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Design of rain gauge networks for flash flood prediction: assessment based on spatial moments of catchment rainfall

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Despite the availability of weather radar data at high spatial (1 km2) and temporal (5–15 min) resolution, ground-based rain gauges continue to be necessary for accurate estimation of storm rainfall input to catchments during flash flood events, especially in terrain characterized by complex orography.
A long-standing problem in catchment hydrology is to establish optimal placement and density of a rain gauge network to acquire data on both rainfall depth and spatiotemporal variability of intensity during extreme storm events. Using weather radar observations and a dense network of rain gauges, this study examines whether it is possible to determine a reliable "best" set of rain gauge locations for a number of catchments subject to flash floods observed in Europe. High-quality rainfall data are used to evaluate several configurations of a raingauge network with variable spatial densities.
A methodology is used for the selection of raingauge sites, given a certain spatial density, which is based on the use of the spatial moments of catchment rainfall. This set of statistics quantifies the dependence existing between spatial rainfall organisation, basin morphology and runoff response. These statistics describe the spatial rainfall organisation in terms of position and dispersion as a function of the distance measured along the flow routing coordinate.
Rainfall estimates obtained from the 'optimised' raingauge network are used as input for a distributed hydrological model. Results from these simulations are compared with those obtained by using the measured rainfall and with those obtained by estimating rainfall from randomly designed network ensembles. Our results show that indications from the optimization of the spatial moments of catchment rainfall may help to provide a robust design for rain gauge network design.