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Impact of rainfall spatial distribution and resolution on flash floods response

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Uncertainty in flash flood forecasting critically depends on the space-time monitoring resolution of the flood-triggering rainfall. Hence, it is important to better understand at what space-time scales rainfall has to be monitored, given certain catchment and storm characteristics, and what are the effects of space-time aggregations on model simulations and forecasts.
This work exploits the concept of spatial moments of catchment rainfall to quantify the dependence between rainfall spatial distribution, rainfall resolution, catchment morphology, and runoff response. The spatial moments of catchment rainfall describe rainfall organization in terms of concentration and dispersion along the flow distance coordinate. Assuming that rainfall distribution at equal flow distance is averaged by runoff propagation, these statistics provide a useful metric to examine how the catchment filters out rainfall spatial variability into runoff response. The effect of a variation in spatial rainfall resolution on spatial moments of catchment rainfall should therefore explain, at least partially, the pattern of runoff model sensitivity to spatial rainfall resolution. Since these statistics can capture the interactions between rainfall distribution and basin morphology, they can also be useful to compare its influence across scales and events. High resolution radar observations and a distributed hydrological model have been used to apply these statistics in five extreme flash floods occurred in various European regions in the period 2002–2007. This application allowed to verify the assumptions and to quantify how effective are these statistics in describing the role of spatial rainfall organization and of spatial resolution for flash flood modeling. The size of the study catchments ranges between 36 to 982 km2. The timing error introduced by neglecting the rainfall spatial variability, that ranges between -30% to 72% of the corresponding catchment response time, is well explained by the statistics of rainfall distribution. The good correlation with hydrograph properties indicates that the statistics of rainfall distribution have some descriptive capacity for flash floods. Finally it was studied the effect of aggregating rainfall from 1 to 4, 9 and 16 km2 on spatial moments of catchment rainfall. An important error source related to spatial rainfall aggregation, and not described by spatial moments, is the rainfall volume error caused by incorrectly "smoothing rainfall volume" either into or out of the watershed. The remaining error is well explained by the statistics. Implications concerning the monitoring requirements in the frame of the flood risk management activities are discussed.