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Spatial patterns for canopy drainage translate into soil moisture dynamics – empirical evidence

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Heterogeneity in below canopy precipitation has often been hypothesized to induce spatial variation of soil water content especially in forests. However, we are not aware of any observational study relating the spatial variation of soil water content directly to net precipitation or alternatively to deep percolation. Here, we investigate whether throughfall patterns affect the spatial heterogeneity of soil water response in the main rooting zone. We assessed rainfall, throughfall and soil water contents (two depths: 7.5 cm and 27.5 cm) in a very dense observation network on a 1 ha temperate mixed beech forest plot in Germany during two growing seasons. Because throughfall and soil water content cannot be measured at the same location, we used kriging to derive the throughfall values at the locations where soil water content was measured.

Throughfall spatial patterns were related to canopy density. Although spatial auto-correlation decreased with increasing event sizes, temporally stable throughfall patterns emerged, leading to reoccurring high and lower input locations across precipitation events. A linear mixed effect model analysis showed, that soil water content patterns were only poorly linked to throughfall spatial patterns, and it was rather shaped by unidentified but time constant factors. Instead the increase soil water content after rainfall corresponded more closely to throughfall input patterns. Furthermore, soil water patterns additionally affected how much water was stored, and ancillary data suggest that this was related to preferential flow.

In this comprehensive study we show that throughfall patterns imprint less on soil water contents and more on soil water dynamics shortly after rainfall events, therefore only partly confirming previous modelling with data. Our findings highlight at the same time systematic patterns of times and locations where the capacity to store water is reduced and water probably conducted quickly to greater depth. Our results indicate percolation patterns may already be triggered in the canopy.