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Statistical simulation of ensembles of precipitation fields for data assimilation applications

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The simulation of the hydrological cycle by models is an indispensable tool for a variety of environmental challenges such as climate prediction, water resources management, or flood forecasting. One of the crucial variables within the hydrological system, and accordingly one of the main drivers for terrestrial hydrological processes, is precipitation. A correct reproduction of the spatio-temporal distribution of precipitation is crucial for the quality and performance of hydrological applications. In our approach we stochastically generate precipitation fields conditioned on various precipitation observations.
Rain gauges provide high-quality information for a specific measurement point, but their spatial representativeness is often rare. Microwave links, e. g. from commercial cellular operators, on the other hand can be used to estimate line integrals of near-surface rainfall information. They provide a very dense observational system compared to rain gauges. A further prevalent source of precipitation information are weather radars, which provide rainfall pattern informations. In our approach we derive precipitation fields, which are conditioned on combinations of these different observation types. As method to generate precipitation fields we use the random mixing method. Following this method a precipitation field is received as a linear combination of unconditional spatial random fields, where the spatial dependence structure is described by copulas. The weights of the linear combination are chosen in the way that the observations and the spatial structure of precipitation are reproduced. One main advantage of the random mixing method is the opportunity to consider linear and non-linear constraints.
For a demonstration of the method we use virtual observations generated from a virtual reality of the Neckar catchment. These virtual observations mimic advantages and disadvantages of real observations. This virtual data set allows us to evaluate simulated precipitation fields in a very detailed manner as well as to quantify uncertainties which are conveyed by measurement inaccuracies. In a further step we use real observations as a basis for the generation of precipitation fields. The resulting ensembles of precipitation fields are used for example for data assimilation applications or as input data for hydrological models.