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Farm-scale spatio-temporal variability of rainfall characteristics – do we use the right inputs to develop and test erosion models?

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The variability of rainfall in space and time is an essential driver of many processes in nature but little is known about its extent on the farm and event scale, although many hydrological and environmental experiments are carried out on these scales. A network of 13 tipping-bucket rain gauges was operated on a 1.4 km^2 test site in Southern Germany for four years to quantify spatial trends in rainfall accumulation, intensity, and erosivity. The effects of the measured spatio-temporal variability of rainfall accumulation on surface runoff and soil erosion were simulated for the largest watershed of the test site (8.5 ha) using a spatially-distributed, event-based surface runoff and erosion model.

In the hydrological summer half years (1994-1998) 37% of all events ($>$ 5 mm) had a significant spatial gradient in rainfall accumulation. Gradients derived by multiple linear regressions ranged from 0.7 to 15.7 mm km^{-1} with a mean of 4.0 mm km^{-1} (median 3.0 mm km^{-1}). They mainly developed during short bursts of rain and thus gradients were even larger for rain intensities and caused a variation in rain erosivity of up to 255% for an individual event. The trends did not have a single primary direction and thus level out on the long term, but for short time periods or for single events the assumption of spatially uniform rainfall is invalid on the farm scale. Moreover, an increasing strength of spatial trends with increasing rain intensity was recognized. Simulated surface runoff for single events varied substantially if minimal, maximal or spatially interpolated rainfall was used as model inputs. In case of the event with the

steepest gradient in rainfall accumulation (gradient 15.7 mm km^{-1}; average rainfall 23.9 mm) the simulated surface runoff in the largest watershed of the test site was 0.0 mm, 0.8 mm and 8.1 mm for minimal, spatially interpolated and maximal rainfall, respectively. The difference was even more pronounced for modelled sediment delivery. It ranged from 0 kg ha^{-1} for minimal to 4 kg ha^{-1} for spatially distributed to 191 kg ha^{-1} for maximal rainfall accumulation of the event. Compared to surface runoff the higher sensitivity was mainly caused by the highly non-linear behaviour of rill and ephemeral gully erosion.

In general, the farm-scale spatio-temporal variability in rainfall has important implications for any hydrological or geomorphologic process sensitive to maximum rain intensities, especially when focusing on large, rare events. The variability is highly relevant for environmental processes acting on short time scales like flooding or erosion. Hence, it is necessary to take this variability into account to develop and test any event-based runoff or erosion model.