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Towards a new multi-sensor heavy rainfall statistic for Germany (KOSTRA-DWD-Hybrid): combining long-term rain gauge measurements with high-resolution radar data

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As heavy rainfall events (HPEs) become more frequent and intense with ongoing climate change, accurate and comprehensive analyses of their patterns, including the generation of depth-duration‐frequency (DDF) curves, are crucial for enhancing our understanding of rainfall dynamics, assessing associated risk, and implementing effective mitigation strategies. DDF curves are essential for designing water management systems and facilities, such as dams, dikes, spillways, flood retention basins, and urban drainage systems. For Germany, this data is provided by KOSTRA-DWD (*Koordinierte Starkniederschlagsregionalisierung und -auswertung des Deutschen Wetterdienstes*), a product developed since the 1980s at the Department of Hydrometeorology of the *Deutscher Wetterdienst*.

In recent years, KOSTRA-DWD has been thoroughly revised, considering state-of-the-art (geo)statistical methods and additional rainfall data. The latest version, KOSTRA-DWD-2020, is based on the annual maximum series (AMS) obtained from 1900 rain-gauge stations. AMS have been calculated for 22 durations from 5 min to 7 days. Subsequently, the generalised extreme value distribution (GEV; Fréchet distribution with shape parameter fixed to 0.1) has been fitted to AMS of a particular duration. Considering the interconnectedness of HPEs of different durations, the concept of Koutsoyiannis et al. (1998) has been implemented to smooth heavy rainfall statistics over all durations. Ultimately, regionalisation of GEV parameters using kriging with external drift, along with estimation of DDF curves for 9 return periods ranging from 1 to 100 years, has been conducted.

However, preliminary comparisons between DDF maps from KOSTRA-DWD-2020 and those generated from radar data have revealed some discrepancies. Firstly, radar data yields quantitatively lower levels of DDF estimates than KOSTRA-DWD-2020, mainly due to the shorter time series of only 20 years. We hypothesise that in numerous grid points of radar data there may not be a sufficient number of HPEs observed within this relatively short time period, resulting in lower levels of DDF curves. Another reason may be the smoothing of HPEs in the 1 km² grid cells of radar data compared to point measurements from rain-gauge stations. Secondly, the spatial patterns of DDF estimates at short durations (e.g. 60 min and less) are more heterogeneous in radar data than in KOSTRA-DWD-2020. Above all, HPEs identified from radar data do not seem to be as strongly linked to the orography as demonstrated in KOSTRA-DWD-2020.

This preliminary study compares DDF estimates obtained from both data sources and outlines the first steps towards developing a hybrid methodology called KOSTRA-DWD-Hybrid, which seeks to combine long-term rain-gauge measurements with high-resolution radar data. By combining these two data sources, we aim to harness the strengths of each and overcome their respective limitations, enhancing the accuracy and comprehensiveness of heavy rainfall statistics.

Koutsoyiannis et al., 1998, A mathematical framework for studying rainfall intensity-duration-frequency relationships. J. Hydrol. (206), 118-135, https://doi.org/10.1016/S0022-1694(98)00097-3