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Surface roughness variations in time – modelling the effects of precipitation on microtopography

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Microtopography strongly affects velocities and patterns of overland flow, water retention and mineralization of soil organic matter. Bare surfaces experience a restructuring of the small-scale relief during rainfall events due to rainsplash, crusting, sealing and rill initiation. Such restructuring in turn affects hydrologic processes at larger scales. Considering these processes in rainfall-runoff models is challenging due to the different scales involved.

(Semi-)variograms provide valuable parameters about the spatial organization of microrelief, which can be used as measure of surface roughness at different scales. Our work focuses on the changes of the variogram parameters during rainfall events and how topographic variations can be parameterized based on these changes. We applied rainfall experiments on bare soil surfaces and surveyed relief evolution at fixed timesteps using a laser scanner. We also used the grid representation of the initial surface conditions to simulate relief evolution with a diffusion equation.

Our study shows that the variogram parameters significantly change during a rainfall event. This variability can be reproduced by analyzing variogram parameters of surfaces simulated by the diffusion equation. With the development of distinct flow pathways a significant reorganization of microtopography occurs. These surface patterns can be parameterized by anisotropic variogram models.

Anisotropy in variogram models offers another parameter for surface roughness characterization in hydrologic models and may have the potential to serve as parameter describing surface conditions relevant for runoff concentration. Therefor anisotropy could provide a measure to bridge the gap between micro-scale processes and catchment scale hydrology.