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Everything is connected: On the links between forest structure, throughfall patterns, soil-permeability, and hydrologic connectivity

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Throughfall - rain that drops through forest canopies - greatly varies in space. Yet, this spatial variation is not similar across forests; instead, recent research provides evidence that forest structure influences the strength and range of throughfall autocorrelations. Moreover, throughfall patterns can be temporally quite persistent, which hints at their potential hydrological relevance. Whether or not these patterns indeed influence the hydrological response of forested hillslopes remains an open question. Some studies reported an influence of the throughfall spatial structure on runoff generation whereas others indicate that throughfall patterns are of secondary importance. Most of the previous simulation studies focused on the throughfall pattern but neglected soil variability. In this study we try to overcome this limitation by combining multiple high-resolution, real-world throughfall and soil-permeability datasets. Based on stochastic simulations we investigate the interaction of throughfall and soil-permeability spatial patterns by calculating the size of connected patches where throughfall intensities exceed the permeability in the topsoil. Because the spatial structure of throughfall does not only depend on forest type but also on the size of the rain event, we conduct our simulations for a wide range of rainfall amounts and intensities. So far, our results provide strong evidence that spatially structured throughfall patterns decrease hydrologic connectivity. That is, an increasing autocorrelation in throughfall always decreases the connectivity of those patches in which throughfall intensities exceed soil-permeability. Interestingly, our data further indicate that throughfall patterns in old-growth forests have more impact on hydrologic connectivity compared to patterns typically found in young forests. Based on these results we discuss the hypothesis that during forest growth the canopy becomes increasingly structured which in turn decreases hydrologic connectivity.