dynamics varied spatially, vertically, and seasonally. Shallow depths and landscape positions with minimal contributing area exhibited flashier dynamics comparable to the stream hydrographs while positions with more contributing area exhibited relatively muted dynamics. Most well positions showed minimal response to precipitation throughout the summer, and even occasionally observed response rarely co-occurred with streamflow generation. Our initial findings suggest that characterizing the terrain of a watershed must be coupled with the subsurface soil hydrology in order to understand spatiotemporal patterns of streamflow generation in regions possessing both complex vertical structure and terrain.