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Statistical analysis of very high-resolution precipitation data and relation to atmospheric circulation in central Germany

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Since the 1990s, more and more measuring stations have been equipped with PLUVIO-OTT precipitation gauges, based on a weighing system which allows the recording of high-intensity precipitation events in a very high temporal resolution (1 min). This contribution investigates the data of two different observational networks, one operated by the German Weather Service (DWD) and the other by the regional water authority of the county of Hesse (HLNUG) in central Germany.
Generally, short-term high-intensity precipitation (some minutes up to some hours) is mainly linked to warmer temperatures supporting convection, while large precipitation on a daily scale often connects to frontal precipitation. To distinguish between these types, we look at data of the winter half year (October to March) and the summer half year (April to September) separately. By using 47 HLNUG und 79 DWD stations, we achieve a good spatial distribution within the study area.
The observational dataset (2000 to 2016) is analyzed for the first time to answer the following questions:
- Are the recorded precipitation data plausible/homogeneous? Which sources of error can be identified and which of them may be eliminated?
- Is there a connection between short-term precipitation intensity and atmospheric circulation characteristics?
Atmospheric circulation is investigated by the Grosswetterlagen classification and two different indices of the North Atlantic Oscillation (CPC and Li & Wang).
Both (DWD and HLNUG) datasets show similar characteristics concerning their daily and annual precipitation sums. Yet, comparing their 1-min peak intensity values revealed large deviations between the datasets. They could be minimized by adding up the data to 15 minutes and considering only independent precipitation events. Subsequently, the daily 15-minute maximum precipitation and the daily 24-hour precipitation sums were analyzed to reveal the impact of atmospheric circulation patterns on intensive precipitation events on both temporal scales. The significance of the results was tested with the hypothesis test of Kolmogorov and Smirnov.
Westerly air mass inflow has a positive effect on precipitation intensity during the winter half year and a clear correlation with topography concerning the 24-hour precipitation. In summer, the inflow of continental air masses from Southern and Eastern Europe results in a higher risk of heavy (convective) rainfall over Hesse, spatially randomly distributed over the region. The highest probability of strong daily precipitation connects to centrally located low pressure systems over or near the region, uniformly impacting the whole study area during the summer half year. Southern inflow (especially during trough conditions) has a greater impact on summerly short-term precipitation events.
Our study reveals a clear connection between atmospheric circulation and heavy precipitation events over Hesse and indicates some noticeable differences between daily and sub-daily events, underlining the importance of expanding and enhancing high-resolution precipitation observations.