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Rainfall disaggregation for hydrological modeling: Is there a need for spatial consistence?

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Rainfall data with a high temporal resolution is required for rainfall-runoff modeling. Observed time series of this kind are short and can thus not be used in most cases. However, time series with daily resolution exist for longer periods and denser networks. The objective is to derive time series with a long duration and a high resolution by disaggregating time series of the non-recording stations with information of high-resolution time series.

The multiplicative random cascade model can be used for temporal rainfall disaggregation. It disaggregates time series without consideration of time series of other surrounding stations. This method (hereafter referred to as method 0) yields unrealistic spatial patterns of rainfall if it is applied to more than one station since the sub-daily rainfall is distributed randomly in time for each site. Two methods are analyzed for the subsequently implementation of spatial consistence. Method 1 is based on a simulated annealing algorithm that resamples relative diurnal cycles of the disaggregated time-series with the aim to reproduce spatial dependence of rainfall. Method 2 assigns the relative diurnal cycle of the station with the highest rainfall amount to all other stations for each day. Disaggregated time series using both methods as well as without implemented spatial consistence are used as input for rainfall-runoff modeling in the conceptual, semi-distributed model HBV. Investigation areas are three mesoscale catchments (62-321 km^2) in Northern Germany.

The results show clear differences between the three approaches with regard to bivariate spatial rainfall characteristics. With the resampling algorithm of method 1 the observed characteristics can be reproduced. With method 0 and method 2 they are underestimated and overestimated, respectively. These differences can also be found for areal rainfall intensities.

However, the statistics of the simulated discharge show only slight differences concerning discharge duration curves and derived flood frequencies for summer and winter terms. Results between the three approaches are similar with calibration of the models, without calibration and for different station densities. This poses several questions concerning the influence of spatial rainfall patterns at this scale. Additional investigations are under way, e.g. using WaSiM-ETH as an alternative, more physically based and distributed model.