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Set storage to the rain – Experimental and model-based evidence in mitigating extreme rainfall excess with green roofs

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Green infrastructure plays a key role in contemporary concepts to mitigate flooding in urban environments. Concepts like water sensitive cities, sponge cities, and water sensitive urban design aim to mimic features of the natural water cycle even in highly urbanized districts. For instance, green roofs – as a key element of green infrastructure – reduce runoff due to their storage capacity. Hence, evapotranspiration is also increased at the expense of runoff, which better matches the characteristics of the natural water cycle. In this presentation, we demonstrate the added value of green roofs for stormwater mitigation. First, a green roof test plot with a slope of zero degrees and dimensions of 20 m in length and 1 m in width is built under laboratory conditions. The vertical extent is 0.08 m filled with a homogeneous substrate layer with a 300 g m^{-2} drainage mat below. The runoff leaving the green roof at one of the 1 m edges is collected in tanks, which allows to continuously monitor the outflow. The water level in the green roof is observed using cameras. In this physical experiment, a sprinkler system is set up in order to generate an artificial rainfall event that mimics a design storm with a rainfall volume of 27 l m^{-2} in total falling within 15 minutes. This corresponds to a return period of 100 years at the experimental site in Hanover, Germany. A numerical model utilizing the open source Catchment Modelling Framework (CMF) is developed to represent the green roof in a physically based model representation, which solves the Darcy flow along a 1D numerical grid with a grid spacing of 0.2 m. The model captures the dynamics of the green roof's hydrological response very well. The comparison of observed and modelled runoff time series, each with a temporal resolution of 1 minute, suggest a Nash-Sutcliffe model efficiency of 0.64. The root mean square error (RMSE) of modelled water levels in the green roof amounts to 1.2 cm. Both the physical experiment and the model suggest a runoff coefficient of 9% after 15 minutes. At present, we also focus on analyzing other configurations of green roofs with altered dimensions and slope (50 experiments in total with up to three repetitions each). These results highlight that (i) CMF represents the hydrology of the green roof with high accuracy, and (ii) green roofs are a very efficient measure of green infrastructure that helps to reduce runoff even for design storms well beyond return periods usually considered in urban drainage planning. This is especially relevant in the process of transforming grey to green infrastructure in the light of climate change adaptation.