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The case of distributed rainfall and spatially adaptive modeling

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How important is information about distributed precipitation when we do rainfall-runoff modeling on the catchments scale?

The latter is surely one of the more frequently asked research questions in hydrological modeling. Most studies tackling the issue seem thereby to agree that distributed precipitation becomes more important if the ratio of catchment size against storm size decreases or if the spatial gradients of the rainfall field increase. Furthermore, is it often highlighted that catchments are surprisingly effective in smoothing out the spatial variability of the meteorological forcing, at least, if the focus is simulation integral fluxes and average states.

However, despite these agreements there is no straightforward guidance in the hydrological literature when these thresholds have been reached and when the spatial distribution of the precipitation starts dominating. This is because the answer to the above drawn question depends on the spatial variability of system characteristics, on the system state variables as well as on the strength of the rainfall forcing and its space-time variability. As all three controls vary greatly in space and time it is challenging to identify generally valid rules when information about the distribution of rainfall becomes important for predictive modelling.

The present study aims to overcome this limitation by developing a model framework to identify periods where the spatial gradients in rainfall intensity are larger than the ability of the landscape to internally dissipate those. This newly developed spatially adaptive modeling approach, uses the spatial information content of the precipitation to control the spatial distribution of our model. The main underlying idea of this approach is to use distributed models only when they are actually needed resulting in 1) a drastic decrease in computational times as well as 2) in a more appropriate representation of a hydrological system. Our results highlight that only during a few periods throughout a hydrological year do distributed precipitation data actually matter. However, they also show that these periods are often highly relevant with respect to certain extremes and that the successful simulation of these extremes require distributed information about the forcing and state of a given system.