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Virtual experiment on the effect of spatial throughfall patterns on the generation of subsurface stormflow and occurring soil moisture patterns

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The generation and behaviour of subsurface stormflow at the hillslope scale is still poorly understood. Interactions between the permeable soil and the less permeable bedrock can cause a high non-linearity in the subsurface flow and depend on several hillslope attributes like soil depth, slope angle, and bedrock permeability. Furthermore, also the size of storm events controls subsurface flow generation. The effect of the spatial variability of throughfall on subsurface stormflow (SSF) generation and soil moisture patterns has not yet been studied in detail.

The objectives of this study are three-fold:

1. to investigate if and how different configurations of the same throughfall pattern change the SSF behaviour;
2. to investigate the interplay between the spatially variable input and the hillslope attributes (slope angle and soil depth) on the generation of SSF;
3. to investigate a geo-statistical tool, that uses semi-variogram characteristics, to analyse if soil moisture patterns during an event are dominated by throughfall patterns or by bedrock topography patterns.

To meet these objectives virtual experiments can be helpful. A virtual experiment is a numerical experiment driven by collective field intelligence. It provides a learning tool to investigate the effect of separated processes in a complex system. In our virtual experiment we combined spatial throughfall data from the Huewelerbach catchment in Luxembourg with the topography characteristics of the Panola hillslope in Georgia, USA. We used HYDRUS-3D as a modeling platform.

The forcing caused by the spatial throughfall pattern appears to be large on both SSF generation and the spatial variability of SSF along the hillslope, but only marginal on total SSF amounts. The spatial variability of SSF along the hillslope appears to be related to the drainage pattern of the bedrock. The effect of the interplay between input and hillslope attributes on different hydrograph features of SSF is limited. The geo-statistical analysis suggested that during the event the soil moisture distribution reflected throughfall patterns whereas after the event, during the drainage of the hillslope, the bedrock topography increasingly dominated soil moisture patterns.