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Dealing with rainfall location uncertainty in flood forecasting: a distance-dependent depth-duration approach

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The difficulty (or, rather, impossibility) of predicting the exact location of heavy rainfall events, in particular of convective origin, is a long-standing obstacle in hydro-meteorological forecasting. The relatively recent development of convection-permitting atmospheric forecasting models has generally improved the accuracy of extreme intensities, even for highly localized cloudbursts, but their location remains uncertain due to the chaotic processes involved. In a hydrological context, the impact of any location error is strongly dependent on the size and character of the basin under study; in a large, rural basin the error may virtually "disappear" in the slow runoff generation process anyway whereas in a small, urban basin the error is fundamentally decisive for risk assessment and warning.

Ensemble forecasting is a natural and attractive way to tackle the location uncertainty from the point of view of atmospheric modelling. The resulting ensemble will indicate different locations of the highest intensities, ideally within a rather limited area. However, considering the very small scales involved, i.e. the areas of both the high-intensity cores of convective events and of the urban basins, only feeding this ensemble into a hydrological model will not be sufficient to accurately capture flood risk. Basins that happen to be located in between forecasted rainfall extremes will still be signalled as having no flood risk, which is not true.

A natural way to take it one step further is by using a neighbourhood approach, considering not only the rainfall forecasted at the basin location but also in its vicinity. In this study we adopt a neighbourhood approach in combination with depth-duration analysis in order firstly to identify critical rainfall forecasts at different distances from the basin and secondly to generate a "worst-case ensemble" of hydrologcial forecasts for the basin. These forecasts cannot be interpreted as ordinary ensembles but rather used for early warning that rainfall with (flash-)flood-producing potential is to be expected in the region, which is generally difficult to assess from the rainfall forecasts alone. The method is demonstrated using re-forecasts of a cloudburst in Malmö City, Sweden, in August 2014 that caused the worst urban flooding on record in Sweden.