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Dynamics at the urban soil-atmosphere interface - water store of paved surfaces depends on rain events

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This contribution investigates the surface store of paved urban surfaces, which governs the rainwater partition e.g. evaporation, infiltration and run-off. Generally, water storage of paved surfaces is considered under the perspective of run-off generation, for which a rough estimation of storage capacity might be sufficient. However, stored water on and in pavements can be evaporated, leading to cooling effects, a fact which is mostly ignored by urban climatologists.

The surface store S is usually regarded as a fixed value, dependent on surface relief and porous material characteristics. Especially for small rain events, which account for the greatest part of the total rainfall in temperate climate cities, a great fraction of the rain water is stored. Ignoring or over-simplifying the storage leads to an overestimation of run-off and to an underestimation on evaporation.

This study aimed to investigate the dynamics of the surface store. Contrary to the usual way, we assume the surface storage not to be a fixed value, but to be variable depending on the boundary conditions.

This hypothesis was investigated experimentally. Additionally, an established soil physical model was applied to explain the findings. In a simple laboratory experiment, we studied the surface store filling dynamic for dense (DP), porous (PP) and highly infiltrative (IP) paving materials under different irrigation intensities, p. Irrigation intensities ranged from 0.016 to 0.1 $\mathrm{mm\,min^{-1}}$ which represent the 25 % to 88 % -quantiles of the precipitation event distribution in Berlin, Germany (1961 to 1990).

Three surface stores could be separated: Storage until initial run-off, S_f, at maximum filling, S_m and for steady state run-off, S_eq. The equilibrium store varies from 0.2 to 3 mm for DP, PP and IP for the investigated rainfall intensities. For all pavers, the surface store depends on rainfall intensity, which was shown experimentally and confirmed by numerical simulation of the infiltration using HYDRUS-1D.

We found that pavers can evaporate a multiple of their surface store per day, depending on temporal rainfall distribution. If cooling effects due evaporation shall be investigated, we suggest to consider the surface store in a more advanced way than today and to use high temporal resolution in urban hydrology modeling.