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# Modeling subsurface stormflow initiation in low-relief landscapes

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Shallow lateral subsurface flow as a runoff generating mechanism at the hillslope scale has mostly been studied in steeper terrain with typical hillside angles of 10 - 45 degrees. These studies have shown that subsurface stormflow is often initiated at the interface between a permeable upper soil layer and a lower conductivity impeding layer, e.g. a B horizon or bedrock. Many studies have identified thresholds of event size and soil moisture states that need to be exceeded before subsurface stormflow is initiated. However, subsurface stormflow generation on low-relief hillslopes has been much less studied.
Here we present a modeling study that investigates the initiation of subsurface stormflow on low-relief hillslopes in the Upper Coastal Plain of South Carolina, USA. Hillslopes in this region typically have slope angles of 2-5 degrees. Topsoils are sandy, underlain by a low-conductivity sandy clay loam Bt horizon. Subsurface stormflow has only been intercepted occasionally in a 120 m long trench, and often subsurface flow was not well correlated with stream signals, suggesting a disconnect between subsurface flow on the hillslopes and stream flow. We therefore used a hydrologic model to better understand which conditions promote the initiation of subsurface flow in this landscape, addressing following questions: Is there a threshold event size and soil moisture state for producing lateral subsurface flow? What role does the spatial pattern of depth to the impeding clay layer play for subsurface stormflow dynamics?
We reproduced a section of a hillslope, for which high-resolution topographic data and depth to clay measurements were available, in the hydrologic model HYDRUS-3D. Soil hydraulic parameters were based on experimentally-derived data. The threshold analysis was first performed using hourly climate data records for 2009-2010 from the study site to drive the simulation. For this period also trench measurements of subsurface flow were available. In addition, we also ran a longer-term simulation, using daily climate data for a nine year period to include more variable climate conditions in the threshold analysis. The model captured the observed subsurface flow instances very well. The threshold analysis indicated that the occurrence of subsurface stormflow uncommon, with a large proportion of the water perching above the clay layer percolating vertically into the clay layer. Event sizes of approximately 70-80 mm were required for initiating subsurface stormflow. The hourly data from 2009-2010 was subsequently used to test if the actual spatial distribution of depth to clay is a major control for the occurrence and magnitude of lateral subsurface flow. Results suggest that in this low-relief landscape also a spatially uniform mean depth to clay reproduces well the hydrologic behavior.